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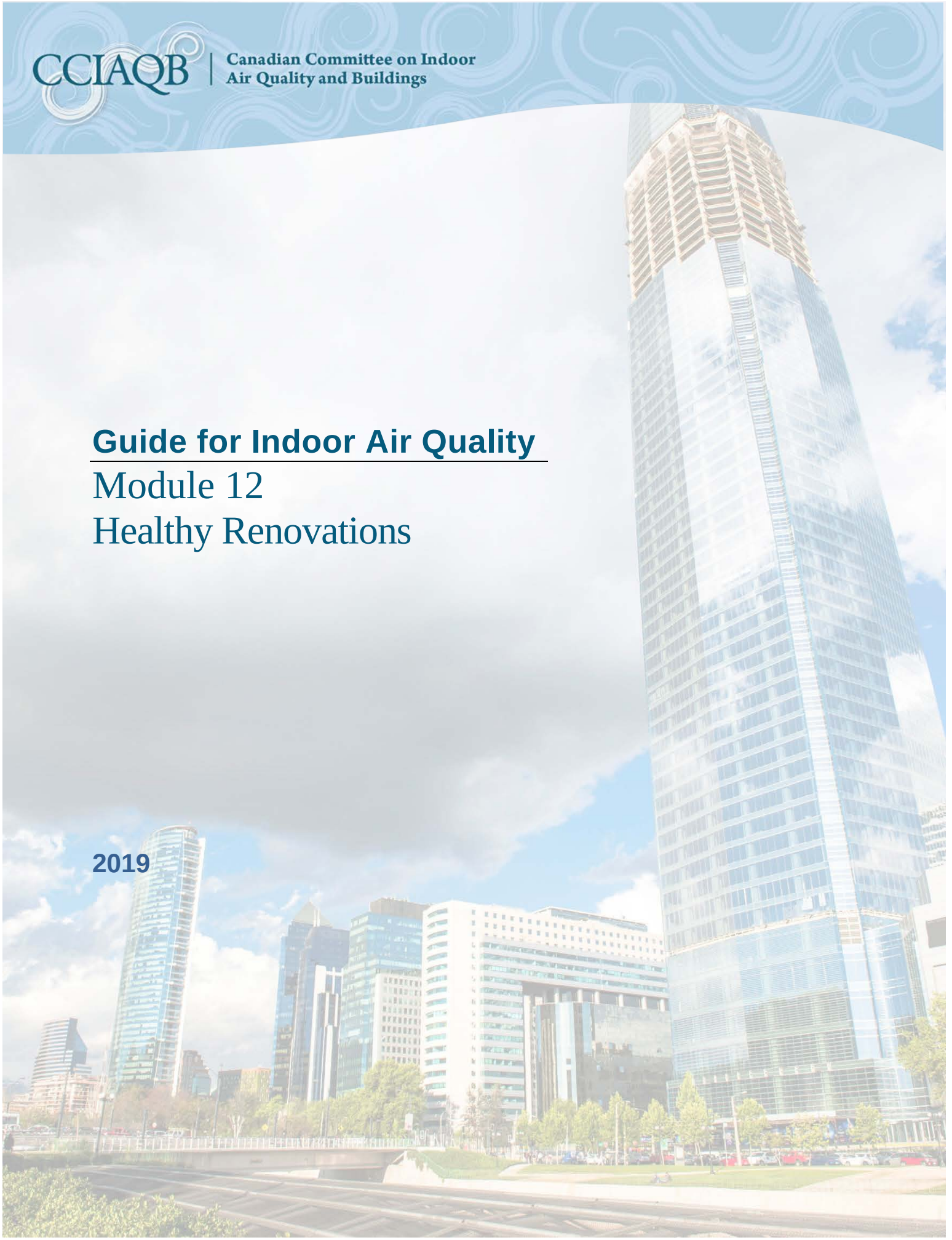

Guide for Indoor Air Quality

Module 12
Healthy Renovations

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.

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 12: Healthy Renovations

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1. Purpose of this Module

The purpose of this guide is to provide renovators and occupants with information and resources about the dangers to indoor air quality during renovation, restoration, remodelling or retrofit work as well as the opportunities to improve indoor air quality in the long run by improving the materials and systems that affect human health. Industrial, commercial, multi-family residential buildings, and single family homes share the fact that indoor air quality is important to human health, even to the health of the building itself. When work is done to a building, even if it is regular maintenance or minor or major renovations, there are usually ramifications, positive or negative, on indoor air quality that can affect both workers and occupants.

In many commercial, industrial and most health care facilities there exist health and safety regulations, standards, and guidance documents, with many relating to indoor air quality and some specifically to renovation activities. Other buildings may fall outside of such enforced rules, or other best practices may often be omitted by minor work projects or uninformed sub-contractors. As the understanding of building contaminants and occupant sensitivities increases with time, it is necessary to be aware of the possible dangers and the respective precautions that should be taken. This guide is not a repeat of codified health and safety regulations, but a reminder and resource for improving indoor air quality everywhere.

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

2. Introduction

2.1 How to use this guide

In this guide, an overview of how and where IAQ problems can arise is laid out, followed by general techniques to avoid problems, and lastly a detailed listing of contaminants, their health effects, and specific requirements for their control. In a given project, IAQ problems can be approached from any of these three connections.

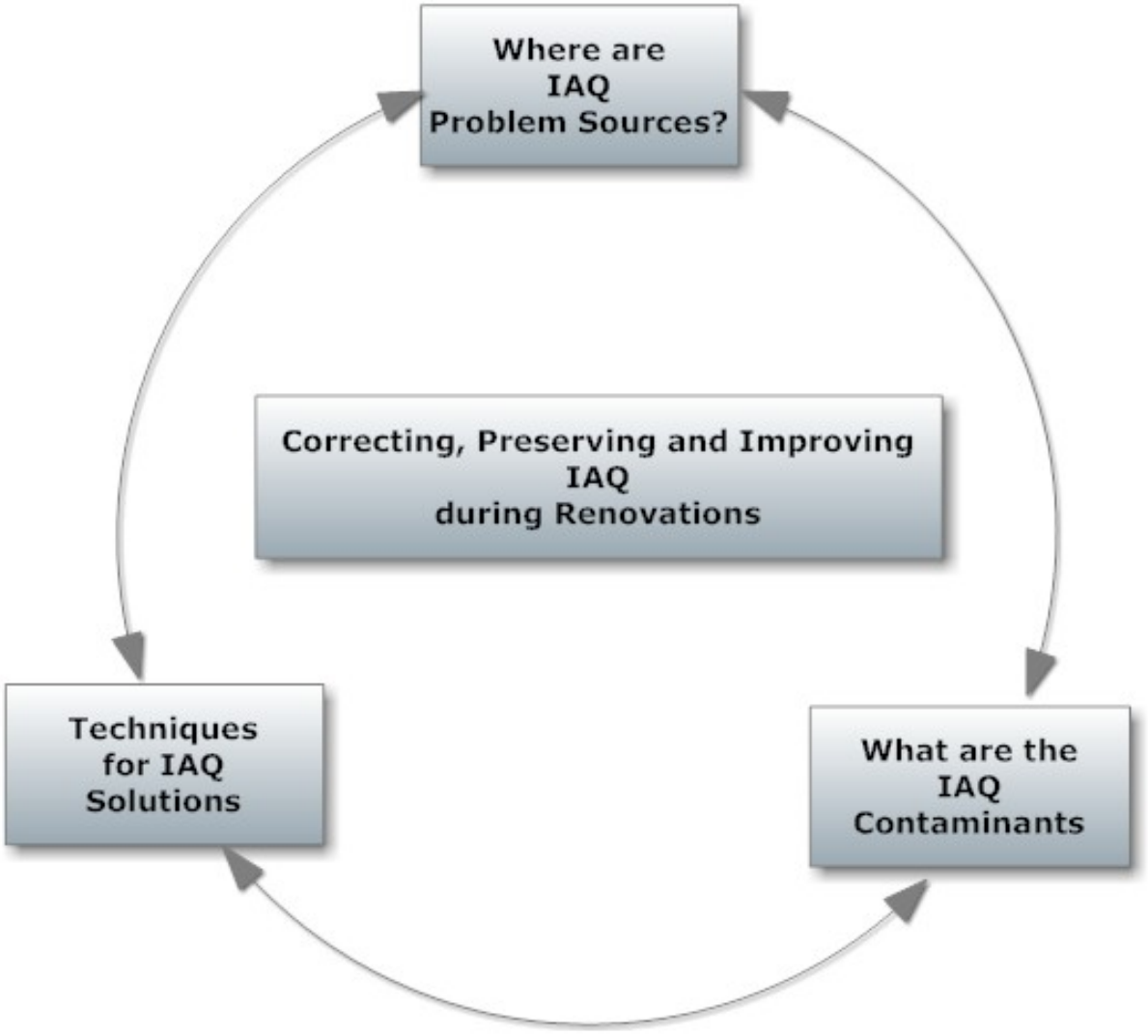
2.2 IAQ - contaminants, sources and solutions

