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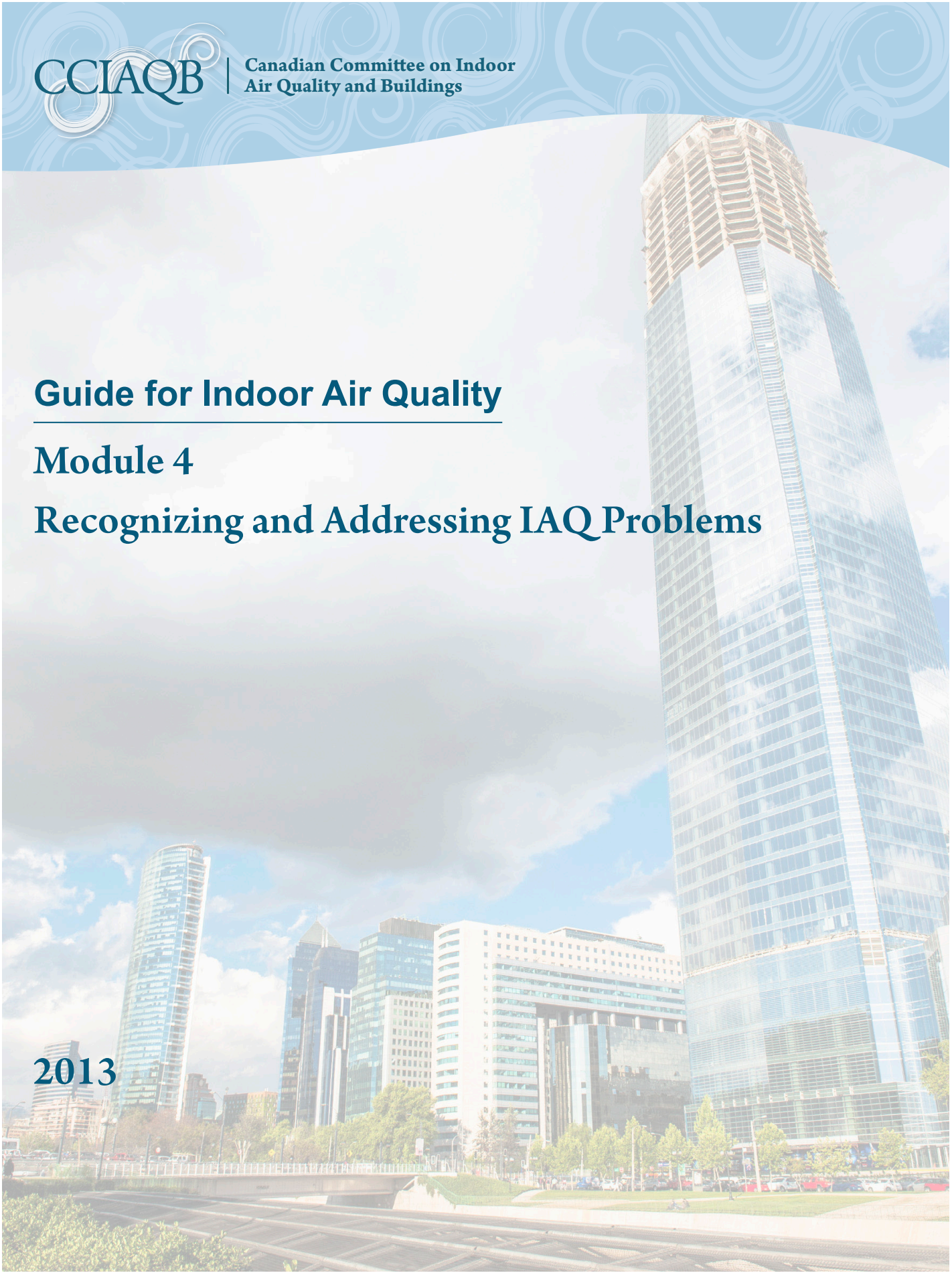

Guide for Indoor Air Quality

Module 4

Recognizing and Addressing IAQ Problems

2013

Canadian Committee on Indoor Air Quality and Buildings (CCIAQB)

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Indoor air quality is a very complex issue and there is currently a significant gap between knowledge of the effects of indoor air quality on the health of occupants and the effectiveness of various air quality technologies and solutions. User discretion is advised.

