Health & Safety Department

(Environmental Health Section)

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1. Introduction

Clean air is a basic requirement of life, the indoor air quality of air-conditioned built environment is a subject of public health importance.

The quality of air inside homes, offices, schools, day care centers, public buildings, health care facilities or other private and public buildings where people spend a large part of their life is an essential determinant of healthy life and people's well-being, because when not in the home urban populations spend most of the time indoors working in commercial buildings, enjoy leisure time in hotels, shopping malls or indoor entertainments and sports, or maybe using services in hospitals and transportation centers among other types of facilities.

The Emirates of Dubai are characterized by an orbital desert climate (Hot and humid in summer and warm with raining in winter), highly built environment, and energy conservation requirements pose special constraints and challenges to the building industry in ensuring that indoor air quality remains acceptable. Indoor exposure to air pollutants Hazardous substances emitted from buildings, construction materials and indoor equipment or due to human activities indoors, such as combustion of fuels for cooking or heating and tobacco smoke, lead to a broad range of health problems and may even be fatal. Causes very significant damage to health globally, the chemicals and other pollutants reviewed in this Guideline are common indoor air pollutants in all regions of the world, and This guidance presented here is based on what is known and generally accepted at this time in the relevant fields of building science and indoor air quality.

Controlling the quality of the indoor air can have enormous social benefits in terms of comfort and health of the population, therefore enhancing productivity and minimizing absenteeism in commercial premises, and improving the well-Being in existing Building and Built environment, as an aim of this document, to provide a general guidance to have good quality of indoor air.

2. Ultimate objective

Dubai Municipality as part of its mandate is striving to attain the highest level of health and safety condition with the public establishment to achieve its goal to protecting and promoting public health through indoor exposure and contaminations control preventive measure,

The primary aim of these guidelines is to provide a uniform basis for the protection of public health from adverse effects of indoor exposure to air pollution, and to eliminate or reduce to a minimum exposure to those pollutants that known or are likely to be hazardous.

These guidelines intended to minimized and control the indoor exposure and air contamination inside buildings and the built environments.

This guideline issued by Dubai Municipality to serve as a tool to enable concerned establishment to comply with relevant local regulation.

3. Purpose

The purpose of the Guideline is to provide guidance for healthy indoor air quality and to improve the performance of buildings and built environments.

4. Scope

These guidelines are applicable to the indoor environments of all kinds of Public facilities, installations and buildings, which occupied by persons, including regular users, clients, office employee, etc. (for example and not limited to Hotels, Residential building, office premises, shopping mall, Education premises, ..etc.), except those that are exclusively dedicated to industrial and medical sectors (for example Hospitals and (specific place), Factories (work place),...etc.) and/or agriculture activities,.. etc.).

5. Definitions and terms

Definition	Meaning
Acceptable indoor air quality	air in which there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction.
Air-cleaning system	a device or combination of devices applied to reduce the concentration of airborne contaminants such as microorganisms, dusts, fumes, respirable particles, other particulate matter, gases, vapors, or any combination thereof.
Exposure	Contact made between a chemical, physical, or biological agent and the outer boundary of an organism. Exposure quantified as the amount of an agent available at the exchange boundaries of the organism (e.g., skin, lungs, and gut).
Air conditioning	the process of treating air to meet the requirements of a conditioned space by controlling its temperature, humidity, cleanliness, and distribution
Air ambient	the air surrounding a building; the source of outdoor air brought into a building.
Air exhaust	air removed from a space and discharged to outside the building by means of mechanical or natural ventilation systems.
Air, indoor	the air in an enclosed occupiable space, and exfiltration.
Air, outdoor	ambient air and ambient air that enters a building through a ventilation system, through intentional openings for natural ventilation, or by infiltration.
Air, recirculated	air removed from a space and reused as supply air.
Air, ventilation	that portion of supply air that is outdoor air plus any recirculated air that has been treated for maintaining acceptable indoor air quality.
Ventilation	the process of supplying air to or removing air from a space for controlling air contaminant levels, humidity, or temperature within the space.

Definition	Meaning
Mechanical ventilation	ventilation provided by mechanically powered equipment such as motor-driven fans and blowers but not by devices such as wind-driven turbine ventilators and mechanically operated windows.
Natural ventilation	ventilation provided by thermal, wind, or diffusion effects through doors, windows, or other intentional openings in the building.
Breathing zone	the region within an occupied space between planes 3 and 72 in. (75 and 1800 mm) above the floor and more than 2 ft. (600 mm) from the walls or fixed air-conditioning equipment.
Conditioned space	that part of a building that heated or cooled, or both, for the comfort of occupants.
Contaminant	an unwanted airborne constituent with the potential to reduce acceptability of the air.
Microorganism	a microscopic organism, especially a bacterium, fungus, or protozoan.
infiltration	uncontrolled inward air leakage to conditioned spaces through unintentional openings in ceilings, floors, and walls from unconditioned spaces or the outdoors caused by the same pressure differences that induce exfiltration.
Odor	a quality of gases, liquids, or particles that stimulates the olfactory organ.
IAQ profile	a description of the features of the building structure, function, and occupancy that affect indoor air quality.
H.V.A.C.	Heating Ventilation and Air Conditioning system
S.B.S.	sick building syndrome
B.R.I	Building-related illness
MERV	Minimum Efficiency Reporting Values

6. What is Good Indoor Air Quality (IAQ)?

This Guide intended to help building owners and operators move beyond current practice to provide "good IAQ." Good IAQ is achieved by providing air in occupied spaces in which there are no known or expected contaminants at concentrations likely to be harmful and no conditions that are likely to be associated with occupant health or comfort complaints and air with which virtually no occupants express dissatisfaction. It includes consideration of both indoor air pollution levels and thermal environmental parameters. However, however, current practice does not always achieve compliance with minimum standards or with good practice, and many building owners and practitioners desire to achieve better-than-acceptable IAQ. These are the primary motivations for the development of this Guide.

7. Importance of the design, construction, and commissioning process

While there is ample information and experience on achieving good IAQ in commercial, institutional buildings, and Built environment, it does not happen automatically.

It takes a level of awareness and commitment that is not typical of most projects and buildings, including an effort to make IAQ part of the design at the very beginning of the project.

There are two primary reasons to include IAQ considerations in the earliest stages of project planning: **avoiding problems** that occur when IAQ is treated as an afterthought and allowing consideration of alternative design concepts that involve decisions made early in the design process. Incorporating IAQ at the very beginning of conceptual design gets a number of key issues before the design team, enabling them to make informed decisions that will affect the project through the construction and occupancy phases.

These issues and decisions are addressed in general details in this guideline which is should be considered to expectations for good IAQ in the building, outdoor contaminant sources in or near the site, the activities expected to occur in the building (and the contaminants that might be associated with these activities), the characteristics of the occupants (e.g., their age range and health status, as well as the possibility of short term visitors that may have very different expectations than occupants who will remain in the building for a long time), and the approaches used to heat, cool and ventilate the building.

If these considerations are not addressed until after the building layout is defined, the ventilation system type is selected, and the ventilation rate design calculations are complete, it will be difficult if

not impossible to accommodate the particular needs of the building, its owner, and its occupants. Many design decisions that can lead to poor IAQ are made in the early phases of design and are difficult to modify or correct later on.

Early design missteps can be avoided if IAQ is put on the table as a key design issue at the start. Examples are inadequate space for mechanical equipment, limiting access for inspection and maintenance, and selection of interior finishes that can lead to high levels of volatile organic compound (VOC) emissions or to moisture problems in the building envelope.

Making IAQ part of the initial discussion of design goals—on par with building function, image, and energy use—allows consideration of high-performance design concepts that can support good IAQ, energy efficiency, and other important design goals.

Examples include mechanical systems that separate outdoor air ventilation from space conditioning, the application of natural ventilation, high-efficiency air cleaning in conjunction with lowered ventilation rates, and the selection of low-emitting materials based on sound technical consideration of the options.

Making a commitment to good IAQ at the beginning of a project and maintaining that focus through design, construction, and Commissioning will result in a building that is more successful in meeting its design goals and achieving the desired level of performance throughout its life.

8. The IAQ problems in buildings

8-1 What are the IAQ problems in buildings?

The information in this guideline is based on the IAQ problems that have been occurring in commercial, residential and institutional buildings for several decades and the authors' experience in investigating, resolving, and avoiding these problems. The causes of these problems were used to develop of this Guide.

8-1-1 IAQ during Design and Construction

Many IAQ problems are the result of IAQ not being considered as a key issue at the very beginning of the design process. Basic design decisions related to site selection, building orientation, and location of outdoor air intakes and decisions on how the building will be heated, cooled, and ventilated are of critical importance to providing good IAQ.

Efforts to achieve high levels of building performance without diligent considerations of IAQ at the beginning of the design process often led to IAQ problems and represent missed opportunities to ensure good IAQ.

8-1-2 lack of commissioning

While a good design is critical to providing good IAQ, if the building systems are not properly installed or commissioned so that they operate as designed, IAQ conditions may be seriously compromised, therefore, a key factor in achieving good IAQ is a serious commitment to a comprehensive Commissioning effort that starts in the design phase and continues well into occupancy.

This effort should include a focus on Commissioning of systems and assemblies critical to good IAQ.

8-1-3 Moisture in Building Assemblies

There have been many notable cases of building IAQ problems associated with excessive levels of moisture in building assemblies, particularly in the building envelope.

Such situations can lead to mold growth that can be very difficult to fix without major renovation efforts and costs. Moisture problems arise for a variety of reasons, including roof leaks, rain penetration through leaky windows, envelope design and construction defects such as low-permeability wall coverings in hot and humid climates, and poor building pressure control.

These problems are largely avoidable but require an understanding of building moisture movement and attention to detail in envelope design and construction and in mechanical system selection, installation, and operation.

8-1-4 Poor Outdoor Air Quality

As noted previously, the traditional means of dealing with IAQ is through outdoor air ventilation. While ventilation can be an effective means to dilute indoor contaminants, it assumes that the outdoor air is cleaner than the indoor air. In many locations and for many contaminants, this is not the case, and insufficiently treated ventilation air can actually make IAQ worse.

Poor outdoor air quality includes regionally elevated outdoor contaminant levels as well as local sources, such as motor vehicle exhaust from nearby roadways and contaminants generated by activities in adjacent buildings. Some programs encouraging higher levels of building performance recommend increasing outdoor air ventilation rates, but such recommendations should base on the consideration of the potential impacts of poor outdoor air quality.

ASHRAE Standard 62.1 requires the assessment of outdoor air quality in a building vicinity and requires outdoor air cleaning under some circumstances.

8-1-5 Moisture and dirt in Ventilations Systems

Dirt accumulation in ventilation systems, combined with poor management of water, can lead to biological growth in the airstream and serious IAQ problems. These conditions generally result from inadequate levels of particle filtration (Appendix 5), poor filter maintenance, and problems with cooling coil condensate or other moisture sources. ASHRAE Standard 62.1 contains several requirements related to dirt and moisture management in ventilation systems.

8-1-6 Indoor Contaminant Sources

Many IAQ problems are associated with indoor contaminant sources that are unusually strong or otherwise cannot be handled by typical or code-compliant levels of outdoor air ventilation. Normal building materials and furnishings, especially when new release many contaminants, also by materials and substances brought into the building during operation. Unusual, unexpected, or atypically high contaminant emissions from indoor sources are associated with many IAQ problems, and this Guide speaks to the issues of material selection, cleaning, and other indoor sources.