Whenever a building is worked on, the health of both workers and occupants must be considered. Sometimes the work is specific to correct an existing health problem, like flood or mould damage. In other situations, the work is an opportunity to improve health, especially indoor air quality (IAQ). In all cases, the work should be carried out in such a manner as to not introduce new health issues.

There are different definitions for the types of work done. Restoration is a term used primarily with historical buildings, meaning to return to a past condition. Retrofit is fitting something new into something existing, usually updating technology like installing new insulation or new

heating systems. Renovation is technically returning something to a good state of repair and adding value. Remodelling is altering a structure, generally associated with aesthetics and functionality. All work types create dust and odours, introduce new materials, and often alter air circulation. All have the potential to improve or deteriorate indoor air quality and hence affect occupant health.

With any building work, health questions may arise at any time. It is useful to realize that any question is part of a circle of things to be considered as shown below.



If a contaminant is identified, it is necessary to know where it comes from and how to deal with it. If a problem is found, it may be necessary to determine the contaminants that produce the

problem. If working on solutions, it is necessary to fully understand the IAQ problem and if the contaminants can cause the problem.

2.3 What is a contaminant?

A contaminant is anything in the environment that can or does cause health problems. Some contaminants can enter the body through skin contact, some, like lead in old paint, can actually be ingested by children touching painted materials and then licking their fingers. An important category of contaminants float in the air, such as dust, volatile organic compounds (VOC) and moulds, and these enter the body by breathing them into the lungs.

2.4 For how long is a contaminant problematic?

Fixed materials, like asbestos, are contaminants mainly when they are disturbed, allowing small fibers to float in the air. One may think of asbestos as being disturbed with a hammer, saw or the like, but asbestos can also be disturbed in very subtle ways, such as air flowing across friable asbestos fireproofing in ceiling plenums, or by just lifting a ceiling tile that has asbestos fibers resting on top of it.

When mould is growing, it can spread contaminating spores into the air as long as it grows and even after it dies – it simply must be removed.

Many VOC contaminants are problems only during their drying or curing periods. For most renovations using low VOC materials, a week or two of ventilating the building is enough to clear out all irritants. Many contaminants come with new building materials or furnishings. These also need a couple of weeks or longer of good ventilation to allow for off-gassing. Some materials, like flooring products made of recycled auto tires, can take months or years to lose their odours and should be avoided for indoor use.

2.5 Who is sensitive to contaminants?

A contaminant could become a serious health concern for one occupant of a building, but may only be an irritant for another, while a third person is not even aware of its existence. Many people are affected by a contaminant without being aware of it as they have a healthy system that deals well with it and cold or flu like symptoms are written off to other causes. For some people, common construction materials like latex paints and caulking can knock them out with migraine headaches. At this level, the issue is known as chemical sensitivity and Module 13- Addressing Chemical Sensitivities in this series of CCIAQB guides provides additional information on that topic.

At the planning stage of any work, sensitivities should be discussed with the occupants and the contractor. Follow general guidelines for the general population but give special care for any susceptible occupants such as babies, pregnant women, elderly, chronically sick and

hypersensitive individuals. Other reference guidance documents for renovations in occupied health care facilities may be useful when dealing with concerns of vulnerable occupants. See section 7.1 for sample links.

3. How and Where IAQ Problems Can Arise

3.1 Residential, multi-family and commercial buildings

When talking about restoration, retrofit, renovation, or remodelling these terms are dealing with existing buildings. Some were built with old building codes and contain systems and products that are not allowed with new building codes and standards. Some have been modified over time with partial implementation of new practices which can create new problems. Low rise single family houses function very differently than high rise multi-family housing or large open space commercial buildings. Although the contaminants are much the same and the principles of dealing with them are similar, there are significant differences in applying solutions.

3.2 The building as a system

Each building has its own dynamics. That means that the way they gain and lose heat, the way the air flows into, through and out of the space, the way stresses and strains from frost, wind and the weight of snow make things move all interact. We call that a building as a system. If one thing is changed, something else reacts and may change. Because of this, there is a need to plan ahead for the potential consequences of what may have appeared to be a job with no connection to other things within the building.

The most glaring example is installing a beautiful big commercial range hood in a residence without realizing that this fan has enough power to reverse the flow of exhaust gas in the home's furnace chimney. The most common example is upgrading all the windows in the building without realizing that most of the air leakage in that building (new windows are installed air tight, old windows almost all had wind blowing between the window and the wall) has now been eliminated. The result is an inevitable rise in humidity in the winter leading to the creation of condensation on hidden cold surfaces and possible mould. With modern sealed windows, a modern mechanical ventilation system is required to take over the moisture control, two things now required in new construction.

Few speciality contractors may even mention this because they are in a lowest cost simplest installation competition. The building owner needs to research such things to see the true total cost of the change to the building. Not looking at "system" consequences can make it more expensive to maintain the building's and the occupant's health. Seeking out professionals who take a "whole building" approach is worth the trouble. A professional "whole building" consultant could be very useful if the intention is to hire several separate specialist contractors, or

even to guide significant maintenance level changes or a large DIY project. The more specialized the contractors, the more someone needs to keep the larger picture in mind.

3.3 Sources and activities related to contaminants

Before, during, and after the renovation there is a need to look closely at applying, installing, creating and disturbing such things as:

- Solvents, poisons, pesticides, fertilizers, even household cleaners;
- Fine particles: wood dust, silica dust, gypsum and concrete dust, spray paints, insulation materials
- Old protective or building materials that are friable: piping insulations; tiles and siding, anything that could contain asbestos;
- Sewer gas, radon, combustion by products;
- Paints and sealants (caulking);
- New furnishings with strong off-gassing.

Health Canada has developed a visual fact sheet on indoor air related issues and how to address them. See Section 7.1

It is often difficult to identify the health impacts of any given building material and even more difficult to find healthy alternatives to traditional building materials, but the world is rapidly changing. Commonly we relied on material safety data sheet (MSDS) data, but those are inconsistently formatted and difficult to evaluate. The newer format safety data sheet (SDS) from the recently updated 2015 WHMIS legislation in Canada is more standardized, but both are oriented to protecting tradespersons – not the long term occupation of the building.

Focusing on more commonly available information about low VOC content materials is often as good as can be done. To understand where the industry is going, limitations of current knowledge and disclosure as well as to learn a lot about tools already in place, the American Institute of Architects published in the spring of 2018, the “Prescription for Healthier Building Materials: A Design and Implementation Protocol”.

This protocol is basically designed for architects and large projects but is useful right down to the single family DIY project. Systematic material evaluation exists in Europe but this is the first comprehensive discussion using all available resources appropriate to North America. It discusses material evaluation systems currently available (starting in the spring of 2018 with promises of updating) and provides a working framework for how to apply the most appropriate evaluations to a given project, how to turn general guidelines into procurement, installation and even future maintenance of more healthy building materials. See the resource section for a link to this free publication. This is an evolving process, but this protocol can give any project a comprehensive overview of what could be done, and how well they are doing it.

