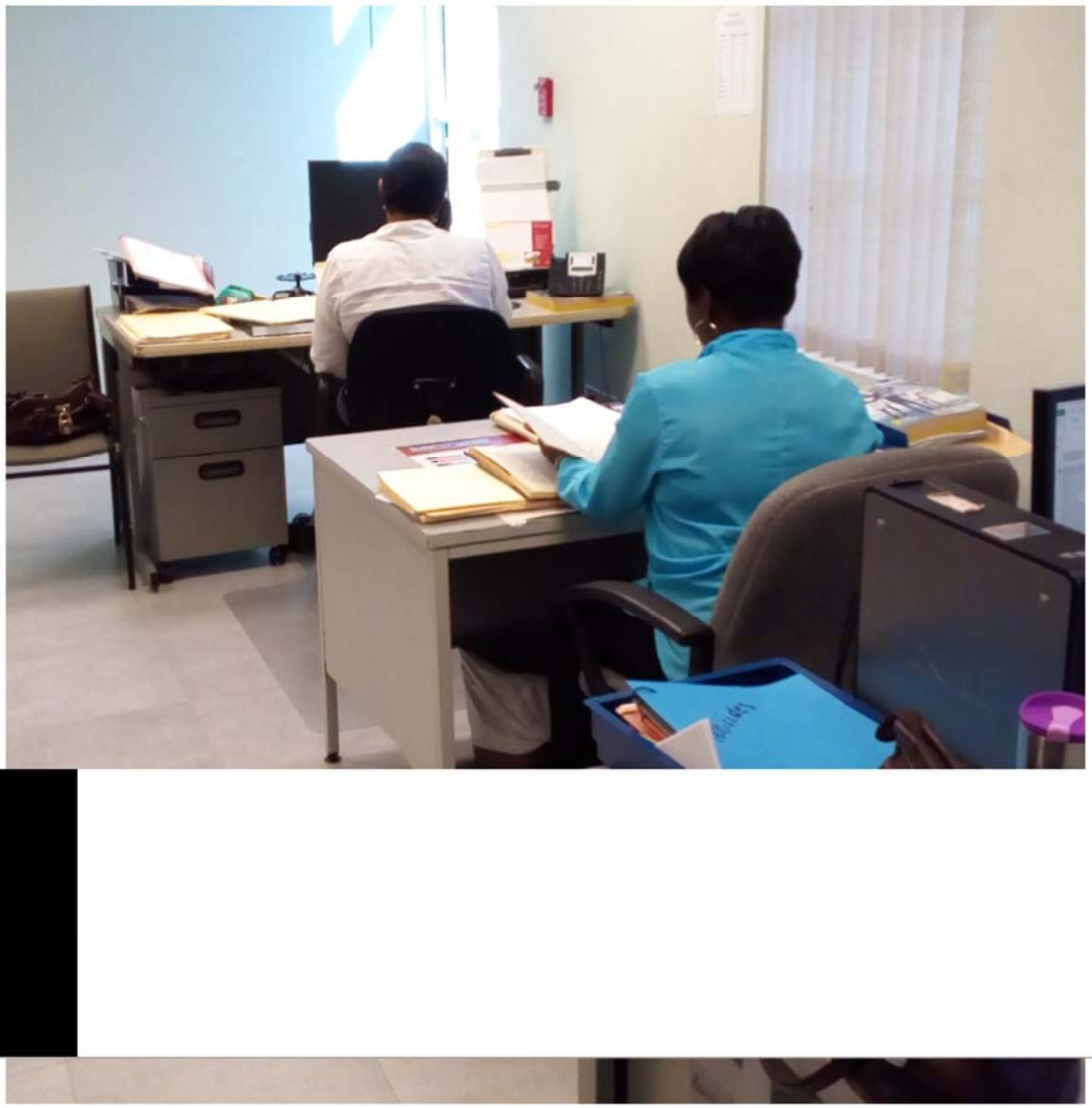

2016

ENVIRONMENTAL PROTECTION DEPARTMENT

FOREWORD

The purpose of this guidebook is to educate and provide guidance for those individuals responsible for building maintenance and monitoring the indoor air quality up to and including the maintenance of the Ventilation and Air Conditioning Systems (VAC).

The majority of indoor air quality complaints in Barbados are the result of poor ventilation, fungal growth, poor housekeeping practices and use of chemicals.

It should be noted that the information contained in this manual was adapted from literature published by Health Canada, The United States Environmental Protection Agency (US EPA), British Columbia Ministry of Health, State of California Health and Welfare Agency, the US Centers for Disease Control (CDC) of the National Institute for Occupational Health and Safety (NIOSH) and the International Agency for Research on Cancer of the World Health Organization (WHO).

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GLOSSARY

Adsorption	A process where gases adhere themselves to a material's surface.
Air Curtain	A device that is used to separate two different zones by generating a high velocity stream of air. These curtains are usually mounted over doorways and powered by a fan that generates enough thrust to create an air stream that reaches the floor and will limit air flow into the office or room.
ASHRAE	American Society for Heating, Refrigerating and Air-Conditioning Engineers
Building Related Illness (BRI)	A clinically diagnosable disease or condition (as Legionnaires' disease or an allergic reaction) caused by a microorganism or substance demonstrably present in a building (Merriam Webster, 2013)
Conditioned Air	A blend of outdoor and recirculated air that has been filtered heated or cooled and sometimes humidified or dehumidified depending on the specific needs of the building and it occupants.
Diffusion	The spontaneous migration of substances from regions where their concentration is high to regions where their concentration is low.

Electrostatic	To have a static charge. This is not dependent on the motion of the particles involved.
Free Radicals	Free radicals are atoms or groups of atoms with an odd number of electrons and can be formed when oxygen interacts with certain molecules, once formed these highly reactive radicals can start a chain reaction. Their chief danger comes from the damage they can do when they react with important cellular components such as DNA, or the cell membrane.
IAQ	Indoor Air Quality
Interception	Particles are prevented from getting past the filter into the air stream.
Impaction	This is the process by which particles strike and become firmly fixed in the filter preventing others from passing through.
MSDS	Material Safety Data Sheet
Parts per million (ppm)	The concentration of CO_2 and other gases is normally represented in units of parts per million (ppm). For example, 2 ppm represents 2 parts out of a million parts.
Pest Management	Pest management involves the handling, storage and application of pesticides.
Sick Building Syndrome	SBS is a phenomenon in which “people have a range of symptoms related to a certain building, most often a workplace

and there is no specific identifiable cause." Examples of symptoms include nausea, headaches, dizziness and fatigue (National Health Service, 2012).

1 INDOOR AIR QUALITY IN BARBADOS

Indoor Air Quality (IAQ) has become a significant environmental issue in Barbados in recent years. Consequently, there have been increasing numbers of IAQ complaints from all sectors of society.

Historically, buildings were designed with the tropical climate and the prevailing trade winds in mind. Hence, older buildings were designed to use natural ventilation and cooling to provide a comfortable environment. As urban centres developed, buildings became significantly larger with the introduction of multiple internal offices. This restricted the flow of air within the newer buildings, which created the need for improved ventilation within the buildings. Hence, newer buildings generally use Ventilating and Air Conditioning (VAC) systems, which provide cooling, ventilation and humidity control for the building.

In the past, coral-stone and wood were frequently used as building materials because they were readily available and easy to use. Modern office buildings in Barbados tend to be constructed from steel and concrete with some buildings using sheets of various materials for internal partitions. Different issues are associated with the different types of materials; for example, coral-stone and wood can absorb moisture and this can lead to mould growth in some cases. This can become worse when these wooden and coral-stone buildings that were originally intended to be naturally ventilated are sealed, enclosed and air-conditioned. In newer buildings, some synthetic materials can release gases that can negatively impact on IAQ.

Additionally, the modern office is filled with potential pollution sources including electronic devices like photocopiers, laser printers and computers; and chemicals such as cleaning products and pesticides. Outdoor air pollution can enter the building via different pathways such as VAC plant rooms and through pedestrian traffic, thereby causing the level of contaminants in the indoor air to increase. The rising numbers of vehicles on the roads, as well as the development of industries such as auto body

repairs and manufacturing have increased the levels of pollutants in the air. Therefore, there is an increased need to filter the air being introduced into a building.

The health effects of these contaminants may have led to the phenomenon of sick building syndrome (SBS). With SBS the causes of occupant complaints are multi-faceted and often elusive and can involve chemical, microbiological, physical and psychological mechanisms. Analysis of air samples may not reveal significant concentrations of any one contaminant, so the problem is often attributed to the combined effects of many pollutants at low concentrations, complicated by other environmental factors. For example, several factors influence thermal comfort, such as temperature extremes, humidity extremes, drafts and lack of air circulation. Likewise, odours are often associated with a perception of poor air quality, whether or not the source of the odours can cause adverse reactions. Environmental stressors such as noise, vibration, overcrowding and poor workplace design and lighting can produce symptoms that may be confused with the effects of poor air quality. Further, physical discomfort or psychosocial problems (such as job stress) can reduce tolerance for substandard air.

The majority of indoor air quality complaints in Barbados are the result of:

- poor ventilation due to inadequately designed ventilation systems and/or inappropriate layouts;
- poor housekeeping practices in the form of inadequate cleaning schedules, poor cleaning practices and inappropriate storage of papers and chemicals;
- use of chemicals inside and outside of a building;
- fungal growth which is usually due to excess moisture caused by leaks from VAC units, leaky water coolers, excessive watering of plants and moisture trapped in building materials; and
- maintenance and renovation activities being conducted in occupied buildings without the appropriate controls in place.

The old adage “prevention is better than the cure” generally holds true when it comes to IAQ issues. Therefore it can be said that the expense and effort involved in preventing IAQ problems is significantly less than what it would cost to fix problems after they have occurred. Most IAQ problems can be prevented by educating staff, building occupants and facility/building managers about the factors that cause such problems. Additionally, the majority of IAQ problems can be resolved by simple adjustments in maintenance and housekeeping practices inside and outside of the building, as well as changes in employee habits.

