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Fan Coil Contamination of Growing Concern:

The effects of mould growth within fan coil units in Canadian high-rise buildings

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Preface

The World Health Organization (WHO) identifies healthy indoor air as a basic right. Protecting human health is of great importance, and with most Canadians spending about 90% of their time indoors[1], it is increasingly important to ensure that a healthy indoor air environment is maintained. Understanding the impacts of mould on indoor air quality will allow stakeholders – building users and occupants, building owners, managers, and Condominium Boards – to effectively maintain indoor air and protect human health.

The objectives of this paper are to provide a clear and concise guide to provide readers with:

- an understanding of the state of science outlining evidence of health problems associated with mould exposure.
- an understanding of mould issues within fan coil units including an overview of mould species commonly found on the inside surfaces of fan coil units.
- an overview of various mould remediation guidelines across North American jurisdictions.
- an evaluation of legal and liability risks posed to Management Companies (Property Managers) and Boards of Directors if a resident adversely affected by mould brings a claim for damages.

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1.0 Introduction

Since the 1990s, health scientists and building industry leaders have recognized that mould growth in indoor environments can negatively impact human health. There is little debate over whether action must be taken to ensure that human health is protected; however there are inconsistent opinions regarding the best methods of managing mould growth within ventilation systems. This inconsistency makes it difficult for stakeholders – building users and occupants, building owners, managers, and Condominium Boards – to understand and prevent these issues from happening since guidelines from various agencies often conflict with claims by local contractors and product suppliers.

One of the common sources of indoor mould can be found within fan coil units (FCUs), which are individual heating and cooling systems widely installed in Canadian high rise residential units. FCUs are highly susceptible to becoming contaminated with mould and distributing spores throughout the living areas. Since these units are out of sight, they are often out of mind, a situation that poses potentially serious health and legal risks. From coast to coast, Condominium Boards of Directors have the responsibility to address mould issues within fan coil units and can be held accountable should an occupant file a complaint. Therefore, understanding mould related issues within fan coil units is crucial for Property Managers and Boards of Directors to be proactive in achieving effective communication with building users and occupants, minimizing associated risks.

This paper analyzes the mechanical, biological and legal complexities surrounding mould growth within fan coil units to inform stakeholders and assist them in understanding mould growth issues within fan coil units, as well as their own roles and responsibilities when it comes to dealing this growing problem.

2.0 Defining Mould

Mould is a lay term commonly applied to visible colonies of fungal filaments, usually micro fungi. Fungi are naturally occurring decomposers found in all outdoor environments where they help break down animal and plant debris. They can grow over the surface and inside of nearly all substances of plant or animal origin where there is sufficient moisture. Micro fungi are composed of multicellular filaments called hyphae that form spore forming fruiting bodies for reproduction. Since fungi are dispersed into the air in the form of both spores and hyphal fragments, they can be inhaled depending on their size. In outdoor environments, fungal spores and fragments are rapidly dispersed by the wind or captured by precipitation, but in indoor environments, they may be encountered at levels that can pose human health effects. Health Canada identifies mould as one of the most commonly found indoor air pollutants.[2] The most common types of mould are *Cladosporium, Penicillium, Aspergillus and Alternaria* species (see Appendix A). The impact of mould spores on human health can vary depending on the age and immunity of the person being exposed, as well as duration and the intensity of exposure to mould within indoor environments.

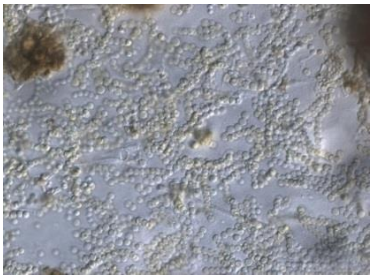

Figure 1. The above microscopic photo shows chains of *Aspergillus* which are often released together as clusters of spores.[3]

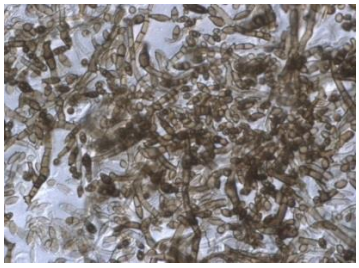

Figure 2. The above picture shows *Cladosporium,* which contributes to the entire ecosystem of mould within a fan coil unit.[3]