8-1-7 Contaminants from Indoor Equipment and Activities

The wide range of occupancies and activities in commercial and institutional buildings or any built environment involve many different types of equipment and activities. IAQ problems have resulted from improper equipment operation, inadequate exhaust ventilation, and poor choices of materials used in some of these activities. This Guide contains information on how to decrease the likelihood of such problems.

8-1-8 Inadequate ventilation Rates

While building codes and standards have addressed outdoor air ventilation for decades, many buildings and spaces are poorly ventilated, which increases the likelihood of IAQ problems. There are varieties of reasons for inadequate ventilation rates, including lack of compliance with applicable codes and standards, installation or maintenance problems that lead to the design ventilation rate not being achieved in practice, or space use changes without an assessment of the need for updated ventilation rates.

Also, system-level outdoor air intake rates may be adequate, but air distribution problems can lead to certain areas in the building being poorly ventilated. While ASHRAE Standard 62.1 covers the determination of design ventilation rates, additional guidance is provided in this Design Guide to help address these issues.

8-1-9 Ineffective Filtration and Air Cleaning

Filtration and air cleaning are effective means of controlling many indoor air pollutants, particularly those associated with poor outdoor air quality. Air filtration or air cleaning, therefore, can provide an important adjunct, and in some cases substitute, for outdoor air ventilation. This Guide provides a detailed treatment of

filtration and air cleaning alternatives that, when properly administered and maintained, can improve both IAQ and energy performance.

8-2 Identifying Indoor Air Quality Problems

The owner, Management or representative of the building should identify the indoor air quality problem in the premises.

8-2-1 Types of Pollutants

General pollutant types that affect air quality include (**Appendix 1- table1**):

- **Biological**: bacteria, fungi, viruses, molds, pollen, animal hair, dander and excrement are examples of common biological pollutants that can affect air quality.
- **Chemical**: cleaners, solvents, fuels, adhesives, various combustion by-products and emissions from furnishings and floor and wall coverings are typical examples of airborne chemicals.
- **Particles and Aerosols**: are solids or liquids that are light enough to be suspended in air. Particles are classified in three general categories—coarse, fine, and ultrafine—and are derived from dust, construction activities, printing, photocopying, manufacturing processes, smoking, combustion and some chemical reactions in which vapors condense to form particles. These can be categorized as dust, smoke, mist, fume and condensates.

8-2-2 Factors Affecting Indoor Air Quality

In any building the indoor environment generally and IAQ problem is a result of the interaction between the four major factors, which are involved in the development of indoor air quality problems, which should be controlled, by owner, management, or representative of the building, and these four major factors are:

8-2-2-1 Sources of Indoor Air Contaminants

There is a source of contamination or discomfort indoors, outdoors, or within the mechanical systems of the building, If contaminant sources are not controlled, IAQ problems can arise, even if the HVAC system is properly designed and well-maintained. see the **(Appendix 1-table-2).**

Source categories as follow but not limits:

- **Contaminated outdoor air** (industrial pollutants, pollen, dust, fungal spores....etc.)
- **Emissions from nearby sources** (re-entrained (drawn back into the building) exhaust from the building itself or from neighboring buildings, loading docks, odors from dumpsters....etc.).
- **Soil gas** (radon, contaminants from previous uses of the site (e.g., landfills)...etc.).
- **Moisture or standing water promotes excess microbial growth**.
- **HVAC system** (microbiological growth in drip pans, humidifiers, ductwork, coils, refrigerant leakage... etc.).
- **Equipment** (emissions from office equipment (volatile organic compounds, ozone), emissions from shops, labs, cleaning processes... etc.
- **Human Activities** (smoking, cooking, housekeeping activates, maintenance activity ...etc.
- **Building Components and Furnishings**
- **Other Sources** (Accidental events like fire damage, Special use areas and mixed-use buildings like (labs in building, food preparation areas, beauty salons...etc.), Redecorating/remodeling activities like odors and volatile organic and inorganic compounds from paint, caulk, adhesives, etc.).

8-2-2-2 HVAC System Design and Operation

The HVAC system includes all heating, cooling, and ventilation equipment serving a building: chillers, cooling towers, air handling units, exhaust fans, ductwork, filters, steam (or heating water) piping. Most of the HVAC discussion in this guideline applies both to central HVAC systems and to individual components used as stand-alone units, a properly designed and functioning HVAC system should to:

- provides thermal comfort.
- Distributes adequate amounts of outdoor air to meet ventilation needs of all building occupants.
- Isolates and removes odors and contaminants through pressure control, filtration, and exhaust fans.

8-2-2-3 Pollutants Pathways and Driving Forces

Airflow patterns in buildings result from the combined action of mechanical ventilation systems, human activity, and natural forces. Pressure differentials created by these forces move airborne contaminants from areas of relatively higher pressure to areas of relatively lower pressure through any available openings, The HVAC system is generally the predominant pathway and driving force for air movement in buildings. However, all a building's components (walls, ceilings, floors, penetrations, HVAC equipment, and occupants) interact to affect the distribution of contaminants **(Appendix 1- table3,4).**

The basic principle of air movement from areas of relatively higher pressure to areas of relatively lower pressure can produce many patterns of contaminant distribution, including:

- Local circulation in the room containing the pollutant source.
- Air movement into adjacent spaces that are under lower pressure (note: even if two rooms are both under positive pressure compared to the outdoors, one room is usually at a lower pressure than the other is.)
- Recirculation of air within the zone containing the pollutant source or in adjacent zones where return systems overlap.
- Movement from lower to upper levels of the building
- Air movement into the building through either infiltration of outdoor air or reentry of exhaust air.
- Air moves from areas of higher pressure to areas of lower pressure through any available openings. A small crack or hole can admit significant amounts of air if the pressure differentials are high enough.

8-2-2-4 Building Occupants

The term “building occupants” is generally used in this guideline to describe people who spend extended periods (e.g., a full workday) in the building.

Occupancy factors that affect indoor air quality include the type and intensity of human activity, spatial characteristics of a given activity, and the operation schedule of a building, several human activities—such as smoking, cleaning, and cooking—generate gaseous and participate contaminants indoors. The number of occupants of a space and the degree of their physical activity (i.e., metabolic rate at rest or under intense activity) are related to the production of various pollutants, such as carbon dioxide, water vapor, and biologic agents. If the only source of indoor carbon dioxide production is that caused by occupants, ventilation rates may be proportional to the number of people and their metabolic rates. The importance of occupancy in indoor air quality is illustrated by the fact that the choice of natural or mechanical ventilation is based on occupant density and the spatial characteristics of the building under consideration.

It is important to understand the role that each of these factors may play in order to prevent, investigate, and resolve indoor air quality problems.

Clients and visitors are also occupants; they may have different tolerances and expectations from those who spend their entire time and workdays in the building and are likely to be more sensitive to odors.

8-2-3 IAQ Impacts on Occupants Health

Groups that may be particularly susceptible to effects of indoor air contaminants include, but are not limited to:

- Allergic or asthmatic individuals.
- People with respiratory disease.
- People whose immune systems are suppressed due to chemotherapy, radiation therapy, disease, or other causes
- Contact lens wearers

Some other groups are particularly vulnerable to exposures of certain pollutants or pollutant mixtures. For example, people with heart disease may be more affected by exposure to lower levels of carbon monoxide than healthy individuals. Children exposed to environmental tobacco smoke have been shown to be at higher risk of respiratory illnesses and those exposed to nitrogen dioxide have been shown to be at higher risk from respiratory infections.

A single indoor air pollutant or problem can trigger different reactions in different people. Some may not be affected at all. Information about the types of symptoms can sometimes lead directly to solutions. However, symptom information is more likely to be useful for identifying the timing and conditions under which problems occur as **(Appendix 2)**

8-2-3-1 Sick Building Syndrome (SBS)

The term "sick building syndrome" (SBS) is used to describe situations in which building occupants experience acute health and comfort effects that appear to be linked to time spent in a building, but no specific illness or cause can be identified. The complaints may be localized in a particular room or zone or may be widespread throughout the building **(Appendix 2).**

<u>Indicators of SBS include:</u>

- Building occupants complain of symptoms associated with acute discomfort, e.g., headache; eye, nose, or throat irritation; dry cough; dry or itchy skin; dizziness and nausea; difficulty in concentrating; fatigue; and sensitivity to odors.
- The cause of the symptoms is not known.
- Most of the complainant's report relief soon after leaving the building.
- The problem may be caused by any or all the following:
  - The combined effects of multiple pollutants at low concentrations
  - Other environmental stressors (e.g., overheating, poor lighting, noise).
  - Ergonomic stressors.

- Job-related psychosocial stressors (e.g., overcrowding, labor-management problems).
- Unknown factors.

8-2-3-2 Building-relates illness (BRI)

The term "building related illness" (BRI) is used when symptoms of diagnosable illness are identified and can be attributed directly to airborne building contaminants. (e.g., certain allergies or infections) and can be directly attributed to environmental agents in the air. Legionnaire's disease and hypersensitivity pneumonitis are examples of BRI that can have serious, even life-threatening consequences.

Indicators of BRI include:

- Building occupants complain of symptoms such as cough; chest tightness; fever, chills; and muscle aches.
- The symptoms can be clinically defined and have clearly identifiable causes.
- Complainants may require prolonged recovery times after leaving the building.

Sometimes several building occupants experience rare or serious health problems (e.g., cancer, miscarriages, Lou Gehrig's disease) over a relatively short period. These clusters of health problems are occasionally blamed on indoor air quality and can produce tremendous anxiety among building occupants. State or local Health Departments can provide advice and assistance if clusters are suspected. They may be able to help answer key questions such as whether the apparent cluster is actually unusual and whether the underlying cause could be related to indoor air quality

8-3 Assessment and action plan

Assessment and action plan is to lead you through a logical set of steps to achieve the goal of better indoor air quality in your building and to help evaluate IAQ complaints, and an action plan to monitor and resolve them.

8-3-1 Assessment – Technical Framework

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

- **Scoping**

  Identify the scope of an IAQ problem in terms of physical areas, people, timeframes, and budget to appropriately focus investigative actions.
- **History**

  Demonstrate the importance of collecting building and occupant history; depending on the situation this may include, but not be limited to location/setting, construction/renovation dates, previous land use, management structure, building and HVAC design/operation/ maintenance records (blueprints, as-built reviews, etc.), occupant surveys/interviews and prior sampling and investigation data.
- **Data Gathering**

  1- Identify the components of an IAQ investigation, such as the collection of multiple data points including identifying the scope of the problem; collecting building and occupant history; walkthrough inspection observations, and potential environmental sampling.

  2- Conduct an effective interview, extract valuable information, and avoid pitfalls in the interview process.
- **Scientific Method**

  1- Apply the scientific method to IAQ investigations.

  2- Develop hypotheses regarding the potential causes of IAQ concerns, collect and evaluate data to test these hypotheses, and reach conclusions accepting or rejecting the hypotheses.

  3- Apply critical thinking skills to differentiate between simple and complex IAQ concerns.

  4- Demonstrate an understanding that hypotheses development begins before the initial walk-through and continues until resolution of the issue.

  5- Recognize that, in some cases, simple solutions may be effective and should be a priority when developing recommendations.
- **Walkthrough Inspection**

  1- Demonstrate an understanding of the walkthrough inspection for fostering occupant communication and data collection.

2- Understand that the walkthrough inspection includes the area of concern, adjacent areas, and related building enclosure and HVAC systems.
3- Recognize common contaminant sources, pathways, and other problematic conditions in the field.
4- Identify what types of preliminary environmental measurements may be appropriate for an initial walkthrough.