Before the renovation :

- Identify existing problems and the plan for their solution during the new work. This would include any requirements for work that needs to be done when there are no occupants present and their possible re-location if required.
- Improper previous work
  Abandoned plumbing pipes not capped properly can lead to ingress of sewer gas.
  Improper installation of plumbing traps and plumbing ventilation pipes leading to traps going dry and sewer gas entry into the building is all too common.
  Rarely used drains that need dry traps or automatic wet discharge.
- Unresolved previous issues
  Poor maintenance: clothes dryer lint blockage; clogged air handling filters or dirty ducts obstructing air flow; damp basement; cold humid surfaces or pipes.

During the renovation :

- Clean up and immediately and properly dispose of any contaminated building materials.
- Use low VOC products: paint; caulking; adhesives; floor finishes; particle board: and plywood.
- Coordinate between contractors and occupants for any periods that it would be best for some or all occupants to leave the building or a specific area because of off-gassing – such as during and immediately following a large paint job.
- Use active dust control: vacuum collection on power tools used indoors; wet cutting for concrete, ceramic and stone; work zone isolation with negative pressure filtered fans to the outdoors.
- Protect all air handling ducts from renovation dust. Leadership in Energy and Environmental Design (LEED) requirements on ductwork is a good best practice to apply to all renovations: any ducts under construction are to be sealed off at any openings any time they are not being worked on. All existing vents are to be closed and protected in any dusty areas.

After the renovation :

- Clean ventilation and heating ducts if they were not protected during renovation.
- In a large building, all HVAC systems must be inspected and possibly balanced when they are put back into full service. This is a good time to discover and correct inadequate air flow in portions of existing systems.
- Many homes may not yet have a whole house ventilation system but the renovation itself may have reduced air infiltration to the point that moisture can become a problem. Instruct the occupants on how to use screened windows for cross

ventilation, at least on a regular "clear out the house" blow through; put a humidistat control on the bathroom exhaust fan to automatically dry the house a little; install a dehumidifier in the basement to lower the humidity in the summer.

- Multi-family buildings may have individual or common air handling systems or even a mix of the two. Assure that whatever the system is, it is functioning adequately for the post-renovation condition of the building.
- Learn to pay close attention to signs of stress in a building such as condensation; strange odours; wall cracks near door or window corners; foundation cracks; puddling of water near the foundation; moisture on the inside of foundation walls or basement floors. In larger buildings look for unexpected "system" problems such as discomfort in areas purported to be properly ventilated. System problems are often the cause when technicians say that everything is perfect but the occupants are complaining.

4. General Guidelines to Avoid IAQ Problems

Whether working in a large building where there is a Health & Safety committee or something as small as a single family home, health and safety issues should be discussed before any renovation to assure both safety and health for the occupants. Identify and address any particular sensitivity amongst the occupants, like allergies, chemical sensitivities, and lung problems. Special screening or air filtration may be required during or even after the renovation. If necessary, insist on the use of special acceptable paints, caulking, and adhesives products that do not bother the occupants or visitors to the building. Contractors are only beginning to become aware that "standard" or even "green" materials may not be good enough for many people. Sensitive individuals react differently to the same product from different manufacturers, hence in some cases, testing of specific products may be required before use. Extremely low VOC products are slowly coming onto the market. See Module 13- Addressing Chemical Sensitivities for more information. Specify such materials or products prior to the renovation, not after someone reacts and the materials need to be removed.

4.1 Ventilation

We need fresh air to be healthy, especially when many occupants in cold Canadian climates spend most of their time indoors, at least in the winter. Until the 1980's, what was coined "natural ventilation" was generally relied upon. That basically meant occasionally opening windows and letting the cold air drafts blow through the walls. With the first energy crises, sealing began on new and even renovated buildings to make them more and more air tight. While trying to rely on windows that tended to freeze shut, or even freeze open, it became evident that better mechanical ventilation was required. Mechanical ventilation not only brings outdoor air in and exhausts stale air, but it tends to control moisture and other contaminants, an important element in preventing mould growth.

Buildings have come a long way since 1980 and now new building codes require air tightness and mechanical ventilation for all new buildings, commercial and residential. The details of how much is delivered where and how is defined by the ASHRAE standards (American Society of Heating, Refrigeration and Air Conditioning Engineers) and referenced in various building codes. When renovations are done well, old buildings begin to approach the energy efficiency of a new building, and ventilation systems need to be retrofitted. That should be high on the priority list for achieving good indoor air quality – especially since heat recovery ventilators (HRVs) not only get rid of stale air, but bring in outdoor winter air that is close to room temperature with their efficient heat exchanger cores. It is not usually necessary to add auxiliary and expensive heat to the outdoor air, since heat from the stale indoor air going out is captured. Unfortunately, in the rules, heat recovery is often an option, not a requirement. In Canada, that simply leads to people turning off the ventilation to save money or stop the cold draft. HRVs also need to have their filters cleaned and the system maintained in order to continue to work properly and deliver balanced ventilation flows.

Using exhaust fans when cooking and in bathrooms can help to control moisture sources, whether they are required by code or not. If forced air heating does not exist, air circulation within the building becomes more important. Depending on the building and its divisions this could be a centralized whole building system for large buildings or even single family homes, or a series of independent zone ventilators such as in individual condo units. Radiant heated zones always need mechanical ventilation of some kind.

If a ventilation system is not present, windows should be used. Leaving a window open in the winter just doesn't work. It gets too cold and frost forms, eventually breaking the mechanism. The way to clear the air in a house with windows is to open one window on each side of the house and let the wind blow through for just 5 minutes, then shut it down. The house has not cooled down significantly, the air has been exchanged to a degree, and the windows still work. In addition, occupants are not sitting hours on end in a cold air draft. That is harder to do in a commercial building.

It may seem too obvious to mention, but outdoor air intakes for any ventilation system need to be positioned so as to not become a pollution source themselves. There are best practice recommendations for the distance between the exhaust and the intake to avoid cross contamination. They must not be placed near garbage cans or bins, near any exhaust hoods, near any idling cars or so low on a wall as to be buried in snow during winter. Cats and skunks have caused more than one ventilation system to be shut down.

Health Canada has developed extensive documents on ventilation and the indoor environment. See Section 7.1 for links.

4.2 Plumbing

Neither plumbing supply lines nor drain lines should leak because leaks lead to mould – enough said.

Some simple plumbing changes can lead to serious air quality and health hazards because the plumbing is a system unto itself and is also part of the building as a system.

Cold supply lines can cause condensation and dripping in a humid basement or on pipes running through a building zone that has just become more humid because of a renovation. Reduce the humidity by closing off sources like open sump pumps, or basement saunas or by using dehumidifiers. Cover the cold water pipes with insulation to prevent sweating and potential mould. In a building that already has humidity problems, anything that increases overall humidity levels, like an indoor garden, can turn small condensation problems into health hazards.

Drain lines need traps and proper plumbing ventilation to prevent sewer gases from entering the building. Un-used drains, like the basement floor, an old clothes washer drain, or an abandoned toilet or maintenance room, should either be filled regularly with water or capped off. Sewer gas is not healthy. Some areas of Canada experience ice capping on the plumbing vent going through the roof. This stops the plumbing ventilation system and easily causes the sink traps to drain, letting in sewer gases. Insulating the attic can increase this problem, insulating the plumbing stack in the attic can decrease it. Several anti-icing devices are now available to effectively stop plumbing stack ice capping.

Retrofitting low flow toilets in existing commercial buildings where there is a long horizontal run into the stack can cause regular blockages that never occurred previously. The building was originally designed with a certain pipe size and water flow to be able to carry waste all the way to the discharge. Radically changing the water flow changes all of that, usually leading to a sign on the toilet advising users to double flush. Low flush toilets carry solid matter further with three inch drain pipes than with four inch drain pipes, it simply floats the waste higher. One may need to forgo that particular water efficient toilet, change the drain pipe, or find a way to add water shortly after a flush especially for isolated, rarely used distant toilets.

