LONG LASTING ANTIMICROBIAL SURFACE PROTECTION

PREVENTION OF MICROBIAL GROWTH IN VENTILATION SYSTEMS BY SURFACE MODIFICATION

A White Paper from Design1 Indoor Environmental Inspections

Safe | Durable | Effective

PROTECT YOUR BUSINESS FROM INVASIVE MICROBES

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1 Introduction

The indoor environment in any building is the result of the interactions between a wide variety of conditions and situations - the building site, the building design, the building use, the climate, and the mechanical equipment systems. Much attention has focussed on the air handling system as a source and dispersal vehicle for a variety of pollutants. The debate on the "fault" of design, materials of construction, operating conditions and maintenance schedules seems to be unending. However, out of this debate comes a clear mandate to upgrade and better maintain the various components.

Mould, mildew, bacteria, and germs, often called **microbes**, are everywhere. In some circumstances, microbial growth in buildings represents a real indoor air quality issue. This really is no longer debatable. Some have implications for human health because they can cause disease, exacerbate allergic and asthmatic conditions, cause toxic reactions, or just make us unhappy because they smell and deteriorate the environment that surrounds us. A few more common examples include:

- Environmental bacteria such as *Legionella pneumophila* can colonise building ventilation systems and result in Legionnaire's disease through exposure.
- Kinds of mould such as *Penicillium, Aspergillus* and *Stachybotrys* that can live on damp surfaces and in humid environments that can cause musty odours, surface deterioration and a wide variety of human responses including headaches, sinus infections, skin irritations and allergic reactions.

Such problems are expanded by the press and the public's fears are then further fuelled. Dealing with illnesses that result from exposure to these organisms is the realm of the medical community.

HVAC systems are the lungs of a building. As HVAC operators and building managers responsible for the cleanliness of the air we breathe, we need effective ways to reduce exposure before we contract diseases and have detrimental health effects.

2 Kinds of Microbes

For the purposes of this paper, microbes can be divided into two main groups based on how they react with surfaces. These include:

- Microbes such as mould and some types of bacteria that colonise and then live on surfaces that we touch and are exposed to. Examples include:
  - Bacteria living on building surfaces such as air conditioning and dehumidifier cooling coils, wet insulation, pool decks, wet clothing such as socks, garbage chutes and sporting equipment.
  - Fungi – mainly species of mould – that live on building materials and systems exposed to dampness and high humidity, in crawl spaces, on our furniture, and on outdoor equipment and fabrics that remain chronically wet.

This category includes the organisms that are important in ventilation equipment.

- Microbes such as bacteria and viruses that do not colonise the environment around us but come from us and that can be present on these surfaces from deposition from other places – from hand contact and from the air – and can remain alive long enough to be passed from surface to surface by hand contact. The most newsworthy types are in this group – MRSA, bird flu, SARS, Norovirus and others. This group of organisms includes the ones that humans typically refer to as "germs".

This group is less significant in HVAC systems because they normally are not growing on HVAC components although HVAC systems certainly help to move them around a building.

These categories are not scientific groups but simply are ways to look at microbes when trying to determine effective means to control them.

3 Requirements of Microbes

Microbes are not particularly demanding – they like the same environments that we do. Conditions of temperature and humidity suitable to us are also suitable for microbes.

From the perspective of humans and our potential exposure routes, the *growth* of microbes on environmental surfaces really just requires a suitable surface with sufficient water availability. *Survival* of microbes (i.e. germs) for long enough for us to make contact with them requires only a hospitable/friendly surface for them to remain on. Accordingly, our efforts have correctly focussed on surfaces.

4 The Role of the Ventilation System

One often overlooked issue with respect to controlling microbes in buildings is the air handling system – including large air handling units with cooling towers, rooftop heat pump systems, ductless units, fan coil systems common in older hotels and high-rise apartments, and residential air conditioners. Although maintenance firms routinely adjust belts, change filters, fix damper motors, etc., all too often the concept of the air handling unit as a "micro-environment" is ignored. Given that we know that microbes love damp environments, should we not believe that the interior of an air handling unit, especially the front portion that has filters, cooling coils, humidifiers, soundproofing, and other places where wetness is unavoidable, would not support a wide range of organisms? Furthermore, can we also not accept that these biological life processes can occur past the filter banks that are designed to protect the units and receiving environments themselves from biological contamination?

