Indoor Air Quality

A Duty of Care

An IAQ Industry Initiative

Guidelines for a Healthier Workplace

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A Breath of Fresh Air

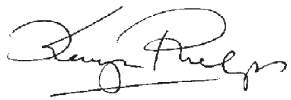
Despite an image as the nation which loves the great outdoors, Australians spend some 90% of their time indoors. As a consequence, indoor air quality and the health problems created by contaminated air are issues of very significant community health concern.

It is now well documented that poor indoor air quality leads directly to a number of worrying health effects on the occupants of affected buildings. These range from minor skin and eye irritations to asthma, allergies, respiratory complaints and suppression of the immune system. Legionnaires' Disease is just one deadly example.

A World Health Organisation report in 1995 estimated that up to one third of buildings in industrialised countries are so-called "sick buildings". In Australia, the CSIRO concluded in 1998 that this problem costs 12 billion dollars per year in lost productivity and illness. The issue of air quality is one with very real health and economic implications. It is with good reason that this topic is now among the most hotly debated in environmental medical literature.

While we all enjoy the comforts afforded us by modern air conditioning systems, it is important at the same time that we recognise them as a source of potentially harmful micro-organisms and take steps to ensure that they are properly operated and maintained. By simply ensuring that the air delivery systems in modern buildings remain free of biological contamination, we can go a long way towards improving the health and quality of our indoor environments.

The issue of indoor air quality is critically important and warrants an increased level of community responsibility. This booklet is both timely and commendable in its promotion of a greater level of community awareness of and response to the issue.



Dr Kerryn Phelps

Dr Kerryn Phelps

Your Right to Healthy Air

"Indoor air quality is a most significant environmental issue that has not been seriously addressed in this country...

Australia is failing its responsibilities of a 'duty of care' to protect the community in the environment where we spend most of our time."

"Indoor Air Quality in Australia:
A Strategy for Action"
The Clean Air Society of Australia
and New Zealand, May 2003

In recent years there has been significant focus on the hazards associated with outdoor pollution. However, insufficient emphasis has been placed on the potentially greater dangers associated with contaminated indoor environments.

We all have a right to healthy indoor air.

The World Health Organisation found in 1995 that "up to one third of buildings in industrialised countries are sick". Contaminated indoor air is a significant health issue, impacting on a large proportion of the community. The CSIRO reported in 1998 that, "the airborne chemical cocktail Australians inhale in their homes and offices is costing the nation 12 billion dollars a year in sickness and lost productivity."

The health implications, on both an individual and a community-wide level, are immense.

We all have a legislated right not to be exposed to hazards in the workplace. Government and business groups continue to spend vast resources on Occupational Health and Safety programs. Yet, with every breath we take, we expose ourselves to a wide range of potentially toxic substances, within even the most apparently safe and secure workplaces.

This situation is easily avoidable and should no longer be accepted.

Duty of Care

It is a fundamental duty of employers not to knowingly subject staff to hazards in the workplace.

Through a wide range of initiatives, Australian government, business and employee groups have collaborated to continually improve the safety and security of the work environment. Increasingly harsh penalties are imposed for willful contravention of codes of practice and safety guidelines.

In the past, the focus of many of these programs has been on helping to minimise the occurrence of acute incidents, which lead directly to some identifiable physical injury. More recently, there has been a shift towards the recognition of workplace hazards where the symptoms manifest only over the long term. Active, and in some cases drastic measures are now taken to limit exposure to heavy metals in paint, asbestos from building materials, "passive" tobacco smoke and various environmental pollutants, all of which are considered contributors to chronic, long term health problems.

Directors and employers can no longer take comfort from the knowledge that measures have been taken to avoid only those acute incidents. Increasingly, employers, directors and owners must assume responsibility for any long term health consequences that staff might experience as a result of the particular environments in which they operate.

The chronic health effects of biologically contaminated air are now well documented. Unfortunately, the problem impacts a significant proportion of modern buildings and a very large percentage of the Australian workforce.

Directors and employers have a duty of care, owed to each of their employees and to any other person who they should reasonably expect to come into their company's normal working environment, to ensure that all reasonable measures are taken to minimise the levels of harmful airborne contaminants in their buildings. This duty - as may be augmented by contract – impacts directly the landlords and owners of the buildings in which such companies operate.

