SINGAPORE STANDARD

CP 13 : 1999

(ICS 91.140)

CODE OF PRACTICE FOR

Mechanical ventilation and air-conditioning in buildings

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CODE OF PRACTICE FOR MECHANICAL VENTILATION AND AIR-CONDITIONING IN BUILDINGS

AMENDMENT NO.1

February 2000

1. **Page 15, Table 2**

   (a) Under 'Type of building/Occupancy', *replace* 'lobbies' with 'lobbies***'

   (b) *Add* the following note after the table:

   *** Lobbies of area of 10m^2 or less are exempted from being mechanically ventilated.

2. **Page 27, Clause 7.1.3**

   Delete ', not lower than the design value' at the end of this subclause.

3. **Page 32, Clause 7.11.6(a)**

   Replace 'should not be designed' with 'should be designed'.

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CODE OF PROTECTION FOR

Mechanical ventilation and air-conditioning in buildings

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Contents

Foreword

This code of practice was revised by the Technical Committee on Building Services under the direction of the Construction Industry Practice Committee.

The code represents a standard of good practices for mechanical ventilation and air-conditioning systems with particular emphasis on indoor air quality, energy conservation, fire safety and maintainability.

This code helps to establish a broad standard for engineers, architects, contractors and owners to comply with in matters relating to mechanical ventilation and air-conditioning. It also directs them to references on the various topics of concern. However, due attention must be given to the requirements of relevant statutory regulations or by-laws of the regulatory authorities or other government departments.

This code does not cover industrial ventilation in control of specific air contaminants inside work places as such requirements are separately covered by a different set of regulations.

In preparing this code, reference was made to the following documents:

ASHRAE Standard 15-1994	Safety code for mechanical refrigeration
CP10 : 1993	Installation and servicing of electrical fire alarm systems

ENV Guidelines for good indoor air quality for office premises 1996

Code of practice for fire precautions in buildings 1997

Acknowledgement is made for the use of information from the above references.

NOTE

1. *Singapore Standards are subject to periodic review to keep abreast of technological changes and new technical developments. The revisions of Singapore Standards are announced through the issue of either amendment slips or revised editions.*

2. *Compliance with a Singapore Standard does not exempt users from legal obligations.*

Code of practice for mechanical ventilation and air-conditioning in buildings

1 Scope

1.1 This code of practice provides general guidance in the design, construction, installation, testing and commissioning, maintenance and operation of mechanical ventilation and air-conditioning systems. It does not confer immunity from statutory requirements in government by-laws nor from relevant regulations of government departments. This code does not apply to industrial ventilation in control of air contaminants inside work place.

NOTE – The installation of mechanical ventilation and air-conditioning systems may effect fire risks; it is therefore necessary for the architect or the responsible engineer to obtain the approval of the building authority to the proposed scheme. It is desirable that the architect should indicate any special risk before the design engineer proceeds.

1.2 The majority of mechanical ventilation and air-conditioning systems in Singapore do not require any form of heating and hence heating installations are not covered in this code.

1.3 The purpose of this code of practice is to establish the minimum requirements in mechanical ventilation and air-conditioning engineering practice such that an acceptable indoor thermal environment can be attained in an energy conserving way with due consideration of indoor air quality, fire safety, and maintainability of the equipment.

NOTE – It is not intended that this code should impose unnecessary restrictions on design and installations of systems, nor on the development and use of new improved or unusual materials, design or methods of constructions or installation not covered by this code. However, in the event that this code is applied as a requirement by regulations of regulatory authorities, any departure from this code will require the specific approval of the regulatory authority.

2 Definitions

For the purpose of this code, the following definitions and general trade terminology shall apply:

2.1 Access door

Door provided in an air-handling plant, duct or plenum to permit inspection of the interior.

2.2 Activated carbon

A form of carbon made porous by special treatment by which it is capable of adsorbing various odours, anesthetics and other vapours.

2.3 Air, ambient

Generally speaking, the air surrounding an object.

2.4 Air changes

A method of expressing the rate of air entering or leaving a space by natural or mechanical means in terms of the number of volumes of the space.

2.5 Air cleaner

A device designed for the purpose of removing air-borne impurities such as dusts, gases, vapours, fumes and smokes. Air cleaners include air washers, air filters, electrostatic precipitators and charcoal filters.

2.6 Air conditioning

The process of treating air so as to control simultaneously its temperature, humidity, cleanliness and distribution to meet the requirements of the conditioned space.

2.7 Air diffuser

A circular, square or rectangular air-distribution outlet, generally located in the ceiling and consisting of deflecting members discharging supply air in various directions and planes, and arranged to promote mixing of supply air with room air.

2.8 Air-handling system

A system for the purpose of providing air in a controlled manner to specific enclosures by means of one or more air-handling plants, ducts, plenums, air distribution devices and automatic controls.

2.9 Air, outdoor

Air taken from outdoors.

2.10 Air, return

Air returned from conditioned or refrigerated space.

2.11 Air, supply

The quantity of air delivered to each or any space in the system, or the total delivered to all spaces in the system.

2.12 Condensate

The liquid formed by the condensation of a vapour, such as water which is extracted from moist air as it flows across the cooling coil of an air-conditioner.

2.13 Condenser

A vessel or arrangement of pipes or tubings in which vapour is liquefied by removal of heat.

2.14 Control

Any device for the regulation of a system or component in normal operation, manual or automatic. If automatic, the implication is that it is responsive to changes of pressure, temperature or other property whose magnitude is to be regulated.

2.15 Cooling tower, water

An enclosed device for the evaporative cooling of water by contact with air.

2.16 Covering, duct

Duct covering includes materials such as adhesives, insulation, banding, coating(s), film and jacket used to cover the outside of a duct, fan casing or duct plenum.

2.17 Damper

A device used to vary the volume of air passing through an air outlet, inlet or duct.

2.18 Direct digital control (DDC)

The use of microcomputer to directly perform the control logic for control loops.

2.19 Duct

A passageway made of sheet metal or other suitable materials, used for conveying air.

2.20 Energy, new

Any kind of energy obtainable from a conventional source, excluding that obtained through an energy recovery process.

2.21 Evaporator

That part of a refrigeration system in which the refrigerant is vaporised to produce refrigeration.

2.22 Exfiltration

Air that flows outward through a wall, door, window, crack, etc.

2.23 Exhaust opening

Any opening through which air is removed from a space which is being air-conditioned or ventilated.

2.24 Exit

A means of egress from the interior of the building to an exterior space which is provided by the use of the following either singly or in combination: exterior door openings, exit staircases, exit ramps or exit passageways but not including access stairs, aisles, corridor doors or corridors.

2.25 Grille

A louvered or perforated covering for an air passage opening which can be located in the side-wall, ceiling or floor.

2.26 Humidity, relative

The ratio of the mole fraction of water vapour present in moist air to mole fraction of water vapour in saturated air at the same temperature and pressure.

2.27 Infiltration

Air that flows inward through a wall, door, window crack, etc.

2.28 Insulation, sound

Acoustical treatment of fan housings, supply ducts and other parts of the system, and equipment for the isolation of vibration, or to reduce transmission of noise.

2.29 Insulation, thermal

A material having a relatively high resistance to heat flow and used principally to retard the flow of heat.

2.30 Kilowatt (thermal)

The kilowatt (thermal) is the unit of cooling and heating effects. Approximately 4.15 kW (thermal) are required to change the temperature of one kilogram per second of water flow by 1°C at 15°C.

2.31 Lining, duct

Duct lining includes materials such as adhesives, insulation, coating and film used to line the inside surface of a duct, fan casing, or duct plenum.

2.32 Plenum chamber 高压室

An air compartment connected to one or more distributing ducts.

2.33 Register

A grille and damper assembly covering an air opening.

2.34 Smoke

An air suspension (aerosol) of particles, usually but not necessarily solid, often originating in a solid nucleus, formed from combustion or sublimation. Also defined as carbon or soot particles less than 0.1 micron in size which resulted from the incomplete combustion of carbonaceous materials such as coal, oil, tar and tobacco.

2.35 Temperature, dry-bulb

The temperature of a gas or mixture of gases indicated by an accurate thermometer after correction for radiation.

2.36 Temperature, effective

An arbitrary index which combines into a single value the effect of temperature, humidity and air movement on the sensation of warmth or cold felt by the human body. The numerical value is that of the temperature of still air at 50% relative humidity which induce an identical sensation.

2.37 Temperature, mean radiant

The temperature of a uniform black enclosure in which a solid body or occupant would exchange the same amount of radiant heat as in the existing non-uniform environment.

2.38 Temperature, wet-bulb

Thermodynamic wet-bulb temperature is the temperature at which water (liquid or solid state) by evaporating into air can bring the air to saturation adiabatically at the same temperature. Wet-bulb temperature (without qualification) is the temperature indicated by a wet-bulb psychrometer, constructed and used according to specification.

2.39 Ton of refrigeration

A commercial unit of refrigerating effect. It is equal to 3.52 kW (thermal).

2.40 Vapour barrier

A moisture-impervious layer applied to the surfaces enclosing a humid space to prevent moisture travel to a point where it may condense due to low temperature.

2.41 Ventilation

The process of supplying or removing air, by natural or mechanical means, to or from any space. Such air may or may not have been conditioned.

2.42 Zone

A space or group of spaces within a building with sufficiently similar cooling requirement.

2.43 Zone, comfort

Acceptable ranges of operative temperature and humidity for people in typical summer (and winter) clothing during primarily sedentary activity.

3 Exchange of information

3.1 Preliminary discussion

In the initial planning of a project, information should be exchanged between the client, architect and consulting engineer regarding the various aspects of the air-conditioning and ventilation installation.

The following items should be discussed and the responsibility for these items should be clearly stipulated in the contract:

(a) Hoisting of equipment, tools and materials

(b) Supply and erection of scaffolding and ladders

(c) Preparation and final completion of foundations and equipment bases

(d) Cutting away and making good of every description including built-in brackets and fixtures

(e) Joinery and carpentry

(f) Plumbers' work on cold water supply pipes to cooling towers, and floor traps

(g) Electrical wiring and cabling

(h) Temporary artificial lighting and water supply for installation purposes and supply of workshop and lock-up store accommodation

(i) Fuel, power and water for testing and commissioning

3.2 Planning

The consulting engineer for each type of installation covered by this code should be consulted at the planning stage to ensure a good and economical design. The various matters should be settled in principle, including the following:

(a) Location of plant rooms, outdoor air intakes and exhaust air outlets

(b) Occupancies of buildings

(c) Restrictive conditions governing pipe and duct runs

(d) Drainage facilities for discharge of condensate and emptying installation

(e) Source and quantities of internal heat and moisture gains, e.g. people, lighting, equipment, appliances, etc

(f) Noise and air pollution to/from adjacent buildings

3.3 Information to be provided by the architect

(a) Scale plan drawings of the premises showing orientation together with cross-sections having sufficient details based upon which a reasonable appraisal can be made of the heat transfer through the structures.

(b) Scale plan drawings of the premises with all the air-conditioned, mechanically ventilated and naturally ventilated areas clearly marked.

(c) Location of fire-resistance walls, partitions and floors.

(d) A schedule of builders' work as a forecast during the early stages of design.

3.4 Information to be provided by consulting engineer

(a) Scale drawings indicating the layout of the inlet and extract fan sets, air filters, duct heater and duct routings, and the volume of air flow at each point of inlet and outlet of the air distribution system.

(b) Drawings and/or specifications indicating full requirements for the complete installation, starting capacities, ratings and conditions of performance of each item to comply with the specific requirements.

3.5 Information to be provided by the installation contractor

(a) Shop drawings relating to special fabrication of ducts and pipes, and assembly of plant items covered by his contract.

(b) Work drawings relating to layout and sections of ducts, pipes and plant items superimposed on architectural drawings.

(c) Builders' work drawings showing the extent of all builders' work required for installation.

(d) A set of working instructions and at the conclusion of the installation work, a set of record plans on which all work "as installed" is clearly defined.

(e) A set of operating and maintenance instruction manuals.

3.6 Time schedule

The installation contractor should be informed before the award of contract of the commencement and completion dates of the installation.

4 Rules and regulations

4.1 The installation shall be designed and carried out to comply with all relevant acts, regulations and bylaws, and all amendments thereof, in particular the following:

(a) Building Control Act (Chapter 29)
Building Control Regulations

(b) Fire Safety Act (Chapter 109A)
Fire Safety (Building Fire Safety) Regulations

(c) Public Utilities Act (Chapter 261)
Public Utilities (Electricity) Regulations 1997
Public Utilities (Electricity Supply) Regulations 1997

(d) Environmental Public Health Act (Chapter 95)

(e) Water Pollution Control and Drainage Act (Chapter 348)

(f) Factories Act (Chapter 104)

5 Ventilation rates

The purpose of providing ventilation to a room or occupied space within a building is to remove heat from the space and also possible contaminants, such as the products of respiration, bacteria, odours, product of combustion etc., so that an acceptable indoor air quality can be maintained. The air from the space should be continuously withdrawn and replaced by outdoor air drawn from external sources.