Many occupants are quick to say "test the air!" However, you must first have an idea of the source of the problem to determine what pollutant(s) to test. A test will only reveal the concentration of the pollutant(s) being tested for and when you get the readings, there must be a standard or guideline against which you can compare it to determine what the readings actually mean in terms of health or environmental impacts. An air test can also be inconclusive as pollutants may be present in levels too low to monitor, or symptoms being experienced may be the result of a combination of contaminants. Therefore, any air testing should be done in conjunction with a walkthrough of the building. More often than not, the walkthrough itself will identify any issues that need to be addressed. While air sampling can be very useful, it can be quite expensive to have it done. Where IAQ complaints exist, persons responsible for property management should conduct an investigation in order to identify any problems and find solutions.

The approach put forward in this manual is solution-oriented and systematic in nature. The investigator must read the clues and carefully interpret them in order to solve any problems that may arise. It should be noted that most complaints, especially in smaller buildings, can be handled on site by persons who understand the layout and operation of the building, and how components of these may contribute to IAQ issues. This handbook should equip the reader with the basic tools to carry out this investigation.

2 VENTILATION

Ventilation involves the introduction of outdoor air, the removal of "stale" air and the circulation of air around a room, building or space. If an area is well ventilated there is adequate fresh/outdoor air coming in, adequate removal of irritants or pollutants (such as smoke, odours, moisture, etc) and adequate circulation of air. Good ventilation contributes to good indoor air quality because it:

- helps control the level of irritants/pollutants present;
- aids with temperature and moisture control;
- replenishes oxygen;
- adequately distributes air to the area/room; and
- removes excess carbon dioxide.

2.1 Two basic types of ventilation- Natural or forced

Ventilation can be natural or forced. Natural ventilation requires no equipment while forced ventilation utilises some type of equipment.

Natural ventilation can be facilitated by simply opening a window or door. Provided the windows, doors or other openings are suitably positioned, this can result in the free flow of air through the building or space. With natural ventilation there is no fan, machine or device that brings in air, removes air or circulates it.

On the other hand forced ventilation means that a mechanical device (e.g. a fan) forces air in, out or around a space. Some devices also cool the air before circulating it. Standing fans, wall fans, ceiling fans and hoods above kitchen stoves are all common examples of equipment that facilitate forced ventilation. The air conditioning unit is an example of a piece of equipment that can facilitate forced ventilation and additionally cools the air before pushing it into a room/space.

Some points to note about the two types of ventilation are as follows:

Table 1: Natural ventilation versus forced ventilation

Natural Ventilation	Forced Ventilation
No mechanical means is used to facilitate the exchange or circulation of air. Complex systems allow warm air to rise and flow outside via upper openings. This forces cooler air into the building.	A fan or other mechanical means is used to facilitate the exchange or circulation of air.
These systems use very little or no energy and there is little control over variables such as the rate at which air is exchanged. Continuous monitoring is necessary to ensure that the occupants are comfortable.	Energy input is required, often electrical, and there is greater control over variables such as flow rate.
Effective in cooling small spaces.	Once designed properly it can be effective at cooling small as well as large spaces.

Since natural ventilation methods such as opening doors or windows or using fans are quite simple and familiar, we will focus now on ventilation and air conditioning (VAC) systems. The VAC system should be designed to

- provide thermal comfort;
- distribute outdoor air to occupants; and
- remove odours and contaminants.

VAC systems pass a refrigerant through pipes/coils (evaporator) which then get cold. Air is passed over these cooled coils and this causes the temperature of the air to decrease (i.e. get cool) before being distributed. The refrigerant is then pumped to another component of the system (condenser), where the heat is removed from the refrigerant. When the refrigerant has cooled down enough, it is sent back to be reused in the process.

There are various types of air conditioning systems. Three of the most popular types of air conditioning systems are:

i. central VAC systems,
ii. duct-less mini split units (commonly referred to as a “split systems”); and
iii. window units.

2.1.1 CENTRAL VAC SYSTEM

In Barbados, central air conditioning systems are most often seen in offices and public buildings like shopping malls. Central systems are usually large systems that filter, cool and distribute air from one (centralized) location before distributing the air via ducts to various rooms or spaces. Central VAC systems distribute a mixture of outdoor and re-circulated indoor air.

There is a minimum amount of outdoor air that should be brought in by a central system. This minimum volume of outdoor air depends on factors such as the number of occupants and the activity being conducted in the room(s) and should be calculated according to ASHRAE Standard 62. The outdoor air is usually brought in to the VAC system through a vent in the wall which opens to the outdoors. The vent is sometimes just a simple opening in the wall with a mesh screen or even a louvered window that can be manually adjusted by the air conditioning technician. The outdoor air vent can also be fitted with a damper which is controlled by the VAC system to modify the volume of air that is drawn into the system. In some instances, there may be a fan which helps to draw the outdoor air towards the cooling unit.

It should be noted that untreated outdoor air may enter the building in unknown and uncontrolled quantities through windows, doors, gaps in the buildings structure and vents. Uncontrolled introduction of outdoor air can put strain on the VAC system.

If your building has a central system you should have these basic parts of the system:

- **The air cooling unit**

This is a combination of components that filter and cool the air before distributing it to the rooms. These components may not be in plain sight as they may be in a room (See Figure 1), on the roof or outside.

Figure 1: Evaporative component of the air handling unit, commonly referred to as the 'air handler'. This is usually located within an air-handling room.

The type of condenser used by your system depends on the type of refrigerant used. Many systems in Barbados use a gaseous refrigerant to cool the air and the condenser has the following appearance (Figure 2).

Figure 2: Condensing component of an air-handling unit. This is usually located on the roof of a building

There are various types of units, but they all work on similar principals:

- Some buildings use **'package units'** where the evaporator and condenser are housed in the same unit, which is placed on the exterior of the building.
- Very large buildings or complexes may use a **chilled water system**. In these systems, cold water is the refrigerant, fan coil units act as the evaporators, and the condenser is in the form of a cooling tower.

- **Ducts**

  Some ducts bring air into the room (supply ducts) and others carry it away from the room (return ducts). Ducts are usually hidden within the ceiling and not usually in plain sight (See Figure 3).

Figure 3: Ducts in ceiling

- **Diffusers**

  These vents are the points at which the cooled air enters the room (from the ducts). You would see these in the ceiling. They may have different appearances but most look like the photo shown in Figure 4.

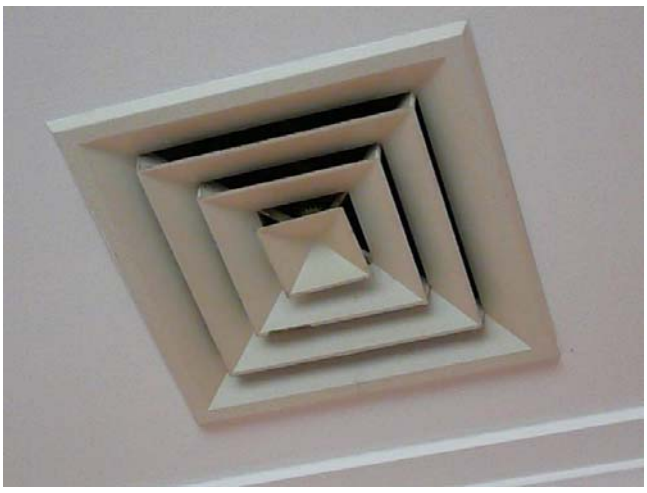
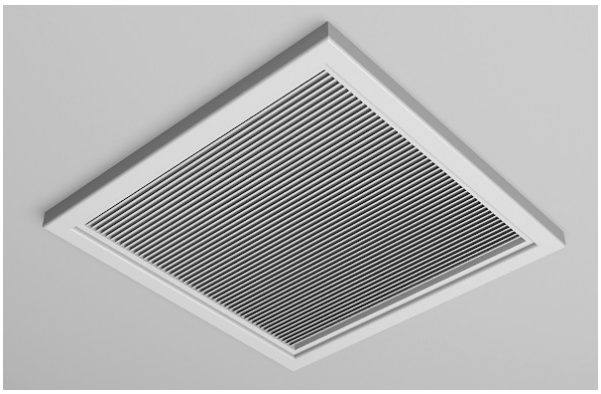


Figure 4: Typical diffuser vent

- **Returns**

  These are the points at which air leaves the room and goes back to the evaporative (air cooling) unit. They have different appearances but may look like the photo in Figure 5. They are usually located in the ceiling or in the door.

Figure 5: Typical return grille



The alternative to using a large system and a bulky network of ducts to cool an area is to use unit ventilators such as window units and/or split systems.

2.1.2 DUCTLESS MINI SPLIT (COMMONLY REFERRED TO AS A "SPLIT SYSTEM")

Ductless mini split air conditioning units are also known as 'mini splits' or 'split systems'. Mini splits do not introduce outdoor air nor will they remove irritants/ pollutants. This can result in office occupants experiencing discomfort due to the accumulation of polluted air. Hence these systems require the appropriate supplemental intake and extraction systems. For further information on inspecting mini-split systems, please see Chapter 7. Mini-split systems can have various external appearances. Examples of the components of the most common type in Barbados are shown in Figure 6 and Figure 7.

Figure 6: Typical components of a ductless mini-split: The evaporator is mounted on the wall inside of the area being cooled.

Figure 7: Typical components of a ductless mini-split: The condenser is placed on the outside of the building.

2.1.3 WINDOW UNITS

Window air conditioning units are mounted in a window or through a wall. These units are designed for the delivery of cool conditioned air to the room either without ducts or with very short ducts. Window units usually bring in outdoor air. In these units, both the evaporator and the condenser are housed in an all-in-one body. A typical window air conditioning unit is shown in Figure 8.

Figure 8: Typical window unit

Window units have all of the components housed in one box. Window units tend to be noisy because the compressor *(which is a part of the condenser)* is noisy.

3 FACTORS AFFECTING THE INDOOR ENVIRONMENT

The indoor environment is affected by the climate, ventilation system, occupants and potential contaminant sources. Contaminants can have a variety of indoor and/or outdoor sources as demonstrated in Table 2.

