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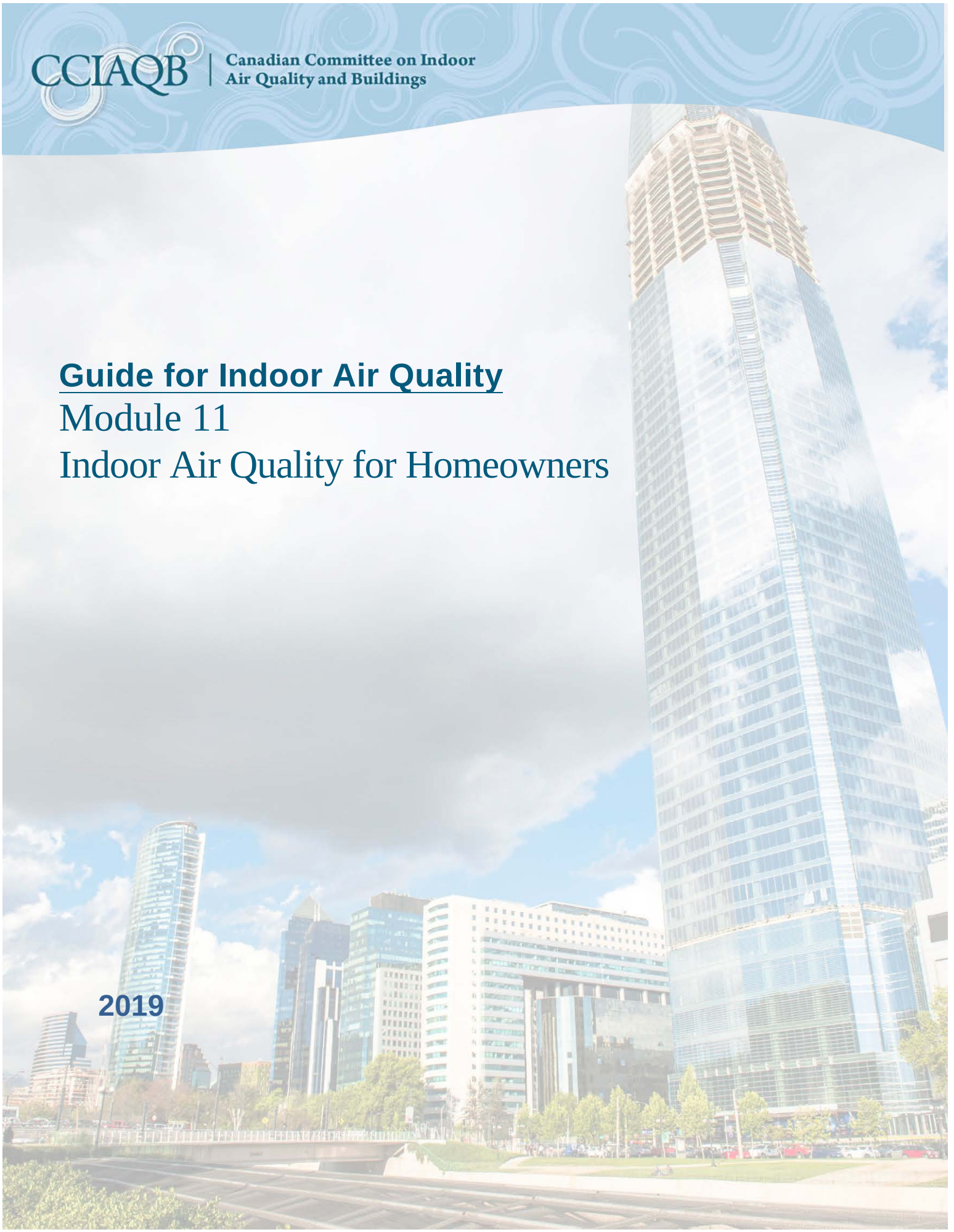

Guide for Indoor Air Quality

Module 11

Indoor Air Quality for Homeowners

2019

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 (IAQ) 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.

Although the focus to date has been on the types of buildings shown in the table below, the CCIAQB recognizes the importance of homeowners understanding how indoor air quality can affect health and what can be done to create healthier home environments, since people spend the majority of their time indoors at home over their lifetime. Module 11 – Indoor Air Quality for Homeowners, is a response to this important need.

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.IAQforum.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 11: Indoor Air Quality for Homeowners

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1. Purpose of this Module

The purpose of this Module is to provide homeowners with information about the importance of indoor air quality (IAQ), help them to establish and maintain good air quality in their homes, and to recognize and correct IAQ problems that do occur either on their own or with the help of professionals.

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

2. The Importance of Good Indoor Air Quality

Most people spend up to 70% of their time indoors at home over a lifetime, hence indoor air quality is important for occupants. Although there have been significant advances in the science of indoor air quality, it remains a complex subject, further complicated by the fact that not everyone reacts the same way to indoor pollutants. Some people are more susceptible than others. For some contaminants, the link between contaminant levels and health has become obvious, and health-related guidelines have been provided by recognized authorities. For many others, it remains difficult to predict which concentrations and exposures might lead to adverse health effects.

Poor indoor air quality may cause symptoms such as headaches, wheezing, tiredness, coughing, sneezing, sinus congestion, shortness of breath, dizziness, nausea, and irritation of the eyes, nose or throat. Allergy or asthma symptoms may also be worsened due to poor indoor air quality. Some contaminants are linked to chronic health conditions, such as cancer, respiratory and heart disease, as well as effects on the brain. Exposures during pregnancy and childhood can be particularly harmful.

3. What is Acceptable Indoor Air Quality?

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.” For individuals who suffer from chemical sensitivities, the above definition of acceptable air quality will fall short.

People may encounter hundreds of contaminants in indoor environments, but generally in low concentrations; by themselves, these contaminants are mostly considered harmless, especially if exposure times are short. The big question is how these different compounds and particles together affect human health in the long term. Some contaminants in indoor air can be perceived as odour, for example, the musty smell emitted by mould; but others such as radon give off no odour at all. In general, minimizing the *sources* of air quality problems is essential to providing a

healthy indoor environment. This is especially true for people who are hypersensitive, and those who have allergies and asthma.