Sick Building Syndrome

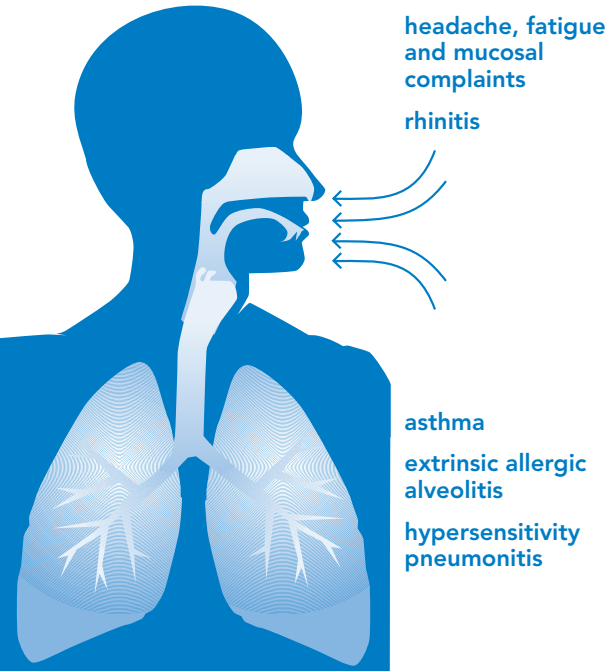
In 1983, the World Health Organisation defined the phenomenon of Sick Building Syndrome as "an excess of work-related irritations on the skin and mucous membranes and other symptoms including headache, fatigue and difficulty concentrating reported by workers in modern buildings."

Symptoms of high contaminant concentrations in indoor air include eye, nose and throat irritation and allergy, nausea and headaches. Some contaminants may also be potentially carcinogenic.

A Cocktail for Illness

"Macromolecular Organic Dust may cause inflammation of the airways, often accompanied by systemic symptoms such as headache, fatigue and joint pains."

Professor Ragnar Rylander,
University of Gothenburg,
Sweden, 2001



Repeated exposure to organic materials of bacterial or fungal origin commonly found in indoor air can result in allergies such as asthma and rhinitis, extrinsic allergic alveolitis (a group of lung diseases), hypersensitivity pneumonitis (which has flu-like symptoms), headache, fatigue and mucosal complaints, or organic dust toxic syndrome (recognised by tightness of the chest and bronchitis).

Exposure to these contaminants has also been shown to suppress the immune system, leading to increased susceptibility to infection.

As well as fungal and bacterial substances, air circulated by air conditioning systems may also pick up and recycle a number of other microscopic particles. This organic dust carries various substances known to produce an inflammatory response. As a consequence, non-specific airways inflammation may play a crucial role in creating conditions for more serious illness.

It is likely that several of the systemic symptoms, such as headache, fatigue and joint pains which are associated with contaminated indoor air are caused by inflammatory mediators, produced in the lung after inhalation and distributed to different parts of the body (Rylander 97).

Current research suggests that even inactive organic dust, comprising the non-viable fragments arising from the fungal and bacterial matter within the Heating, Ventilation and Air Conditioning (HVAC) system, might well cause symptoms of chronic illness. As a result, building occupants might experience significant health complaints even in instances where counts of viable airborne bacteria are at acceptable levels.

"Whether dead or alive, mould is allergenic, and some moulds may be toxic."

US Environmental Protection Agency
Mould Remediation in Schools and
Commercial Buildings, March 2001

The Source of the Problem

Air conditioning systems are the single greatest contributor to energy consumption in a modern building. To maximise energy efficiency, indoor ventilation systems generally recycle the vast majority of the indoor air volume, introducing very little outside "fresh" air. As a result, indoor concentrations of potentially toxic particles can, over time, increase dramatically.

Airborne contaminants originate from a multitude of sources, ranging from the operation of office equipment to the fumes from solvents and resins used in furniture, carpets and building materials.

However, it is well understood that a primary source of indoor air contamination is the bacterial and fungal colonisation of air filters, heat transfer coils and ductwork within the HVAC systems of modern buildings.

Dust Filters

Air passes through dust filters prior to being cooled and introduced into the indoor environment. However, even high grade dust filters are ineffective at removing the smallest airborne particulates, which pass unhindered into the indoor space.

Those dust particles trapped by the filter provide a source of nutrients, leading typically to rapid fungal colonisation. Through the course of their working lives, commercial dust filters become highly contaminated. The fungal colonies produce spores, volatile organic compounds and glucan particles, all of which contribute to elevated levels of harmful airborne contaminants.