Table 2: Possible sources of air pollution and their causes[1]

FACTOR	SOURCE / CAUSE
Temperature and humidity extremes	Improper placement of thermostats, poor humidity control, inability of the building to compensate for climate extremes, tenant-added office equipment and processes
Carbon dioxide	People, combustion of fossil fuels (e.g., gas and oil furnaces or boilers)
Carbon monoxide	Automobile exhaust (garages, loading docks, air intakes), combustion
Formaldehyde	Unsealed plywood or particleboard, urea, formaldehyde, foam insulation, fabrics, glues, carpets, furnishings, carbonless copy paper
Particulate matter	Smoke, air inlets, paper, duct insulation, water residue, carpets, VAC filters, housekeeping activities
Volatile organic compounds (VOCs)	Copying and printing machines, computers, carpets, furnishings, cleaning materials, smoke, paints, adhesives, caulking, perfumes, hairsprays and solvents
Inadequate ventilation	Poorly designed energy-saving and maintenance measures, improper system design or operation, occupant tampering with VAC system, poor office layout, uneven airflow
Microbial matter	Stagnant water in VAC system, wet and damp materials, humidifiers, condensate drainage pans and water towers

1 Health Canada. (1993)

3.1 Thermal Comfort and Humidity

An individual's comfort level in relation to the temperature of the indoor air can be affected by variables such as, age, physiology, activity levels, humidity, uniformity of temperature and radiant heat gain or heat loss. The American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) Standard 55-2010 "Thermal Environmental Conditions for Human Occupancy" has proposed temperature and humidity ranges (Table 3) that should be comfortable for persons involved in sedentary activities.

Table 3: Temperature and humidity ranges that provide thermal comfort for 80% of the individuals in an office

Temperature/ Humidity Ranges for Comfort[2]		
Conditions	**Relative Humidity**	**Acceptable Operating Temperatures/°C**
Summer (light clothing)	If 30 % then	24.5 - 28.0
	If 60 % then	23.0 - 25.5
Winter (warm clothing)	If 30 % then	20.5 - 25.5
	If 60 % then	20.0 - 24.0

When the relative humidity is high this affects a person's ability to cool down efficiently through the evaporation of perspiration. An increase in humidity has a similar effect to an increase in temperature. Humidity extremes outside of the optimal range of 25-60 % can cause discomfort. Additionally, high relative humidity can promote the growth of moulds and other fungi. In order to combat this, air-conditioned buildings often have sealed windows, to prevent untreated air from entering the system.

A dehumidifier is a device used to reduce the humidity of a room or building. These are often deployed in areas like basements which have a higher relative humidity and tendency for damp floors and walls. Conversely, a humidifier increases the humidity of a building; however, these are uncommon in this tropical climate.

With respect to temperature, it is impossible to please everyone. As a rule of thumb, the temperature is satisfactory when eighty percent (80%) of people are satisfied.

2 CCOHS (2011).

3.2 Radiant Heat

Radiant heat is emitted from any object which is warmer than its surrounding environment. As a result, the surrounding air is heated via convection. (Convection is the transfer of heat by currents within a fluid, which is air in this case.)

Even if the ambient temperature is within the comfort range, radiant heat can make building occupants uncomfortable. Examples of radiant heat sources include windows without shades, curtains, tinting or a reflective coating to minimise heat gained during the course of the day as the angle of the sun changes. Large vertical surfaces can produce natural convection currents creating drafts resulting in temperature fluctuations. Additionally, un-insulated walls can be sources of radiated heat gains within a building. People sitting close to these sources can be affected by the temperature differences.

- **Identify radiant heat sources and take steps to minimise their impact.**

3.3 Moisture and Mould/Fungi

In modern buildings, the main sources of excess moisture are as follows:

- Leaks (e.g. roof, windows, plumbing)
- Infiltration through porous building materials (e.g. coral-stone, soft-stone)
- Inadequate removal of moist air from 'wet' areas (e.g. bathrooms, kitchens, janitorial closets with sinks)
- High relative humidity (e.g. from untreated humid outdoor air)
- Excess water (e.g. spillage from over-watering office plants, overflowing VAC unit condensate pans, condensate dripping from uninsulated VAC pipes)

While excess moisture may compromise the structural integrity of floors, walls and ceilings, it can also promote the growth of moulds (filamentous fungi). Fungi are found in nature and play a necessary part in the breakdown of leaves, wood and other plant debris but these micro-organisms can enter a building directly or when their spores are carried by the air. When found in a building, they can grow on wood, drywall, upholstery, fabric, wallpaper, drapery, ceiling tiles, carpeting and even inside of the air-conditioning duct network.

The presence of mould does not always mean that health problems will occur. However, when the mould, mould fragments or spores are inhaled, this can lead to health problems or aggravate existing conditions for some people. In addition, some moulds produce "mycotoxins" that can slowly wear down the immune system and can lead to allergic or respiratory problems. When manifested, these symptoms may be similar to hay fever, asthma attacks and dermatitis.

Exposure to toxinogenic moulds may result in headaches, sore throat, coughing, skin rash, flu-like symptoms, fatigue and fever. Mould spores become airborne when mould growth is disturbed, after which they can be inhaled by persons who may have allergic reactions. For example, asthmatics may develop more frequent and severe asthma attacks. Prolonged exposure to mould in buildings may result in the development of allergies or *hypersensitivity pneumonitis,* which can cause permanent lung damage.

Moulds can also exacerbate the symptoms of allergies including wheezing, chest tightness and shortness of breath as well as nasal congestion and eye irritation. People who are immunosuppressed or recovering from surgery are usually more susceptible to health problems from moulds.

Moulds flourish in Barbados due to the warm, humid climate. They are found especially in buildings with moisture problems due to leaks and moisture seepage into walls, particularly those made of coral stone. There is no practical way to eliminate all mould and mould spores in the indoor

environment; so the key to controlling indoor mould growth is to control moisture.

- **Fix all leaks promptly and replace all moisture damaged material if it cannot be adequately dried**.

3.4 Carbon Dioxide

Carbon dioxide (CO_2) is a colourless, odourless gas. It is a normal constituent of the atmosphere at approximately 400 ppm (parts per million). CO_2 is generated indoors primarily through human metabolism. The concentration of carbon dioxide indoors varies throughout the day and can range from 350 to 2500 ppm[3]. Levels of carbon dioxide above 850 ppm can result in discomfort, lethargy, stuffiness and headache. The concentration in indoor air can, under certain conditions, provide a good indication of the ventilation rate.

The VAC engineer can consider the following to address high CO_2 levels:

- **Adjust and rebalance the system** to reflect current occupancy levels, heat and contaminant generation locations.
- **Increase the (filtered) outdoor air supply.**
- **Control pressure relationships** by exhausting (extracting air to the outside from) areas where pollutants are generated.
- **Upgrade the air distribution system** by increasing fan capacity in either the supply or the return system.
- **Alter the source/distribution relationship** by changing the physical arrangements of supply and return diffusers.

The office manager can review the areas where staff members are stationed and where certain functions are carried out.

3 Mendell et al (as cited in Apte et al, 2000)

3.5 Carbon Monoxide

Carbon monoxide (CO) is a colourless, odourless, toxic gas that is a product of incomplete combustion. Carbon monoxide pollution occurs when combustion gases are not properly exhausted or are being re-entrained into the building. CO should be measured if there are complaints of exhaust odours or if there is some other reason to suspect a problem with internal combustion gases.

In offices and commercial buildings, common sources of combustion contaminants include smoking areas, garages and loading docks that are attached or have a pathway to working spaces. Air intakes located at ground level or adjacent to vehicles or other combustion sources can transport contaminants to areas served by the air handling system.

Carbon monoxide is an extremely toxic gas as it bonds more readily with haemoglobin in the blood, reducing the oxygen supply to the body. Carbon monoxide levels higher than 5 ppm can indicate a problem. At elevated levels, symptoms of exposure include headaches, decreased alertness, flu-like symptoms, nausea, fatigue, rapid breathing, chest pain, confusion and impaired judgment. The degree to which these symptoms occur depends on health status and individual variations in sensitivity, so specific responses at a given concentration will vary among individuals.

The building manager can:

- **Close pathways between the contaminated area and the occupied space.** (e.g. ensure that doors are well sealed)
- **Modify operating procedures.** (e.g. have delivery drivers turn off engines while waiting)
- **Remove or relocate the source.**

The VAC engineer can:

- **Ensure that offices adjacent to parking garages and loading docks are under positive pressure.** (i.e. air should move from the office out to the exterior of the building, not the other way around)
- **Increase the (filtered) outdoor air supply to the problem area.**
- **Modify the ventilation system** – (e.g. install local exhaust or

Particulates are solid or liquid matter with aerodynamic diameters ranging from 0.005 to 100 μm. Dusts, fumes, smoke and organisms such as viruses, pollen grains, bacteria and fungal spores are solid particulate matter, whereas mists and fog are liquid particulate matter. Fibres such as asbestos and fibreglass are also classified as particulates. Regardless of a person's health, particulates can still irritate the respiratory tract, thereby exacerbating or triggering respiratory ailments such as asthma.

Indoor particulates can come from either sources inside the building or outdoor sources, which can enter the building via infiltration and be drawn in through outdoor intakes. The mechanical ventilation system itself may be a source of particulates (e.g. lime, scale, rust, disinfectants, micro-biological growth and duct and pipe insulation). The duct system requires careful maintenance to prevent microbial growth and accumulation of particulates. Therefore, a thorough inspection of the ductwork system should be undertaken periodically, in order to ensure sanitary conditions within the air-distribution system.

It should be noted that the structural integrity of fibreglass ductwork may deteriorate over time and this may generate particles that are small enough to become airborne. Fibreglass can irritate the eyes, nose and throat and can cause irritation and rash on sensitive skin. Most airborne fibreglass fibres are trapped in the nose and throat where they can cause irritation. However, some of the particles are much smaller and penetrate deeper into the lungs where they can cause *pneumoconiosis*, which affects the lungs. Damage can be severe enough to lead to disability and eventually death. It is common knowledge that asbestos is a carcinogen, given that fibreglass has similar properties, it is also anticipated to be human carcinogen by the international community. Therefore, although no comfort standards currently exist for respirable glass fibres, exposure should be minimised through safe work practices. Additionally, asbestos removal should only be done by a contractor certified by the EPD.

