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Volume 5, Number 2, Winter 2023/24

CONSTRUCTION AND RENOVATION

in Hospitals and Healthcare Facilities

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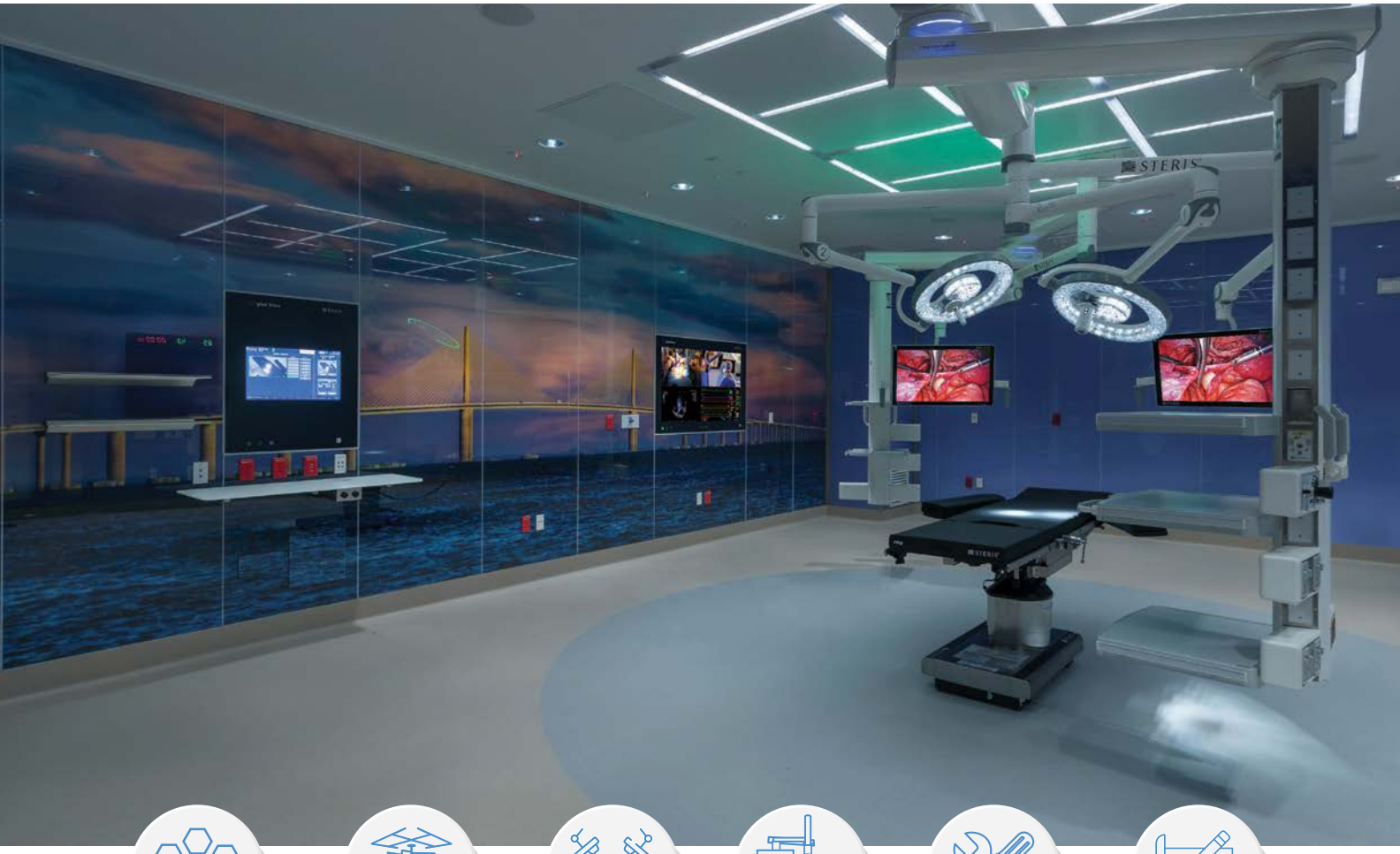

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Foreword

"Construction/ renovation/maintenance work in a health care environment can be challenging, but by working together with our Project Planners and Managers, Facilities, Infection Prevention and Control, Constructors, and Industry Partners we can ensure the successful completion of our projects in the safest manner possible."

Dear IPAC Canada Members,

Welcome to the Winter 2023 issue of ***Industry Innovations***, IPAC Canada's publication aimed at highlighting technological innovations offered by our industry partners.

Since Health Canada's 2001 publication ***Construction-related Nosocomial Infections in Patients in Health Care Facilities, Decreasing the Risk of Aspergillus, Legionella and Other Infections***, and the subsequent first edition of the 2003 CSA standard ***CSA Z317.13 Infection Control during Construction, Renovation, and Maintenance of Health Care Facilities***, there has been increasing awareness as to the risks associated with construction, renovation, and maintenance activities in health care environments. Dust or water particles contaminated with fungi and bacteria can be disrupted and dispersed during construction works. These pathogens can cause significant morbidity and mortality among immunocompromised patient populations. Insufficient construction barriers, lackadaisical material handling and storage, and inappropriately design and installed mechanical systems can all contribute to the risk posed to susceptible building occupants. Source containment with environmental controls, prevention of construction material contamination, and carefully designed and installed ventilation and plumbing systems are essential to prevent exposure. Advances in industry methods and technology can significantly improve the set-up time, reliance, and safety of these preventive measures.

This issue of ***Industry Innovations*** highlights technologies from three different companies. Abatement Technologies reminds us about the risks associated with mould and how portable HEPA filtration systems and reusable hard-sided containment barriers can be used to reduce that risk during construction works. Pinchin Ltd. describes their new ActiveIAQ system and how real-time sensors have improved detection and notification of construction site breaches. Finally, Delta presents a potential design feature for surfaces and fixtures to aid in the reduction of surface bioburden.

I also encourage all readers involved in health care construction/renovation/ maintenance to review the recently released 2022 edition of ***CSA Z317.13 Infection Control during Construction, Renovation, and Maintenance of Health Care Facilities***. There have been many updates, including new provisions for modular hoarding systems, updated testing and certification requirements for construction air handling units, restructuring of Clause 8 New Construction, addition of a fourth category of new construction – significant renovation in place, and updates to several annexes. CSA also offers training and certification in the Z317.13 standard.

Construction/renovation/maintenance work in a health care environment can be challenging, but by working together with our Project Planners and Managers, Facilities, Infection Prevention and Control, Constructors, and Industry Partners we can ensure the successful completion of our projects in the safest manner possible.

Jessica Fullerton M.Sc., CIC
Guest Editor, *Industry Innovations* ■

Construction and Renovation in Hospitals and Healthcare Facilities

ActiveIAQ:
Using wireless sensors to monitor construction-related infection control projects.

1.0 Abstract

Recent changes to the *CSA Standard Z317.13:22, Infection control during construction, renovation, and maintenance of health care facilities* recommends the use of real time monitoring technology to improve adherence to preventative measures.

ActiveIAQ effectively improves monitoring and infection control quality assurance. Pinchin successfully pairs technology with industry experience to; support hospital organizations in reducing the risk of nosocomial infections, reduce site monitoring costs, and develop an interactive understanding of how work procedures impact the effectiveness of infection control preventative measures.

Environmental parameters of specific interest for Construction-Related Infection Control monitoring include negative pressure differential, ambient particulate and door open/close status.