- **Sampling**

1- Recognize that sampling is not necessarily the best or first approach in determining the cause of IAQ issues.
2- Demonstrate the importance of evaluating the need and purpose of a clearly defined and communicated sampling plan prior to collection.
3- Demonstrate an understanding of background levels of contaminants and generally accepted exposure guidelines for indoor environments.
4- Demonstrate an understanding of how to select the most appropriate instruments and how data will be interpreted prior to collection.
5- Sample, analyze and interpret results related to common IAQ contaminants and conditions.

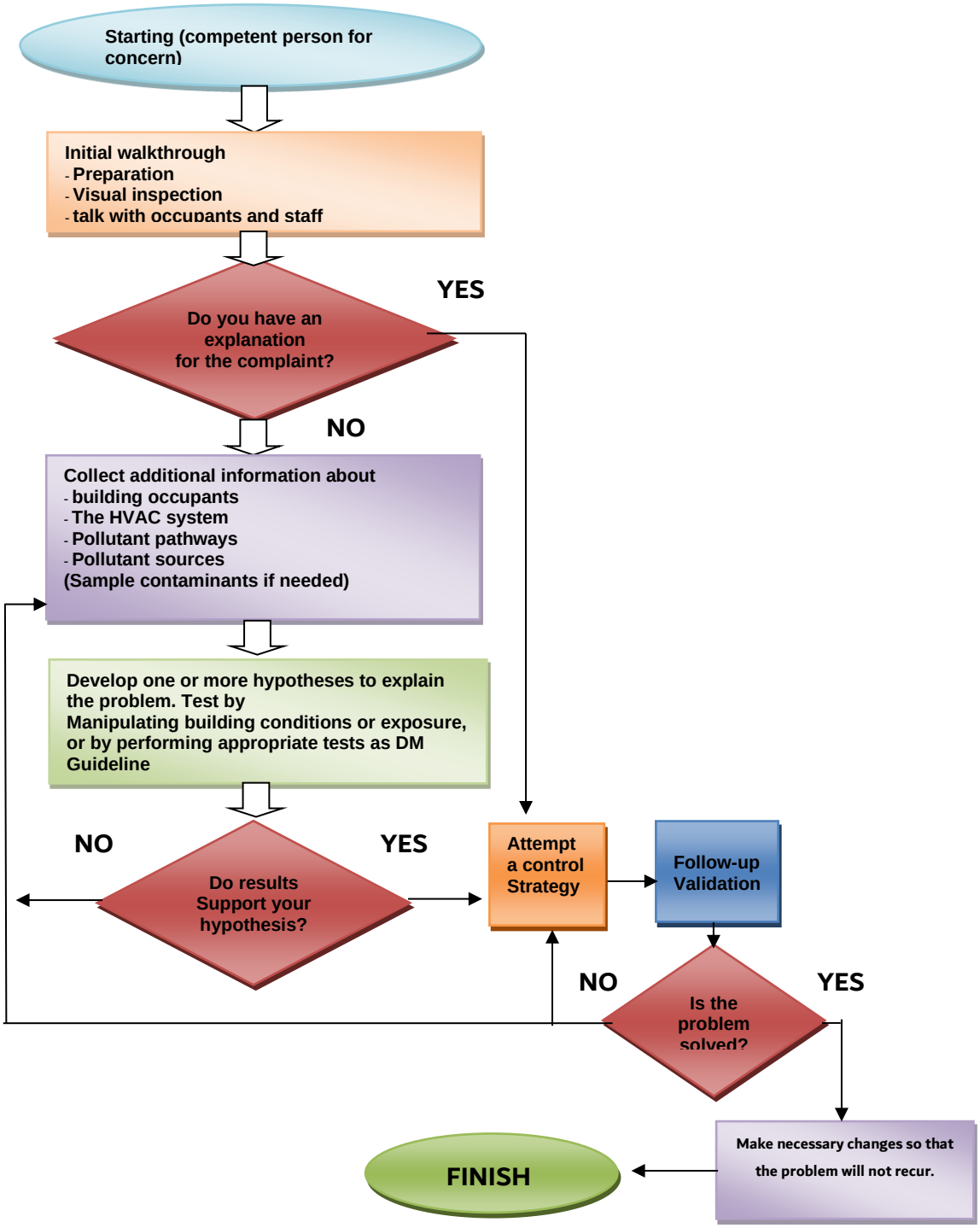
- **Limitations**

Demonstrate and understanding of practitioner limitations and when additional expertise (HVAC engineers, medical professionals, architects, etc.) is necessary.

8-3-2 Diagnosing IAQ Problems

The goal of the diagnostic building and premises investigation is to identify and solve the indoor air quality problem / complaint in a way that prevents it from recurring and that does not create other problems in the short or long terms. This section describes a method for discovering the cause of the IAQ problem / complaint. IAQ investigator should be a competent person enough that use only the investigative techniques that are needed, because diagnosing some indoor air quality problems may require equipment and skills that are complex and unfamiliar, many IAQ problems have more than one cause and may respond to (or require) several corrective actions.

Diagnosing IAQ Problems Chart



8-3-3 Action plan to achieve good IAQ

In the suspicion that the indoor air quality is not good, the following should be made to achieve good IAQ:

1- Recognize conditions that may require immediate emergency action relative to a building or individual occupants.

2- If background activities or the event indicate that a problem with IAQ, in the next step actions aiming at improvement of the IAQ should be undertaken:

- Identifying and reviewing the documents that should already exist at your building and other documents including:
- "As built" layout drawing with the details of HVAC location and building specifications that have been up-dated to indicate current conditions,
- List of control system set points and ranges for all HVAC equipment.
- Manufacturers' operating instructions and maintenance records for HVAC system components, and
- Historical complaint logs relating to air quality and comfort

3- Conduct a whole-building walkthrough inspection including all the HVAC system, and should be conducted by the competent persons to identify possible irregularities, and take in consider the factors that affecting the IAQ. A sample checklist for building inspection is provided in (**Appendix 3)**

4- During the walk around inspection, professional judgment must be exercised to determine if samples should be collected to evaluate potential sources and potential contaminants including gases, vapors, and particulates.

5- Immediate corrective actions Recommended for common IAQ problems (remove, substitute, replace, etc.).

6- The competent persons should obtain feedback from occupants on the conditions in the building and the operation of the HVAC system. A sample confidential questionnaire which can be administered to obtain information is provided in (**Appendix 4)** and establish Procedures for Responding to IAQ Complaints.

7- Indoor air analysis, and any environmental or biological sampling, should be conducted by a competent qualified professional familiar with this type of air monitoring, if deemed necessary for the investigation so that adjustments or alterations can be made.

8- Address Existing and Potential IAQ Problems and seek solutions that will correct or mitigate the problems and prevent them from recurring. Considering the general strategies to correct IAQ problems include:

- Identifying sources, then removing or reducing the source, sealing, or covering the source, or modifying the environment.
- Improving ventilation to provide outside air to occupants and to dilute and/or exhaust pollutants.
- Improving air filtration to clean air from outside and inside the building; and

- Controlling occupant exposure through administrative approaches such as scheduling contaminant-producing activities during unoccupied periods.

9- Based on the findings of **(1)-(6)**, 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.

10- Effective Communication:

A. Demonstrate an understanding of the fundamentals of risk communication and methods of conflict resolution when interacting with stakeholder groups – Dubai Municipality

B. Demonstrate the importance of effectively communicating information (scope, observations, verified/unverified information, hypotheses, testing plans, findings, assumptions, uncertainties, conclusions, recommendations, references, etc.) to the client and other stakeholders - Dubai Municipality

9. Improving Indoor Air Quality

9-1 Design and Constructions

1- A new or retrofitted building should be designed with regard to the pollution that 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.

2- Integrate Design Approach and Solutions describes approaches to integrate design across disciplines, enabling achievement of IAQ and other performance goals. Many IAQ problems occur because building elements are designed by different disciplines working in relative isolation. Even design elements that do not appear to be related can sometimes interact in ways that are detrimental to IAQ.

3- The HVAC 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.

4- Select HVAC Systems to Improve IAQ and Reduce the Energy Impacts of Ventilation explains how the type of HVAC system selected can constrain the level of IAQ achievable by limiting the capability for filtration, space humidity control, building pressurization, or separation of intakes from contaminant sources. It can also have a major impact on the energy required for ventilation. Yet the type of system is often selected by the architect before the engineer is involved or chosen based on cost, space required, or other factors without adequate consideration of IAQ implications.

5- Filters and Microbial Growth in HVAC Equipment. Highly efficient filters provide an important tool for reducing the amount of dirt and dust on airstream surfaces that are nutrients for microbial growth under damp-wet conditions. Filters type provided in (**Appendix 5**).

6- Proper building pressurization is required to limit moisture and contaminant transfer across the building envelope. Moisture transfer can result in mold damage within the envelope and, along with other contaminant transfers, can contaminate occupied spaces within the building.

7- 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. Selecting appropriate materials, finishes, and furnishings reduces the likelihood of emissions-related IAQ problems.

8- 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.

9- Outdoor air intakes should be placed where the air admitted is likely to be cleanest, taking into consideration the outdoor.

10- Limit Entry of Outdoor Contaminants:

- Investigate Regional and Local Outdoor Air Quality describes assessment of outdoor air pollution levels and control measures to limit the entry of these contaminants.
- Locate Outdoor Air Intakes to Minimize Introduction of Contaminants addresses separation of air intakes from such local and on-site sources as motor vehicle exhaust, building exhausts, and cooling towers...etc.
- Provide Effective Track-Off Systems at Entrances describe strategies to reduce tracked-in pollutants.
- Contaminants in exhaust air can re-enter the occupied space if exhaust ductwork is not well sealed, especially if the exhaust duct static pressure is higher than that in the surrounding area. Exhaust discharge can also be re-entrained into outdoor air intakes or windows. Refer to ASHRAE Standard 62.1/2 standards for Strategy– Design Exhaust Systems to Prevent Leakage of Exhaust Air into Occupied Spaces or Air Distribution Systems addresses duct sealing, fan location, and discharge design to reduce the risk of re-introducing exhaust to the occupied space.

11- Provide Comfort Conditions that Enhance Occupant Satisfaction addresses design for thermal comfort and integration of comfort and ventilation design.

12- At all stages of the construction of the building and its HVAC 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.

13- Water Accumulation in HVAC Drain Pans. Adequate drainage design is critical to limiting microbial contamination. The drain hole for the pan needs to be flushed with the bottom of the pan. When the air-

handling unit (AHU) is mounted in a mechanical room, it is important to make certain that allowance is made for mounting the drain line at the very bottom of the pan.

14- 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.

15- Duct liners with fibrous or rough surfaces present the potential for mold growth since the dirt that accumulates on the surface promotes the retention of moisture and the organic material in the accumulated dirt provides nutrients for mold growth. In addition, it is difficult to remove mold structures, such as hyphae that have grown into fibrous materials.

16- In the construction of the HVAC 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.

17- 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.

9-2 commissioning and operation

1- At completion of a new building, contaminant emissions from building materials and interior surfaces are typically at their highest. It is useful, therefore, to operate the building HVAC systems at a higher-than-normal ventilation rate for a period to help flush the building of these contaminants prior to occupancy and even during initial occupancy. It is important to delay building occupancy until a reasonable flush-out operation to reduce contaminant levels from early-phase product emissions has been completed.

