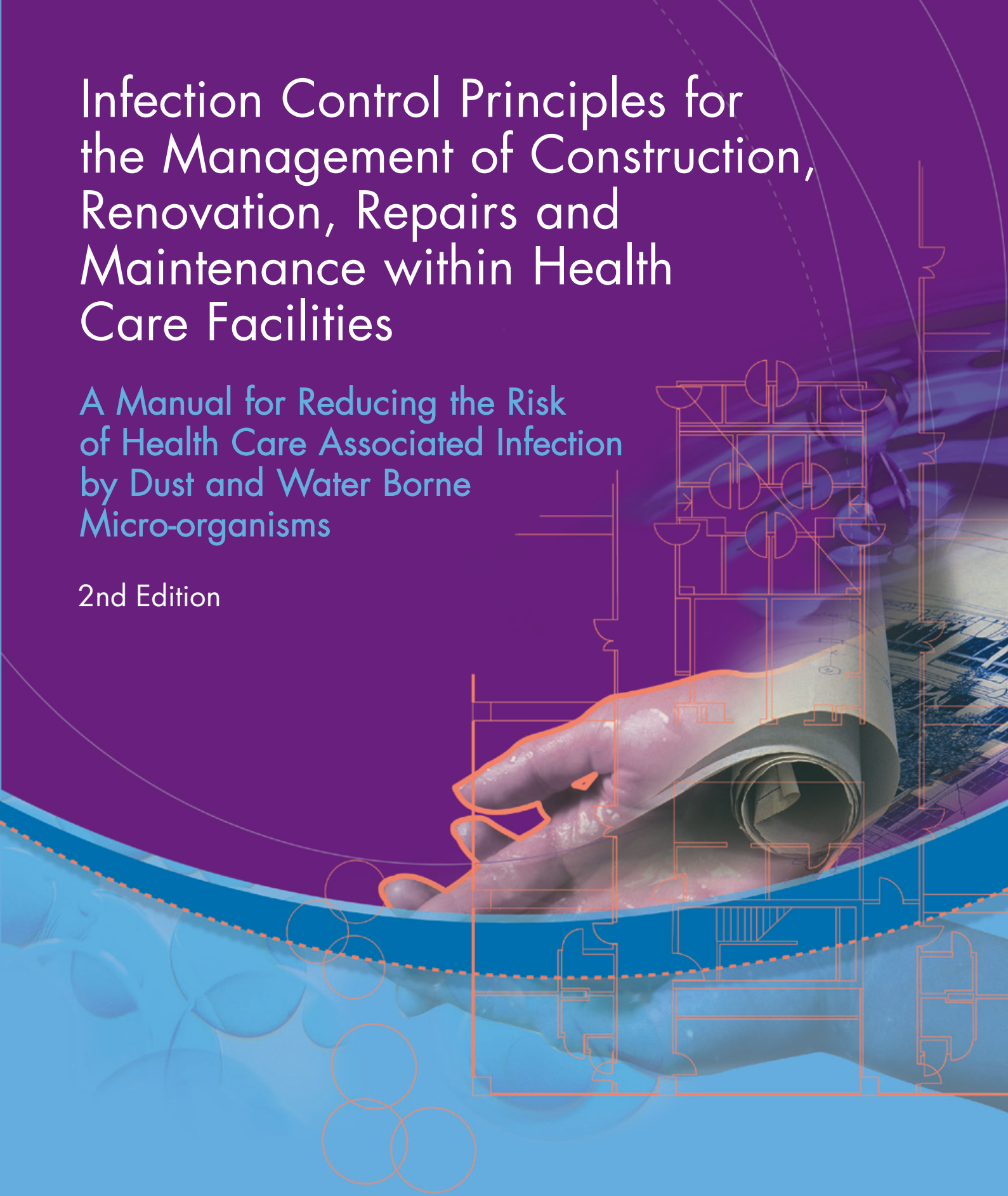
Infection Control Principles for the Management of Construction, Renovation, Repairs and Maintenance within Health Care Facilities

A Manual for Reducing the Risk of Health Care Associated Infection by Dust and Water Borne Micro-organisms

2nd Edition



LODDON MALLEE REGION
INFECTION CONTROL RESOURCE CENTRE

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Health Canada. *Construction-related Nosocomial Infections for Hospitalized Patients: Decreasing the Risk of Aspergillus, Legionella and Other Infections.*

Austin & Repatriation Medical Centre. Engineering & Building Services

Austin & Repatriation Medical Centre. Microbiology Department

Austin & Repatriation Infectious Diseases Unit

Bendigo Health Care Group Infection Prevention & Control Unit

School of Molecular and Biomedical Science. The University of Adelaide, Australia. Kaminski Digital Image Library.

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Introduction

Infection control is one of the key priorities in Australian hospitals. A strong focus on improvement of clinical practices related to infection control is leading to better patient outcomes. On the other hand patient wellbeing can be diminished due to construction related infection. These infections are a result of continual changes in technology leading to almost constant construction activities within hospitals.

Current construction practices can impact on patient wellbeing by disseminating bacteria and filamentous fungi that can cause nosocomial infections. Of these nosocomial infections, the vast majority are due to filamentous fungi.

Know your patient population at risk status

A formal approach to risk management should be part of all construction, renovation and maintenance activities within a health care facility.

Identify the at risk population, identify the location of the at risk population in relation to the construction, know the transmission route of a likely pathogen, and then mitigate the risk in the planning stages. Most importantly we must educate others in the process.

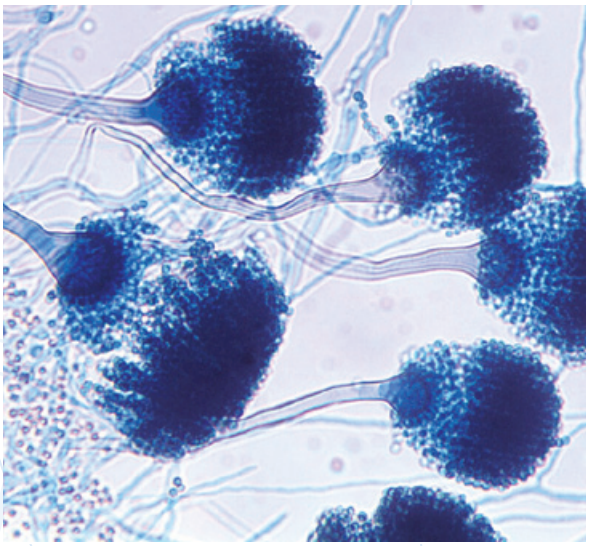
Lack of planning, risk identification and risk control practices to abate airborne contaminants during construction can lead to serious environmental contamination within a health care facility. Cross education between infection control and engineering should be encouraged. This will increase the awareness and enable better lines of communication to be established between clinical and engineering staff. Clinical staff seem to speak a different language to engineering staff. Often important facts are missed due to this. Clinical staff must be educated in the basics of the building process as well.

Risk index = Frequency x consequences

Before starting a project, scheduled maintenance or initiating breakdown maintenance, do we ever ask?