In order to minimise the release of particulates to the work environment, any work areas undergoing renovations or remodelling should be sealed off and damaged ceiling tiles, pipe insulation, sound barriers and so on should be replaced or repaired. The steps to follow during renovations are discussed further in Section 4.2.2.

- **Place a mat at the entrance to the building so that persons can remove excess material from their shoes.**
- **Use wet wiping rather than dry dusting. Vacuum rather than sweep.**
- **Use positive pressure or air curtains to reduce the volume of particulates entering through doorways.**
- **Employ efficient housekeeping and filing techniques to manage the stored paperwork.**
- **Remove or relocate the source of particulates.**
- **Select a filter with a minimum efficiency reporting value (MERV) rating of 9 and up.**
- **Ensure that the filters are changed regularly, if not they will slow the airflow and also become a source of contaminants.**
- **If necessary, use an appropriate mechanical or electronic air cleaning device. NOTE!!! Some electronic cleaners can produce ozone as a by-product. See Section 3.8.1.)**
- **Choose the air cleaning device according to its efficiency and effectiveness.** "Efficiency" measures the percentage of airborne particles and gaseous pollutants a device can remove from the air passing through it. "Effectiveness" measures how well the device can reduce airborne particles or gaseous pollutants within the occupied space.

3.7 Volatile Organic Compounds (VOCs)

The term "organic compounds" refers to all chemicals containing carbon and hydrogen. Volatile organic compounds are those organic compounds that have boiling points roughly in the range of 50˚C - 250˚C. There are several thousand synthetic and natural chemicals that can be called VOCs.

Of these, over 900 have been identified in indoor air, with over 250 recorded at concentrations higher than 1 ppb (parts per billion)[4]. Some of the most commonly encountered ones and their sources are listed in Table 4.

Table 4: Commonly Encountered VOCs and their Sources [5]

Contaminant	Source
Acetone	Paint, coatings, finishers, paint remover, thinner, caulking
Aliphatic hydrocarbons (octane, decane, undecane hexane, isodecane, mixtures, etc.)	Paint, adhesive, gasoline, combustion sources, liquid process photocopier, carpet, linoleum, caulking compound
Aromatic hydrocarbons (toluene, xylenes, ethylbenzene, benzene)	Combustion sources, paint, adhesive, gasoline, linoleum, wall coating
Chlorinated solvents (dichloromethane or methylene chloride, trichloroethane)	Upholstery and carpet cleaner or protector, paint, paint remover, lacquers, solvents, correction fluid, dry-cleaned clothes
n-Butyl acetate	Acoustic ceiling tile, linoleum, caulking compound
Dichlorobenzene	Carpet, moth balls, air fresheners
4-Phenylcyclohexene (4-PC)	Carpet, paint
Terpenes (limonene, α-pinene)	Deodorizers, cleaning agents, polishes, fabrics, fabric softener, cigarettes

All buildings contain a large variety of chemical sources, such as plastics, floor wax, cleaning compounds, printers and copiers. Exposure to these can lead to a variety of respiratory problems.

- **Minimise the source by choosing materials and products that do not give off VOCs.**
- **Seal sources (such as particle board) with impermeable barriers like latex paint.**
- **Allow building materials, furniture and carpeting time to off-gas before bringing them into the building.**
- **Increase ventilation in the affected area.**
- **Only install new carpeting when the area is vacant.**

5 Health Canada. (2006).

- **Buy small quantities of paints, cleaners and solvents.**
- **Follow the manufacturer's instructions when using chemicals**. (e.g. If the label says, "use in well ventilated area" the chemicals should only be used outdoors or where an exhaust fan or open windows will provide extra ventilation.)
- **Do *NOT* mix different household cleaners or solvents together**. **This can be dangerous!**
- **Store these materials in separate buildings or areas with a separate exhaust and away from all VAC plant rooms and air intakes**.

3.7.1 FORMALDEHYDE

Although formaldehyde is a volatile organic compound (VOC), it has been given special mention due to how common it is as compared to the other VOCs. Formaldehyde resins are used in many construction materials like plywood, particleboard and carpeting as well as in everyday materials such as cleaning fluids and adhesives. Since these materials slowly give off formaldehyde over time, formaldehyde is one of the more common indoor air pollutants.

Formaldehyde is a colourless gas. A pungent odour often indicates its presence at a concentration greater than 0.2 ppm. At concentrations above 0.1 ppm in air, inhaled formaldehyde can irritate the eyes and mucous membranes, resulting in watery eyes, headache, a burning sensation in the throat and difficulty breathing. The International Agency for Research on Cancer (IARC) classifies formaldehyde as carcinogenic.

The methods for controlling formaldehyde are similar to those recommended for VOCs.

- **Minimise the source.**
- **Seal sources**.
- **Allow furnishings and building materials to off-gas in storage prior to installation.**
- **Dilute the indoor concentration by increasing the flow of outdoor air during the occupied and non-occupied hours**.
- **Control air pressure relationships** *(local exhausting, eliminating pollutant pathways).*
- **Control source/distribution relationships by relocating occupants, and avoiding the recirculation of contaminated air.**

3.8 Indoor Ozone (O_3)

The oxygen molecule in the air we breathe is a stable molecule composed of two oxygen atoms. However, ozone is an extremely reactive molecule composed of three atoms of oxygen. The ozone layer in the upper atmosphere absorbs most of the harmful ultraviolet radiation from the sun and thus protects life on earth. However, at ground level, ozone is an air pollutant. In the office building setting, ozone can be produced in small amounts by office equipment such as printers, copiers, scanners and computers, or it can be intentionally introduced into the environment using an ozone generator or 'air purifier'.

Short term exposure to ozone can result in coughing and chest pain on deep inhalation; irritation of the eye, throat and nose; and increased sensitivity to airborne allergens and irritants. Long term exposure to high levels of ozone (i.e. levels higher than 0.10 ppm[6]) may result in permanent lung damage, while long-term exposure to low-level ozone may also lead to permanently reduced lung capacity. Some asthmatic individuals are especially susceptible to ozone toxicity, which causes constriction of the airways. Children are most at risk from exposure to ozone because their lungs are still developing.

6 This is the OSHA Permissible Exposure Limit TWA(time weighted average)

Ozone can also impact on items within an office building. It can adversely affect indoor plants and damage materials such as rubber, electrical wire coatings and fabrics. It can also damage art work containing susceptible dyes and pigments.

3.8.1 OZONE AIR PURIFIERS AND OZONE GENERATORS

Ozone-generating air purifiers are marketed based on ozone's ability to oxidize, reduce or eliminate indoor air pollutants such as odours and disease causing microbes present in the air. Ozone air purifiers are available in three forms;

i. in-duct units that can be outfitted in central air-conditioning systems;
ii. portable indoor units; and
iii. personal battery powered units that can be worn on the body.

Air ionizers also expose air to negatively charged high voltages to create negatively charged particles, and this process produces a small amount of ozone.

Both the United States Occupational Safety and Health Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH) recommend that workers should not be exposed to an ozone concentration (in ambient air) above 0.10 ppm over an 8 hour day[7]. However, it may be difficult to control the concentration of ozone when domestic units are used.

- **DO NOT USE ozone air purifiers while the building is occupied.**
- **An ozone generator can be used to disinfect an UNOCCUPIED area. It should be used to generate a specific concentration of ozone for a specific duration so that the amount of ozone generated would completely dissipate before the area is reoccupied.**

7 USEPA (2015)

Instead of an ozone air purifier, you may consider using a purifier that uses activated carbon filters. Activated carbon consists of a vast system of highly adsorbent pores which form a strong bond/attraction to odorous gaseous and liquid contaminants.

4 MANAGING INDOOR AIR QUALITY

4.1 What is The Role of the Building Occupant?

The building occupant has a role to play in maintaining indoor air quality and can do a number of things to help alleviate and reduce many common IAQ problems. The approach to reducing IAQ problems consists of proactive and appropriate reactive responses such as:

i. DO NOT block air vents or grilles. Keep supply vents or return air grilles unblocked. The air-conditioning technicians that installed the central air-conditioning system within the building would have worked hard to balance it. If one person blocks the diffuser in his/her office, the volume of air that was designed to come through this vent will now be pushed out of other vents. Imagine the combined effect of five or ten people taping paper over their diffusers. This could completely unbalance the system! Furniture, boxes or other materials placed near to supply vents or return air grilles may also affect air flow. Follow your office's procedures to notify building management if your space is too hot, too cold, stuffy or draughty. You should bear in mind that the balancing process takes time, so please be patient while the air-conditioning technicians address the problems.

ii. Smoking is banned in public spaces. Only smoke in designated external areas and follow all rules regarding use of the area designated for smoking.

iii. Water and maintain office plants in the correct manner. Water creates a hospitable environment for the growth of micro-organisms such as fungi. If they become airborne, some of these microbes can cause health problems. Therefore, any excess moisture should be removed from the office area. When plants are watered the liquid level should not be seen above the soil.

iv. Dispose of garbage promptly and properly. Dispose of garbage in appropriate containers that are emptied daily to prevent odours, biological contamination and pests.

v. Store food properly. Food attracts pests. Some foods, if left unrefrigerated, can spoil and generate unpleasant odours. Never store

perishable food products in your desk or on shelves. Refrigerators should be cleaned on a regular basis to prevent odours. Keep kitchens and dining areas clean and sanitize as necessary to prevent pests and maintain hygiene.

vi. Avoid bringing products into the building that could release harmful or bothersome odours or contaminants. Many common products used in offices release pollutants such as odours and irritants. Examples of these include aerosol fresheners, strong perfumes or colognes, acetone (nail polish remover), nail polish and insecticides. These should not be used in the office environment without adequate ventilation. Pollutants and odours (which may or may not indicate a health concern) generated in your space may not only bother those in the immediate area, but may also enter the building's ventilation system and cause problems for other tenants in other parts of the building.

4.1.1 What should I do if I think my building has an Indoor Air Quality problem?

If more than ten percent (10%) of the persons in your office are experiencing health or comfort problems that you suspect may be caused by the indoor environment, you can do the following:

i. Inform the building management of your concerns through your organizations approved channels.
ii. Report your problems to the company physician, nurse or health and safety officer.
iii. Talk with your doctor or other health care provider.
iv. Cooperate with management during any indoor air quality investigation. Please be patient as the process of identifying and solving problems can sometimes be difficult.