5 Existing Control Methods

The only certain way to eliminate microbial problems in metal duct systems is to remove the dust and dirt that the microbes colonise. Non-porous sheet metal offers little if any, hospitality to a microbe. Microbial growth in metal duct systems normally is associated only with dust accumulations. However,

given that many parts of a modern air conveyance system contain materials other than non-porous sheet metal, to pretend that cleaning alone will prevent microbial colonisation is a fallacy.

Cleaning has been the most commonly used means to control microbes that are easily accessible to most people. Intuitively, keeping surfaces clean is paramount to reducing exposure to germs. This is not a bad strategy for building components that are seen every day, such as walls, ceilings and furniture in occupied spaces, but it tends to be less effective in locations that are "out of mind" and seldom inspected unless they no longer work. A huge industry has developed around this concept with every commercial cleaning supply company selling an endless array of cleaners, sanitisers, disinfectants, wipes, brooms, mops and other devices specifically sold to help kill microbes. However, simply cleaning of HVAC surfaces may not be enough to control the growth of microbes between scheduled maintenance given that suitable growth conditions for mould and bacteria are present for much of the time.

Reducing dampness and humidity has also been a main microbial control strategy. The use of dehumidifiers, air exchangers, fans and ventilation systems has all increased in popularity as a means to reduce the damp conditions that are suitable to allow the growth of microbes on environmental surfaces in occupied spaces. However, ventilation systems, by their very nature, create these environments by drawing in humid air from outside and creating wet places from air conditioning and humidification efforts.

The responses that we have to microbes are the result of three main factors:

- Virulence. Some microbes are simply more dangerous than others. Our control strategies can do little to address this – they are what they are.
- Susceptibility. Some people are simply more susceptible to developing health issues with exposure. Cleaning and control strategies cannot address this either.

- Dose. This is the one factor over which we should have control – reduction of exposure by reduction of numbers of microbes accumulating on and growing on surfaces is the focus of our cleaning efforts.

As noted earlier, with all of these strategies in place and readily available to almost everybody, one would presume that the battle against the microbes is being won.

But it is not. Why?

6 Limitations of Existing Methods

Existing methods to control microbes in ventilation equipment suffer from a few main obstacles that limit their effectiveness. These include:

1. No lasting effect. Cleaning and surface disinfection all have this inherent limitation – the newly-cleaned surface can be contacted and then colonised by microbes virtually immediately after cleaning and those new microbes will not be destroyed because the cleaning does not provide lasting defence, either because it evaporates or is simply removed by airflow. To be effective, surface disinfection would need to be done very often.
2. Lack of practicability. Some surfaces simply cannot be easily cleaned often enough to make much difference. This is especially true in environments such as the interior of HVAC components where dampness is inevitable, especially during air conditioning and humidification. To make matters worse, the damp conditions cannot really be eliminated as they are part of these processes. To add further to the difficulty, the interiors of HVAC components are often not accessed frequently and serious problems can develop between inspections.
3. Cost. Fighting a war against microbes can be expensive, especially if you want to win. Control of humidity, provision of fresh air, replacement of products, and use of disinfectants and sanitisers all add cost to our control strategy. The cost includes both the products being used and the time required to use them. Often, the cost is prohibitive and, as a result, the defence simply isn't good enough.

Our main efforts have always focussed on:

- removal of microbes from surfaces.
- improvement of conditions that support microbial growth - mainly for moulds and some environmental bacteria that like dampness.
- control of microbial survival by adding toxic chemicals to our products during manufacture – this is simply not practical for use on existing surfaces.

We simply need more choices.

Unless we are genetic engineers and have the means to change the virulence of organisms, or are biochemists with formulations that can selectively neutralise microbes of concern, our control methods need to focus on reducing exposure by reducing growth on the surfaces that surround us. Surfaces need to be able to resist microbial attack. The science behind this is already here.

Microbes do not need to be controlled on surfaces only by poisoning. They can also be destroyed by physical contact with surfaces that can mechanically disrupt their delicate cell membranes as they try to grow. Cellular membranes in most microorganisms are very susceptible to electrostatic disruption. Once the membrane has been broken the organism will die soon after. The challenge is simply to modify a ventilation component's surface such that cell membranes of microorganisms that contact it can be damaged without the modification being removed by routine cleaning or air movement. Like Achilles' heel, like Goliath's forehead, like the underbelly of Smaug, we don't need to mass poison the microbes, we just need to know where to direct the efforts.

We need a way to make a surface defend itself.