Nevalainen et al. (2015) have noted that different fungal genera have different capacities to release spores and particles into the air.[4] For example, dry spores of *Penicillium* and *Aspergillus* are more easily released than *Cladosporium* spores under the same indoor air conditions. Furthermore, fungal spores are dispersed from surfaces on which they grow or deposit into surrounding air mainly through air movements caused by ventilation systems.[4] It is estimated by mycologist George White that if mould can be seen, there are likely greater than a quarter million spores per square centimeter in fan coil unit insulation (personal communication).

The toxic effects of mycotoxins depend on the species that produced them but also on factors related to the exposed individual – i.e. the age of the person being exposed, the nature of any other chemicals that the individual might be exposed to, and the duration of exposure. Mould becomes an issue to human health when it starts to rapidly grow under ideal conditions within fan coil units and if inhaled/ingested in sufficient quantities over time.

3.0 Issues Within Fan Coil Units

As previously mentioned, the chilled water fan coil units (FCUs) are individual heating and cooling systems installed in Canadian high rise residential units. The ideal conditions required for most mould growth include oxygen, carbon-based nutrient sources and an ambient temperature range of 4-30°C. The controlling factor is moisture, which can support mould growth and is related to dampness (relative humidity).[5] Relative humidity is the ability of air to hold water vapour. For example, 50% relative humidity (RH) means a unit of air contains half of the water vapour it can hold at a specific temperature. Warmer air can hold more water vapour than cooler air. A common definitive relative humidity threshold does not exist for all fungal growth; moisture requirements are species specific. In general, studies have shown that fungal growth can occur at and above 65% RH.[6] Therefore, it is recommended that indoor RH

should be kept below 60%.[7] Excessive moisture within a dwelling may be caused by a building assembly problem such as leaks or condensation, occupant use/lifestyle, or the lack of maintenance and housekeeping that leads to increased risk of mould growth.

For air conditioning, water is centrally chilled and circulated to FCUs at approximately 10°C. The relative humidity levels within an insulated FCU cabinet are between 75% and 97%, allowing mould growth within the damp fiberglass insulation lined FCU. Although fiberglass is not a food source for mould species, the paper backings can be, as can some volatile organic compounds in the building air. Once established, mould colonies can reproduce exponentially and spores may be distributed by the fan throughout the indoor living space.

Mould remediation experts from RIFDS Inc. and Certified Clean Air Services, estimate that tens of thousands of fan coil units have been discovered to be the site of uncontrolled mould growth (personal communication). A small fraction have been remediated, replaced or otherwise the subject of professional attention. The attempted remedies vary from spraying bleach or organic cleaners, installing ultraviolet light, painting over contamination, right through to the installation of solid insulation instead of fibrous insulation. There is no statute or *Canadian Building Code* standard for the replacement or remediation process nor for new units themselves. This leaves managers and occupants to investigate and develop a plan of action from the best available information. This paper summarizes that information.

4.0 Growing Concern for Human Health

Fungi are critical members of healthy ecosystems and their spores are often transported in the atmosphere, and therefore it is not possible to eliminate fungal spore exposure. However, the nature of indoor spaces means that exposure to high levels of micro fungal spores is possible, and can become a health risk. A public health risk exists where there is an overlap of *receptors*, *hazard* and *exposure,* where this overlap causes an adverse health effect. Receptors are defined as those who are impacted by the hazard such as unit occupants and tenants ranging from toddlers to the elderly, chronically ill, immunosuppressed individuals, building staff, managers, and pets.

Exposure is how people are impacted by the contaminant, whether it may be through ingestion, inhalation or contact with mould.

The most significant mechanism for exposure to mould growth within FCUs is inhalation in indoor environments.[5] People can also be exposed through skin contact and/or swallowing mould. The following three components should be taken into consideration when assessing how mould exposure may impact human health:[8]

1. Degree of exposure to mould (the amount and duration)
2. Nature of the material (allergen, irritant, mycotoxin)
3. Susceptibility of the individual (individuals with underlying health conditions, compromised immune systems such as those with HIV/AIDS, age)

It is important not to generalize the risk to individuals due to the wide range of sensitivities across the human population. While mould is considered a low health risk to the general population, there are sensitive individuals for whom exposure is a serious issue, and concern for this subset of the population dictates that a solution is found in a timely manner. Prevention is one of the most powerful tools a Property Manager or Director can use to deal with mould issues.

