CCIAQB | Canadian Committee on Indoor Air Quality and Buildings

Guide for Indoor Air Quality

Module 1

Introduction to Indoor Air Quality (IAQ)

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

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Module 1: Introduction to Indoor Air Quality (IAQ)

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1. Purpose of the Guide for IAQ

In 2010, the Canadian Committee on Indoor Air Quality and Buildings (CCIAQB) commissioned a survey, which revealed that building professionals considered themselves generally knowledgeable about indoor air quality and its potential harm to human health. The results also indicated a need for guidelines to help train personnel. For this reason, the CCIAQB is developing a series of modules intended to help building designers, owners, operators, and managers understand how to avoid and correct indoor air quality problems and maintain acceptable indoor air quality.

Although the Committee is interested in all buildings and their occupants, its initial focus is on buildings with a high number of occupants such as office buildings and schools. However, many of the general principles in the guide are applicable to other types of buildings.

This document is the first of a series of modules forming the CCIAQB *Guide for Indoor Air Quality* available at www.IAQforum.ca.

The modules are not intended to be complete information about IAQ, but rather, a summary of current best practices and knowledge. They reflect the collective views of the CCIAQB, not those of individual members or their organization (*Please read the Disclaimer*). Most of the reference documents are available online. See Section 9, Sources of Additional Information.

2. Purpose of this Module

The purpose of this module is to provide introductory-level information about indoor air quality that will help users of the guide understand and apply the information presented in the more specific modules.

3. What Causes Indoor Air Quality Problems?

Over the past several decades, it is likely that occupant exposure to indoor air pollutants has increased due to a variety of factors including:

- The construction of more tightly sealed buildings;
- Reduced ventilation rates to save energy;
- The use of synthetic building materials and furnishings;
- The increased complexity of modern building systems;
- Increased time spent indoors and,
- Building deterioration due to age, improper maintenance or design.

In a broad context, IAQ is the result of the complex interactions among buildings, building systems and people. It is a constantly changing interaction of complex factors that can be categorized as follows:

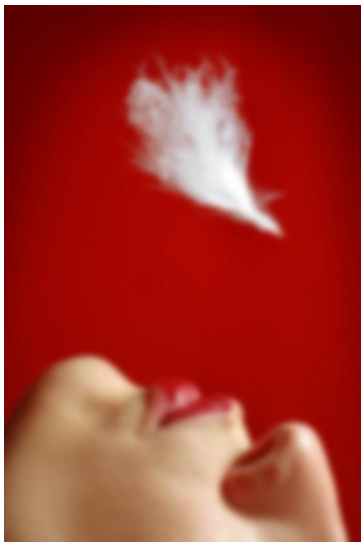
1. **Sources of air pollutants**: air pollutants can originate either within a building or be imported from outdoors. They can result from moisture problems, materials, and occupants and their activities. Air pollutants consist of tiny particles or particulates (such as dust, pollen, soot or fungal spores), fibres, mists, aerosols and gases.

2. **Heating, ventilation and air-conditioning (HVAC) system**: the HVAC system is crucial for limiting, diluting and removing contaminants. A system that operates poorly can also be a source of air quality problems (dirty filters, etc.). To function properly, an HVAC system should:
    - Control temperature and humidity to provide thermal comfort;
    - Provide reliable operation in response to demand;
    - Distribute adequate amounts of clean outdoor air to meet the ventilation needs of occupants when present;
    - Isolate areas in order to contain problems and remove odours and pollutants through pressure control, dilution, filtration, and exhaust;
    - Be maintained by personnel trained in system operation and maintenance; and
    - Provide adequate access for the inspection and maintenance of all components.

    Detailed information about HVAC systems is provided in *Module 5 – Hygienic Operation of Air-Handling Systems.*
3. **Pathway between the source and the location of an IAQ problem**: Airflow patterns in buildings result from the combined action of mechanical ventilation systems, human activity, and natural forces. Pressure differentials created by these forces move airborne contaminants from areas of relatively higher pressure to areas of relatively lower pressure through any available openings.
4. **Occupants**: Occupants can contribute to indoor air quality problems by their activities (photocopying, cooking, etc.) what they bring into a building (plants, personal equipment etc.) and how they use the building (business type, number of occupants, etc.)