5.1 General requirements

5.1.1 All rooms and occupied spaces which are not naturally ventilated shall be clearly designated in the architectural drawings to be either mechanically ventilated or air-conditioned.

5.1.2 There shall be no smoking in air-conditioned spaces.

5.2 Outdoor air intakes

5.2.1 The location of outdoor air intakes for air-handling systems shall take due account of any other intake openings for ventilation or exhaust. The intakes of outdoor air to all air-conditioning and mechanical ventilation systems, including those for the ventilation and pressurisation of stairshafts, shall be located at external walls or at roof level, arranged so as to pick up outdoor air free of contamination or odours.

5.2.2 Outdoor air intakes shall be covered with an insect screen and protected from rain entrainment.

5.2.3 Outdoor air intakes shall not be within 5 m of exhaust discharges from any buildings, kitchens, toilets, car parks, cooling towers, laundries, rubbish dumps or plant rooms. The distance from an air intake to a cooling tower is measured from the base of the cooling tower.

5.2.4 Outdoor air intakes should be protected from the water droplets emitted by cooling towers, such that no water droplet can enter the ventilation air stream.

5.2.5 For air-conditioned spaces, the bottom of the outdoor air intakes shall not be less than 2.1 m above the outside floor level, when the air intakes are adjacent to car parks or busy thorough fares.

5.3 Outdoor air supply

5.3.1 For design purposes, the minimum quantity of outdoor air supply for comfort air-conditioning of any room or floor space in a building shall be based on the floor area and determined according to the rates given in Table 1. The quantities of outdoor air stated in the table have taken into consideration the occupancy load given in the Fire Code, the requirement for diluting the odour caused by people and their activities, and the requirement for diluting the pollutants caused by the interior furnishing.

5.3.2 The quantity of outdoor air supply for mechanical ventilation for any room or floor space in a building shall be based on its volume and determined according to the rates given in Table 2.

5.3.3 The rates of ventilation given in Tables 1 and 2 apply to normal types of buildings with normal heat gains from occupants and activities and no-smoking in air-conditioned spaces. When abnormal conditions prevail, the ventilation rate may be increased to prevent undue concentration of body odours, bacteria-carrying particles, gas, vapour or dust and to prevent undue accumulation of carbon dioxide and to remove products of combustion.

5.3.4 A refrigeration machinery room under normal operation should be ventilated when occupied with a least 2.5 litres per second of air per square metre of machine room area.

5.3.5 If necessary for operator comfort, the ventilation rate should be such that the heat-producing machinery in the room does not raise the temperature beyond 5°C above the ambient.

5.3.6 For any type of room or floor space not specified in this section, the ventilation rate shall be determined by the qualified person subject to the approval of the relevant authority.

Table 1 – Outdoor air supply requirement for comfort air-conditioning

Type of building/ Occupancy	Minimum outdoor air supply L/s per m^2 floor area	m^3/h per m^2 floor area
Restaurants	2.80	10
Dance halls	5.30	19
Offices	0.65	2.3
Shops, supermarkets and department stores	1.00	3.6
Lobbies, concourses and corridors	0.25	0.9
Classrooms	2.60	9.2
Theatres and cinemas	2.00	7.3
Factories and workshops:		
Light	1.20	4.3
Medium	0.70	2.6
High	0.35	1.3
Hotel guest rooms	15 L/s per room	54 m^3/h per room

Table 2 – Outdoor air supply for mechanical ventilation in non air-conditioned buildings

Type of building/ Occupancy	Minimum outdoor air supply Air-change/h
Offices	6
Restaurants, canteens	10
Shops, supermarkets and department stores	6
Workshops, factories	6
Classrooms	8
Theatres and cinemas	8
Lobbies***, concourse, corridors, staircases and exits	4
Toilets**, bathrooms	10
Kitchens (commercial, institutional and industrial)	20
Car Parks	6*
Fire Command Centres	6
Civil Defence Shelters	16*
Wastewater facilities/pumping installation	8

* Where the ceiling exceeds 2.5 m, the air change rate will be calculated based on 2.5 m ceiling height.
** For heavily used public toilets, refer to Code of Practice on Environmental Health.
*** Lobbies of area of 10m² or less are exempted from being mechanically ventilated.

5.3.7 In air-conditioned office premises, classrooms, theatres and factories, if a reduction in the supply of outdoor air is allowed under Clause 7.4.1, the outdoor air supply rate can be reduced down to 20% of its design value but in no case should it be less than 1.2 m^3/h per m^2.

5.3.8 In existing buildings where the air-conditioning systems have been designed for a lower ventilation rate, the indoor air quality can be improved by using suitable filters for the particulates or gases.

6 Mechanical ventilation systems

6.1 Car parks

It is required to ventilate the car parking areas in a building in order to remove carbon monoxide and other combustion products from the areas.

6.1.1 Except where natural ventilation is available as described in Clauses 6.1.6 and 6.1.7, a mechanical ventilation system incorporating a supply part and an exhaust part, and capable of providing 6 air changes per hour is required for car parking areas in a building.

6.1.2 The mechanical ventilation system may be operated at a lower rate at times of low occupancy subject to the condition that the carbon monoxide concentration is maintained below the permitted level of approximately 25 ppm averaged over an eight-hour period.

6.1.3 The mechanical ventilation system in residential car parking areas may be switched off whenever the carbon monoxide concentration is below 9 ppm or the ambient level.

6.1.4 For the exhaust part of the ventilation system, at least 50% of the exhaust air shall be extracted at low level not exceeding 650 mm above the finished floor, as measured from the top of the grille to the finished floor.

6.1.4 ~~For the exhaust part of the ventilation system, at least 50% of the exhaust air shall be extracted at low level not exceeding 650 mm above the finished floor, as measured from the top of the grille to the finished floor.~~

6.1.5 The supply air shall be drawn directly from the external and its intake shall not be less than 5m from any exhaust discharge openings. Outlets for the supply air shall be adequately distributed over the car park area.

6.1.6 The discharge points of the exhaust ventilation system:

(a) shall be arranged to discharge directly to the external and shall not be less than 5m away from any intake openings, doorways or apertures to prevent the re-entry of objectionable odours or flammable vapour into the premises; and

(b) shall not face or discharge in the direction of any adjacent residential building.

6.1.7 Aboveground car park

6.1.7.1 For aboveground car park, no mechanical ventilation is required for any part of the car park where natural ventilation opening of not less than 20% of the floor area served is provided. The naturally ventilated part of the car park shall be within 12m from the ventilation opening except where cross-ventilation is provided.

6.1.7.2 For aboveground car park without cross ventilation, where additional natural ventilation opening of not less than 20% of the areas beyond 12m of the opening is provided, a reduced mechanical ventilation system in the form of fume extract may be provided to these areas as follows:

(a) the extract system shall be able to provide 1.2 air changes per hour;

(b) the supply part can be omitted; and

(c) the extract points shall be wholly located at low level not exceeding 650 mm above the finished floor, as measured from the top of the grille to the finished floor.

6.1.7.3 Where natural ventilation opening equivalent to not less than 2% of the mechanically ventilated area is provided, the supply part may be omitted.

6.1.7.4 In a large car park, a combination of natural and mechanical ventilation may be provided as illustrated in Table 3.

Table 3 – Mode of ventilation for aboveground car park

Size of ventilation opening (% of floor area)	Mode of ventilation to be provided (NV, MV or fume extract)	
	Zone 'A'	Zone 'B'
20% of A + 20% of B	NV	Fume Extract
20% of A + 2% of B	NV	MV without supply
20% of A	NV	MV
2% of A + 2% of B	MV without supply	MV without supply
2% of A	MV without supply	MV

Zone 'A' refers to part of car park within 12m of natural ventilation opening.
Zone 'B' refers to part of car park beyond 12m of natural ventilation opening.

6.1.8 Basement car park

6.1.8.1 For basement car park, the mechanical ventilation system shall be designed in such a way that the quantity of replacement air shall not exceed that of the exhaust air. This requirement is necessary so that the car park can be maintained under negative pressure at all times to prevent the spread of noxious gases into adjacent occupied areas. In addition, the system shall be so designed that it can be operated in two or more sections conforming to the following requirements:

(a) the capacity of each section shall be such that in the event of breakdown the remaining sections should at least be able to provide half the total required air for the storey.

(b) the sections may operate through a common duct work;

(c) each section of the ventilation system shall be so controlled that in the event of failure of one section, the other shall continue to operate;

(d) the exhaust and supply parts of each section shall be electrically interlocked such that failure of any section of the exhaust part shall automatically shut-down the corresponding section of the supply part;

(e) the exhaust and supply parts shall be such that they can continue to run automatically in the event of a failure in the principal source of electrical supply.

6.1.8.2 For basement car park exceeding one level, the supply and exhaust parts shall be designed in such a way as to minimise intermixing of air between the different levels.

6.1.8.3 For car park located on the first basement level where some degree of natural ventilation is available, the mechanical ventilation requirements as specified in Clause 6.1.7.1 may be modified as follows:

(a) Where natural ventilation opening equivalent to not less than 2% of the mechanically ventilated area is provided, the supply part may be omitted.

(b) Where the natural ventilation opening provided is not less than 20% of the car park area served, a reduced mechanical ventilation system in the form of fume extract as described in Clause 6.1.7.2 may be provided.

6.1.8.4 In a large basement car park, a combination of different modes of mechanical ventilation may be provided as illustrated in Table 4.

Table 4 – Mode of ventilation for basement car park

Size of ventilation opening (% of floor area)	Mode of ventilation to be provided (MV or fume extract)	
	Zone 'A'	**Zone 'B'**
20% of A + 20% of B	Fume Extract	Fume Extract
20% of A + 2% of B	Fume Extract	MV without supply
20% of A	Fume Extract	MV
2% of A + 2% of B	MV without supply	MV without supply
2% of A	MV without supply	MV

Zone 'A' refers to part of car park within 12m of natural ventilation opening.
Zone 'B' refers to part of car park beyond 12m of natural ventilation opening.

6.1.9 Smoke purging systems for basement car parks

When any car park area in a basement storey exceeds a total of 1900 m^2, a smoke purging system shall also be provided.

(a) The smoke purging system shall provide a purging rate of not less than 9 air-change per hour.

(b) The system shall be independent of any other supply and exhaust systems serving other parts of the building.

(c) It can make use of the same exhaust air duct for ventilating the car park if the size of the air duct is adequate.

(d) Horizontal ducts shall be fabricated from heavy gauge steel (1.2 mm thick).

(e) The exhaust fan shall be capable of operating effectively at 250°C for two hours.

6.1.10 Where cars are parked and retrieved with the engines off, the ventilation requirement shall be determined by the relevant authority.

6.2 Kitchens

6.2.1 Mechanically ventilated kitchens shall be designed for a ventilation rate of not less than 20 air-changes per hour as given in Table 2. When kitchen hoods are in operation, the exhaust air through the hoods can be considered as contributing to the exhaust requirement for ventilation.

6.2.2 Mechanical exhaust system for the cooking area of a kitchen in a hotel, restaurant, coffee house or the like shall be independent of those serving other parts of the building.

6.2.3 Sufficient make-up air shall be provided and negative pressure in the kitchen area shall be maintained when the kitchen hood is in operation. Whether or not the kitchen hood is in operation, the kitchen shall be provided with ventilation in accordance with Table 2.

6.2.4 Kitchen-exhaust hoods shall be installed above appliances of heating capacity greater than 8 kW and likely to generate grease vapour (e.g. ranges, fryers, barbecues). Where grease is present, kitchen hoods incorporating grease filters shall be used.

6.2.5 For appliances requiring a kitchen exhaust hood, the exhaust flow rate Q[m^3/s] shall not be less than that given in the following formula, if it is an "island" hood:

$$Q = 1.4V \times 2(L + W)H \times F \qquad (6.1)$$

where:

V = capture velocity which shall not be less than 0.30 m/s for commercial type kitchens

L = length of cooking surface, m

W = width of cooking surface, m

H = distance of hood to emitting surface, m

F = 1.0 for heavy duty high temperature, grease burning, deep-fat frying cooking with equipment such as woks, broilers, char-broilers normally associated with solid or gas-fuel burning equipment

F = 0.7 for light duty, medium and low temperature cooking with equipment such as ovens, steamers, ranges, griddles and fryers.

For wall-mounted hoods, it can be considered as part of an island type hood composed of actual hood and its mirror image in the wall. Thus the above formula can also be applied and corrected.

6.2.6 Design

6.2.6.1 The hood and ducts for the exhaust shall have a clearance of 500mm from unprotected combustible materials.

6.2.6.2 The exhaust shall be discharged directly to the external and shall not be less than 5 m from any air intake openings.