Determining the risk from mould exposure comes with limitations and complexities. For example, comparing data between studies to relate exposure levels to human health effects is often difficult due to the large number of mould species and strains in buildings, as well as inter-individual variability in human response to mould[2]. For this reason, there is no established exposure limit for mould. Despite the absence of exposure limits, Health Canada recognizes that mould growth in residential buildings may pose health hazards, especially to susceptible individuals. Appendix B tabulates the studies that have investigated the human health effects of indoor mould spore exposure. The effects are summarized below.

Allergic Effects

Some individuals may be overly sensitive to mould spores, because the body identifies them as allergens. Immunoglobulin E (IgE) has a very important role in allergic

diseases. When IgE binds to allergens such as fungal spores, it triggers the release of substances from cells called mast cells. These mast cells have special binding receptors for IgE, and eventually the mast cells can cause inflammation through the release of histamine and other inflammatory substances. As a result of the release of inflammatory substances, some allergens can trigger a range of reactions from milder reactions in some and very strong allergic reactions experienced by others.[9] The series of allergic reactions is known as the allergic cascade where reactions in the immune system occur (Figure 3). This leads to symptoms such as sneezing, runny nose, itchy throat, eye irritation, and cough.[8,10,11,]

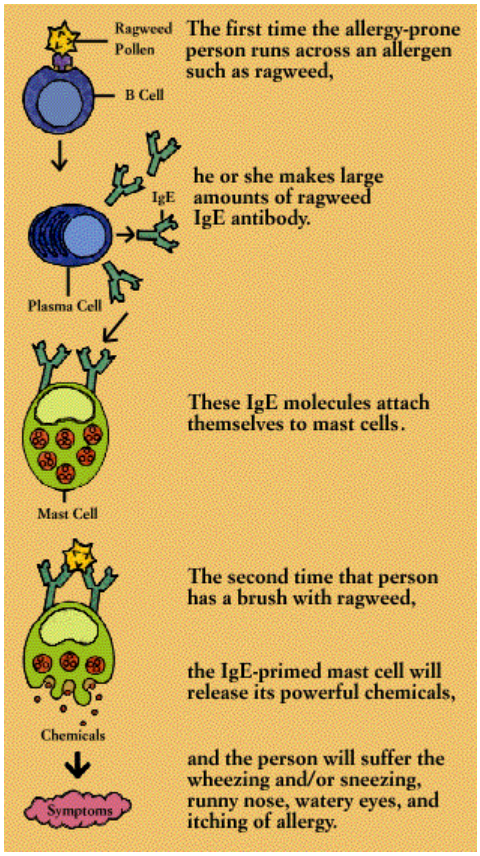

Figure 3. This figure shows the process of the allergic cascade when an individual is exposed to an allergen.[12]

Allergic reactions to fungi are typically manifested as “allergic rhinitis”. Symptoms include congestion, runny nose, sneezing and are often associated with symptoms of “hay fever”.[813]

A much more serious reaction is Allergic Bronchopulmonary Aspergillosis (ABPA), a rare allergic reaction to *Aspergillus* fungal growth in particular. This results in symptoms similar to asthma and chronic sinusitis and usually affects those with underlying health problems such as cystic fibrosis or asthma.[13] It has been estimated that ABPA affects about 1-2% of asthmatics[14] and 2-15% of adult cystic fibrosis patients.[15]

Asthma and Respiratory Tract Effects

Many studies over past decades have tried to show an association between mould exposure and asthma, upper respiratory tract symptoms as well as respiratory infections, but these results have often been difficult to interpret. In 2004, many of these studies were summarized and reviewed by the U.S. Institute of Medicine (IOM). In 2012, the Canadian National Collaborating Centre for Environmental Health published a detailed evidence review on the associations between mould exposure and different health effects (Appendix B). Furthermore, the World Health Organization[16], Health Canada[2] and New York City Department of Health[8] have identified associations between indoor mould and asthma symptoms through thorough literature review of epidemiological studies.