ActiveIAQ is a technology platform created by Pinchin Ltd. based in Mississauga Ontario, in collaboration with eleven-x of Waterloo, Ontario.

ActiveIAQ is composed of a suite of carefully selected LoRaWAN wireless sensors, wireless LoRaWAN gateways, and a data management system that provides access to real time data, visualizations, notifications and analytics.

Early in Pinchin's work with ActiveIAQ the use case for monitoring infection control containments using wireless technology was identified. The hypothesis was that this technology could significantly reduce monitoring costs, while providing 24/7 data. It is the right time to adopt this technology, based on updated network technology, advancements in data management, availability of low-cost reliable sensors and observed improvements to quality assurance of infection control containments.

2.0 Specifications

Network ActiveIAQ relies on LoRaWAN gateway technology to connect sensors to a cloud-based monitoring system. The gateways use mobile networks to backhaul data, which is both flexible and convenient. This configuration is frequently the preference of in-house IT teams, as they do not need to apply efforts to security architecture prior to system implementation. LoRaWAN is well suited to deployments in existing buildings. The wireless network propagates well through most building materials (concrete walls/floors, etc.). Fewer LoRaWAN gateways are required when compared to Wi-Fi based solutions.

Medical Equipment Interference When ActiveIAQ was first deployed into the healthcare environment, hospital stakeholders expressed concerns about possible interference between the LoRaWAN gateways and sensitive hospital equipment. LoRaWAN equipment is registered by Industry Canada under the same section of the Telecommunications Act as applies to medical equipment. LoRaWAN technology does not interfere with medical equipment.

Sensors Pinchin has carefully selected and tested 20 sensors for various applications within the ActiveIAQ platform. Within the LoRaWAN marketplace there are 1000s of sensors and navigating this can be complicated. Key considerations when a sensor is evaluated for ActiveIAQ integration include, cost, accuracy, reliability, ability to apply over-the-air updates, battery consumption and availability.

Battery Life LoRaWAN sensors are generally available in battery-operated and plug-in variants. Battery-operated units are *peel-and-stick* in terms of deployment, and are very versatile. The batteries in these sensors are expected to last 5 to 10 years. This performance is validated by ActiveIAQ sensors that have been deployed for 4 plus years, and are going strong.

Data Management ActiveIAQ leverages the Pinchin CORE data management system. Pinchin CORE is a java-script based data ingestion,

storage and query and visualization platform. The system is sensor platform agnostic, meaning that it can serve as an aggregator for data from a diverse collection of sensors, manufactures and monitoring networks.

Cyber Security Pinchin applies industry best practices for cyber security, encryption and user authentication. The platform is tested on an annual basis, and continually improved as cyber threats evolve.

User Management Data from ActiveIAQ can be shared in a portfolio-wide view, or to a specific building, or area of a floor. This flexibility allows "need to know" access to be provided to all stakeholders. Users are authenticated through multi-factor authentication via Microsoft Azure Active Directory. Pinchin CORE can also be configured to authenticate using your organization's enterprise authentication provider, providing additional convenience.

Visualizations Pinchin CORE provides a number of visualization options for data from the ActiveIAQ system, including a map overview of sites where sensors are installed, floor plans indicating precise sensor locations, summary of important notifications sent in the last week, customizable graphing tools, and the ability to create customized PDF reports and data summaries that are delivered by email on a daily or weekly basis.

Notifications Individual sensors, or sets of sensors can be configured with custom trigger points (maximum, minimum, rolling average, etc.) that initiate a notification service. Users can decide to receive these messages over SMS or email. What this means is that the project team is made aware of conditions on site at all times, and can remedy any issues as soon as they occur. This feature has by far received the most positive feedback from Pinchin's Healthcare clients.

3.0 Metrics

Parameters of specific interest for Construction-Related Infection Control monitoring include negative pressure differential, ambient particulate and door open/close status.

Pressure Differential is the primary parameter of interest when monitoring infection control containments. Demonstrating that effective negative pressure has been established demonstrates that both the containment and negative pressure have been properly constructed and implemented. The placement of these sensors (close to the ante room, distant to the ante room), etc. is helpful to understanding pressure dynamics within the work area. With this system in place it is easy to monitor negative pressure within the CSA specification (-7.5 Pascals).

Ambient Particulate is also a key parameter of interest for infection control monitoring. Sensors situated outside of the work area, and on the "clean" side of critical barriers can provide early warning that a containment leak may be occurring. An effective technique and best practice to determine a threshold of what is considered acceptable involves deploying these sensors before any construction activity occurs to establish baseline data and calibrate those with notifications. Before proceeding with monitoring, it is helpful to establish what is "normal", and can support interpretation of results during the project.

Door Status sensors are an inexpensive way to monitor a critical component of any infection control containment, proper usage of the doors in the ante room. Based on our experience monitoring infection control projects with legacy data-logging technology, it was observed that leaving ante rooms open or ajar for extended periods of time was one of the leading cause of negative pressure drops. If a door is left open for more than 5 minutes, a notification is sent to the project team. This has proven to be a very simple but effective monitoring technique.

4.0 Practice Changes

Construction-related infection control projects rely on preventative measures that include select administrative, worker and engineering controls to protect sensitive healthcare patients. Inspections of work areas are frequently conducted by Infection Control Professionals, but it is challenging to be on-site full-time to observe the work and conduct quality checks. ActiveIAQ provides an enhancement to these quality checks by providing full time monitoring of key site conditions as the work is being performed (24/7/365). Real time notifications sent the site foreman and IPAC team with insights into how well the infection control procedures are working. By closing the loop between site behaviour (leaving a door open, negative air machine being turned off, etc.) having a negative impact on site conditions (minor dust release, loss of negative pressure, etc.), the site team can learn how to refine their work procedures iteratively through the project to minimize or eliminate construction dust releases. This feedback increases visibility, accountability and drives project outcomes that reduce risk.

5.0 Implementation

New technology requires commitment, and open communication to operate successfully. When Pinchin works with clients interested in deploying ActiveIAQ, it is important for the project team to understand how the technology works, any limitations that exist, and best practices in order to succeed. The most effective way to work together is through a pilot project. The benefit of pilot projects is that they are generally low cost and low commitment, while providing the project team with an opportunity to test things out, learn about the technology in more detail, and determine if it is suitable. A pilot is how Pinchin introduced The Ottawa Hospital to ActiveIAQ, and is described in the narrative below. Implementation of an ActiveIAQ system is usually comprised of the following steps; client interviews to understand stakeholders needs and the "problem" at hand, review of site plans to establish network and sensor requirements, fee proposal development, site deployment, repositioning of network or sensors to optimize performance.

One key benefit of the ActiveIAQ system is that technology is very portable and can be deployed rapidly. This means that equipment can be setup in "kits" which can be moved from work area

to work area as a project progresses. ActiveIAQ is a truly wireless solution, and is typically up and running within 30 minutes of sensors installation.

6.0 Narrative

To highlight the benefits of ActiveIAQ for infection control monitoring, this narrative is presented based on our experiences working with the Infection Prevention and Control, Construction and Facilities team at The Ottawa Hospital campus (TOH), in Ottawa, Ontario, Canada.

Pinchin's ActiveIAQ relationship with TOH was initiated while responding to a request to provide conventional infection control monitoring using direct-read equipment for a year-long project to upgrade medical equipment and technology in a sensitive patient care area. During discussion of the monitoring scope (full time vs. part time), it was suggested that this might be a good opportunity to deploy remote sensor technology as a pilot. This technology is available 24/7, and is significantly more cost effective than the manual spot-measurement approach.