6.2.6.3 The exhaust duct where it runs outside the kitchen shall either be enclosed in a structure or be constructed to give at least the same fire rating as the kitchen or that of the room through which it traverses, whichever is higher. The rating shall apply to fire exposure from both the internal and external part of the duct or structure. Where the duct riser is required to be enclosed in a masonry shaft, it shall be compartmentalised from the rest of the shaft space containing other ducts or services installations.

6.2.6.4 Fire damper shall not be fitted in kitchen exhaust ducts.

6.2.7 Ducts

6.2.7.1 Kitchen-exhaust ducts and shafts shall be sized and installed for the flow rate of air necessary to remove the effluent.

6.2.7.2 Ducts forming part of a kitchen exhaust system shall be manufactured from:

(a) Mild steel of thickness not less than 1.2 mm, or

(b) Stainless steel of thickness not less than 0.9 mm, or

(c) other approved materials.

6.2.7.3 Ducts shall be installed with a fall in the direction of flow of not less than 0.5 percent. To enable cleaning of all the ductwork, openings large enough shall be provided at suitable intervals and locations and/or appropriate cleaning apparatus/systems shall be incorporated. A drain shall be provided at the lowest point of each run of ducting.

6.2.8 Exhaust hoods

6.2.8.1 Exhaust air flow shall be suitably distributed over the exhaust hood to capture the cooking vapour emission under still air conditions, which will be considered as room air motion not exceeding 0.15 m/s velocity.

6.2.8.2 Kitchen exhaust hoods shall be manufactured from rigid impervious hard-faced and non-combustible materials, such as mild steel, stainless steel or aluminium.

6.2.8.3 The seams shall be made liquid-tight seams and the joints made by either fusion welding, lapping, riveting and soldering; or other approved methods.

6.2.8.4 Hoods shall be fitted with washable grease filters mounted in frames in positions enabling convenient removal and replacement, and installed so as to prevent significant leakage of air around the filters.

6.2.8.5 All internal surface of hoods shall be vertical or sloped at an angle not greater than 40° from vertical. The faces of filters shall be vertical or sloped at an angle not greater than 30° from vertical.

6.2.8.6 It should be possible to assess the pressure drop of the ventilation air as it flows across the grease filter.

6.2.8.7 Gutters shall be located beneath any protruding surface or edges such as lower edges of filters, except light fittings inside hoods. Internal gutters not greater than 50 mm or less than 35 mm wide and not less than 10 mm deep shall be located around the lower edges of hoods. Plugged drainage holes shall be provided at intervals not greater than 6 m along the gutter.

6.2.8.8 Canopy type hoods

The lower edges of canopy type exhaust hoods shall be not higher than 1.2 m above the cooking surface nor lower than 2 m above floor level; and extend not less than 150 mm outside the plan perimeter of the appliance over which the hood is installed.

6.3 Bathrooms, toilets and locker rooms

When a bathroom, toilet, locker room or the like is not provided with natural ventilation, it shall be mechanically ventilated as follows:

(a) Air shall be supplied through a ventilation duct directly from the outdoor or from a permanently air-conditioned or naturally ventilated room through louvers in the doors or undercutting the doors or by other openings;

(b) The exaust system shall dispel the vitiated air directly to the outdoors; and

(c) The quantity of replacement air shall not exceed that of exhaust air.

6.4 Exits

6.4.1 Mechanical ventilation systems for exits shall provide ventilation at the rate of 4 air-changes per hour.

6.4.2 Protected shaft of exits, smoke-stop lobbies, including its concealed space shall not be used for supply, exhaust or return air plenum of air handling systems.

6.4.3 Mechanical ventilation system for each exit staircase and internal exit passageway, if provided, shall be an independent system of supply mode only, exclusive to the particular staircase, and it shall comply with the following requirements:

(a) Supply air for the system shall be drawn directly from the external, with intake point not less than 5m from any exhaust discharge openings.

(b) For exit staircase serving more than 4 storeys, supply air shall be conveyed via a vertical duct extending throughout the staircase height and discharging from outlets distributed at alternate floor.

(c) Where the supply air duct serving the exit staircase has to penetrate the staircase enclosure, the portion of the duct where it traverses outside the staircase shall be enclosed in masonry construction of at least the same fire resistance as the element of structure and it shall not be fitted with fire dampers.

6.5 Smoke-stop and fire-fighting lobbies

6.5.1 Mechanical ventilation system for smoke-stop lobbies and fire fighting lobbies shall be a system exclusive to these lobbies, and it shall comply with the following requirements:

(a) The ventilation system shall function in supply mode only and it shall provide ventilation at the rate of 4 air-changes per hour. Upon activation by the building fire alarm system it shall supply at not less than 10 air changes per hour.

(b) Supply air shall be drawn directly from the external with intake point not less than 5m from any exhaust discharge or openings for natural ventilation.

(c) Any part of the supply duct running outside the smoke-stop or fire fighting lobby which it serves shall either be enclosed or constructed to give a fire resistance rating of at least 1 hour. The relevant authority may at its discretion require a higher fire resistance rating if the duct passes through an area of high fire risk.

(d) A remote manual start-stop switch shall be made available to firemen at the fire command centre, or in the absence of a fire command centre, at the fire indicating board. Visual indication of the operational status of the mechanical ventilation system shall be provided.

6.6 Engine driven fire pump room and generator room

6.6.1 Where mechanical ventilation is installed to provide air for the operation of an engine driven fire pump or emergency generator, such systems shall be independent of each other and any other system serving other parts of the building.

6.6.2 The system shall operate upon activation of the pump or generator equipment.

6.6.3 The ventilation rate shall be adequate for the operation of the equipment.

6.6.4 The system shall comply to the following requirements:

(a) Supply air shall be drawn directly from the external and its intake point shall not be less than 5m from any exhaust discharge openings. Exhaust discharge shall also be direct to the external and shall not be less than 5m from any air intake openings.

(b) Where the corresponding ducts run outside the room they shall either be enclosed in a structure or be constructed to give at least the same fire rating as the room which they serve or that of the room through which they traverse, whichever is higher. The rating shall apply to fire exposure from both the internal and external part of the duct or structure. Where the duct risers are required to be enclosed in a masonry shaft, they shall be compartmentalised from the rest of the shaft space containing other ducts or services installations.

(c) No fire damper shall be fitted in either the supply or the exhaust duct required under this clause.

(d) Duct serving areas other than rooms housing the equipment stated in this clause shall not pass through such rooms.

6.7 Fire command centre

6.7.1 An air-conditioning system or mechanical ventilation system, if required for the fire command centre, shall be independent of each other and any other system serving other parts of the building.

6.7.2 The mechanical ventilation rate shall be 6 air changes per hour.

6.7.3 The system shall comply with the following requirements:

(a) Supply air shall be drawn directly from the external and its intake point shall not be less than 5 m from any exhaust discharge openings. Exhaust discharge shall also be direct to the external and shall not be less than 5 m from any air intake openings.

(b) Where the corresponding ducts run outside the fire command centre, they shall either be enclosed in a structure or be constructed to give at least the same fire rating as the room which they serve or that of the room through which they traverse, whichever is higher. Where the duct risers are required to be enclosed in a masonry shaft, they shall be compartmentalised from the rest of the shaft space containing other ducts or services installations.

(c) No fire damper shall be fitted in either the supply or the exhaust duct required under this clause.

(d) Duct serving areas other than the fire command centre shall not pass through the room.

6.8 Rooms involving use of flammable and explosive substances

6.8.1 Mechanical ventilation system where required for rooms in which there is use of flammable and explosive substances shall be independent from those serving other parts of the building.

6.8.2 The ventilation system shall consist of exhaust and supply part with a rate of 20 air changes per hour or any other rates acceptable to the relevant authority.

6.8.3 Design

6.8.3.1 The exhaust shall be direct to the external and shall not be less than 5 m from any air intake openings.

6.8.3.2 Where such ducts run outside the room they shall either be enclosed in a structure or be constructed to give at least the same fire rating as the room which they serve or that of the room through which they traverse, whichever is higher. The rating shall apply to fire exposure from both the internal and external part of the duct or structure. Where the duct risers are required to be enclosed in a masonry shaft, they shall be compartmentalized from the rest of the shaft space containing other ducts or services installations.

6.8.3.3 No fire damper shall be fitted in either the supply or the exhaust duct.

6.8.3.4 Ducts serving other areas shall not pass through rooms involving use of flammable and explosive substances.

6.9 Pressurisation system for exit staircases

6.9.1 General

6.9.1.1 Internal exit staircases without provision for natural ventilation shall be pressurised to comply with the requirements in the Code of Practice for Fire Precautions in Buildings and this code.

6.9.1.2 In a building comprising more than 4 basement storeys, exit staircases connected to the fire fighting lobby in the basement storeys shall be pressurised to comply with the requirements in the Code of Practice for Fire Precautions in Buildings and this code.

6.9.1.3 Pressurisation may be extended to the smoke-stop lobby provided the pressurisation level complies with Clause 6.9.2.

6.9.2 Pressurisation level

6.9.2.1 When in operation, the pressurisation system shall maintain a pressure differential of not less than 50 Pa between the pressurised exit staircase and the occupied area when all doors are closed.

6.9.2.2 Where a pressurisation system is extended to the smoke-stop lobby, the pressure gradient shall be such that the pressure at the exit staircase shall always be higher.

6.9.2.3 The force required to open any door against the combined resistance of the pressurising air and the automatic door-closing mechanism shall not exceed 110 N at the door handle.

6.9.2.4 When in operation, the pressurisation system shall maintain an airflow of sufficient velocity through open doors to prevent smoke from entering into the pressurised area. The flow velocity shall be attained when a combination of two doors from any two successive storeys and the main discharge door are fully open. Magnitude of the velocity averaged over the full area of each door opening shall not be less than 1.0 m/s.

6.9.3 Leakages

6.9.3.1 The rate of supply of pressurised air to the pressurised areas shall be sufficient to make up for the loss through leakages into the unpressurised surroundings.

6.9.3.2 Adequate relief of leaked air out of the occupied area shall be provided to avoid a pressure build-up in this area. The relief may be in the form of perimeter leakages or purpose-built extraction systems.

6.9.3.3 Reference may be made to BS 5588: Fire precautions in the design, construction and use of buildings; Part 4 : Code of practice for smoke control using pressure differentials for nominal leakage areas used to compute the leakage into the surrounding non-pressurised accommodation areas.

6.9.4 Distribution of pressurising air

6.9.4.1 The number and distribution of injection points for supply of pressurising air to the exit staircase should ensure an even pressure profile complying with Clause 6.9.2. In systems serving five storeys or greater the separation between air injection points shall not be greater than two storeys.

6.9.4.2 The arrangement of the injection points and the control of the pressurisation system shall be such that when the opening of doors or other factors cause significant variations in pressure difference, the conditions in Clause 6.9.2 should be restored as soon as practicable.

6.9.5 Installation

6.9.5.1 All the equipment and the relevant controls associated with the pressurisation system shall be so designed and installed to ensure satisfactory operation in the event of and during a fire.

6.9.5.2 The pressurisation system shall be designed and constructed so that its integrity within the exit staircase shall be preserved as a passage for air under fire conditions from the points of intake to all points of discharge.

6.9.5.3 Supply air for pressurisation system shall be drawn directly from the external and its intake shall not be less than 5 m from any exhaust discharge openings.

6.9.5.4 The pressurisation system shall be automatically activated by the building fire alarm system. In addition, a remote manual start-stop switch shall be made available to firemen at the fire command centre, or in the absence of a fire command centre, at the main fire indicating board. Visual indication of the operational status of the pressurisation system shall be provided.

6.9.5.5 The control of the pressurisation system shall be such that when the opening of doors or other factors cause significant variations in pressure difference and air flow, the equilibrium conditions shall preferably be restored within 15 s and should not exceed 60 s.

6.9.5.6 Fans shall be selected for their flat pressure-to-flow characteristics as they are required to supply large flow on demand without building excessive static pressure in low demand.

6.10 Pressurisation of internal corridors in hotels

Where internal corridors in hotels are required to be pressurised in compliance with the Code of Practice for fire precautions in buildings, the pressure within such corridors shall be higher than that in the guest rooms, and the pressure within the internal exit staircases higher than that of the corridors.

6.11 Mechanical smoke control systems for basement occupancies (other than car parking areas)

6.11.1 Mechanical smoke control where required under the Code of Practice for fire precautions in buildings for basement occupancies shall be in the form of an engineered smoke control system.

6.11.2 Smoke purging system

6.11.2.1 Smoke purging systems, where permitted under the requirements of the Code of practice for fire precautions in buildings for basement occupancies of plant/equipment room and service areas such as laundries, office, storeroom and workshops, shall conform to the following requirements:

(a) The purge rate shall be at least 9 air changes per hour.

