GUIDELINES FOR GOOD INDOOR AIR QUALITY IN OFFICE PREMISES

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CONTENTS

INTRODUCTION

The indoor air quality of air-conditioned offices is a subject of public health importance because we spend a substantial amount of time in these premises. Good indoor air quality can lead to improved productivity at the workplace. On the other hand, poor indoor air quality will cause productivity to drop because of comfort problems, ill health and sickness-absenteeism.

Our city's tropical climate, highly built environment, and energy conservation requirements pose special constraints and challenges to the building industry in ensuring that indoor air quality remains acceptable. In 1995, my Ministry appointed a Technical Advisory Committee on Indoor Air Quality comprising members from both private and public sectors to advise on the guidelines for good air quality. This document represents a very important first step towards interdisciplinary consensus on the issue of indoor air quality.

The objective of this document is to provide general guidance on improving the indoor air quality of air-conditioned office premises and acceptable values for selected parameters. It also provides information on the potential health effects of indoor contaminants, and an action plan to achieve good indoor air quality. The contents are intended to complement the engineering specifications set out in the Singapore Standard Code of Practice for Mechanical Ventilation and Air-conditioning in Buildings (SS CP13), and should be useful to building owners/management corporations, those involved in servicing the ventilation and air-conditioning systems, and all others responsible for designing, operating and maintaining the building environment. As research continues, amendments may be made from time to time in subsequent editions.

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MINISTRY OF THE ENVIRONMENT
SINGAPORE

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GUIDELINES FOR GOOD INDOOR AIR QUALITY IN OFFICE PREMISES PART I

PRELIMINARY

1. Purpose
2. Scope and application
3. Glossary

Part I

PRELIMINARY

1 Purpose

1.1 The purpose of this document is to provide guidelines for good indoor air quality.

2 Scope and application

2.1 This document applies to all buildings, new and existing, which are air-conditioned and used as office premises in Singapore.

2.2 The indoor air quality parameters addressed are carbon dioxide, carbon monoxide, formaldehyde, ozone, volatile organic chemicals, total bacterial counts, total fungal counts, suspended particulate matter, air temperature, relative humidity, and air movement.

2.3 Guideline maximum concentrations for acceptable indoor air quality are specified for carbon dioxide, carbon monoxide, formaldehyde, and ozone based on their known health effects.

2.4 Recommended maximum concentrations for acceptable indoor air quality are specified for suspended particulate matter, volatile organic chemicals, bacteria and fungi based on their potential health effects.

2.5 Because human health and comfort are complex issues responsive to the interaction of multiple factors, guideline acceptable values are specified for indoor air temperature, relative humidity, and air movement.

3 Glossary

3.1 ACMV system refers to the air-conditioning and mechanical ventilation system of the building.

3.2 Acceptable indoor air quality refers to air in which there are no known contaminants at harmful concentrations as determined by the public health authorities, and with which a substantial majority of the people exposed do not express dissatisfaction.

3.3 Air-conditioning refers to the process of treating air to meet the requirements of a conditioned space by controlling its temperature, humidity, cleanliness and distribution.

3.4 Air temperature refers to the dry-bulb temperature of the air surrounding the occupant.

3.5 Building-related illness refers to any illness which occurs directly as a result of human exposure to a specific health hazard present in the building.

3.6 Contaminant refers to an unwanted airborne constituent that may reduce acceptability of the indoor air quality.

3.7 Indoor air refers to the air inside a building, including air which is within a room and air which is removed from a room by mechanical means.

3.8 Occupied zone refers to the region normally occupied by persons within a space, generally considered to be between the floor and 1.8 m above the floor, and more than 0.6 m from the walls.

3.9 Outdoor air refers to the air in the external surroundings.

3.10 Sick building syndrome refers to an excess of work-related irritations of the skin and mucous membranes and other symptoms (including headache and fatigue) reported by occupants in modern office buildings.

3.11 Suspended particulate matter refers to the mass of particles suspended in a unit volume of air when collected by a high volume air sampler.

