INDUSTRY CODE OF PRACTICE ON INDOOR AIR QUALITY 2010

DEPARTMENT OF OCCUPATIONAL SAFETY AND HEALTH
MINISTRY OF HUMAN RESOURCES, MALAYSIA

JKKP DP(S) 127/379/4-39

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PREFACE

This Industry Code of Practice is known as the Industry Code of Practice on Indoor Air Quality 2010 approved by the Minister on 30 August 2010 and will replace the Code of Practice on Indoor Air Quality launched by the Minister on July 2005.

Good indoor air quality (IAQ) is required for a healthy indoor work environment. Poor indoor air quality can cause a variety of short-term and long-term health problems. Health problems commonly associated with poor IAQ include allergic reactions, respiratory problems, eye irritation, sinusitis, bronchitis and pneumonia. IAQ problems occur in buildings that are served by a mechanical ventilating and air conditioning (MVAC) system including air-cooled split unit. IAQ problems can be due to indoor air pollutants or to inadequate ventilation.

There are many sources of indoor air pollutants and among the common ones are environmental tobacco smoke (ETS) emitted due to burning of tobacco products; various chemical substances such as formaldehyde emitted from furnishings; volatile organic compounds emitted from the use and application of solvents; and ozone emitted from photocopiers and laser printers. It should be noted here that ETS has been recognized as a human carcinogen by the International Agency from Research on cancer (IARC) in 2002 and exposure to it will increase the risk of coronary heart disease.

This Industry Code of Practice has been drawn up to ensure employees and occupants are protected from poor indoor air quality that could adversely affect their health and well being, and thereby reduce their productivity. It is the general duties of employers and self-employed persons to their employees as stipulated under Section 15 of Occupational Safety and Health Act 1994 (OSHA) while Section 17 of OSHA stipulated that it is also the general duties of employers and self-employed persons to persons other than their employees.

The Industry Code of Practice also emphasize on the duties of an occupier of a place of work to persons other than his employees stipulated in Section 18 of OSHA. An occupier is a person who has the management or control of the place of work. This duty is owed to persons who are not his employees but go to their premises to carry out work. Compliance to this Industry Code of Practice can be used as evidence of good practice in a court.

Director General
Department of Occupational Safety and Health
Malaysia
2010

ACKNOWLEDGEMENTS

This Industry Code of Practice may be cited as the Industry Code of Practice on Indoor Air Quality 2010.

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DEFINITIONS

"accredited laboratory" means analytical laboratory accredited by Department of Standards Malaysia;

"ceiling limit" means the airborne concentration that should not be exceeded during any part of the working day;

"contaminant" means an unwanted airborne constituent that may reduce acceptability of the indoor air quality;

"domestic building" means a building constructed, used or intended to be used for habitation but excluding the use of it for a hotel, guest-house, boarding-house, hostel, dormitory or similar accommodation and the expression "domestic purposes" is construed accordingly;

"environmental tobacco smoke" means substances in the indoor air arising from tobacco smoke;

"indoor air" means the air inside a building, including air which is within a room and air which is removed from a room by mechanical means;

"indoor air quality assessor" means an employee or any person appointed by the employer and registered with the Director General to carry out assessments of indoor air quality;

"industrial purpose" means work activities involving articles manufacturing, altering, cleaning, repairing, ornamenting, finishing, adapting for sale, breaking up or demolishing, storing, warehousing, or in which materials are transformed;

"mechanical ventilating and air conditioning (MVAC) system" means the equipment distribution network and terminal that provide, either collectively or individually, the processes of heating, cooling, humidification, dehumidification, ventilation or air-purification or any other associated processes to a conditioned space;

"normal business activity" means the typical or usual business activity;

"occupant" means any person in a place of work, and include an employee, client, patient, resident, patron, student, visitor or guest;

"office" means a room, set of rooms or building where people work, usually sitting at desks;

"prescribed activities" means any activity that could pose health hazard to the occupants, including but not limited to-

(a) applying or removing floor coverings including carpeting, floor tiles and other surfaces;

(b) applying wall coverings;

(c) painting or the application of similar coatings;

(d) cleaning carpets;

(e) applying floor finishing and stripping products;

(f) applying pest control products; and

(g) applying caulking, sealing, or glazing compounds;

"unacceptable" means-

(a) the value of one or more physical parameters is not within the acceptable range listed in **Table 1 (Acceptable range for specific physical parameters)**;

(b) the concentration of one or more air contaminants have exceeded the maximum limits as specified in **Table 2 (List of indoor air contaminants and the maximum limits)**;

(c) the safe work procedure for prescribed activities is not established and implemented;

(d) there are medical findings at a point of time from employees or occupants related to the indoor air quality; or

(e) any other situations related to indoor air quality deemed relevant by the indoor air quality assessor;

"ventilation" means the process of supplying air or removing air from a space for the purpose of controlling air contaminant levels, humidity, or temperature within the space.

1.0 INTRODUCTION

1.1 Purpose

The purpose of this industry code of practice is to provide guidance on improving the indoor air quality (IAQ) and to set minimum standard for selected parameters that will avoid discomfort and/or adverse health effect among employees and other occupants of an indoor or enclosed environment served by a mechanical ventilating and air conditioning (MVAC) system including air-cooled split unit. It is one of the general duties as prescribed under the Occupational Safety and Health Act 1994 [*Act 514*] for the employer and an occupier (including building owner and building management) to provide a safe workplace to their employees or other person than his employees (occupant).

1.2 Scope and application

1.2.1 This industry code of practice-

(a) establishes a set of acceptable exposure limits for chemical and biological contaminants;

(b) establishes a set of acceptable values for specific physical parameters;

(c) describes a mechanism to identify, evaluate and control these indoor air contaminants; and

(d) specifies other appropriate occupational safety and health measures.

1.2.2 This industry code of practice applies to all buildings or any part of the building or totally enclosed areas served by a mechanical ventilating and air conditioning (MVAC) system including air-cooled split unit, where there are persons at work, except-

(a) domestic buildings;

(b) any area or any part of the building which is constructed, used or intended to be used for domestic or industrial purposes;

(c) any area or part of building where any chemicals hazardous to health are used for analytical, research or preservation purposes; or

(d) removal and disposal of asbestos containing materials.

1.2.3 **Appendix 1** gives further information on issues of indoor air quality and the common adverse effects associated to its exposure.