4.3 Occupational safety and health standards and regulations

Professional work standards deal with everything from fall prevention to noise control and air quality. The standards, some of them very recent, are required in the commercial and industrial fields but would certainly stand out as best practices in a residential renovation environment as well.

There is little awareness of new regulations requiring dust collection for cutting or drilling concrete, tile or stone as silica dust has become known as almost as dangerous to the lungs as asbestos dust. Dry dust collection is done at the tool itself, or wet sawing and wet drilling traps

the dust in a water slurry that won't get to the lungs. These devices are now universally available for almost all tools and should be used in any work, even single family homes.

4.4 Isolation of work area

Taping doors shut, sealing off furnace and ventilation ducts, and using plastic sheet barriers makes it possible to isolate a work zone from the active occupant zone of the building. This allows containment of dust and odours as well as does using exhaust fans to create a negative pressure in the area under renovation. With filters on the fans, dust is not sent back in through open windows or blown toward the neighbours. Vacuums that discharge indoors should have high efficiency particulate air (HEPA) filters on them. This is a well-developed technique because it is required in hazardous waste work as well as occupied health care facilities. Using it on an ordinary job is more than just good customer relations; it allows healthy living during heavy work. Some work may also need to be conducted when there are no occupants in the area, especially if there are VOCs off-gassing from a particular activity.

4.5 Hospitals have the highest health standards for renovation work

Hospitals renovate all the time, even while very vulnerable sick people are near-by. The requirements for low VOC and clean work are not left to chance but are codified and followed. Some of these rules could well be applied to large building and residential renovations. Large hospital renovations are generally well supervised. It is the small maintenance level work that sometimes borders on a renovation where dust control and VOC discharges create problems. Equipping drills and saws with dust collection collars and assuring that the maintenance team has HEPA filtered vacuums are essential first steps to not letting smaller activity sabotage the larger effort.

The isolation work discussed in paragraph 4.4 is a primary element of clean work. Ventilating isolated areas until VOCs have essentially finished off-gassing is often necessary before re-occupation is allowed.

4.6 Incorporation of "Best Practices"

Building codes and standards are defined as minimum guidelines for healthy and safe work.
"State of the Art" is a loose definition of doing things well by tradition.
"Best Practices" are generally construction practices that exceed the code and the state of the art standards. They are considered the best way known today, and are more often found in new construction than in renovation. Many training programs and exceptional building programs such as LEED for residences and buildings promote Best Practices. Common amongst these are:

- Not tracking outdoor rain, dirt or mud into the building;
- Cleaning-up regularly indoors and outdoors;
- Sealing off all air ducts from construction dust;

- Carefully selecting materials for their health and durability ratings; like formaldehyde free particle board and plywood and low off-gassing insulation;
- Using extra protection against water ingress with window installations and flashing installations.

4.7 Construction and demolition

Building to the limit of the codes can backfire, such as using the largest possible span for a kitchen floor. It is safe and legal, but if someone later puts something heavy in the middle, like an island with a granite countertop, it will begin to spring like a trampoline. That can break water lines and cause a flood, perhaps resulting in mould. It is necessary to anticipate what might be a likely future addition to that kitchen that would require a stronger floor.

Commercial and industrial buildings are carefully engineered to support wide spans on flat roofs and include a margin for heavy snow and wind. When the function for a room was not clarified in the original plans, or it was changed over time, it is advisable to go back to the structural engineers before hanging seemingly light weight additions to the trusses. A warehouse converted into a video studio might have had structural problems with the addition of a full lighting grid to the ceiling if the attachment anchors were not installed in specific designated positions on the truss by an engineer. Aside from structural problems, improperly allocated weight could cause a failure in the roof drainage, hidden water entry and consequent mould formation – an indoor air quality problem caused by the weight of additional lighting.

Changing the function of space, such as converting storage space into occupied office space, requires a different level of ventilation. If the ventilation available in that area of the building is already limited, simply opening grills to this new space can cause a lack of ventilation elsewhere.

It is tempting to keep all the wood from a demolition for firewood. Homeowners need to be aware that anything other than bare wood should never be burned. Stained and painted wood can give off gasses and fine toxic particles; while pressure treated wood can concentrate heavy metals in the ashes, making the ashes toxic even though the wood itself was not.

Any material with mould on it should be removed from the premises and disposed of immediately. Mould gives off spores all the time, even when it is simply sitting around. If renovations take place during inclement weather (common in Canada) the materials must be protected from incursion of snow or rain through openings. Construction materials should be kept dry or given time to dry out, otherwise this will present an easy opportunity for mould problems to occur.

During renovations the construction sequence with respect to vapor barriers, insulation etc. must be carefully planned to ensure that moisture does not get trapped in the building or within the building construction assemblies and create mould problems. Additional ventilation, temperature and humidity control may be required as well.

4.8 Clearance sampling

"Clearance sampling" is a test procedure to determine if an area where work was done on a hazard, like asbestos or lead or mould, is now clean enough to be considered "cleared" or adequately cleaned up. "Before" and "After" air quality testing is often done to determine if the indoor air quality has been brought up to safe levels by the work undertaken. It can also be used to determine if any renovation work has caused a problem that did not exist previously.

4.9 Communicating with occupants

A renovation always goes smoother when there is good communication between the contractor and occupants. But this communication is usually about timing, cost and work accomplished – not about health. Occupant health and indoor air quality should be a topic right from the start, especially if any occupants have special health needs. Module 7 – Communicating with Tenant Organizations and Individual Occupants, provides some useful background information on communicating with building occupants.

This communication needs to be about sensitivities and material choices as well as being open and clear as to when off-gassing and dust may be worse. This is especially true for the demolition phase if any mould is being removed. If there are vulnerable occupants as discussed in section 2.4 and in Module 13 on Addressing Chemical Sensitivities, there should be an open discussion about relocating some or all of the occupants during certain phases of the project and for how long. So whether office or industrial workers are moved to another part of the building or telework for short periods, or a homeowner is asked to go to a hotel, both the contractor and the occupants need to be flexible in these decisions as issues can be discovered as the work progresses which may prolong the re-location, or on the other hand, problems could be cleared out faster than anticipated, reducing the duration of a re-location.

Even in the case of a residential DIY project, a homeowner would be wise to discuss this and be open to comment and criticism from the entire family during their own work. It is the same mould and the same dust. A child or elderly occupant complaining about dust or odours could be more serious than initially thought.

4.10 Hiring experienced qualified consultants and contractors

The larger and more complex the project is, the more it makes sense to hire experienced qualified consultants and contractors to anticipate what may never have been thought about, and deal with it in a safe and healthy manner. An experienced "whole building" consultant can keep individual sub-contractors working in harmony. Even if there is no perceived problem at the beginning, if health problems arise with the building occupants, a construction consultant may be worthwhile before a doctor's visit is required. The doctor can deal with symptoms while an

experienced consultant will see the cause if there is one in the renovation process. The doctor can guess there might be mould; the consultant will inform where, why, and what to do about it.

Aside from keeping occupants from being too cold in winter, or too hot in summer, a buildings' most important function is to supply a healthy indoor environment every day, all day when at work or at play or at home.

5. Dealing with Specific Contaminants

The following section discusses details on some of the most common indoor air contaminants. When a contaminant is considered a hazardous material, it is advised, and under certain conditions required to create a work plan starting with an inventory of such materials and specifying working and clearance verification procedures. Many such work plans have been developed for asbestos removal and are worth reviewing when dealing with any hazardous material. See references in section 5.1.

5.1 Asbestos

Asbestos was one of the materials that made the industrial revolution possible with its long strong fibers and great resistance to fire, heat and electricity. It is this very indestructability of the fibers that makes it such a threat to health since when very small asbestos fibers get into the lungs, they never degrade or leave. Most asbestos products in most of the world are now banned or restricted. In large buildings as well as homes, asbestos fibres can be found in older building products including flooring tiles, house siding, insulation around furnaces, flue pipes and hot water heating pipes. Health Canada lists many more such products.