(b) 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 fire command centre, or in the absence of a fire command centre in the building, at the main fire alarm panel on the first storey. Visual indication of the operational status of the smoke purging system shall also be provided with this remote control.

(c) Horizontal ducts shall be fabricated from heavy gauge steel (1.2 mm thick).

(d) The exhaust fan shall be capable of operating effectively at 250°C for 2 hours and supplied from a secondary source of supply.

(e) Replacement air shall be provided and if it is supplied by a separate mechanical system, such a system shall be connected to a secondary source of power.

6.12 Engineered smoke control system

6.12.1 The engineered smoke control system shall be in the form of a smoke ventilation system by natural or mechanical extraction designed in accordance with:

(a) BR 186 - Design principles for smoke ventilation in enclosed shopping centres; and

(b) BR 258 - Design approaches for smoke control in atrium buildings; or

(c) Other acceptable standards.

NOTE – BR 186 and 258 are reports published by the Fire Research Station, Building Research Establishment, Borehamwood, Herts WD62BL.

6.12.2 The building provided with smoke ventilation system shall be sprinkler protected.

6.12.2.1 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:

	Fire size	
Occupancy (sprinklered)	Heat output (MW)	Perimeter of fire (m)
Shops	5	12
Offices	1	14
Hotel guest room	0.5	6
Hotel public areas	2.5	12
Assembly occupancy with fixed seating	2.5	12

6.12.2.2 The capacity of a smoke ventilation system shall be capable of handling the largest demand for smoke exhaust from the worst case scenario.

6.12.2.3 The design smoke layer base shall be above the heads of people escaping beneath it. The minimum height shall be 2.5 m.

6.12.2.4 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.

6.12.2.5 For cases where smoke is removed from the room of origin the smoke reservoir size for a smoke ventilation system shall not exceed:

(a) 2000 m^2 for natural smoke ventilation system

(b) 2600 m^2 for mechanical smoke ventilation system

6.12.2.6 For cases where smoke is removed from the circulation space or atrium space the smoke reservoir size for a smoke ventilation system shall not exceed :

(a) 1000 m^2 for natural smoke ventilation system

(b) 1300 m^2 for mechanical smoke ventilation system

6.12.2.7 For cases where smoke is removed from the circulation space or atrium space, the rooms discharging smoke into the circulation space/atrium spaces shall either:

(a) have a floor area not exceeding 1000 m^2 for natural ventilation system or 1300 m^2 for mechanical 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 1000 m^2 for natural ventilation system or 1300 m^2 for mechanical ventilation system adjacent to the circulation space or atrium. However, the remainder of the room needs to be provided with an independent smoke ventilation system(s).

6.12.2.8 The maximum length of the smoke reservoir shall not exceed 60 m.

6.12.2.9 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.

6.12.2.10 Owing to practical limitations, a smoke ventilation system shall have:

(a) A maximum mass flow not exceeding 175 kg/s; and

(b) A minimum smoke layer temperature of 18°C above ambient.

6.12.2.11 Replacement air shall be by natural means, drawing air directly from the external.

(a) The design replacement air discharge velocity shall not exceed 5.0 m/s to prevent the escapees being hindered by the air flow.

(b) Replacement air intake shall be sited at least 5 m away from any exhaust air discharge.

(c) Replacement air shall be discharged at a low level, at least 1.5 m beneath the designed smoke layer, to prevent "fogging" of the lower clear zone.

(d) Where the inlet cannot be sited at least 1.5 m below the smoke layer, a smoke curtain or a barrier 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.

6.12.2.12 For cases where the smoke reservoir is above the false ceiling, the ceiling shall be of the perforated type with at least 25% opening.

6.12.2.13 The smoke ventilation system shall be provided with a secondary source of power supply.

6.12.2.14 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 on a non-fire zone due to smoke spills or spread from other areas, can be prevented.

6.12.2.15 Provision of activating smoke detectors shall comply with CP 10.

6.12.2.16 Remote manual activation and control switches as well as visual indication of the operational 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.

6.12.2.17 Except for the mechanical ventilation system as listed in Clause 10.4.1, all other air-conditioning and ventilation systems within the areas served shall be shut down automatically upon activation of the smoke ventilation system.

6.12.2.18 Either a standby fan or multiple fans with excess capacity shall be provided for each mechanical smoke ventilation system such that in the event the multiple duty fan or the largest capacity fan fails, the designed smoke extraction rate will still be met. The standby fan shall be automatically activated in the event the duty fan fails.

6.12.2.19 Fans shall be capable of operating at 250°C for 2 hours.

6.12.2.20 The fans and associated smoke control equipment shall be wired in protected circuits designed to ensure continued operation in the event of fire.

6.12.2.21 The electrical supply to the fans shall, in each case, be connected to a sub-main circuit exclusive thereto after the main isolator of the building.

6.12.2.22 The cables shall be of at least 1hour's fire resistance in accordance with SS 299.

6.12.2.23 Smoke ventilation ducts (both exhaust and replacement air ducts) shall be of at least 1 hour's fire resistance. Where a duct passes through other fire compartment of higher rating, the duct shall be constructed to have the same rating as that of the compartment. The rating shall apply to fire exposure from both the internal and external part of the duct or structure and the duct shall also comply with the requirements in this code.

6.12.2.24 Fire damper shall not be fitted in the smoke ventilation system.

6.12.2.25 The time taken for the smoke ventilation system within a smoke zone to be fully operational shall not exceed 60 seconds from system activation.

6.12.2.26 For natural smoke ventilation systems the natural ventilators shall be :

(a) 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.

6.12.2.27 Natural exhaust ventilation shall not be used together with powered smoke exhaust ventilation.

6.12.2.28 All smoke curtains where required, unless permanently fixed in position, shall be brought into position automatically to provide adequate smoke-tightness and effective depth.

6.12.2.29 Smoke curtain or other smoke barriers 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 a route.

6.12.2.30 Where glass walls or panels are being used as smoke screens to form a smoke reservoir or as channelling screens, they shall be able to withstand the design screen's highest temperature.

6.12.2.31 All smoke control equipment (including smoke curtains) shall be supplied and installed in accordance with the accepted standards e.g. BS 7346.

7 Air-conditioning design

An air-conditioning system should be designed such that it can maintain a comfortable and healthy environment under all the operating conditions that can be expected, in an energy conserving manner.

7.1 General requirements

7.1.1 In designing a central air-conditioning system for a building, the cooling load of the building, both sensible and latent, and the ventilation load should be calculated.

7.1.2 An air-conditioning system should be designed to meet the indoor temperature and humidity requirements when it operates at full load and at part-load. Its ability to maintain the indoor conditions at part-load should be checked at the design stage.

7.1.3 If the sensible cooling load of a space to be air-conditioned can be expected to fall below half its design value, in designing the system it is necessary to ensure that the indoor relative humidity does not exceed 70% when the sensible cooling load is at half its design value and the sensible heat factor is at its anticipated value, ~~not lower than the design value~~.

7.1.4 Documentation on the design of an air-conditioning system should be kept for future reference.

7.2 Calculation of cooling load

7.2.1 Cooling loads for the purpose of sizing systems and checking of performance shall be determined in accordance with one of the procedures described in the ASHRAE Handbook of Fundamentals or an equivalent computation procedure.

7.2.2 The normal design indoor conditions for comfort air-conditioning can vary between 23°C to 25°C dry-bulb and relative humidity between 55% to 65% for sedentary occupants.

7.2.3 The specification of indoor conditions shall take into consideration the anticipated mean radiant temperature and air movement.

7.2.4 When the indoor dry-bulb temperature is equal to the mean radiant temperature, for lightly clothed sedentary occupants, the usual design indoor dry-bulb temperature is 24°C, the relative humidity 55% and the air movement at occupied level not to exceed 0.25 m/s to prevent draft.

7.2.5 The design outdoor air conditions can be taken at 32°C dry-bulb and 26°C wet-bulb with a daily range of 8°C. The dry-bulb temperature value is not exceeded more than 2% of the total hours during the months of June to September and the wet-bulb value is the average of the coincident wet-bulb temperature occurring at the design dry-bulb temperature.

7.2.6 The load contribution from the outdoor air introduced into a building for ventilation shall be calculated. The ventilation rates for specific places are given in Table 1.

7.2.7 The load contribution from outdoor air infiltrating into a building shall be calculated by the procedures in ASHRAE Handbook of Fundamentals or equivalent computation procedures. The maximum rate of outdoor air infiltration for aluminium windows and swinging, revolving or sliding door is given in SS212 and SS268 to be 12 m^3/h per metre length of opening joint.

7.3 Indoor thermal environment

When the air-conditioning system is in operation, the indoor dry-bulb temperature should be maintained within 22.5°C and 25.5°C dry-bulb and the air movement should not exceed 0.25 m/s, measured at the occupants level 1500 mm from the floor, and the average relative humidity should not exceed 70%.

7.4 Outdoor air supply

7.4.1 In office premises, classrooms and theatres, the supply of outdoor air can be varied according to occupancy if the requirements given in Appendix E of the ENV Guidelines for good indoor air quality for office premises 1996 can still be met. In regulating the outdoor air flow rate, carbon dioxide can be used as the surrogate contaminant and its concentration should be maintained below 1000 ppm. The minimum outdoor air flow rate required is given in Clause 5.3.7.

7.4.2 Unless there is monitoring and control of the concentration of carbon dioxide indoors, the design outdoor air quantity should be maintained during the air-conditioning operation.

7.5 Indoor supply air

7.5.1 The cool supply air should be directed away from the fenestration glazing or the glazing adjacent to a non air-conditioned area to prevent moisture condensing on the outside surface.

7.5.2 The cool air leaving the supply diffuser should be designed at a temperature less than 2°C below the room dew point to prevent moisture condensing on the diffuser surface.

7.6 Re-circulation of air

Air from any of the following rooms or spaces shall not be recirculated:

(a) hospital operating rooms and mortuary rooms;

(b) bathrooms and toilets;

(c) rooms used by persons suffering from infectious or contagious diseases; and

(d) any space where there is present or likely to be present flammable vapour, dust, odours or noxious gases in such quantity as to be a danger to life or public health.

7.7 Purging of indoor air

In the event that the indoor air quality becomes unacceptable, because of renovation or other reasons, it should be possible to purge the contaminants from the affected floor without affecting the rest of the building.

7.7.1 For air-conditioned buildings, an air purging system should be provided at each floor so that contaminated air can be exhausted when necessary to improve the indoor air quality.

7.7.2 The air purging system should be able to introduce outdoor air into the space and then discharge the indoor air to outside the building at a minimum rate of 2 air-change per hour.

7.7.3 The capacity of the exhaust fans shall be higher than the flow rate of the outdoor air introduced into the space.

7.7.4 For buildings with fixed windows, the outdoor air for purging can be supplied by the fan for air-conditioning or others.

7.7.5 The exhaust discharge shall be at least 5m away from the outdoor air intake of another system.

7.8 Air filtration

The particulate contaminants in the air in an air-conditioned space should be continuously removed in order to maintain the cleanliness of the air.

7.8.1 Outdoor air for ventilation and indoor air that is to be recirculated should be filtered for particulate.

7.8.2 An air filter should be placed specifically for cleaning the outdoor air only. The minimum arrestance efficiencies of the pre-filter for cleaning the outdoor air should be 60% or better.

7.8.3 The minimum arrestance efficiency of the primary filter for cleaning the recirculated air or mixed air should be 80% or better.

7.8.4 Air filters should be installed such that no unfiltered air can bypass the filters and enter the air handling system.

7.8.5 It should be possible to assess at any time the condition of the air filter and the pressure drop across it.

7.8.6 For a better indoor air quality, it is recommended that a filter of 80% dust spot efficiency or better be used as the secondary filter for cleaning the recirculated air or mixed air in places for continuous occupancy. The use of such filter can be helpful when the quality of outdoor air is poor. It can also reduce the need to clean the air ducts of dust cake that will form with time which can support the growth of micro-organisms.

7.8.7 Where no secondary filter is used, it is recommended that the recirculated air or mixed air or outdoor air is further cleaned of fine particles whenever the pollution standard index of the outdoor air exceeds 100 based on PM10 over 24 hours.

7.8.8 To meet the requirement stated in Clause 7.8.7, an air filter of 80% dust spot efficiency or better can be inserted into the stream of recirculated air or mixed air after the primary filter. For this purpose the fan motor needs to have been sized accordingly such that the required air flow rate can be maintained.

7.8.9 The requirement of Clause 7.8.7 can similarly be met, if an air filter of 80% dust spot efficiency or better is used to filter the intake outdoor air further after the pre-filter.

7.8.10 The requirement stated in Clause 7.8.7 or 7.8.8 can also be met by other types of air cleaning devices of similar performance.

7.8.11 Highly efficient air filtration is usually necessary for areas like hospitals, clean rooms in laboratories and manufacturing plants, and where odour removal is required, activated carbon filters are normally used.