2.0 COMPLAINTS AND INVESTIGATION OF AN INDOOR AIR QUALITY PROBLEM

2.1 Complaint Procedure

2.1.1 The building owner or building management shall establish a procedure to deal with complaint from employer and occupants related to signs and symptoms perceived to be due to indoor air quality.

2.1.2 Upon receiving a complaint, the building owner or building management shall ensure that an investigation is conducted to ascertain the cause of the complaint, and a report prepared, without delay.

2.2 Establishment of complaint procedure

The establishment of a complaint procedure shall include the following -

(a) procedures for receiving and dealing with complaints including -

(i) documentation of the occurrence of complaints including record of signs and symptoms of employees or occupants discomfort or affected by the indoor air quality;

(ii) alleged location of the source, and

(iii) date and time of the complaint.

(b) a description of the process or processes for response to a complaint;

(c) regular reviews of complaints by the occupant;

(d) identification of individuals responsible for administering the complaint process;

(e) procedures for communicating any remedial action to the complainant; and

(f) follow-up procedures to ensure that the remedial action recommended, if any, has been taken.

Sample of IAQ Complaint Form is given in **Appendix 2.**

2.3 Investigation of indoor air quality problem

It shall be the responsibility of the building owner or building management to investigate concerns about indoor air quality when-

(a) complaints are received;

(b) the occupancy in the space exceeds the recommended number of occupancy in the original design; or

(c) renovations are made that involve significant changes to the ventilation system e.g. a room without supply or return air.

2.4 Investigation process

Appendix 3 illustrates the steps to be taken in the investigation process. The IAQ complaints and investigation process involves the following-

2.4.1 Walkthrough inspection

2.4.1.1 A walkthrough inspection provides basic information on the factors which affect indoor air quality (e.g. number of occupants, MVAC system, pollution pathways and potential contaminant sources).

2.4.1.2 Walkthrough inspection may involve these activities-

(a) collecting available information about the history of the building and its ventilation system;

(b) collecting previous record of IAQ complaints;

(c) notifying the building occupants of the upcoming investigation;

(d) identifying key individuals for access to relevant information as well as relevant locations within the building; and

(e) identifying potential contaminants and their sources.

2.4.1.3 To facilitate the walkthrough inspection, a checklist is provided in **Appendix 3-A**. The person who conducts the inspection shall exercise professional judgement to modify the checklist according to different premises/building uses and previous experience as well as to develop tailor-made checklist for specific situations.

2.4.2 Initial findings

2.4.2.1 If there is an obvious solution for the complaints, the building owner or building management shall take immediate action to rectify the problem.

2.4.2.2 On the other hand if the causes of indoor air quality problem cannot be identified or resolved, an assessment by an indoor air quality assessor shall be conducted.

2.4.2.3 If the employee have significant symptoms of building related illnesses or sick building syndrome, the building owner or building management shall notify the employer of the condition and the employer shall sent the employee for medical examination to ascertain the medical condition.

2.4.3 Assessment of indoor air quality by indoor air quality assessor

2.4.3.1 The assessment conducted shall be carried out during normal business activity and must take into consideration the following-

(a) the sources of indoor air contaminants;

(b) an occupant's exposure to environmental tobacco smoke;

(c) an occupant's exposure to air contaminants, either from indoor or outdoor sources;

(d) the prescribed activities;

(e) the adequacy of mechanical ventilation at the place of work; and

(f) the necessary actions to be taken to improve the indoor air quality at the place of work.

2.4.3.2 The assessment referred to in sub paragraph 2.4.3.1 shall include the measurement of the specific physical parameters and indoor air contaminants as listed in **Table 1** and **Table 2**, symptom survey and walkthrough inspection as carried out under paragraph 2.4.1. Sample of symptoms survey questionnaire is provided in **Appendix 3-B**.

2.4.3.3 **Appendix 4** gives further guidance on measurement and analysis of indoor air quality parameters.

2.4.3.4 **Chapter 6.0** describes the procedure for registration as an indoor air quality assessor.

2.4.3.5 The indoor air quality assessor shall present and submit the assessment report to the building owner or building management within one month upon completion of the assessment.

Table 1: Acceptable range for specific physical parameters

Parameter	Acceptable range
(a) Air temperature	23 – 26 ^{o}C
(b) Relative humidity	40-70%
(c) Air movement	0.15 – 0.50 m/s

Table 2: List of indoor air contaminants and the acceptable limits

Indoor Air Contaminants	Acceptable limits		
	ppm	**mg/m³**	**cfu/m³**
Chemical contaminants			
(a) Carbon monoxide	10	-	-
(b) Formaldehyde	0.1	-	-
(c) Ozone	0.05	-	-
(d) Respirable particulates	-	0.15	-
(e) Total volatile organic compounds (TVOC)	3	-	-
Biological contaminants			
(a) Total bacterial counts	-	-	500*
(b) Total fungal counts	-	-	1000*
Ventilation performance indicator			
(a) Carbon dioxide	C1000	-	-

Notes*:*

- *For chemical contaminants, the limits are eight-hour time-weighted average airborne concentrations.*
- *mg/m³ is milligrams per cubic meter of air at 25° Celsius and one atmosphere pressure.*
- *ppm is parts of vapour or gas per million parts of contaminated air by volume.*
- *cfu/m³ is colony forming units per cubic meter.*
- *C is the ceiling limit that* shall *not be exceeded at any time. Readings above 1000ppm are indication of inadequate ventilation.*
- ** excess of bacterial counts does not necessarily imply health risk but serve as an indicator for further investigation.*

2.5 Assessment report

The assessment report prepared by an assessor shall include the following-

(a) description of assessment and sampling methods;

(b) identification of potential sources of indoor air problems;

(c) the measurement results for the contaminants as listed in **Table 2** and specific physical parameters listed in **Table 1**;

(d) the condition of the ventilation system, including the number of air changes per hour and the rate of fresh air changes;

(e) health complaints as well as signs and symptoms perceived to be related to indoor air quality problem;

(f) conclusion of the assessment; and

(g) recommendations to improve the indoor air quality.

3.0 CONTROL OF INDOOR AIR QUALITY

3.1 Duty to control exposure

3.1.1 The building owner or building management shall maintain the working environment conforming to the acceptable range as specified in **Table 1**.