A home's air can be affected by many things: excessive moisture leading to mould growth; off-gassing and release of toxic particles from building materials, finishes and furniture; inadequate ventilation; and incomplete combustion of gases from heating systems. Daily activities also have a big impact through moisture from cooking, bathing and laundering; the use of personal care products, household cleaners, air "fresheners" and other common products; hair dander and litter from pets; certain hobbies; and even emissions from equipment in a home office.

Indoor air needs to be free from harmful levels of contaminants and needs to be at a humidity level that is healthy and comfortable. Relative humidity refers to the quantity of water vapour in the air relative to the maximum amount of water vapour it can hold at a given temperature. Relative humidity can range from 0 to 100%. Studies show that the optimum range for comfort is between 30 and 55%. Low humidity can cause static electricity, dry scratchy throats for occupants, and excessive dust problems. High humidity can lead to condensation on cool surfaces such as windows and mould growth.

4. Types and Sources of Residential Indoor Pollutants

Contaminants that affect indoor air quality can be separated into three broad categories:

- *Biological pollutants* originate from living organisms in the forms of mould (fungi), insects such as dust mites and cockroaches, dander from fur-bearing animals such dogs or cats, and dusts and pollen. Mould refers to fungi that can grow on any surface, such as food and building materials.
- *Chemical pollutants* are gases and particles that come from, for example, combustion appliances, tobacco smoke, household and personal care products, paints, gasoline, various building materials, soil gas and outdoor air (sources).
- *Particulate matter* is pollution suspended in air such as dust, pollen, soot, smoke, and liquid droplets.

4.1 Biological Pollutants

4.1.1 Mould

Mould is one of the most common indoor air quality concerns. It can grow when there is excess humidity or moisture either from indoor sources not adequately vented or due to drainage or leakage problems in the building. Mould can be any colour, such as black, white, green, or red. Once it grows, mould releases spores into the air that can easily be inhaled. Mould spores are a trigger for asthma and other allergy-like symptoms including wheezing and itchy eyes and throat among sensitive individuals. Mould exposure can be a serious problem for children already diagnosed with asthma and it is suspected to be linked to the onset of asthma.

To grow, mould needs oxygen, water, organic nutrients and a suitable temperature. Removing any one of these contributors will make conditions unsuitable for mould growth. However, in a heated building, moisture is the only contributor to mould growth that can be practically controlled. Therefore, the challenge is to have a humidity level that is conducive to comfort and health, but low enough to avoid mould growth.

Mould can grow on nearly all organic materials, including paper and paper products, cardboard, ceiling tiles, and wood products. Other materials such as paint, wallpaper, some insulation materials, drywall, carpet, fabric, upholstery, and even dust, may also support mould growth. It can even grow on glass or aluminum, which are inorganic materials, if a thin (often invisible) layer of organic matter is present.

Since moisture is necessary for mould growth, dampness is one of the most common causes of poor indoor air quality in homes. Controlling the level of moisture is one of the best and easiest ways to improve indoor air and protect health.

4.2 Chemical Pollutants

4.2.1 Combustion (burning) by-products

Combustion by-products are gases and small particles produced by the incomplete burning of fuels such as oil, gas, kerosene, wood, coal and propane. Examples of combustion by-products found indoors include fine particulate matter, carbon monoxide, and nitrogen oxides.

Carbon monoxide (CO) is a colourless, odourless, and tasteless gas. It can be released into indoor air from various sources including fuel-burning appliances (such as furnaces, fireplaces, gas stoves and water heaters) especially where these are not properly vented or maintained, or when chimneys are blocked or dirty. Additional sources include idling vehicles in attached garages, tobacco smoke, and the inappropriate use indoors of barbecues, grills, space heaters and other non-vented fuel-burning appliances. In most jurisdictions, houses built in the past 10 years with attached garages are required to have an air barrier and a self-closing door between the garage and the living space, and carbon monoxide alarms must be installed in the suite adjoining the garage.

Because it cannot be detected by human senses, CO can cause health problems before people even notice it is present. At high levels, CO exposure can be lethal in as few as one to three minutes. At lower but still hazardous levels, exposures for several hours can cause headaches, tiredness, shortness of breath, impaired motor function, dizziness, chest pain, convulsions, or coma.

4.2.2 Volatile organic compounds (VOCs)

VOCs belong to a large and diverse family of chemicals containing carbon and hydrogen, which are gaseous at room temperature. One of the most studied VOCs is formaldehyde, which is used in some insulation materials and in many types of particleboard and medium-density-fibreboard, commonly used for cabinets and furniture. VOCs can be emitted by a wide range of modern products including:

- Building materials such as vinyl or laminate flooring, paneling, some insulation materials and paints, varnishes, glues, adhesives and caulking;
- Home furnishings such as those made from particleboard, appearance (non-structural) plywood and fibreboard, carpet backing, and vinyl products such as shower curtains, carpets, and drapes;
- Hobby and arts-and-crafts materials such as some paints, markers, and adhesives;
- Permanent press fabrics, air fresheners, cleaning products and disinfectants; and
- Combustion sources including fuel-burning appliances, vehicle exhaust and tobacco smoke.

Short-term exposure to high levels of some VOCs can cause irritation of the eyes, nose, and throat, in addition to headaches. Exposure to certain levels of formaldehyde has been found to worsen asthma in children, and may cause allergic sensitization.

4.2.3 Asbestos

Asbestos is the generic term used to describe six naturally occurring minerals containing various silicates. Asbestos was widely used in building products until the mid 1980s. Asbestos-containing products may be present in Canadian homes and buildings built or renovated between the 1930s and the early 1980s, or insulated with vermiculite up until the mid 1990s. In addition to older vermiculite insulation, asbestos can be present in a wide variety of materials. Some common examples are ceiling tiles, old vinyl flooring, shingles (roofing and siding), textured paints and coatings, insulation used on stoves, furnaces and pipes, ducts; plaster walls, ceilings, mouldings, and drywall compound. Federal regulations under the Hazardous Products Act now restrict the use of asbestos in most products with the result that very few products on the market in Canada today contain asbestos. It is likely only to be present in older houses. Exposure to asbestos can cause a number of diseases, the main ones being asbestosis, pleural disease, lung cancer or mesothelioma, a specific cancer of several membranes such as the pleura or peritoneum.