4.2 <u>What is the role of the Building Manager?</u>

The relationship between the building manager, the occupants and staff plays a major role in determining the status of indoor air quality in a building/office, despite each of those entities having different objectives.

Occupants would prefer being in a comfortable and safe working environment and if they are paying tenants, they will want to get maximum use of the space available. On the other hand, building managers generally weigh the cost of maintenance against profits while trying to maintain a healthy indoor environment.

In order to maintain satisfactory IAQ the building manager should:

i. Implement a preventative maintenance plan for the building and the ventilation and air-conditioning systems. This should include the following:
- ✓ Regular inspections of building systems (recommended quarterly)
- ✓ Regular cleaning/maintenance of VAC system (recommended quarterly)
- ✓ Regular industrial cleanings (recommended quarterly)
- ✓ Periodic professional inspection of ductwork to determine structural integrity and sanitary condition (recommended every annually)

ii. Oversee activities of staff, contractors, housekeeping and maintenance that could possibly affect IAQ. This should include the following:
- ✓ Educating occupants on how their actions can affect IAQ e.g. tampering with AC vents
- ✓ Storing chemicals and cleaning agents in the correct manner so as to prevent unwanted and potentially toxic exposures (See Section 4.2.3.2 for more details)
- ✓ Using safer, less toxic products to replace existing chemicals including cleaning agents
- ✓ Correct usage of chemicals and pesticides ensuring that there is no incompatible mixing of items.
- ✓ Usage of appropriate trash disposal practices and constant monitoring to determine whether pest control has been effective.

iii. Maintain communication with staff and tenants so that any IAQ complaints can be quickly and efficiently addressed. This may

involve collaboration with the Health and Safety Committee and administrative management.

iv. Implement an Integrated Pest Management plan. See Section 4.2.1 for more details.

v. Identify aspects of planned projects that can impact the indoor air quality. Manage projects to ensure that a high standard of indoor air quality is maintained. See Section 4.2.2 for more details.

vi. Conduct an IAQ Walkthrough to monitor and detect any possible IAQ problems – More details of an IAQ walkthrough can be found Section 5.

vii. Keep records of all maintenance procedures and certifications as required. These must be readily available and produced to any government officials that request them. This list includes the following:

- ✓ Copies of approved building plans and ventilating and air-conditioning (VAC) plans
- ✓ A certificate of satisfactory operation provided by a suitably qualified engineer for the VAC system and wastewater system.
- ✓ Certificate from a registered structural engineer to qualify the integrity of various aspects of the building structure including the walls, floors, ceilings, stairways and apertures.
- ✓ Certificate of inspection for the elevators and/or escalators from an approved inspector.
- ✓ Certificate of Inspection from the Barbados Fire Service for the building/facility.
- ✓ Certificate of inspection from the Government Electrical Engineering Division for the emergency/auxiliary generator.

4.2.1 Integrated Pest Management

Uncontrolled pest treatments can have a significant impact on IAQ even when conducted outside of the building. The implementation of an Integrated Pest Management Plan is more effective as it reduces the need for heavy pesticide application. In order to implement this plan you may consider the following:

i. Always consult professional pest control operators. It is a good idea to oversee their application practices.

ii. Schedule pesticide applications during times the building is unoccupied.

iii. Notify occupants even when minor pesticide application is being conducted as some may become seriously ill even after minor exposures.

iv. It may be necessary to shut off or modify the ventilation of the system to limit the spread of contaminated air throughout the building.

v. No spraying should be conducted in the air handling rooms of the VAC system. Bait should be placed in these areas instead.

vi. It is a good idea to allow 2-3 days of natural ventilation following interior treatments.

vii. Use pesticides that are specific to the target species and use bait wherever possible. This reduces toxicity levels to humans and non-target species.

viii. Seal cracks, crevices and holes to eliminate areas that can harbour pests.

ix. Implement proper cleaning procedures to reduce food and garbage that will attract pests.

If problems with pests such as roaches and rodents persist consult the Environmental Health Officer for your area.

4.2.2 Construction and Renovation

Construction and renovation projects can severely compromise the indoor air quality of a building through the release of contaminants and pollutants. Once released, contaminants travel through the VAC system and can be transported throughout the building and affect persons occupying the building even if they are not occupying the construction zone.

4.2.2.1 CONSTRUCTION AND RENOVATION CONTROL STRATEGIES

It is the responsibility of the Building Manager, Project Manager and Construction Manager to ensure the following steps are taken during the construction and renovation process:

i. Obtain the relevant approvals!

- Schematics/ floor plans should be prepared showing the following:
  - ✓ intended spatial arrangement of the offices
  - ✓ proposed allocation of human and physical resources
  - ✓ proposed modifications to the VAC system
- Approval must be received from the Town and Country Development Planning Office and the Environmental Protection Department prior to construction. However, it should be noted that for material alterations buildings that have previously been approved for office use will only need additional approval from the Environmental Protection Department.

ii. Establish and maintain effective communication with all parties.

- Establish communication with building occupants during the planning phase of the project.
- Maintain this relationship during and after construction activities in order to ensure occupant comfort.

iii. Engage in a thorough preliminary planning process.

- Identify the scope of work and determine potential IAQ impacts.
- Identify any potential hazards, especially existing hazards such as asbestos and lead which may be disturbed by the activity. Potential sources of dust and mould/fungi should be documented.
- Review the proposed building materials and ensure that the most appropriate ones are selected.
- Implement effective pollution control strategies.
- Ensure that contracts are detailed and include the contractor's obligations for before, during and after the renovation /construction process.

iv. Identify contamination sources and address their locations.

- Identify all possible sources of contamination i.e. generators, paints and chemicals.
- Ensure that these items are placed in the appropriate locations. for example, they should be sited away from ducts and vents and also where particulates and gases associated with those materials will not contaminate locations outside of the work area.

v. Examine the possibility of source substitution.

- Identify materials and carefully review the material data safety sheets (MSDS) for the materials to be used in the renovation. Determine whether a less toxic or volatile substitution can be used. See Table 5 below for examples.

Table 5: Possible substitutions for toxic materials

Choose this	Instead of this
latex or water based paint	oil based or automotive paint
hardwood	pressed wood
water based adhesives	solvent based adhesives
low formaldehyde fabrics	traditional fabrics
low volatile organic compounds (VOCs) emitting furniture	traditional furniture

vi. Use appropriate barriers. The area undergoing renovation should be isolated from the other occupied areas of the building. This may be achieved by the following:

- Shut off the air conditioning system and vents to prevent the recirculation of air from the work areas to the occupied areas.
- Physically isolate the work area using impervious materials such as panels and/or polyethylene sheeting.
- Keep doors and stairwells closed and limit access to personnel.
- Ensure adequate decontamination protocols are in place to prevent contamination of the occupied spaces.

vii. Employ specific ventilation controls.

- If strong odours are expected, make the area as airtight as possible and keep the area with the odours under negative pressure. Ensure all ventilation systems are rated and shielded to reduce explosive risk.
- Reduce contaminant levels by isolating the area and diluting the contaminants or using local ventilation.
- Install additional filters on air handling units if they are located within the work area.

viii. After construction/renovation is complete, carry out the necessary post construction/renovation remediation.

- Inspect the plenum (ceiling space), ductwork and other 'hidden' areas to see if particulates have infiltrated those areas.
- Perform a thorough industrial cleaning of the entire area, including the occupied spaces. Include the plenum and 'hidden' spaces if necessary.
- Change all filters at the end of the renovation.
- These steps should all be taken before the VAC system is switched back on.

4.2.3 Storage Area Management

Deficiencies in storage area design along with improper and incompatible storage of materials may impact upon indoor air quality.

4.2.3.1 STORAGE AREA DESIGN

i. Generally, areas used for storage should be appropriately designed and separate from other areas. This is especially true for
   - janitorial closets
   - chemical storage
   - document storage areas (e.g. vaults)

ii. Storage areas should be easily accessible and easy to clean.

iii. The ventilation system for storage areas should be separate from the main VAC system.

iv. Storage areas should be kept under negative pressure to prevent contamination of the main VAC system and the adjacent work spaces.
v. Storage areas should be kept at optimal temperatures consistent with the type of items stored.
vi. VAC air handling rooms should NOT be used as storage spaces due to the risk of contaminating the ductwork and indoor air.

4.2.3.2 STORAGE OF MATERIALS AND COMPATIBILITY

The term '*chemical substance*' usually conjures up images of industrial-strength, caustic, foaming substances that need to be handled with very long, corrosion-proof safety equipment. In truth and in fact, many household staples are chemical substances, such as disinfectants, spray-insecticides and even air-fresheners. Although these chemicals may be harmless in small quantities in well-ventilated areas, their use in enclosed air-conditioned buildings is not encouraged. Furthermore, these items must be stored in such a manner as not to compromise the air quality in the building.

i. Chemicals should be stored according to the directions on their labels and the MSDS. Proper storage will reduce the possibility of violent chemical reactions or fire occurring in the storeroom.
ii. Chemicals such as cleaning supplies should be kept in dedicated storage locations separate from stationery and foodstuff.
iii. Ideally, foodstuff should be kept in a different storage location.
iv. Store different categories of items separately and in a manner to prevent cross contamination or chemical reactions. For example bleach and ammonia should not be stored together since these commonly used materials react to produce toxic gas.
v. During various investigations, EPD officers have observed the storage of paint, paint thinners, pesticides and even gasoline in office areas. Air-conditioning plant rooms are often seen as extra storage space. However, any release of these substances through a leak, spill or opened bottle in these spaces can cause a whole host of IAQ problems in the entire building. Offices and VAC plant rooms should NOT be used as storage areas.

5 CONDUCTING AN IAQ WALKTHROUGH INVESTIGATION

A walkthrough investigation is useful in finding out whether the building occupants have been affected by any possible pollutants within the building, the length of time that they have been experiencing these problems and also to identify any possible causative agents.

This exercise entails a review of the building design, location of the staff and equipment and layout of the ventilation system. A sample walkthrough questionnaire and ventilation checklists have been attached in the appendices of this document and can be used to assist in the investigation.