What can go wrong?
– Hazard identification
How likely is this to happen?
– Frequency analysis
What are the consequences if it does?
– Consequence analysis.[1]

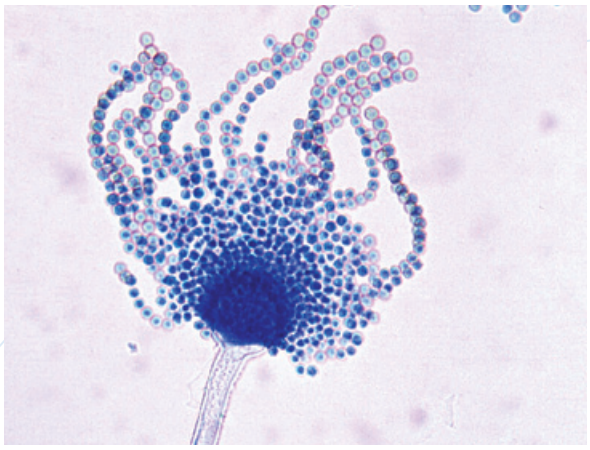
Risk identification is likely to be the most difficult stage of the risk management process. It is generally more difficult to identify patient safety issues that can create an adverse event than it is to devise systems to overcome the adverse event once it is identified. Many tools are included within this manual to aid in this process.



Risk management, occupational health and safety and business continuity are best managed when considered together and not in isolation. Furthermore, some form of quality system is necessary to manage the large number of tasks that need to be done.

The key to undertaking any process, such as risk analysis, is to integrate the task into other processes.

Consider the various tasks that when addressed can provide a tangible benefit to the project. The aim is to improve the overall outcome of the project by reducing the risks.



Micro-Organisms

Fungi and bacteria inhabit almost every part of every building we occupy. Many fungi and bacteria are ubiquitous and lay dormant in any place that gathers dust. The vast majority of construction related nosocomial infections are due to filamentous fungi.[2] Bacteria such as *Clostridium perfringens* can also present hazards, but this is less common. This manual concentrates on filamentous fungi due to their more frequent association with nosocomial infections.

Fungi are a separate part of the microbial world. They are micro-organisms that grow either as yeasts (round, budding cells) or moulds (filamentous, sporulating, cottony growth). Moulds typically produce many airborne spores that can be inhaled. These organisms can survive in almost any place. The type of environment determines which micro-organism will proliferate, lay dormant or die. Fungi multiply quickest in warm humid conditions.

The most common pathogenic fungi is *Aspergillus*, principally *Aspergillus fumigatus, A. flavus and A. nigar.*[1,2] They are xerotolerant (resistant to desiccation), thermotolerant to 45°C and buoyant.[3]

The fungi spores are transmitted via the airborne route. Due to the size (2–3.5 µm) and the rough surface of the spores, *Aspergillus* can remain suspended indefinitely.[4]

Severely immunocompromised patients such as bone marrow transplant (BMT), solid organ transplant, haematology, oncology and those receiving immunosuppressive medication represent the group most at risk. Generally these patients will be grouped together in speciality wards. Frequently they will spend some time in ICU, theatre, outpatients, or the emergency department and most importantly of all, in transit between departments such as radiology and radiotherapy. It is advisable that this group of patients wear surgical masks while being transported.[10]

Aspergillus species represent the greatest threat to neutropenic patients

Clinical infection of invasive pulmonary aspergillosis is both difficult to diagnose and difficult to treat. Early symptoms are non-specific and the rate of culturing the fungi from sputum is low.[2] Depending on the patient's underlying condition, but principally in bone marrow transplant, mortality rates can be as high as 100%.[2]

Where do the Bugs Come From?

Aspergillus fungi are ubiquitous and are commonly found in soil, water and decaying vegetation. They have even been found in battery acid and at altitudes of 3,000 metres.[3] These fungi are readily adaptable to most environments that contain moisture such as decaying cellulose material and all unfiltered air.

Water damaged ceiling tile with fungal growth

Accumulated dust inside a hospital ceiling has been shown to contain as much as 10^3 CFU/g (colony forming units per gram) of *Aspergillus fumigatus*.[1]

Building and maintenance activities disturb these reservoirs and can send millions of spores throughout the health care facility. These spores can infect any person whose immune system is severely compromised. Humid spaces such as riser shafts, wall cavities with plumbing, and ceiling spaces with services provide the ideal environment for the proliferation of fungi.

What are the Likely Causes of Fungal Related Infections?

Environmental Exposure

Patients in health care facilities are exposed to airborne fungal spores that are derived from indoor sources and outdoor sources.

Aspergillosis in high-risk immunosuppressed patients has been associated with indoor environmental reservoirs from sources including bird droppings in the air ducts supplying high-risk patient areas, contaminated fireproofing material, damp timber and plaster (especially particle board) and potted indoor plants. Protective environment rooms and strict management procedures are generally used to reduce the risk of infection from these sources.

The outdoor environment is by far the largest reservoir of fungal spores. Building supply air systems must be designed, installed and maintained in such a way as to control the number of fungal spores delivered to an occupied space. Correctly fitted and maintained high efficiency deep bed filters (Grade F7) will remove 90–95% of spores at 2–3.5 µm.

The removal of just one ceiling tile can send millions of fungal spores into an occupied area

Building and Maintenance

Building works are a recognised source of *Aspergillus sp* related nosocomial infections.[2] The Health Canada publication *Construction-related Nosocomial Infections for Hospitalized Patients: Decreasing the Risk of Aspergillus, Legionella and Other Infections* cites 25 outbreaks of nosocomial Aspergillus sp infections over a twenty year period resulting in 106 deaths. These deaths were either suspected or confirmed as being caused by construction activity.

Before You Start – Plan, Plan, Plan

Establishing a Multidiscipline Team

Before a project starts a multidisciplinary team should be established to consider infection control strategies, business and services continuity, and occupational health and safety (OHS) for patients, staff and Contractors.[11] This team can consist of senior representatives of the client department, infection control, engineering, architect, project manager, OHS and specialised areas concerned with or impacted upon by the project. The key functions and responsibilities of this team could be to:[2]

Ensure your team has members that represent all the areas affected by the work

- Coordinate members' input in developing a comprehensive project management plan
- Conduct a risk assessment of the project to determine potential hazards to susceptible patients[11]

Don't forget the cleaners, -they are important!

- Prevent unnecessary exposures of patients, visitors, and staff to infectious agents
- Oversee all infection control aspects of construction activities
- Establish site-specific infection control protocols for specialised areas
- Provide education about the infection control impact of construction to staff and construction workers
- Ensure compliance with technical standards, contract provisions, and regulations
- Establish a mechanism to address and correct problems quickly
- Develop contingency plans for power failures, water supply disruptions, fires, short or long term delays (due to industrial action or material's delays) and emergency response
- Provide a water damage management plan (including drying protocols) for handling water intrusion from floods, leaks, and condensation
- Develop a plan for maintenance on the site during construction as well as afterwards.

Pre-design Planning & Consultation Stage

For any project the most important time is the pre-design planning.[8] When the Project Control Group (PCG) is established ensure the Infection Control Practitioner (ICP) is a member.

A small working party consisting of the Project Architect, Hospital Engineer and ICP should be formed to develop detailed project-specific control risk plans based on the risk assessments provided by the multidisciplinary team. This will be the document the Project Architect and Consultant Engineers will use to design protective systems and procedures for the duration of the project. An infection control policy specifically for construction and maintenance works should be available.

Infection Control Practitioners (ICP) need to develop a basic working knowledge of the systems that make up a building. This basic knowledge is essential to enable effective communication between the ICP and the design team.

Risk Assessment

Risk assessment is the most crucial step in identifying potential hazards and the type of containment measures necessary for a safe environment. This task is the responsibility of the multidisciplinary team. The Project Team then develops measures that are incorporated into the design and documentation. Before the Infection Control and OHS recommendations can be defined Infection Control, Business Continuity and OHS risks need to be identified, quantified and analysed for consequences.