The following examples demonstrate the variety of research determining associations between mould exposure and asthma symptoms:

- A study conducted by Karvonen et al. (2015) followed 398 children from 5 months old to the age of 6. Homes were inspected by a trained engineer for moisture damage and ranked by whether repairs were needed or not as a result of the damage. The strongest associations between moisture damage with visible mould and asthma was in the child's bedroom with an adjusted odds ratio of 4.82 (95% CI, 1.29-18.02) and living room with an adjusted odds ratio of 7.51 (95%CI, 1.49-37.83), suggesting moisture damage and mould are associated with physician diagnosed asthma and respiratory symptoms.[17]

- Researchers conducted a chart review of patients who reported mould attributed symptoms. They looked at clinic visits, previous medical history of asthma and allergies and followed up with questionnaires to determine recent health

symptoms. Results from this study were compared to subjects who have "darkroom disease" (features of sick building syndrome) to determine similarities and differences. Out of 32 indoor mould-exposed patients, 79% of test patients reported cough, 70% reported shortness of breath and 54% reported wheezing and nasal stuffiness when exposed to *Stachybotrys, Aspergillus* and *Pencillium.*[18]

5.0 Overview of Mould Remediation Guidelines

Table 1 outlines key findings from mould guidelines issued by government and industrial groups in North America. Common trends that exist across these guidelines is the importance of worker protection, as well as fixing the underlying cause of mould to prevent the issues from reoccurrence.

Table 1. Key points regarding mould remediation identified from various guidelines

Guideline Source	Key Points
Health Canada[2]	• All mould, regardless of the species should be dealt with as soon as possible • When determining if there is a mould issue, look for obvious signs such as visual identification or musty odour • Mould that comes back after cleaning is usually an indication that the source of moisture has not been removed. Fix the underlying cause of mould (excessive humidity or water leaks within FCUs)
Canadian Construction Industry[19]	• Scientific and public health communities agree that indoor mould contamination could be a health issue for some and therefore mould should be removed • There is a standard mould exclusion used by most insurers which includes fungi or spores • If building staff are performing any work, it is very important that information such as how mould exposure may cause health effects are effectively communicated

	• For remediation of HVAC systems including fan coil units, the underlying cause of microbial contamination must be fixed before remediation begins • The application of biocides and disinfectants to treat contaminated materials is not recommended because they are not effective and may have adverse health effects • Guidelines for selecting mould remediation contractors includes having an approved remediation plan and continual training programs for workers
Occupational Health and Safety Council of Ontario[20]	• All mould contamination must be removed • Initial assessment must answer what is the extent of the mould contamination, what materials are affected and what is the source of moisture causing mould growth • Biocides were previously recommended but are not proven to be any more effective than other methods • Although the *Occupational Health and Safety Act* does not specifically address mould, every precaution reasonable must be taken to protect workers (including building staff who may be involved in remediation)
Public Works and Government Services Canada[21]	• There should be no wet insulation or stagnant water within fan coil units • The lining of condensate pans should not be internally lined with porous insulation because this is the breeding site for microbial growth • Condensate pans should be cleaned annually and maintained according to a schedule and protocol • Caution should be exercised in removal of mouldy areas and applies not only to the person doing the task but the entire process including building occupants

Institute of Inspection, Cleaning and Restoration Certification (IICRC)[22]	The IICRC follows five major principles of mould remediation: • Safety and health precautions are taken to ensure anyone involved with the remediation is protected from exposure through controls and practices • Eliminating mould at the source of contamination is essential • A post-cleanup assessment by an independent environmental expert should be done • Mould must be physically removed from the structure, removing it from the surface is not adequate • Ensure moisture is controlled to limit further contamination
New York City Department of Health and Mental Hygiene[8]	• Correcting the underlying cause can reduce mould exposures and health related symptoms • Effective communication with building occupants is an important component of all remedial efforts • The goal of remediation is to remove or clean mould-damaged materials which protecting occupants and remediation workers from exposures to mould • Some quality assurance indicators to see if remediation is effective: underlying moisture problem is identified and eliminated, isolation of the work area was effective, mould removal and cleanup was performed according to the site-specific plan

6.0 Fan Coil Unit Remediation Best Practices

It is unrealistic to continually reassess the health and financial consequences of mould exposure on a person-by-person basis. A more realistic approach is to manage and maintain the fixed equipment in a mould free condition to reduce risk to present and future occupants. Even with regular pan clean out, drain lines cleaned, minor

vacuuming and filter changes, every chilled water FCU is at risk of developing into a serious, hidden mould growth and amplification site.