Preamble

The objective of the CCIAQB is, ultimately, to improve indoor air quality for all Canadians in every type of building. The CCIAQB has decided that its initial focus should be on buildings where many Canadians spend time outside their home, working, learning, shopping, being entertained, etc. For the most part, these buildings have relatively complex heating, ventilating and air conditioning systems that are operated and managed by knowledgeable persons. The table below gives examples of buildings that are covered using the classification found in the National Building Code of Canada (NBC). Documents produced by the CCIAQB are primarily intended for the use of building operators and facility managers, but the information contained in the guides can be helpful to anyone seeking a general understanding of indoor air quality issues.

The Committee welcomes feedback on the documents as well as ideas for the development of new materials. Contact the CCIAQB Secretary at info@IAQforum.ca or register on the website at www.IAQ-forum.ca.

NBC Classification	Examples
Group A, Division 1	Theatres, movie theatres and other facilities for the performing arts
Group A, Division 2	Art galleries, museums, libraries, educational facilities (schools, colleges and universities), gymnasia, air and rail terminals
Group A, Division 3	Arenas and swimming pools
Group C	Apartments, hotels, college residences
Group D	Offices, including medical and dental offices
Group E	Department stores, supermarkets, shops, retail space

Guide for Indoor Air Quality
Module 4: Recognizing and Addressing IAQ Problems

Table of Contents

List of tables, checklists, forms and figures

1. Purpose of This Module

The purpose of this Module is to help building managers identify and correct indoor air quality problems. Building operators and employers must provide a safe and healthy workplace for all employees, including acceptable quality indoor air. The 2010 edition of the National Building Code (NBC) includes some changes to Part 6 that affect the design and operation of building ventilation systems for new buildings. It sets maximum levels of particulate matter, ground-level ozone and CO for air used for building ventilation purposes. Several guides in this series provide helpful information about actions that help prevent IAQ problems from occurring: *Module 3, Custodial Activities, Maintenance, Repair and Renovation, Module 5, Hygienic Operation of Air Handling Systems and Module 6, Scent-Free Buildings*. In addition, a record of baseline building operating conditions will facilitate locating and identifying changes or deficiencies that may be at the root of the problem: refer to *Module 8 Creating a Building IAQ Profile*.

This document is part of a series of modules forming the CCIAQB *Guide for Indoor Air Quality available* at www.IAQForum.ca. For definitions and acronyms, refer to *Module 1 Introduction to Indoor Air Quality (IAQ)*.

2. Recognizing IAQ Problems

2.1. Reception and Acknowledgment of IAQ Complaints

IAQ problems are best addressed by having an established procedure in place for accepting complaints, communicating issues and progress to occupants, and reaching solutions. Table 4-1 shows essential actions for responding to IAQ problems.

Table 4-1 Actions for responding to IAQ problems

- ✓ Designate a competent person as IAQ manager.
- ✓ Communicate with occupants about their role in maintaining good IAQ (see *Module 7, Communicating with Tenant Organizations and Individual Occupants*).
- ✓ Develop and maintain an IAQ profile for the building (see Module 8).
- ✓ Educate building personnel about IAQ.
- ✓ Establish procedures for accepting complaints (see **Form 4-1**) and for communicating information before, during, and after an investigation.
- ✓ Ensure building occupants know how to file IAQ complaints.
- ✓ Listen and respond to building occupants' comments about IAQ.
- ✓ Handle complaints promptly and treat each incident thoroughly.
- ✓ Keep complaint records that will allow comparison to the IAQ profile and to irregularities in HVAC operation and maintenance.
- ✓ Use the records to identify patterns of problems (for example, time of day or building area).
- ✓ Communicate to explain the nature of a complaint and what steps will be taken to confirm and rectify a complaint, the schedule for completion, and who to contact for additional complaints or questions.

Adapted from EPA IAQ Guide and EPA (1998) Building Air Quality Action Plan

Communications with occupants about indoor air quality should include making them aware of how to register a complaint. Form 4-1 is a sample form that can be used to register and receive complaints. Complaint data falls into two categories: symptoms (e.g., discomfort, teary eyes, chills) and perceptions of building conditions (e.g., odors, draftiness). Investigators can gather valuable information about potential indoor air problems from listening to occupants, and use that information for:

- Defining the complaint area within the building;
- Suggesting directions for further investigation, which may assist in identifying other events that seem to happen at the same time as the incidents of symptoms or discomfort, or by identifying possible causes for the types of symptoms or discomfort that are occurring;
- Indicating potential measures to reduce or eliminate the problem.

For further information about accepting IAQ complaints and communicating actions, refer to the US Environmental Protection Agency (EPA), *Building Air Quality - A Guide for Building Owners and Facility Managers*. [Go to http://www.epa.gov/iaq/ and search for title or publication # 400191033.]

