


5. INDOOR ENVIRONMENTAL QUALITY AND ENVIRONMENTAL PROTECTION

5.1. EFFECTIVE VENTILATION SYSTEM

5.1.1. CARBON MONOXIDE (CO) MONITORING AND CONTROL

CO sensor should be installed at every floor of enclosed and/or semi-enclosed car park to control the ventilation fans. The fans should be controlled to ensure that the CO concentration is maintained below the permitted level of approximately 25ppm averaged over an eight-hour period. The fans can be switched off when the CO concentration is below 9 ppm. The fan should be controlled by variable speed drive to ensure energy is used efficiently


Automobile engines generate CO. Car park users should be protected against this toxic gas by measuring the CO level in the car park and regulating the ventilation so as to keep the CO concentration below the recommended level.

CO sensor	Potential saving
	<p>By using CO sensors to control the car park ventilation system instead of conventional constant flow system, significant savings can be achieved. Normally the pay back period varies from 9 to 24 months and typical pay back period is about 12 months.</p> <p>For example, a building with 25,000m² basement car park space is estimated to save about S\$335,000 a year after installing the CO sensors to control the car park ventilation system.</p>

5.1.2. Carbon Dioxide (CO₂) Monitoring & Control

Air-conditioning space should be installed with CO₂ sensors to modulate the amount of outdoor air introduced into the air conditioning system so that the CO₂ level for the area served will always be below 1000ppm.

Higher than normal levels of CO₂ can be an indicator of inadequate ventilation which may affect the indoor air quality within an enclosed office space. This can have substantial effect on the wellbeing and productivity of the occupants. The installation of CO₂ monitoring system can automatically adjust fresh air supply rates. This design can reduce the energy consumption without compromising the indoor air quality.

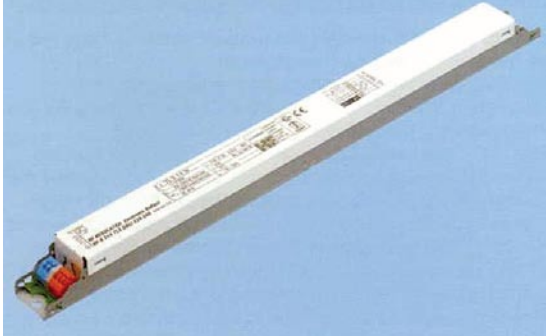
CO ₂ sensor	Potential saving
	<p>The CO₂ control system controls the amount of fresh air supplied to the office spaces according to the actual indoor fresh air demand. The CO₂ control system increases fresh air supplied when the occupancy is high so as to maintain good indoor air quality. It decreases fresh air supplied when the occupancy is low so as to conserve energy.</p> <p>The CO₂ control system can contribute to savings of between 8 to 50% by maintaining a CO₂ level of below 1000ppm.</p>

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5.2. HIGH FREQUENCY BALLAST

High frequency ballast should be designed for fluorescent luminaries.

Conventional fluorescent luminaries operate at a frequency of 50Hz (i.e. mains frequency). This results in the light switching on and off 100 times per second and may cause headaches and eyestrain. The use of high frequency ballasts in the range of 20kHz and higher will provide smoother, non-flickering lamp operation. At this frequency, the flicker is totally undetectable.

High frequency ballast	Potential saving
	High frequency fittings will also result in prolonged lamp life and significant energy savings (see section 2.5.2).

5.3. LUMINANCE LEVEL

The building should provide adequate lighting for occupant comfort without over designing. Table below list the recommended illuminance range and level stated in CP 38 for various types of occupancy.

Area/Activity	Illuminance (Lux)	
	Recommended design value	Unified glare rating limit
Office		
Conference rooms, executive office, computer workstation, drawing office (general)	500	19
Filing print room	300	19
Computer and data preparation rooms, drawing boards	750	19
General office		
- Normal	500	19
- Deep plan	750	19
Hotel		
Entrance halls	300	22
Kitchens	500	22
Bedrooms, bathrooms		
- General	100	NA
- Local	300	NA
Homes		
Bedrooms		NA
- General	75	
- Bed-head	200	
- Study area	500	
Bathrooms		
- General	100	
- Shaving, make-up	500	
Living rooms		
- General	100	
- Reading, sewing, computing	500	
Kitchens		
- General	200	
- Working areas	500	
<i>Source: SS CP 38:1999</i>		

Lighting luminance levels are an important factor in determining occupant wellbeing and health in an office. Lighting that is too weak or too strong can cause discomfort and strain for office occupants.

The changing nature of certain activities may affect the illuminance levels required, for example, the increasing importance of computer and visual display terminal (VDTs) in the workplace. VDTs are replacing the drafting table and many paper-based reading and writing activities. These tasks aided by computers require less illumination.

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5.4. THERMAL COMFORT

Good indoor thermal comfort improves productivity at workplace. Air-conditioning system should be designed to take into consideration the fluctuation in ambient air temperature to ensure the following thermal comfort:

- o Air temperature 22.5-25.5 Deg C
- o Relative humidity < 70%
- o Air movement <0.25m/s



5.5. INTERNAL NOISE LEVEL

Internal noise is a significant factor in terms of occupant satisfaction and wellbeing. It can affect workplace productivity.

5.5.1. BUILDING SERVICES NOISE LEVEL

The equipment of building services should not contribute more than 5dB to space noise levels. Some examples on how to reduce noise level are as follows:

- Select mechanical and pumping devices, ductwork and piping that generate less noise and dampen the noise generated.
- Prevent noise transmission by absorbing noise and vibration at source through use of isolation pads or enclosing equipment in sound-absorbing walls, floors and ceilings. To be effective, the door to this place should also be sound insulated.