4.2.4 Lead

Lead is a heavy metal that is ubiquitous in the environment. Lead can be present in dust, air, water, soil, and consumer products. Lead was added to household paints until the mid 1970s. Regulations in Canada now strictly limit the lead content of consumer paints and surface coating materials. For this reason, leaded paint is likely only to be present in older houses. It may be

benign until disturbed, as might occur during maintenance or a renovation activity. In older homes, plumbing pipes may also have been made from lead until 1975, and lead solder was used to join piping until 1986. Exposure to lead causes reductions in cognitive function of the brain, neurological and behavioural impairment, kidney toxicity, and reproductive complications. Because of its harmful effects on the developing brain, it is particularly important to minimize children's exposures to lead.

4.2.5 Radon

Radon is a naturally occurring radioactive gas given off during the decay of uranium, which is found in rock and soil. Radon gas is odourless, invisible and has no taste. It can enter any home directly through the building's foundation, generally from the surrounding soil. Over time, high levels of inhaled radon gas may lead to lung cancer. Radon is the second leading cause of lung cancer among smokers, and the leading cause among non-smokers in Canada.

4.2.6 Second-hand smoke

Second-hand smoke (SHS) is made up of smoke breathed out by smokers and the side stream smoke released from the burning end of cigarettes, cigars and pipes. It is more than just a nuisance – it is one of the most harmful indoor air pollutants. SHS consists of thousands of pollutants, including fine particulate matter, CO, VOCs, and polycyclic aromatic compounds (PAHs).

Smoke from a single cigarette can stay in a room for hours, even with an open window. Many of the toxic chemicals remain in the air and the carpets, curtains, furniture, and clothes. Air purifiers and ventilation systems may remove some of the smoke, but these may not remove all the toxic chemicals.

In the long term, people exposed to second-hand smoke have a greater risk of suffering from lung cancer, nasal sinus cancer, heart disease, stroke, and breathing problems, including increased coughing, wheezing, pneumonia, bronchitis, and asthma. Second-hand smoke is harmful to children, especially those with asthma and other chronic lung conditions because the second-hand smoke makes the health conditions worse. Children who do not have asthma are more likely to get asthma when exposed to second-hand smoke. Exposure to second-hand smoke is also harmful to pregnant women and affects fetal development and increases the risk of low birth weight and premature delivery.

4.2.7 PCBs

PCBs (polychlorinated biphenyls) were used in materials such as sealing and caulking compounds, and fluorescent light fixtures made prior to 1978. Buildings constructed or renovated in Canada between 1950 and 1978 could also have PCB-contaminated caulk around windows and door frames, between masonry columns and in other masonry building materials.

The adverse health effects of PCBs include a severe form of acne (chloracne), swelling of the upper eyelids, discolouring of the nails and skin, numbness in the arms and/or legs, weakness, muscle spasms, chronic bronchitis, and problems related to the nervous system.

4.2.8 Ozone

Most people recognize ozone from its presence in the ozonosphere, or ozone layer, where it functions to protect the Earth from harmful ultraviolet rays. Ozone found at ground level, by contrast, poses health risks. Ozone is an important component of summer-time "smog". Ground level ozone is produced when sunlight reacts with volatile organic compounds, such as those from hydrocarbon vehicle emissions. Ozone can also form inside the home, although in most cases the concentration of ozone outdoors is greater than that indoors. Electrical sparks which create ozone may occur from any equipment that uses high voltage or ultraviolet light. These items include electric motors, and high power office equipment (photocopiers or laser printers that have been improperly installed). Some types of air cleaners may produce ozone either as part of the cleaning mechanism (e.g. ozone generators) or as a by-product (e.g electronic precipitators). Ozone generators in particular can release harmful levels of ozone, especially when used in small spaces with poor ventilation, and are not recommended for use in homes. Ground level ozone is linked to respiratory problems. Exposure to ozone can cause coughing, shortness of breath, decreased lung function, irritation of eyes, nose, and throat, in addition to asthma. It can also worsen existing asthma and chronic obstructive pulmonary disease (COPD).

4.2.9 Other toxic substances

There are other toxic substances that may be present at low levels in indoor air and in ordinary house dust, mostly stemming from consumer products and furnishings. Phthalates, mercury, flame retardants, and pesticides are a few key examples.

Phthalates are plasticizers used in resins, paints and cosmetics and to make plastic soft and flexible. In personal care items, they're used to help lubricate other substances, help lotions penetrate and soften the skin, and help fragrances last longer. Phthalates are not chemically bound to their host products and are continuously released and thus end up in indoor air and dust. Some phthalates have been linked to disruption of normal endocrine function.

Mercury from broken fluorescent light bulbs and tubes contain a small amount of mercury sealed within their glass tubing. If a mercury containing bulb or tube breaks, mercury can be released (as vapour). Mercury vapour is odorless, colorless and harmful to human health when inhaled, in particular to the brain of the developing fetus in the womb, infants, and children.

Flame retardants are compounds added to manufactured materials including furniture and drapery upholstery to inhibit, suppress, or delay the production of flames to prevent the spread

of fire. Flame retardants are linked to multiple health concerns, including effects on the developing brain and disruption of normal endocrine function.

Pesticides may be present in the air either from outdoor sources, or due to applications made indoors for pest control. Health effects can be wide ranging depending on the pesticide, the amount present, and the mode and duration of exposure. Some effects of exposure are skin irritation, coughing, and nervous system and endocrine system effects; children may be more susceptible including effects on brain development.

4.3 Particulate Matter

4.3.1 Particulate matter

Particulate matter (PM) is the name for a wide range of particles that are released into the air through combustion or other processes. These particles can be solid or liquid, or a mixture of both, and are small enough to be carried by the air and therefore be inhaled. The toxicity of particles is related to both their size and composition. The smaller the particle, the further down into the respiratory tract it can be inhaled. Much of the health research on particulate matter has focused on fine particulate matter (PM2.5), which consists of particles that are 2.5 µm in diameter or smaller.

Indoor particulate matter is a mixture of substances such as carbon (soot) emitted by combustion sources, tiny liquid or solid particles in aerosols, fungal spores, and pollen, as well as small amounts of toxic substances.