3.12 Ventilation refers to the process of supplying and removing air by natural or mechanical means to and from any space. Such air may or may not be conditioned.

GUIDELINES FOR GOOD INDOOR AIR QUALITY IN OFFICE PREMISES PART II

IDENTIFYING INDOOR AIR QUALITY PROBLEMS

4. Assessment of indoor air quality problems

5. Indoor air quality and health

6. Action plan to achieve good indoor air quality

Part II

IDENTIFYING INDOOR AIR QUALITY PROBLEMS

4 Assessment of indoor air quality problems

4.1 It should be the responsibility of the owner of the building to:

(a) assess the risks to health arising from the indoor air quality;

(b) set up a programme to ensure acceptable indoor air quality, implement the programme, and monitor the effectiveness of the programme; and

(c) keep records of all activities implemented.

4.2 The owner should ensure that the building inclusive of its installations is designed, constructed, operated and maintained in such a way that acceptable indoor air quality is achieved.

4.3 Those engaged by the building owner to carry out the assessment of any indoor air quality problems should be competent persons who are adequately qualified and experienced, and provide supervision for the management of the indoor air quality programme.

5 Indoor air quality and health

5.1 Good indoor air quality improves productivity at the workplace. On the other hand, poor indoor air quality could lead to losses in productivity as a result of comfort problems,

ill health and sickness-absenteeism.

5.2 Building-related illness is said to occur when occupant exposure to indoor contaminants results in a clinically defined illness, disease or infirmity. Some common indoor air contaminants and their sources are listed in Appendix A. Those affected usually require prolonged recovery after leaving the building.

5.3 Sick building syndrome is said to occur when a substantial proportion of the occupants of a building experience symptoms associated with acute discomfort that are relieved upon leaving the premises. The mechanisms are still not fully understood, but indoor air quality is thought to be contributory. Those affected typically recover completely soon after leaving the building.

5.4 Factors affecting indoor air which can give rise to poor air quality are: the presence of indoor pollution sources; poorly designed, maintained or operated ACMV systems; and uses of the building that were unplanned for when the building was designed or renovated.

6 Action plan to achieve good indoor air quality

6.1 In the event or on the suspicion that the indoor air quality is not good, the following should be made available for inspection during an investigation:

(a) building plans showing the details of all the floors, and location of the cooling towers and fresh air inlets to the building;

(b) ACMV system layout plans or schematics; and

(c) ACMV system operating schedule and maintenance records.

6.2 A walk-through inspection of the premises and the ACMV system should be conducted by the competent persons to identify possible irregularities. A sample checklist for building inspection is provided in Appendix B.

6.3 Feedback from occupants on the conditions in the building and the operation of the ACMV system should be obtained by the competent persons. A sample confidential questionnaire which can be administered to obtain information is provided in Appendix C.

6.4 Indoor air analysis, and any environmental or biological sampling, should be conducted by the competent persons if deemed necessary for the investigation so that adjustments or alterations can be made.

6.5 Based on the findings of (6.1)-(6.4), building remedial measures should be formulated, implemented and evaluated so that good indoor air quality can be achieved and does not deteriorate again in future.

GUIDELINES FOR GOOD INDOOR AIR QUALITY IN OFFICE PREMISES PART III

IMPROVING INDOOR AIR QUALITY

7. Design
8. Construction
9. Commissioning and operation
10. Renovation
11. Maintenance
12. Quality control

Part III

IMPROVING INDOOR AIR QUALITY

7 Design

7.1 A new or retrofitted building should be designed with regard to the pollution which may arise within the building. Unless a space has adequate openable windows that can meet natural ventilation requirements, the building should be provided with a mechanical ventilation system that can be operated when required to purge the indoor air from the space, in addition to the air-conditioning system.

7.2 The ACMV system should be designed so that the potential spread of contaminants in the building is kept low. Materials used should not include those that emit chemicals, bacteria or fungi to the supply air. Pollution sources, or pollutive activities of frequent occurrence, should be provided with such process ventilation of the encapsulation, hood or local extraction type so that the spread of contaminants is prevented.