7.8.12 For areas like operating theatres in hospitals where bacterial control is required, several measures may be necessary including air filtration, air cleaning, air sterilisation, etc. and they are covered in the ASHRAE Handbook on HVAC applications.

7.9 Control

7.9.1 The design of the control of an air-conditioning system shall be such that its operation utilises energy efficiently, while maintaining the desired room conditions.

7.9.2 When an air-conditioning system has to serve areas with different cooling requirement, sufficient number of zones shall be provided.

7.9.3 At least one thermostat of suitable operating range shall be provided to each separate air-handling system and zone for the regulation of space temperature.

7.9.4 A readily accessible manual or automatic means shall be provided to partially restrict or shut off the cooling to each zone.

7.9.5 For the purpose of meeting the requirements of Clause 7.9.4 the following devices can be regarded as satisfactory:

(a) manually adjustable automatic timing devices

(b) manual device for use by operating personnel, or

(c) automatic control systems

7.9.6 Control of indoor thermal environment by using new energy to reheat the air is an inefficient use of energy, and shall not be used.

7.10 Air handling units

7.10.1 Air handlers should be equipped with control devices that are appropriate for the intended control of indoor thermal environment.

7.10.2 Finned coils used in an air handler should not be more than 8-row deep. When more number of rows are required in the air treatment process, more than one cooling coil can be used, each separated by a distance sufficient for cleaning.

7.10.3 The condensate from the cooling coil shall be provided with a U-bend on leaving the air handler and there should be an air break between the condensate drain pipe and the floor trap.

7.10.4 A air handler should be constructed and installed such that the condensate from the cooling coil can be completely drained after the fan is switched off.

7.10.5 No chilled water should continue to be supplied to the cooling coil after the fan is switched off.

7.10.6 The inner surfaces of air-handling units shall be easy to clean and abrasion resistant.

7.10.7 Air-handling unit rooms shall not be used for storage and shall not house installations not related to the air-conditioning system.

7.10.8 Where the air handling units in a building are not centrally controlled, each air-handling unit exceeding 8,500 m^3/h shall be provided with a manual stop switch located at a convenient and accessible point to facilitate quick shutting down of the fan in case of fire. This switch shall preferably be located on the wall next to the door opening of the air-handling equipment room.

7.10.9 Where the air handling unit serves more than one compartment, fire dampers shall be provided in air ducts to comply with the requirements in the Code of practice for fire precautions in buildings 1997 and this code.

7.10.10 Smoke detectors shall be incorporated in the return air stream immediately adjacent to an air handling system serving more than one storey or compartment, or a single system in excess of 4167 l/s (15,000 m^3/h), or any air handling system as may be required by the relevant authority.

7.10.11 The type and installation of the smoke detectors shall comply with the requirements of SS CP10 : Code of practice for the installation and servicing of electrical fire alarm systems.

7.10.12 The function of the smoke detectors is to shut down the air handling system to prevent propagation of smoke via the air handling system. The return air smoke detector need not form part of the electrical fire alarm system in the building. When it is desirable to do so, the designer should consult the relevant authority early with regard to the zoning requirement.

7.10.13 The smoke detector is permitted to draw power from the same electrical supply to the air handling system.

7.10.14 Air handling systems shall not use protected shaft of exits, smoke-stop lobbies, including its concealed space for supply, exhaust or return air plenums.

7.11 Plants

7.11.1 The air-conditioning equipment and motor drives used in the plant should comply with SS CP24: 1999 : Code of practice for energy efficiency standard for building services and equipment.

7.11.2 The design of the chilled water system should ensure that the chillers will be able to operate properly over the full range of cooling demand that can be expected and supply chilled water to the building at the required temperature. The surging or frequent starting and stopping of the compressors should be avoided.

7.11.3 The refrigerant used in chillers should be non-CFC.

7.11.4 The safety requirements on the use of refrigerant in a plant room can be referred to in ASHRAE Standard 15.

7.11.5 Fan system design criteria

(a) For fan systems which provide a constant air volume whenever the fans are running, the power required by the motor for the combined fan system at design conditions shall not exceed 0.47 W per m^3/h of supply air.

(b) For fan systems which are able to vary system air volume automatically as a function of load, the power required by the motors for the combined fan system at design conditions shall not exceed 0.74 W per m^3/h of supply air.

7.11.6 Pumping system design criteria

(a) Piping systems should ~~not~~ be designed at a friction pressure loss rate of no more than 4.0m of water per 100 equivalent metre of pipe.

(b) The water transport factor shall not be less than 30 for chilled water and 40 for the condensing water circuit, whether open or closed.

(c) For constant volume systems the factor shall be based on design water flow.

(d) For variable pumping systems, the factor shall be based on 75% of maximum design water flow.

(e) Variable speed or stage pumping should be considered in the design of large systems.

(f) Pumping power required for heat recovery devices shall not be included in the water transport factor calculation. However, such power ought to be included in the evaluation of the effectiveness and economics of the heat recovery system.

(g) Water transport factor = Heat transfer to circulating water/(Pump power input)

7.11.7 Energy recovery

It is recommended that consideration be given to the use of recovery systems which will conserve energy (provided the amount expended is less than the amount recovered) when the energy transfer potential and the operating hours are considered.

7.11.8 The location of mechanical ventilation and air-conditioning plants may be arranged in the basement, on the roof, or in any other convenient position having due regard to the problems of noise transmission, location of outdoor air intakes and exhaust from the plants, and accessibility for maintenance and future replacement.

7.12 Noise and vibration

Noise and vibration in mechanical ventilation and air-conditioning systems arise from mechanical and electrical equipment, and from the flow of water through pipes and the flow of air through ducts and grilles. Table 5 gives the recommended design criteria (for guidance only) to assist designers in providing acoustical environment within occupied spaces in buildings compatible with the activities and areas mentioned, and is intended for use in the selection of the air-conditioning and ventilation plant and equipment to be used in these spaces.

Table 5 – Recommended ambient sound level

Area	Low dBA	Average dBA	High dBA
Cinema, theatres	-	35	40
Private executive type offices	35	40	45
General offices, other private or semi-private offices	40	45	50
Conference rooms	35	40	45
Air-conditioned classrooms	40	45	50
Hotel bedrooms	35	40	45
Hospital wards	35	40	45
Places of public resort e.g. shops	40	50	55
Circulation areas e.g. staircases, lobbies, car parks	50	55	60

8 Ductwork and other air passages

This section applies to the design, construction and installation of the air duct system including fittings and accessories for mechanical ventilation or air-conditioning, and the precautions which need to be taken to minimise the spread of fire and smoke via the system throughout the building in the event of a fire. This section has to be read in conjunction with the requirements of the Code of practice for fire precautions in buildings 1997.

8.1 Design

8.1.1 In designing the ductwork for an air distribution system, consideration should be given to the air velocities in ducts, choice of materials and construction of the ducts, etc.

8.1.2 Ventilation ducts should not pass through smoke-stop or fire fighting lobbies. Where unavoidable, the part of the ventilation duct within the lobby shall be enclosed in construction with fire resistance rating at least equal to that of the elements of structure. Such construction shall be in masonry. If other forms of fire resisting construction is used, fire dampers shall be fitted where the duct penetrates the lobby enclosure.

8.1.3 A concealed space between the ceiling and floor above it, ceiling and roof, or raised floor and structural floor of a building may be used as a plenum provided that:

(a) The concealed space contains only:

(i) mineral-insulated metal-sheathed cable, aluminium-sheathed cable, copper-sheathed cable, rigid metal conduit, enclosed metal trunking, flexible metal conduit, liquid-tight flexible metal conduit in lengths not more than 2 m, or metal-clad cables;

(ii) electric equipment that is permitted within the concealed spaces of such structures if the wiring materials, including fixtures, are suitable for the expected ambient temperature to which they will be subjected;

(iii) other ventilation ducts complying with Clause 3;

(iv) communication cables for computers, television, telephone and inter- communication system;

(v) fire protection installations;

(vi) pipes of non-combustible material conveying non-flammable liquids.

(b) The supports for the ceiling membrane are of non-combustible material.

8.1.4 No air conditioning or ventilation ducts shall penetrate separating walls.

8.1.5 Ventilation ducts which pass directly through a compartment wall or compartment floor shall comply with the following:

(a) where the ventilation duct does not form a protected shaft or is not contained within a protecting structure, the duct shall be fitted with a fire damper where it passes through the compartment wall or compartment floor;

(b) where the ventilation duct forms a protected shaft or is contained within a protecting structure, the duct shall be fitted with fire dampers at the inlets to the shaft and outlets from it.

8.1.6 Fire resisting floor-ceiling and roof-ceiling

(a) The space above a suspended ceiling which forms part of a fire-rated floor ceiling or roof-ceiling construction shall not contain ducting unless ducting was incorporated in a prototype that qualified for the required fire-resistance rating, in which case the ducting shall be identical to that incorporated in the tested prototype.

(b) Openings in the ceiling, including openings to enable the ceiling to be used as a plenum, shall be protected by fire dampers identical to those used in the tested prototype and such openings in the ceiling shall be so arranged that:

(i) No opening is greater in area than that corresponding in the prototype test panel;

(ii) The aggregate area of the openings per unit ceiling area does not exceed that of the prototype test panel; and

(iii) The proximity of any opening to any structural member is not less than that in the prototype test panel.

8.1.7 Where proprietary fire rated materials are used to construct the fire rated duct, the fire rating of the fire rated duct shall have the same period of fire resistance as the wall or floor it penetrates. Proprietary fire rated duct shall be tested to BS 476 Pt 24 or equivalent and its usage be approved by the relevant authority.

8.1.8 Running of non-fire rated duct and/or other building services above the proprietary fire rated duct should be avoided. When unavoidable due to physical constraints, the supports to such non-fire rated duct and/or other building services running above the proprietary fire rated duct shall be strengthened such that the tensile stress generated on the supports shall not exceed 10N/mm^2 and the non-fire rated duct and/or building services shall also be adequately protected to prevent collapse in a fire which will otherwise affect the stability of the proprietary fire rated duct below.

8.1.9 Air ducts shall be made substantially air tight throughout, and shall have no openings other than those required for proper operation and maintenance of the system. Access openings shall be provided where debris, paper or other combustible materials may accumulate in plenums and ducts. Removable grilles requiring only the loosening of catches of screws for removal may be considered as access openings.

8.1.10 Locations of intakes and return air openings

(a) Openings for the intakes of outdoor air to all air handling systems, mechanical ventilation systems, pressurisation systems of exit staircases and internal corridors, and smoke control systems shall be no less than 5m from any exhaust discharge openings.

(b) All return air openings and outdoor air intakes shall be so located and arranged that sources of ignition such as lighted matches and cigarette butts accidentally entering the openings and intakes shall not be deposited onto the filter media.

8.1.11 Exhaust ducts from toilets and domestic kitchens shall not be connected to duct systems serving other areas except at the inlet of the exhaust fan. Where such connection is made, devices shall be installed to prevent the circulation of exhaust air through the dwelling units when the fan is not operating. Exhaust ducts for industrial or commercial kitchens shall be of a separate system.

8.1.12 Exhaust ducts shall discharge directly to the outdoors. Where the exhaust duct passes through air-conditioned space, the duct shall be insulated when necessary to prevent condensation in the duct.

8.1.13 Outdoor air intake and exhaust outlets shall be shielded from weather and insects. Screening shall be of corrosion resistant material not larger than 10 mm mesh.

8.1.14 Ducts shall not be located where they will be subject to damage or rupture. Where so located they shall be suitably protected.

8.1.15 Return air ducts should be routed away from toilets or places where odours are expected and may recirculate into the supply air stream.

8.2 Construction

8.2.1 The inner surfaces of the ducts for supply and return air should be smooth and resistant to abrasion to reduce dust accumulation.

8.2.2 Where ceiling space is used as a return air plenum, the ceiling and the side-walls should be properly plastered and painted.

8.2.3 Rigid ducts shall be manufactured from steel, aluminium, glass-fibre batt or mineral wool or other approved materials. Ducts or duct linings where glass fibre batt or mineral wool are exposed to the air stream, shall be suitable protected to prevent erosion of fibres.

8.2.4 Ducts shall be substantially supported. Hangers and brackets for supporting ducts shall be of metal.

8.2.5 Duct covering, duct lining and flexible connection materials should be non-combustible. However, if it is necessary to use combustible material, it shall comply with the following requirements:

(a) when tested in accordance with the methods specified in Chapter 3 of the Code of practice for fire precautions in buildings 1997, it should have a surface flame spread rating of not lower than Class 1. But in areas of the building where Class 0 flame spread rating is required for the ceiling construction under the said code, a Class 0 rating for the covering and lining materials shall be required; and

(b) when involved in a fire, it should only generate a minimum amount of smoke and toxic gases.