In a properly maintained home, most of the airborne particulate matter comes from outdoors. However, some homes do have significant sources of indoor particulate matter that can come from the following sources:

- Cigarette smoking is the greatest single source of particulate matter in homes where people smoke;
- Cooking (especially frying);
- Malfunctioning combustion appliances (for example, furnaces without a proper air filter);
- Non-vented combustion appliances like gas stoves;
- Wood-burning appliances like wood stoves and fireplaces (especially if the smoke leaks or backdrafts into the home);
- Workshops and hobbies; and
- Mould spores.

Airborne particulates can settle into house dust on floors and other surfaces. Because of their frequent hand-to-mouth behaviour and more rapid breathing rate, young children are more highly exposed to contaminants in dust.

There are very few studies on the health effects of indoor PM, but those available seem to link exposures to respiratory symptoms such as wheezing and coughing, especially in children.

5. The Evolution of Canadian House Construction

Although owners of newer and older houses share some common air quality challenges, they also have unique challenges. For example, newer houses are tightly sealed to conserve energy and therefore, an effective ventilation system is needed to remove indoor pollutants and excess humidity. On the other hand, older houses tend to use more energy because air leakage occurs through the walls and ceiling. This air leakage can also provide a degree of ventilation and help to remove buildup of indoor pollutants and excess humidity, but it can also bring in more pollutants from outdoor air. Older houses are also more likely to contain harmful materials such as leaded paint and plumbing, and asbestos, which have since been banned in newer construction.

In the mid-1980s, the Federal government launched the R-2000 program in Canada to increase energy efficiency in homes by making houses more air-tight. Air leakage through cracks and openings is a major source of heat loss and creates the possibility of the moisture in warm, escaping air to enter wall spaces, risking mould development and structural damage. In the early 1990s, it was recognized that improved ventilation was needed to offset the effect of increased air-tightness. This resulted in the development of a standard for residential mechanical ventilation systems that was incorporated into the 1995 edition of the National Building Code of Canada.

For the purpose of this Module, older housing means homes built prior to 1985 and newer housing is generally that built after 1997. Houses built between 1985 and 1997 may or may not have tighter envelopes and ventilation systems. This is because provinces and territories adopt features of revised national building codes on different schedules.

Since 2012 (in several jurisdictions), minimum insulation values were added to building codes. This means that housing is moving in the direction of energy efficiency and tighter building envelopes.

Older houses, in general, do not have ventilation systems like those common in newer housing, and may rely largely on natural ventilation. Gradually newer houses began to have exhaust fans installed. Tighter construction after 1980 and retrofits began to introduce full house ventilation systems. Most new houses built after 2012 now have heat recovery ventilation systems installed, since they have been mandated recently.

Table 11.1 summarizes the issues that affect houses of different ages.

Table 11.1 House age and air quality issues

House vintage / Air quality issue	Houses built before 1980	Houses built 1980-2012	Houses built since 2012	Renovations	New furnishings
Biological pollutants					
Mould	Mould can affect houses of any age.				
Chemical pollutants					
Combustion by-products, including carbon monoxide	Old heating appliances can release combustion gases into the house. Poor installation or unbalanced ventilation systems can cause combustion by-products to be pulled into living spaces.			New heating appliances installed during renovations need to meet code and manufacturers' installation requirements.	
VOCs	VOCs dissipate with time. Therefore emissions from building materials are not usually a factor in older houses		New houses need to be well-ventilated to disperse VOCs.	VOCs can be introduced to houses of all ages when new building materials are added during renovations.	New furniture, drapes and carpeting can introduce VOCs to houses of all ages. Increase ventilation during initial off-gassing periods
Asbestos	Asbestos may be present in older homes.	Not usually a risk.	Not usually a risk.	Renovations may disrupt asbestos products in older houses.	
Lead	Lead may be present in older homes. Deteriorating lead-painted surfaces can pose a risk to indoor occupants. Sealing the lead paint by covering it (surface) with non-leaded paint is advisable.	Not usually a risk.	Not usually a risk.	Renovations may disrupt lead paint or expose lead plumbing pipes during plumbing retrofits in older houses.	
Radon	Radon can exist in the ground below a house of any age. All houses should be tested using a long-term radon detector (minimum 3-month test, e.g., during the winter months). In areas with known (elevated) radon concern, ensuring that a new house is constructed in accordance with the National Building Code radon requirements (sub-slab venting rough-in pipe stub installed at construction) will facilitate reducing radon levels if necessary.				
Second-hand smoke	Second-hand smoke is a result of occupant behavior, and, therefore, all affected premises are susceptible.				

PCBs	PCBs may be present in older houses.	Not usually a risk.	Not usually a risk.	Not usually a risk.	
Ozone	Ozone is a result of electrical devices and pollutants in the general environment.				
Other toxic substances	All houses are susceptible to other toxic substances, such as phthalates from plastics and cosmetics, mercury from broken fluorescent light bulbs and tubes, flame retardants used in upholstery, or pesticides.				
Particulate matter	Controlling air-borne and settled dust should be part of regular house-keeping and maintenance in all ages of housing.			Dust control is a particular concern during renovations, especially if the house remains occupied during the work.	

5.1 How new home construction promotes IAQ

Modern building codes are intended to deliver housing that is safe, durable and comfortable. Although homeowners rarely have control over the quality of construction, building codes and municipal code officials and inspectors play an important role in enforcing code requirements. Examples of how building codes help promote good indoor air quality are:

- Moisture: The building envelope is intended to shed rain and snow and keep walls and ceiling assemblies dry. The air and vapour barriers are intended to minimize the movement of moisture from inside a house into wall spaces where mould can develop. The air barrier is also intended to separate a house from an attached garage so that fumes don't enter the living space.
- Ventilation: Ventilation and heat exchange is intended to provide outdoor air and remove contaminants and excess moisture.
- Fuel-burning devices: Appliances such as furnaces and water heaters are required to be mechanically vented so that combustion gases cannot be drawn back into the living space.
- Radon: Since 2010, new houses in many jurisdictions are required to have provisions for reducing radon ingress or for simplifying radon removal should long-term post-occupancy testing indicate that this is required.