Form 4-1 IAQ Complaint

Fill out this form to make a complaint related to indoor air quality. Indoor air quality complaints include concerns about temperature, ventilation, and air pollutants.

Return the completed form to _____

or call _____ to make your complaint by phone.

We try to respond to indoor air quality complaints as quickly as we can.

Date _____

Name _____ Title _____

Telephone _____

Department and location in building _____

Describe the nature of the complaint and any potential causes. _____

_____

_____

_____

_____

Office use only

Complaint # _____ Received by _____ Date received _____

Adapted from *WorkSafe BC (2005) Indoor Air Quality: A Guide for Building Owners, Managers, and Occupants*

Indoor air contaminants can originate within a building or be imported from outdoors. Typical sources of air contamination are shown in Table 4-2.

IAQ problems can be caused by many factors that often interact. Complaints may arise from chemical, microbiological, pathological, physical or psychological reasons. Table 4-3 shows some factors that can adversely affect air quality and some of their sources.

Table 4-2 Typical sources of air contamination in buildings

1. **Contaminated outdoor air**
   - 1.1 Pollen, dust, fungal spores
   - 1.1 Industrial pollutants
   - 1.2 Exhaust from vehicles on nearby roads, parking lots, garages, or loading docks
   - 1.3 Odors from dumpsters
   - 1.4 Importation of exhaust from the building itself or from neighbouring buildings
   - 1.5 Unsanitary debris near air intakes
   - 1.6 Pesticides
2. **Soil gas**
   - 2.1 Radon
   - 2.2 Leakage from underground fuel tanks
   - 2.3 Contaminants from previous site uses (e.g., landfills)
3. **HVAC system**
   - 3.1 Dust or dirt in ductwork or other components
   - 3.2 Microbiological growth in drip pans, humidifiers, ductwork, coils
   - 3.3 Improper use of biocides, sealants, and/or cleaning compounds
   - 3.4 Improper venting of combustion products
   - 3.5 Refrigerant
   - 3.6 Building air flows and gradients causing cross-zone air movement
4. **Non-HVAC equipment**
   - 4.1 Emissions from office equipment (volatile organic compounds, ozone)
   - 4.2 Supplies (solvents, toners, ammonia)
   - 4.3 Emissions from shops, labs, cleaning processes
   - 4.4 Elevator motors and other mechanical systems
5. **Personal activities**
   - 5.1 Smoking
   - 5.2 Cooking
   - 5.3 Portable devices (e.g., humidifiers and air cleaners)
   - 5.4 Body odor
   - 5.5 Personal care products
6. **Housekeeping activities**
   - 6.1 Cleaning materials and procedures
   - 6.2 Emissions from stored supplies or trash
   - 6.3 Use of deodorizers and fragrances
   - 6.4 Airborne dust or dirt (e.g., circulated by sweeping and vacuuming)
7. **Moisture or standing water**
   - 7.1 Rooftops after rainfall
   - 7.2 Crawlspaces
   - 7.3 In-ground duct systems
8. **Maintenance activities**
   - 8.1 Microorganisms in mist from improperly maintained cooling towers
   - 8.2 Airborne dust or dirt
   - 8.3 Volatile organic compounds from use of paint, caulk, adhesives, and other products
   - 8.4 Pesticides from pest control activities
   - 8.5 Emissions from stored supplies
9. **Building components and furnishings**
   - 9.1 Textured surfaces such as carpeting, curtains, and other textiles
   - 9.2 Chemicals released from building components or furnishings
   - 9.3 Clutter
   - 9.4 Open shelving
   - 9.5 Old or deteriorated furnishings
   - 9.6 Materials containing damaged asbestos
10. **Unsanitary conditions and water damage**
    - 10.1 Microbiological growth on furnishings or building components
    - 10.2 Standing water from clogged or poorly designed drains
    - 10.3 Dry traps that allow the passage of sewer gas
11. **Accidental events**
    - 11.1 Spills of water, food or other materials
    - 11.2 Microbiological growth due to flooding or to leaks from roofs, piping
    - 11.3 Fire damage (soot, PCBs from electrical equipment, odors)
12. **Special use areas**
    - 12.1 Smoking lounges
    - 12.2 Laboratories
    - 12.3 Print shops, art rooms
    - 12.4 Exercise rooms
    - 12.5 Beauty salons
    - 12.6 Food preparation areas
13. **Redecorating/remodeling/repair activities**
    - 13.1 Emissions from new furnishings
    - 13.2 Dust and fibers from demolition
    - 13.3 Odors and volatile organic and inorganic compounds from paint, caulk, adhesives
    - 13.4 Microbiologicals released from demolition or remodeling activities