As part of the initial pilot a small deployment of LoRaWAN gateways, pressure differential and particulate sensors were deployed onsite. Within 24 hours of deployment an unexpected particulate exceedance was identified. It was determined by the contractor on site that the ante room had been cleaned using dry cleaning techniques resulting in a minor short duration particulate release. Before the IPAC team could even fully review the data, the contractor had reviewed work procedures, identified the problem and communicated corrective actions to workers on site. ActiveIAQ rapidly demonstrated that it was a very effective way to monitor site conditions.

Based on the initial pilot some changes were made to the user notification system so that the data from each project was discretely made available to each project team. Additionally door sensors were added to the system to evaluate their effectiveness.

Subsequent to the pilot, and at the time of writing this article Pinchin has successfully deployed 5 ActiveIAQ monitoring system across the TOH Campus.

The following response was provided by Tomas Whillans, *Construction Coordinator, Infection Prevention & Control* of The Ottawa Hospital in response to the hospital's experience using ActiveIAQ:

The Pinchin ActiveIAQ system has provided beneficial real-time, remote Indoor Air Quality monitoring during construction, renovation and maintenance, resulting with the correlation of specific construction activities or work practices with changes to established air quality parameter set points. The automated alerts, coupled with strong communication between the multidisciplinary team, has directed changes in work practices reducing construction-related infection risk at the Ottawa Hospital.

In addition to the aforementioned and predicted successes of the system, we've also observed unintended benefits through the monitoring of ambient conditions; most notably in response to adverse environmental air quality advisories (summer 2023). As the ActiveIAQ system is included in more initiatives and capital projects, we anticipate developing better baseline conditions at The Ottawa Hospital, while learning of externalities stemming from a more robust information set at our campuses.

Based on this account, ActiveIAQ has effectively improved monitoring and infection control quality assurance, as well as delivered unexpected insights into work procedures and ambient environmental conditions. Pinchin looks forward to continuing work with TOH and other clients, pairing technology with industry experience to reduce risk of nosocomial infections, while reducing site monitoring costs, and developing a strong understanding of how work procedures impact the effectiveness of infection control preventative measures.

7.0 Cost Estimate

The costs to implement a monitoring system are dependent on a few variables, including the density of sensors deployed (how may), network propagation characteristics within the building (thick concrete walls/floors, lead shielding, etc.)

Sensor Density is established by reviewing site plans, and discussing project objectives. Small areas can be monitored with as few as 3 sensors, while larger work areas require significantly more.

Network costs are established by reviewing the building construction, relevant to where sensors will be installed. Small deployments can function on a single gateway where larger deployments benefit from the redundancy of multiple gateways. LoRaWAN infrastructure is much cheaper to deploy than wired or wi-fi based systems.

Sensors are selected based on the project needs. Many sensors come in a multi-parameter configuration. Understanding how to leverage these sensors to get the best coverage and representative results comes from Pinchin's experience conducting IAQ monitoring in buildings for over 40 years.

Cost Summary A basic ActiveIAQ system kit costs about $5000 (CAD) to purchase, including one year of network access and data management. More elaborate systems are budgeted on a bespoke basis, relying on an analysis of the items discussed above.

8.0 Contact Information

Pinchin Ltd. is one of North America's premier environmental, engineering, building science, and health & safety consulting firms. Established in 1981 by Dr. Don Pinchin to provide consulting services to the asbestos abatement industry, the company has grown to over 1000 staff in 50+ offices across North America.

Pinchin are active members of the Canadian Healthcare Engineering Society, Ontario Long Term Care Association and the International Facility Management Association Health Care Council.

To learn more about ActiveIAQ, please contact:

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Minimizing Bacterial Loading Using Copper Alloys in Healthcare

Dr. Bill Schwingel, Ph.D., Principal Scientist, Microbiology, Masco Research & Development
Frank Stauder, MASC, MBA, P. Eng. Director, Innovation, Masco Canada Limited

Deadly Pathogens

Healthcare-associated infections (HAIs) are infections that are caused by a wide variety of bacteria, fungi, and viruses while receiving medical treatment or surgical procedures in a healthcare facility. Microbiological contamination on various surfaces in patient areas and rooms such as door handles, tables, IV poles, bed rails, faucet handles, toilet handles, or sinks can be a source of transmission of infections [1].

In Canada, approximately 200,000 patients are infected every year while receiving healthcare [2]. In the past 20 years, the overall incidence of HAIs in the U.S has increased by 36 percent [3]. Annually, in the U.S., approximately two million patients suffer from HAIs, and an estimated 90,000 of these patients die. The most frequent type of HAIs are lower respiratory tract infections (LRTIs), bloodstream infections, urinary tract infections (UTIs), surgical site infections (SSIs), and systemic infections [4,5,6]. Each day, about one in 31 U.S. hospital patients are diagnosed with at least one infection related to hospital care alone; additional infections occur in other healthcare settings [7].

The overall direct cost of HAIs to hospitals ranges from US$28 billion to US$45 billion [3] and while the range is wide, HAIs are clearly expensive in real dollars as well as in the toll it takes on patients. The reality is that most HAIs are thought to be preventable; however, published guidelines to prevent HAIs vary considerably [8]. Recently, the trend has been to see a decline in HAI, but there continues to be an increase in the amount of antibiotic-resistant organisms found [8].

Hand hygiene practices, environmental cleanliness procedures including standard cleaning and disinfecting procedures utilizing detergents and disinfectants (alcohols, bleaches, quaternary ammonium compounds, phenolics) to wipe down work surfaces, as well as UV light treatments, have been employed to reduce the number of microorganisms that lead to increased HAIs [9, 10].

However, most cleaning methods do not provide sustained disinfection and surfaces may quickly become re-contaminated with microbes within a short time after cleaning [9,11,12]. Hand hygiene is critical for reducing HAIs and is highly dependent on human behaviour, washing protocols, and compliance to protocols [13,14]. Despite adoption of standard cleaning procedures and hand-hygiene protocols, HAIs continue to have an impact on patient care and healthcare costs.

In response, hospitals have continued to implement enhanced cleaning technologies such as the use of hydrogen peroxide vapor and mist generators, ultraviolet irradiators, ozone generators, high-pressure steam cleaners, and high-efficiency particulate air filtration devices. Antibacterial copper surfaces have also been suggested as a possible means of reducing HAI risk. In fact, some state legislatures have introduced bills requiring the use of antibacterial copper surfaces in all publicly funded new construction [15].

When evaluating the current standard methods of disinfection, fewer than 50 percent of hospital surfaces can be considered clean after disinfection procedures [16]. In addition, it was reported that 94.3 percent of healthcare workers in an EU-based study do not wash their hands for more than 15 seconds [16].

This research suggests that current protocols and healthcare workers' variable adoption of those protocols are not reducing the bacterial load to the recommended level of 250 to 500 CFU/cm^2 or less, which may be responsible for the current incidence rate of HAIs [17]. These standards are recommended by the Centers for Disease Control and Prevention (CDC). For these reasons, the development and evaluation of selfdisinfecting surfaces to help minimize the bacterial load is important.

Properties of Copper

Copper and copper alloys are compounds that have received much attention as solutions to help further

reduce microbial load due to their unique characteristics:

- Copper has shown efficacy as a sanitizer;
- Copper has residual self-sanitizing activity (doesn't get used up or wear off appreciably over time);
- Copper provides a continuous reduction of microbial load, even after repeated contamination with microorganisms [18].