2- Employ Strategies to Limit the Impact of Emissions outlines steps that can be taken to limit the impact of unavoidable emissions, including the use of emission barriers, material conditioning, in-place curing, delayed occupancy, building flush out, and short-term use of gas-phase air cleaning.

3- Moisture Carryover from Cooling Coils. Make sure that if the air velocity is too high over part of the coil section (e.g., due to localized accumulation of dirt or poor design), water droplets can and will wet downstream surfaces.

4- Minimize IAQ Impacts Associated with Cleaning and Maintenance addresses selection of easily cleaned materials and finishes, provision for proper storage and handling of cleaning materials, inclusion of cleaning protocols in O&M documentation and training, and other steps to reduce the IAQ impacts of cleaning.

5- 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 (**table no 1&2**). 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.

6- Facilitate Effective Operation and Maintenance for IAQ related to HVAC operation schedules needs to also consider provision of adequate ventilation during cleaning activities, Minimize IAQ Impacts Associated with Cleaning and Maintenance) and any other activity where high emissions might be expected (e.g., painting, caulking, applying adhesives).

7- 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.

8- Instructions for the operation of the building and its HVAC 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 HVAC 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- Limit Condensation of Water Vapor within the Building Envelope and on Interior Surfaces.

10- Rooms where air-handling units are situated should not be used as passageways or for storage. Where they open to a source of contamination, the doors of the rooms should remain airtight.

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.

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

9-3 Renovation

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 points in the stages of design and construction, respectively.

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.

3- 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 (**table no 2&4)**

4- After any major renovation to the building where the HVAC system has been affected (eg. by partitioning of office space or changing the layout of the floor), rebalancing of the air distribution should be required.

9-4 Maintenance

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

2- The schedule of maintenance for the HVAC system should be in accordance with the manufacturer's recommendations to ensure that the equipment operate efficiently, and your preventive maintenance schedule could **include examining:**

- Proper shielding of outdoor air intakes to prevent entry of wind driven rain and sandstorms.
- Measuring fresh air supply rates and comparing to design specifications, to see whether the HVAC system is delivering adequate fresh air for the space and number of people it serves.
- Unit ventilators more frequently than other ventilation equipment to see if cleaning should be done more often (such as every month)
- Different areas seasonally (create a different checklist for each season)

3- The building and its HVAC system should be inspected at **least every Three months or as need seasonally** 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.

4- The HVAC 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.

5- 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.

6- Cooling coils, condensate pipes and water trays should be checked regularly for signs of sludge, algae or rust build-up, 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 and based on condition** to ensure that contaminants do not build up. Any ferrous metal surface should be treated with an anticorrosion coating. Re-circulating water should also be treated to prevent rust, but that treated water must not be allowed to enter the airstream.

7- Cooling towers should be cleaned and treated in accordance with **technical guidelines specified in the control of legionella Guideline.**

8- The HVAC system should be checked and adjusted to ensure correct airflow, temperature, and humidity after the **first year of operation and at least every year** thereafter.

It should also be checked and adjusted after **any renovations or changes in floor layout** that might affect air distribution.

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

9-5 Parking ventilation

For all buildings with enclosed parking:

A. Mechanical ventilation must be provided to ensure that the Carbon Monoxide (CO) concentration in the enclosed parking area is maintained below fifty (50) parts per million (ppm) by:
   - Providing a minimum of **six (6)** outside air changes per hour, or
   - Installing a variable volume ventilation system controlled in response to input.

B. From a minimum of one CO sensor per four hundred square meters (400 m2) floor area of parking. B. A supply of outdoor air must be provided to each parking level.

C. Occupied areas such as offices, shopping centers, hotels, waiting rooms, educational institutes, ticket booths and any Built environment connected to enclosed parking, must be supplied with conditioned air under positive pressure compared with adjoining parking area.

D. Ventilation systems must be capable of providing ten (10) air changes per hour for smoke clearance purposes in case of a fire incident.

E. CO monitoring equipment must be installed with a minimum of one CO sensor per four hundred square meters (400 m2) floor area of parking. Sound alarm triggers when the CO concentration reaches or exceeds seventy-five (75) ppm in, at least, five percent (5%) of the monitored locations.

F. Where a Building Management System (BMS) or Central Control and Monitoring System (CCMS) is installed, the CO concentration must be monitored to allow real-time profiling and management of air quality.

G. CO monitoring equipment must be checked and recalibrated every six (6) months or according to manufacturer specification by a specialized calibration company certified by Dubai Municipality. Test results and calibration certificates must be kept onsite and be readily available for inspection by DM staff.

9-6 Environmental Tobacco Smoke

A. Smoking is strictly prohibited in all public in accordance with Local Order **No 11 – 2003** including but not limited to shopping centers, hotels, restaurants, government buildings, hospitals, healthcare facilities, commercial buildings, common accommodation, coffee shops and amusement and entertainment or any other places determined by Dubai Municipality **except for places in which smoking is permitted.**

B. Places in which smoking is permitted are determined in accordance with the conditions listed in the Manual of Regulating Smoking in Public Places issued by Dubai Municipality by administrative resolution no 92 for the year 2009 in which public places where smoking is strictly prohibited and places where smoking is permitted are determined according to specific conditions.

C. Smoking designated areas must be at least twenty-five (25) feet (7.6m) away from the building entrances of the building, doors and operable windows and ventilation system outdoor air intakes.

D. An annual permit is issued from the Health and Safety Department of Dubai Municipality for all places in which smoking is permitted after providing all required documents and drawings mentioned in the guide.

9-7 Quality control

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

2- During the normal operation of a building, an audit should be conducted by the **Accredit** competent persons **at least every 2 years** to ensure that the indoor air quality is acceptable and conforms to the specifications listed in **(Table 2, 3 & 4).**

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 Company or laboratory accredited under **EIAC Accreditation Scheme**.

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.

5- A formal record book containing adequate and accurate information on the HVAC 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 program; and

(e) Details of maintenance, **including**:

- Date and result of visual inspection;
- Date and type of cleaning/treatment works conducted; and
- Date and nature of any remedial works (if required).

9-8 Indoor air quality measurements

Air quality is paramount for people's well-being, as well as the environment. Poor air quality, both indoors and outdoors, can lead to numerous adverse health problems, such as nausea, headaches, skin irritation, sick building syndrome, kidney failure, and even cancer. In fact, since people spend around 90% indoors, indoor air quality has a significant impact on people's health, therefore, it is no surprise that setting strict standards and guidelines is fundamental for people's environmental health. Note that for some pollutants there are no safe levels of exposure. Although threshold limit values vary between countries and organizations.

9-8-1 short term & immediate effects to pollutants exposure

Some health effects may show up shortly after a single exposure or repeated exposures to a pollutant, the likelihood of immediate reactions to indoor air pollutants depends on several factors including age and preexisting medical conditions. In some cases, whether a person reacts to a pollutant depends on individual

sensitivity, which varies tremendously from person to person. Some people can become sensitized to biological or chemical pollutants after repeated or high-level exposures.

9-8-2 Long-term effects to pollutant exposure

Other health effects may show either up years after exposure has occurred or only after long or repeated periods of exposure. These effects, which include some respiratory diseases, heart disease and cancer, can be severely debilitating or fatal. It is prudent to try to improve the indoor air quality in your home even if symptoms are not noticeable but showing that the exposure are high.

While pollutants commonly found in indoor air can cause many harmful effects, there is considerable uncertainty about what concentrations or periods of exposure are necessary to produce specific health problems. People also react very differently to exposure to indoor air pollutants.

9-8-3 Indoor air quality compliance - new buildings

For all new buildings, suitable ventilation for the building occupants and ensure the air quality in accordance with the technical guidelines issued by Dubai Municipality.

The buildings which optionally apply the following procedures will be awarded indoor air quality certificate by Dubai municipality.

A. Indoor air quality testing must be carried out prior to occupancy. The maximum limit for indoor air contaminants included in **Table (1)** must not be exceeded. A report which shows compliance with these requirements must be submitted to Dubai Municipality.

Table No: 1 – Air Pollutants in New Building

Pollutant & Contaminant parameter (Sample Type)		Long Term Exposure		Short Term Exposure		Threshold Limit Value – Ceiling (TLV-C)
		Max-acceptable	Average Time	Max-acceptable	Average Time	
Gaseous pollutants	Total Volatile Organic Compounds (TVOC)	300 µg/m3	8-hour	3 ppm	N/A	5.5 ppm
	Formaldehyde (HCHO)	0.01 ppm	8-hour	0.08 ppm 0.1 mg/m3	30 min	1 ppm
	Lead	0.15 µg/m3	3 month	30 µg/m3	8-hour	50 µg/m3
Particulate & Biological	Particle Pollution (PM) (PM2.5)	35 µg/m3	24- hour	100 µg/m3	1-hour	
	Particle Pollution (PM) (PM10)	150 µg/m3	24- hour	100 µg/m3	8-hour	
	Total bacterial counts	500 CFU/m3				
	Total fungal counts	500 CFU/m3				

B. Air Quality testing must be carried out by an air testing accredited company or laboratory by Emirates International Accreditation center (EIAC), and the Compliant test results must be submitted to DM.

C. Air quality testing equipment must have initial and periodical calibration certificate as per manufacturer requirement from an external calibration facility accredited by DM or at least annual calibration certificate. The initial and periodical calibration certificates must be saved in a special register to be checked by DM to ensure the accuracy of the readings as condition of renewal the indoor air quality certificate.

9-8-4 Indoor Air Quality Compliance - Existing Buildings

Indoor air testing for the contaminants listed in Table (2) must be carried out to ensure the air quality in a building / Premises is suitable for occupation; the maximum limit for indoor air contaminants included in Common Air Pollutant **Table (2)** must not be exceeded.

Table No: 2 - Common Air Pollutant in Existing Building

Pollutant & Contaminant parameter (Sample Type)		Long Term Exposure		Short Term Exposure		Threshold Limit Value – Ceiling (TLV-C)
		Max-acceptable	Average Time	Max-acceptable	Average Time	
Gaseous pollutants	Total Volatile Organic Compounds (TVOC)	0.6 mg/m3	8-hour	3 ppm	N/A	5.5 ppm
	Formaldehyde (HCHO)	0.01 ppm	8-hour	0.08 ppm 0.1 mg/m3	30 min	1 ppm
	Carbon dioxide (CO2)	800 ppm	8-hour	700 ppm above outdoor air levels	N/A	5000 ppm
	carbon monoxide (CO)	9 ppm (10 mg/m3)	8-hour	25 ppm (35 mg/m3)	1-hour	200 ppm
		(7 mg/m3)	24-hour	90 ppm (100 mg/m3)	15 MIN	
	ozone (O3)	0.06 ppm (100 µg/m3)	8-hour	0.1 2 ppm	1-hour	800 µg/m3
	nitrogen dioxide (NO2)	40 µg/m3	annual average	0.1 ppm (200 µg/m3)	1-hour	10 ppm (in 5 min)
		150 µg/m3	8-hour	1 ppm	15 min	
Particulate & Biological	Particle Pollution (PM) (PM2.5)	35 µg/m3	24	100 µg/m3	1-hour	
	Particle Pollution (PM) (PM10)	150 µg/m3	24	100 µg/m3	8-hour	
	Total bacterial counts	1000 CFU/m3				
	Total fungal counts	500 U/m3				

A. Air Quality testing must be carried out by an air testing accredited company or laboratory by Emirates International Accreditation center (EIAC), and the Compliant test results must be submitted to DM.