While other factors such as lighting, noise and electromagnetic fields (EMF) have an impact on indoor environment and should be recognized, they are not typically addressed as part of an IAQ assessment.

4. What is Acceptable Indoor Air Quality?



The guide modules are based on the goal of providing *acceptable* air quality in buildings. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) defines acceptable air quality as: "*air in which there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction."* However, air quality is a complicated topic and it is recognized that other definitions for acceptable air quality may be desired or required.

A healthy indoor environment is one that contributes to productivity, comfort, and a sense of health and well-being. It is free from unacceptable levels of odours, dust and contaminants. Air circulation meets air change requirements without creating drafts. Temperature and humidity

are appropriate for the activities in the building. Sanitation is maintained and water-related problems are quickly recognized and corrected. Failure to maintain acceptable air quality can have consequences such as:

- Increased health problems (e.g., coughing, eye irritation, headache, allergic reactions) and, in rare cases, more serious health problems (e.g., Legionnaire's disease, carbon monoxide poisoning);
- Absenteeism and loss of productivity;
- Strained relations between landlords and tenants, and employers and employees;
- Negative publicity that could threaten leasing opportunities or bring liability problems; and
- Accelerated deterioration of furnishings and equipment.

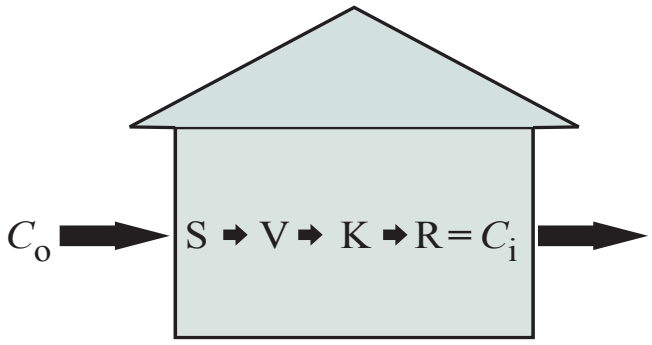
Provision of good air quality requires conscientious effort by both building staff and occupants. The commitment to address IAQ problems starts with the building owner or facility manager – the person who has an overview of the organization, sets policy, and assigns staff responsibilities.

Although energy conservation is an important goal, it should not be achieved by actions that compromise air quality, such as reducing the amount of outdoor ventilation air without taking action to maintain the quality of the recirculated air. The modules of this guide indicate that acceptable air quality begins with good design and is continually supported by general maintenance, HVAC maintenance and operation, attention to detail during repairs and renovations, and communication with, and education of, building occupants.

5. Understanding IAQ

This model shows the interrelationship among key factors that are discussed in the series of modules that are part of this guide. A very simple mass balance model based on this figure could be written as:

$$C_i = C_o + \frac{S - R}{KV}$$



In which:

C_i = indoor concentration
C_o = outdoor concentration
S = indoor sources
R = indoor removal mechanisms
V = ventilation rate
K = mixing efficiency
C_i is the result of all the other interactions. C_i cannot be managed unless all of the other parameters are understood and addressed.

Consider the following:

C_o: introducing contaminated air is a "root cause" of poor air quality. Most filters collect only a fraction of particles present in the air stream and none of the gas contaminants. The quality of the outdoor air and location of the outdoor air intakes relative to potential sources of contamination are critical.

V: ventilation is a basic component of IAQ management and indoor contaminant dilution. During occupancy, ventilation should be continuous, reliable and adequate for the types of activities that are being carried out in the building. It is important to maintain good hygienic conditions in the HVAC system to prevent it from becoming a source of contaminants.

K: supply air must be well mixed and distributed in the occupied areas. "Short circuits" not only reduce the efficiency of ventilation, but rob the building of the benefit: money is spent to heat or cool air that did not provide the anticipated level of comfort and air quality for the occupants.

Think about S: reducing or eliminating indoor sources of contamination is an effective and efficient method of maintaining acceptable air quality. It is better, simpler and less expensive to not introduce contaminants than trying to remove the contaminants after they are brought into the building. When selecting any material, furniture or product that will be inside the building, enquire about emissions and custodial requirements (cleaning products, etc.)