8.2.6 Flexible connections at the extremity of ventilation ductwork connecting terminal units, extract units and ventilation grilles shall not exceed 4 m.

8.2.7 Flexible joints, which are normally provided to prevent and/or allow for thermal movements in the duct system, shall not exceed 250 mm in length.

8.2.8 Flexible joints shall be made of material classified as 'not easily ignitable' when tested under BS 476: Part 5: 1989.

8.2.9 Ducts shall be installed with openings at suitable intervals and locations to enable cleaning of all the ducts.

8.2.10 The construction and support of air ducts, fittings and plenums, including joints, seams, stiffening, reinforcing and access openings shall conform to the appropriate requirements of the duct construction standards contained in ASHRAE Handbook, IHVE guide books or SMACNA Manuals.

8.2.11 Tapes and sealants used for sealing joints in air ducts, plenums and other parts of air ducts systems shall be subject to the approval of the relevant authority.

8.3 Fire dampers

8.3.1 Any fire damper shall have a fire resisting rating of not less than that required for the compartment wall or compartment floor through which the relevant section of the ventilation duct passes.

8.3.2 Fire dampers shall be of the type approved by the relevant authority and constructed in accordance with the requirements in SS 333 - Specifications of fire dampers.

8.3.3 Installation of fire dampers

Fire dampers shall be installed so that the casing completely penetrates through the compartment wall or floor and the casing shall be retained either:

(a) On both sides by means of flanges in such a manner that it can expand under fire conditions without distorting the blades in the closed position, or

(b) On the accessible side by means of one flange only, which can be fixed to the damper and to the wall through slotted holes to allow for expansion.

8.3.4 Flanges shall be butted against the face of the compartment wall or floor and fixed to the damper casing.

8.3.5 Ductwork connected to the damper shall be attached in such a manner as to ensure that the damper remains securely in position and is fully functional in the event of damage of ductwork.

8.3.6 The clearance between the damper body and the sides of the penetration shall not be less than that of the tested prototype and not greater than half the width of the angle section of the collar.

8.3.7 The space between the damper body and the opening in the wall or floor shall be fire-stopped.

8.3.8 Vertically positioned fire dampers shall be installed in such a manner that the direction of air flow assists the closure of the damper.

8.3.9 Connections to fire dampers

The distance between the plane through a closed fire damper and ducting, flexible connections, duct coverings, internal linings and the like, shall be:

(a) Not less than 1 m when such parts are made of materials with fusing temperatures less than 1000°C, and

(b) Not less than three times the diagonal or diameter of the damper and in no case less than 2 m when such parts are made of materials that are combustible except for vapour barrier to thermal insulation.

8.3.10 Access door in ventilation duct for inspection of fire damper

Each fire damper installation shall be provided with an inspection access door either upstream or downstream as appropriate. The access door dimension shall preferably measure 450 mm (length) × 450 mm (width); for smaller ducts, the door width dimension may be reduced to the width or depth of the duct. Access doors shall be hinged and fitted with sash locks, and constructed of minimum 1.25 mm sheet steel suitably braced. Openings in ducts shall be stiffened by sheet steel frame.

8.3.11 Provision of fire dampers not required

(a) Fire dampers need not be fitted at openings in compartment walls that has a supply branch duct passing through it provided that:

  (i) The opening has a cross sectional area not greater than 0.02 m^2 and is located at a height not greater than 1.2 m above floor level and at a distance not less than 6 m from other similar unprotected openings; and

  (ii) The duct is of a non-combustible material having a fusing temperature not lower than 1000°C; and

  (iii) The space between the duct and wall opening is properly fire stopped with non-combustible material.

(b) When a ventilating duct forms a protected shaft or is contained within a protected shaft and the shaft is maintained at a negative pressure at all times and functions to exhaust air from bathrooms and/or toilets, fire dampers need not be fitted at openings in protected shaft provided that:

  (i) The opening has a cross sectional area not greater than 0.02 m^2; and

  (ii) The air is discharged through a sub-duct of a non-combustible material having a fusing temperature not lower than 1000°C; and

  (iii) The sub-duct has a vertical upstand within the shaft of not less than 500 mm from the upper side of the opening; and

  (iv) The space between the duct and the shaft wall opening is properly fire stopped with non-combustible material.

9 Pipework

This section applies to the design and installation of the piping system for air-conditioning installation.

9.1 Design

9.1.1 In designing and planning the layout of the pipework, due attention should be given to the choice of material, rate of flow, accessibility, protection against damage, corrosion, avoidance of airlocks, water hammers, noise transmission, unsightly arrangement, vibration and expansion of fluid, stress and strains, etc.

9.1.2 The use of protected shafts for the passage of pipes between compartments, and the protection of openings permitted in compartment walls and compartment floors for the passage of pipes shall be in accordance with the requirements of Chapter 3 of the Code of practice for fire precautions in buildings 1997.

9.1.3 Every pipe used shall be designed to have adequate strength and durability. Pipes shall be adequately supported. Hangers and brackets for supporting pipes shall be of metal.

9.1.4 Pipes shall not be located where they will be subject to damage or rupture. Where so located, they shall be suitably protected.

9.2 Installation

9.2.1 Materials for piping and associated fittings shall be suitable for the intended service.

9.2.2 Sufficient unions or flanged fittings and valves shall be provided for disconnecting equipment, controls, etc.

9.2.3 Standard fittings such as tees, elbows, etc, shall be used; fittings fabricated by welding together segmented pieces are not recommended.

9.2.4 The construction and support of pipes, fittings and valves shall conform to the applicable requirements of the pipe construction standards contained in the ASHRAE Handbook, IHVE Guide Books or other recognised Piping Handbooks.

9.2.5 All installed pipework which are intended to contain/convey pressurised fluid shall be pressure tested.

9.2.6 Thermal insulation for pipework associated with air-conditioning and mechanical ventilation system shall comply with the following requirements:

(a) Thermal insulation material for pipework together with vapour barrier lining and adhesives shall, when tested in accordance with the methods of insulation specified in Chapter 3 of the Code of practice for fire precautions in buildings 1997, have a surface flame spread of not lower than Class 1 but in areas of buildings where Class 0 flame spread is required for the ceiling construction under this said code, a Class 0 rating for the insulation material shall be required.

(b) Notwithstanding the requirements of Clause 9.3.6(a), the use of plastic and foam rubber insulation materials of a lower classification may be permissible if:

  (i) the material is the self-extinguishing type to the satisfaction of the relevant authority;

(ii) the insulation material is covered by or encased in a metal sheath or hybrid plaster or other non-combustible cladding materials acceptable to the relevant authority;

provided that any opening in the element of structure or other parts of the building penetrated by the pipework shall be effectively fire-stopped by replacement of the insulation material at the junction of penetration with fire resistant materials having equal fire rating. Fire rated proprietary pipework system may be used if it is tested in the manner acceptable to the relevant authority.

9.2.7 Identification of pipeline, if required, shall be in accordance with the colour codes in Annex C.

10 Electrical work

10.1 General

All electrical works shall comply with CP 5 : Code of practice for electrical installations.

10.2 Design

10.2.1 General power distribution

In planning the electrical distribution system, consideration should be given to a central control of all the fans in the air handling system, such that they can be partially or completely shut down in the event of fire. A central monitoring and control system, when incorporated, can serve the same purpose.

10.3 Installations

Wiring installation in ducts, plenum chambers and concealed spaces, used to transport supply air, return air and outdoor air require the use of specific metallic types to minimise the products of combustion or flame spread in such areas. The use of metallic systems reduces the products of combustion and fuel contribution during a fire. Where wiring installation penetrates fire compartmented walls, floor and ceiling, the opening shall be sealed with fire-stop material, having the same rating as the compartment through which they penetrate.

10.3.1 No wiring system shall be installed in any duct used to transport dust, loose stock or flammable vapours, or for ventilation of commercial type cooking equipment, and no wiring system shall be installed in any shaft, which contains such ducts.

10.3.2 Wiring in ducts or plenum chambers

(a) Wiring systems to be installed in such ducts and plenum chambers shall be of mineral-insulated metal-sheathed cable (MIMS), aluminium-sheathed cable, or copper-sheathed cable.

(b) Flexible metal conduit and liquid-tight flexible metal conduit are permitted in length not exceeding 1 metre to connect physically adjustable equipment and devices in these ducts and plenum chambers. The connectors used with flexible metal conduit shall effectively close any opening in the connection.

(c) Equipment and devices are permitted within such ducts or plenum chambers only if their functions are needed there.

(d) Where equipment or devices are installed in such ducts and plenum chambers and illumination is necessary to facilitate maintenance and repair, totally enclosed type fixtures can be installed there.

10.3.3 Wiring in concealed spaces

(a) Wiring in concealed spaces, such as spaces above the ceiling, requires the use of mineral-insulated metal-sheathed cable (MIMS), aluminium-sheathed cable, or copper-sheathed cable.

(b) Rigid metal conduit, enclosed metal trunking, flexible metal conduit, liquid-tight flexible metal conduit in lengths not more than 2 metres, or metal-clad cables can also be used.

(c) Other electric equipment is permitted within the concealed spaces of such structures if the wiring materials, including fixtures, are suitable for the expected ambient temperature to which they will be subjected.

10.3.4 Wiring of integral fan systems

The wiring installation of integral fan systems, which have been specifically designed and constructed for the purpose, and the installation of motors and control equipment in air-handling ducts, where such equipment have been specifically approved and listed by recognised authorities for the particular application, shall be deemed to comply with the requirements of this section.

10.4 Secondary source of power supply

10.4.1 Power supply to essential services

Apart from the supply from normal mains, a secondary source of power supply shall be provided to serve the mechanical ventilation systems and equipment serving the following:

(a) exit staircases and exit passageways,

(b) smoke-stop and fire fighting lobbies,

(c) areas of refuge within the same building,

(d) basement carparks,

(e) fire command centres,

(f) flammable liquid/gas storage rooms,

(g) emergency power generator room, and engine driven fire pump room,

(h) carpark smoke purging system

(i) powered smoke control systems.

The electrical circuit wiring from the supply source to the utilisation points of such equipment shall be of the fire-resistant type complying with SS 299, or suitably protected along their entire length within fire-rated ducts, or shafts.

10.4.2 Motor and motor control

10.4.2.1 All motors and their control equipment as well as the associated wiring and accessories shall be suitable for their particular application and for the environment they are exposed to.

10.4.2.2 High rupturing capacity fuses shall be installed and capable of:

(a) protecting the cable connections to the motor

(b) carrying the stalled current of the motor for a period of not less than 75% of the period which such a current would cause the motor windings to fail

10.4.2.3 Any no-volt release mechanism shall be of the automatic resetting type such that on restoration of supply the motor can start automatically.

10.4.2.4 Magnetic and thermal overload trips shall not be permitted.

10.5 Start-stop control

Start-stop control and visual indication of operation shall be provided in the fire command centre, or in the absence of a fire command centre in the building, at the main fire indicator board, for the mechanical ventilation systems serving the following :

(a) exit staircase pressurisation

(b) smoke-stop and fire fighting lobbies

(c) basement carparks

(d) carpark smoke purging system

(e) powered smoke control systems

10.6 Energy auditing

All buildings used or intended to be used as offices, hotels or shops or a combination thereof shall be provided with data logging facilities for the collection of data for energy auditing.

10.6.1 Suitable means or facilities for the monitoring of energy consumption shall be provided to all incoming power supply to a building and the sub-circuits serving:

(a) a central air-conditioning system including chillers, condenser and chilled water pumps, cooling towers; and

(b) major mechanical ventilation systems including air handlers and fans.

10.6.2 The suitable means for data collection could consist of either of the following:

(a) current and voltage taps at the panel meters on the switchboards for indicating incoming supply voltage and current, as well as outgoing supplies to the systems. A suggested installation is shown in Figures D1 and D2 in Annex D. This facility would enable short term monitoring of the building energy consumption to be conducted with minimal interruption to electrical supplies. For the purpose of such monitoring, external watt transducers and data logging equipment could be connected to the external terminals.

(b) a building monitoring system capable of making trend logs of electrical consumption of the systems.

11 Equipment installation

The following basic considerations are intended as guidelines for installing equipment of plants/systems so that they can be properly secured and their operations later on will cause less environmental problems to the surroundings.

11.1 Location

When selecting a site or a room for the location of any piece of equipment, various factors have to be considered including the following:

(a) Type of equipment (e.g. indoor or outdoor)

(b) Environmental air (e.g. corrosive, dust)

(c) Hoisting for initial installation, future replacement and maintenance work

(d) Scaffolding for installation

(e) Transmission of noise and/or vibration to adjacent areas in the building and to adjacent buildings

(f) Discharge of heat to and from adjacent buildings

(g) Ventilation requirements

(h) Space for service access and operational requirements and future expansion

(i) Support structure for equipment, pipes, ducts, etc.

(j) Electricity and water supply

(k) Fire hazard and construction of fire-rated walls, doors, etc.