B. Air quality testing equipment must have initial and periodical calibration certificate as per manufacturer requirement from an external calibration facility accredited by DM or at least annual calibration certificate. The initial and periodical calibration certificates must be saved in a special register to be checked by DM to ensure the accuracy of the readings as condition of renewal the indoor air quality certificate.

9-8-5 Thermal and Physical Comfort

For all new and existing buildings, the heating, ventilation, and air conditioning (HVAC) system must be capable of providing the following range of conditions for ninety five percent (95%) of the year:

Table No: 3 - Thermal & Physical Comfort

Parameter	Recommended Range for acceptable IAQ	Unit	Remarks
Dry bulb Air temperature	22.5 - 25.5 Db	°C	Based on 80% of occupants comfort
Relative humidity	20 - 60	%	Never to exceed 56%RH at 80F (27C) and 86%RH at 67F (19C).
Air movement	0.2 - 0.3	M/s	

9-8-6 IAQ Objective for Individual VOC

Table No: 4 - Individual VOC

Compound	8-hour average
Benzene	17µg/m3 (0.0053 ppm)
Naphthalene	10µg/m3 (0.0019 ppm)
Polycyclic aromatic hydrocarbons	0.012ng/m3 (1.2 × 10−4 ppm)
Trichloroethylene	230µg/m3 (0.0043 ppm)
Tetrachloroethylene	250µg/m3 (0.037 ppm)
1,2-Dichlorobenzene	500µg/m3 (0.083 ppm)
Toluene	1,092µg/m3 (0.29 ppm)
1,4-Dichlorobenzene	200µg/m3 (0.033 ppm)
Styrene	100 ppm
Xylene	1,447µg/m3 (0.333 ppm)

9-8-7 Assessment of indoor air quality parameters

- **Sample position**

The sampling probe should be located between 150 to 200 cm from walls, and 100 to 200 cm from the floor at the center of the room or an occupied zone, not directly in front of air supply diffusers, induction units, floor fans, or heaters, or the exhaled breath of the operator, not under direct sunlight that will impact instrumentation, not within 3.5 m of an elevator or entrance if sampled at a corridor / lobby, 3m from doors

- **Sampling Criteria**

Measurement should not be made in any part of the premises/building where it is totally enclosed but not served by MVAC system, such as store rooms, plant rooms, switch rooms, or kitchens (in the case of restaurants), etc.

- **Sampling Period**

Measurements should be made on an 8-hour basis except otherwise specified.

Where it is not practicable 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 accepted. A competent and accredited person should take into account the operation pattern of the premises/building when choosing the four time-slots. As a guideline, the four time-slots should be evenly distributed over the business hours, for office for example, buildings whereas for public places they should cover the worst-case scenario such as periods of highest occupancy.

- **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:

Table No: 5 - Number of sampling points (Indoor):

Area of building (m2) (Served by MVAC System)	Minimum number of sampling points
< 3,000	1 per 500 M2
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
More than 30,000	1 per 1200 M2

Outdoor

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

9-8-8 Quality Control

1- Owner, Management or representative should ensure the competence of all who participate in the IAQ survey and action plan process. All measurements should be conducted using calibrated instrument/equipment and the calibration should be conducted according to manufacturer's specifications where available. Also, the calibration standards should have a well-defined as **ISO /IEC 17025**.

2- Real-time monitors should be checked before use. Time must be allowed for the real-time monitors to reach a steady state before taking measurements. Records should be maintained for each of the real-time monitors, including the following minimum data:

   a. manufacturer's name, serial number or other unique identification;
   b. Real-time monitors' compliance with the product specifications;
   c. The manufacturer's instructions;
   d. Dates, results and copies of reports and certificates of all calibrations, adjustments, and the due date of next calibration;
   e. The maintenance plan and maintenance carried out to date; and
   f. Any damage, malfunction, modification, or repair to the monitors.

3- To ensure the data quality, a quality control (QC) plan including sample preparation and handling, calibration, data processing, etc. should be prepared. At least one sample or 10% of the total field samples for each project measurement, whichever is larger, should serve as field blanks and accompany the samples to the field and back to the laboratory, without being used for sampling. Similarly, at least one sample, or 10% of the total field samples for each project job, whichever is greater, should be collected as duplicate samples. To prevent contamination or deterioration of the integrated samples, the chain-of-custody log detailing the storage and treatment of samples prior to analysis should be prepared.

9-8-9 Compliance Requirements

1- The 8-hour average IAQ Objectives in **Table 1 & 2** will be used as the benchmark for assessing compliance, except for the alternative measurement of TVOC.

2- For a Good IAQ objective, the TVOC objective is also considered met if the measurements of 10 more commonly found individual VOCs complies with the requirements set out in **Table 4.** Details are: –

a. if the level of TVOC measured exceeds the level in **Table 1&2**, measurement of individual VOCs as listed in Table 4 may be carried out in the failed sampling points;
b. Measurements of individual VOCs should be conducted with analytical methods based on the USEPA's organic (TO) compendium procedures;
c. A TVOC-failed sampling point complying with all the 10 individual VOCs objectives in **Table 4** will be regarded as a passed sampling point in respect of TVOC.

9-8-10 Non-compliance Areas

1- The owners/management of the premises/buildings, with the assistance of the competent Consultant accredited investigator, should carry out remedial actions on those non-compliance areas.

2- Competent Consultant investigator may carry out IAQ re-measurements for those failed parameters after remedial actions have been taken.

10. Appendix

10-1 Appendix 1

10-1-1 type of pollutants

Common pollutants or pollutant classes of concern in commercial & Residencies buildings along with common sources of these pollutants are provided below.

Pollutant or Pollutant Class	Potential Sources
Biological Contaminants	Wet or damp materials, cooling towers, humidifiers, cooling coils or drain pans, damp duct insulation or filters, condensation, re-entrained sanitary exhausts, bird droppings, cockroaches or rodents, dust mites on upholstered furniture or carpeting, or body odors.
Combustion Contaminants	Furnaces, generators, gas or kerosene space heaters, tobacco products, outdoor air, and vehicles
Volatile Organic Compounds (VOCs)	Paints, stains, varnishes, solvents, pesticides, adhesives, wood preservatives, waxes, polishes, cleansers, lubricants, sealants, dyes, air fresheners, fuels, plastics, copy machines, printers, tobacco products, perfumes, and dry-cleaned clothing
Formaldehyde	Particle board, plywood, cabinetry, furniture, and fabrics
Soil gases (radon, sewer gas, VOCs, methane)	Soil and rock (radon), sewer drain leak, dry drain traps, leaking underground storage tanks, and land fills
Pesticides	Termiticides, insecticides, rodenticides, fungicides, disinfectants, and herbicides

Particles and Fibers	Printing, paper handling, smoking and other combustion, outdoor sources, deterioration of materials, construction/renovation, vacuuming, and insulation
Environmental Tobacco Smoke	Lighted cigarettes, cigars and pipes

10-1-2 Protocols for Managing Major Sources of Pollution in Buildings

Type of Protocol	Solution
Remodeling and Renovation	• Use effective strategies for material selection and installation. • Isolate construction activity from occupants.
Painting	• Establish a protocol for painting and ensure that the protocol is followed by both in-house personnel and by contractors. • Use low VOC emission, fast drying paints where feasible. • Painting during unoccupied hours. • Keep lids on paint containers when not in use. • Ventilate the building with significant quantities of outside air during and after painting. Insure a complete building flush prior to occupancy. • Use more than normal outside air ventilation for some period after occupancy. • Avoid spraying, when possible.

Pest Control Integrated Pest Management	• Use or require the use of Integrated Pest Management by pest control contractors in order to minimize the use of pesticides when managing pests. • Control dirt, moisture, clutter, foodstuff, harborage and building penetrations to minimize pests. • Use baits and traps rather than pesticide sprays where possible. • Avoid periodic pesticide application for “prevention” of pests. • Use pesticides only where pests are located. • Use pesticide specifically formulated for the targeted pest. • Apply pesticides only during unoccupied hours. • Ventilate the building with significant quantities of outside air during and after applications. • Insure a complete building flush prior to occupancy. • Use more than normal outside air ventilation for some period after occupancy. • Notify occupants prior to occupation. • If applying outside, keep away from air intake.
Shipping and receiving	• Establish and enforce a program to prevent vehicle contaminants from entering the building. • Do not allow idling of vehicles at the loading dock. Post signs and enforce the ban. • Pressurize the receiving area relative to the outside to ensure that contaminants from the loading area do not enter the building. Use pressurized vestibules and air locks if necessary. • Periodically check the pressure relationships and compliance with the protocol. • Notify delivery company supervisors of policy.
Establish and Enforce a Smoking Policy	• Environmental tobacco smoke (ETS) is a major indoor air contaminant. A smoking policy may take one of two forms: • A smoke-free policy, which does not allow smoking in any part of the building. • A policy that restricts smoking to designated smoking lounges only. • (Partial policies such as allowing smoking only in private offices are not effective.)
Smoking Lounge Requirements	A designated smoking lounge must have the following features to be effective in containing ETS. • The lounge should be fully enclosed. • The lounge should be sealed off from the return air plenum.

	• The lounge should have exhaust ventilation directly to the outside at 60cfm per occupant (using maximum occupancy). • Transfer air from occupied spaces may be used as make up air. • The lounge should be maintained under negative pressure relative to the surrounding occupied spaces.
Managing Moisture and Mold	Mold thrives in the presence of water. The secret to controlling mold is to control moisture and relative humidity. • Keep relative humidity below 60% (50%, if feasible, to control dust mites) • Keep all parts of the building dry that are not designed to be wet. • Adequately insulate exterior walls or ceilings to avoid condensation on cold surfaces. • Insulate cold water pipes to avoid sweating. • Clean spills immediately. Thoroughly clean and dry liquid spills on porous surfaces such as carpet within 24 hours or discard the material. • Do not allow standing water in any location. • Maintain proper water drainage around the perimeter of the building. • Provide sufficient exhaust in showers or kitchen areas producing steam. Thoroughly clean areas that are designed to be wet. • Wash floors and walls often where water accumulates (e.g., showers) • Clean drain pans often and ensure a proper slope to keep water draining. • Ensure proper maintenance and treatment of cooling tower operations. • Discard all material with signs of mold growth. • Discard furniture, carpet, or similar porous material having a persistent musty odor. • Discard furniture, carpet, or similar porous material that has been wet for more than 24 hours. • Discard ceiling tiles with visible water stains

10-1-3 Pollution Transport

Major Driving Force	Effect
Wind	• Positive pressure is created on the windward side causing infiltration, and negative pressure on the leeward side causing exfiltration, though wind direction can be varied due to surrounding structures.
Stack Effect	• When the air inside is warmer than outside, it rises, sometimes creating a column of rising air -- up stairwells, elevator shafts, vertical pipe chases etc. This buoyant force of the air results in positive pressure on the higher floors and negative pressure on the lower floors and a neutral pressure plane somewhere between.
HVAC/Fans	• Fans are designed to push air in a directional flow and create positive pressure in front, and negative pressure behind the fan
Flues and Exhaust	• Exhausted air from a building will reduce the building air pressure relative to the outdoors. Air exhausted will be replaced either through infiltration or through planned outdoor air intake vent.
Elevators	• The pumping action of a moving elevator can push air out of or draw air into the elevator shaft as it moves.