5.1 Step 1: Classify the Building

You will need to determine how you will classify the findings from the investigation. How will you divide the building into zones to assist you in classifying the various observations that you will make during the investigation of the building?

A building can be classified into the following:

- Individual VAC zones
- Types of VAC zones
- Complaint versus non-complaint areas
- Proximity to pollutant sources or complaint types

However, if there are various complaints from the occupants, it might be more logical to target complaint types and distribution and see how these can be influenced by the building's characteristics.

5.2 Step 2: Review Complaints

In order to thoroughly define the problem, it is important to speak first-hand with the complainants and gather information on the symptoms and also the spatial pattern (distribution vs. location) of complaints. In addition, you may wish to distribute questionnaires to the staff for them to complete. (You can use the questionnaire in Appendix 1. After you have reviewed the complainants' concerns, see if you can identify any patterns regarding the location of a large proportion of complainants, the type of complaints and such like.

There are a number of obvious indicators of problems within a building. These include odours, overcrowding, excessive dust, moisture problems/leaks, visible fungal growth and inappropriate chemical storage.

For example, some odours can easily indicate their source. If any of the occupants indicate that they have detected these odours, then Table 6 can be used for guidance in identifying the possible source. Hence, you will have a head start in looking for the possible cause!

Table 6: Complaints/Symptoms in relation to the odours associated with the causative agents [8]

Description of Odour	*Possible cause*	*Complaints (Symptoms)*
Auto exhaust, diesel fumes	Carbon monoxide	*Headaches, nausea, dizziness, tiredness*
Body odour	Overcrowding low ventilation rate (high carbon dioxide levels)	*Headaches, tiredness, stuffiness*
Musty smell	Microbial material, wet surfaces	*Allergy symptoms*
Chemical smell	Formaldehyde, pesticides, other chemicals	*Eye, nose and throat irritation*
Solvent smell	Volatile organic compounds (VOCs)	*Odour, allergy symptoms, dizziness, headache*
Wet cement, dusty, chalky smell	Particulates	*Dry eyes, respiratory problems, nose and throat irritation, coughing, sneezing*

8 *Health Canada* (1993)

Sewage gas odour	Dry water traps in washroom floor drains or toilets, unsealed grease traps or septic tanks	*Foul smell*

5.3 Step 3: The Walk-around (Exterior)

This phase should entail a walk around the exterior of the building to determine the potential impact of external sources on IAQ. You can use the questionnaire located in Appendix 2 in conjunction with this section.

Important questions include:

- Is the building in good condition or is it in need of repairs?

- Have there been recent instances of exposure to temporary pollutants such as pesticide application, renovation, construction, painting or road works? Were there recent possible sources of combustion products, such as bush/cane fires and open/domestic burning?

- Is the building/VAC fresh air intake downwind from permanent pollutant sources such as toilet vent pipes, kitchen exhausts, generators, industrial stacks, sewers, wells and grease traps?

- Remember that you can also be impacted by pollutants emanating from other people's property.
    a. Are there volatile or short-lived sources? E.g. Is there a spray painting facility close by?
    b. Is the building situated next to a busy roadway or is there a parking lot or another building's loading dock situated nearby? If this is the case, do they allow drivers to let their vehicle engine idle for the time that they are on the premises?

5. In the case of underground or enclosed parking and/or loading docks attached to the building, are these areas properly ventilated?
    a. Do you allow drivers to let their vehicle engine idle for the time that they are on your premises?
    b. Are there provisions for the introduction of outdoor air?
    c. Is an exhaust system installed to remove polluted air?
    d. Is the exhaust blocked off?
    e. Are carbon monoxide sensors installed? Are they working properly?

f. Are carbon dioxide sensors installed? Are they working properly?
g. Is there a direct access area from the garage to other areas in the building? Do stairways, shafts and ducts act as pathways for exhaust pollutants such as particulates and odours?
h. Do odours occur during peak hours of incoming and outgoing traffic?
    i. *Are outdoor air intakes close to a heavily trafficked street?*
    ii. *Intakes below the third floor level can be heavily impacted. If the occupants are ill or reporting symptoms of headaches, fatigue, dizziness and nausea, then they may be affected by the exhaust from these areas.*

6. What is the condition of water drainage around the building?
    a. Ensure that water drains away from the building and that there is no ponding nearby.
    b. Determine if water sprinklers wet the building or discharge excessively around the building.

7. Finally, check if there are clean mats at every exterior entrance. These mats are instrumental in reducing dust entering the building.

5.4 Step 4: Check the Roof

1. Inspect the roof of the building to see if it is in good condition. Do you see any areas that may cause leaks inside?

2. Is there any evidence of ponding?

3. Check the area of the outdoor air intake duct to ensure it is not impacted by contaminant sources.

5.5 Step 5: Walkthrough (Interior)

The following points must be considered for **each room** that is to be inspected:

5.5.1 TEMPERATURE

1. Is the temperature and relative humidity acceptable?
    a. Temperature is recommended to be between 23 °C and 25 °C. However, the temperature will be considered adequate if 80% or more of the occupants are satisfied.
    b. Relative humidity is recommended to be between 30% and 70%.
    c. It should be noted that the higher the relative humidity, the more difficult it is for a person to cool down through evaporation. This is why even when the temperature is 'okay' if the air is humid people feel uncomfortable. It should also be noted that high relative humidity in an indoor environment can lead to moisture issues.

2. Are the temperatures fairly constant throughout the building or are there hot and cold spots?

3. If there are fluctuations, are they due to occupant interference?
    a. Was new equipment installed recently?
    b. Are there local sources of heating and/or cooling? For example, is there a considerable solar load through un-tinted windows?
    c. Have the occupants tampered with the vents?

4. Are thermostats appropriately positioned, calibrated, unobstructed?

Temperature readings should be taken using a thermometer. The physical feeling of the inspector may be used as an indicator of the temperature of the room. However, this method is subjective as different persons respond to temperature in various manners. It may be useful to check the thermostat if the building is cooled by a central air-conditioning system.

5.5.2 CONDENSATION AND MOULD

1. Is there visible condensation on any surface?

2. Are there signs of mould growth or mildew on any surfaces?
    a. Look around single air conditioning units or central system diffusers for water droplets.
    b. Also, look at surfaces opposite to these vents. The surfaces should not be damp.

3. Are there any mouldy odours?
    a. If there is a mouldy smell, then fungi is probably present. Moulds can grow on or in any damp surface and they feed on a variety of substances, especially dust and dirt.
    b. There may be hidden growth of moulds within ventilation equipment, or on carpets and porous building materials such as wood, cardboard panelling and soft stone.
    c. Check around portable cooling fans or around any water coolers because these may contain algae.

4. Is there obvious water damage?
    a. This may be evident in stained ceiling tiles or water marks on walls. Water damage may also cause paint to 'bubble' or wood to warp.
    b. Mouldy, wet or dirty ceiling tiles, plaster, carpet, window sills, or window treatments can be indicators of severe water damage.

5.5.3 DUST AND PARTICULATES

- Is the area dusty?
    a. You can measure the particulate settling rate by cleaning a surface and monitoring the time for the accumulation to re-occur.

b. Look for particulates on hard surfaces such as walls, desks, cupboards, shelves and windows.
c. Areas on the interior where paper-based products are stored and/or shredding can also contribute to the quantity of dust in the indoor environment.
d. Files, books, paper, soft furnishings and even window treatments can trap dust, so you will need to inspect them carefully!

5.5.4 CHEMICAL STORAGE AND USAGE

1. Are/were any chemical substances stored in the area?

2. Are/were any chemical substances used in the area? When are/were they used and for what period of time?

3. Is the air-conditioning system switched on during and/or immediately after the area is cleaned or is the space allowed to vent before being reoccupied?

5.5.5 AIR FLOW

1. Is the airflow within the room adequate for size and number of inhabitants?

2. Do the occupants complain about dead zones/stagnant air flow within the office? Are the occupants using fans to assist with circulating the air?

3. Are any diffusers and returns closely positioned?

4. Has any post-design construction/renovation modified the ceiling return air pathway? If this is the case, this may result in short-circuiting of the air current.
    a. Does the design of the office obstruct the circulation of the air?
    b. Has open office space been converted to enclosed offices?

c. Is the space usage different from what it had been designed for?

5. Has the average or peak occupancy exceeded the design occupancy?

6. Is the airflow impeded in any way?
    a. High partitions, bookshelves and cabinets can obstruct the flow of air, especially if they extend to ceiling height.
    b. If the diffusers are blocked by paper, tape or anything placed there by the occupant, this can severely hamper the even distribution of the air.

7. Are occupants situated in the direct path of the air emanating from the diffusers? These persons may experience excessive flow rates due to their position and their location and/or the orientation of the office may have to be reassessed.

You should know what type of air-conditioning system is used in your building since this governs the next portion of the inspection.

6 ASSESSING VENTILATION AND AIR-CONDITIONING SYSTEMS

6.1 Assessment of Window and Split Unit Systems

1. If the building is served by individual split or window units, these must be examined in each office that is inspected.
    a. The front grilles of these units should be inspected to ensure that they are clean and well maintained.
    b. You should also familiarise yourself with the correct method to inspect the filters.
    c. You should ensure that the units and associated equipment are clean and sanitary.
    d. If possible, also check the drainpipe to ensure that it is draining correctly and that there is no visible fungal growth.

2. Examine the fresh air intake for the unit and make sure it is clean and working properly. Make sure that there is appropriate screening / filtration of outdoor air intakes, especially if the intake is below the third floor.
    a. Window units are provided with a switch to allow them to introduce outdoor air or to just re-circulate the air inside the space.
    b. Mini-split unit air-conditioners do not have any means of introducing conditioned outdoor air, so there should be separate measures installed to facilitate.
    c. Check if the fan inside the outdoor air intake is working properly. Also, make sure that the blades of this fan are clean because dirt will be introduced into the building via this duct and excessive quantities of dirt can also inhibit the efficiency of the fan.

3. For both types of unit, it should be determined based on the pollutant load whether an exhaust system would be required to remove any build-up of pollutants. If one is required, examine it to make sure that it is clean and working properly.