Specific micro-organisms commonly found within dust filters include:

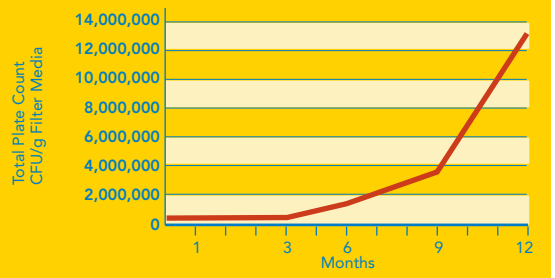
- Aspergillus
- Penicillium
- Alternaria
- Cladosporium

Exposure to these organisms and to the mycotoxins that they produce can lead to immunological responses such as airway inflammation, hypersensitivity pneumonitis and asthma as well as respiratory tract infections (such as aspergillosis) and various allergic and toxic reactions.

Aspergillus

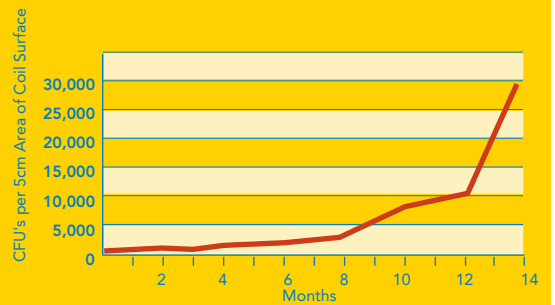
The Source of the Problem

Proliferation of fungi in a typical dust filter over a 12 month period



Novapharm Research (Australia) PTY LTD, 2001

Heat Exchange Coils - Monthly Microbial Counts



Novapharm Research (Australia) PTY LTD, 2000

Cooling Coils

The primary heat exchange components in a modern air handling system are the cooling coils. After passing through the filters, warm air is blown across the surface of the coils, where it is cooled, or "conditioned". This cooling process draws moisture out of the air, resulting typically in the precipitation of large volumes of water onto the coil surface.

The air passing across the coils carries with it a range of contaminants, including dust, micro-organisms and hydrocarbon fumes not removed by the filters. These particulates become entrapped on the wet coil surface. The entrapped micro-organisms have a natural predisposition to form biofilms, complex structures that enable extensive bacterial colonies to become entrenched. The damp cooling coils surfaces provide a plentiful supply of both nutrients and water, producing an ideal environment for micro-organisms to proliferate within these biofilms.

As the bacteria within the biofilms regenerate, they shed bacterial endotoxins and a range of other potentially toxic organic fragments. These particulates, along with the micro-organisms themselves, are introduced into the occupied space via the HVAC system.

Specific micro-organisms common within air conditioning cooling coils include:

- Bacillus
- Pseudomonas
- Flavobacterium
- Candida
- Rhodotorula

Exposure to these organisms can lead to various immunological responses and allergic reactions. In cases where one's immune system has been compromised, exposure to these organisms can lead to pneumonia. This is of particular concern in hospital environments where poor indoor air quality is known to induce a range of nosocomial infections.

Ducts

The ductwork within air conditioned buildings presents by far the greatest surface area for potential microbial colonisation. However, it is the dust filters and the heat exchange coils within the air handling units that typically provide the source of bacteria and fungi. Provided these components are appropriately treated, significant microbial colonisation of the ductwork is unlikely.

Ducts should be inspected periodically to ensure that the surfaces remain clean. Where microbial growth is evident, immediate remediation is required. A specialist duct cleaning company should be contracted to remove any accumulated debris. Internal duct surfaces should be treated to prevent further microbial growth.

Mould Contamination

Mould can grow on any surface within the building where moisture and nutrients are present.

Acoustic ceiling tiles are particularly susceptible when they become damp. This generally occurs when the drain line from a ceiling mounted air conditioning unit becomes blocked, leading to an overflow of condensate water onto the ceiling tiles. This is easily prevented by ensuring regular servicing of these units and through use of treatments to inhibit biofilm growth in the condensate trays.

Carpets and other fabrics are also prone to mould growth when they become damp. It is essential that effected carpets are treated or replaced as soon as practicable. All sources of moisture into a building should be monitored.

Any water ingress that causes surfaces susceptible to mould growth to become damp should be rectified immediately.