Those at Risk

The patients most at risk patients in a hospital are the severely immunocompromised.[3] This group of patients have very depressed immune functions as a result of chemotherapy (oncology patients), immune suppression drugs (organ and bone marrow transplant patients, renal,

chronic underlying medical conditions being treated with high dose steroids), and diseases that affect the immune system (HIV/AIDS patients, leukaemia, lymphoma).[5]

Do you know if your patients are at risk?

Generally these patients will be grouped together in speciality wards, but most will spend some time in ICU, Theatre, Outpatients, the Emergency Department and in transit between departments such as Radiology and Radiotherapy which will expose them to increased risk. In many smaller facilities patients will be in mixed wards, not specialty wards. The following lists identify some of the key issues needed to undertake a risk assessment. The lists are by no means exhaustive, but merely a starting point, and should be tailored to suit individual requirements.

Patient Profile

- Identify the patient populations at risk during all phases of construction.
- Determine which essential services or utilities could be affected that are necessary for the delivery of patient care in the short or long term.
- Identify activity occurring in sensitive areas such as Surgery, Oncology Unit, and Intensive Care.
- Determine if there is a need to relocate susceptible patients or employees.

Do not underestimate the immune status of your patients

- Project what will happen to patient care delivery should an essential service unintentionally be interrupted.

External Projects

- Determine the location of air intakes in relation to any projects.
- Investigate whether the ventilation system will function correctly with the added pressure drop caused by excess contaminants collecting on the air intake system.
- Investigate the need to increase preventative maintenance of the ventilation system to ensure proper functioning during external demolition or excavation.
- Locate any infiltration points pre-construction such as windows and doors.
- Determine whether the project requires penetration of existing walls and if so, how the occupants will be affected.
- Determine how environmental issues affect the project such as prevailing winds, outdoor temperatures.

Internal Projects

- Investigate whether the project requires utility outages, and if so, the effect on occupants by outages.

- Determine the outage's effect on ventilation upstream and downstream.

Ensure you consult widely to develop a comprehensive risk plan

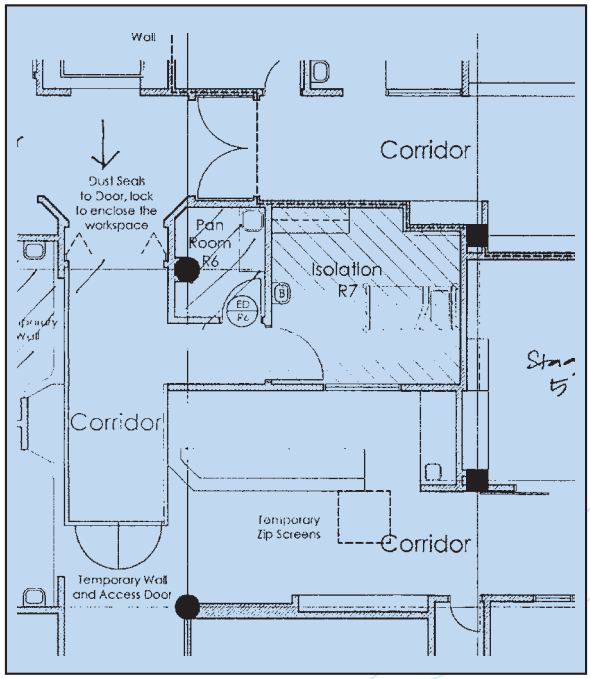
- Determine whether ventilation requirements for special care areas can be achieved during shut.
- Decide whether to use recirculated air, and if so, how contaminants from the construction site will be trapped so they are not dispersed into the general circulation.
- Determine where sensitive patient care areas are located under the project site.
- Investigate whether the construction activities produce vibrations, if so specify type.
- Investigate whether the vibrations create problems for facility operations such as surgery.

Project Delivery

- Make a person responsible for Risk Management and OHS.
- Investigate whether adequate resources are available for that person to accomplish their duties.
- Determine project specific training needs.
- Ensure all OHS management systems been documented such as site employee register, induction register and electrical tool inspections.
- Determine the high risk activities to be undertaken.
- Determine whether a system in place to ensure that task-specific Job Safety Analysis (JSA) is undertaken.
- Ensure appropriate systems exist so that the hazard control measures identified in the JSA are put in place.
- Ensure standard operating procedures have been written for activities identified as high risk.
- Determine who should be included in discussions as the design and specifications are defined.

Design Stage

Infection control precautions should be integrated into all documentation from the



beginning of the design stage. It is important that the dust and infection control principles developed during the pre-design stage are integrated at the initial stages of design development. It is important that the pre-design team comprehensively brief the design team and submit the findings of the survey and risk profile. The following items need to be addressed.

- Determine the extent and locations of dust barriers. Barriers should be properly sealed right up to the slab, not just the ceiling, and to the floor and around all services to prevent air leakage. The barriers should be as air tight as possible.
- Establish locations for negative pressure HEPA filter units to negatively pressurise the site. If an exhaust can be ducted to the outside and no air intakes are in the vicinity, subject to risk assessment, a HEPA filter may not be required and a simple temporary duct and fan used.
- If the site is close to a high-risk area determine locations for HEPA filter clean air units outside the site access points.
- Determine type of barrier required, such as light duty or temporary for jobs only taking hours through to a framed and sheeted wall for long duration job. The risk level must be considered when choosing the barrier type.
- Determine the location of the nearest smoke or firewalls. Use of these can reduce the amount of above ceiling barrier required.
- Document sealing of windows, upgrading of air filter elements to a higher efficiency, and a higher frequency of air filter replacement if exterior work is required. The extent of this will be determined by how dusty the activity is.
- Develop and document a demolition strategy including the method of safely removing debris. Consider that external chutes have a stack effect that can potentially draw dust back up from the bin presenting potential dangers.

- Develop and document construction personnel traffic routes, taking into account high-risk patient locations. Construction workers tend to leave doors open and leave openings in barriers.
- Determine and document locations remote from the construction site that can be used for dirty/dusty work.
- Develop and document material handling, material transport and materials, storage, taking into account high-risk patient locations.
- Check locations above and below the site if penetrations are required. Develop strategies for the protection of high-risk patients during these events.
- Develop comprehensive dust and infection control specification clauses specific to the project. Ensure appropriate penalties are included for repeated breaches of infection control clauses. As *Aspergillus sp* thrive on water-damaged plasterboard, a clause should state that all gypsum plasterboard be protected from water damage. If wetted it must be replaced if not totally dry within 72 hours.

Contract administration and supervision is the key to satisfactory outcomes. Ensure a nominated representative is empowered to enforce the contract provisions and that representative is available when needed.

What You Don't Know Can't Hurt You?

Educate and Train or It May Hurt Someone Else

Infection Control Practitioners have an obligation to educate all people involved in activities that can promote the dissemination of microbial contamination. If an employee or Contractor does not know a risk exists – how can they implement systems to control that risk? Educate the construction or maintenance team and the healthcare staff in immunocompromised patient-care areas about the airborne infection risk associated with construction projects, dispersal of fungal spores during such activities, and methods to control the dissemination of fungal spores.[11] In-service training and job specific induction training must be a routine task for the ICP. Once the training systems are established and others have achieved competency, the training function can be handed over to the Engineering department and be subjected to regular monitoring to ensure training aims are being met.