More recently, the EPA has recognized a new class of compounds referred to as Supplemental Residual Antimicrobial Products [19]. With the recent COVID-19 Pandemic, there has been increased interest in obtaining residual efficacy claims (i.e., claims that a product provides an ongoing antimicrobial effect beyond the initial time of application, ranging from days to weeks to months or longer). Traditional liquid-based antimicrobial (antimicrobials such as those on the EPA N List of disinfectants (*https://www.epa.gov/lep/pdflist-n-disinfectants-use-against-sars-cov-2-covid-19-accessed-june-12-2020*) treat the surface at the time of application but do not provide antimicrobial efficacy beyond the time of application.

There is current interest by the industry and the public in products that are continuously active and can provide efficacy in between regular cleaning and disinfection [20]. These products are designed to reduce the level of contamination on high-touch surfaces that have repeated contamination events. Because of their unique antibacterial properties, copper and copper alloys are good candidates for consideration in this new antibacterial product category.

A recent review provides details of copper's possible modes of action in the killing and inhibition of microorganisms [21]. It is generally believed that the mode of action of copper against bacteria follows several different mechanisms. The precise chemical and molecular mechanisms responsible for copper's antibacterial capabilities are still being researched, however, several theories exist.

They include concepts that elevated copper levels:

- Rupture the cell membrane wall, leading to leakage of specific essential cell nutrients ultimately leading to cell death;
- Disrupt osmotic pressure (osmotic balance), weakening the cell wall and allowing contents to leak out;
- Bind to proteins that do not require copper for their function leading to loss-of-function of the protein, and/or breakdown of cellular proteins into nonfunctional portions;
- Cause oxidative stress and the generation of hydrogen peroxide resulting in chemical reactions that cause oxidative damage to the cell;
- "Steal" electrons from the lipids in the cell membrane, causing oxidative degradation, which leads to cell death.

While the exact mechanism by which copper kills bacteria is still not completely understood, the data on copper's effectiveness is compelling.

Surfaces as Transmission Vectors

The transmission of infectious agents in healthcare settings is complicated by the multiple modes of dispersal that can take place, along with the opportunity for more than one pathogen to be present at the same time in patient environments. Transmission can take place through direct contact from one infected person to another or through indirect contact, whereby surfaces provide an opportunity for the pathogen to wait for a suitable host for transmission to occur.

Aerosols (<5um) and droplets (>5um) expelled by toilets, sink drains, shower drains, patients, guests, and healthcare workers also may transmit microorganisms to surfaces [22]. What this means is both patients and room devices can continually harbour infectious agents on surfaces within the patient room.

The patient room, if cleaned thoroughly, should remain that way until someone enters the room. The use of medical devices and the activities of the patient or others entering the room begins the cycle of significant surface contamination until the next cleaning event. Unfortunately, patient rooms are not the only exposure patients may have to infectious diseases. Depending on the level of care required, patients may leave their room and be exposed to other areas of the hospital.

A simple walk down the corridor to look out the window while holding a handrail or sitting in a chair chatting with another patient presents a variety of pathogen contact events (PCE). Not all PCE's will infect the patient or staff, but with multiple events, the chances of transmission of microorganisms increases, particularly when cleaning activity has not recently occurred and bacterial loads are at their peak.

The Cost of Disinfection

All surfaces within the healthcare environment are potential vectors for microorganism transmission. This includes hard horizontal and vertical surfaces such as handles, tables, handrails, etc. as well as flexible surfaces such as curtains, clothing, and even exposed healthcare supplies. An open box of gloves on a table or a paper towel hanging from a dispenser are available for fine droplet deposition. Of course, some surfaces are more likely to be touched and more heavily contaminated like faucet and toilet flush valve handles, handrails, stethoscopes, and tablets.

Complicating the control of infectious microorganisms on surfaces is that they are often not easily detected and may be difficult to trace to a source. Therefore, all surfaces should be considered potential sources of contamination.

To minimize PCE's, all surfaces must be continuously cleaned. Continuous manual cleaning can be expensive (labour and materials), disruptive to patient care, difficult to carry out with 100 percent compliance, and time-consuming. In addition to these factors, the risk to populations within the hospital vary depending on the department and patient vulnerability [23]. What appears clear is that continuous clean surfaces are needed. In addition, there is the need for different levels of disinfection for different microorganisms and different patient care areas.

Disinfection Challenges

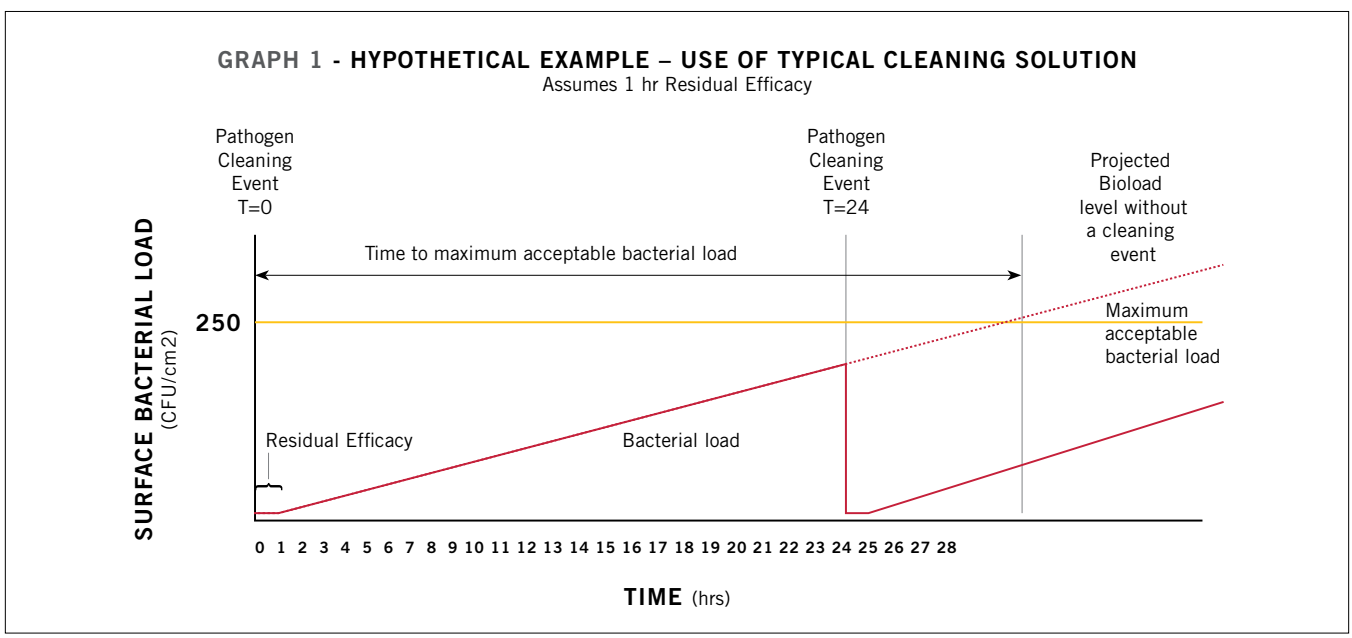
There are several methods available today to achieve efficacy and create antimicrobial surfaces. These each bring a unique approach and are often more effective on some surfaces and patient populations than others. These methods have the following attributes:

- Residual Efficacy (RE): biocidal cleaning solutions vary in concentration and toxicity but typically last for only minutes to days on surfaces. Copper provides continuous disinfection for the life of the product. In short, each cleaning method has an expected residual efficacy. The shorter the RE, the more frequent the need for cleaning to keep the surface disinfected, and consequently, the more costly to maintain disinfected surfaces.
- Time to maximum acceptable bacterial load: When surfaces are wiped with a disinfectant, the remaining disinfectant will continue to work for some time (RE). After that, as organisms are deposited on the surface through patient care activities, the bacterial load increases to a point where it becomes prudent to clean and disinfect the surface again. In practice, cleaning should be carried out before a bacterial load of 250 CFU/cm2 is reached. This assumes no gels or other microbiological materials contaminate the surface which would trigger a cleaning event. The rate of bacterial loading may also differ by surface use and location, so a high level can be achieved quickly or slowly depending on the circumstances. In short, the longer the disinfectant is effective on the surface, the longer the interval can be between cleaning cycles.