Asbestos is not dangerous to touch. What is dangerous is to break it, scratch it, or raise its dust; creating asbestos dust is very dangerous as it floats easily in the air and is breathed into the lungs, never to leave. In some renovations where it is not necessary to disturb it, it can be encapsulated by paint, such as undisturbed asbestos wrap on heating pipes. See the vermiculite insulation discussion in section 5.2 below for possible asbestos in residential attics. There are professionals that can check a house or building for the presence of asbestos prior to any demolition activity.

If asbestos must be disturbed, such as by removing it, a full hazmat protocol is required to safely dislodge, encapsulate, and dispose of it. This is not a DIY job or even a job for an untrained contractor. The removal protocol includes protecting the workers, the occupants, the neighbours and future occupation. Training, certification and special equipment are needed for asbestos removal. See the reference section for some protocols.

5.2 Vermiculite insulation

The residential attic insulation called Zonolite, one brand of vermiculite, was found to be contaminated with asbestos fibres. This product was installed in Canada between 1920 and 1990. Testing dust collected from the attic floor under any vermiculite is the only way to know if an attic is contaminated but much of the vermiculite found in Canadian attics is contaminated unless the house was insulated prior to 1920.

If left undisturbed, it will not affect health, hence sealing all ceiling electrical fixtures, wall electrical fixtures, and window and door frames just below the attic and by not going into the attic, it is possible to wait to remove it when the full removal job is economically feasible. If not removed, its presence will reduce resale value. If any renovation or retrofit work is done in the attic, it will need to be first removed by a certified hazardous waste specialist who can provide written laboratory test proof that it is gone. See section 4.8 on Clearance Sampling.

5.3 Lead (Pb)

Like asbestos, lead is a building material with some useful characteristics. It is a stable chemical element, from the heavy metal section of the periodic table. When used in plumbing pipes it would not corrode. When used in paint, it gave long lasting stability and colour fastness to exterior house paints.

It was eventually discovered that lead accumulates in humans in soft tissues and bones and acts as a neurotoxin damaging the nervous system and interfering with the function of biological enzymes. It is especially a problem for children.

In plumbing, lead was mostly used for drain pipes, or joints in cast iron drain pipes, as well as the basic element of solder for joining copper pipes, and as an ingredient in brass. When used in plumbing of potable water, some lead can dissolve into flowing water with certain characteristics and has now been banned for use in potable water supply lines. Only public water systems with widespread use of lead pipes are being replaced for health purposes. Lead free copper solder now exists but is more difficult to use than the old lead based solder as it requires a higher temperature flame and more skill. This has led to the use of alternative products for joining copper pipe without soldering in much of the residential market, or the use of plastic piping

For healthy renovations, lead in paint is a far more important contaminant. It is no longer legal to put lead into paint, just as it has been removed from gasoline. If lead-based paint becomes airborne dust via sanding, or vaporized by propane or commercial hot air gun removal, it could become a significant source of exposure. This is one reason why dust control with paint removal is critically important. Merely tearing down lead painted wood or drywall and disposing of it is not hazardous, but one should wear a mask, gloves, and wash hands before eating.

Paint samples can be tested to determine if they contain lead or not, and it is necessary to send a paint chip sample to a test laboratory in order to confirm the presence of lead. Check with local health authorities for a list of hazardous materials testing laboratories and follow the lab's directions for obtaining and sending the paint chip sample to the lab.

5.4 Mould

Mould is a very large subject area and entire books have been written dealing with mould. Actually mould is a natural decay process, something essential to the good health of forests, which means that mould spores exist everywhere outdoors and can come easily into a home through windows, doors and ventilation systems. The level of mould spores in outdoor air is not generally a problem for humans.

Excessive mould growth inside the house requires the constant presence of moisture, so an occasional wetting of organic material like wood is not a problem. However floods that are not dried out immediately, or slow long-term plumbing, roofing or window leaks can keep the wood moist and the decay sets in. A constantly wet surface that is inorganic, like shower tiles, can also support some forms of mould growth.

Mould is a serious indoor air quality problem because well-established moulds project spores into the air that are toxic to most people on a rather constant basis. Even dry dead mould can give off toxic spores into the air so just killing mould does not eliminate the toxicity problem, it must be physically removed. See reference section for Health Canada's guideline on mould.

In a house, mould is usually caused and maintained by two sources of water: leaks as mentioned above; or condensation of high humidity on cold surfaces. Unfortunately many cold surfaces are hidden under counters, in the back of cupboards, in the corners of the basement and if the combination of cold surface temperatures and high relative humidity in the air create water condensation, a good chance of sprouting mould exists. Generally speaking, if under normal winter conditions condensation is not occurring on thermal windows, there is probably not enough condensation in the home to create mould problems.

Basements in the summer are not so cold but are much more humid. Avoiding condensation is always a balance between surface temperature and relative humidity (RH) of the air. Wherever condensation shows up, the indoor surfaces must be warmed, and/or the RH reduced, or some combination of the two. The first can be accomplished with insulation, the second with ventilation.
Significant renovations can actually cause mould simply by sealing up old air drafts which used to dry out the house. Even with no new water sources, the relative humidity of the house can rise, condensation can increase, and mould formation can start. Whole house ventilation is often the best solution. See Ventilation in section 4.1.

Ductwork of any kind that runs through an unheated space, like an attic or some crawl spaces, can easily chill the air flowing inside the ductwork to the point of condensation. Under these conditions, dips in flexible ducting can actually collect stagnant water. That can lead to the growth of mould right inside the ducts that are supposed to be carrying clean air throughout the house. Ductwork in the attic is easy and convenient but must be exceptionally well sealed, kept level and heavily insulated all around. Lowering the ceiling of a hallway is an alternate way to run ducts to every room of that floor without being noticed with the ducts now on the heated side of the insulation. This can often be easily included in a renovation project. No-one notices a dropped ceiling in a hallway.

Split-head air conditioning units are particularly prone to the growth of mould for two reasons: first, one of their functions is to create condensation on the cold indoor grills to reduce the humidity in the room, so water is always present; second, they are not designed to be easily cleaned, something especially true for the fan itself. The only answer from the industry for the moment is a $200 professional cleaning every season. Since almost no-one has this on the regular maintenance schedule, there is a high probability that mould spores will be coming out of split-head air conditioners and hence cleaning should be an important task before completing any healthy renovation. Please see Module 5 – Hygienic Operation of Air Handling Systems for additional information on maintaining air handling systems.

When mould appears, don't wait to act. Under the right conditions mould can double in size in as little as 24 hours. Some mould can go dormant when dry and start to reproduce as soon as it gets moist again.

The CMHC at one point defined one square meter of mould to be the size of a problem that a homeowner could simply clean up with dish soap. Mould that was larger than that or that penetrated into walls would require professional decontamination. Health Canada has taken a position against DIY mould test kits because they will always find mould in every house and they provide no sense of what kind of mould it is, or if it is of any real concern to health. Professional indoor air quality testing can quantify problems and set a benchmark to judge if remedial measures were successful or not. These should be used with any serious mould in any sized building. See section 4.8 Clearance Sampling.

Although pollen is not a mould, it affects many people's lungs. Blocking pollen from entering a building can require special filters capable of capturing its small particle size in conjunction with more frequent filter maintenance. To allow for fresh air through open windows where pollen is a problem, special window screening material does exist specifically to block pollen. It does block a bit more incoming light, but it also blocks much smaller particle sizes, not just large insects. Module 10 — Management Strategies for Moulds and Microbiologic Agents provides additional information on mould management.

Health Canada has an infographic as well as a manual on Mould. See Section 7.1 for links.