3.1.2 Where the assessment report indicates that the indoor air quality is unacceptable, building owner or building management shall initiate to implement any of the following measures within one month after receiving the report -

(a) elimination or relocation of the source of the air contaminants, and the appropriate location of the air supply or exhaust openings of the mechanical ventilation system;

(b) control of exposure to environmental tobacco;

(c) preventing microbial growth by-

(i) implement control of water leaks;

(ii) ensuring building material are not damp or wet, or

(iii) other appropriate action;

(d) ensure cleaning or the removal of microbial contamination to minimize the release of airborne hazardous substances into the ventilation system or general work space;

(e) repair or replace the material where microbial growth has taken place on a material;

(f) substitution of the building material or chemicals with those that have a lower emission rate or emitting a less hazardous contaminant;

(g) sealing the source or blocking the contaminant pathway;

(h) improving ventilation;

(i) installation of air purification devices except devices producing or emitting ozone;

(j) administrative controls including work scheduling, limiting the period an individual can spend operating equipment that may produce contaminants, relocating more susceptible individuals from the area where they experience symptoms, provision of information, instruction and training; establishment of healthy work practices, procedure or policies; or

(k) a combination of the above measures.

3.1.3 For any air conditioning system including air-cooled split unit, the building owner or building management or employer shall ensure the provision for adequate fresh air ventilation such as the use of Demand Control Ventilation (DCV), extractor or other suitable means.

3.2 Microbial contamination

3.2.1 The building owner or building management shall regularly inspect ductwork, dehumidifiers, internal building surfaces, cooling coils, filters and any other MVAC system components at least every 6 month where it is reasonably likely that standing water will unintentionally accumulate and which could reasonably cause microbial growth.

3.2.2 Where the inspection required in 3.2.1 uncovers an unintentional accumulation of water in ductwork, dehumidifiers, internal building surfaces, cooling coils, filters or any MVAC system components which could reasonably cause microbial growth, the building owner or building management shall -

(a) promptly remove the water; and

(b) make necessary repairs to prevent further accumulation.

3.3 Inspection and maintenance of MVAC

3.3.1 The schedule of maintenance for the MVAC system shall 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 3.3.2 – 3.3.6 shall constitute the minimum requirements.

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

3.3.3 The MVAC system and the air handling unit room shall 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 shall be cleaned at least every six months, depending on the condition of the incoming air and use of the system. Filters shall be cleaned or replaced so that they are performing properly at all times and do not become clogged.

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

3.3.5 Building owner or building management is recommended to use non-chemical water treatment for the cooling tower. However, if biocides are used, the dosing shall be carried out as per manufacturer recommendation on cooling tower.

3.3.6 The MVAC system shall 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 shall also be checked and adjusted after any renovations or changes in floor layout that might affect air distribution.

3.3.7 Records shall be kept of all maintenance work - when and what was done.

3.4 Control for prescribed activities

The building owner or building management or employer shall ensure that adequate work procedures and control are used during prescribed activities which may includes but not limited to-

(a) the use of approved personal protective equipment;

(b) sealing of the area where prescribed activities is carried out;

(c) displaying signage to warn about hazard associated with prescribed activities;

(d) safe work procedures;

(e) using portable exhaust system; or

(f) administrative control measures such as carry out prescribed activities not during working hours.

3.5 Prevention and control for renovation work

3.5.1 Where renovation work is carry out, the building owner or building management shall not use materials containing toxic substances which could pose a hazard to health when used in the occupied building. Fittings, fixtures, furnishings and furniture shall be manufactured, selected, handled, stored and used so that emission to the room air is the least possible. It is highly recommended to use low volatile organic compound emission materials.

3.5.2 For occupied buildings undergoing partial renovation, spaces to be renovated shall be effectively isolated from the occupied zones. If necessary, supply air shall 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 shall be within the limits specified in **Table 2**.

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

3.6 Pest control

3.6.1 The need to use pesticides in non-commercial buildings shall be minimised, as far as practicable, by caulking and plastering cracks and crevices, improving sanitation and waste management, and physical measures to keep pests at bay.

3.6.2 Pesticide spraying shall be carried out by licensed pest control operator as stipulated under the Pesticides (Pest Control Operator) Rules 2004.

3.6.3 The spraying of pesticides shall be carried out outside normal working hours, and preferably during the weekends.

3.6.4 Occupants in areas to be sprayed shall be notified in advance to avoid any unnecessary exposure. Pesticides shall be applied in targeted locations, with minimum treatment of exposed surfaces. If hydrogen cyanide is used for pest control, the building owner or management shall comply with the requirement of the Hydrogen Cyanide (Fumigation) Act 1953 (Revised-1981) [Act 260].

3.6.5 General periodic spraying shall be kept to a minimum and may not be necessary.

3.6.6 The building management or other person who organises the pest control activities shall have information on the chemical identities and the potential health hazards of all pesticide products used. This information is usually available from suppliers of pesticides in the form of Safety Data Sheets (SDSs).

3.7 Housekeeping and cleaning

3.7.1 Housekeeping is important in preventing indoor air quality problems as it keeps dust levels down and removes dirt which could otherwise become sources of contamination.

3.7.2 The cleaning schedule shall be arranged with reference to occupancy patterns and activity levels. Daily cleaning of surfaces and steam vacuuming of floors is advisable for areas with high traffic or which are in constant use during the day. These include most office areas and public places.

3.7.3 When chemical based cleaning agents are used, SDSs on the cleaning agents shall be available to the building manager and other occupants.

3.8 Environmental Tobacco Smoke (ETS)

3.8.1 Tobacco smoking is prohibited in many public area as stipulated under Control of Tobacco Product Regulations 2004 [P.U.(A)324/2004] as amended from time to time.

3.8.2 In all indoor areas which are not covered by the Tobacco Product Regulations 2004, smoking shall also be prohibited in order to achieve good indoor air quality standard.

4.0 INFORMATION, INSTRUCTION AND TRAINING

4.1 Information

An employer shall ensure that all his employees are informed, on the –

(a) causes of poor indoor air quality and the adverse effects to health arising from it;

(b) complaints procedure;

(c) detrimental effects from environmental tobacco smoke and its contribution to the overall indoor air quality;

(d) modification or improvement to the poor ventilation system at the work station, if any; and

(e) findings of the assessment.

4.2 Instruction

Employees shall follow all instructions given by the employer with respect to maintaining good indoor air quality in particular, but not limited to the following –

(a) prohibition of smoking except at designated area(s);

(b) not to tamper with MVAC system;

(c) not to store material/chemical or equipment inside AHU room or ducting;

(d) ensure fresh air intake is not blocked at any time or contaminated with undesirable and hazardous elements; and

(e) to inform the employer of any discomfort related to indoor air quality.