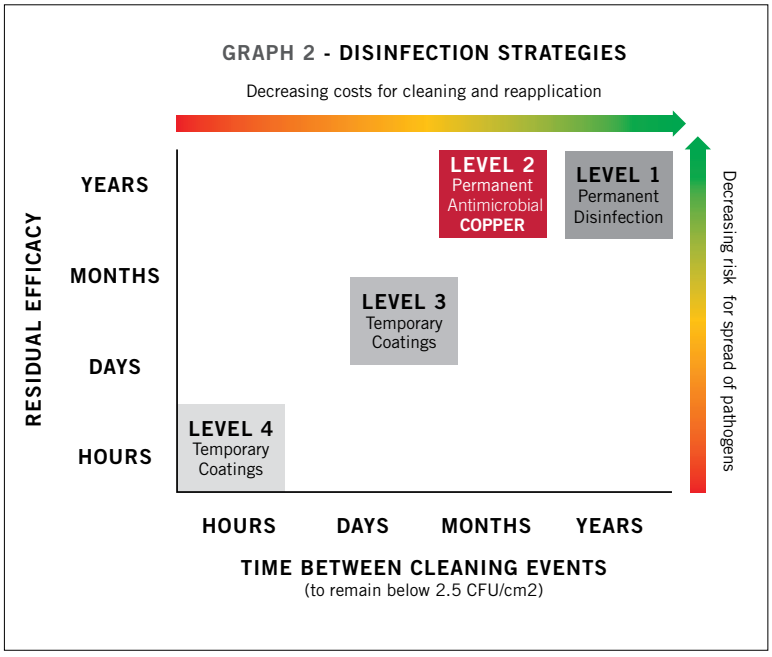
To help understand how different antimicrobial disinfectants might impact a surface, the following levels of antimicrobial strategies are proposed:

- **Level 1 – Permanent disinfecting Surfaces:** Permanent disinfecting surfaces require no routine cleaning. All antimicrobial action stays at the surface with no chemical leaching into the environment. An example is a heated surface that destroys all contaminants, including organic materials that come in contact with it.
- **Level 2 – Permanent disinfecting surfaces that require routine cleaning:** All antimicrobial actions stay at the surface with no chemical leaching into the environment (eg: copper alloy metal surfaces, strongly adhered antimicrobial coatings). Organic materials are not removed from the surface in the process, so cleaning is still required at some interval.
- **Level 3 – Temporary surface coatings that require routine cleaning:** All antimicrobial action stays with the surface and there is no chemical leaching into the environment. The antimicrobial activity lasts only if the surface remains intact. This group might include "regenerative technologies" which activate only when excited.
- **Level 4 – Instant surface coatings that require routine cleaning:** Active chemicals are released (leached) into the environment and will be depleted over time requiring recoating or replacement of the active ingredient.
- **Level 5 – Surfaces with very little or no antimicrobial properties:** This group includes stainless steel, wood and polymers which must be cleaned and disinfected with additional chemicals on a regular basis. This is the most traditional and currently used approach.

Disinfection methods that have a long or infinite residual efficacy can have longer periods between cleaning events. This is particularly important when surfaces fail to be cleaned thoroughly with routine housekeeping.



Graph 1



Graph 2

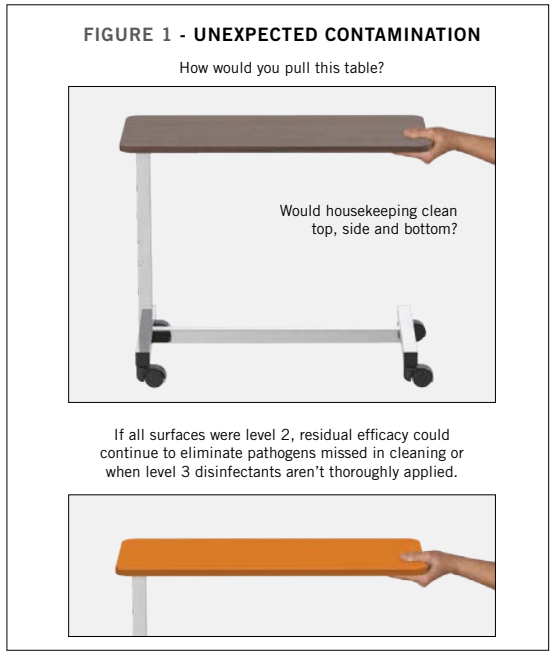


Figure 1

Disinfection methods with extended or infinite residual efficacy require fewer cleaning cycles and may continue to disinfect in areas where cleaning is missed. Graph 1 conceptually shows a linear bacterial loading on a surface and how a pathogen cleaning event might be scheduled. Complicating this simple graph is the fact that each surface has its own rate of bacterial loading based on its location and use, and that bacterial loading on a surface is not likely homogeneous. Excretion of endospores by infected persons might contaminate surfaces and generate a long-term reservoir for transmission.

In spite of the robustness of these spores, killing by metallic copper has been reported in some cases. In one study, viable spores were found to be diminished by 99.8 percent in three hours on solid copper [24], while complete inactivation of spores in 24-to-48 hours was reported in a second study [25]. Clearly, endospores are more resilient to contact killing by copper than vegetative cells, but killing may still occur and thus warrant the strategic use of copper to curb spreading of C. difficile [26]. This research suggests that using copper surfaces may be beneficial even when organic buildup takes place.

Health System Costs

To achieve the best patient outcomes, facilities should be striving towards patient rooms and corridors that are consistently pathogen-free. The need to create this condition must be balanced against hospital budgets (frequency of cleaning) and patient care (patient room intrusion). Longer-term disinfecting surfaces provide 24/7 disinfection, are not intrusive to the patient or the healthcare worker, and work silently and without odors.

Copper alloy surfaces have been shown to have excellent efficacy within two hours, and during the two hours, pathogens on copper decrease in numbers. Unfortunately, the optimum method, a permanent disinfecting surface that kills on contact, is not yet available. Until then, surfaces such as copper are viable options for surface disinfection technology. This is contrasted with liquid solutions that kill on contact but are not persistent when the pathogen is later deposited on the surface.

Long-lasting disinfecting surfaces, or level two methods, require less cost to maintain than level three, four, and five since there are no labour or material costs to reapply to the surface. In addition, disinfecting surfaces can be designed to encase the entire surface that may be touched so that areas not easily cleaned, or often missed in cleaning, can continue to be disinfected.