Door with sound insulation

POINT TO NOTE

- When designing the acoustical environment within occupied spaces in buildings, the designer should take into consideration the noise and vibration in mechanical ventilation and air-conditioning systems arising from the following:
 - o mechanical and electrical equipment
 - o flow of water through pipes
 - o flow of air through ducts and grilles

5.5.2. OVERALL BUILDING SOUND LEVEL

The design sound level of building should be as follows:

- o General offices 45-55dB L_{AeqT}
- o Private offices 40-45 dB L_{AeqT}

Where T is taken as the normal working day (8 hours)

The noise levels fluctuate and a number of scales are used to represent this. L_{AeqT} measures the average energy of the noise level. It is the equivalent steady state level of a fluctuating noise level over a period of time T.

The noise from all sources, internal and external should be included. Where windows are openable, these should be deemed to be opened for the purpose of the calculation.

The following examples could be considered to ensure the design sound level of a building is within the limit:

- Site, orientate and layout the building such that external noise sources can be attenuated by distance or by topographic features or walls.
- Layout of plant rooms and location of noise sources with respect to noise-sensitive areas. For example, place acoustic buffers such as corridors, lobbies, stairways, storage rooms between noise-producing and noise-sensitive spaces.

5.6. INDOOR AIR POLLUTANT

5.6.1. LOW VOLATILE ORGANIC COMPOUNDS (VOC) PAINTS

Low-VOC paints (paints with no more than 150gm/l of VOCs) should be used for 95% of interior painted surface or alternate surface coating.

Paints may have a major negative impact on the health of a building because they can contain VOCs and other toxic components which evaporate into the air and are harmful to the occupants. The health effects of exposure to VOCs are eye, nose and throat irritation, headache, nausea and more serious illnesses - heart, lung and kidney damage.

5.6.2. COMPOSITE WOODS

Composite wood product should not be used or use only composite woods with low emission formaldehyde i.e. these products do not emit, under any reasonable circumstances of manufacture, storage and use, formaldehyde to cause its concentration in air greater than 0.1ppm.

Formaldehyde is a gas at room temperature and is widely used as an adhesive in the manufacture of composite wood such as MDF and particleboard. The health effects of exposure to formaldehyde could result in eye, nose and throat irritation; wheezing and coughing; fatigue; skin rash or severe allergic reactions. High concentration may trigger attacks in asthma. It may also increase risk of cancer.

Formaldehyde exposures of 0.1ppm or less are well below both the irritant and cancer thresholds, and no adverse health effects would be expected in even the most sensitive individuals, including the young, the aged, and the ill.

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5.7. REFRIGERANT

For years, CFCs and HCFCs provided the appropriate chemical stability and efficiency required for air conditioning systems. However, they contain chlorine which will damage the Earth's ozone layer. Ozone is an extremely rare gas in the atmosphere. The ozone layer absorbs most of the harmful ultraviolet-B radiation from the sun. It also completely screens out lethal UV-C radiation.

The Montreal Protocol has set up a timetable to ban the production and consumption of ozone depleting substances in developed and developing countries. Table 8 lists the type of chlorine based refrigerants to be banned. The availability of those refrigerants will be from reclaimed refrigerant from systems no longer in operation.

Table 8: Montreal Protocol Restriction Schedule

Type	Examples	Developed countries	Developing countries
CFCs (Chlorofluorocarbons)	CFC-11, 12, 113, 114, 115 etc	Phased out end of 1995	Total phase out by 2010
HCFCs (Hydrochlorofluorocarbons)	HCFC-22, 123, 141b, 142b, 225, etc	Total phase-out by 2020	Total phase out by 2040

5.7.1. REFRIGERANT ODP AND GWP

Air-conditioning system should be provided without refrigerants or with refrigerants which have an Ozone Depletion Potential (ODP) of zero. HFCs do not contain any chlorine and do not cause depletion of the ozone layer. Example: HFC-32, 125, 134a, 143a, 152a, etc.

The use of CFCs and HCFCs as refrigerants has been addressed under the Montreal Protocol. However, the replacements currently favoured by the industry are Hydrofluorocarbons (HFCs) which have a high global warming potential (GWP). The GWP provides a measure of the potential for damage that a chemical has relative to 1 unit of CO₂, the primary Greenhouse gas. Hydrocarbons and ammonia-based refrigerants have low or zero GWP. These refrigerants are valid alternative to HFCs.

5.7.2. REFRIGERANT LEAK DETECTION

A refrigerant leak detection system should be designed to cover high-risk parts of the plant (evaporator or condenser coils can be omitted from this). For new buildings, permanently installed multi-point sensing detectors should be specified.

Refrigerant leaks are responsible for substantial releases of ozone depleting and greenhouse gasses to the atmosphere. Reducing the leakage levels of refrigerants can also have direct economic benefit as leakage can result in loss of efficiency in air-conditioning plants.

Examples of leak detectors are as follows:

- o **Indicator Dyes**

Fluorescent or a coloured dye is inserted into the system. When the refrigerant leaks, the dye will show the leakage site.

- o **Halide Torch**

A halide torch leak detector can only be used to detect chlorinated refrigerants such as CFCs and HCFCs. The dye may be considered as contaminate to the sealed system and it is difficult to get into the system without moisture contamination. The use of the dye should be approved by the compressor manufacturer. Non-ozone depleting refrigerants such as HFCs cannot be detected by a halide torch leak detector.



5.7.3. REFRIGERANT RECOVERY

Automatic refrigerant pump down should be installed to the heat exchanger (or dedicated storage tanks) with isolation valves.

Refrigerants can cause damage to the environment even when their ozone depletion potential is zero. The specification of the automatic refrigerant pump down can further limit potential losses and damage to the environment.