Large Project Training (Train the Trainer Induction)

Training requirements will vary depending upon the size of the project. Large projects will have dedicated Safety Officers who will normally be a union delegate. The ideal situation is to develop an infection control training package for the Safety Officer to deliver as part of the site induction training.

The Safety Officers are usually full-time employees of the builder and hold multiple safety course certificates. When training the Safety Officer provide a certificate certifying completion of the short infection control course. This will evoke a sense of ownership of the health specific issues and ultimately lead to a better flow of information to the workers on the site.

Construction Stage

Attention to detail in the planning stages will ensure correct processes are in place for the construction phase. When a formalised approach to risk management is undertaken in conjunction with sound infection control procedures, the risk to patients from construction and maintenance activities is greatly reduced. It is not satisfactory to take the attitude that nothing has happened in the past, as the changing profile of the patient population means patients are far sicker than they were ten years ago.

The construction stage is where things can go wrong. Constant vigilance is required to ensure that processes are set in place and adhered to. Some points to consider are:

1. Infection control site induction of building workers should be carried out as a major component of the Occupational Health and Safety induction. This induction process should be documented and signed off by each person inducted.
2. Monitor worker compliance with procedures. The results of this monitoring should be fed back to the workers routinely through the Builder. Have a system in place to manage major breaches.
3. Ensure that adequate inspections by the nominated representatives take place during the construction of the barriers. These inspections should be documented and reported on. Routine inspections of barriers should be conducted during the life of the job by the hospital's nominated representative and a nominated representative from the Contractor. These inspections should be documented and reported on.

It is important to establish correct airflows from clean areas to dirty areas. The nominated representative should have the necessary equipment to measure airflow direction on a regular basis. These inspections should be documented and reported on.

After water damage or flooding, test plasterboard with a moisture meter. The plasterboard should be at the manufacturer's moisture content within 72 hours or be replaced. This is critical for horizontal surfaces. These occurrences should be documented and reported on.

Negative pressurisation of the construction zone is essential to maintain correct airflow direction. The exhaust / extraction systems specified in the contract documentation must be constantly monitored and maintained to ensure no failures occur. These inspections should be documented and reported on.

If HEPA filtration is required, a person must be nominated as the responsible person for that duty. The filters should have differential pressure monitoring with alarms. Spare filter elements must be kept on hand. These inspections should be documented and reported on.Viable particle air sampling should be considered by the hospital to monitor the effectiveness of the barriers, pressurisation and housekeeping procedures. All air sampling should be documented and reported on.

A high level of site cleanliness is essential. Use tools with efficient dust extraction systems connected to HEPA filters. Tasks such as sanding plasterboard present a high level of potential risk; therefore only mechanical sanding should be used.

Demolition and jack hammering of concrete should be undertaken with a filter unit in close proximity. HEPA vacuuming, not sweeping, should be used to clean up. Conventional

vacuum cleaners disseminate huge quantities of dust and fungal spores and should not be used.

Control movement in and out of the site by restricting access to only those who have undergone site induction. This will assist in reducing the spread of contaminants. Document all inspections. Include a non-conformance system for defaults complete with a corrective and preventative action loop. All Inspections must be documented and reported on.

Hand-over and Pre-Occupation Stage

After hand-over it is the hospitals responsibility to ensure the area complies with hospital cleanliness standards for occupation. As a minimum the hospital should thoroughly clean and decontaminate all surfaces including walls, ceilings, and windows as well as in high-risk area ventilation systems, service cavities and ceiling spaces.

If air sampling and particle counts are being conducted, allow enough time for culturing and results prior to occupation. It is advisable to implement a program of air sampling in high-risk areas for a period of time after hand-over and occupation. Allow 48 hours for all culture results prior to occupation. Once all these tasks have been completed, re-certify HEPA filters and laminar / clean flow systems where installed.

Management, Supervision, Audit and Compliance

Comprehensive control and monitoring systems appropriate for the tasks being undertaken are required to ensure pre-construction planning is effective. Using a Quality Management approach there are five key issues that should be addressed:

- Document all procedures identified by the risk analysis.
- Undertake appropriate levels of training for tasks but particularly those identified by the risk analysis.
- Set standards.
- Monitor performance by audit, observation and or testing.
- Provide non-conformance reporting with a corrective and prevention feedback system.[4]

Experience shows that simple checklists such as in Appendix 3 & 4 work best for inspections and data gathering. It is critical to collect only the data that will be used. Data should only be collected to:

- Understand the capability or performance of an existing process or system
- Prioritise opportunities for improvement
- Measure and demonstrate improvement as changes are made
- Sustain improvement in the process
- Communicate information to other people.[4]

Key Performance Indicators

Data collected for specific purposes can be used to generate key performance indicators. Some indicators are legislative such as total number of injuries and number of days lost due to injuries, but others are for internal use and are a measure of the important criteria nominated by the project team. Key performance indicators should be limited to one or two for senior management, three to five for middle management and no more than eight for the operational level. Any more than this and the data can become meaningless due to information overload. Most key performance indicators will be a quantitative measure of an identified risk that requires monitoring. Key performance indicators should be defined and reported on to senior management.

Specifications and Contract Conditions

All specifications and contracts should include comprehensive infection control risk and OHS clauses that clearly identify legislative requirements, site-specific requirements and impose sanctions for non-compliance. The following list, although not exhaustive, is indicative of the clauses that will be required just to meet minimum statutory obligations:

- General Occupational Health & Safety Requirements
- Legislative Compliance
- Contractor OHS Management Systems
- Risk Management Systems
- Infection Control Requirements
- Tenderer OHS Management System Questionnaire
- Job Safety Analysis
- Site Safety Management Plan
- OHS Performance Reporting
- Incident Notification
- Non-Compliance Requirements
- Sub-contractors
- Workplace Induction and Training

The items listed should be the responsibility of the site Safety Officer. It is essential to include them in the site-specific training of the Safety Officer.

Air Sampling

Introduction

Airborne sampling can be a useful part of an infection control risk management program but only in certain circumstances.[11] Cumulative data is used to establish indoor and outdoor background levels of fungi or bacteria for a particular site. This will enable establishment of risk profiles and baseline data sets for particular locations in and around the hospital.

Air sampling is a controversial issue with many experts not convinced of its efficacy. The Centres for Disease Control (CDC) as of February 2001 do not recommend routine airborne sampling due to the following unresolved issues:[11]

- Lack of standards linking fungal spore levels with infection rates (what is a safe level of exposure?)
- Lack of standard protocols for testing (what sampling intervals, number / location of samples?)
- Need for substantial laboratory support
- New, complex PCR analytical methods
- Unknown incubation period for *Aspergillus* spp. infection
- Variability of sampler readings
- Sensitivity of the sampler used (i.e. the volumes of air sampled)
- Lack of details in the literature about describing sampling circumstances such as unoccupied rooms verses ongoing activities
- Expected fungal concentrations, rate of outdoor air penetration
- Lack of correlation between fungal species and strains from the environment and clinical specimens
- Confounding variables with high-risk patients such as visitors, time spent outside of protective environment without protective respiratory equipment
- Need for determination of ideal temperature for incubating fungal cultures (35°C is preferred)
- The need for a slit or sieve impactor sampler capable of collecting large volumes of air in short periods of time to detect low numbers of fungal spores in highly-filtered areas.