4.3 Training

4.3.1 An employer shall ensure that all his employees are trained on the following –

(a) contents of this industry code of practice;

(b) identification of sign and symptoms associated with the illnesses commonly associated with poor indoor air quality; and

(c) identification of poor ventilation conditions and signs of deterioration in the air-conditioned or MVAC system.

4.3.2 The training programme shall be reviewed and conducted at least once in two years.

4.3.3 The training programme shall be documented and kept for inspection by occupational safety and health officer.

5.0 RECORDKEEPING

5.1 Keeping of records

5.1.1 All records that are generated under this industry code of practice shall be kept for a period of not less than five years except assessment report, which shall be kept for a period of not less than thirty years.

5.1.2 Whenever the building owner, building management or employer ceases to carry on business and no person succeeds him, they shall transmit the records required to be maintained to the Director General.

5.2.3 At the expiration of the retention period for the records required to be maintained the building owner, building management or employer shall give the Director General at least three months notice in writing that he intends to dispose of such records, and he shall transmit those records to the Director General, if requested to do so within that period.

5.2 Record to be kept

Under this industry code of practice, records to be kept include -

(a) complaint records;

(b) investigation reports;

(c) assessment reports including the results of indoor air contaminant measurement; and

(d) training records.

6.0 REGISTRATION AS AN INDOOR AIR QUALITY ASSESSOR

Indoor air quality assessor shall register with the Director General of Occupational Safety and Health.

6.1 Qualifications, experience and training

Those eligible for consideration for registration must possess the following qualifications, experience and training -

(a) a person with at least a Diploma in pure or applied sciences and has 1 year experience in occupational hygiene and has attended training in indoor air quality assessment conducted by recognised training providers and passed the examination conducted by NIOSH; or

(b) a registered assessor under the USECHH Regulations 2000 who has attended training in indoor air quality assessment conducted by recognised training providers and passed the examination conducted by NIOSH; or

(c) a registered Hygiene Technician I under the USECHH Regulations 2000 who has attended training in indoor air quality assessment conducted by recognised training providers and passed the examination conducted by NIOSH; or

(d) any other person with equivalent IAQ competency as recognised by the relevant authority.

6.2 Registration procedure

6.2.1 An applicant must apply in writing to be registered with the Director General and he must forward together the following items -

(a) a certified true copy of academic or professional qualifications;

(b) a certified true copy of the National Registration Identity Card (for Malaysian citizen) or Passport (for foreign resident);

(c) a certified true copy of work permit issued by the Malaysian Government (only for foreign resident);

(d) details of working experience in occupational safety and health including the name of supervisor(s) & his qualifications;

(e) a certified true copy of the certificate of attendance of relevant courses; and

(f) a certified true copy of the results of relevant course examination.

6.2.2 The completed application shall be forwarded to: -

The Director General
Department of Occupational Safety and Health,
Ministry of Human Resources,
Aras 2, 3, & 4, Blok D3, Kompleks D,
Pusat Pentadbiran Kerajaan Persekutuan,
62530,Wilayah Persekutuan, Putrajaya.

6.2.3 Every application will be checked to ensure all documents submitted are complete and meet requirements set by the Director General. The prospective applicant may be asked to attend an interview or present the finding of an assessment he had conducted, if necessary.

6.3 Registration validity

6.3.1 Successful applicants will be registered for a maximum period of three (3) years. The Director General may, however, prescribe a shorter duration. Notwithstanding, the Director General may revoke the registration of any person before its expiration date if -

(a) his registration was obtained by fraud or misrepresentation; or

(b) he has failed to discharge his duties as an indoor air quality assessor; or

(c) he has been convicted of an offence under the Act or any regulations made there under.

6.4 Renewal of registration

6.4.1 A person applying to renew registration with the Director General should-

(a) show proof that he had been engaged in work activities of an indoor air quality assessor every year; and

(b) have undergone continuing education in the field of occupational safety and health.

6.4.2 Application for renewal of registration must be made at least three (3) months before the expiration date of the current registration, writing to the Director General.

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APPENDIX 1

GENERAL INFORMATION ON INDOOR AIR QUALITY

A1.1 Background

Good indoor air quality (IAQ) is desired for a healthy indoor environment. Poor indoor air quality can cause a variety of health problems ranging from temporary to long term. Health problems commonly associated with poor IAQ include allergic reactions, respiratory problems, eye irritation, sinusitis, bronchitis and pneumonia.

IAQ problems arise in non-industrial buildings (an indoor or enclosed work space that is served by a ventilating and air conditioning system where there are person at work, but does not include premises that are used primarily as manufacturing and production facilities and vehicles) when there is an inadequate quantity of ventilation air being provided for the amount of air contaminants present in that space. Hence, IAQ and mechanical ventilating and air-conditioning systems (MVAC) are closely related.

Agents derived from or that are living organisms (e.g. viruses, bacteria, fungi, and mammal and bird antigen) that can inhaled and can cause many types of health effects including allergic reactions, respiratory disorders, hypersensitivity diseases, and infectious diseases.

Compounds that evaporate from the many housekeeping, maintenance, and building products made with organic chemicals. These compounds are released from products that are being used and that are in storage. In sufficient quantities, VOCs can cause eye, nose and throat irritations, headaches, dizziness, visual disorder, memory impairment; some are known to cause cancer in animals; some are known to cause cancer in humans.

A1.2 Sources of poor IAQ

IAQ problems can be due to indoor air contaminants or to inadequate pollution controls despite otherwise normal or baseline rates of ventilation. Sources of indoor air pollutions are from different origins –

(a) the occupants themselves (such as exhaled carbon dioxide gas);

(b) inadequate materials or materials with technical defects used in the construction of the building;

(c) the work performed within (such as cleaning of carpet);

(d) excessive or improper use of normal products (pesticides, disinfectants, products used for cleaning and polishing);

(e) combustion gases (such as from smoking); and

(f) cross-contamination coming from other poorly ventilated zones.

A1.3 Parameters to indicate IAQ status

The parameters to indicate whether an indoor environment is comfortable and healthy or otherwise can be summarised as follows-

(a) Chemical contaminants, such as carbon dioxide, carbon monoxide, formaldehyde and environmental tobacco smoke (ETS);

(b) Physical conditions, such air temperature, air velocity and humidity;

(c) Biological agents, such as mites, virus, and spores; and

(d) Radiation such as radon.