(l) Safety of working personnel

11.2 Foundation and bases

The equipment should be properly levelled and mounted on supports which shall be capable of supporting the entire operating weight of the equipment. When alignment of equipment is necessary, framed bases are recommended.

11.3 Vibration isolators

All mechanical equipment shall be mounted as necessary on vibration isolators to prevent the transmission of vibration and mechanically transmitted sound to the building structure; additional mass may be added to the bases if appropriate.

Where appropriate, flexible joints shall be provided to prevent transmission of vibrations from equipment to the connecting pipework or ductwork.

11.4 Heat rejection

Heat rejected from an air-cooled condenser into an air well or partially enclosed space should not raise the air temperature at the inlet to the condenser or an adjacent working air-cooled condenser by more than 3°C above the undisturbed ambient.

*11.5 Ventilation in refrigerating machinery room

11.5.1 Each machinery room shall contain a detector, located in an area where refrigerant leak will concentrate, which shall actuate an alarm and mechanical ventilation when its concentration is at a value not greater than the corresponding time weighted average of the threshold limit value.

11.5.2 The mechanical ventilation required to exhaust an accumulation of refrigerant due to leaks or a rupture of the system shall be capable of removing air from the machinery room in not less than the following quantity:

$$Q = 70 \times G^{0.5}$$

where:

Q = airflow rate in l/s

G = the mass of refrigerant in kg in the largest system.

11.5.3 When natural ventilation is provided, the free-aperture cross-section for the ventilation of a machinery room shall be at least

$$F = 0.138 \times G^{0.5}$$

where:

F = free opening area in m^2,

G = the mass of refrigerant in kg in the largest system.

11.6 Space for service access

11.6.1 All equipment rooms should be adequately sized so that there can be sufficient spacing, maintenance and future replacement of equipment. All equipment should be located in such a way that they are accessible for servicing and maintenance.

11.6.2 All gauges should be installed in such a way that they are easily readable and replaceable.

11.6.3 All sensors should be installed in such a way that they are easily accessible for regular calibration.

11.6.4 Access panels should be provided for VAV boxes, fan coil units, dampers, valves, fans and any accessory concealed in ceiling space.

11.6.5 There should be adequate space in the air-conditioning plant room or equipment space for the servicing of shell and tubes and other accessories in air-cooled and water-cooled chillers.

11.6.6 There should be adequate circulation space in the air-handling unit room for the maintenance and servicing of pipes, ducts and dampers, valves, controls, electrical installations and replacement of filters etc. Space around an air handling unit should be kept as clear as possible for maintenance and servicing.

11.6.7 Platform-supported air handling units in ceiling void should not be provided unless they can be easily accessible for servicing and maintenance and do not become a source of noise and vibration.

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11.6.8 Pipes in riser shafts should be adequately spaced so that they can be easily accessible for repair.

11.6.9 Catwalks should be provided in high ceiling void areas for balancing of air in ductwork, maintenance of pipes and other accessories in the ceiling void which require regular maintenance.

12 Testing and commissioning

After installation, the equipment of plants/systems are tested to check that they can function. This is followed by commissioning works.

12.1 Before undertaking the testing and commissioning of individual items of plant as well as systems, the following shall be established:

(a) Objects of the tests

(b) Method and duration of the test

(c) Type and degree of accuracy of instruments to be used

(d) The persons carrying out the tests

(e) The state of the plant and machinery with special reference to the cleanliness of heat transfer surfaces

(f) The conditions of outdoor air as representing the required test condition.

12.2 Performance tests and adjustments

Appropriate sections of the plant shall be run and all necessary adjustments of valves, dampers and controls should be made to fulfil the function for which it has been designed, e.g. room temperature and humidity to be maintained, air quantity to be handled, etc.

12.3 Room temperature and humidity shall be measured 1.5 m above floor level at points away from influence of draughts or radiation from hot or cold surfaces.

12.4 Measurements of noise level should be made at locations likely to be occupied.

12.5 Tests on site of individual items of plant/system

Besides tests by manufacturers for various equipment or components, the following tests on site should be considered appropriate:

(a) Ductwork should be checked for tightness, the absence of vibration and the operation of all movable fittings.

(b) Pipework should be hydrostatically tested.

(c) Insulation and the associated vapour barrier on ducts and pipes should be checked for its integrity.

(d) Air flow rate for each grille should be checked.

(e) Fans should be checked for alignment, blade angles, rotational frequency, air flow rate, sound levels and operating pressures.

(f) Pumps should be checked for alignment, rotational frequency, flow rate and pressure, and checked to comply with the required capacity.

(g) Heat transfer coils and automatic control valves should be checked for water flow, pressure drops, as well as heat transfer on air-side and water-side to meet the required capacity.

(h) All control equipment and components should be calibrated and set points adjusted. Time and control sequence should also be tested.

(i) Each refrigerant compressor should be tested in accordance with manufacturer's instructions. Each water chilling unit should be checked under design conditions if practicable.

(j) All electrical equipment and installation shall be tested in accordance with CP 5: Code of practice for electrical installations.

12.6 Newly installed plants and systems should be re-commissioned after one year of operation and then repeated every two years.

13 Maintenance

A satisfactory service and efficient running of a plant requires regular and proper maintenance of the plant.

13.1 There should be competent staff in charge of maintenance.

13.2 Shop drawings and operation manual of the plant, operation and maintenance manuals of the equipment should be available.

13.3 Electrical single line diagram of the switchboard should be available.

13.4 There should be provisions for the following:

(a) adequate access for inspection, cleaning and repair of all component parts of the installation

(b) facilities for emptying the piping services

(c) reasonable operating space; air handling unit room should not be used for maintenance purpose

(d) 600 mm minimum clearance with no obstruction around each air-handling unit

13.5 The frequency at which maintenance is required varies from equipment to equipment depending on the number of hours the equipment is operated and the operating environment.

13.6 Manufacturer's instructions regarding operation, recording of readings and maintenance must be adhered to.

13.7 Operating log sheets

Hourly and daily records of operating conditions of all major equipment (e.g. refrigerating compressors) as well as records of all faults, breakdown and repairs are necessary to serve as reference for operation and planned maintenance of the plant and systems.

13.8 Service and maintenance schedule

Service of all plant and systems shall be undertaken regularly in accordance with the manufacturers' instructions or as may be demanded by the nature of the installation, operation or equipment.

13.9 At each such inspection, service and maintenance of the complete installation, the following minimum items of work should be considered:

(a) Inspect all refrigerant compressors and refrigerant systems including checking of refrigerant and oil levels, refrigerant filters, oil filters, transmission, controls, safety devices, suction and discharge pressures.

(b) Inspect all water pumps and check all seals, glands, bearings, alignment, transmission, and conditions between pumps and motors.

(c) Inspect all fans, filters, coils and check and clean/replace all air filters, check/clean all coils, purge air from coils, check fan bearings, transmission, operation of automatic valves and dampers, clean condensate pans.

(d) Inspect all cooling towers and check the condition of the infill of all fan bearings, transmission, clean water screens, drain/clean/flush out water tanks of the cooling towers when found necessary, analyse condenser water and check on chemical treatment system, check make up water system and the water tightness of the compartment.

(e) Inspect all water tanks and clean as necessary.

(f) Inspect all electric motors and check all bearings, carbon brushes/slip rings, safety devices.

(g) Inspect and check the routine operation of all electrical starters, control gears and ancillary apparatus, and check all bearings and moving parts, electric contactors, fuses.

(h) Inspect and check the routine operation of all automatic control gears and relays.

(i) Inspect and check the condition and operation of smoke-control and car park ventilation systems and components.

(j) Check and analyse the oil and the refrigerant of all refrigerant compressors and replace the oil and refrigerant if necessary.

(k) Check and balance outside air quantities for all air-handling units.

(l) Check and clean all strainers on condenser water pipework and on chilled water pipework.

(m) Check and balance water flow rates for all equipment.

(n) Overhaul all refrigerant compressors, if necessary, including inspection and cleaning of heat exchanger tubes of condensers and evaporators.

(o) Check all electrical motors for power consumption.

(p) Check and balance system components to ensure that the indoor design conditions are satisfied.

(q) Records should be kept of all maintenance work - when and what was done.

13.10 Requirement for the maintenance of indoor environment and air quality

(a) All thermostats for the control of indoor temperature has to be calibrated to meet the design specification at least once every six months.

(b) Coils should be cleaned at least every six months and the condensate pipe every month to ensure that contaminants do not build up.

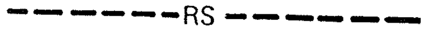
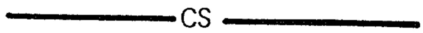
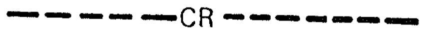
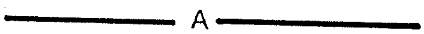
(c) Cooling tower has to be cleaned and treated every month following the Code of Practice for the control of legionella bacteria.

Annex A

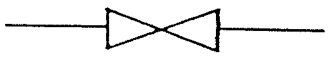
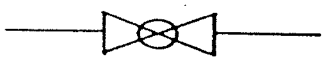
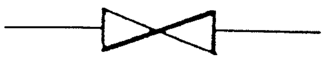
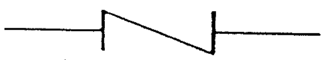
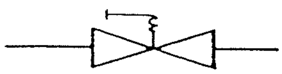
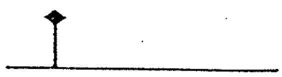
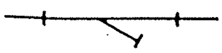
Symbols

Graphical symbols for drawings

Air-conditioning pipework

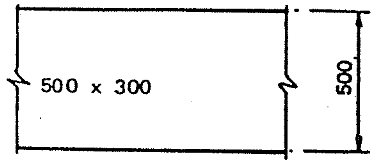
Refrigerant discharge	
Refrigerant suction	
Condenser water supply	
Condenser water return	
Chilled water supply	
Chilled water return	
Make up water	
Drain	
Compressed air	

Valves

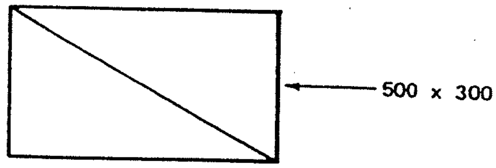
Gate valve	
Globe valve	
Ball valve	
Butterfly valve	
Non-return valve	
Relief valve	
Air valve or cock	
Drain cock	
Strainer	

Ductwork

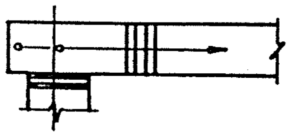
Duct, plan or elevation



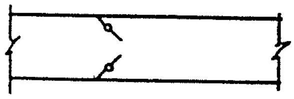
Duct, section (indicate larger dimension first)



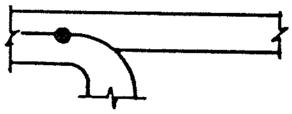
Flexible joint



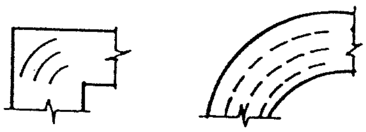
Volume damper



Spliter damper

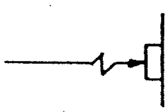


Vane



Grilles, Registers, Difussers, etc.

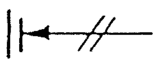
Louvre opening



Outdoor air grille	OAG
Exhaust air grille	EAG
Supply air register	SAR
Return air grille	RAG
Supply air diffuser	SAD

Supply outlet

Exhaust inlet

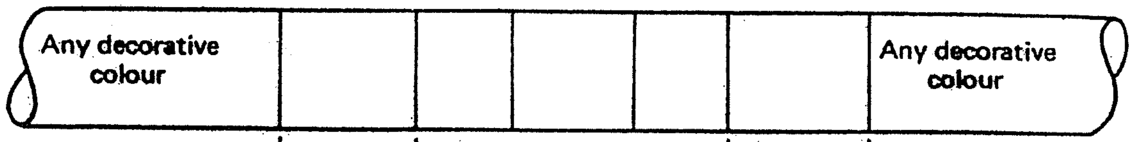


Annex B

Identification of pipelines (colour code)

To identify pipes conveying fluids in air-conditioning systems, the following colour code shall be used. They shall be place at all junctions, at both sides of valves, near service appliances, wall/floor penetrations and at any other place where identification is necessary.