When to sample

Air sampling should only be conducted for commissioning and recommissioning of operating rooms and clean rooms. It may also be useful during building works that may impact on immunocompromised patients, during an investigation into a cluster of infections, and to establish historical background levels.[11]

It is important to remember that air sampling will only measure indoor air quality at a single point of time. Sampling results will be affected by a variety of factors including indoor traffic, visitors coming into the facility, temperature, time of day or year, relative humidity, relative concentration of particles or organisms and the performance of the air handling system components. All results need to be compared to results from other defined areas with similar conditions, or time periods in order to be meaningful.

What are acceptable results?

Sampling results are highly variable due the factors already outlined. Depending upon the season, outdoor spore levels can commonly exceed 1,000 CFU/m^3 but can be as high as 10,000 CFU/m^3 total spore count. *A. fumigatus* levels in outdoor air averages 1–15 CFU/m^3.[5] Indoor spore levels below 100 CFU/m^3 total spore count are considered to be inconsequential in areas not housing an at risk population.[6] In outbreaks involving at risk patients, aspergillosis cases have occurred when fungal spore concentrations in protective environment ambient air ranged as low as 0.9–2.2 colony-forming units per cubic meter (CFU/m^3) of air.[11]

Investigators have also suggested limits of 15 CFU/m^3 for total spore counts of fungal organisms and <0.1 CFU/m^3 for *Aspergillus fumigatus* and other potentially opportunistic fungi in HEPA filtered areas with at least 12 ACH and positive air pressure.[6] There has been no reported correlation of these values with the incidence of healthcare-associated fungal infection rates.[11]

Other investigators suggest specialised areas with HEPA filtered supply air systems with an air change rate of at least 15 air changes per hour should achieve a concentration of 0.03 CFU/m^3 of *A. fumigatus* for BMT and laminar flow suites should achieve a concentration of 0.01 CFU/m^3 of A. fumigatus.[3] Total indoor spore counts in these areas should not exceed 15 CFU/m^3.[5]

Sampling Methodologies

Air sampling can be divided into two categories: passive and active sampling. Passive sampling is the collection of airborne particles onto settle plates due to gravity whereas active sampling pumps air onto agar plates mechanically. Each method has distinct characteristics that are claimed to be useful for certain applications.[16] Along with airborne sampling, routine surface sampling can be undertaken.[14] A combination of settle plates and surface swabbing can be employed to augment airborne sampling.

Active sampling

Active air sampling involves the use of a device that pumps or draws air through a metered orifice then deposits that air onto nutrient media. The nutrient media is then incubated and the results read as CFU/m^3. Active sampling is the most widely recognised method of sampling for microbial contamination but extreme care must be exercised in its application. A clear understanding of the outcomes sought and the methodology required is essential.

Active sampling generally only provides usable readings when a baseline level of counts is available to compare the latest results with. When commencing a sampling program, baseline sampling must be undertaken to establish both background levels and historical records. Historical records are essential to allow sessional variations in spore count to be taken into account. The following table lists some of the advantages and disadvantages of active air sampling:

Advantages

- Collection is rapid
- Most widely accepted sampling method
- Can measure low airborne counts
- Measures droplet nuclei

Disadvantages

- Equipment is expensive
- Results are difficult to reproduce
- Device difficult to sterilise
- Results require statistical correction
- Disturbs the surrounding air

Active airborne sampling should be considered as part of a building risk management program. Cumulative data is used to establish indoor and outdoor background levels of filamentous fungi for a particular site. This will enable establishment of risk profiles for particular locations in and around the hospital. Note that elevated temperatures will inhibit the growth of other fungi whereas Asp sp will thrive at 37ºC. It is important to consider the time delay of several days involved in the culture of the samples if real time monitoring of a construction area is being undertaken.

There are two distinct sampling methodologies for the active detection of viable airborne fungal spores. These are high air volume sampling and low air volume sampling.

Sampling for viable fungal spores almost universally in Australia is via low or medium air volume sampling. Low volume sampling is used to measure high spore concentrations such as in dirty areas or outdoors. High volume sampling is used to measure low spore concentrations such as indoors.

Passive Sampling

Passive air sampling entails the placing of solid nutrient media in the open air to allow airborne particles to settle upon the plate due to gravity. The plates are left open in the area to be tested for a predetermined period of time then incubated and the results read as total CFU. The results from settle plates are considered neither quantitative nor qualitative. The following table lists some of the advantages and disadvantages of settle plates:

Advantages

- Cheap
- Widely available
- Multiple simultaneous sampling
- Meaningful surface sample results
- Reproduces real conditions
- Sterile
- Room airflow is not disturbed
- Comparable results

Disadvantages

- Not quantitative
- Not qualitative
- Selectively collects larger particles
- Results are not widely accepted
- Not suitable for commissioning theatres

General criticism of settle plate sampling centres on the lack of correlation with active sampling results.[13] However settle plates may be useful as they allow the study of airborne contaminants settling onto horizontal surfaces.

It has been shown that bacterial counts obtained from wound washes closely correlate with those of settle plates.[13] This concludes that a settle plate exhibits similar characteristics to that of an exposed wound. On this basis settle plates should be considered as an adjunct to infection control investigations, particularly in operating suites.

In an attempt to standardise passive air sampling, the 1/1/1 sampling scheme offers a methodology for sampling with settle plates.[14] This method suggests settle plates are positioned one metre off the floor, one metre from the walls or any obstacle and left open for one hour.

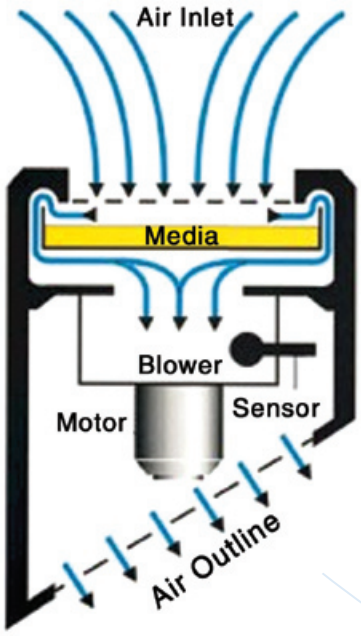
Active Sampling Procedure

The main principle of active sampling of air is to sample the air for the enumeration of bacteria and fungi. As part of a building program or as an aid to investigation into infection clusters, air sampling is conducted at an interval determined by the Infection Control Committee, to determine fungi including Aspergillus fumigatus spore loads.

Equipment

Microbial Air Monitoring System Merck MAS-100.

The following sampling procedure is based on using a Merck MAS-100. The Merck is an impactor type of instrument based upon the principles described by Andersen, which aspirates air through a perforated plate. The resulting air-stream, which contains particles, is directed onto the agar surface of a standard Petri dish. After a collection cycle the Petri dish is incubated and the colonies are counted and expressed as colony forming units (CFU/m^3). Other sampler types and brands are available. All samplers have advantages and disadvantages that should be considered prior to purchase.[16] It is important to fully consider what is required of a sampler prior to purchase.



References: Manufacturer's Manual, MAS-100. Distributed by Merck Eurolab/Brussels and EM Science.

Media for Fungal Collection

Sabouraud's Dextrose Agar (SABG). Sabouraud's agar, a selective inhibitory mould agar (IMA) media for fungi is used for this test but if the test is for bacteria then other media like horse blood agar (HBA) and Tryptone Soya Agar (TSA) can be used. (IMA is available from the Microbiological Diagnostic Unit [MDU], Microbiology Department, Melbourne University).