A1.4 Health effects due to poor IAQ

The health effects due to IAQ can be categorized as follows-

(a) health effects due to environmental tobacco smoke (ETS);

(b) Sick building syndrome (SBS);

(c) Building related illnesses (BRI); and

(d) Legionnaire's disease

A.1.4.1 Health effects of ETS

ETS is defined as substances in indoor air arising from tobacco smoke. The main source of ETS is cigarette smoking. ETS comprises smoke that is generated from the combustion of cigarette in between puff (main components) and also comprises smoke that is exhaled out by the smoker. ETS contains more than one thousand chemical substances and more than 20 toxic chemicals and carcinogens. Chemicals usually associated with ETS are nicotine, nitrosamines, polyaromatic hydrocarbons (PAHs), carbon monoxide, carbon dioxide, oxides of nitrogen, acrolein, formaldehyde and hydrogen cyanide.

The International Agency for Research on Cancer (IARC) had announced in 2002 that ETS is a human carcinogen and it increases the risk of coronary heart diseases.

A.1.4.2 Sick-Building Syndrome

"Sick building syndrome" is the name that has commonly been used for illnesses that occur among occupants as a result of poor indoor air quality in building.

Sick building syndrome describe situation in which building occupants experience acute health and/or comfort effects that appear to be linked to time spent in a particular building, but where no specific illness or cause can be identified. The complaints may be localized in a particular room or zone, or may be spread throughout the building.

Some of these buildings may be inadequately ventilated. For example, mechanical ventilation systems may not be designed or operated to provide adequate amounts of outdoor intake air. People generally have less control over the indoor environment in their offices than they do in their home. As a result, there has been an increase in the incidence of reported health problems.

Sometimes building occupants experience symptoms that do not fit the pattern of any particular illness and are difficult to trace to any specific source. This phenomenon has been labelled as *sick building syndrome*. Symptoms that have arisen among occupants of "sick building" have varied from eye and nose irritation, fatigue, cough, rhinitis, nausea, headache, sore throat or a combination of these.

A.1.4.3 Building Related Illnesses

A number of well-identified illnesses, such as Legionnaires' disease, asthma, hypersensitivity pneumonitis, and humidifier fever, have been directly traced to specific building problems. These are called building-related illnesses. Most of these diseases can be treated; nevertheless, some pose serious risks.

Legionnaires' disease is one of the building-related illnesses. It is a form of bacterial pneumonia that is characterized by fever, chills and dry cough associated with muscle aches and occasional diarrhea. Legionnaire' disease acquired its name when people attending an American Legion's convention in Philadelphia in July 1976 were affected by the disease. Pontiac fever on the other hand is a milder form characterized by fever and muscle aches with no symptoms of pneumonia.

The bacteria that cause Legionnaires' disease, *legionella pneumophila* will grow in any environmental reservoir in which its nutrient, water and temperature requirement are met, and enters the air when such sites are disturbed. The bacteria thrives in temperatures between 25 °C and 45 °C (77 and 113 °F), with an optimum around 35 °C (95 °F). Although this organism is ubiquitous in the environment, airborne concentrations only occasionally reach levels adequate to infect otherwise normal subjects.

Water-cooling towers and warm water systems in buildings have been identified as major sources of this organism. Without treatment of the water or without adequate maintenance of the system, *legionella* can proliferate and then be distributed throughout the building by the air-handling system.

APPENDIX 2

INDOOR AIR QUALITY COMPLAINT FORM

This form can be filled out by the building occupant or by a member of the building staff. This form should be used if your complaint may be related to indoor air quality. Indoor air quality problems include concerns with temperature control, ventilation, and air contaminants. Your observations can help to resolve the problem as quickly as possible.

Date: _____

Department/Location in building: _____

Name of complainant: _____Job Title: _____

Telephone no: _____ Email: _____

Please describe the nature of the complaint and any potential causes.

1. What is the nature of the problem?

2. Where is the problem experienced (in one or more locations)?

3. When was the problem first experienced?

4. When does it occur or when is it the worst (time of day, day of week, related to certain activities/ events)?

5. We may need to contact you to discuss your complaint. What is the best time to reach you?
   _____

So that we can respond promptly, please return this form to:

_____
(Assigned Person or Contact Person)

OFFICE USE ONLY

File Number: _____ Received By: _____ Date Received: _____

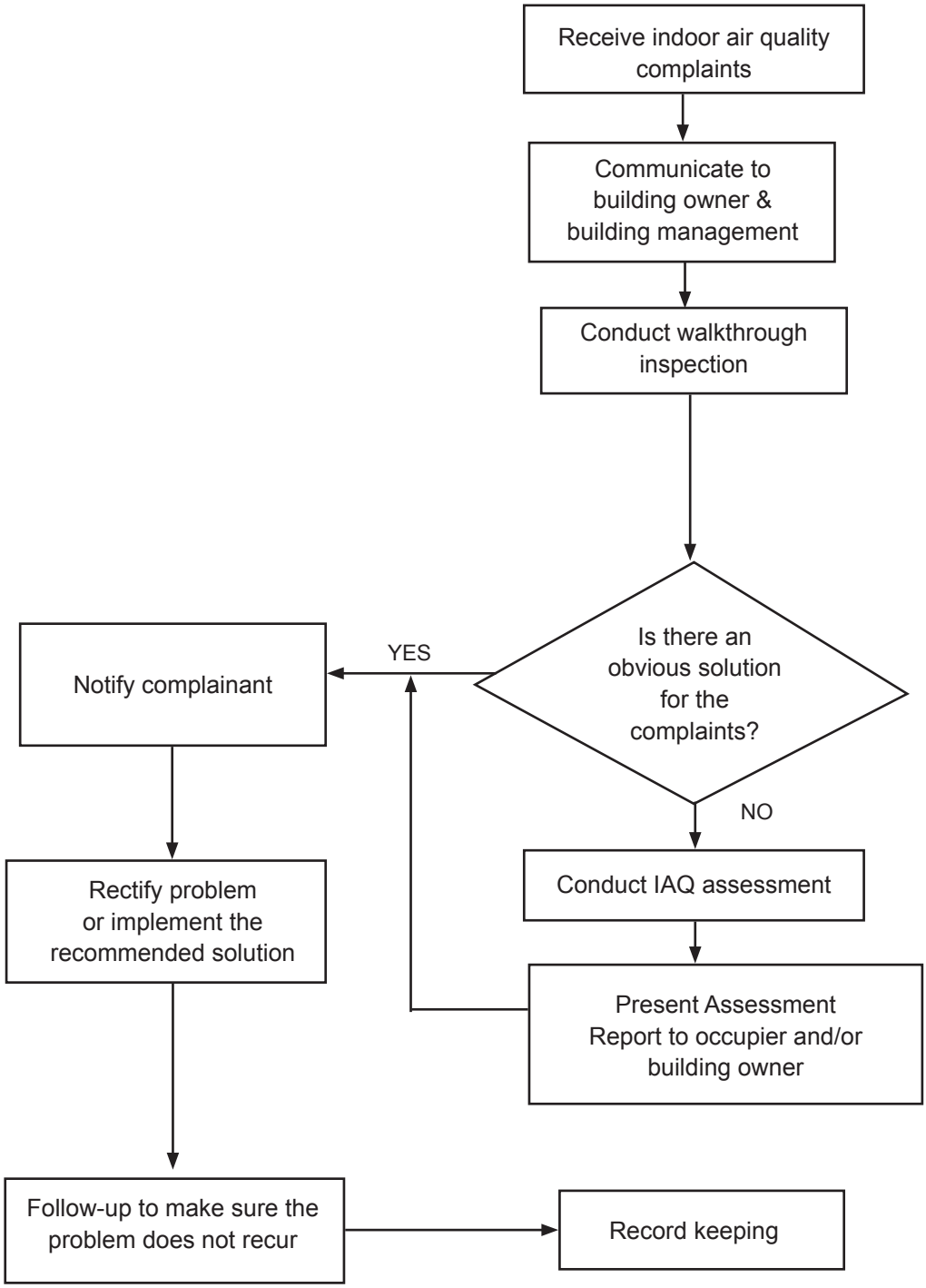
IAQ related: ☐ Yes: notify complainant and investigate
☐ No: notify complainant and keep record