As outlined by the various guidelines, mould remediation of fan coil units should involve two processes: removing mould contamination and remedying the underlying causes such that mould will not regrow. The ideal fan coil unit installed into residents' homes should be CSA standard for Heating and Cooling Equipment approved (CSAC22.2 No. 236-11). This standard speaks to the product's safety and performance. Areas of concern within fan coil units are outlined below including suggested remediation practices to prevent underlying causes of mould growth:

1. **Replace mould fiberglass insulation**

   The purpose of insulation is for sound dampening as well as to prevent the unit from sweating on the outside. The millions of glass fibers in the customary acoustic duct liner insulation cannot be effectively decontaminated. This is a poor material to use in a high humidity environment of the chilled water fan coil unit since the millions of glass fibers make for large surface areas to hold moisture and provide an ideal buffered environment for mould spores to grow and multiply. Porous insulation in a fan coil unit is like carpet in a shower stall. It needs to be replaced with smooth, non-porous insulation material.

2. **Assess condensate pan for water pooling, corrosion and contamination**

   A condensate pan holds water that drips off the chilled water tube from the condensed humidity. Existing condensate pans are flat and result in pooled water which allows fungi to grow at the air-water interface. The residue that is often mistaken for rust can be algae or fungal bloom residue. The old, flat condensate pans should be replaced with a sloped, stainless steel drain pan so there is not water accumulation, especially if there is any leakage.

3. **Assess heat exchanger coil condition**

   Clean coils positively affect energy efficiency, indoor air quality and long-term system performance. After many years in service, the heat exchanger coil will often become blocked with normal dust including mould spores that has collected

on wet fins of the coil. This wet dust forms a material that can substantially block the airflow and lower cooling and dehumidification efficiency. With regular, non-acid detergent coil washing, this obstruction can be prevented. Coil washing involves applying non-acid detergent to the coils, allowing it to sit for some time and rinsing it off while vacuuming away the foam. Non-acid detergents are recommended because acid chemicals can damage the coils by causing metal loss over time. Yet, if the buildup is substantial, coil washing is not effective on the thick heat exchanger finned coils typical in chilled water fan coil units. It is often more energy efficient to replace the heat exchanger coil. This also reduces chances of burst coils and flooding from aging copper piping. The remedy for this is to replace or clean the coil depending on its current condition.

4. **Blower fan and housing**

   The blower fan moves the air across the coil and into the living space. When dirty or blocked heat exchanger coils are present, the heat exchanger coil drips condensate water onto the blower fan and housing. This can result in water and mould accumulation in the blower housing. Some housings have drainage nipples incorporated which allows water from the blower fan to drain away. In these cases, residents also seem to use aluminum turkey roasting pans to catch the water dripping from the coil or fan housing. The blower fan and housing unit needs to be replaced, cleaned or modified based on its condition.

Remediation

In the context of mould, remediation means to reduce or minimize contamination of the surrounding area and harm to persons occupying that space. Personal protection and property protection are of key consideration.

Personal Protection

Mould and fiberglass dust are considered workplace hazards and exposure of workers requires personal protection devices be employed. Tight fitting face masks with N95 particulate filtration have a nozzle on the front with removal cartridges that trap mould

spores. These masks, eye protection, gloves and disposable coveralls are required when removing mould from fiberglass insulation within fan coil units.

Condominiums and apartment buildings are also people's workplace. Employees may also be at risk if they make adjustments to the units. These workers are exposed to mould growth within fan coil units. Controlling dispersion of mould from the work area and protecting workers from exposure to mould can be done through appropriate worker training identifying health hazards and correct procedures.