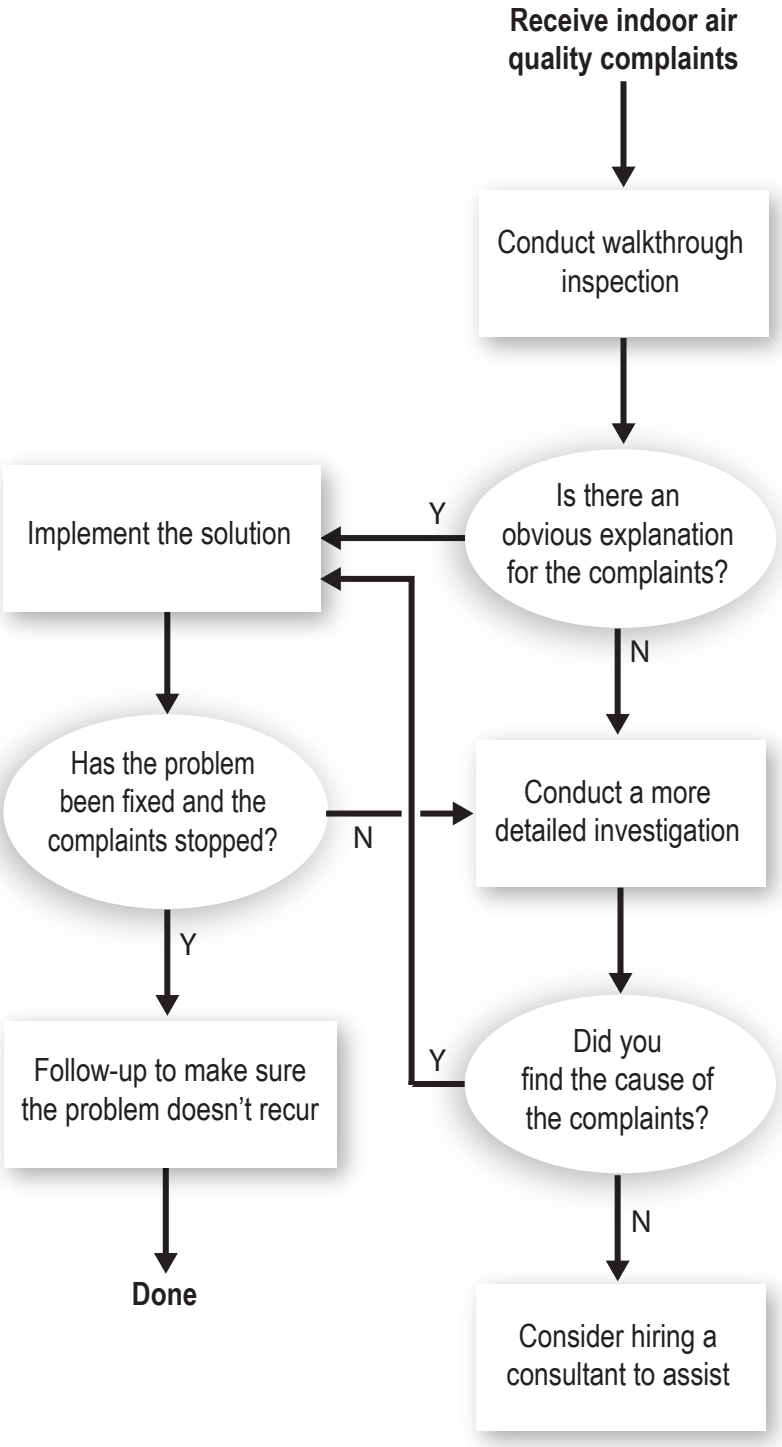
Adapted from *Building Air Quality: A Guide for Building Owners and Facility Managers, EPA (1996)*