USED FOR: Culturing of fungus
STORED: In 4°C cold room.
SUPPLIER: Oxoid (CM 129)

Media for Total Bacteria Count Collection

Horse blood agar (HBA) and Tryptone Soya Agar (TSA)

Functions of the Equipment:

The MAS-100 comes with in-built software, which is capable of working its way automatically through all the required parameters.

- Press the YES button to accept a parameter, press the NO button to ignore it.
- Once the desired parameters have been set, press the YES button to start the instrument.
- The MAS-100 is factory calibrated to 100 litres per minute.
- The green light indicates the instrument is sampling.
- The red light appears once the preset volume has been sampled.
- After the collection the red LED will illuminate. In this position the MAS-100 will switch off in 30 minutes. In all other menu positions it will switch off automatically in 5 minutes.
- After the collection cycle the volume of air sampled will be displayed. Press YES or NO to bring it to the 5 minute shut off position. (For further information refer to Manufacturer's Manual p10–13)

The instrument batteries should be recharged periodically. Once the instrument is charged fully it can aspire approximately 50,000 litres of air (refer to Manufacturers Manual p5).

Precautions:

Avoid movement in and around the air sampler when the sampling is in progress.

Do not hold the hand over the petri dish.

Make sure that the holes in the perforated lid are not clogged.

Handle culture plates carefully so as not to spread spores.

Procedure

1. Place the MAS-100 on a firm support.
2. Sterilize sampling heads prior to use.
3. The sampling head can be adjusted to any angle from horizontal to vertical airflow direction.
4. Program the MAS-100 to sample 1000 litres of air in 10 minutes with no delay action.
5. Open the perforated lid by turning it to the right.
6. Wipe the sampling head thoroughly with sterile alcohol wipes before every sampling. Allow to dry before using the air sampler.
7. Place the standard petri dish filled with SABG agar on the dish support.
8. Take the lid off the petri dish, store lid in an empty sterile 150 mm petri dish.
9. Close the MAS-100 perforated lid.
10. Remove the dust cover and start the collection cycle by pressing the YES button in the menu.
11. After the collection is over the red LED will light up and the sampled volume will be displayed.
12. Open the sampling head, cover the petri dish with the dish cover and remove.

13. The edges of the petri dish are then covered with parafilm to prevent contamination during transport and spread of fungal spores during incubation.
14. Incubate the SABG plates at 30°C for 7 days for total fungal counts or at 36°C for 7 days for selective Aspergillus spp counts.
15. The fungal culture is examined at 4 days and 7 days. Handle plates very carefully especially at the 4 day reading. Take care not to spread spores as the plates are reincubated for up to 7 days.
16. Record:
    Total fungal count (Colony Forming Units, CFU)
    Aspergillus spp CFU
    Aspergillus fumigatus CFU

Confirm any Aspergillus fumigatus cultures by microscopic examination and record results.

The CFU counts will require adjustment if the colony count is >21 according to the positive hole conversion table. The microbial count is corrected based on Fellar's statistical correction table (see page 17 Manufacturer's Manual or appendix). The principle of this correction table is; "as the number of organisms per sample rises, the chance that several organisms will enter the same hole in the perforated lid also increases". Two micro-organisms in the same hole will only produce one colony.

Interpretation:

There are no guidelines for the interpretation of fungal counts in the general environment.

Fungal counts should not vary significantly from baseline values (refer to initial and previous test results). Report results to a supervisor if results exceed:

- >0.1 CFU/m^3 of Aspergillus fumigatus in a protective environment
- >1 CFU/m^3 of Aspergillus fumigatus in an area with at risk patients
- >4 CFU/m^3 of Aspergillus fumigatus in a general area.

The number of colony forming units that are counted on the Petri dish after appropriate incubation needs a statistical correction. The number of colonies is then related to the number of organisms per cubic meter of air sampled. This kind of correction was first described by mathematician, FELLER in 1950.

(Active air sampling methodology reproduced with the kind permission of Austin & Repatriation Medical Centre, Microbiology Department)

Table of statistical corrections according to Feller

r = Number of colony forming units counted on standard Petri dish
Pr = Probable statistical total

r	Pr	r	Pr	r	Pr	r	Pr	r	Pr	r	Pr	r	Pr	r	Pr
1	1	51	54	101	116	151	189	201	279	251	394	301	557	351	836
2	2	52	56	102	118	152	191	202	281	252	397	302	561	352	844
3	3	53	57	103	119	153	193	203	283	253	400	303	565	353	853
4	4	54	58	104	120	154	194	204	285	254	402	304	569	354	861
5	5	55	59	105	122	155	196	205	287	255	405	305	573	355	870
6	6	56	60	106	123	156	197	206	289	256	408	306	578	356	879
7	7	57	61	107	124	157	199	207	291	257	411	307	582	357	888
8	8	58	63	108	126	158	201	208	293	258	413	308	586	358	897
9	9	59	64	109	127	159	202	209	295	259	416	309	591	359	907
10	10	60	65	110	128	160	204	210	297	260	419	310	595	360	917
11	11	61	66	111	130	161	206	211	299	261	422	311	599	361	927
12	12	62	67	112	131	162	207	212	301	262	425	312	604	362	937
13	13	63	68	113	133	163	209	213	304	263	428	313	608	363	947
14	14	64	70	114	134	164	211	214	306	264	431	314	613	364	958
15	15	65	71	115	135	165	212	215	308	265	433	315	618	365	969
16	16	66	72	116	137	166	214	216	310	266	436	316	622	366	981
17	17	67	73	117	138	167	216	217	312	267	439	317	627	367	992
18	18	68	74	118	140	168	218	218	314	268	442	318	632	368	1005
19	19	69	76	119	141	169	219	219	317	269	445	319	637	369	1017
20	20	70	77	120	142	170	221	220	319	270	449	320	642	370	1030
21	22	71	78	121	144	171	223	221	321	271	452	321	647	371	1043
22	23	72	79	122	145	172	224	222	323	272	455	322	652	372	1057
23	24	73	80	123	147	173	226	223	325	273	458	323	657	373	1071
24	25	74	82	124	148	174	228	224	328	274	461	324	662	374	1086
25	26	75	83	125	150	175	230	225	330	275	464	325	667	375	1102
26	27	76	84	126	151	176	232	226	332	276	467	326	673	376	1118
27	28	77	85	127	153	177	233	227	335	277	471	327	678	377	1134
28	29	78	87	128	154	178	235	228	337	278	474	328	684	378	1152
29	30	79	88	129	156	179	237	229	339	279	477	329	689	379	1170
30	31	80	89	130	157	180	239	230	342	280	480	330	695	380	1189
31	32	81	90	131	158	181	241	231	344	281	484	331	701	381	1209
32	33	82	92	132	160	182	242	232	346	282	487	332	706	382	1230
33	34	83	93	133	161	183	244	233	349	283	491	333	712	383	1252
34	35	84	94	134	163	184	246	234	351	284	494	334	718	384	1276
35	37	85	95	135	164	185	248	235	353	285	497	335	724	385	1301
36	38	86	97	136	166	186	250	236	356	286	501	336	730	386	1327
37	39	87	98	137	167	187	252	237	358	287	504	337	737	387	1356
38	40	88	99	138	169	188	254	238	361	288	508	338	743	388	1387
39	41	89	101	139	171	189	255	239	363	289	511	339	749	389	1420
40	42	90	102	140	172	190	257	240	366	290	515	340	756	390	1456
41	43	91	103	141	174	191	259	241	368	291	519	341	763	391	1496
42	44	92	104	142	175	192	261	242	371	292	522	342	769	392	1541
43	45	93	106	143	177	193	263	243	373	293	526	343	776	393	1591
44	47	94	107	144	178	194	265	244	376	294	530	344	783	394	1648
45	48	95	108	145	180	195	267	245	378	295	534	345	791	395	1715
46	49	96	110	146	181	196	269	246	381	296	537	346	798	396	1795
47	50	97	111	147	183	197	271	247	384	297	541	347	805	397	1895
48	51	98	112	148	185	198	273	248	386	298	545	348	813	398	2028
49	52	99	114	149	186	199	275	249	389	299	549	349	820	399	2228
50	53	100	115	150	188	200	277	250	391	300	553	350	828	400	2628