6.2 Assessment of Central Air-Conditioning System

1. Verify the temperature and humidity are set to the appropriate levels based on the comfort range.

2. Inspect diffusers and return vents of the air conditioning system to ensure that:
    a. The surfaces of the vents are clean and without fungal growth and condensation. Also, look closely at the ceiling tiles around the vents. If the surface of the ceiling appears to be dirty, then it is likely that the material of the ductwork is in need of cleaning.
    b. The equipment is functioning correctly. For instance the vents may be blocked and not providing the adequate amount of air.

3. Inspect the cooling coils of the air conditioning unit. From visual inspection, are both sides of the cooling coil clean?
    a. If you point a flashlight into the cooling coil, does light shine through the other side? It should if the coil is clean.
    b. Are the coil fins straight and evenly spaced? They should not be bent over and smashed together.
    c. Are the blower blades clean and free of oil and debris? Is the blower compartment free of visible dust or debris?
    d. Check the drain pan. Is water accumulating here or is it draining properly? Condensation on the cooling coils of air conditioning units is cited as a major factor in moisture contamination of the system.

4. Check the outdoor air intake of the air handling unit. Is the intake blocked by debris?
    a. Is it adequately screened to prevent the entrance of birds, vermin and other animals?
    b. Are the dampers functioning properly?
    c. Is there a source of contamination from the outside air?

5. Evaluate the current VAC to determine if it is the same as the original design.

6. Evaluate the layout of the diffusers, return vents and exhaust to ensure that there is efficient air distribution to all areas of the building and adequate removal of pollutants.

7. What kind of ductwork does the VAC system use?
    a. Ductwork can be made from galvanised metal sheeting, fibreglass or even plastic.
    b. A recent trend has been observed where the ductwork in many buildings is constructed entirely from fibreglass duct board. However, the EPD recommends the use of galvanised metal ducts or other material that can be easily cleaned.

8. What is the condition of the ductwork and related insulating material?
    a. Existing fiberglass ductwork should be inspected to determine its structural integrity to ensure that fiberglass particles are not being distributed within the system.
    b. Cleaning of ductwork should follow the standards from National Air Duct Cleaners Association and the Northern American Insulation Manufacturers Association.

9. Is the ductwork covered in mould?
    a. Fibreglass is porous and therefore has the ability to hold water. Combined with the dust retention abilities, this is the perfect environment for microbiological growth to occur.
    b. If the relative humidity is high, or if there is condensation, there is the potential for mould growth on any type of duct. However, unlike fibreglass ducts, galvanised metal ducts can be easily cleaned.
    c. Controlling moisture is the most effective way of preventing biological growth in air ducts. Moisture can enter the duct system through leaks or if the system has been incorrectly installed or if it is not adequately serviced.

d. Different species of moulds have different effects on health, but you should note that all moulds are allergenic. Symptoms of exposure to moulds include irritation of the eyes, throat and skin. (Refer to Section 3.3)

10. What type of filters are used? What is the condition of the filters?
    a. Central air conditioning systems use a variety of filters. Hog hair filters are popular in Barbados especially since they are washable and are reusable. However, this type of filter is extremely inefficient and therefore not recommended.
    b. The EPD recommends filters with a MERV rating of 9 and above.

11. The following questions should also be considered as you attempt to find out the cause of the problem:
    a. What time of day does the air seem worse?
        i. *Is there an increased problem near the end of the day? If this is the case, then it is likely that there isn't enough infusion of outdoor air.*
        ii. *You must also determine whether there is equipment or any process inside the building that gives off more pollutant products as time progresses, such as photocopiers. Local exhaust systems should be employed in these types of areas where pollutants may be generated by activities conducted within the building.*

6.2.1 WHAT HAPPENS NEXT?

- Consult your A/C technicians if you are concerned about the ventilation system.
- Make arrangements with maintenance personnel, contractors etc. to rectify the problem as quickly as possible with little disruption to staff.
- Communicate findings to tenants and staff.
- Contact an IAQ specialist or the Labour Department if the problem cannot be identified or rectified in house.

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8 APPENDICES

Appendix 1 Environmental / Health Questionnaire

Appendix 2 Inspection Checklist

ENVIRONMENTAL / HEALTH QUESTIONNAIRE

Please take a moment to answer the following questions to assist with the assessment of your work environment.

SECTION 1: BASIC INFORMATION

1. Name of Section ……..
2. Date of Investigation ……/……/……
   Year Month Day
3. Location of Section ……
4. Name of Staff Member *(optional)* ……

SECTION 2: BRIEF PERSONAL HISTORY *(Please tick the relevant box)*

1. Do you suffer from any of the following respiratory problems?

Asthma ☐ No, I do not ☐

Hay Fever ☐ Sinusitis ☐ Other ☐

If other give details ……

2. Are you presently taking medication? Yes ☐ No ☐

Give details *(optional)*……

……

3. Do you smoke? Yes ☐ No ☐

If so, how many cigarettes per day?

1-5 ☐ 6-10 ☐ 11-15 ☐ 16-20 ☐ 20+ ☐

SECTION 3: WORK ENVIRONMENT *(Please tick the relevant box)*

1. Have you experienced irritations of any of the following areas recently?

Eyes ☐ Nose ☐ Skin ☐

Throat ☐ Nasal Tract ☐

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Environmental Protection Department
Ministry of Environment and Drainage
L. V. Harcourt Lewis Building
Dalkeith, St. Michael, Barbados

Tel: (246) 310 3600
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Email: enveng@caribsurf.com
Website: www.epd.gov.bb

2. Have you experienced any of the following symptoms while carrying out your duties in the building?

Headaches	☐	Nausea	☐	Hoarseness	☐		
Dizziness	☐	Physical Fatigue	☐	Change of voice	☐		
Stuffiness/ Sneezing	☐	Dry Eyes	☐	Congestion	☐		
Coughing	☐	Wheezing	☐				
Change in sensation of taste	☐	Change in sensation of smell	☐				

3. For how many months have you been experiencing these problems at work?

Less than 1 month ☐ 1-3 ☐ 4-6 ☐ 7-9 ☐ 10-12 ☐ Greater than a year ☐

4. Were these symptoms triggered by a specific event? Yes ☐ No ☐

If yes, please describe. .....

.....

5. Have you visited a doctor with respect to these symptoms/irritations? Yes ☐ No ☐

What was your doctor's conclusion? *(optional)* .....

.....

6. Would you say that the working environment (air quality and cleanliness of surroundings) is generally comfortable or acceptable? Yes ☐ No ☐

7. Where in the building have you experienced these problems? .....

.....

8. Do you experience some relief from symptoms after you leave the building?

Yes ☐ No ☐

9. How do you find the temperature of the office?

Too cold ☐ Too hot ☐ Satisfactory ☐

Additional comments

……

……

……

……

……

……

……

……

THANK YOU FOR COMPLETING THIS QUESTIONNAIRE

INSPECTION CHECKLIST

This Inspection Checklist has been designed to prompt you during your inspection of your building. Depending on the complexity of the layout, the response to the questions may vary from area to area. You may wish to perform an overall assessment and record your findings here, or use multiple checklists for the individual areas.

Building Characteristics

This section should assist you with determining building characteristics. You should keep the information from this section on file.

- Building age _____
- Number of floors _____
- Type of building materials _____
  _____
  _____
- Type of windows (clear, tinted, etc.) _____
  _____
- Do windows open? ❑ Yes ❑ No
  _____
  _____
- What is the building layout? (i.e., open space, individual offices, combination)
  _____
  _____
  You may wish to get a building plan and keep on file.
- Has the building been renovated? ❑ Yes ❑ No
  If so, what changes were made and when were they made?
  _____
  _____
  _____
- Who is responsible for the building:
  Management_____
  Maintenance_____
  Ventilation (on-site or contractor)_____

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Ventilation Characteristics

This section should help you determine how your ventilation system was designed. You should keep the information from this section on file.

- How many air conditioning units service your company/business? _____
  In the case of multiple units, you should identify which areas are serviced by which units.

- Who designed or manufactured the air conditioning system? _____
  _____
  _____

- Is your company the only one serviced by these units? ❑ Yes ❑ No

- Which of the following features does your ventilation system have?
  - Central air handling units? ❑ Yes ❑ No
  - Area (zone) air handling units? ❑ Yes ❑ No
  - Individual (window) air handling units? ❑ Yes ❑ No
  - Individual (mini-split system) air handling units? ❑ Yes ❑ No
  - Plenum-type return air? ❑ Yes ❑ No
  - Ducted return air? ❑ Yes ❑ No
  - Return air at air handling unit? ❑ Yes ❑ No
- Does unit provide continuous circulation? ❑ Yes ❑ No
- Is system air volume constant? ❑ Yes ❑ No
- Is system air volume variable? ❑ Yes ❑ No
- Does computer control system? ❑ Yes ❑ No

  If so, is performance monitored? ❑ Yes ❑ No
  By whom? _____

  How often? _____
- What kind of ductwork does the VAC system use? Ductwork can be made from galvanised metal sheeting, fibreglass or even plastic. _____
- Does system provide outside makeup air? ❑ Yes ❑ No

- Are makeup air controls: ❑ manual ❑ automatic
- How much make-up air is provided (CFM per person or % of makeup) _____
  _____
  _____
  _____
  - Have there been any recent ventilation changes? _____
    _____
    _____
    _____
    _____
- Was the ventilation system commissioned (tested on installation)? ❑ Yes ❑ No

  If yes, by whom _____

  When _____

  Is report available? ❑ Yes ❑ No
- Has the system ever been balanced or adjusted? ❑ Yes ❑ No

  If yes, by whom _____

  When _____

  Is report available? ❑ Yes ❑ No
- Has the volume of air per room occupant been measured? ❑ Yes ❑ No

  If yes, what was the result? _____

Routine Ventilation System Inspection and Maintenance

This section should help you establish the maintenance schedule for the system(s). You should keep the information from this section on file.

- Are routine inspections and maintenance performed? ❑ Yes ❑ No

  If so, how often? _____

  - What does the maintenance of the air conditioning system involve?

    _____
    _____
    _____

- When was the last maintenance (servicing & cleaning) of the A/C system done?

  _____
  _____

  By whom?_____

- Who inspects/adjusts makeup air controls? _____

- Are maintenance personnel properly trained to perform routine inspection and maintenance? Are they familiar with equipment, where filters are located and how often to change them? ❑ Yes ❑ No

- Do the following components receive routine inspection/maintenance?