Think about R: the removal of indoor sources of contaminants may be active (controlling entry, filtration, custodial practices, etc.) or passive (settling on surfaces, absorption into materials or "sinks", i.e. places into the space where contaminants are soaked-up). While useful and sometimes necessary, removal is not a substitute for inadequate source management.

6. Six Basic IAQ Control Strategies

Strategies for controlling the quality of indoor air can be condensed into six basic control methods:

Source Management is the action of identifying, avoiding and isolating or removing a source of air contamination. It is one of the most important strategies because it addresses root causes of IAQ problems.

Local Exhaust involves the removal of point sources of pollutants before they can disperse into the indoor air, by expelling contaminated air directly outside. Sites where local exhaust is used include restrooms and food preparation areas. Other locations where pollutants originate at specific points and can be easily exhausted include storage rooms and photocopying rooms.

Ventilation introduces outdoor air into a building to displace or dilute contaminants in the indoor air. Generally, local building codes specify the quantity (and sometimes quality) of outdoor air that must be continuously supplied to an occupied area. For activities such as painting, or in the event of chemical spills, a temporary increase in ventilation can help to dilute the concentration of noxious fumes in the air. In such cases, reducing or eliminating recirculated air is advisable. Ventilation should not be considered as a substitute for proper work practices and other measures that eliminate or control the original source of the pollutants. Ventilation is most efficient and effective when applied to a well-designed and managed facility.

Exposure Control includes adjusting the time and location of building occupancy to minimize exposure to intentionally released air contaminants. For example, the best time for stripping and waxing floors may be on weekends. This schedule would allow the floor products to off-gas over the weekend, reducing the level of odours or contaminants in the air when the building is occupied. This strategy may require adjusting ventilation rates which are often reduced during weekends and other unoccupied periods.

Air Cleaning is the capture of particles from the air. Various types and levels of particle filtration are normally included in ventilation systems. Gaseous contaminants can also be removed, but in most cases these types of systems are complex and expensive and should be evaluated on a case-by-case basis.

Education of the building occupants about IAQ is critical. People must be provided with information about the sources and effects of contaminants (including those under their control), and about the proper operation of the ventilation system. With this knowledge, they will better understand their indoor environment and can take steps to reduce their personal exposure and improve the overall IAQ.

7. Definitions and Abbreviations

This section defines common IAQ terms (adapted from the U.S. Environmental Protection Agency (EPA)) and some abbreviations used in many of the modules. Text in square brackets [] has been added by the authors of this document.

Air changes per hour (ACH): the amount of air in a building that leaks out or is removed by a fan and is replaced by outdoor air, usually listed as a fraction of one air change per hour, such as 0.35 ACH. [ACH is sometimes referred to as air exchange rate or AER.]

ASHRAE: American Society of Heating, Refrigerating and Air-Conditioning Engineers.

Building envelope: [the] elements of the building, including all external building materials, windows and walls that enclose the internal space.

Biological contaminants: agents derived from, or that are, living organisms (e.g., viruses, bacteria, fungi, and mammal and bird antigens) that can be inhaled and can cause many types of [adverse] health effects including allergic reactions, respiratory disorders, hypersensitivity diseases, and infectious diseases, also referred to as "microbiologicals" or "microbials."

Carbon dioxide (CO_2): a colorless, odorless, and tasteless product of combustion. All combustion processes and human metabolic processes are sources of CO_2. Concentrations of CO_2 from people are always present in all occupied buildings, and at concentrations normally found in buildings, CO_2 is not a health hazard.

Carbon monoxide (CO): a colorless, odorless, and tasteless gas which results from [incomplete] combustion of fuels. It is often associated with combustion heating devices (e.g. boilers, furnaces) and auto, truck, or bus exhaust from attached garages, nearby roads, or parking areas. At moderate concentrations, angina, impaired vision, and reduced brain function may result. At higher concentrations, CO exposure can be fatal.