Rhodotorula

Candida

The Source of the Problem

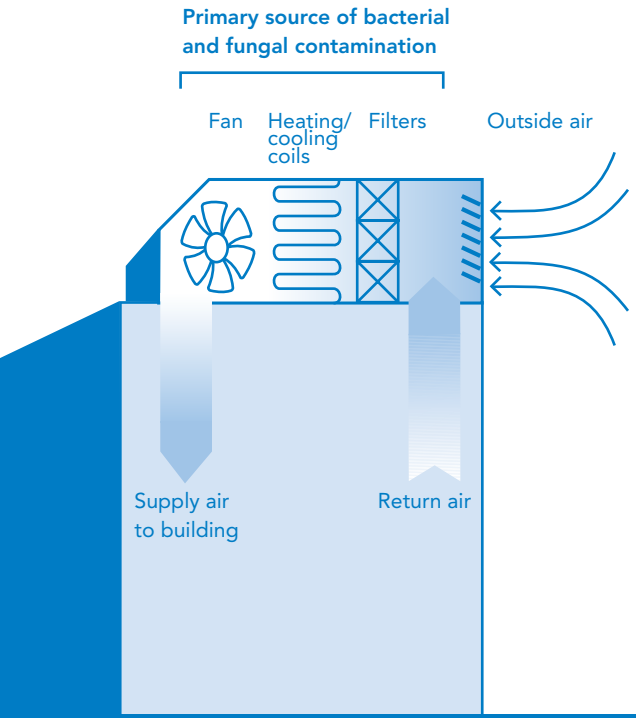
Air Handling Rooms – A Critical Issue

The air handling rooms in centrally air conditioned buildings house the dust filters and heat exchange coils, the components most susceptible to gross microbial contamination.

All air introduced into these buildings passes first through these relatively small air handling rooms. As a result, the levels of airborne biological pollutants in these rooms are potentially many times greater than those found within the general atmosphere of the building that they service.

The health risks arising from contaminated indoor air are of particular concern to the mechanical service personnel responsible for the maintenance of these areas. The air handling rooms require servicing – filter changes, coil cleaning and general mechanical maintenance. Maintenance staff are often unaware of the serious health hazard posed by regular exposure to the amplified levels of organic contaminants in these areas.

Management personnel responsible for the servicing of these rooms have a duty of care to ensure that maintenance staff are aware of these hazards and that appropriate safety equipment is provided. At a minimum, gloves, protective eyewear and respiratory masks are essential in environments where a program of appropriate scheduled maintenance has not been assured.



Biofilm growth in a cooling coil

Legionella – An Acute Manifestation of Poor Maintenance

Legionellosis (or Legionnaires' Disease) is unquestionably the highest profile danger to human health associated with the mechanical plant of modern air conditioned buildings.

Legionella pneumophila bacteria, the organisms that cause this potentially life-threatening form of pneumonia, proliferate in bulk water systems and are common in the cooling towers associated with centralised HVAC plants.

Cooling towers extract heat from the condenser circuits of large air conditioning systems. They dissipate this heat through a process of evaporation into the atmosphere, leading to significant atomisation of the condenser water. Inhalation of this atomised water containing legionella bacteria can lead to infection. According to the Centre for Disease Control (CDC) in the US, between 25,000 and 100,000 cases of legionellosis occur annually in the United States.

Due to the acute risks associated with legionella, the treatment of cooling towers is the most highly regulated aspect of mechanical plant maintenance. Strict procedures are in place to ensure periodic cleaning and testing of cooling tower water. As a consequence, outbreaks of legionella arising from poor cooling tower maintenance are relatively infrequent.

As we move towards an understanding of the multiple sources of biological contaminants within modern buildings, the focus that has been applied in recent times to cooling tower maintenance should be replicated across all other aspects of HVAC infrastructure.

Legionella pneumophila

Prevention Rather than Cure

There are several potential reasons for compromised air quality in a building. However, bacterial or fungal colonisation of air conditioning systems represents by far the most significant source of introduced biological contaminants.

In the United States and elsewhere it has become recognised that even a relatively minor amount of visible mould in a building requires drastic action. It is clear that microbial control is most effectively achieved by addressing the problem at its source.

It is essential that building managers establish a program of regular scheduled maintenance and that Indoor Air Quality management becomes an integral component of standard maintenance programs. Quality assured procedures should be clearly documented, regularly reviewed and available for inspection by building engineers, facility managers, building owners, property insurers and tenant groups.

While specific maintenance protocols will necessarily vary between buildings, all should incorporate periodic cleaning and treatment of key air handling surfaces along with regular objective assessment to confirm the efficacy of any biological treatment processes. Where visible mould is evident on any air handling surface, immediate remediation is required. Remediation processes are comprehensively documented in the ACR2002 industry standard, developed and published by NADCA[1].

Air filters should never be left in place for longer than their rated life (or pressure drop) and, where appropriate should be treated to inhibit fungal proliferation. Filters left in place too long become primary sources of amplification of fungal contaminants.