To maintain good indoor air quality, it is important to get rid of the stale or excess moist air generated in the course of everyday living. Every new home comes equipped with mechanical ventilation, such as exhaust fans in high-humidity areas of the house. Many new homes use a heat recovery ventilator (HRV), a whole-house ventilation system that continuously brings in outdoor air to all living areas of your home and exhausts the stale air. To make sure the system is not simply bringing in problems from the outside, the incoming air is filtered. The filter should be changed on a regular basis, as per manufacturer's recommendations. The incoming air is also

pre-heated in winter (or pre-cooled in summer) by the outgoing air to save energy-this is the heat recovery part of the system.

6. Maintaining Acceptable Indoor Air Quality

This section describes measures homeowners can take to improve residential air quality.

Four basic steps can be followed to maintain indoor air quality:

1. Avoid or get rid of a source so that a problem does not have a chance to develop. For example, fix water intrusion problems, choose low-emitting finishes and furnishings, select fragrance-free cleaning and personal care products, and do not smoke indoors.
2. Isolate hazards from living areas. For example, a sealed air barrier beneath the basement floor slab will help reduce radon ingress in new builds and soil depressurization systems will keep radon from entering existing homes; storing paints and chemicals outside the living space will eliminate fumes from these sources.
3. Capture pollutants at the source. For example, dust frequently with a damp cloth, wet mop or HEPA vacuum cleaner, and use the kitchen and bathroom venting systems.
4. Ensure that systems which contribute to good IAQ are working well. Control indoor relative humidity and clean or replace the air filter in the ventilation system regularly. Ensure that gas appliances and fire places are properly installed and maintained.

6.1 House operation and maintenance

The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) lists ten practices related to ventilation that will contribute to good indoor air quality:

1. Vent bathrooms, kitchens, toilets and laundry rooms directly outdoors. Use energy-efficient and quiet fans.
2. Avoid locating furnaces, air conditioners and ductwork in garages or other spaces where they can inadvertently draw contaminants into the house.
3. Properly vent fireplaces and wood stoves. Use tight doors and outdoor air intakes when possible.
4. Vent clothes dryers and central vacuum cleaners directly outdoors.
5. Store toxic or volatile compounds such as paints, solvents, cleaners and pesticides outside of the occupied space.
6. Minimize or avoid unvented combustion sources such as candles, cigarettes, indoor barbecues, decorative combustion appliances or vent-free heaters.
7. Provide operable windows to accommodate unusual sources or high-polluting events, such as the use of home cleaning products, hobby activities, and painting.

8. Use sealed-combustion or condensing water heaters and furnaces. When natural-draft applications must be used, they should be tested for proper venting and should be located outside the occupied space when possible.
9. Put a good particle filter or air cleaner in the air handling system to keep dirt out of the air and off ductwork and cooling components.
10. Distribute a minimum level of outdoor air throughout the home, using whole-house mechanical ventilation.

6.2 Further considerations for occupants

Occupant activities such as smoking, poor housekeeping, hobbies, use of high-VOC cleaners and solvents, and failure to maintain the ventilation system can seriously affect indoor air quality. To increase the likelihood of having good indoor air quality, homeowners should be aware of the following factors:

- Relative humidity: Maintain a comfortable level of relative humidity and add moisture if the air is too dry and feels uncomfortable. Remove moisture as required to avoid dampness and condensation, at least over longer time periods.
- Particulate matter: Keep ventilation fans, supply air inlets and air ducts clean. Use appropriate filters to reduce particulate matter and debris in air ducts. Vent central vacuum systems to the exterior. Use HEPA filters in vacuum cleaners.
- Chemical contaminants (VOCs): Select water-soluble cleaners, glues and solvents and look for Environmental Choice products. Select furnishings and contents that are not high VOC emitters (Health Canada www.hc-sc.gc.ca/ewh-semt/air/in/poll/construction/organi-eng.php).
- Mould: Take steps to prevent vapour condensation, dampness and free water over extended time periods (anything over a few hours). Dry building materials, carpets, etc. that have become wet as a result of leakage or spillage immediately.
- Scents: Choose fragrance-free laundry, cleaning and personal care products and avoid the use of air “fresheners” including plug-ins.
- Combustion gases: Maintain heating appliances on a yearly basis. Limit automobile idling in the garage and keep the door between the house and the garage closed when doing so. Operate kitchen fans when using gas stoves. Install CO alarms and if battery powered, change the batteries at the recommended frequency. Choose CO alarms that are certified by the Canadian Standards Association (CSA) or the Underwriters Laboratories of Canada (ULC). Follow the manufacturer's directions for installing, testing and replacing alarms. Store the manual in a handy place. If it is hard-wired to the house's electrical supply, ensure it has a battery-powered back-up.
- Radon: Test the home for radon gas using a long-term (3 month) C-NRPP approved test kit and engage a qualified C-NRPP (Canadian National Radon Proficiency Program) radon contractor if remedial (radon mitigation) work is required.

6.3 Renovations

Many homeowners undertake renovations and these can be periods when occupants' exposure to air quality hazards is highest. Find a temporary place to live during major repairs and renovations such as hardwood floor refinishing. Take steps to have the contractor control dust during the work and select materials and furnishings that are not high VOC emitters. Remove all dust after the renovation is completed and ventilate the space thoroughly. If leaded plumbing pipes are being removed during renovations, precautions should be taken to avoid exposure to lead from airborne particulates (e.g. from pipe cutting). During renovations may be a good time to install or upgrade heat recovery ventilation systems.

7. Recognizing and Correcting Problems

7.1 Biological Pollutants

7.1.1 Mould

Moisture problems in a building can originate from any one or a combination of factors:

- Moisture that is already present in the building (e.g., due to indoor living practices).
- Elevated relative humidity levels inside or outside the building; thereby, causing condensation on building surfaces.[1]
- Rain and groundwater entry (due to drainage or leakage problems) into the building.

Since moisture is necessary for mould growth, it is important to

- control the level of moisture within the building to reduce the potential of mould growth within a building; and
- identify any building (construction) deficiency(ies) that may be causing or providing the conditions suitable for mould growth.

Removing mould without removing the moisture source(s) will result in the mould returning.