5.5 Mercury (Hg)

Mercury is highly toxic. It is commonly found in some thermometers and compact fluorescent (CFL) lightbulbs, although the quantity in a CFL bulb is 100 times less than in a typical thermometer. We already know that batteries must be specially recycled because of their mercury content. All fluorescent bulbs must be deposited in designated recycling bins usually available where you buy new bulbs.

Mercury is a liquid that can easily change into a vapour and into powder. That is important because if a CFL or fluorescent light bulb or a mercury thermometer is broken, certain precautions must be followed, be this at home or at work.

First get children and pets and pedestrian traffic out of the way. Open windows. Turn off ventilation and heating systems or at least block their grills. Do not use a vacuum cleaner as it can spread mercury vapour throughout the building. Dab up the mercury and any glass with paper towels and put them in sealed plastic bags. Check local rules about disposing of fluorescent bulbs in your area, such as taking them to a recycling centre. For more clean-up details look up "fluorescent light bulbs cfls" on the US www.epa.gov site. See more CFL links in reference section.

5.6 Polychlorinated biphenyls (PCBs)

PCBs are another category of industrial chemicals that was very useful until it was discovered that they had a wide variety of health and neurological effects on humans and were banned in 1979. They were problematic in leaking power transformers containing PCBs. There were hundreds of commercial and even consumer products that contained PCBs, from paints, to printed packaging, to caulking and electrical transformers. Disposal of PCB-containing consumer products into municipal or other landfills not designed to handle hazardous waste is listed as one of today's important sources of PCBs in the environment.

There has been a major effort to replace power transformers and lighting ballasts that were built using PCBs but much work is left to be done. The management and phase out of these devices is highly regulated.

In terms of renovation and demolition it is important to focus on the old transformers used for common fluorescent lighting. These should all be taken to hazardous waste collection sites. If the oil has spilled from one of these transformers, clean it up with the same careful techniques used for Mercury in section 5.5. Industrial transformer spills involving PCBs require the use of a hazmat team. See the link to more information on PCBs in the reference section.

5.7 Formaldehyde

Formaldehyde was and remains a common industrial product used in many applications, especially adhesives. It is also a by-product of some combustion processes. In fact several studies have pegged formaldehyde from heavy cigarette smoking as the primary source of formaldehyde in some homes.

Although now considered a respiratory irritant and even a probable human carcinogen, it is so prevalent in modern chemistry that it has not been banned. So both the building owner and renovator need to learn how to avoid or control it. Please see the reference section for Health Canada's guideline on formaldehyde.

UFFI or the famous urea-formaldehyde spray foam insulation was a scandal in the 1980's, but if UFFI still resides in walls today, all the formaldehyde will have drifted away – off-gassed. Similarly many things like old kitchen counters that were made with formaldehyde based glues may no longer be offensive today. However new particle board panels can make people sick. Check the SDS sheets for the presence of formaldehyde in any renovation product.

Offending panels can be sealed off with shellac or it can be specified that items from counters to floor panels be built with formaldehyde-free materials. The best strategy is not to bring new formaldehyde containing materials into a newly renovated home or building. Formaldehyde or even solvent based adhesives can all be replaced with water based adhesives. Commonly available formaldehyde-free rugs exist as do formaldehyde-free plywood. Chip board, often used for house sheathing, is made of resins, not formaldehyde.

5.8 Refrigerant gases

Although not generally an indoor air quality problem, occasionally refrigerant gases such as chlorofluorocarbons (CFCs) and bromotrifluoromethane (commonly referred to as Halon) are encountered during renovations, and these are considered either significant greenhouse gases whereas others act to deplete the ozone layer. These gases were primarily used as a refrigerant gas in refrigerators, freezers and air conditioners. CFC production ceased in 1995 and has been replaced with various less harmful gases. Halon was also used as a refrigerant as well as for fire suppression. Ammonia was also a commonly used toxic refrigerant with many units still in place today.

Today all refrigerant gases must be captured and destroyed at the end of life of a refrigerator, freezer, air conditioner or heat pump. The refrigerant technician will pump the gas out of the compressor, the radiators and all piping before disposing of any of these appliances.

For someone involved in remodeling their home or maintenance personnel in a larger building, that means that refrigerant systems cannot simply be broken apart and disposed of at the landfill, nor can they simply be bled out to the atmosphere. If a professional is changing a system, they

will automatically take care of this. If something is simply being moved or removed, it will have to be bled out into a capture tank before disassembling the unit. For portable appliances like a refrigerator, they should be deposited at an appropriate recycling centre where the CFC problem will be taken care of, or often suppliers of new systems will dispose of them.

5.9 Radioactive products

It may be surprising, but radioactive items may exist all around us. One such possible hazard is smoke detectors. Not all smoke detectors use radioactive sources but most do, usually americium-241. These smoke detectors should be collected at the end of their useful life and taken to a special depot that deals with this kind of waste.

In addition, smoke detectors have a definite life span, 5, 10 or 15 years. Lately manufacturers are putting expiry dates on them. If it is unknown as to how long smoke detectors have been in service, put new smoke detectors on the building maintenance to-do list and if they don't have replacement dates already printed on them, use a felt pen to tell the next person when it should be replaced. Smoke detectors always need to be kept functional.

5.10 Radon gas

Radon, is a colourless, odourless and tasteless naturally occurring radioactive gas. It is a decay product of naturally occurring uranium and emanates from rock and soil found everywhere around the world. Radon, when it reaches the earth's surface is diluted in outdoor air to low concentrations and is not considered a health hazard, but with our energy efficient cold climate buildings, it is possible for this gas to accumulate to high levels within a building. Health Canada lists radon as the second greatest cause of lung cancer after tobacco smoking and has determined that about 7% of all Canadian housing has concentrations of radon that exceed the 200 Bq/m^3 Canadian radon guideline. The difficulty is that one house can have high radon levels, while the neighbouring one does not; hence all houses should be tested for radon. The primary reliable way to measure radon levels is with an inexpensive test for three months. There exist national campaigns to encourage testing of all houses and buildings. Large buildings are usually tested for radon on the low floors (basement or first couple of above grade floors) since radon almost always comes from the soil surrounding or under a building.

The good news is that there are inexpensive methods for new construction to greatly reduce the route for radon gas to infiltrate into the basement with radon membranes under the basement slab and where necessary, fans drawing the gas out from under the house and expelling it outdoors where it is rapidly diluted. Large buildings can also be mitigated by using active soil depressurization techniques used in existing homes, or sometimes by using the HVAC system to bring in more outdoor air to dilute radon levels.
There are also effective methods to seal cracks in and around the basement slab and install fans for evacuation in existing buildings. Of course work like this can be most easily carried out

before remodeling a basement. In all homes or buildings it is a good idea to test for radon. See links in the reference section for more details.

5.11 Furniture

Furniture in general is not an indoor air pollutant, but glues used in many particle board panels contain formaldehyde and flame retardants as well as stain repellents for upholstery and these can have serious effects on some people. When home or office furniture that is not yet manufactured is being ordered, it is often possible to specify leaving out these products.

If new furniture bothers a building occupant, over-ventilate or air out the room for about a week. For more sensitive people it may be necessary to house new furniture elsewhere until the "new smell" has off-gassed.

Today, formaldehyde free wood panels do exist and can be specified for any custom cabinets. Alternatively the exposed sides of panels can be sealed with shellac.

5.12 Building use chemicals

Many chemicals are used around homes and buildings like salts, pesticides, and fertilizers, as well as gas, propane, and various other cleaning products. Surprisingly, what are considered ordinary cleaning products can become toxic when exposed to large doses, like cleaning a large area with bleach or ammonia. In fact, even just what has been stored under the sink at home could be a serious lung irritant. Despite tight fitting lids, stored chemicals and gases can leak. Often they simply have spilled material on the outside after use that will evaporate into the air.

Identify what is not affected by temperature extremes, and store it in an outdoor vented shed. All fuels like gasoline and propane fit this category. For items that must be kept indoors, like paints and glues, purchase large air tight plastic containers for storage. Ideally, it is best not to open these indoors, but instead take them outdoors to open and close the containers, minimizing any exposure due to necessary indoor storage.