Formaldehyde: Formaldehyde is a colorless water-soluble gas. Due to its wide use, it is frequently considered separately from other VOCs. Materials containing formaldehyde include building materials, furnishings, and some consumer products. [It is also a by-product of combustion.] Formaldehyde has a pungent odor and is detected by many people at levels of about 100 parts per billion (ppb). Besides the annoyance, it also causes acute eye burning and irritates mucous membranes and the respiratory tract. [The risk of cancer associated with formaldehyde levels, sufficiently low to prevent irritation and inflammatory responses, appears to be negligible (Health Canada, 2006)].

Fungi: any of a group of parasitic lower plants that lack chlorophyll, including molds and mildews.

HEPA: high-efficiency particulate arrestance [air] (filters).

IAQ profile: a base-line description of the features of a building structure, function, and occupancy that impact indoor air quality. A completed IAQ profile provides an understanding of the current status of air quality in the building and baseline information on the factors that have a potential for causing problems in the future. For more information about developing and using an IAQ profile, see *Module 8 – Creating an IAQ Profile.*

NBC: National Building Code of Canada.

NFC: National Fire Code of Canada.

Off-gassing: the production of gases from the chemical deterioration of a substance over time, and the release of gases from materials into the air. [See VOCs]

Pollutant pathways: avenues for distribution of pollutants in a building. HVAC systems are the primary pathways in most buildings; however all building components interact to affect how air movement distributes pollutants.

Radon: radon is a colorless, odorless, radioactive gas that occurs naturally in the environment [from the breakdown of uranium in soils and rocks]. Outdoors, its concentration is rendered negligible. But when it is emitted into an enclosed space, such as a building, it can accumulate to high levels and be a carcinogen. [Exposure to high levels of radon has been associated with an increased risk of lung cancer.] Radon can seep from the ground into buildings through cracks and unsealed penetrations in the floor and walls abutting the ground.

Volatile organic compounds (VOCs): compounds that vaporize (become a gas) at room temperature. Common sources which may emit VOCs into indoor air include housekeeping and maintenance products, and building and furnishing materials. In sufficient quantities, VOCs can cause eye, nose, and throat irritations, headaches, dizziness, visual disorders, memory impairment; some are known to cause cancer in animals; some are suspected of causing, or are known to cause, cancer in humans.

For a more complete list of terms, see http://www.epa.gov/iaq/glossary.html

8. Checklists

Several of the guide's modules contain checklists that can be used to standardize procedures and investigations.

9. Sources of Additional Information

Indoor air quality is a relatively new and an evolving science. Several important reference documents have been created and are available on the Internet. The CCIAQB provides these references as useful sources, but does not endorse the organizations, or the literature and products that are available from them.

1. Building Air Quality: A Guide for Building Owners and Facility Managers: http://www.epa.gov/iaq/largebldgs/pdf_files/iaq.pdf

2. Pennsylvania Green Building Maintenance Manual: http://www.mass.gov/Eoaf/docs/dcam/mafma/manuals/o_and_m_pa_green_bldg_o&m_manual.pdf
3. Indoor Air Quality: A Guide for Building Owners, Managers, and Occupants, Work Safe BC http://www.worksafebc.com/publications/health_and_safety/by_topic/assets/pdf/indoor_air_bk89.pdf
4. Environmental Tobacco Smoke (ETS): Workplace Policy, Canadian Centre for Occupational Health and Safety: http://www.ccohs.ca/oshanswers/psychosocial/ets_resolutions.html
5. California Department of Public Health, Indoor Air Quality Program: http://www.cal-iaq.org/
6. LEED User: http://www.leeduser.com/browse
7. An Office Building Occupant's Guide to Indoor Air Quality, US EPA: http://www.epa.gov/iaq/pubs/occupgd.html
8. Indoor Air Quality - Action Kit for Canadian Schools, Health Canada: http://www.hc-sc.gc.ca/ewh-semt/pubs/air/tools_school-outils_ecoles/index-eng.php
9. Health Canada (2006). Residential Indoor Air Quality Guideline. Formaldehyde. ISBN: 0-662-42661-4. Available at: http://www.hc-sc.gc.ca/ewh-semt/alt_formats/hecs-sesc/pdf/pubs/air/formaldehyde-eng.pdf
10. IAQ Tools for Schools - Action Kit, US EPA: http://epa.gov/iaq/schools/