7.3 Building materials and surface finishes should not contain any substances that emit chemicals, bacteria or fungi. They should be able to stand up to the intended use and not cause any emission of contaminants to the indoor air.

7.4 Water supply, drainage, sewerage and other installations should be planned for construction in such a way that the risk of leaks and consequential damage caused by leaks is prevented.

7.5 Outdoor air intakes should be placed where the air admitted is likely to be cleanest, taking into consideration the outdoor air quality standards specified in Appendix D, the position of

the building, the exhaust opening position, traffic routes, carparks, unloading bays, refuse chutes and other nearby sources of pollution. Intakes should not be located below ground level or close to evaporative cooling towers. Outdoor air filters should be placed as close as possible to the intake points.

7.6 The building should be designed so that cleaning of windows, doors, floors and other surfaces in contact with supply air or room air is possible. Such surfaces should be cleaned before the building is taken into use. Surfaces which are likely to become heavily soiled should be readily accessible and easily cleanable.

8 Construction

8.1 At all stages of the construction of the building and its ACMV system, inspections should be made by the competent persons so that acceptable indoor air quality can be secured when the system is put into operation.

8.2 The building structure should be constructed in such a way that harmful spread of contaminants from the outside, the ground, or some other separate part of the building does not occur.

8.3 In the construction of the ACMV system, the supply and return air ducts should be made accessible for inspection and cleaning. Components should be made of materials which stand up to the intended use and maintenance. Those which require attendance and maintenance should be sited so that they are readily accessible and replaceable, and mounted so that work can be carried out easily and safely. To reduce dust accumulation, the inner surfaces of the ducts for supply and return air should be smooth and resistant to abrasion.

8.4 Outdoor air for ventilation and indoor air that is to be

recirculated should be filtered for particulates. A filter should be placed for outdoor air that is to be introduced into an air handling unit room. The filter should be protected from being wetted by sprays, rain, etc. In placing the filters, there should be an adequate seal between the air filters and the walls of the surroundings ducts or units.

8.5 Installations unrelated to the ACMV system should not be located in the air-handling unit rooms.

9 Commissioning and operation

9.1 Before a new or retrofitted building is commissioned into service, it should be demonstrated that the ACMV system has been constructed and is able to function in the way intended. The entire ACMV system should be cleared of any construction debris and dirt, and cleaned before operation starts.

9.2 The specifications and operations of the ACMV system should be in accordance with all provisions of the Singapore Standard Code of Practice for Mechanical Ventilation and Air-conditioning in Buildings (SS CP13).

9.3 Unless there are strong pollutants sources, in which case corrective action should be taken, the ventilation rate should be sufficient to dilute or remove any airborne contaminants to levels which comply with the indoor air quality guideline values specified in Appendix E. Where this is not possible, an air-purging system should be activated to enable purging of the contaminated air, routinely or as and when required.

9.4 It should be possible to assess at any time the condition of the filter, including the pressure drop, the contamination and the installation. The minimum arrestance efficiency for the air filters for cleaning outdoor and indoor air should be 60% and 80%, respectively.

9.5 Instructions for the operation of the building and its ACMV system should be drawn up in direct cooperation with the operations and maintenance staff, including all necessary information for satisfactory ventilation of the rooms served. The instructions manual for each ACMV system should include:

(a) a schematic plan of the system;

(b) its operation; and

(c) the precautions to be taken specifying checks and their frequency, and steps to be taken to remedy defects and deficiencies.

9.6 Rooms where air handling units are situated should not be used as passage ways or for storage. Where they open to a source of contamination, the doors of the rooms should remain air-tight. The inner surfaces of the units and equipment should be easy to clean and abrasion-resistant. Sufficient space for cleaning and for access to the units should be provided.

9.7 Air distribution should be efficient, effective and uniform to ensure no stagnation of air in dead spaces.

10 Renovation

10.1 Major renovation works should be undertaken in such a way that a satisfactory indoor environment is secured. Where relevant to the renovation works, consideration should be given to (7.1)-(7.6) and (8.1)-(8.5) in the stages of design and construction, respectively.