Too often, the approach to mechanical plant maintenance as it relates to indoor air quality is reactionary, with remediation work conducted in response only to known problems. It is essential that this approach be replaced by a focus on prevention. By implementing and adhering to a proactive monitoring, maintenance and treatment program, building managers can dramatically impact the levels of airborne biological contaminants within their indoor environments, contributing materially to the improved health and well-being of building occupants.

"40 to 60 per cent of occupants in some buildings may experience symptoms of sick building syndrome"

NSW Parliamentary Committee, 2000

1. Assessment, Cleaning and Restoration of HVAC Systems, ACR 2002, An Industry Standard Developed by the National Air Duct Cleaners Association, USA.

Benefits Beyond Human Health

Importantly, effective plant maintenance gives rise to a multitude of additional benefits beyond improved indoor air quality. Biofilm accelerates the corrosion and degradation of aluminum coil surfaces, while fungal growth accelerates the rate at which filters become blocked.

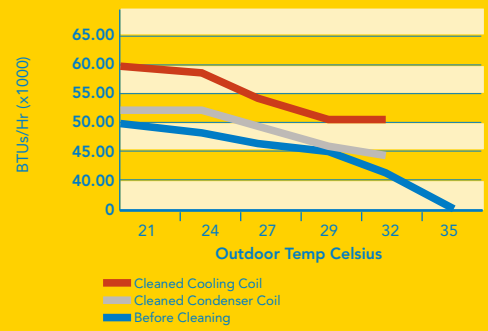
By inhibiting microbial colonisation, one helps to extend the useful life of key air handling components. Well maintained mechanical plant consumes far less energy than systems whose heat exchange and air resistance characteristics have been impaired by the presence of biofilm. Well maintained systems yield significant cost savings through improved operating efficiencies. With HVAC contributing materially to global energy use, this improved efficiency also yields direct environmental benefits and greenhouse gas reductions.

The case for effective IAQ maintenance procedures is compelling. Given its low implementation cost along with the human health, productivity, energy saving and environmental benefits, it should be an integral component of all effective building maintenance practices.

Implementation of an effective IAQ maintenance program delivers multiple benefits:

- A healthier work environment
- Improved staff productivity
- Reduced staff absenteeism
- Reduced energy consumption
- Longer equipment life
- Reduced greenhouse gas emissions and significant environmental gains

System Efficiency BTUs/ Hr



Louisiana Department of Natural Resources, Technology Assessment Division

Healthy Building Checklist

The following aims to provide tenants and employee groups with a simple list of questions to help develop constructive dialogue with their building owner or manager.

- **Is there in place a clear and documented program of air quality assessment?**
- **How often are the air handling units inspected for mould or bacterial contamination?**
- **Is there in place a clear and documented procedure for controlling the microbial contamination of HVAC infrastructure?**
- **Is there in place a program of regular cleaning and treatment of the air handling rooms, and the heat exchange coils in particular?**
- **Are filters inspected regularly and changed according to a predetermined protocol?**
- **Are filters treated to inhibit fungal colonisation?**
- **How often is the internal ductwork and building infrastructure inspected?**
- **Is there any provision in the maintenance budget for mould remediation ?**

Occupational Health and Safety Act 2000 No 40

8. Duties of employers

(1) Employees

An employer must ensure the health, safety and welfare at work of all the employees of the employer.

That duty extends (without limitation) to the following:

(a) ensuring that any premises controlled by the employer where the employees work (and the means of access to or exit from the premises) are safe and without risks to health,

(b) ensuring that any plant or substance provided for use by the employees at work is safe and without risks to health when properly used,

(c) ensuring that systems of work and the working environment of the employees are safe and without risks to health,

(d) providing such information, instruction, training and supervision as may be necessary to ensure the employees' health and safety at work,

(e) providing adequate facilities for the welfare of the employees at work.

(2) Others at workplace

An employer must ensure that people (other than the employees of the employer) are not exposed to risks to their health or safety arising from the conduct of the employer's undertaking while they are at the employer's place of work.

Website Links and References

World Health Organisation
www.who.int

US Environmental Protection Agency
www.epa.gov

National Air Duct Cleaning Association
www.nadca.com

US Indoor Air Quality Association
www.iaqa.org

American Society of Heating, Refrigeration and Conditioning Engineers
www.ashrae.org

American Lung Association
www.lungusa.org

Australian Institute of Refrigeration, Air Conditioning and Heating
www.airah.org.au

CSIRO
www.csiro.gov.au

Clean Air Society of Australia and New Zealand
www.casanz.org.au

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