10-1-4 Common Airflow Pathways for Pollutants:

Common Pathway	Comment
Indoors	
• Stairwell • Elevator shaft • Vertical electrical or plumbing chases	• The stack effect brings about air flow by drawing air toward these chases on the lower floors and away from these chases on the higher floors, affecting the flow of contaminants.
Receptacles, outlets, openings	• Contaminants can easily enter and exit building cavities and thereby move from space to space.
Duct or plenum	• Contaminants are commonly carried by the HVAC system throughout the occupied spaces.
Duct or plenum leakage	• Duct leakage accounts for significant unplanned air flow and energy loss in buildings.
Flue or exhaust leakage	• Leaks from sanitary exhausts or combustion flues can cause serious health problems
Room spaces	• Air and contaminants move within a room or through doors and corridors to adjoining spaces
Outdoors to Indoors	
Indoor air intake	• Polluted outdoor air or exhaust air can enter the building through the air intake
Windows/doors, Cracks and crevices	• A negatively pressurized building will draw air and outside pollutants into the building through any available opening

Substructures and slab penetrations	• Radon and other soil gases and moisture-laden air or microbial contaminated air often travel through crawlspaces and other substructures into the building.

10-1-5 VOCs Typical Sources:

Components	Typical source
Formaldehyde*	Germicide, pressed-wood products, urea-formaldehyde foam insulation (UFFI), plywood, medium-density fiberboard, adhesives, particle boards, laminates, paints, carpeting, upholstered furniture coverings, gypsum boards, joint compounds, ceiling tiles and panels, non-latex caulking compounds, acid-cured wood coatings, wood paneling, plastic/melamine paneling, vinyl floor tiles, parquet flooring, sealants, varnishes and lacquers, cleaning agents, nail polish and hardeners, insecticides
Benzene*	Furnishing materials, polymeric materials (vinyl, PVC, rubber floorings), nylon carpets, particle boards, plywood, fiberglass, flooring adhesives, wood paneling, caulking compounds, paint removers, solvents, paints, stains, varnishes, fax machines, computer terminals and printers, joint compounds, floor tile adhesives, spot/textile cleaners, Styrofoam, synthetic fibers
Carbon Tetrachloride	Solvents, refrigerants, aerosols, fire extinguishers, grease solvents, cleaning agents
Trichloroethylene*	Solvents, dry-cleaned fabrics, upholstered furniture covers, printing inks, paints, lacquers, wood stains, varnishes, lubricants, adhesives, fax machines, computer terminals and printers, typewriter correction fluid, paint removers, spot removers
Tetrachloroethylene*	Dry-cleaned fabrics, upholstered furniture coverings, spot/textile cleaners, fax machines, computer terminals and printers
Chloroform	Cleaning agents, solvents, dyes, pesticides, fax machines, computer terminals and printers, upholstered furniture cushions, chlorinated water
1,2-Dichlorobenzene	Dry cleaning agents, degreasers, insecticides, carpeting
1,4-Dichlorobenzene	Deodorant, mold and mildew control agents, air fresheners/deodorisers, toilet bowl and waste-can deodorisers, mothballs and moth flakes
Ethylbenzene	Cleaning products, paints, styrene-related products, synthetic polymers, solvents, fax machines, computer terminals and printers, polyurethane, furniture polishes, joint compounds, caulking compounds, floor tile adhesives, carpet tile adhesives, lacquered hardwood parquet flooring
Toluene	Solvents, perfumes, nail polishes, detergents, dyes, water-based adhesives, edge sealing, molding tapes, wallpaper, joint compounds, calcium silica sheets, vinyl coated wallpaper, caulking compounds, paints, carpeting, pressed-wood furnishings, vinyl floor tiles, paints (latex and solvent-based), paint thinners, adhesives, grease solvents, printer

Xylenes	Solvents, dyes, insecticides, polyester fibers, adhesives, joint compounds, wallpaper, caulking compounds, varnishes, resin and enamel varnishes, carpeting, wet-process photocopying, pressed-wood products, gypsum boards, water-based adhesives, grease solvents, paints, carpet adhesives, vinyl floor tiles, polyurethane coatings, synthetic fragrance
Naphthalene*	Paints, insecticides, moth repellents and disinfectants, deodorizers
Polycyclic Aromatic Hydrocarbons*	Cooking, domestic heating with fuel stoves and open fireplaces, incense and candle burning

* Quantitative guidance levels were recommended in the "WHO guidelines for indoor air quality: Selected Pollutants". WHO (2010).

10-1-5-1 The guidelines of TVOC levels and the corresponding recommendations

Level	Hygienic Rating	Recommendation	Exposure Limit	TVOC (ppb)
5 Unhealty	Situation not acceptable	Use only if unavoidable /Intense ventilation necessary	hours	2200 – 5500
4 poor	Major objections	Intensified ventilation / airing necessary Search for sources	< 1 month	660 – 2200
3 Moderate	Some objections	Intensified ventilation / airing recommended Search for sources	< 12 months	220 – 660
2 Good	No relevant objections	Ventilation / airing recommended	no limit	65 – 220
1 Excellent	No objections	Target value	no limit	0 – 65

10-2 Appendix 2 health effects of major air contaminants

Carbon Dioxide:

- **Sources**: Unvented gas and kerosene appliances, improperly vented devices, processes, or operations which produce combustion products, human respiration.

Measuring CO2 concentration is one of the most practical investigative tools available to a practitioner for determining that specific occupied spaces are adequately ventilated.

- **Acute health effects**: Difficulty concentrating, drowsiness, increased respiration rate.

Carbon Monoxide:

- **Sources**: Tobacco smoke, fossil-fuel engine exhausts, improperly vented fossil-fuel appliances.
- **Acute health effects**: Dizziness, headache, nausea, cyanosis, cardiovascular effects, and death. In details as follow:
  - At low Carbon Monoxide concentrations, fatigue in healthy people and chest pain in people with heart disease. At moderate concentrations, impaired vision, and coordination; headaches; dizziness; confusion; nausea. Can cause flu-like symptoms that clear up after leaving the space that contains the elevated concentrations. May be fatal at very high concentrations.

Formaldehyde:

- **Sources**: Off gassing from urea formaldehyde foam insulation, plywood, particle board, and paneling; carpeting and fabric, glues and adhesives, and combustion products including tobacco smoke.
- **Acute health effects**: Hypersensitive or allergic reactions; skin rashes; eye, respiratory and mucous membrane irritation; odor annoyance.

Nitrogen Oxides:

- **Sources**: Combustion products from gas furnaces and appliances, tobacco smoke, welding, and gas- and diesel-engine exhausts.
- **Acute health effects**: Eye, respiratory and mucous membrane irritation, nose, and throat irritation. May cause impaired lung function and increased respiratory infections in young children.

Ozone;

- **Sources**: Copy machines, electrostatic air cleaners, electrical arcing, smog.
- **Acute health effects**: Eye, respiratory tract, mucous membrane irritation; aggravation of chronic respiratory diseases (aggravate asthma); cause significant temporary decreases in lung capacity of 15 to over 20 percent in some healthy adults; cause inflammation of lung tissue ; impair the body's immune

system defenses, making people more susceptible to respiratory illnesses, including bronchitis and pneumonia.

Radon;

- **Sources**: Ground beneath buildings, building materials, and groundwater.
- **Acute health effects**: No acute health effects are known but chronic **exposure** may lead to increased risk of lung cancer from alpha radiation.

Volatile Organic Compounds (VOC's):

Volatile organic compounds include trichloroethylene, benzene, toluene, methyl ethyl ketone, alcohols, methacrylate, acrolein, polycyclic aromatic hydrocarbons, and pesticides.

- **Sources**: Paints, cleaning compounds, moth-balls, glues, photocopiers, "spirit" duplicators, signature machines, silicone caulking materials, insecticides, herbicides, combustion products, asphalt, gasoline vapors, tobacco smoke, dried out floor drains, cosmetics and other personal products.
- **Acute health effects**: Nausea; dizziness; eye, respiratory tract, and mucous membrane irritation; headache; fatigue; damage to liver, kidney, and central nervous system. Some organics can cause cancer in animals; some (such as Benzene) are suspected or known to cause cancer in humans.

Miscellaneous Inorganic Gases:

Includes ammonia, hydrogen sulfide, sulfur dioxide.

- **Sources**: Microfilm equipment, window cleaners, acid drain cleaners, combustion products, tobacco smoke, blue-print equipment.
- **Acute health effects**: Eye, respiratory tract, mucous membrane irritation; aggravation of chronic respiratory diseases.

Asbestos:

- **Sources**: Insulation and other building materials such as floor tiles, dry wall compounds, reinforced plaster.
- **Acute health effects**: Asbestos is normally not a source of acute health effects. However, during renovation or maintenance operations, asbestos may be dislodged and become airborne. Evaluation of employee exposure to asbestos will normally be covered under the OSHA Asbestos standard.

Synthetic Fibers:

- **Sources**: Fibrous glass and mineral wool.
- **Acute health effects**: Irritation to the eyes, skin, and lungs; dermatitis.

Tobacco Smoke:

- **Sources**: Cigars, cigarettes, pipe tobacco, shisha.
- **Acute health effects**: Tobacco smoke can irritate the respiratory system and, in allergic or asthmatic persons, often results in eye and nasal irritation, coughing, wheezing, sneezing, headache, and related sinus problems. People who wear contact lenses often complain of burning, itching, and tearing eyes when exposed to cigarette smoke.

Tobacco smoke is a major contributor to indoor air quality problems. Tobacco smoke contains several hundred toxic substances including carbon monoxide, nitrogen dioxide, hydrogen sulfide, formaldehyde, ammonia, benzene, benzo(a)pyrene, tars, and nicotine.

Most indoor air particulates are due to tobacco smoke and are in the respirable range.

Microorganisms and Other Biological Contaminants (Microbials):

Includes viruses, fungi, mold, bacteria, nematodes, amoeba, pollen, dander, and mites.

- **Sources**: Air handling system condensate, cooling towers, water damaged materials, high humidity indoor areas, damp organic material and porous wet surfaces, humidifiers, hot water systems, outdoor excavations, plants, animal excreta, animals and insects, food, and food products.

Acute health effects: Allergic reactions such as hypersensitivity diseases

- (hypersensitivity pneumonitis, humidifier fever, allergic rhinitis, etc.) In addition, infections such as legionellosis are seen. Symptoms include chills, fever, muscle ache, chest tightness, headache, cough, sore throat, diarrhea, and nausea.

Acetic Acid:

- **Sources**: X-ray development equipment, silicone caulking compounds.
- **Acute health effects**: Eye, respiratory and mucous membrane irritation.

10-3 Appendix 3: CHECKLIST FOR WALKTHROUGH INSPECTION

General

Check whether there is any -

- Odor
- Dirty or unsanitary conditions (e.g. excessive dust)
- Visible fungal growth or moldy odor (often associated with problem of excessive moisture)
- Staining or discoloration of building materials
- Sanitary conditions in equipment such as drain pans and cooling towers
- Inadequate ventilation
- Inadequate exhaust air flow
- Blocked vents
- Uneven temperature
- Overcrowding
- Poorly-maintained filters
- Personal air cleaners (e.g. ozone generators)
- Presence of hazardous substances
- Unsanitary mechanical room, or trash or stored chemicals in mechanical room

Specific

Thermal comfort

- Check for any evidence of high or low temperature. Are these due to occupant interference, such as installation of new equipment?
- Check for evidence of thermal gradients. The floor-to-ceiling differential should not exceed 3°C.
- Check for any obstruction of air circulation, such as partitions, taped diffusers, or blocked by files, papers, books, or cabinets, ... etc.
- Ensure that thermostats are functioning, calibrated, correctly located, and not obstructed or enclosed.
- Is there any system intervention, such as blockage of the ventilation grilles?