Action taken: Investigation/Others (specify action taken/closed file)

_____

APPENDIX 3

IAQ COMPLAINTS AND INVESTIGATION PROCESS



APPENDIX 3-A

CHECKLIST FOR WALKTHROUGH INSPECTION

Date of inspection : _____ Time: _____

Location: _____

Name of inspector: _____

1.0 **General**	YES	NO	REMARK
Check whether there is any -			
1.1 Odour	☐	☐	_____
1.2 Dirty or unsanitary conditions (e.g. excessive dust)	☐	☐	_____
1.3 Visible fungal growth or mouldy odour (often associated with problem of excessive moisture)	☐	☐	_____
1.4 Staining or discolouration of building materials	☐	☐	_____
1.5 Unsanitary conditions in equipment such as drain pans and cooling towers	☐	☐	_____
1.6 Inadequate ventilation (e.g stuffy, stale air)	☐	☐	_____
1.7 Blocked vents	☐	☐	_____
1.8 Uneven temperature	☐	☐	_____
1.9 Overcrowding	☐	☐	_____
1.10 Poorly-maintained filters	☐	☐	_____
1.11 Air cleaners e.g. ionisers etc specify type:			
1.12 Presence of hazardous substances	☐	☐	_____
1.13 Unsanitary mechanical room, or trash or stored chemicals in mechanical room	☐	☐	_____

2.0	**Human exposure and comfort levels**	**YES**	**NO**	**REMARK**
2.1	How many occupants are there in the work area?	_____		
2.2	How long are the occupants in the work area?	_____		
2.3	Is the indoor temperature regulated by thermostats? If yes	☐	☐	
	2.3.1 Where are they located?	_____		
	2.3.2 Have they been correctly positioned following building alterations?	☐	☐	_____
	2.3.3 Are they set to the correct temperature?	☐	☐	_____
2.4	Is there discomfort from heat radiation from visual display units?	☐	☐	_____
2.5	Is there discomfort due to radiant heat from warm window surfaces?	☐	☐	_____
2.6	Are temperature, relative humidity and air flow rates checked regularly during working hours?	☐	☐	_____
2.7	Does air reach all parts of the office or there are no dead spaces?	☐	☐	_____
2.8	Is the building still being used for the purpose it was intended?	☐	☐	_____
2.9	Have partitions/walls been added or removed?	☐	☐	_____
2.10	Have occupancy levels changed?	☐	☐	_____

3.0 **Potential sources of contaminants**	YES	NO	REMARK
3.1 Are there any occupants smoking? If Yes, indicate where and If No, indicate the designated areas for smoking?	☐	☐	_____
3.2 Are there furniture, furnishings, carpets, etc. that emit noticeable odours?	☐	☐	_____
3.3 Have detergents, pesticides or other chemicals been used in the building?	☐	☐	_____
3.4 Has there been any recent renovation or maintenance in any part of the building-			
3.4.1 Done during working hours	☐	☐	_____
3.4.2 That can be a source of contaminants, such as painting, carpet installation, air conditioning repairs, use of acid drain cleaners, carpet cleaning, disinfecting of HVAC system, pesticide application	☐	☐	_____
3.4.3 That can alter air flow patterns such as installation of partitions or relocation of air intake or exhaust?	☐	☐	_____
3.5 Is there a kitchen or pantry where cooking is done?	☐	☐	_____
If Yes, is exhaust ventilation provided there?	☐	☐	_____
3.6 Is the building adequately cleaned?	☐	☐	_____
3.7 Is regular dusting of office furniture, ledges, shelves, etc. carried out to help keep dust to a minimum?	☐	☐	_____

	YES	NO	REMARK
3.8 Are the carpets vacuum-cleaned regularly?	☐	☐	_____
3.9 Are there any office equipment giving off gases or fumes such as copying machines, blueprint machines and other office machines?	☐	☐	_____
4.0 <u>Ventilation and air-conditioning</u>			
4.1 Is there at least one supply air and extract air vents in every room or area?	☐	☐	_____
If Yes, how many supply air and extract air vents are there in each room or area?	_____		
4.2 Are supply air or extract air vents blocked in any way by partitions, files or other structures that obstruct air flow?	☐	☐	_____
4.3 Has dust collected around the air vents?	☐	☐	_____
4.4 Is the air-conditioning system turned off-			
4.4.1 Any time during the day?	☐	☐	_____
4.4.2 After office hours?	☐	☐	_____
4.4.3 Are there still occupants in the building after office hours?	☐	☐	_____
4.5 Where is the outdoor air intake duct located?			
4.5.1 Near the cooling tower in this building	☐	☐	_____
4.5.2 Near adjacent buildings?	☐	☐	_____
4.5.3 At street level	☐	☐	_____

	4.5.4 Near a car park	☐	☐	_____
	4.5.5 Is it obstructed?	☐	☐	_____
	4.5.6 Others, please specify:	_____		
4.6	Are heavy industries located nearby?	☐	☐	_____
4.7	Are there any construction work going on nearby?	☐	☐	_____
4.8	Is outdoor air actually getting into the building?	☐	☐	_____
4.9	Is there a regular schedule for cleaning and maintenance of the air-conditioning system in the building?	☐	☐	_____
4.10	Are all the components of the air-conditioning system regularly inspected for leaks, breaches etc.?	☐	☐	_____

APPENDIX 3-B

QUESTIONAIRE FOR BUILDING OCCUPANTS

This short questionnaire has been given to you to facilitate the identification of potential sources of indoor air quality (IAQ) pollutants and to identify adverse health effects that may be associated with exposure to these pollutants. Your answers will remain confidential. Please complete the form as accurately as possible before returning to us.