Air Sampling Data Sheet

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Site No.	Site	Time Tested	RH%	Temp	Volume for fungal sample (m^3)	Sample period culture (min)	Sampled by	Total fungal count		Total Aspergillus sp		Aspergillus fumigatus		Culture by	Comment
								cfu/m^3 4–5 days	cfu/m^3 6–7 days	cfu/m^3 4–5 days	cfu/m^3 6–7 days	cfu/m^3 4–5 days	cfu/m^3 6–7 days		

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Appendix No 1: Risk Matrix for Sub-Acute Facilities

Step One

Use the table to identify the **CONSTRUCTION ACTIVITY TYPE**

Types of construction activity

Type A	Inspection and non-invasive activities: These include, but are not limited to, activities that require removal of ceiling tiles for visual inspection (limited to one 600 mm square tile per 15 m^2), painting but not sanding, wall covering, electrical work, minor plumbing that disrupts water supply to a localised patient care area [e.g. one room] for less than 15 minutes, access to floor ducts, and other maintenance activities that do *not generate* dust or require cutting of walls *or* access to ceilings other than for visual inspection.
Type B	Small scale, short duration activities that create minimal dust. These include, but are not limited to, activities that require access to duct spaces, cutting of walls or ceilings where dust migration can be controlled for the installation or repair of minor electrical work, ventilation components, telephone wires or computer cables, and sanding of walls for painting or wall covering to *only repair* small patches. It also includes plumbing that requires disruption to the water supply of more than one patient care area (> two rooms) for less than 30 minutes.
Type C	Any work that generates a moderate to high level of dust or requires demolition or removal of any fixed building components or assemblies such as counter tops, cupboards, and sinks. These include, but are not limited to, activities that require sanding of walls for painting or wall covering, removal of floor coverings, ceiling tiles, new wall construction, minor duct work or electrical work above ceilings, major cabling activities, and any activity that *cannot be completed* within a single work shift. It also includes plumbing that requires disruption to the water supply of more than one patient care area (> two rooms) for more than 30 minutes but less than one hour.
Type D	Major demolition, construction and renovation projects. These include, but are not limited to, activities that involve heavy demolition or removal of a complete cabling system and new construction requiring consecutive work shifts to complete. It also includes plumbing that result in disruption to the water supply of more than one patient care area (> two rooms) for more than one hour.

Step Two

Use the table to identify the **PATIENT RISK GROUPS** affected by the activity. If two groups are affected select the highest risk group

Population and Geographic Risk Groups

Group One Lowest Risk	• Office areas • Public areas • Workshops • Plantrooms (subject to risk assessment)
Group Two Medium Risk	• Unoccupied wards • Outpatient clinics (except for oncology & surgery) • Admission/discharge units • Research laboratories • Allied Health areas including but not limited to: * Physiotherapy * Occupational therapy * Social work * Dietetic / Nutrition * Prosthetics / Orthotics * Psychology
Group Three Medium to High Risk	• All patient care areas including but not limited to: * General medical & surgical wards * Geriatrics * Long-term care • Transport routes of patients from any of the above categories • Physiotherapy respiratory function areas • Dental clinics

Step Three

Match the **CONSTRUCTION ACTIVITY TYPE** with the **PATIENT RISK GROUP NUMBER** on the Construction Class Matrix to establish the **CONSTRUCTION CLASS**

Construction Class Matrix

Risk Group	Construction Activity			
	Type A	Type B	Type C	Type D
Group One	I	II	II	III / IV
Group Two	I	II	III	IV
Group Three	I	III	III / IV	IV

A copy of the Risk Assessment and Preventive Measures Checklist must be sent to the Infection Prevention and Control Department when the matrix indicates that Class III and/or Class IV preventive measures are required (see shaded areas).

Adaptations to the prevention measures can be made only after approval has been provided by the Infection Control Practitioner. The Infection Control Practitioner should also be consulted when construction activities need to be undertaken in hallways adjacent to Class III and Class IV areas.

Step Four

Concise Description of Required Infection Control Precautions by Class

	During Construction Project	Upon Completion of Project
Class I	1. Execute work by methods to minimise raising dust from construction operations. 2. Immediately replace a ceiling tile displaced for visual inspection.	1. Clean work area upon completion of task.
Class II	1. Provide active means to prevent airborne dust from dispersing into atmosphere. 2. Water mist work surfaces to control dust while cutting. 3. Seal unused doors with duct tape. 4. Block off and seal air vents. 5. Place dust mat at entrance and exit of work area 6. Remove or isolate HVAC system in areas where work is being performed.	1. Clean work surfaces with hot water and detergent. 2. Contain construction waste before transport in tightly covered containers. 3. Wet mop and/or vacuum with HEPA filtered vacuum before leaving work area. 4. Remove isolation of HVAC system in areas where work is being performed.
Class III	1. Remove or isolate HVAC system in area where work is being done to prevent contamination of duct system. 2. Complete all critical barriers i.e. plasterboard, plywood, plastic, to seal area from non-work area or implement control cube method (cart with plastic covering and sealed connection to work site with HEPA vacuum for vacuuming prior to exit) before construction begins. 3. Maintain negative air pressure within work site utilising HEPA equipped air filtration units. 4. Contain construction waste before transport in tightly covered containers. 5. Cover transport receptacles or carts. Tape covering unless solid lid.	1. Do not remove barriers from work area until completed project is inspected by the OHS Department and Infection Control Department and thoroughly cleaned by the Environmental Services Department. 2. Remove barrier materials carefully to minimise spreading of dirt and debris associated with construction. 3. Vacuum work area with HEPA filtered vacuums. 4. Wet mop area with hot water and detergent. 5. Remove isolation of HVAC system in areas where work is being performed.
Class IV	1. Isolate HVAC system in area where work is being done to prevent contamination of duct system. 2. Complete all critical barriers i.e. plasterboard, plywood, plastic, to seal area from non-work area or implement control cube method (cart with plastic covering and sealed connection to work site with HEPA vacuum for vacuuming prior to exit) before construction begins. 3. Maintain negative air pressure within work site utilising HEPA equipped air filtration units. 4. Seal holes, pipes, conduits, and punctures appropriately. 5. Construct anteroom and require all personnel to pass through this room so they can be vacuumed using a HEPA vacuum cleaner before leaving work site or they can wear cloth or paper coveralls that are removed each time they leave the work site. 6. All personnel entering work site are required to wear shoe covers. Shoe covers must be removed each time the worker exits the work area. 7. Do not remove barriers from work area until completed project is inspected by the OHS Department and Infection Control Department and thoroughly cleaned by the Environmental Services Department.	1. Remove barrier material carefully to minimise spreading of dirt and debris associated with construction. 2. Contain construction waste before transport in tightly covered containers. 3. Cover transport receptacles or carts. Tape covering unless solid lid 4. Vacuum work area with HEPA filtered vacuums. 5. Wet mop area with disinfectant. 6. Remove isolation of HVAC system in areas where work is being performed.