Potential sources of contaminants

- Enquire about any recent change in the physical set-up and use of the space (e.g. open
- Office space converted to closed offices, transformation of office space into a waiting room or computer room etc.).
- Inspect the loading dock and car parks connected with the premises/building:
  - Are they properly ventilated?
  - Are stairways, elevator shafts, and ducts acting as pathways for automobile exhaust and diesel fumes?
  - Are carbon monoxide sensors (for ventilation control) and alarms installed in the garage calibrated and operating properly?
- Are stoves and other sources fitted with exhaust system?
- Is the building less than a year old, or has any area been renovated, redecorated, or newly furnished within the past month?
- Are suitable cleaning products being employed? Is time of use optimum, to reduce exposure of occupants?
- Do any activities involve the use of large amounts of chemicals, especially highly volatile?
- solvents? Is solvent odor present? Are soaked materials and solvents being disposed of properly?
- Have pesticides been improperly applied?
- Is the trash properly disposed of daily?
- Is extra ventilation or a separate ventilation system being used where there are localized?
- sources? Is the ventilation system recirculating volatile organic compounds from a source throughout the building?
- Any there any moldy, damp odor or evidence of a previous flood or water leak?
- Records should be examined for evidence of recent renovation, painting, installation of plywood or particleboard, replacement of carpets, and installation of new furniture.
- Are there dirt marks or white dust on diffusers, indicating particulates entering from the ventilation system?
- Is smoking only restricted to designated areas with independent ventilation system?
- Are carpets cleaned regularly?

MVAC system

- Is the amount of fresh air provided to the premises/building in line with the latest version of ASHRAE Standard 62?
- Are the electrostatic precipitators the approved type from Fire Services Department?

- Where is the fresh air intake duct located? Is it blocked up? Is it nearing the cooling tower? Is it at street level or near a car park (air intakes located below third-floor level can conduct fumes from vehicular traffic and parking garages)? Are heavy industries located nearby? Is there any construction work going on nearby?
- Are the fresh air controls and dampers functioning properly?
- Is the minimum fresh air damper opening set at approximately 15%?
- Are all air distribution dampers functioning properly and cleared of obstruction?
- Are filters installed and maintained properly (e.g. no bypassing, not overloading with dust)?
- Is the filtering system designed for primary filters rated between 10% and 30% dust-spot or efficiency, and for secondary filters rated between 40% and 85% dust-spot efficiency or as the MERV?
- Are the drain pans clean, properly drained, and without visible mold growth?
- Are the fan motors and belts working properly?
- Are diffusers and exhaust outlets close together, causing short-circuiting?
- Is the air-conditioning system turned off at any time during the day?
- Is there a regular schedule for cleaning and maintenance of the MVAC system?
- Are all the components of the MVAC system regularly inspected for leaks or breaches, etc.?
- Are the cooling towers treated according to the **"Code of Practice for Prevention of Legionnaires 'disease" published by Dubai Municipality Health and Safety Department?**
- Are the mechanical rooms clean and free of contaminants (e.g. refuse or chemicals)?
- Are the exhaust fans operating properly?
- Are all air distribution paths unobstructed?

10-4 Appendix 4: occupant interview

Building Name: _____ File Number: _____

Address: _____

Occupant Name: _____ Work Location: _____

Completed by:_____ Title: _____Date:_____

Section 4 discusses collecting and interpreting information from occupants.

SYMPTOM PATTERNS

What kind of symptoms or discomfort are you experiencing?

Are you aware of other people with similar symptoms or concerns? Yes _____ No _____

If so, what are their names and locations? _____

Do you have any health conditions that may make you particularly susceptible to environmental problems?

- contact lenses.
- chronic cardiovascular disease
- undergoing chemotherapy or radiation therapy
- allergies
- chronic respiratory disease
- immune system suppressed by disease or other causes.
- chronic neurological problems

TIMING PATTERNS:

When did your symptoms start?

When are they generally worst?

Do they go away? If so, when?

Have you noticed any other events (such as weather events, temperature or humidity changes, or activities in the building) that tend to occur around the same time as your symptoms?

SPATIAL PATTERNS:

Where are you when you experience symptoms or discomfort?

Where do you spend most of your time in the building?

ADDITIONAL INFORMATION:

Do you have any observations about building conditions that might need attention or might help explain your symptoms (e.g., temperature, humidity, drafts, stagnant air, and odors)?

Have you sought medical attention for your symptoms?

Do you have any other comments?

10-5 Appendix 5: Type of filter & typical used for controlling contaminate:

MERV Range	Type of Filter	Typical Controlled Contaminant
1-4	Viscous Impingement Washable Aluminum Mesh	pollen, Spanish moss, dust mites, sanding dust, spray paint dust, textile fibers, carpet fibers
5-8	Dry Media: Pleated (1-5 inch thickness)	mold, spores, hair spray, fabric protector, dusting aids, cement dust, pudding mix, snuff, powered milk
9-12	Dry Media: Bag Dry Media: Pleated (6-12 inch thickness)	legionella, humidifier dust, lead dust, milled. flour, coal dust, auto emissions, nebulizer drops, welding fumes
13-16	Dry Media: Bag Dry Media: Pleated (6-12 inch thickness)	all bacteria, most tobacco smoke, droplet nuclei (sneeze), cooking oil, most smoke, insecticide dust, copier toner, most face powder, most paint pigments
17-20	High Efficiency Particulate Air Ultra Low Particulate Air (ULPA)	virus (unattached), carbon dust, sea salt, all combustion smoke, radon progeny

10-6 Appendix 6: Air Purification Solutions Technologies Fact sheet

Will air technologies reduce health effects?

Air cleaners may reduce the health effects from some particles - small solid or liquid substances suspended in air such as dust or light spray mists.

a. Some air cleaners under the right conditions can effectively remove certain respirable-size particles (for example tobacco smoke particles). These invisible particles are of concern because they can be inhaled deeply into the lungs. Removing such particles may reduce associated health effects in exposed people. These effects may range from eye and lung irritation to more serious effects such as cancer and decreased lung function.

b. Some controversy exists about whether air cleaners can reduce the allergic reactions produced by larger particles such as pollen, house dust allergens, some molds and animal dander. Most of these particles are found where they settle on surfaces in the home, rather than in the air. They cannot be removed by an air cleaner unless disturbed and re-suspended in the air.

c. Air cleaners that do not contain special media, such as activated carbon or alumina, will not remove gaseous pollutants, including radon, or reduce their associated health effects. Whether air cleaners that contain these media are effective in reducing health risks from gaseous pollutants cannot be adequately assessed at this time. In addition, the effectiveness of air cleaners in reducing the health risks from radon progeny (decay products) cannot be adequately evaluated at present.

The use of air cleaning devices may help to reduce levels of smaller airborne allergens or particles. However, air cleaners may not reduce adverse health effects in sensitive population such as children, the elderly, and people with asthma and allergies. For example, the evidence is weak that air-cleaning devices are effective in reducing asthma symptoms associated with small particles that remain in the air, such as those from some airborne cat dander and dust mite allergens. Larger particles, which may contain allergens, settle rapidly before they can be removed by filtration, so effective allergen control measures require washing sheets weekly, frequent vacuuming of carpets and furniture, and dusting and cleaning of hard surfaces. The most effective ways to improve your indoor air are to reduce or remove the sources of pollutants and to ventilate with clean outdoor air. In addition, research shows that filtration can be an effective supplement to source control and ventilation.

Types of air cleaners technologies and pollutants can be removed:

Air cleaners are of various types, some of them may be installed in in the ducts, which are part of central ventilation and air conditioning systems in buildings, or home air conditioning system. Or Portable air cleaners stand alone in a room. The available technologies vary in the type of pollutant that they can remove or reduce (e.g., different PM sizes, different kinds of gases, airborne microbes), their mechanism of action (e.g., pollutant collection, conversion, inactivation, destruction), and the potential side effects of their use (e.g., primary energy use requirements, secondary impacts on equipment performance, direct emissions of pollutants, secondary pollutant formation).

- **Mechanical Air filters**: Similar to and including the typical Ventilation and Air Conditioning systems filter. Remove particles by capturing them on filter materials. High efficiency particulate air (**HEPA**) filters are in this category.
- **Electronic air cleaners: (**for example electrostatic precipitators) which trap charged particles using an electrical field.

  Remove particles; use a process called electrostatic attraction to trap charged particles. They draw air through an ionization section where particles obtain an electrical charge. The charged particles then accumulate on a series of flat plates called a collector that is oppositely charged.
- **Ion generators:** Ion generators, or ionizers, disperse charged ions into the air, similar to the electronic air cleaners but without a collector.

Which act by charging the particles in a room. These ions attach to airborne particles, giving them a charge so that they attach to nearby surfaces such as walls or furniture, or attach to one another, etc and settle faster. or a charged collector.

- **Hybrid devices:** which contain two or more of the particle removal devices discussed above or one of Pollutant Destruction Technology such as UVGI, PCO and Ozone generators.
- **Pollutant Destruction:**

a. **UVGI cleaners** use ultraviolet radiation from UV lamps that may destroy biological pollutants such as viruses, bacteria, allergens, and molds that are airborne or growing on HVAC surfaces (e.g., found on cooling coils, drain pans, or ductwork), or deactivating them. If used, they should apply with, but not as a replacement for, filtration systems.

b. **Photocatalytic Oxidation (PCO) cleaners** use a UV lamp along with a substance, called a catalyst that reacts with the light. They are intended to destroy gaseous pollutants by converting them into harmless products, but are not designed to remove particulate pollutants.

c. **Ozone generators:** Ozone is a colorless gas, use UV light or an electrical discharge to intentionally produce ozone. Ozone is a lung irritant that can cause adverse health effects. At concentrations that do not exceed health and Safety standards, ozone has little effect in removing most indoor air contaminants. Thus, ozone generators are not always safe and effective in controlling indoor air pollutants. Additionally, ozone may even react with existing chemicals in the air to create harmful by-products (e.g., formaldehyde). Consumers should instead use methods proven to be both safe and effective to reduce pollutant. (Recommended to contact Dubai Municipality for more Information before to Use).

- Sorbent media air filters: use a material with a very high surface area called a sorbent to capture gaseous pollutants. Two main sorbent processes can be used to remove gaseous contaminants: a physical process known as adsorption and a chemical reaction called chemisorption.
- Activated carbon is the most common adsorbent used in HVAC systems and portable air cleaners to remove gaseous contaminants. It has the potential to remove most hydrocarbons, many aldehydes, organic acids through adsorption, and ozone through chemisorption. Adsorbent media filters can have high removal efficiency for many gaseous pollutants, but they can also have different removal efficiency for different gases at different concentrations
- Plasma air cleaners: apply a high-voltage discharge to ionize incoming gases, breaking their chemical bonds and chemically altering them, non-thermal plasma air cleaners accelerate electrons to generate reactive ions and radicals, which convert compounds by oxidation reactions.
- plasma air cleaners can have high removal efficiency for some gases as well as particles, and they can also kill or deactivate airborne microorganisms.

Notes:

a. Ion generators and electronic air cleaners may produce ozone, particularly if they are not properly installed and maintained. Ozone can be a lung irritant that can cause adverse health effects.
b. Ion generators especially those that do not contain a collector may cause soiling of walls and other surfaces.
c. Gases and odors from particles collected by the devices may be dispersed into the air.
d. Some devices scent the air to mask odors, which may lead you to believe that the odor causing pollutants have been removed.
e. Some portable air cleaners may case a Noise even at low speeds.
f. Plasma emitted directly to indoor air contains ozone and other reactive oxygen species such as hydroxyl radicals, superoxides, and hydrogen peroxide. Plasma air cleaners are sometimes combined with other air-cleaning technologies, such as PCO or adsorbent media, but very little information exists on the performance of these systems in real indoor settings. and also, a number of harmful byproducts are known to form, including particles, ozone, carbon monoxide, and formaldehyde

how is the Performance of an Air Cleaner Measured?