A surface modification strategy to control the growth and survival of microorganisms would ideally have the following characteristics:

- easily applied to existing surfaces
- not visible (colourless and odourless)
- durable and long-lasting, even with repeated washing and exposure to air movement
- no toxicity to humans
- broad spectrum of effectiveness (should destroy a variety of organisms)
- compatible with all other cleaning activities

Products used to control microbes can be divided into two major categories; bound and unbound. These terms simply refer to whether or not the antimicrobial has the capacity to molecularly bond to the surface on which it is applied.

An unbound product like a traditional disinfectant must diffuse or leach from the treated surface and be consumed by the microorganism to be effective. Most conventional antimicrobials, such as alcohol or quat-based consumer disinfectants, are intended to kill organisms on contact while wet and dissipate (evaporate) quickly to minimise the danger to humans, animals and treated objects. Hand cleaner is a good example of this. Others use the time-release capsule approach and obtain a longer working life by burying the antimicrobial in paint, glue, binder or other coating and counting on slow migration to the surface. Certain types of condensation drain pan disinfectants fall into this category.

Once inside the organism, the chemical agent will act like a poison, interrupting some key metabolic, or life-sustaining process of the cell and causing it to die. In all cases, once the antimicrobial is depleted or washed away during regular maintenance, protection vanishes.

A bound product, or surface modifier like the AEGIS Microbe Shield, forms a durable chemical bond upon application and remains chemically attached to the surface on which it is applied. It functions by electrostatically interrupting the organism's delicate cell membrane. This prevents microorganisms from carrying on vital life processes. This antimicrobial acts on contact with organisms and can do so again and again. One can think of the bound antimicrobial as a sword that is capable of repeated use. In comparison, a conventional antimicrobial treatment is more like a gun with limited ammunition. Since a bound antimicrobial is fixed to the surface it continually operates at full strength.

Unfortunately, a bit of chemistry is needed here as the chemistry of surface modification technology is unique. A conventional quaternary ammonium salt, a product which is the basis of many conventional antimicrobials, is chemically spliced to a silane molecule (silanes are used to hold heat shields on spacecraft), resulting in a highly active molecule that has both tenacious bonding capabilities as well as excellent antimicrobial properties. Once applied to a target surface it bonds everywhere, resulting in the creation of a large co-polymer involving the target and the treatment. Since there is no unused chemical there is no dislodgeable residue and no odour, leaching, off-gassing, migration or diffusion of the molecule can occur.

All other conventional antimicrobials used legally in Canada, including alcohols, quaternary ammonium compounds, bleach, peroxides, paint formulations, etc., work on the basis of either destroying what is present while the product is wet or by diffusing away from the treated surface over time. This promotes microbial adaptation and loss of activity. The AEGIS Microbe Shield used as a surface modification strategy is essentially permanent, and the problems associated with conventional chemicals are not of concern.

The AEGIS Microbe Shield is easily applied on virtually any surface by spraying. It is approved by the Pest Management Regulatory Agency of Health Canada for use on virtually all hard and soft surfaces found in building environments. It can easily be incorporated into existing maintenance operations, providing a

long-lasting defence to control the growth and survival of microbes on just about any surface. The modified surface will retain antimicrobial activity for an extended period of time, even after repeated cleanings.

The AEGIS Microbe Shield allows surfaces to begin to defend themselves. It provides critical protection and reduction of growth and eventual exposure of people in receiving environments to dangerous microbes on ventilation equipment. This protection is continuous and does not require frequent reapplication. With reductions in exposure come reductions of risk.

Building managers are discovering something medical researchers and competent indoor environmental experts have known for over a decade; irritating odours and diseases caused by bacteria, mould and mildew can be controlled by the proper application of an antimicrobial. The greatest gains in reducing building-related illnesses will be made through implementing a systematic approach to microbial contamination in each building. With research scientists agreeing that microbial contamination is a major component in sick building syndrome, it makes sense to take a holistic approach to resolve microbial contamination problems. While a building envelope's environmental conditions can be mechanically controlled to make it less susceptible to microbial contamination, the same tool used to control the indoor environment - the HVAC system - can contribute to microbial contamination of the receiving environment. The only way such contamination can be held in check in the environmental conditions that functioning air conditioning /HVAC systems create associated with normal usage is with an antimicrobial.

The AEGIS Microbe Shield is not a replacement for good mechanical system hygiene and maintenance. However, effective risk management requires more than one tool. Cleaning and disinfection simply have no lasting effect. The AEGIS Microbe Shield enables the concept of surface modification in HVAC systems to become a reality. Albert Einstein once said that we should use tools and ideas to solve problems that are better than those that we used to create them. It is time for new ideas and time for the AEGIS Microbe Shield.

7 Reference Materials

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