Table 4-3 Typical factors and sources affecting IAQ *	
Factor	**Possible Source**
Temperature and humidity extremes	Poor thermostat performance, malfunctioning HVAC equipment, poor humidity control, inability of the building to compensate for climate extremes, occupant-added office equipment and processes, occupant intervention (e.g., blocked diffusers, etc.)
Carbon dioxide	People, combustion of fossil fuels (e.g., gas and oil furnaces and heaters)
Carbon monoxide	Automobile exhaust (garages, loading docks, air intakes), combustion of fossil fuels (e.g., gas and oil furnaces and heaters), tobacco smoke, failed or improperly isolated building chimney venting
Formaldehyde	Unsealed plywood or particleboard, urea formaldehyde foam insulation, fabrics, glues, carpets, furnishings, renovations that add new building products
Particulates (Coarse, Fine and Ultrafine)	Smoke, air inlets, paper shredding, duct insulation, water residue, carpets, housekeeping, vehicle exhaust, sources of combustion (furnaces, burning), chemical reactions, laser printers, photocopiers, other office machines, canister vacuum cleaners
Volatile organic compounds (VOCs)	Copying and printing machines, computers, carpets, furnishings, cleaning materials and supplies, smoke, paints, adhesives, caulking, solvents, personal care products (e.g., perfumes, hairsprays), odour masking air fresheners, outdoor sources
Inadequate ventilation (insufficient outdoor air supply, insufficient airflow, inadequate circulation)	Energy-saving and maintenance measures, improper HVAC system design, operation or balancing, occupant tampering with the HVAC system, poor office layout
Contamination from outdoors	Motor vehicle exhausts, plumbing vents, building exhausts (bathrooms, kitchens, etc.), nearby industries, roofing fumes
Microbial matter	Delayed clean-up of water leaks and floods, water carried in ventilation units due to excessive air speed, stagnant water in the HVAC system, wet and damp materials, humidifiers, condensate drain pans, water towers, animal dander, bird and bat droppings, occupant personal belongings, food and garbage, washrooms and showers
Ozone	Ozone generating air cleaners (electrostatic precipitator), photocopiers
Radon	From soil and ground water
Nitrogen dioxide	Vehicle exhaust (diesel), other combustion products (unventilated stoves, furnaces, etc.)

* Information contained in this table has been adapted from many sources including Health Canada.

The acceptance of a complaint is recognition of a possible IAQ problem and should set in motion a systematic approach for narrowing the range of possible causes similar to that shown in Figure 4-1.

Figure 4-1 The investigative process for IAQ problems



Adapted from *WorkSafe BC (2005) Indoor Air Quality: A Guide for Building Owners, Managers, and Occupants*

2.2. Communications

It is important to respond to all complaints about the indoor environment promptly and thoroughly and to establish credibility through open communication with building occupants ((see Module 7, Communicating with Tenant Organizations and Individual Occupants). Without open communication, any IAQ problem can become complicated by anxiety, frustration, and distrust, delaying resolution or acceptance of eventual resolution. A competent communications person should be assigned (see Table 4-1). Complainants and other building occupants should be kept informed of complaints, action plans for addressing complaints, progress, results and solutions.

2.3. Health Symptoms of IAQ Problems

Poor IAQ, or the belief that there is poor IAQ in a building, can lead to occupants experiencing anxiety, reduced performance and/or increased sick leave.

Recognizing and solving IAQ problems can be difficult as many of the symptoms can be caused by illnesses unrelated to a building. This requires the delicate task of taking all complaints seriously and using the complaint log, common sense and analysis to eliminate these complaints in a professional and supportive manner. Typical symptoms of poor IAQ are: eye, nose and throat irritation; sensation of dry mucous membranes and skin; erythema (skin redness), mental fatigue, headache; high frequency of airway infections; coughing; wheezing; itching; nonspecific hypersensitivity; nausea; and, dizziness.

In addition, IAQ issues do not affect everyone in the same way. Some people may be more sensitive than others and will report issues before other occupants, or one person might be the only individual affected but may report serious symptoms or concerns. Some people may not be susceptible to IAQ problems in the early stages of exposure, but can react more severely or more often as exposure continues over time. People that have pre-existing health conditions, such as respiratory problems or compromised immune systems, may be more sensitive to poor IAQ.

In general, the indoor environment should be investigated when occupants report symptoms within a few hours of being in a workplace, and when they feel better after being away from the building for a weekend or longer. Investigations should also be conducted when a group of occupants report similar symptoms. Typically, as air quality deteriorates and the length of exposure increases, more people will report issues and the symptoms may become more serious.

An interdisciplinary team can provide a more comprehensive approach to an IAQ investigation. Affected individuals should be encouraged to deal with their health professionals to ensure that their individual circumstances are being addressed.

3. Addressing IAQ Problems

The purpose of an IAQ investigation is to identify and solve an indoor air quality complaint in a way that prevents it from recurring and that does not create other problems. Investigations may require several stages of gathering information, formulating a hypothesis and making changes to the working conditions (e.g., ventilation adjustments, building repairs, etc.) until a satisfactory solution is obtained. In cases where a problem has several causes, it may be necessary to re-investigate and make numerous adjustments until the issue is completely resolved.