10.2 Processes and activities should be selected so that they have

the lowest possible emission. Where processes and activities which pollute the air cannot be avoided, they should as far as possible be encapsulated, provided with local extraction, carried out in areas with direct exhaust to the exterior, or limited to times when few people are exposed.

10.3 The building materials should not contain any toxic substances which could pose a hazard to health when used in the occupied building. Fittings, fixtures, furnishings and furniture should be manufactured, selected, handled, stored and used so that emission to the room air is the least possible.

10.4 For occupied buildings undergoing partial renovation, spaces to be renovated should be effectively isolated from the occupied zones. If necessary, supply air should be separated so that acceptable indoor air quality for the occupants is maintained. Concentrations of formaldehyde, volatile organic compounds, suspended particulate matter and other contaminants in room air should be within the limits specified in Appendix E.

10.5 After any major renovation to the building where the air-conditioning system has been affected (eg. by partitioning of office space), rebalancing of the air distribution should be required.

11 Maintenance

11.1 Competent persons should be employed specifically to ensure that regular maintenance of the building inclusive of the ACMV system is carried out on a routine basis. Maintenance staff should be familiar with the prevention of any hazard arising from the building.

11.2 The schedule of maintenance for the ACMV system should be in accordance with the manufacturer's recommendations

to ensure that the equipment operate efficiently. If this is not specified for any component, the frequencies listed in (11.3)-(11.7) should constitute the minimum requirements.

11.3 The building and its ACMV system should be inspected **at least every six months** with regard to functions which are significant for the indoor air quality. Normal operation of the system should be monitored so that it continues to operate at maximum efficiency and breakdowns are avoided.

11.4 The ACMV system and the air handling unit room should be cleaned and maintained in such a way that the indoor air quality is not adversely affected by the cleaning and maintenance. The components of air-handling units such as fans and dampers should be cleaned **at least every six months**, depending on the condition of the incoming air and use of the system. Filters should be cleaned or replaced so that they are performing properly **at all times** and do not become clogged.

11.5 Cooling coils, condensate pipes and water trays should be checked regularly for signs of sludge, algae or rust build-up, chokage and leaks where water could enter the airstream. Coils and condensate pipes should be cleaned **at least every six months**. The trays should be cleaned **at least every one month** to ensure that contaminants do not build up. Any ferrous metal surface should be treated with an anti-corrosion coating. Re-circulating water should also be treated to prevent rust but that treated water must not be allowed to enter the airstream.

11.6 Cooling towers should be cleaned and treated in accordance with guidelines specified in the Code of Practice for the control of legionella bacteria in air-conditioning cooling towers in Singapore (Ministry of the Environment, August 1992).

11.7 The ACMV system should be checked and adjusted to

ensure correct air flow, temperature and humidity **after the first year of operation** and **at least every two years** thereafter. It should also be checked and adjusted after any renovations or changes in floor layout that might affect air distribution.

11.8 Records should be kept of all maintenance work - when and what was done.

12 Quality control

12.1 An audit should be conducted by the competent persons **within six months after commencement** of operation of the ACMV system. The information for such an audit is similar to that which is collected in (6.1)-(6.4) when investigating an occurrence of building-associated illness, but includes the entire building rather than focusing on any area with an identified problem.

12.2 During the normal operation of a building, an audit should be conducted by the competent persons **at least every two years** to ensure that the indoor air quality is acceptable and conforms to the specifications listed in Appendix E.

12.3 When indoor air testing is required to study if the air quality complies with the relevant specifications, the tests should be carried out by a laboratory accredited under the Singapore Laboratory Accreditation Scheme.

12.4 The necessary plans, drawings and specifications on the building and its installations should be kept by the owner or the management corporation of the building, and made available for inspection when necessary.