The following actions will help reduce the causes or sources of excess moisture:

- Direct roof runoff away from the building (Figure 11.1).
- Repair basement, roof and plumbing leaks.
- Keep Relative Humidity Low – Keeping relative humidity low will help keep the dew point temperature low, and reduce the potential of condensation in the residential premise. Indoor relative humidity should be kept ideally between 30% and 50%.
    - Use a dehumidifier in a damp basement; and
    - Keep bathroom and kitchen exhaust ventilation fans in good repair and utilize them.

[1] Context: In cooling climates, the humid exterior air condenses upon surfaces at or below dew point, i.e., within the wall cavity. In heating climates, the humid air in the house condenses on wall surfaces or within the wall cavity (upon attaining the dew point).

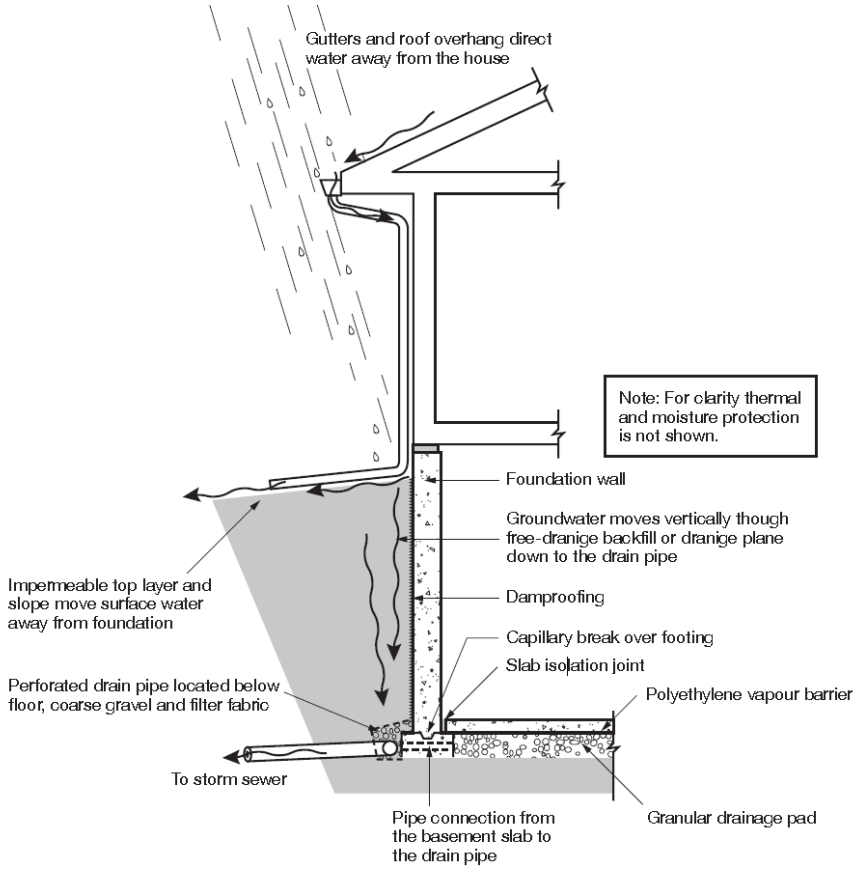

Figure 11.1 Measures for keeping precipitation from entering living spaces (adapted from the CHBA Builders' Manual)

The source of the recurring mould problem may be related to a building construction deficiency (e.g., lack of flashing installation, inadequate window or wall insulation, etc); hence, an inspection of the building by a qualified person (e.g., building inspector) is recommended. The inspection should provide an:

- Evaluation of the building in terms of the extent of the mould presence, and the symptoms of excess moisture intrusion that led to mould (or its potential for) growth;
- Identification of the source(s) of moisture and the conditions (including building construction deficiency) that contributed to the elevated moisture (or humidity) level within that building; and
- Recommended solutions for the remediation or mitigation of identified building construction problems.

Upon receiving the building inspection report and recommendations, it is prudent that the owner address the underlying building issue(s), as per the inspection report.

During renovations, it is often a central objective to tighten the building envelope to reduce energy use. Ensure that moisture issues are addressed so that they are not made worse by the renovation process.

Older homes may have concrete, stone, or masonry block foundations that do not have adequate damp proofing on the foundation walls or have blocked drain tiles.

Water damage from basement flooding creates conditions for mould growth. Obtain professional help to ascertain which materials can be salvaged and which ones need to be replaced.

Remove mould from non-porous (hard) surfaces by wiping or scrubbing with water, or water and detergent. It is important to dry these surfaces quickly and thoroughly to discourage further mould growth. Porous materials that are wet and have mould growing on them may have to be discarded. Since mould will infiltrate porous substances and grow on or fill in empty spaces or crevices, the mould can be difficult or impossible to remove completely.

Wet vacuum cleaners can be used to remove water from floors, carpets, and hard surfaces where water has accumulated. They should not be used to vacuum porous materials, such as gypsum board. They should be used only when materials are still wet – they may spread spores if sufficient liquid is not present.

If the remediation work disturbs mould, and mould spores become airborne, then the risk of respiratory exposure increases. Avoid actions that are likely to stir up mould which include: breakup of mouldy porous materials such as wallboard; invasive procedures used to examine or remediate mould growth in a wall cavity; actively stripping or peeling wallpaper to remove it; and using fans to dry items.

7.2 Chemical Pollutants

7.2.1 Combustion (burning) by-products

- If a CO alarm sounds, leave the home immediately.
- Call local authorities (9-1-1) and do not go back into the home until a professional has fixed the problem.

Making a home more airtight during an energy efficiency retrofit can potentially increase levels of combustion products in the home, including CO. For example, kitchen and bathroom fans can cause exhaust from wood stoves and naturally venting furnaces and hot water heaters to be drawn back into a house (known as backdrafting).

7.2.2 Volatile organic compounds (VOCs)

Few house purchasers have control over the building materials used for construction. In addition, it may be difficult to link air quality problems to VOCs so owners of new homes or homes that have had major renovations that include work such as painting, carpeting, floor finishing or the acquisition of new furnishings should assume that there will be some added level of VOCs. Remembering that VOCs dissipate with time, new home owners and renovators can increase ventilation during the first several months to exhaust VOCs by opening windows during mild weather.