3.1. Initial (Walkthrough) Assessment

A walk-through inspection is a preliminary step to help document the extent and severity of an issue. The investigation team should include the employer, the building operator, the supervisor of the area where complaints are noted, a person familiar with the building's HVAC system, and a member of the health and safety committee. The building maintenance and cleaning staff should also be represented.

The investigative team may be able to solve simple IAQ problems from observations made during the walk-through inspection and other information sources. Checklist 4-1 shows the types of observations to make during the walk-through inspection. Before conducting an inspection, the investigation team should collect as much background information such as:

- Building floor plans and HVAC system arrangement;
- History of recent renovations or changes to past operation or maintenance, particularly those done prior to IAQ complaints;
- Occurrence of unscheduled or unusual actions (e.g., roof tarring, carpet cleaning, etc.);
- The symptoms building occupants have been experiencing. Information on symptoms, timing of onset and relief, and where in the building these issues occur should be obtained from building occupants to define the problem as completely as possible. The pattern of complaints in Checklist 4-2 may help identify where to look for the problem; and
- HVAC system operating parameters and schedule.

Examine the walk-through survey information to:

- Compare the original uses of the complaint area and surrounding rooms with the present use;
- Identify areas where remodeling, repair, or redecorating activities are in progress or have recently been completed. Check that proper control procedures are being used to isolate dust, paint fumes, and other off-gassing contaminants;
- Check that temperature, humidity and carbon dioxide (CO2) levels in the complaint area are in the comfort range; and
- Evaluate measured CO2 levels as an indicator of ventilation adequacy in occupied areas.

When the initial assessment has been completed, the investigation team should, as a minimum, establish:

- The nature of the complaints;
- The number of occupants affected;
- Building system parameters that may be related – by timing, location, activity, etc. – to the complaints;
- Possible HVAC deficiencies and general operating and maintenance conditions,
- Signs of occupant interference with the ventilation system; and
- Obvious internal and external contaminant sources.

Begin the investigation with a walkthrough

Checklist 4-1 Walkthrough inspection checks	
Items to check	**Comments/Observations**
✓ Odours ✓ Overcrowding (more occupants than ventilation system is designed to accommodate) ✓ Unsanitary conditions ✓ Dust ✓ Moisture problems, staining and discolouration of ceiling tiles, walls or carpets (mould can grow inside walls or below windows) ✓ Visible fungal growth ✓ Presence of chemical substances (containers or spills) ✓ Temperature, humidity, and air movement compared to other areas in the building ✓ Dirty supply and exhaust air vents ✓ (continued on next page) ✓ Characteristics and cleanliness of filters ✓ Quality of water in humidifier pans ✓ Exhaust of air conditioning system ✓ Areas where short-circuiting may occur (supply and return vents are close together) ✓ Placement of the thermostats ✓ Air movement around the supply and exhaust air vents – note any vents blocked by papers, books or other items ✓ Changes to the ventilation system, renovations, the layout of the area, additional or new furnishings ✓ Unusual sounds or noises from the ventilation system ✓ Use of personal fans or heaters	

Adapted from several sources

Checklist 4-2 Typical patterns of IAQ complaints and suggested actions	
Pattern of complaints	**Suggestions**
Widespread - no real pattern	Check entire HVAC system for proper functioning. Check air intakes for contamination or poor location. Consider sources that are throughout the entire building such as cleaning products. Check for sources that are spread by the ventilation system such as mould inside the HVAC system. Consider other non-IAQ related causes, such as lighting.
Localized – affecting one room, or HVAC zone	Check the HVAC in the affected area for proper functioning. Check for local sources of contamination (such as storage of materials, a cleaning product specific to that area, photocopiers). Check the HVAC for air contamination from a remote source to the affected area (e.g., parking garages, etc.). Check for recent construction, addition of materials or processes.
Individuals	Check for drafts, heat loss or gain, or other local temperature or ventilation issues (e.g., a blocked vent). If individuals have various complaints, consider various causes including known triggers for susceptible individuals. Review if there has been a change in equipment or processes.
Symptoms begin and/ or are worst at start of shift	Review HVAC operation. Source may be accumulating when the building is not occupied or after the HVAC has been operating at a reduced capacity overnight. Consider possibility of employee exposure to contaminants prior to work.
Symptoms get worse over a period of time (during the day)	Determine if the HVAC system is adequately handling routine activities or operations in the building (e.g., not enough fresh air or not enough air exchanges for the number of people). Investigate outdoor air sources for possibility of importing too much contaminated outdoor air (snow, moulds, construction odours, etc.)
Intermittent symptoms	Look for patterns for daily, weekly, or seasonal changes Check for other occurrences, such as weather patterns or special activities (such as increased number of people in building, cleaning activities like floor waxing).
Single event	Determine if there was an event, such as a spill or repair to equipment.
Symptoms get better when away from the building (either immediately, overnight, or after an extended leave)	Check the entire HVAC system for proper functioning. Consider other non-IAQ related causes such as stress, lighting, and noise. Other associated localized working conditions.
Symptoms are never relieved, even after extended absence.	Consider that the problem may not be building related.