Date :_____

General information

1. Building/Company name : _____
2. Department/Division : _____
3. Has your Company carried out any assessment related to IAQ?

☐ Yes ☐ No ☐ In progress ☐ Not sure

Background factor

4. Sex: ☐ Male ☐ Female

5. Age: ☐ < 25 yrs ☐ 25-39 yrs ☐ 40-55 yrs ☐ > 55 yrs

6. Do you smoke? ☐ Yes ☐ No ☐ Sometimes

Nature of Occupation

7. Occupation/Position : _____
8. How long you have been at your present place of work? _____ yr(s) _____ mth(s)
9. No. of hours spent per day at your main workstation : _____hr(s)
10. Brief description of your work:

_____

_____

Environmental Conditions

11. Type of workstation : ☐ Enclosed room ☐ Open concept
12. No. of people sharing your workstation: _____
13. How is your area air-conditioned? ☐ Central unit ☐ Local unit (split unit)

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

	Everyday	2-3 times weekly	Never
a) Typewriter	☐	☐	☐
b) Video display unit/computer	☐	☐	☐
c) Photocopier	☐	☐	☐
d) Fax machine	☐	☐	☐

15. Have you been bothered during the last three (3) months by any of the following factors at your workstation/workplace?

	Yes, often (every week)	Yes, sometimes	No, never
a) Draught	☐	☐	☐
b) Room temperature too high	☐	☐	☐
c) Varying room temperature	☐	☐	☐
d) Room temperature too low	☐	☐	☐
e) Stuffy "bad" air	☐	☐	☐
f) Dry air	☐	☐	☐
g) Unpleasant odour	☐	☐	☐
h) Passive smoking	☐	☐	☐
i) Dust and dirt	☐	☐	☐

Past/Present Diseases/Symptoms

	Yes	No
16. Have you ever had asthmatic problems?	☐	☐
If yes, during last year?	☐	☐
17. Have you ever suffered from sinusitis?	☐	☐
If yes, during last year?	☐	☐
19. Have you ever suffered from eczema?	☐	☐
If yes, during last year?	☐	☐

Present Symptoms

20. During the last three (3) months, have you had any of the following symptoms at work (Answer every question even if you have not had any symptoms)

	Yes, often (every week)	Yes, sometimes (2-3 times/week)	No, never	If yes, do you believe that is due to your work environment? Yes	No
a) Headache	☐	☐	☐	☐	☐
b) Feeling heavy-headed	☐	☐	☐	☐	☐
c) Fatigue/ lethargy	☐	☐	☐	☐	☐
d) Drowsiness	☐	☐	☐	☐	☐
e) Dizziness	☐	☐	☐	☐	☐
f) Nausea/vomiting	☐	☐	☐	☐	☐
g) Cough	☐	☐	☐	☐	☐
h) Irritated, stuffy nose	☐	☐	☐	☐	☐
i) Hoarse, dry throat	☐	☐	☐	☐	☐
j) Skin rash/ itchiness	☐	☐	☐	☐	☐
k) Irritation of the eyes	☐	☐	☐	☐	☐
l) Scaling/itching scalp or ears	☐	☐	☐	☐	☐

21. No. of days in the past one (1) month that you had to take off work because of these complaints:
_____ day(s)

22. When do these complaints occur?
☐ Mornings
☐ Afternoons
☐ No noticeable trend

23. When do you experience relief from these complaints?
☐ After I leave my workstation
☐ After I leave the building
☐ No noticeable trend

24. If female, are you currently pregnant?
☐ Yes
☐ No
☐ Not sure

APPENDIX 4

MEASUREMENT AND ANALYSIS OF IAQ PARAMETERS

A4.1 Objective

Objectives of conducting assessment of indoor air quality are -

(a) to identify the sources of the indoor air contaminants either within the place of work or from the outside air;

(b) to evaluate the exposure of the occupants to the indoor air contaminants either from indoor or outdoor sources;

(c) to determine the air temperature, relative humidity and air movement at the place of work;

(d) to determine the adequacy of mechanical ventilation at the place of work;

(e) to conclude on the compliance to the recommended standard on indoor air quality; and

(f) to recommend necessary actions to be taken to improve the indoor air quality at the place of work.

A4.2 Sampling strategy

A4.2.1 Number of Sampling Points

For IAQ assessment, the minimum required numbers of sampling points are given in **Table A4-1**.

Table A4-1: Recommended minimum number of sampling points for indoor air quality assessment

Total floor area (served by MVAC system) (m^2)	Minimum number of sampling points
< 3,000	1 per 500m^2
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	1 per 1,200m^2

However, depending on the type and nature of the buildings, additional samples should be taken if it is considered necessary.

As outdoor air measurement data may provide some hints on whether outdoor pollutants contribute to poor IAQ, all the IAQ parameters (except air movement) should, in parallel, be monitored outdoors in close proximity to the fresh air intakes of the study areas. At least one sample should be taken. Where accessible, samplers / monitor inlets should be located approximately 1 metre off the edge of the fresh air intake and enclosed in an appropriate shelter to shield from direct sunlight and moisture. Other representative locations should be considered if the fresh air intake is not accessible.