Homeowners undertaking renovations have some control over the materials used. The homeowner and the contractor can work together to select materials, finishes and furnishings that are known to be low VOC emitters. Consumers can get direction from GreenSpec (http://greenspec.buildinggreen.com/).

Further, homeowners can also select personal and cleaning products that are labelled as being low chemical emitters. This step will help reduce the VOC levels indoors.

7.2.3 Asbestos

Asbestos does not cause a health risk unless it is frayed or crumbling and releasing fibers into the air or if it is disturbed such as during renovations. Avoid disturbing loose-fill insulation, removing roof shingles or siding, tampering with roofing felt, ripping away asbestos insulation from a hot water tank, sanding or scraping asbestos floor tiles, breaking apart acoustical ceiling tiles, and sanding plaster or coatings such as roofing compounds, sealants, paint, putty caulking or drywall containing asbestos.

Health Canada recommends that if homeowners suspect asbestos is present and may be disturbed during renovations, they should consult an expert in asbestos abatement and removal.

7.2.4 Lead

Avoid mechanically removing or disturbing (e.g., sanding) old lead-based paint, which can release high levels of leaded dust into the air that can be breathed in or deposited around the home. Be careful when cutting out and removing leaded plumbing pipes to avoid exposure to particulate dusts.

Lead-based paint used on doors or trim should be stripped offsite, either professionally or outdoors in a well-ventilated space. For walls, ceilings or immovable trim, chemical strippers (paste applied with a brush) may be the best solution. All chemical paint strippers contain potentially harmful substances, so proper ventilation protection and personal protective equipment (PPE) is required. Refer also to the manufacturer’s safety data sheets (SDS) and recommendations for use.

7.2.5 Radon

All houses, old and brand-new, should be tested for radon using a long-term (3-month) test kit. Testing is relatively simple and inexpensive. Radon test devices can be purchased by phone or over the internet and are available at some home improvement retailers across Canada. For more information on radon and how to obtain do-it-yourself radon test kits, visit: https://takeactiononradon.ca/test/radon-test-kits/

When conducting a radon test, observe the manufacturer's instructions concerning test location and conditions. If long-term testing shows high radon levels, consult a radon professional to develop a plan for reducing the radon levels. A certified radon measurement professional can also be hired to test and assess. Lists of certified Canadian measurement and mitigation professionals are available through the Canadian National Radon Proficiency Program (C-NRPP).

The most effective radon reduction method is called active soil depressurization (ASD), of which there are several variants (sub-slab, sub-membrane, block-wall, sump pit, drain tile). In the case of active sub-slab depressurization, a pipe is installed through the basement floor concrete slab and routed to either an outside wall near ground level or up through the home to above the roof line. In either case, a small inline fan is attached to the piping which draws the radon from below the house and expels it to the outdoors before it can enter your home. An ASD system can reduce high radon levels in a home by over 90%. Increasing ventilation and sealing major entry routes can also help reduce radon levels but their effectiveness will be limited depending on how high the radon level is and the unique characteristics of each home.

The cost of reducing radon in a house depends on how it was built and the extent of the radon issue. The average radon remediation process, typically done using a contractor, will cost between $1500 and $3000. The cost can be less if either a passive system or a radon rough-in was installed during construction.

To learn more about radon, visit : https://www.canada.ca/en/health-canada/services/radon.html

7.2.6 Second-hand smoke

Keep all smoking outside or better yet, eliminate it altogether.

To facilitate the removal of tobacco residue from a house or apartment,

- ventilate well,
- clean all flat surfaces (e.g., doors, walls, floors, ceilings, window panes and frames, blind slats),
- clean (or replace) carpets and drapery
- re-paint walls and ceiling (note: talk to your local paint store about sealant application).

7.2.7 PCBs

PCBs were also used in some floor finishes during the 1950s and 1960s. Avoid disturbing such finishes during renovations. If the floor needs to be removed, use a qualified contractor. Fluorescent light fixtures manufactured prior to 1978 may also contain PCBs and these should be replaced. The proper disposal method for fluorescent tubes varies depending on your location but may include taking them to a local hazardous waste depot or to an environment day event.

7.2.8 Ozone

Homeowners can control ozone to some degree. Consumers should be cautious when purchasing home equipment which uses ozone to purify air or water. Any high voltage office equipment or electronic air cleaner should also be seen as a potential source of generating ozone.

As with most other indoor air pollutants, a balanced mechanical ventilation system can help by removing indoor air and replacing it with outdoor air. However, in some areas this may not be a solution for ozone pollution since outdoor levels are higher than indoor levels, especially in larger cities. If this is the case, filters can be installed into the ventilation system to combat any ozone influx. The most effective filters are those that make use of activated carbon compounds to chemically convert ozone back into oxygen, making it safe to breathe.

7.2.9 Other toxic substances

Methods for reducing the impact of other toxic substances mentioned in 4.2.9 above are:

Phthalates: Choose personal care products, detergents, and cleansers without phthalates or the word "fragrance" on the label. Select baby-care products that are phthalate-free.

Mercury from broken fluorescent light bulbs and tubes: If a fluorescent light source breaks in the home:

- Have pets and people leave the room.
- Open windows and leave room with the doors closed. Ventilate the room for at least 10 minutes.
- Turn off the heating and air handling systems because heat will make the mercury vaporize into the air more quickly and a blower fan will distribute the mercury vapour throughout the home.
- Do not vacuum or sweep as these activities will spread the mercury vapour into the air more quickly. Using rubber gloves, scoop up larger glass fragments with stiff cardboard.
- Use sticky tape to pick up the small pieces and clean hard surfaces with a damp paper towel or cloth**.** If the spill occurs on a carpet or rug, cut-out and dispose of the mercury-contaminated section. If the carpet is removable, take it outside to clean.

- Use a fresh piece of sticky tape to pick up any small pieces of glass or fine particles that remain.
- Put clean-up materials and glass fragments in a glass container (for example, a jar with a tight-fitting lid). If a glass container is not available, use a sealable plastic bag and remove the bags from the home immediately.
- Dispose of the jar of CFL materials as hazardous waste, if local facilities exist.
- Use personal protective equipment.
- Wash hands and arms thoroughly after disposing the clean-up materials and CFL debris.
- If possible, continue to air out the room for several hours.