Adapted from *Alberta Workplace Health and Safety , Indoor Air Quality Tool Kit (Aug. 2009)*

3.2. Detailed Assessment

If the initial assessment has not resulted in a solution, it will be necessary to proceed with a more detailed investigation. There are two main activities done during a detailed assessment of an indoor environment:

- The HVAC system is thoroughly checked; and
- Air quality indicators and contaminant levels are measured.

Tools for these activities include checklists (used to screen for issues) and appropriate measuring equipment (to test the air). Some measurements may require the use of complex instruments and laboratory analysis. Specialists may be required at certain stages of the diagnostic process.

Review occupant complaints and seek observations from a greater number of occupants in and around the area of the building generating complaints. The investigation may also include occupant interviews with building occupants who do not have complaints. Information about the history of complaints could also stimulate theories about potential causes of the problem. For interviews, develop a standard set of questions.

3.2.1. The HVAC System

IAQ complaints often arise because the quantity or distribution of outdoor air is inadequate to serve the ventilation needs of building occupants. Problems may also be traced to air distribution systems that are introducing outdoor contaminants or transporting pollutants within the building. See Module 5: Hygienic Operation of Air-Handling Systems

The investigation should begin with the components of the HVAC system that serve the complaint area and surrounding rooms, but may need to expand if connections to other areas are discovered. An evaluation of the HVAC system may include limited measurements of temperature, humidity, air flow, and CO2, as well as smoke tube observations to determine air flow patterns.

Complex investigations may require more extensive or sophisticated measurements of the same variables (e.g., repeated CO2 measurements taken at the same location under different operating conditions, continuous temperature and relative humidity measurements recorded with a data logger).

3.2.2. Pollutant Pathways

Architectural and mechanical pathways may allow pollutants to enter a complaint area from surrounding spaces, including the outdoors. An examination of architectural.and mechanical plans can help in developing a list of connections to surrounding areas. These include:

- Doors
- Operable windows
- Stairways
- Elevator shafts
- Utility chases
- Ductwork and plenums
- Areas served by common HVAC controls (e.g., shared thermostats)
- Unsealed ceiling spaces and other building chases

If complaints are limited to a few areas of a building, the investigation of pollutant pathways can be useful. If complaints are registered from throughout a building, the evaluation of pathways could be a very time-consuming process, and it may be more practical to look for and contain major contaminant sources before trying to discover how the contaminants move within the building.

3.2.3. Pollutant Sources

Any public or commercial building is likely to contain a number of sources that produce odors, contaminants, or both. The investigator's task is to identify the sources that may be responsible for complaints.

Very few sources of indoor air contaminants are both continuous and constant in volume over time. Pollutant concentrations often vary in strength over time, and may not be evident at the time of the site visit. Some sources are subtle and might only be noticed by a trained investigator. As the investigation progresses, the inventory of pollutant sources may need to be revised by expanding the definition of the complaint area or examining specific locations more closely (e.g., under various operating conditions).

3.2.4. Sampling

Air sampling may need to be done if other investigative methods have not determined the source of IAQ problem. If sampling is required, the procedures should be based on a complete understanding of how the building operates and the nature of the complaints. While trained personnel can undertake preliminary testing (humidity, temperature, carbon monoxide, etc.), expert assistance may be required for more complicated situations (see *Module 2 – VOC Sampling Strategies and Methods*).

Before initiating air sampling, investigators should develop a sampling strategy that is based on a comprehensive understanding of building operation and HVAC functionality, the nature of the complaints, and a plan for interpreting the results. Consider:

- How the results will be used (e.g., comparison to standards or guidelines, comparison to levels in complaint-free areas);
- What substances(s) should be measured;
- Where to take samples;
- When to take samples; and,
- The sampling and analysis methods to use.