  - Supply air outlets ❑ Yes ❑ No
  - Filters ❑ Yes ❑ No
  - Thermostats/sensors ❑ Yes ❑ No
  - Coil condensation pans ❑ Yes ❑ No
  - Internal duct work ❑ Yes ❑ No
  - Dampers ❑ Yes ❑ No
  - Belts ❑ Yes ❑ No

    If so, by whom _____
    _____
    _____

- What is the efficiency of the filters for the ventilation system? _____
  The EPD recommends filters with a MERV rating of 9 and up.

Ventilation Assessment

Central System

This section should help you determine whether the central system is operating as it should.

- Are the surfaces of the diffusers and returns clean and without fungal growth and condensation? Are the ceiling tiles around the vents dirty?

- Is each office space equipped with one or more air supply ducts?

- Is air flowing from supply air ducts?

- Is the airflow within the room adequate for size and number of inhabitants? Do the occupants complain about dead zones/stagnant air flow within the office? Are the occupants using fans to assist with circulating the air?

- Has the average or peak occupancy exceeded the design occupancy?

- Are return air grills kept open and clear? Is the airflow impeded in any way such as by high partitions, bookshelves, boxes, cabinets or paper, tape or anything placed there by the occupant?

- Is the air current being short-circuited? Are any diffusers and returns closely positioned? Has any construction/renovation modified the ceiling return air pathway? Has open office space been converted to enclosed offices?

Examine the unit itself:

- Are the cooling coils in good condition? Are both sides of the cooling coil clean? If you point a flashlight into the cooling coil, does light shine through the other side? It should if the coil is clean.

_____
_____
_____
_____

- Are the coil fins straight and evenly spaced? They should not be bent over and smashed together.

_____
_____
_____
_____

- Are the blower blades clean and free of oil and debris? Is the blower compartment free of visible dust or debris?

_____
_____
_____
_____

- Check the drain pan. Is water accumulating here or is it draining properly?

_____
_____
_____
_____

- Is the outdoor air intake of the air handling unit in good condition? Is the intake blocked by debris? Is it adequately screened to prevent the entrance of birds, vermin and other animals? Are the dampers functioning properly?

_____
_____
_____
_____

- Are the ductwork and related insulating material in good condition? The ductwork should not be covered in dirt or mould.

_____
_____
_____
_____

- Are the filters fitting the unit properly? The filters should fit snugly and there should be no gaps between adjacent filters.

_____
_____
_____
_____

Ventilation Assessment

Window Units and Mini- Split Systems

This section should help you determine whether the individual units are operating as they should. This section should therefore be completed for each unit.

- Are the front grilles clean and well maintained? ❑ Yes ❑ No

  _____
  _____
  _____

- Are the filters clean? ❑ Yes ❑ No

  _____
  _____
  _____

- Is the drainpipe draining correctly? ❑ Yes ❑ No

  _____
  _____
  _____

- Is there visible fungal growth on or around the unit? ❑ Yes ❑ No

  _____
  _____
  _____

- Is the fresh air intake for the window unit clean and working properly? ❑ Yes ❑ No

  _____
  _____
  _____

- Some offices may be fitted with a separate intake fan to bring fresh air into the office. Are the blades of the intake fan clean? ❑ Yes ❑ No

  _____
  _____
  _____

- Is there appropriate screening / filtration of outdoor air intakes? ❑ Yes ❑ No

  _____
  _____
  _____

- For both types of unit, the pollutant load should be assessed in order to determine whether an exhaust system is required to remove any build-up of pollutants. If one is in use, is it is clean and working properly? ❑ Yes ❑ No

  _____
  _____
  _____

Exterior walk around

This section should help you assess the condition of the building and identify any possible external sources that could contaminate the indoor air.

- Is the building in good condition or is it in need of repairs? ❑ Yes ❑ No

_____
_____
_____
_____

- Is the building VAC fresh air intake downwind from permanent pollutant sources such as toilet vent pipes, kitchen exhausts, generators, industrial stacks, sewers, wells and grease traps? ❑ Yes ❑ No

_____
_____
_____
_____

- Are there volatile or short-lived sources such as a spray painting facility close by, roadway, parking lot or another building's loading dock situated nearby? ❑ Yes ❑ No

_____
_____
_____
_____

- If there is an underground or enclosed parking and/or loading dock attached to the building, are these areas properly ventilated? Are the fresh air intakes and exhaust systems installed and working properly? Are carbon monoxide and carbon dioxide sensors installed and working properly?

_____
_____
_____
_____

- Is there a direct access area from the garage to other areas in the building? Can pollutants enter the building through stairways, shafts and ducts?

_____
_____
_____
_____

- Do odours occur during peak hours of incoming and outgoing traffic? Are outdoor air intakes close to a heavily trafficked street?

_____
_____
_____
_____

- Is there good water drainage around the building? ❑ Yes ❑ No

_____
_____
_____
_____

- Do water sprinklers wet the building? ❑ Yes ❑ No

- Do guttering downpipes discharge onto the building. ❑ Yes ❑ No

- Are there clean mats at every exterior entrance? ❑ Yes ❑ No

Roof Inspection

- Is the roof of the building in good condition? ❑ Yes ❑ No

- Are there cracks or other areas that may cause leaks inside? ❑ Yes ❑ No

- Is there any evidence of ponding? ❑ Yes ❑ No

8.1 Interior Walkthrough

This section should help you identify any possible internal sources of pollution that could impact on the indoor air quality. These points should be therefore be considered for each room that is to be inspected.

CONTAMINANTS

- Are there operations/processes/machines that can produce air contaminants?

  ❑ Yes ❑ No

  _____
  _____
  _____
  _____

- Are machines installed and operated according to manufacturer's specifications?

  ❑ Yes ❑ No

  _____
  _____
  _____
  _____

- Are machines located in well-ventilated areas? ❑ Yes ❑ No

  _____
  _____
  _____
  _____

- Are local exhaust systems used in these areas where pollutants may be generated ?

  _____
  _____
  _____
  _____

- Does the air seem worse at a particular time of the day? If the air seems worse as the day progresses, then it is likely that enough outdoor air is not being introduced.

  _____
  _____
  _____
  _____

- Is the area dusty? If so, can you identify a potential source?

  _____
  _____
  _____
  _____

- Are/were any chemical substances **stored** in the area? If so, what?

  _____
  _____

_____
_____

- Are/were any chemical substances **used** in the area? If so, what, when and for what period of time?

  _____
  _____
  _____
  _____

- What cleaning products are used on a routine basis or in an emergency?

  _____
  _____
  _____
  _____

- Are materials used properly in accordance with manufacturer's specifications?

  _____
  _____
  _____
  _____

- Are pesticides used for extermination? If so, what?

  _____
  _____
  _____
  _____

- Is a commercial exterminator utilized? If so, who?

  _____
  _____
  _____
  _____

- What materials do occupants bring in?

  _____
  _____
  _____
  _____

- Is a chemical information list compiled, and are material safety data sheets (MSDS) available? ❑ Yes ❑ No

  A hard copy of each MSDS should be kept on file, while another (either printed or electronic) should be kept offsite in case of emergency.

- Have new furniture, carpets, or draperies been installed? ❑ Yes ❑ No

  _____
  _____
  _____

- Is painting, carpet installation, or other repair or renovation performed during periods of low occupancy? ❑ Yes ❑ No

- Is the air-conditioning system switched on during and/or immediately after a cleaning or pest treatment, or is the space allowed to vent before being reoccupied?

_____
_____
_____
_____

TEMPERATURE

- What is the temperature? Temperature should be between 23 ºC and 25 ºC, (however, temperature is acceptable once 80% or more people are satisfied.)

_____

- What is the relative humidity? It should be between 30% and 70%.

_____

- Are the temperatures fairly constant throughout the building? ❑ Yes ❑ No

_____
_____
_____

- Are there local sources of heating and/or cooling? e.g. sunshine through un-tinted windows, new equipment ❑ Yes ❑ No

_____
_____
_____

- Have the occupants tampered with the vents? ❑ Yes ❑ No

_____
_____
_____
_____

- Are thermostats appropriately positioned, calibrated, unobstructed? ❑ Yes ❑ No

_____
_____
_____
_____

- Are occupants in the direct path of the air coming from the diffusers? ❑ Yes ❑ No

_____
_____
_____

MOISTURE AND MOULD

- Do areas of the building repeatedly become wet or damp? ❑ Yes ❑ No

_____
_____
_____

- Are there any areas of the building that leak such as a broken pipe or cracked roof?

  _____

  _____

- Are leaks promptly repaired? ❑ Yes ❑ No

  _____

  _____

  _____

- Is there visible condensation on any surface? ❑ Yes ❑ No

  _____

  _____

  _____

- Are there signs of mould growth or mildew on any surfaces? e.g. water droplets on diffusers, surfaces opposite vents ❑ Yes ❑ No

  _____

  _____

  _____

- Is there mould growth hidden in inconspicuous areas such as within ventilation equipment, carpets and porous building materials or around portable cooling fans, water coolers or potted plants? ❑ Yes ❑ No

  _____

  _____

  _____

- Is there obvious water damage such as stained ceiling tiles, water marks on walls, bubbling paint, warped wood? ❑ Yes ❑ No

  _____

  _____

  _____

Classification of Complaint

This section should help you determine the nature of the complaint, the extent to which it is a problem and the main areas affected.

- What is the complaint? _____
  _____
  _____

- How many persons are currently employed? _____

- How many persons are affected? _____

- What medical care/illnesses/conditions are being experienced by any employee? _____
  _____

- How long have employees been affected by these illnesses? _____

- What is the distribution of employee complaints or illnesses? i.e. in which rooms do they sit and/or where do they experience problems?
  _____
  _____
  _____

- How many persons work in the affected sector(s)? _____

- Can you identify any specific event that triggered the symptoms? Have there been recent instances of exposure to temporary pollutants such as pesticide application, renovation, construction, painting, road works, bush/cane fires and open/domestic burning? If yes, please indicate
  _____
  _____
  _____
  _____

  - When did it occur? _____
    _____
    _____