Property Protection

The process of removing mould and fiberglass insulation will disturb, liberate and distribute a great deal of particulate matter if not properly contained. This will contaminate the carpets, draperies, and personal property of residents. Failure to isolate the work area will often result in the area becoming more contaminated than it was before the remediation process. The work area is typically isolated by plastic sheeting, creating a temporary sealed tent-like enclosure.

The enclosure is ventilated by using a HEPA filtered fan system known as a "Negative Air Machine". This machine draws air from the enclosure, filters it and exhausts it to the outdoors whenever possible.

Care must be taken when personnel exit the enclosure and remove their protective clothing so as to not contaminate the area in which they are changing. Similarly, care must be taken to ensure the contaminated materials and enclosures are handled such that their movement throughout the corridors does not contaminate the common areas. Industrial Hygienists or inspectors from an accredited environmental engineering firm should be on hand from time to time to inspect compliance with remediation protocols. **Note:** Follow-up maintenance should be continued after full remediation.

7.0 Insurance Overview

In 2002, the Insurance Bureau of Canada formed a "Mould Advisory Group" to specify that standard insurance policies shall not insure:

a. loss or damage consisting of or caused directly or indirectly, in whole or in part, by any “fungi” or “spores” unless such “fungi” or “spores” are directly caused by or directly result from a peril otherwise insured and not otherwise excluded by this policy;
b. the cost or expense for any testing, monitoring, evaluating or assessing of “fungi” or “spores”.[23]

The remediation of mould contaminated fan coil units is rarely covered by property or liability insurance as it is considered a maintenance or repair item. Owners, Managers and Directors are most often in a position where they have no coverage against damage awards, civil lawsuits or from the costs to defend against lawsuits related to mould. The coverage restrictions and exclusions for mould would apply in the same fashion if the Corporation is named in the action. Whether claims are framed as negligence, nuisance, or breach of contract, the targets for litigation could include Property Owners, Managers and Directors for providing an allegedly unsafe environment.[23]

Fan coil maintenance is generally an owner’s responsibility depending on what is provided for in the building’s declaration. However, often owners may not choose qualified contractors and end up paying more than necessary. Some condominiums include maintenance of fan coil units under the operating budget in order to prevent the issue from worsening. As mould related damages can be financially devastating, Property Managers and Owners should ensure that any professionals or contractors employed to remediate mould provide a verified Certificate of Insurance naming the client and Mangers as co-insured. The certificate should specifically endorse mould

Owners, Property Managers and Directors may reduce or transfer liability on the advice and services of professionals who carry proper and adequate mould insurance.

related works as named operations. Acceptable liability limits are at the discretion of the client, but $2,000,000 should be considered a minimum amount with $5,000,000 of liability coverage available to more experienced professionals. In addition to financial

protection, this offers comfort to clients in that the service provider has met the underwriting criteria of the insurer.

8.0 Legal Matters Related to Fan Coil Mould

There are two main areas of law to consider when it comes to mould in fan coil units:

1. **Statutory Regulations**

   The *Condominium Act*, the *Residential Tenancies Act*, *Human Rights Act* and related legislation along with the *Occupational Health and Safety Ac*t all impose statutory and affirmative obligations to disclose, and to maintain property and equipment in a safe condition, to protect the occupants and employees from undue exposure to mould.

2. **Civil Litigation**

   a. Financial losses suffered as a result of failure to disclose or address fan coil mould. (ie: *Cost to remediate mould fan coil unit conditions and lowered property value*)

   b. Personal injury “toxic tort” claims related to exposure to fan coil mould.

Both areas of risk can be mitigated by prioritizing the health and safety of the building occupants and by communicating any adverse health or financial exposures in a timely manner.