In any sampling program, high readings may provide evidence of a problem, but may not identify the source. Alternatively, low readings may not necessarily mean that a subtle or intermittent air quality problem does not exist. Air sampling makes it possible to:

- Establish baseline conditions so that levels measured in problem areas can be compared with concentrations at other times and at other locations;
- Compare indoor with outdoor air quality;
- Test or confirm a hypothesis about the source of the problem;
- Confirm that a control approach has had the desired effect of reducing contaminant concentrations or improving ventilation;
- Reveal the existence of compounds associated with particular types of building problems; and,
- Compare measured concentrations with occupational exposure standards and with public health and comfort guidelines for specific contaminants.

Sampling locations may be determined based on:

- Individual HVAC zones;
- Types of HVAC zones (interior vs. perimeter);
- Complaint vs. non-complaint areas; and,
- Relationship to potential sources (e.g., printing shop, parking garages, loading bays); or
- Types of complaints.

The sampling strategy should be designed to assess worst-case conditions, such as when emissions are expected to be highest, or when ventilation is the lowest. "Worst-case" sampling results can establish the highest levels to which an occupant may be exposed. In any case, sampling should include good documentation of building occupancy, use and HVAC system operation so that the sample results can be interpreted in the context of the building configuration at the time the samples were obtained.

Sampling time can vary in length and should be chosen so as to most accurately reflect actual exposure by building occupants. If contaminant emissions are highly variable throughout the day, a longer sampling period may be needed to capture the peaks and valleys in order to get a measure of the true "average" exposure. Contaminants with low analytical detection limits may need longer sampling times to get an adequate sample.

If IAQ problems are not detected through the measurement of individual parameters, these results do not mean that no problem exists. Only a small number of parameters can be practically measured, the measurement may have been taken when the contaminant was not present or present at a non-typical concentration, or existing exposure standards are simply not adequate to determine if the levels measured may pose a health risk or comfort problem for some people.

3.3. Finding Solutions

There are generally two ways to determine if efforts to solve the IAQ issues have been successful:

- Reduced complaints: If complaints are eliminated, or significantly reduced, it may be a sign that the problems have been addressed.
- Measurement of IAQ: If the investigator is able to compare the properties of the air before and after remedial measures have been implemented, these measurements can show what changes have been made (temperature, humidity, air flow patterns, and air contaminant levels etc.).

Using the iterative approach shown in Figure 4-1, each step of the investigation narrows the field of possible causes for an indoor air quality problem. The investigation should be continually adjusted to collect information to support or refute the suspected cause.

As information is reviewed, explanations for the IAQ problem can be based on a comparison of building conditions to occupant complaints.

Potential solutions may be tested by changing operating conditions and measuring change such as ventilation rates or the pressure relationship between spaces, eliminating or isolating suspected sources, sealing pathways, or temporarily relocating affected individuals.

3.4. Obtaining Outside, Expert Assistance

The following are some of the situations that might lead to engaging an IAQ consultant:

- In-house personnel have not been able to resolve IAQ complaints;
- Initial assessment indicates a need for specialized equipment and training;
- Mistakes or delays could have serious health or liability consequences;
- It is concluded that an independent investigation would be better received than an in-house investigation (establishes third party credibility).
- Investigation and mitigation efforts by facility staff have not relieved the IAQ problem.

When hiring any contractor, it is important that contract documents explain as clearly as possible the nature of the problem and the types of issues that need to be addressed. The IAQ consultant should be:

- Familiar with IAQ regulations and guidelines;
- Qualified to assess thermal comfort ,ventilation, and common IAQ contaminants;
- Experienced with HVAC system performance, operation, and maintenance;
- Experienced in IAQ investigations and have references; and
- Prepared to provide regular updates.

The goal is to reach a successful resolution of the complaints, not simply to generate data. The contract Terms of Reference should request potential consultants to:

- Describe the methodology to be used;
- Outline schedule, cost and deliverables such as reports and training for building staff;
- Identify tasks that will need to be provided by building personnel; and
- Stipulate communication frequency and methods between the IAQ professional and the client.

4. Sources of Additional Information

- EPA, Building Air Quality: A Guide for Building Owners and Facility Managers [Go to http://www.epa.gov/iaq, search for title]
- Pennsylvania, The Pennsylvania Green Building Operations and Maintenance Manual [Go to www.health.state.pa.us/, search for title]
- Work Safe BC, Indoor Air Quality: A Guide for Building Owners, Managers, and Occupants http://www.worksafebc.com/, search for:indoor air quality.