Antibacterial copper surfaces offer healthcare settings a unique opportunity to continuously manage bacterial accumulation on surfaces while costing only the initial investment of the product. This suggests that once the product is purchased and installed, continuous disinfection of the surface is free. Routine cleaning is still required to remove organic load that will be deposited by patient care activities and helps to ensure copper surfaces remain exposed. Graph 2 shows the relationship between the various levels of antimicrobial products. For most commercial markets, level two disinfection methods may provide the best efficacy for the least cost while minimizing the adverse impact on patients.

When fixtures are created with long-lasting antibacterial surfaces, the touch surface provides the most complete coverage of disinfecting product. Figure 1 shows how a common device can be compromised by the patient, healthcare worker, or anyone that might move the table.

Using copper, which meets claims of 99.9 percent efficacy against bacteria

on surfaces in two hours or less [18] on as many surfaces as possible will help to manage the bacterial load on those surfaces and could be an important silent ally in the fight against pathogen spread. Many surfaces are now available with at least 67 percent copper content with various efficacy claims to help in this important fight.

Understanding the advantage of copper in the fight against disease transmission, Delta® Commercial has recently launched a series of products with Copper Defense™ technology that feature touchpoints (handles and buttons) which incorporate CuVerro Shield™ alloys, a copper alloy that continuously kills bacteria left behind by dirty hands, killing more than 99.9 percent of bacteria* within two hours (EPA registration # 85353-1, Health Canada / PMRA registration # 31963).

Copper Defense™ technology incorporates CuVerro Shield™ alloys which consist of copper, nickel, and zinc to enhance the surface robustness and improve the look of the surface for the life of the product. The alloy has a warm silver colour tone and has been tested by Delta Commercial and CuVerro against many commercial healthcare cleaners and disinfectants with excellent results. The copper alloy surface performs very well in abrasion tests and will not flake or chip.

Due to the nickel and zinc constituents, the alloy does not patina or turn green as quickly as other higher copper content surfaces. Over time, the colour may darken slightly; however, the surface tarnish is easily removed, and the finish can be brought back to its original look with routine cleaning.

Handles are high-frequency touchpoints that have the potential to see rapid increases in bacterial load from human contact. Using copper alloy technology to disinfect these surfaces helps reduce the spread of dangerous organisms within the healthcare environment, 24/7, everywhere it is used. Delta Faucet Company encourages the use of EPA registered copper alloy surfaces where possible so that disinfection can take place to help fight the spread of pathogens in any environment.

William Schwingel, BS, MS, Ph.D
Industrial Microbiologist with 30+ years of experience in control of microbiological growth in industrial processes and consumer, personal care, household, and building products. William holds a Bachelors of Science degree in Animal Science from Cornell University and a Masters of Science and Ph.D in Animal Science with a minor in Microbiology from the University of Florida where his area of focus was gut microorganisms. After completion of his degrees, William spent several years on a National Research Council sponsored Post-Doc at the Kennedy Space Center in the Controlled Ecological Life Support System Group (CELSS) evaluating waste processing for life support systems for humans in space. William has spent his career supporting research and development and technical sales and service in the areas of microbial control and biocide usage in many different industries including pulp and paper, water treatment, oil and gas, consumer and household products, and most recently in building products including paints, coatings and plumbing products. He has published articles in technical and trade journals and contributed to book chapters on the subject of microbial control in industrial processes. William is currently a Principal Scientist with Masco Research and Development and is responsible for supporting new product development and issues related to microbial contamination and control of processes and products across the portfolio of Masco Companies. Most recently he has been involved in Delta's launch of new copper alloy coated antimicrobial surfaces. William holds several patents on microbiological monitoring and microbiological control in multiple industries. He is a Member of the American Society for Microbiology, The Society of Industrial Microbiology and Biotechnology, and an and active participant in the Industrial Associates Group of the Center for Biofilm Engineering at Montana State University.

Frank Stauder, MASC, MBA, P.Eng.
Professional Engineer with 36 years' experience in consumer and industrial product research and design, manufacturing, and municipal infrastructure. Frank holds a Masters of Applied Science in Mechanical Engineering from the University of Windsor and an MBA from Wilfrid Laurier University in Waterloo. Frank has spent most of his career evaluating, developing, and reducing product costs for industries including natural gas, water distribution, hydro, telecommunication, automotive, and plumbing products. Frank was previously Director, Innovation with Masco Canada Limited (Delta Commercial) and was responsible for the development of commercial focused new products including Delta's recent launch of new copper alloy coated disinfecting surfaces. Frank has received awards and grants for work with heat exchangers and connectivity of distributed controls, and is published in the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHREA) journals. He holds several patents for products in several industries. Most recently Frank has been an active member of the technical committee for CSA Z317.1 - Special requirements for plumbing installations in health care facilities.

* Laboratory testing shows that, when cleaned regularly, CuVerro® surfaces kill greater than 99.9% of the following bacteria within 2 hours of exposure: Methicillin-Resistant Staphylococcus aureus, Staphylococcus aureus, Enterobacter aerogenes, Pseudomonas aeruginosa, E. coli O157:H7, and Vancomycin-Resistant Enterococcus faecalis (VRE).

The use of CuVerro® bactericidal copper products is a supplement to and not a substitute for standard infection control practices; users must continue to follow all current infection control practices, including those practices related to cleaning and disinfection of environmental surfaces. This surface has been shown to reduce microbial contamination, but it does not necessarily prevent cross contamination.

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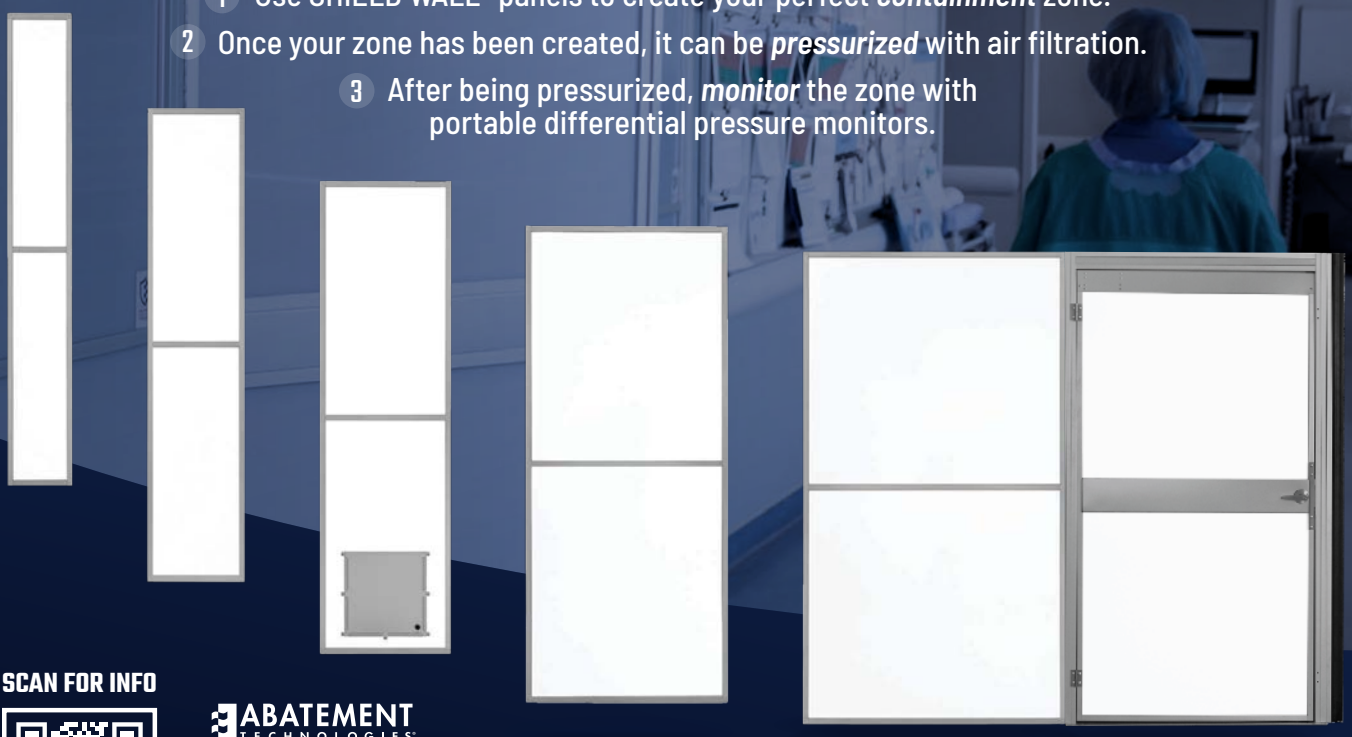