With a growing array of less toxic products becoming available, those responsible for large building maintenance as well as residential occupants should consider if the total volume of toxic products could be reduced or replaced with non-toxic substitutes. Maintenance staff is the group at the highest risk for lung problems, but because of ventilation systems, everyone in the building eventually gets exposed.

5.13 Dust

It is almost impossible to have a dust free home or building but it is possible to significantly control renovation dust: collecting at the source; evacuating from the workspace; blocking with face masks and respirators.

It is always best to control any pollutant at its source. As mentioned in paragraph 4.3, because of evolving occupational health and safety rules, tool manufacturers are developing efficient dust collection systems for just about every tool that creates dust. For a renovator working in an occupied building it is important to use a HEPA filtered vacuum with these devices to avoid sending the finest particles out the exhaust side of the vacuum and all over the building. It is these fine particles that are the most dangerous for human health. If working in a building with particularly vulnerable or sensitive occupants, it would be best to keep the vacuum itself outdoors and just run the hose into the workspace. That would also serve to draw outdoor air into the workspace.

Wood dust is not only a fire hazard but is actually dangerous to health, with some types being worse than others. Some species of wood, like cedar, can wreak havoc on lungs as does dust from pressure treated, stained or painted wood. More and more dust collection devices are now available to capture that dust at its source, coming out of the saw, sander or drill – making for an almost dust free renovation. Even drywall sanding can be dust free with both professional and DIY devices available.

Wet sawing and drilling to control silica dust from concrete, tile and stone work is another way to capture dust at the source. Silica dust is as dangerous to lungs as asbestos. Hollow concrete drills can be attached to vacuums to draw the dust right out of the hole as it is made, or dust shrouds can keep materials from overhead fastener drilling from drifting into the air.

Large shop filter systems exist for continuously cleaning the air in a dusty workspace. These are often used in home woodworking shops but could be temporarily shifted to a renovation work space to make a big difference.

As discussed in section 4.4, isolating the workspace and creating a negative pressure in the enclosed space protects the rest of the house or building from migration of contaminants via air drafts. Plastic sheets with a zipper in the middle are commonly available to cover open doorways while allowing easy passage through.

No dust is good for occupant lungs so the regular use of simple face masks, called non-toxic dust masks, is important as soon as a dusty work space is entered. Dust is actually a common term for the broader category of “particulates”. Some particulates are serious pollutants and every renovation centre sells filtered half-mask respirators that cover the nose and mouth. Two basic types are commonly available at the consumer level: paint and pesticide respirators; or toxic respirators with replaceable filter cartridges specific to contaminants, like oil particulates or asbestos. At the industrial and commercial level, respirators are a highly developed science with specific filters available for many categories of contaminants.

5.14 Combustion by-products

Anything that burns can potentially give off toxic gases. Whether supplementary heat is required during renovations or power failures or as a permanent installation, one needs to be aware of combustion by-products.

It is never recommended to use kerosene heaters in any enclosed space. Propane heaters, if burning with a very clean flame will only give off water and carbon dioxide, but can create harmful by-products if the appliance is not working well. Carbon monoxide (CO) is a gas that can be produced during combustion, and can be fatal in a matter of minutes.

Residential environments with combustion appliances should be equipped with CO detectors and these should be replaced at required intervals. Large construction propane heaters can create moisture problems during renovation because of the significant quantity of water vapour they produce – causing plaster and paint to dry very slowly or mold to form in cold corners. Even wood burning stoves create significant chemical pollutants when they have a smouldering fire, they need a hot clean flame to create efficient burning. Open fireplaces and older wood burning appliances burn poorly, spewing very toxic fine particles into the atmosphere. Many municipalities are banning wood burning appliances that do not meet strict modern pollution control requirements. In a modern tight house, gas fueled kitchen stoves should have mechanical ventilation functioning while the stove or oven is in operation.

In the home, candles often burn with a considerable soot output, creating dark greasy stains on rugs near floor vents, and in the lungs.

Even properly functioning fuel burning furnaces and hot water tanks send hazardous by-products up the chimney that must be vented to the outdoors. But under certain weather, wind and indoor air circulation conditions these chimneys can reverse their flow and backdraft the combustion products back into the occupied building. Residential fireplaces can be backdrafted as well.

Chimneys that have functioned well for years can become problematic after a renovation primarily because the cold air drafts that used to feed the fuel burning appliance may have been sealed by the improvements, or newly installed exhaust fans may also now be drawing air down the chimneys. See section 3.2, The house as a system. Combustion air can be supplied to furnace rooms or new high efficiency appliances can be installed that do not use indoor air for combustion. This uncouples the air being breathed from the combustion process.

Health Canada has both a guideline for carbon monoxide and a recently developed infographic. See the reference section 7.1 for links to more information.

5.15 Biohazardous materials

A half-finished coffee cup sitting inside a renovated ventilation duct quickly becomes a biohazard – coffee, sugar and milk is a recipe for dynamic mould growth. This is so common that the LEED program protects the building's IAQ by banning all drinking of coffee on a LEED construction site.

Mouse droppings are not particularly hazardous as such but they reveal the presence of active or once active rodents usually looking for food in kitchens, pantries, food storage areas or food related areas that are not kept clean. The rodents themselves can be considered as a biohazard as they can carry disease. However, mouse droppings containing hantavirus, can be very dangerous to humans. Similarly, droppings from racoons can be very toxic due to the fact that racoons carry roundworm. Although roundworm does not affect racoons, it can be very toxic and sometimes fatal to humans. If a shovel is used to clean up racoon droppings, do not use that shovel in the garden. Consider this to be toxic waste and do not permit skin contact.

Any dead animals can become an IAQ problem as they decompose – leaving odours and contamination behind long afterwards. After a new brood of any rodent has grown and left the building in the late spring, seal all openings to attics and crawl spaces to keep them out. Wear disposable protective gear when cleaning up any carcasses and ventilate the area well.

Effective mice or rat poisons are ones that make the rodents thirsty – driving them to leave the building looking for water before dying. For any serious infestations, use professional services to get rid of rodents; dead or alive.

5.16 Hydrocarbons

Do not allow any oil or other hydrocarbon spill to sit for a long time as it can seep through concrete and deep into the earth, often requiring very expensive excavation and decontamination. Do not flush oil or solvents into any type of drain; drains usually terminate in a water shed.

Many hydrocarbons give off toxic vapours that should be avoided. Ventilate well when cleaning up solvent spills or using solvents for cleaning up oil spills. Ecological products do exist that permit one to draw oil out of both asphalt and concrete, allowing it to bio-degrade safely without toxic run-off into the water shed.

6. Checklists

6.1 Contaminants potentially already existing in the building

The following is an "awareness" chart. The degree of remediation required depends on the degree of severity: a balance of potency, quantity and location. Prioritize the reduction of indoor contaminants.

This is not an exhaustive list, but a listing of the most common elements to take into consideration.

Contaminant	Location	Potential Severity Scale										Comment	Action
Asbestos		1	2	3	4	5	6	7	8	9	10		
Lead		1	2	3	4	5	6	7	8	9	10		
Mould		1	2	3	4	5	6	7	8	9	10		
Mercury		1	2	3	4	5	6	7	8	9	10		
Polychlorinated biphenyls - PCBs		1	2	3	4	5	6	7	8	9	10		
Formaldehyde		1	2	3	4	5	6	7	8	9	10		
Refrigerant gas		1	2	3	4	5	6	7	8	9	10		
Radioactive products		1	2	3	4	5	6	7	8	9	10		
Radon gas		1	2	3	4	5	6	7	8	9	10		
Pesticides		1	2	3	4	5	6	7	8	9	10		
Fertilizers		1	2	3	4	5	6	7	8	9	10		
Gas		1	2	3	4	5	6	7	8	9	10		
Propane		1	2	3	4	5	6	7	8	9	10		
Ammonia		1	2	3	4	5	6	7	8	9	10		
Bleach		1	2	3	4	5	6	7	8	9	10		
Dust		1	2	3	4	5	6	7	8	9	10		
Combustion by-products		1	2	3	4	5	6	7	8	9	10		
Biohazardous		1	2	3	4	5	6	7	8	9	10		
Hydrocarbons		1	2	3	4	5	6	7	8	9	10		

6.2 Potentially offensive product types to be used

The following is an “awareness” chart. The degree of remediation required depends on the degree of severity: a balance of potency, quantity and location. Prioritize the reduction of indoor contaminants.