The first line of responsibility to manage property and liability risks in multi-unit residential buildings is accepted by the professional Property Management Company hired to do so. While the Property Management Company may have a contractual obligation to, and be indemnified by the owner(s) or the condominium corporation, an aggrieved resident, owner, lender, mortgage insurer or employee may nonetheless bring a lawsuit against the Property Manager. If the Manager fails to disclose or inform of mould conditions that they ***knew*** of, or ***ought to have known*** existed, this may put

the Management Company outside the indemnity provisions of their Management Contract. **If fan coil units within a building have been inspected and there is knowledge by the Board that mould contamination is present, regardless of who owns the unit, is it required by the Directors to disclose this information in the status certificate.**

Ignorance or deference is not a defense

The serious nature of fan coil mould has, or *ought to have*, become well known to professional property managers and companies. Plaintiffs' lawyers will point to the published information on fan coil mould going back a decade, the Management Company's previous knowledge of mould remediation of fan coil units elsewhere in the portfolio, and the many reported mould related cases at various tribunals. It will not be enough to say that there were no complaints of fan coil mould. In buildings where the Corporation has maintained the fan coils, this is especially applicable as the owners and residents relied on the Property Manager and the Board to ensure the inspections and servicing of the fan coils are conducted appropriately and any concerns would be communicated to the owner/resident and an action plan put in place.

Many Property Managers have expressed a reluctance to confront the issue with their Boards or owners for fear of being the bearer of bad news and the resultant risk to their management contracts. This risk can be lessened by advising all clients of a universal risk of fan coil mould in advance of any mould being discovered. Property Management

> *Doing nothing, deferring decisions, or instructing the Property Manager to delay or keep things quiet can have personal consequences on Board Members.*

Volunteer members of the Board of Directors of Condominium Corporations are often reluctant to bring bad or expensive news to their fellow owners. If the fan coil units are

under the operating budget, Reserve Funds and special assessments can be made to maintain and protect the property of the Corporation and the safety of the occupants.

9.0 Summary

Over the last couple of decades, indoor mould growth has received significant attention in the media, but the issue of mould growth within fan coil units has remained largely unrecognized. Although mould naturally occurs in the outdoors, exposure to mould in indoor environments has the potential to cause significant negative impacts on human health. Even though the general population may not experience adverse health effects, the most vulnerable—those with weak or compromised immune systems, elderly, pregnant, and people with existing conditions such as asthma and allergies—are most at risk. As recommended by Health Canada, when mould growth is discovered, it should be dealt with immediately.

The most prudent course of action when it comes to mould growth in fan coil units is to be proactive – i.e. to investigate for fan coil mould growth when complaints are received, communicate any adverse findings in a timely manner to all stakeholders, and remediate mould growth as soon as possible. Experts agree that ignoring the problem or deferring a solution due to the perceived complexity and cost will only serve to increase risk, liability and ultimate cost. Property Managers and Boards of Directors should responsibly work with occupants and unit owners to remediate or replace fan coil units with the ultimate goal of protecting human health and maintaining safe, breathable air.

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Appendix A

As outlined within the document, research on mould and its impact on human health is often complex. When analyzing literature, it is evident that it is difficult to determine whether a specific genus or species of indoor fungi is responsible for specific health outcomes such as asthma symptoms. According to the World Health Organization, individual species of microbes and other biological agents responsible for health effects cannot be identified because people are often exposed to multiple agents at once[16]. Further to the WHO's conclusion in 2006, a recent systematic review investigated the relationship between exposure to indoor fungi identified to the genera or species level on asthma outcomes in children and adults.[24] The authors of the systemic review note that increased exposure to a combination of *Cladosporium, Penicillium, Aspergillus and Alternaria* presents respiratory risk for patients who suffer from asthma but there is inconclusive evidence when assessing species diversity and its impact on symptoms.[24] As outlined by Health Canada, regardless of what type of mould is discovered, it is recommended to remediate the issue as soon as possible.[2]

Figure 4. shows a synthesis of microbial laboratory analysis data collected from fan coil units from 12 sites across the Greater Toronto Area. These samples have been collected over the 2014 – 2015 time period. A total of 24 samples were collected from insulation within the fan coil units ranging from pipe insulation, left side or right side of the FCU. Only mould growth identified as abundant growth (>25% coverage on sample surface) or moderate growth (5-25% coverage on sample surface) was included. Data presented from on-site analysis were consistent with current research in that *Cladosporium, Penicillium, Aspergillus and Alternaria* are the most commonly found types of mould.