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Mould and Indoor Air Quality: An Abatement Technologies White Paper

Moulds are an important part of the natural environment, but given the chance to grow indoors, they can cause big problems. Unexpected disasters – from flooding caused by unpredictable weather events, to burst or leaking pipes – often create excess moisture and standing water, which lead to the growth of harmful mould.

After these disasters may come weeks to months of intense renovations to repair the damage. Mould, however, can grow in as little as 24 to 48 hours after water is present. To prevent its destructive path, it's important to act fast. However, it's not just natural disasters and weather events that can lead to the inhalation of harmful mould spores. General maintenance projects and renovation activities can disturb and release mould into the surrounding environment.

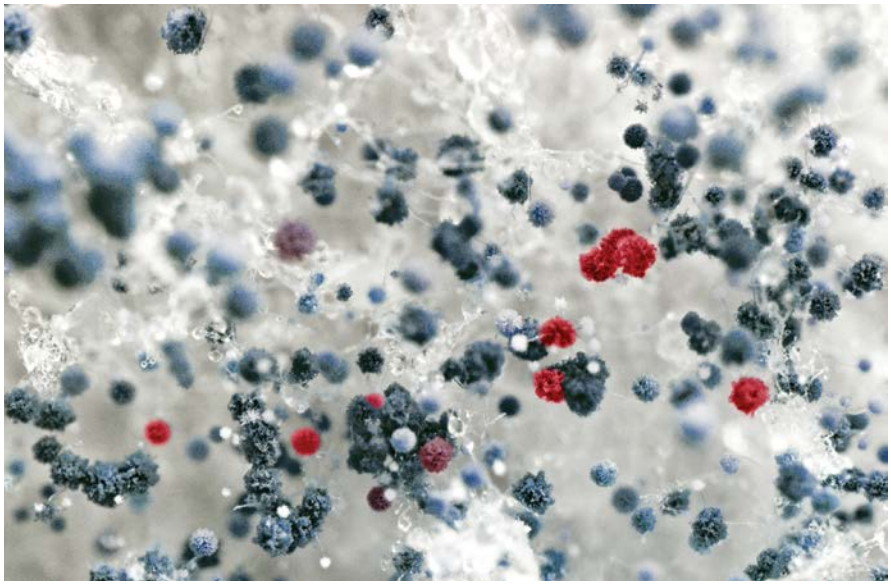
When the proper procedures are followed, using the proper equipment and supplies, mould growth can effectively be remediated, but how do you know where to start?

In this white paper, we'll cover:

- How mould grows;
- The effects it can have on our health;
- Steps and standards for mould remediation; and,
- The tools needed for the job.

Common causes and impacts of mould

Moulds can be found almost anywhere and can grow on virtually *any* organic surface, as long as moisture and oxygen are present. Moulds are a necessary part of the environment. Without them, organic materials, such as leaves, wouldn't decay, and necessary environmental processes, such as soil enrichment, wouldn't occur. Mould's ability, however, to destroy organic materials can result in serious health issues for people, in our homes, businesses, and healthcare facilities.



When excessive moisture accumulates in a building or on building materials, mould growth is likely to occur – particularly if the moisture problem remains undiscovered or unaddressed.

In early stages, mould begins as mildew. It grows on materials like wood products, ceiling tiles, carpets, drywall, insulation, and other organic building components. Often referred to as mould colonies, mould will produce seed-like spores which travel through the air and attach themselves to these materials, eventually destroying them. The spores will then spread to any adjacent organic materials to continue their destructive path.

In addition to damaging building materials, mould can also cause mild to severe health complications. Which types of moulds are dangerous? All types of moulds can cause adverse

health effects, especially to those allergic to mould.

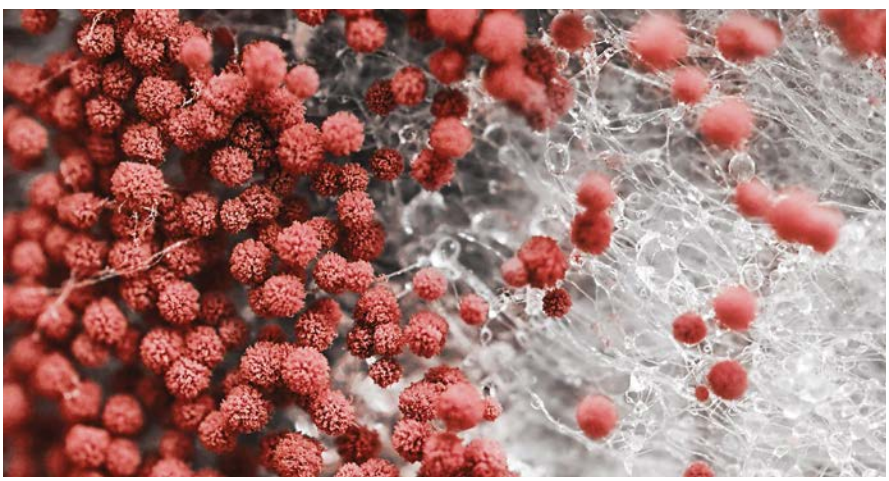
Allergenic moulds can cause reactions and even asthma attacks, while others are known to produce potent toxins and irritants. These health concerns are an important reason to remediate any existing indoor mould growth to prevent it from happening in the future.

Controlling moisture = Controlling mould

While it's impossible to eliminate all mould and mould spores in an indoor environment, mould growth can be kept at bay by controlling moisture. Unfortunately, moisture issues are common in many buildings.

These moisture issues have many causes, from unknown leaks to uncontrolled humidity. In fact, some moisture problems in buildings have been linked to simple changes in building construction practices from the 70s all the way up to the late 90s. These changes have resulted in tightly sealed, unventilated buildings with years of condensation build-up, and a surplus of moisture in the air. Materials in these buildings, such as drywall, absorb and trap moisture, leading to microbial growth.

Other common moisture problems in buildings are related to leaky roofs, unlevelled grading around exteriors causing standing water, and downspouts that drain into building foundations.



Mould remediation and air quality concerns

Mould remediation refers to the process of eliminating mould growth. This methodology includes four stages:

1. **Remove mould** from surfaces;
2. **Apply** an appropriate biocide approved to kill mould;
3. **Clean areas** around the mould growth;
4. **Contain areas** of mould growth by separating non-affected areas.