12.5 A formal record book containing adequate and accurate information on the ACMV system should be kept by the owner or the management corporation of the building, and

made available for inspection when necessary. The information should include:

(a) description of the air-conditioning system;

(b) name of the building manager or person who ensures that proper records are kept;

(c) person or company who is responsible for the assessment of risk, and implementing and managing precautionary measures;

(d) person or company carrying out the maintenance programme; and

(e) details of maintenance, including:
  (i) date and result of visual inspection;
  (ii) date and type of cleaning/treatment works conducted; and
  (iii) date and nature of any remedial works (if required).

GUIDELINES FOR GOOD INDOOR AIR QUALITY IN OFFICE PREMISES

APPENDICES

A. Some common indoor air contaminants

B. Sample checklist for building inspection

C. Sample confidential questionnaire for building occupants

D. Outdoor air quality standards

E. Indoor air quality guidelines

F. References

Appendix A

SOME COMMON INDOOR AIR CONTAMINANTS

Carbon dioxide Carbon dioxide is present in the unpolluted atmosphere at a concentration of about 0.03% percent but since about 5% of the air we breathe out is carbon dioxide the level increases in inadequately ventilated occupied rooms. The level of carbon dioxide is therefore often used to assess the efficiency of ventilation. Outside sources include vehicle exhaust fumes or other exhausts.

Carbon monoxide Any process of combustion can produce carbon monoxide, including cooking and tobacco smoking. A major source of carbon monoxide is vehicle exhaust.

Formaldehyde Formaldehyde is a colourless gas with a pungent odour. It is found in hundreds of different products, including insulation material, ceiling tiles, particle board, plywood, office furniture, carpet glues, various plastics, synthetic fibres in rugs, upholstery and other textiles, pesticides, paint and paper. Levels of emission increase with temperature.

Ozone Ozone is naturally present in the air since it is produced from oxygen by ultraviolet radiation. However, it can also be produced by electrical discharges and is emitted by some items of electrical equipment such as photocopiers and electrostatic precipitator devices used to clean the air by removing dust.

Appendix B

SAMPLE CHECKLIST FOR BUILDING INSPECTION

Note: A walk-through inspection should include the office premises, its air-conditioning system and any other ventilation installations. The purpose of the inspection is to identify irregularities. The following checklist is provided as a guide and is not meant to be exhaustive. Where necessary, assistance should be sought from the building manager.

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1 Human exposure and comfort levels

1.1 How many occupants are there in each work area?

1.2 What time are the occupants in the building?

1.3 Is the indoor temperature regulated by thermostats? Where are they located? Have they been correctly positioned following building alterations? Are they set to the correct temperature?

1.4 Is there discomfort from heat radiation from visual display units?

1.5 Is there discomfort due to radiant heat from warm window surfaces?

1.6 Are temperature, relative humidity and air flow rates checked regularly during working hours?

1.7 Does air reach all parts of the office or are there dead spaces?

1.8 Are there any flickering fluorescent tubes? Are fluorescent tubes regularly replaced before there are obvious signs of wear?

1.9 Is the building still being used for the purpose it was intended? Have partitions/walls been added or removed? Have occupancy levels changed?

2 Potential sources of contaminants

2.1 Are there occupants smoking in any room or area?

2.2 Are there office equipment giving off gases or fumes? If so, are the equipment supplied with separate exhaust ventilation? Does the exhaust convey air to the exterior of the building or into corridors or into the air-conditioning system?

2.3 Are there furniture, furnishings, carpets, etc. that emit noticeable odours? Have detergents, pesticides or other chemicals been used in the building?

2.4 Are renovation works being undertaken in any part of the building? Are they done during working hours?

2.5 Is there a kitchen or pantry where cooking is done? Is exhaust ventilation provided there?

2.6 Is the building adequately cleaned? Is regular dusting of office furniture, ledges, shelves, etc. carried out to help keep dust to a minimum? Are the carpets vacuum-cleaned regularly?

3 Ventilation and air-conditioning

3.1 How many supply air and extract air vents are there in each room or area? Is there at least one each in every room?

3.2 Are vents located in positions that will permit the best air circulation?

3.3 Are supply air or extract air vents blocked in any way by partitions,

files or other structures that obstruct air flow? Has dust collected around the air vents?