Flame retardants in drapes and furniture upholstery: Health Canada is currently conducting health risk assessments for a number of flame retardants. In the meantime, consumers can opt for furniture that uses fire barrier systems or is made of untreated, inherently flame resistant materials.

Pesticides: Store pesticides away from children, ideally outside the building envelope. Utilize integrated pest management (IPM) practices to eliminate entry points and food sources for pests, employ the least toxic forms and smallest amounts of pesticides if they must be used indoors, and always apply them as directed.

7.3 Particulate Matter

If there are continual deposits of dust, determine what the source is, e.g.,

- indoor sources or activities, e.g., (smoking, cooking, hobbies); or
- outdoor sources, e.g., local industrial or commercial activities, road conditions (gravel versus pavement), or others

Ventilation duct cleaning is recommended as part of good building maintenance practice. As an avenue for resolving complaints concerning continual dust deposits within the building, studies on the effectiveness of duct cleaning have not conclusively demonstrated that dust levels in homes increase because of dirty air ducts. This is because much of the dirt in air ducts adheres to duct surfaces and does not necessarily enter the living space. It is important to keep in mind that dirty air ducts are only one of many possible sources of particles that are present in homes. The US Environmental Protection Agency suggests that residential air ducts be cleaned if: there is visible mould growth in ducts; rodents or insects are present in the ducts; or if ducts are clogged with excessive amounts of dust and debris and/or particles are actually released into the home from the supply registers.

8. Identifying the Need for Outside Assistance

A homeowner may need to seek professional assistance in circumstances such as:

- planned renovation;
- recent occurrence of flooding, roof or foundation leaks, or a fire;
- recurring mould after repeated clean-ups;
- presence of any foul odour that cannot be explained or removed; or
- occupants experience ongoing symptoms (e.g., headaches, wheezing, aggravation of asthma, etc.) that they suspect are linked to indoor air quality (i.e., with symptoms disappearing after occupants spend time away from the house).

The Canada Mortgage and Housing Corporation recommends that an initial investigation focus on finding the source of a problem and taking steps to correct it - taking remedial action is far more important than identifying all individual contaminants. Costs for an investigation may range from $400—$500, but vary by location, complexity of the problem, and travel time needed.

9. Considerations for Working with IAQ Consultants and Contractors

A professional indoor air quality (IAQ) investigator is trained to find problems, determine causes, and recommend corrective measures. An investigation should include a written report providing an assessment of the problem, causes and recommended solutions. Determine what will be received from the investigation and at what price.

Companies that provide IAQ investigations advertise in the Yellow Pages™ or the Internet. Before hiring an investigator, inquire about the individual's training, experience and references, and check if the company is endorsed by the Better Business Bureau. The investigator should not be affiliated with a testing laboratory or remediation company, or be selling any product or a service other than IAQ investigation. Take usual precautions when hiring services by requesting a written estimate and a contract, and avoiding up-front payments. Ensure contractors have appropriate insurance.

10. Sources of Additional Information

1. Indoor Air Quality, Health Canada, https://www.canada.ca/en/health-canada/services/air-quality/improve-indoor-air-quality.html

2. Residential Indoor Air Quality Guidelines, Health Canada, https://www.canada.ca/en/health-canada/services/air-quality/residential-indoor-air-quality-guidelines.html

3. Radon, Health Canada,
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4. Guide for Radon Measurements in Residential Dwellings (Homes), Health Canada,
https://www.canada.ca/en/health-canada/services/publications/health-risks-safety/guide-radon-measurements-residential-dwellings.html

5. Breathe Easy: 5 Ways to Improve Indoor Air Quality,
http://www.webmd.com/lung/features/12-ways-to-improve-indoor-air-quality

6. Indoor Air Quality in Homes, United States Environmental Protection Agency,
http://www.epa.gov/iaq/homes/

7. 10 Tips for Home Indoor Air Quality, American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE),
https://www.ashrae.org/resources--publications/free-resources/10-tips-for-home-indoor-air-quality

8. Mould in Housing, Canada Mortgage and Housing Corporation (CMHC),
https://www.cmhc-schl.gc.ca/en/maintaining-and-managing/managing-first-nation-properties/maintenance-solutions/mould-in-housing

9. Indoor Air Quality, Canadian Homebuilders' Association (CHBA),
http://chba.atomicmotion.com/newhomesmonth/consider-the-benefits-of-a-new-home/indoor-air-quality.aspx

10. Indoor Air Quality, HealthLinkBC,
https://www.healthlinkbc.ca/healthlinkbc-files/indoor-air-quality

11. Your Healthy Home, The Lung Association™ ,
http://www.yourhealthyhome.ca/

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13. Creating Healthy Home Environments for Kids: Top 5 Tips, Canadian Partnership for Children's Health and Environment,
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14. Reduce Radon, Canadian Partnership for Children's Health and Environment.
http://www.healthyenvironmentforkids.ca/content/reduce-radon

15. Compact Fluorescent Lightbulbs Fact Sheet, Canadian Partnership for Children's Health and Environment.
http://www.healthyenvironmentforkids.ca/sites/healthyenvironmentforkids.ca/files/CFL%20Fact%20Sheet%20Layout%20Version.pdf

16. The Health Consequences of Involuntary Exposure to Tobacco Smoke. A Report of the Surgeon General: U.S. Department of Health and Human Services, Centres for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health; 2006.
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http://www.hc-sc.gc.ca/hl-vs/iyh-vsv/environ/pcb-bpc-eng.php

18. Residential Indoor Air Quality Guideline: Ozone, Health Canada,
http://healthycanadians.gc.ca/publications/healthy-living-vie-saine/ozone/index-eng.php

19. Guidance for fine particulate matter ($PM_{2.5}$) in residential indoor air, Health Canada,
https://www.canada.ca/en/health-canada/services/publications/healthy-living/guidance-fine-particulate-matter-pm2-5-residential-indoor-air.html

20. Canadian National Radon Proficiency Program (C-NRPP),
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21. Health Risks of Asbestos, Health Canada
https://www.canada.ca/en/health-canada/services/air-quality/indoor-air-contaminants/health-risks-asbestos.html

22. Asbestos Information, Inspectapedia,
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