To safely remediate mould, there are several standards available for companies to follow:

- A widely followed guide for commercial remediation is the Environmental Protection Agency's (EPA) mould remediation guidelines in buildings and schools. The guidelines are based on the size and materials affected by water damage and mould growth, and help experts select the appropriate method for remediation.
- The Institute of Inspection Cleaning and Restoration Certification (IICRC) sets the standards for all mould remediation companies to follow. The IICRC S520 and R520 standards are written for those directly involved in the mould remediation industry, and were created by microbiologists and scientists, health professionals, hygienists, contractors, and restoration service professionals. In 2015, the IICRC S520 standard was updated to reject using the visible size of mould growth as a way

to determine the extent of the issue, contrary to the EPA's remediation guidelines, which rely on the square footage of the issue.

During remediation, it's essential to consider the effects on air quality. Because mould can grow on any surface, remediation is often an invasive process requiring complete demolition to restore the affected area. This can mean tearing down drywall, removing textiles such as carpet, and even removing hardwood flooring. These activities can release mould spores into the air, causing harm when inhaled. To prevent harmful effects, remediation experts will determine the necessary protective equipment needed for the job based on the scope and complexity of the contamination, as well as the technology available on the market.

Mould testing

When a moisture issue is discovered, it's important to take the proper measures to identify how much mould is present. An environmental consultant will evaluate potential mould growth using air samples and surface samples. The air samples will help determine the scope of the mould issue and the type of mould that is being inhaled. Air sampling, and most forms of mould sampling, involve "viable" and "non-viable" testing methods. Viable sampling involves the collection of live spores onto a sampling plate, whereas non-viable sampling is the trapping of spores in a collection cassette. The collector will then analyze the samples to identify alive (viable) and dead (non-viable) mould.

If the assessor identifies mould growth over a 10-square-foot area, remediation would be required. The assessor will identify the types of materials affected to establish the best remediation plan. In healthcare environments, however, any mould discovered should be remediated.

Key tools of mould remediation

To effectively contain mould in a safe and efficient manner, contractors rely on basic personal protective equipment (PPE), including respirators, gloves, and fitted goggles, combined with high-efficiency particulate absorbing (HEPA) filters, cleaners, wet vacuums, and disinfectants. But, because PPE only protects the person wearing the equipment, contractors need to contain the harmful particulates to protect those in adjacent areas.

Taught by various organizations like IICRC, industry training and best practices often involve two key products: reusable containment barriers and negative air machines.

Reusable hard-sided containment barriers

To ensure others are not being affected by mould, it's important to isolate the work area. This process involves closing off heating, ventilation, and air conditioning grills, sealing off penetrations, cracks and crevices,

and setting up containment barriers. Historically, containment has been done with two methods: plastic polyethylene sheeting and drywall with insulation. But because of their one-time-use nature, these materials are often not a great solution. With the rising cost of labour and materials, companies are now looking for a solution that is easy to install and can be used again and again for any project. This is where reusable, hard-sided containment barrier walls come in.

Available on the market today, hard-sided containment walls are easy to use and quick to set up around a remediation area. With a flexible design, these walls can be configured to match the exact measurements needed to get the job done.

By pairing the walls with air filtration devices, remediation experts can create a negative pressure environment within the contained area. Negative pressure will pull the contaminated air out of the area and capture the mould particulates with a HEPA filter.

Portable HEPA Filtration System

HEPA-filtered construction air-handling units (CAHUs) (also termed portable air scrubbers or negative air machines) are used in conjunction with containment to remove contaminated air from a sealed containment area through ductwork. The filtered air is exhausted outside of the containment, creating negative air pressure (a slight vacuum effect) inside the containment relative to surrounding areas.

How do these construction air-handling units help limit the spread of contaminants to other areas inside the building? When the machines draw air in from the surrounding environment, the air passes through a series of filters that remove particulates, including mould spores. Then, the air comes out clean and safe to breathe.

There are several varieties of air filtration devices available on the market today, but it's important to know which device is the most effective option. The best choices are units equipped with true HEPA filters, which are a requirement for healthcare facility projects.

When it comes to mould, these filters are a must. HEPA refers to a filter that is manufactured, tested, certified, and labelled in accordance with filter standards (e.g., EACC Standard). There are several subclasses within the HEPA classification. A true HEPA filter can capture 99.97% of 0.3-micron particulates, including mould spores, dust, and other allergens, and an even higher percentage of larger particles.

Finding the right solution

To safely and effectively remediate mould, it's important to combine the right tools with the necessary expertise. In doing so, it's essential to select a provider with many years of industry experience, excellent support, and state-of-the-art solutions. By utilizing essential equipment, such as portable construction air-handling units and hard-sided, dust-barrier containment walls, remediation and abatement experts can properly get the job done as safely and efficiently as possible, without being exposed to harmful air.

To safely remediate mould, it's important for experts to stay up to date on available technologies, solutions, and techniques. At Abatement Technologies, we offer courses such as the Water Damage Restoration Technician (WRT) IICRC Certification our Aire Guardian Academy. Visit abatement.ca/aire-guardian-academy to learn about our course offerings.

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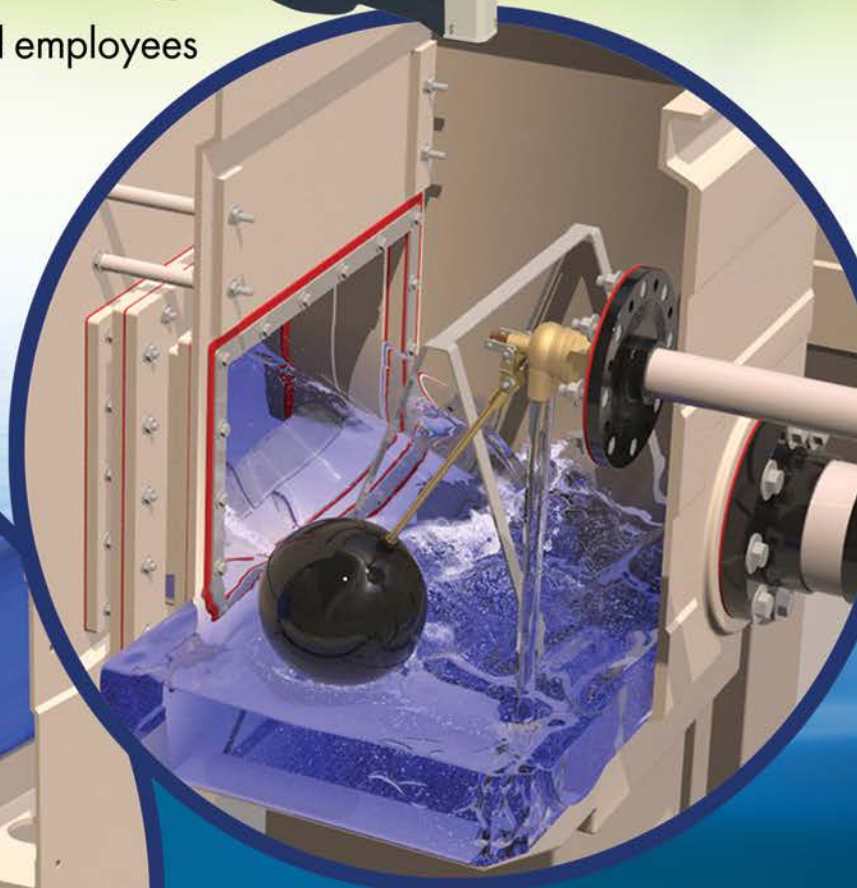

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