Identification colours shall be applied as bands about 100 mm wide depending on the diameter of the pipe and illustrated as follows:



	150mm Approx.	100mm Approx.	150mm Approx.
	Basic Colour	Colour Code	Basic Colour
Chilled Water	Green	White / Emerald Green / White	Green
Condenser Water	Green	White	Green
Drainage		Black	
Compressor Air		Light Blue	

Reference Colour

Colour	Colour Reference (BS 4800)
Green	12D45
Emerald Green	14B53
Light Blue	20B51

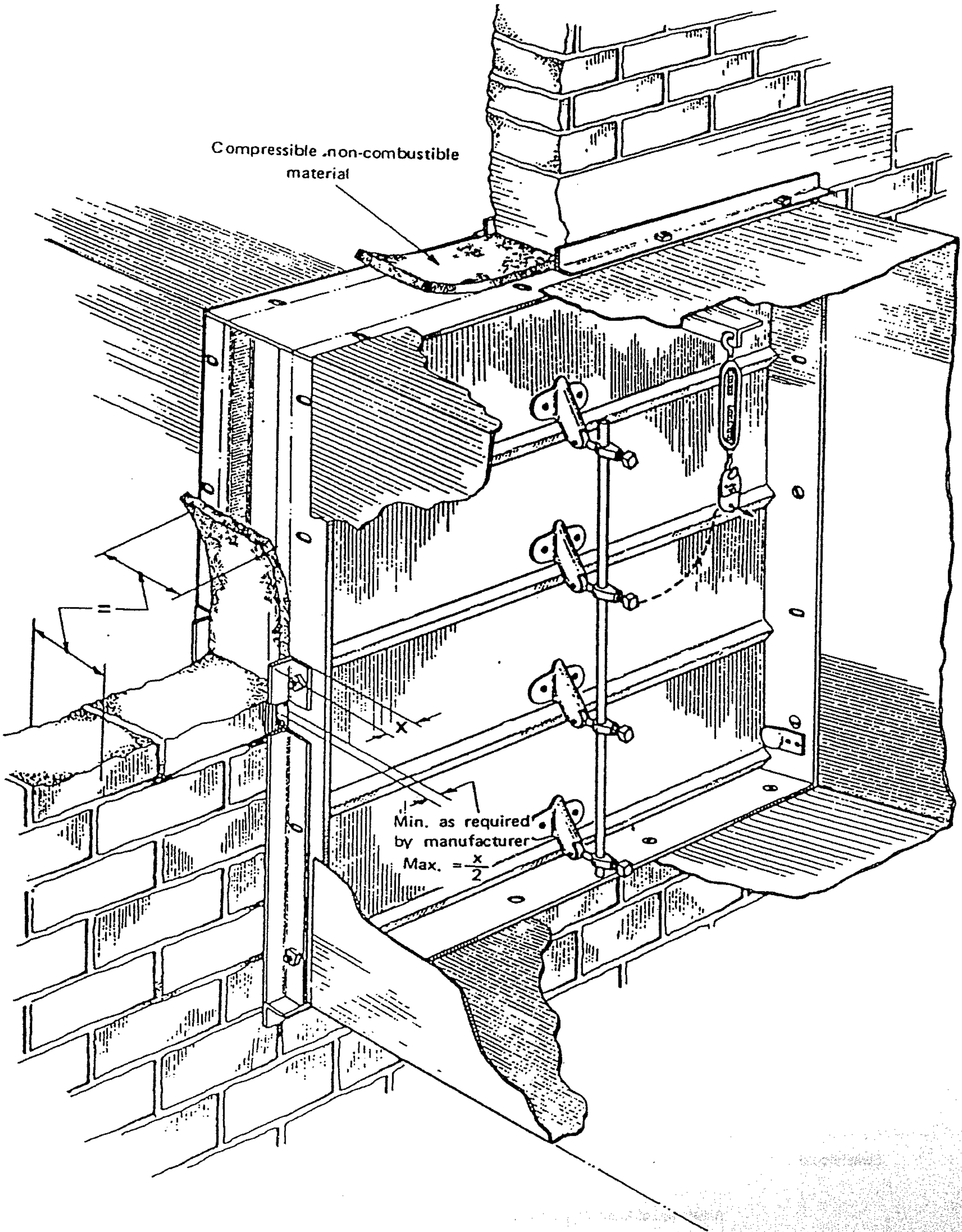
When it is necessary to know the direction of flow of the liquid, this shall be indicated by an arrow.

(i) Arrow shall be painted black.

(ii) Arrows shall be visible from floor.

Annex C

Installation of fire damper in wall



Annex D

Schematic for audit monitoring facility

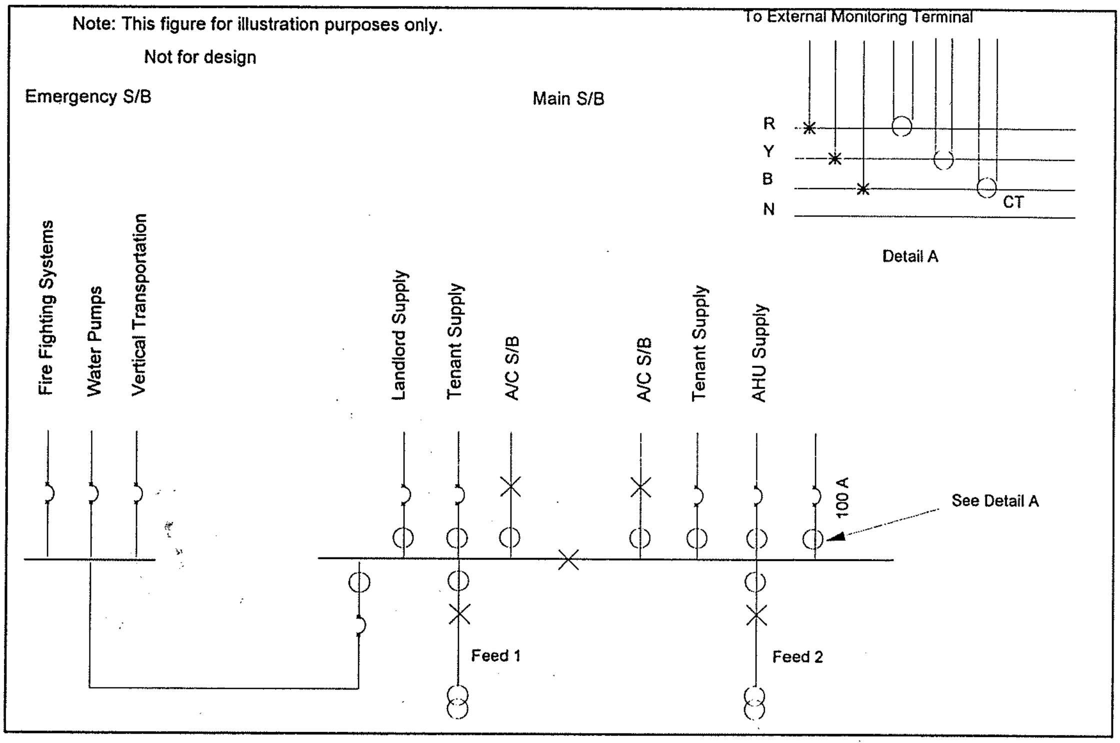


Figure D1 – An illustration of the Monitoring Points for an Air-conditioning plant

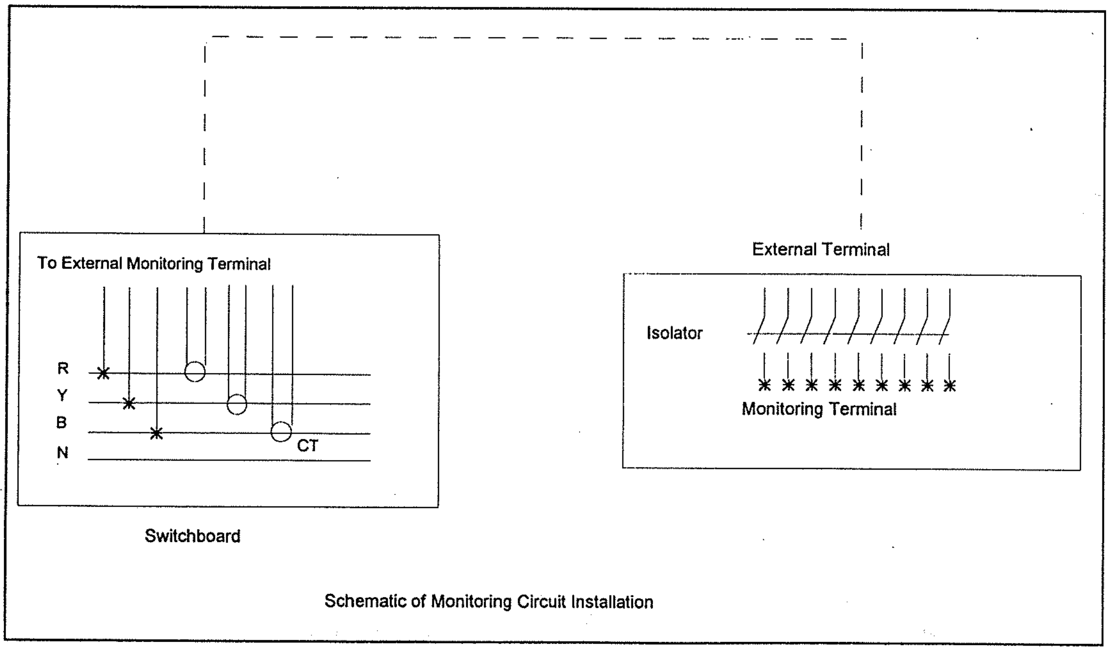


Figure D2 – An example of the tap-off points from the panel meters to an external location on the switchboard

Publications referred to:

AS1668.1 : 1991	Fire and smoke control
AS1668.2 : 1991	Mechanical ventilation for acceptable indoor air quality
AS1682 : 1990	Fire dampers Part 1 : Specification Part 2 : Installation
ASHRAE Standard 55-1992	Thermal environmental condition for human occupancy
ASHRAE Standard 90.1-1989	Energy efficient design of new buildings except low-rise residential buildings
BS 5588	Code of practice for smoke control using pressure differentials Part 4 : 1998 Fire precautions in design and construction of buildings
BS 8313 : 1997	Code of practice for accommodation of building services in ducts
BS 1710 : 1984	Specification for identification of pipelines and services
CP 5 : 1998	Code of practice for electrical installations
CP10 : 1993	Code of practice installation and servicing of electrical fire alarm systems
SMACNA 1995	HVAC duct construction standards - metal and flexible

THE SINGAPORE PRODUCTIVITY AND STANDARDS BOARD

The Singapore Productivity and Standards Board (PSB) is a statutory board established in April 1996, with the integration of the functions of the National Productivity Board (NPB) and the Singapore Institute of Standards and Industrial Research (SISIR) and the takeover of the small and medium-sized enterprise (SME) development function from the Economic Development Board (EDB). It is governed by a board of directors comprising representatives from government, employers, trade unions and academia.

While NPB's activities focused on training, productivity consultancy and promotion, SISIR's work centered on technology, quality, standards and industrial research. With the formation of PSB, synergy is derived by putting the "soft" and "hard" aspects of productivity with the same organisation so that PSB is greater than the sum of NPB and SISIR.

PSB's mission is to raise the productivity and enhance Singapore's competitiveness and economic growth. The Board's vision is to be a leading player with a global perspective in matters related to productivity and standards.

One of the functions of PSB is the establishment of a national standardisation programme to support industrialisation in Singapore. The Board is vested with the authority to appoint a Standards Council to advise on the preparation, publication and promulgation of Singapore Standards, and promotion of their adoption. Standards are in the form of specifications for materials and products, codes of practice, methods of testing, nomenclature, etc. The standards are drawn up by the various Technical Committees appointed by the Product Standards Committees (for product standards), the Practice Committees (for codes of practice) or the Standards Committee (for both product standards and codes of practice), the final approval body being the Standards Council.

To ensure adequate representation of all viewpoints in the preparation of standards, all Committees appointed consist of representatives from various interest groups which include Government agencies, professional bodies, tertiary institutions and consumer, trade and manufacturing organisations.

PSB operates a number of national certification schemes.

The Board is the owner of the Certification Mark shown in Figure 1. This Mark can be used only by manufacturers licensed under the PSB (Singapore Quality Mark) Certification Scheme operated by PSB in accordance with the Singapore Quality Mark Certification Regulations. The presence of this Mark on a product with the inscription "Certified to Singapore Standard" is an assurance that the product has been produced to comply with requirements of the relevant Singapore Standard under a system of supervision, control and testing operated during manufacture and including regular inspection at the manufacturer's premises.

PSB also operates the PSB ISO 9000 Certification Scheme which is a third party quality system certification of manufacturing processes and services to the relevant part of the SS ISO 9000 series of standards on quality systems. The scheme confers recognition to companies which have properly designed and implemented quality systems. It enables companies to gain greater international recognition thereby facilitating access to overseas markets. It also helps companies to reduce reject costs and improve quality and productivity. Certified companies are entitled to use the PSB ISO 9000 symbol as shown in Figure 2 in their marketing programme including letterheads, advertisements and other promotional materials.

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SINGAPORE
QUALITY MARK

Figure 1.

ISO 9000
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Figure 2.

ISO 14000
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Figure 3.

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