There are different ways to measure how well air-cleaning devices work, which depend on the type of device and the basic configuration. Air cleaning devices are configured either in the ductwork of HVAC systems (i.e., in-duct) or as portable air cleaners. The effectiveness of an air-cleaning device or system is a measure of its ability to remove pollutants from the spaces in which it is operated.

➢ In-duct Particle Removal:

Most **mechanical air filter**s are good at capturing larger airborne particles, such as dust, pollen, dust mite and Cockroach allergens, some molds, and animal dander. However, because these particles settle rather quickly, air filters are not very good at removing them completely from indoor areas. Although human activities such as walking and vacuuming can stir up particles, most of the larger particles will resettle before an air filter can remove them.

The efficiency is measured by the minimum efficiency reporting value (MERV) for air filters installed in the ductwork of HVAC systems. MERV ratings (ranging from a low of 1 to a high of 20), which is developed by ASHRAE Standards.

Note:

installation of a HEPA filter in an existing HVAC system would probably require professional modification of the system. A typical residential air handling unit and the associated ductwork would not be able to

accommodate such filters because of their physical dimensions and increase in airflow resistance. And HVAC systems may not have enough fan or motor capacity to accommodate higher efficiency filters.

For **electronic air cleaners** there is no standard measurement for the effectiveness. While they may remove small particles, they may be ineffective in removing large particles. Electronic air cleaners can produce ozone—a lung irritant. The amount of ozone produced varies among models. Electronic air cleaners may also produce ultrafine particles resulting from the reaction of ozone with indoor chemicals such as those coming from household cleaning products, air fresheners, certain paints, wood flooring, or carpets. Ultrafine particles may be linked with adverse health effects in some sensitive populations.

- **In-duct Gaseous Pollutant Removal:**

No standard measurement for the effectiveness of gas-phase air filters, but ASHRAE is developing a standard method to be used in choosing gas-phase filters installed in home HVAC systems.

Notes: some point should be considered when installed in home HVAC system:

- The useful lifetime of gas-phase filters can be short because the filter material can quickly become overloaded and may need to be replaced often;
- There is also concern that, when full, these filters may release trapped pollutants back into the air.
- a properly designed and built gas-phase filtration system would be unlikely to fit in a typical home HVAC system or portable air cleaner.

- **In-duct Pollutant Destruction:**
  - **UVGI cleaners**: Although there is some standard for the measurement of the output of a UV-C lamp, types of UV-C lamp, lamp ballast and evaluating output power of UV-C lamps. There is no standard measurement for the effectiveness of UVGI cleaners. Typical UVGI cleaners used in homes have limited effectiveness in killing bacteria and molds, so when use it some point should be put it into consideration:
    - Effective destruction of some viruses and most mold and bacterial spores usually requires much higher UV exposure than is provided in a typical home unit.
    - dead mold spores can still produce allergic reactions, so UVGI cleaners may not be effective in reducing allergy and asthma symptoms.

- **PCO cleaners**: There is no standard measurement for the effectiveness of PCO. There are few field investigations to validate the performance of PCO air cleaners, and laboratory studies demonstrate high variability and often relatively low removal efficiency for many common indoor gases.

  Notes: some point should be considered when installed in home HVAC system:

  - Currently available catalysts of the PCO are ineffective in destroying gaseous pollutants from indoor air, and there are no enough studies for that.
  - Some PCO cleaners fail to destroy pollutants and instead produce new indoor pollutants that may cause irritation of the eyes, throat, and nose.

➢ **Portable Air Cleaners:**

- Portable air cleaners generally contain a fan to circulate the air and use one or more of the air cleaning devices discussed above.

  Portable air cleaners can be evaluated by their effectiveness in reducing airborne pollutants. This effectiveness is measured by the clean air delivery rate (CADR).

Room area (square feet)	100	200	300	400	500	600
Minimum CADR (cfm)	65	130	195	260	325	390

Summary of Air-Cleaning Technologies:

Here is the summary of Air-Cleaning Technologies and their Advantages and Disadvantages:

Air-cleaning technology	Targeted indoor air pollutant(s)	Mechanism(s) of action	Advantages	Disadvantages	Test standards (and rating metrics)
Chemisorbent media	Particles	Collection: Gases chemically adsorb onto media coated or impregnated with reactive compounds	Potential for high removal efficiency for many gaseous pollutants Chemisorption is an irreversible process, meaning pollutants are permanently captured	-Regular replacement is required because its chemisorption capacity is exhausted -Effectiveness of many consumer-grade systems is unknown -High pressure drops on some sorbent media filters can negatively impact --HVAC systems -Different removal efficiency for different gases at different concentrations	Media: ANSI/ASHRAE Standard 145.1 (no rating metric) In-duct air cleaners: ANSI/ASHRAE Standard 145.2 (no rating metric) No effectiveness standards
Electrostatic precipitation (ESP)	Particles	Collection: Corona discharge wire charges incoming particles, which collect on oppositely charged plates	-Can have high removal efficiency for a wide range of particle sizes -Low pressure drop and minimal impacts on HVAC systems -Low maintenance requirements	Sometimes ESPs have high ozone and nitrogen oxide generation rates Efficiency typically decreases with loading and plates require cleaning High electric power draw requirements	ANSI/UL Standard 867 for electrical safety and ozone emissions (similar to IEC 60335-2-65) (pass/fail; no rating metric)
Ionizers (i.e., ion generators)	Particles	Collection: Similar to ESP, ionizers use	-Typically, low power draw requirements -Quiet	-Generates ozone -Typically, low effectiveness because of very low airflow rates and clean air delivery rates (CADRs)	None specific to ionizers, although AHAM AC-1 can be used to measure CADR
Ultraviolet germicidal irradiation (UVGI)	Microbes	Destruction: UV light kills/inactivates airborne microbes	-Can be effective at high intensity with sufficient contact time	-Uncoated lamps can generate ozone Potential for eye injury -Effectiveness increases with lamp intensity, which is	Air irradiation: ANSI/ASHRAE Standard 185.1 Surface irradiation:

			-Can be used to inactive microbes on cooling coils and other surfaces	typically low in residential UVGI air cleaners -High electrical power draw requirements Inactivates but does not remove microbes	ANSI/ASHRAE Standard 185.2
Adsorbent media	Gases	Collection: Gases physically adsorb onto high-surface-area media (typically activated carbon)	-Potential for high removal efficiency for many gaseous pollutants in air cleaners with a sufficient amount of media for the application -No byproduct formation	-Regular replacement is required because its adsorption capacity is exhausted and physical adsorption is a reversible process, meaning pollutants may not be permanently captured -Effectiveness of many consumer-grade systems with small amounts of activated carbon is unknown -High pressure drops on some sorbent media filters can negatively impact HVAC systems -Different removal efficiency for different gases at different concentrations	Media: ANSI/ASHRAE Standard 145.1 (no rating metric) In-duct air cleaners: ANSI/ASHRAE Standard 145.2 (no rating metric) No effectiveness standards
Chemisorbent media	Gases	Collection: Gases chemically adsorb onto	-Potential for high removal efficiency for many gaseous pollutants -Chemisorption is an irreversible process, meaning pollutants are permanently captured	-Regular replacement is required because its chemisorption capacity is exhausted -Effectiveness of many consumer-grade systems is unknown -High pressure drops on some sorbent media filters can negatively impact HVAC systems -Different removal efficiency for different gases at different concentrations	Media: ANSI/ASHRAE Standard 145.1 (no rating metric) In-duct air cleaners: ANSI/ASHRAE Standard 145.2 (no rating metric) No effectiveness standards
Catalytic oxidation	Gases	Conversion: Most utilize photocatalytic oxidation (PCO) in which a high-	-Can degrade a wide array of gaseous pollutants (e.g., aldehydes,	-Can generate harmful byproduct such as formaldehyde, and acetaldehyde, and ozone -No standard test methods	None specific to PCO

		surface-area medium is coated with titanium dioxide as a catalyst; incoming gases adsorb onto the media and UV lamps irradiate and activate the titanium dioxide, which reacts with the adsorbed gases to chemically transform them	aromatics, alkanes, olefins, halogenated hydrocarbons) -Can be combined with adsorbent media to improve effectiveness	-Often relatively low removal efficiency for many indoor gases, but high variability in removal for different gases Lack of field studies to validate performance -Catalyst often has a finite lifespan	
Plasma	Gases	Conversion: Electric current is applied to create an electric arc; incoming gases are ionized and bonds are broken to chemically transform the gaseous pollutants	-Can have high removal efficiency -Can be combined with other air-cleaning technologies (e.g., PCO) to improve performance and minimize byproduct formation	-Wide variety of plasma generation types yield confusion on how a product actually works -Byproducts are formed from many plasma technologies, including particles, ozone, formaldehyde, carbon monoxide, chloroform, nitrogen oxides, and a large number of other organic gases -Most studies have investigated gaseous removal while fewer have evaluated particle removal	None specific to plasma
Intentional ozone generation	Gases	Conversion: Intentional generation of ozone using corona discharge, UV, or other method to oxidize odorous compounds and other gases	-Reacts with many indoor gases -Can be combined with other less-harmful technologies such as adsorbent media	-High ozone generation rates -High amounts of byproduct formation -Can cause degradation to indoor materials	None specific to ozone generators

11. References

- Local Order No. (11) of 2003 Concerning Public Health and Safety of the Society in the Emirate of Dubai.
- Administrative order No. (30) Of 2007 concerning the issuance of the Executive Regulation of Local Order No. (11) of 2003 Concerning Public Health and Safety of the Society in the Emirate of Dubai.
- Dubai Municipality Approved Consumer Product Guidelines.
  - DM-HSD-GU29-TGHS2_Technical Guidelines for Health Supplement
  - DM-HSD-GU82-BIO2_Technical Guidelines for Biocides
  - DM-HSD-GU30-TGD2_Technical Guidelines for Detergents
- Dubai Municipality guideline for legionella control.
  DM-HSD-GU44-LCWS2_Technical Guidelines for Legionella Control in Water System
- Public swimming pools safety guidelines.
  DM-HSD-GU81-PSPS2_Public Swimming Pools Safety Guidelines
- Public and occupational safety guidelines.
  - DM-HSD-GU39-CSE2_Technical Guidelines for Confined Spaces Entry
  - DM-HSD-GU41-GDM2_Guarding of Dangerous Machinery
  - DM-HSD-GU46-KFPA2_Technical Guidelines for Occupational Health and Safety in Kitchen & Food Areas
  - DM-HSD-GU53-LPGC2_Technical Guidelines for Liquefied Petroleum Gas Cylinders
  - DM-HSD-GU73-SUL2_Technical Guidelines for Safe Use of Ladders
  - DM-HSD-GU74-MAT2_Technical Guidelines for Mobile Access Towers

For (suggestions, comments, and complaints)	For further information
▪ Unified interactive platform that connects Dubai Government and its customers: The 04 Platform https://04.gov.ae/ ▪ ✆ Dubai Municipality - Call Center (24/7): 800900	▪ ✉ ehcinspection@dm.gov.ae ▪ ✆ Dubai Municipality - Call Center (24/7): 800900