This is not an exhaustive list, but a listing of the most common elements to take into consideration.

Contaminant	Location	Potential Severity Scale										Comment	Action
Paint		1	2	3	4	5	6	7	8	9	10		
		1	2	3	4	5	6	7	8	9	10		
		1	2	3	4	5	6	7	8	9	10		
Caulking		1	2	3	4	5	6	7	8	9	10		
		1	2	3	4	5	6	7	8	9	10		
		1	2	3	4	5	6	7	8	9	10		
Solvents		1	2	3	4	5	6	7	8	9	10		
		1	2	3	4	5	6	7	8	9	10		
		1	2	3	4	5	6	7	8	9	10		
Adhesives		1	2	3	4	5	6	7	8	9	10		
		1	2	3	4	5	6	7	8	9	10		
		1	2	3	4	5	6	7	8	9	10		
Insulation		1	2	3	4	5	6	7	8	9	10		
		1	2	3	4	5	6	7	8	9	10		
		1	2	3	4	5	6	7	8	9	10		
Flooring		1	2	3	4	5	6	7	8	9	10		
		1	2	3	4	5	6	7	8	9	10		
		1	2	3	4	5	6	7	8	9	10		

6.3 New materials potentially containing contaminants

The following is an "awareness" chart. The degree of remediation required depends on the degree of severity: a balance of potency, quantity and location. Prioritize the reduction of indoor contaminants.

This is not an exhaustive list, but a listing of the most common elements to take into consideration.

Contaminant	Location	Potential Severity Scale										Comment	Action
Particle Board		1	2	3	4	5	6	7	8	9	10		
		1	2	3	4	5	6	7	8	9	10		
		1	2	3	4	5	6	7	8	9	10		
Plywood		1	2	3	4	5	6	7	8	9	10		
		1	2	3	4	5	6	7	8	9	10		
		1	2	3	4	5	6	7	8	9	10		
Furniture		1	2	3	4	5	6	7	8	9	10		
		1	2	3	4	5	6	7	8	9	10		
		1	2	3	4	5	6	7	8	9	10		
Cabinets		1	2	3	4	5	6	7	8	9	10		
		1	2	3	4	5	6	7	8	9	10		
		1	2	3	4	5	6	7	8	9	10		
		1	2	3	4	5	6	7	8	9	10		
		1	2	3	4	5	6	7	8	9	10		
		1	2	3	4	5	6	7	8	9	10		
		1	2	3	4	5	6	7	8	9	10		
		1	2	3	4	5	6	7	8	9	10		
		1	2	3	4	5	6	7	8	9	10		

7. Sources of additional information

7.1 Direct references from text

2.4 – Most provinces have health facilities guidelines for renovation work.
Ontario general guidelines:
https://www.publichealthontario.ca/en/health-topics/infection-prevention-control/crmd
More detail:
https://www.publichealthontario.ca/-/media/documents/crmd-environmental-cleaning-healthcare-facilities.pdf?la=en

3.3 – Health Canada -- Infographic: Maintain and improve indoor air quality
https://www.canada.ca/en/health-canada/services/publications/healthy-living/infographic-improve-indoor-air-quality.html

American Institute of Architects (AIA)- AIA Writes 'Prescription' for Healthier Materials – cataloging of healthy materials updated 2018
https://www.aia.org/resources/198731-healthier-materials-protocol:2976

4.1 – Health Canada – Fact Sheet : Ventilation and the indoor environment
https://www.canada.ca/en/health-canada/services/publications/healthy-living/factsheet-ventilation-indoor-environment.html

Health Canada – Manual: Ventilation and the indoor environment
https://www.canada.ca/en/health-canada/services/publications/healthy-living/ventilation-indoor-environment.html

4.2 – Products to eliminate plumbing stack ice capping
https://www.joneakes.com/jons-fixit-database/851-Vent-Stack-Ice-Capping-or-Evaporation-I-GET-SEWER-ODOURS-INSIDE-THE-HOUSE-OCCASIONALLY-IN-THE-WINTER

5.1 – Health risks of asbestos
https://www.canada.ca/en/health-canada/services/air-quality/indoor-air-contaminants/health-risks-asbestos.html

Ontario Ministry of Labour, "A Guide to the Regulation Respecting Asbestos on Construction Projects and in Buildings and Repair Operations":
https://www.labour.gov.on.ca/english/hs/pubs/asbestos/
Section 8 "Ongoing Asbestos Management":
https://www.labour.gov.on.ca/english/hs/pubs/asbestos/asbst_8.php

5.3 – Reduce your exposure to lead
https://www.canada.ca/en/health-canada/services/home-garden-safety/reduce-your-exposure-lead.html

5.4 – Health Canada - Infographic on mould
https://www.canada.ca/en/health-canada/services/publications/healthy-living/infographic-mould.html
Health Canada Residential indoor air quality guideline: Moulds
https://www.canada.ca/en/health-canada/services/publications/healthy-living/residential-indoor-air-quality-guideline-moulds.html

5.5 – Mercury clean-up
https://www.epa.gov/cfl/cleaning-broken-cfl

https://www.healthyenvironmentforkids.ca/sites/healthyenvironmentforkids.ca/files/CFL%20Fact%20Sheet%20Layout%20Version.pdf

5.6 – PCB clean-up
https://fortress.wa.gov/ecy/publications/documents/1404035.pdf

PCB regulations:
https://www.canada.ca/en/environment-climate-change/services/pollutants/pcb-in-environment/regulations-overview-objectives.html

5.7 – Residential indoor air quality guideline: Formaldehyde
https://www.canada.ca/en/health-canada/services/publications/healthy-living/residential-indoor-air-quality-guideline-formaldehyde.html

5.8 – Refrigerant gases
CFC's and other Fluorocarbons
https://www.canada.ca/en/environment-climate-change/services/air-pollution/issues/ozone-layer/measures-protect/federal-halocarbon-regulations-information.html#toc0

https://www.canada.ca/content/dam/eccc/documents/pdf/cepa/refrigerant-2015-eng.pdf

Ammonia Refrigerants
https://laws-lois.justice.gc.ca/eng/regulations/C.R.C.,_c._1146/FullText.html

https://www.osha.gov/SLTC/etools/ammonia_refrigeration/emergency/index.html

https://www.worksafebc.com/en/resources/health-safety/books-guides/ammonia-in-refrigeration-systems?lang=en

Halocarbon fire suppression regulations
https://www.canada.ca/en/environment-climate-change/services/air-pollution/issues/ozone-layer/measures-protect/federal-halocarbon-regulations-information/fact-sheet-halons-fire-extinguishing-systems.html

5.10 – Residential radon control
https://www.canada.ca/en/health-canada/services/environmental-workplace-health/radiation/radon/government-canada-radon-guideline.html

https://www.canada.ca/en/health-canada/services/radon.html

https://takeactiononradon.ca/

https://www.joneakes.com/jons-fixit-database/2150-What-is-Radon-and-should-I-be-worried

5.14 – Combustion by-products
https://www.canada.ca/en/health-canada/services/publications/healthy-living/residential-indoor-air-quality-guideline-carbon-monoxide.html

https://www.canada.ca/en/health-canada/services/air-quality/indoor-air-contaminants/keep-carbon-monoxide-out-your-home.html

7.2 Other useful references

Health Canada
https://www.canada.ca/en/health-canada.html

US Environmental Protection Agency
www.epa.gov