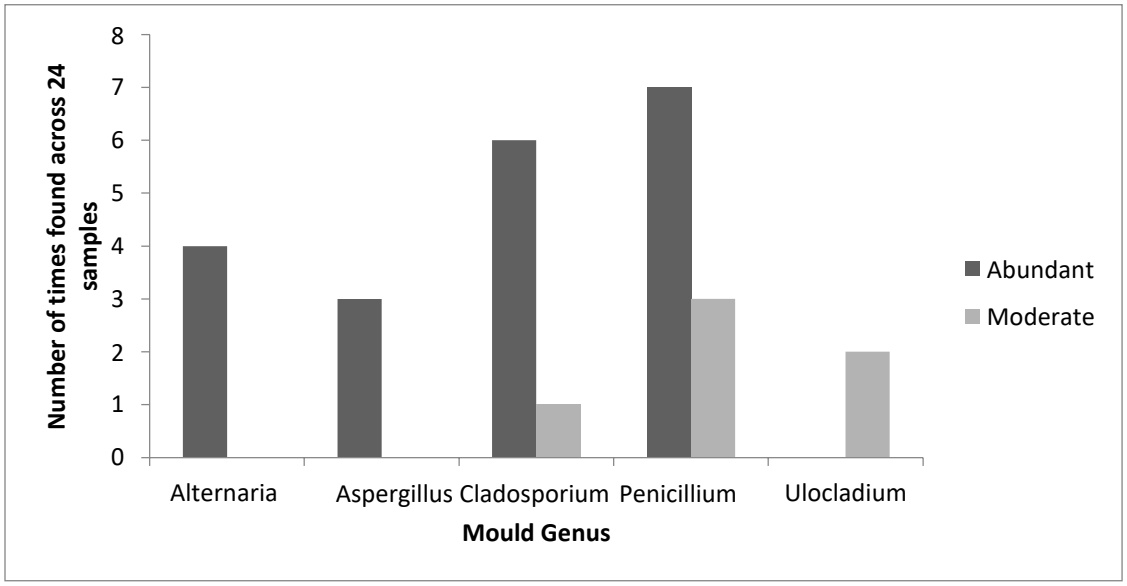

Figure 4. This figure outlines the most commonly found types of mould within fan coil unit insulation based on samples collected from on-site locations across the Greater Toronto Area.

Appendix B

Information in Table 2 is adapted from an evidence review conducted by NCCEH on the health effects from mould exposure or dampness in indoor environments.[5] Only studies that focused on indoor mould as the agent of interest and showing sufficient evidence of an association between indoor mould and various health effects were selected.

Table 2. Evidence reviews as adapted from NCCEH outlining associations between indoor mould and various health effects

Study	Methodology	Conclusion					
		Asthma Symptoms	Asthma Development	Allergy/hypersensitivity	Upper respiratory symptoms	Lower respiratory symptoms	General/toxic health effects
IOM (2004)	Scientific review of literature through late 2003	✓			✓		

Bush et al. (2006)	Position statement based on a review of scientific evidence			✓			
Committee on Environmental Health (2006)	Position paper reviewed literature for pediatricians and government. Supported by accompanying report	✓		✓			✓
Mazur et al. (2006)	Literature review focusing on children's health	✓		✓			✓
Fisk et al. (2007)	Meta-analysis of 33 papers included in the IOM review	✓			✓		
Mudarri and Fisk (2007)	Literature review – public health risk and economic impact	✓			✓		
Health Canada (2007)	Guideline found on earlier Health Canada reviews (1995, 2004) updated	✓					
Seltzer and Fedoruk (2007)	Literature review of over 150 papers focusing on children's health and mould	✓			✓		
Hope and Simon (2007)	Literature review of epidemiological and biological studies				✓		
Sahakian et al. (2008)	Literature review examined epidemiologic evidence	✓	✓		✓	✓	
Portnoy et al. (2008)	Literature review	✓		✓			
Bush (2008)	Qualitative literature review	✓					
World Health Organization (2009)	Literature review of 68 studies (epidemiological, toxicological and clinical)	✓		✓	✓	✓	
Fisk et al. (2010)	Meta-analysis of 64 studies				✓	✓	
Mendell et al. (2011)	Literature review of epidemiological studies and quantitative meta-analysis		✓		✓	✓	