3.4 Is the air-conditioning system turned off any time during the day?

3.5 Is the system turned off after office hours? Are there still occupants in the building after office hours?

33.6 Where is the outdoor air intake duct located? Is it near the cooling tower in this building or is it near adjacent buildings? Is it at street level or near a car park? Is it blocked up? Are heavy industries located nearby? Is there any construction work going on nearby? Is outdoor air actually getting into the building?

3.7 Are filters being used? Are they adequate? Are they being bypassed? How often are they cleaned or replaced?

3.8 Is there a regular schedule for cleaning and maintenance of the air-conditioning system in the building? Are all the components of the air-conditioning system regularly inspected for leaks, breaches, etc.?

Appendix C

SAMPLE CONFIDENTIAL QUESTIONNAIRE FOR BUILDING OCCUPANTS

To the occupant: This short questionnaire has been given to you to help determine the existence of health problems, if any, that may be related to the office environment. Your answers will remain confidential. Please complete the form as accurately as possible before returning to us. Thank you.

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1 Demographic information

1.1 Sex: Male / Female

1.2 Age:

1.3 Marital status: Single / Married

1.4 Ethnic group: Chinese / Malay / Indian / Other

2 Environmental conditions

2.1 Type of workstation: Enclosed room / Open concept

2.2 No. of people who share your workstation:

2.3 How is your area air-conditioned?
Central unit / Local unit

2.4 How is your workstation lighted?
Fluorescent lighting / Non-fluorescent lighting

2.5 Please indicate if you work with or near the following equipment:

Typewriter	-	Everyday / 2-3 times weekly / Never
Video display unit	-	Everyday / 2-3 times weekly / Never
Photocopier	-	Everyday / 2-3 times weekly / Never
Fax machine	-	Everyday / 2-3 times weekly / Never

2.6 Please rate the following conditions at your workstation:

Noise	-	Too much / Just right / Too little
Humidity	-	Too much / Just right / Too little
Lighting	-	Too much / Just right / Too little
Air movement	-	Too much / Just right / Too little
Temperature	-	Too hot / Just right / Too cold

2.7 Do you have to put on extra clothing for comfort?
Regularly / Sometimes / Never

2.8 Does the office air have an unpleasant odour?
Regularly / Sometimes / Never

2.9 Does the office air feel stuffy? Regularly / Sometimes / Never

3 Nature of occupation

3.1 No. of hours spent per day at your main workstation:

3.2 Please rate how you find the stress in your working conditions:

Physical stress experience	-	Low / Moderate / High
Mental stress experience	-	Low / Moderate / High
Climate of cooperation at work	-	Low / Moderate / High

3.3 What is your job category?
Managerial / Professional / Secretarial / Clerical / Other
(if Other, specify):

4 Health complaints

4.1 Please indicate your experience of the following symptoms at work during the past one month:

Headache	-	Daily / 2-3 times weekly / Less
Lethargy	-	Daily / 2-3 times weekly / Less
Drowsiness	-	Daily / 2-3 times weekly / Less
Dizziness	-	Daily / 2-3 times weekly / Less
Nausea/vomiting	-	Daily / 2-3 times weekly / Less
Shortness of breath	-	Daily / 2-3 times weekly / Less
Stuffy nose	-	Daily / 2-3 times weekly / Less
Dry throat	-	Daily / 2-3 times weekly / Less
Skin rash/itchiness	-	Daily / 2-3 times weekly / Less
Eye irritation	-	Daily / 2-3 times weekly / Less

4.2 No. of days in the past one month that you had to take off work because of these complaints:

4.3 When do these complaints occur?
Mornings / Afternoons / No noticeable trend

4.4 When do you experience relief from these complaints? After I leave my workstation / After I leave the building / Never

4.5 Please indicate if you have any of these medical conditions:
Asthma? Yes, on medication / Yes, not on medication / No
Allergy? Yes, on medication / Yes, not on medication / No
Sinus? Yes, on medication / Yes, not on medication / No
Migraine? Yes, on medication / Yes, not on medication / No