A4.2.2 Sample position

During field data collection, monitors should be positioned at the selected sampling location using the following general guidelines -

(a) representing the primary workstation layout and work activities;

(b) the position should be of minimal disturbance of work activities within the study area;

(c) at least 0.5 m from corners or windows, walls, partitions, and other vertical surfaces (e.g. file cabinets);

(d) not directly in front of air supply diffusers, induction units, floor fans, or heaters, or the exhaled breath of the operator, etc;

(e) not under direct sunlight that will impact instrumentation;

(f) preferably not in hallways or passageways;

(g) at least 1 metre from localised sources such as photocopiers, printers, etc;

(h) not within 3 m of an elevator if sampled at a corridor / lobby;

(i) not within 2 m of doors;

(j) not obstructive to, or interfering with, occupant egresses from the study area under normal or emergency situations;

(k) not at the junction connected to stations of the public transport facilities;

(l) placing inlets of samplers at a height between 75 and 120 cm, preferably 110 cm from the floor.

A4.2.3 Sampling period

Measurement of IAQ parameters should be made on an 8-hour basis except otherwise specified. Where it is not practical to take 8-hour continuous measurement, surrogate measurement (i.e. an intermittent measurement strategy based on the average of half- hour measurements conducted at four time-slots) is also accepted. The operation pattern of the buildings should be taken into account when choosing the four time-slots.

As a guideline, the four time-slots should be evenly distributed over the business hours for office buildings whereas for public places they should cover the worst case scenario such as periods of highest occupancy. If real-time monitor is used, at least one reading should be taken every 5 minutes at each sampling point either with a data logging device or by properly recorded in a field data log sheet, regardless of whether the 8-hour continuous or surrogate measurement strategy is adopted.

All measurements should be conducted using calibrated instrument/equipment and the calibration should be conducted according to manufacturer's specifications where available.

A4.2.4 Sampling techniques

There are basically two types of assessment methods, namely real-time measurements and integrated sampling with subsequent laboratory analysis.

Real-time monitors can be used for detection of contaminant sources and provide information on the variation of contaminant levels throughout the day. Integrated samples, normally obtained during the 8 working-hours for offices, can provide information on the total exposure level of a particular contaminant.

Regardless of the choice of the method, it is very important to ensure proper operating of the equipment and handling of the samples, as well as stringent quality assurance procedures including equipment calibrations in accordance with the manufacturer's recommendations, duplicate samples, field and shipment sample blanks. A checklist should be formulated for the instrument operator in the field so that any abnormal readings could be detected instantly.

For active and passive sampling analysis, the accuracy of the methods shall be better than ±10% unless there is evidence to demonstrate that this is not technically possible. For real time monitors, the accuracy shall be better than ±10%. To conduct a valid sampling programme, all equipments or methods adopted should have appropriate detection range and limit of detection to cover the assessment objectives.

A3.0 Physical parameters

A3.1 Air temperature, relative humidity, and air movement

Air temperature, relative humidity and air movement can be measured by several methods ranging from a simple thermometer for temperature and a wet and dry bulb thermometer for humidity to sophisticated electronic instruments. Psychrometers, which measures relative humidity using temperature difference between two temperature sensors, can either employ an electric fan (powered psychrometer) or by simple manual whirling (sling psychrometer) to produce the airstream.

For air movements, the IAQ assessor should set up the monitor at the shoulder level of a seated person or measured at the supply air at the height of the seated person.

A4.4 Chemical contaminants

A4.4.1 Carbon dioxide and carbon monoxide

The level of carbon dioxide and carbon monoxide should be measured by a real-time monitor, such as a non-dispersive infrared (NDIR) analysers or electrochemical oxidation device.

A4.4.2 Formaldehyde

The level of formaldehyde should be determined by sampling and analytical methods as below -

(a) active sampling and analysis by MS ISO 16000-3:2008, MS ISO 16000-4:2008, NIOSH Method 3500, 2541, 2016, or other equivalent methods; or

(b) passive sampling and analysis by HPLC based on the analytical method: desorption of hydrazone and analysis via HPLC; and

(c) real-time measurement of formaldehyde can also be used.

However, assessor should be cautious when using a real-time instrument as the readings could be interfered by the presence of phenol.

A4.4.3 Ozone

The level of ozone should be measured by real-time instruments, such as but not limited to heated metal oxide semiconductors, electrochemical, UV photometric or chemiluminescence detectors.

A4.4.4 Respirable particulates

Respirable particulate are defined as suspended airborne particles with an aerodynamic diameter of 10 µm or less. The level of respirable suspended particulates should be determined by the following methods -

(a) a gravimetric analysis method based on the NIOSH Method 0600 or other equivalent methods; or

(b) a real-time monitoring method with analyzers, such as optical scattering or piezoelectric monitors.

A4.4.5 Total volatile organic compounds (TVOCs)

For continuous 8-hour sampling, the analytical method with whole air sampling by passivated canisters or solid sorbents and followed by direct flame ionisation detection based on:

(a) the NIOSH Method 2549;

(b) USEPA Compendium of Method TO-12;

(c) MS ISO 16017-1:2008;

(d) MS ISO 16017-2:2008;or

(e) MS ISO 16000-6:2008.

For real-time monitoring, monitors such as a photo-ionisation detector (PID) or a flame ionisation detector (FID) could be used. However, assessor should be cautious when using a real-time PID instrument as the readings could be interfered by the presence of other non-VOC compounds such as anaesthetic or disinfecting gases. For calibration of the real-time monitors, isobutylene (2-methylpropene) should be used as the reference calibration gas.

Note:
For chemical contaminants analysis shall be conducted by accredited laboratory. Please refer to Department of Standards Malaysia website (http://www.standardsmalaysia.gov.my).

A4.5 Biological contaminant

When there is a visual evidence of mould growth, it is not necessary to perform the biological sampling. Spore count is appropriate if further investigation is needed.

The level of bioaerosol should be quantified using samplers such as 2-stage cascade, impactor, impinger or equivalent based on NIOSH method

0800, Reuter Centrifugal Sampler (RCS), Surface Air System (SAS) bioaerosol sampler and reference should be made to the "Field Guide for the Determination of Biological Contaminants in Environmental Samples" published by the American Industrial Hygiene Association (AIHA) in 1996.

A4.6 Sample management

After sampling, the chemical samples as collected in sampling tubes / filters / bags / canisters, etc. should be treated, stored and analysed as specified in analytical methods or otherwise, within a maximum period of 5 days.

To ensure sample integrity, appropriate precautions against damage, deterioration and contamination of samples during transportation, storage and handling should be taken.

For bacterial and fungal samples, they should be delivered to the accredited microbiology laboratory* within 24 and 48 hours respectively for analysis.

Note :

* Refer to Department of Standards Malaysia website (http://www.standardsmalaysia.gov.my)