4.6 If female, are you currently pregnant? Yes / No / Not sure

Appendix D

OUTDOOR AIR QUALITY STANDARDS

1 USEPA primary air quality standards

Parameter	Averaging time	Conc.	Method
Gaseous pollutants			
Sulphur dioxide	Annual mean	80 $\mu g/m^3$	Pararos-aniline
	24 hours	365 $\mu g/m^3$	Pulsed Fluorescence
Carbon monoxide	8 hours	9 ppm	Non-dispersive
	1 hour	35 ppm	Infrared Spectrometry
Nitrogen dioxide	Annual mean	100 $\mu g/m^3$	Chemilumi-nescence
Ozone	1 hour	12 pphm	Ultraviolet Photometry
Particulate pollutants			
Respirable suspended particles	Annual mean	50 $\mu g/m^3$	High Volume Sampling
	24 hours	150 $\mu g/m^3$	
Lead	3 months	1.5 $\mu g/m^3$	Atomic Absorption Spectroscopy

2 World Health Organization long term goals

Parameter	Averaging time	Conc.	Method
Gaseous pollutants			
Carbon monoxide	8 hours	9 ppm	Non-dispersive Infrared Spectrometry
	1 hour	35 ppm	
Nitrogen dioxide	1 hour not to be exceeded more than once a month	0.1-0.17 ppm	-
Ozone	1 hour 8 hours	6 pphm 3 pphm	Neutral Potassium Iodide
Particulate pollutants			
Smoke	Annual mean	40 $\mu g/m^3$ (90% of observation below this limit)	British Standard Procedure (BS 1747 Pt 2, 1964)

Appendix E

INDOOR AIR QUALITY GUIDELINES

1 Assessment of indoor air quality parameters

(a) Sample position

The sampling probe should be located between 75 and 120 cm from the floor at the centre of the room or an occupied zone.

(b) Number of sampling points

Indoor

At least one sample should be taken from each floor or from each area serviced by a separate air handling unit. For large floor spaces, the guidelines for the minimum required number of sampling points are as follows:

Area of building (m^2)	Minimum number of sampling points
3,000 - <5,000	8
5,000 - <10,000	12
10,000 - <15,000	15
15,000 - <20,000	18
20,000 - <30,000	21
30,000 or more	25

Outdoor

At least two samples should be taken at the entrance to the building or at the entrance of the fresh air intake.

2 Guideline maximum concentrations for specific indoor air contaminants

Parameter	Averaging time	Limit for acceptable indoor air quality	Unit
Carbon dioxide	8 hours	1800 1000	mg/m^3 ppm
Carbon monoxide	8 hours	10 9	mg/m^3 ppm
Formaldehyde	8 hours	120 0.1	$\mu g/m^3$ ppm
Ozone	8 hours	100 0.05	$\mu g/m^3$ ppm

Note
The guidelines specified have a wide margin of safety such that even if they are exceeded occasionally, toxic effects are unlikely to occur.

3 Recommended maximum concentrations for specific classes of contaminants

Parameter	Limit for acceptable indoor air quality	Unit
Suspended particulate matter*	150	$\mu g/m^3$
Volatile organic compounds**	3	ppm
Total bacterial counts	500	CFU***/m^3
Total fungal counts	500	CFU/m^3

*respirable particles with aerodynamic diameters less than 10 μm sampled with a size selective device (commonly used devices; cyclones and impactors) having a median cut size of 4 μm and the following penetration characteristics:

Particle aerodynamic diameter, μm	Respirable particulate mass, %
0	100
1	97
2	91
3	74
4	50
5	30
6	17
7	9
8	5
10	1

**total photoionisable compounds, reference to toluene

***colony-forming units

4 Guideline values for specific physical parameters

Parameter	Range for acceptable indoor air quality	Unit
Air temperature	22.5-25.5	°C
Relative humidity	≤ 70	%
Air movement*	≤ 0.25	m/s

*at workstation within occupied zone

Appendix F

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