Appendix No 2: Risk Matrix for Acute Facilities

Step One

Use the table to identify the **CONSTRUCTION ACTIVITY TYPE**

Types of construction activity

Type A	Inspection and non-invasive activities: These include, but are not limited to, activities that require removal of ceiling tiles for visual inspection (limited to one 600 mm square tile per 15 m^2), painting but not sanding, wall covering, electrical work, minor plumbing that disrupts water supply to a localised patient care area [e.g. one room] for less than 15 minutes, access to floor ducts, and other maintenance activities that *do not generate* dust or require cutting of walls or access to ceilings other than for visual inspection.
Type B	Small scale, short duration activities that create minimal dust. These include, but are not limited to, activities that require access to duct spaces, cutting of walls or ceilings where dust migration can be controlled for the installation or repair of minor electrical work, ventilation components, telephone wires or computer cables, and sanding of walls for painting or wall covering to *only repair* small patches. It also includes plumbing that requires disruption to the water supply of more than one patient care area (> two rooms) for less than 30 minutes.
Type C	Any work that generates a moderate to high level of dust or requires demolition or removal of any fixed building components or assemblies such as counter tops, cupboards, and sinks. These include, but are not limited to, activities that require sanding of walls for painting or wall covering, removal of floor coverings, ceiling tiles, new wall construction, minor duct work or electrical work above ceilings, major cabling activities, and any activity that *cannot be completed* within a single work shift. It also includes plumbing that requires disruption to the water supply of more than one patient care area (> two rooms) for more than 30 minutes but less than one hour.
Type D	Major demolition, construction and renovation projects. These include, but are not limited to, activities that involve heavy demolition or removal of a complete cabling system and new construction requiring consecutive work shifts to complete. It also includes plumbing that result in disruption to the water supply of more than one patient care area (> two rooms) for more than one hour.

Step Two

Use the table to identify the **PATIENT RISK GROUPS** affected by the activity. If two groups are affected select the highest risk group

Population and Geographic Risk Groups

Group One Lowest Risk	• Office areas • Public areas • Workshops • Plantrooms (subject to risk assessment)

Group Two Medium Risk	• Unoccupied wards
	• Outpatient clinics (except for oncology & surgery)
	• Admission/discharge units
	• Research laboratories
	• Allied Health areas including but not limited to:
	  * Physiotherapy
	  * Occupational therapy
	  * Social work
	  * Dietetic / Nutrition
	  * Prosthetics / Orthotics
	  * Psychology

Group Three Medium to High Risk	• All patient care areas unless stated in Group 3 or 4 including but not limited to:
	  * General medical & surgical wards other than those listed in Group 4
	  * Paediatrics
	  * Geriatrics
	  * Long-term care
	  * Normal newborn nurseries
	• Emergency rooms
	• Transport routes of patients from any of the above categories
	• Radiology/MRI
	• Post anaesthesia care units
	• Labour and delivery (non operating room)
	• Nuclear medicine
	• Physiotherapy respiratory function areas
	• Echocardiography
	• Medical laboratories (specimens)
	• Dental clinics

Group Four Highest Risk	• All Intensive Care Units and High Dependency Units • All Operating Rooms • Day Surgery • Labour & delivery Operating Rooms • Anaesthesia areas • Oncology and Haematology units and outpatient clinics for patients with cancer • Transplant units and outpatient clinics for patients who have received bone marrow or solid organ transplants • Wards and outpatient clinics for patients with AIDS or other immunodeficiency • Dialysis units • Tertiary care nurseries • Transport routes of patients from any of the above categories • All Cardiac Catheterisation & Angiography areas • Cardiovascular/cardiology patients • All Endoscopy areas • Pharmacy admixture rooms • Sterile processing rooms • Computer centre • Central inventory dept.

Step Three

Match the **CONSTRUCTION ACTIVITY TYPE** with the **PATIENT RISK GROUP NUMBER** on the Construction Class Matrix to establish the **CONSTRUCTION CLASS**

Construction Class Matrix

Risk Group	Construction Activity			
	Type A	Type B	Type C	Type D
Group One	I	II	II	III / IV
Group Two	I	II	III	IV
Group Three	I	III	III / IV	IV
Group Four	I–III	III/IV	III / IV	IV

A copy of the Risk Assessment and Preventive Measures Checklist must be sent to the Infection Prevention and Control Department when the matrix indicates that Class III and/or Class IV preventive measures are required (see shaded areas).

Adaptations to the prevention measures can be made only after approval has been provided by the Infection Control Practitioner. The Infection Control Practitioner should also be consulted when construction activities need to be undertaken in hallways adjacent to Class III and Class IV areas.

Step Four

Concise Description of Required Infection Control Precautions by Class

	During Construction Project	Upon Completion of Project
Class I	1. Execute work by methods to minimise raising dust from construction operations. 2. Immediately replace a ceiling tile displaced for visual inspection.	1. Clean work area upon completion of task.
Class II	1. Provide active means to prevent airborne dust from dispersing into atmosphere. 2. Water mist work surfaces to control dust while cutting. 3. Seal unused doors with duct tape. 4. Block off and seal air vents. 5. Place dust mat at entrance and exit of work area 6. Remove or isolate HVAC system in areas where work is being performed.	1. Clean work surfaces with hot water and detergent. 2. Contain construction waste before transport in tightly covered containers. 3. Wet mop and/or vacuum with HEPA filtered vacuum before leaving work area. 4. Remove isolation of HVAC system in areas where work is being performed.
Class III	1. Remove or isolate HVAC system in area where work is being done to prevent contamination of duct system. 2. Complete all critical barriers i.e. plasterboard, plywood, plastic, to seal area from non-work area or implement control cube method (cart with plastic covering and sealed connection to work site with HEPA vacuum for vacuuming prior to exit) before construction begins. 3. Maintain negative air pressure within work site utilising HEPA equipped air filtration units. 4. Contain construction waste before transport in tightly covered containers. 5. Cover transport receptacles or carts. Tape covering unless solid lid.	1. Do not remove barriers from work area until completed project is inspected by the OHS Department and Infection Control Department and thoroughly cleaned by the Environmental Services Department. 2. Remove barrier materials carefully to minimise spreading of dirt and debris associated with construction. 3. Vacuum work area with HEPA filtered vacuums. 4. Wet mop area with hot water and detergent. 5. Remove isolation of HVAC system in areas where work is being performed.
Class IV	1. Isolate HVAC system in area where work is being done to prevent contamination of duct system. 2. Complete all critical barriers i.e. plasterboard, plywood, plastic, to seal area from non-work area or implement control cube method (cart with plastic covering and sealed connection to work site with HEPA vacuum for vacuuming prior to exit) before construction begins. 3. Maintain negative air pressure within work site utilising HEPA equipped air filtration units. 4. Seal holes, pipes, conduits, and punctures appropriately. 5. Construct anteroom and require all personnel to pass through this room so they can be vacuumed using a HEPA vacuum cleaner before leaving work site or they can wear cloth or paper coveralls that are removed each time they leave the work site. 6. All personnel entering work site are required to wear shoe covers. Shoe covers must be removed each time the worker exits the work area. 7. Do not remove barriers from work area until completed project is inspected by the OHS Department and Infection Control Department and thoroughly cleaned by the Environmental Services Department.	1. Remove barrier material carefully to minimise spreading of dirt and debris associated with construction. 2. Contain construction waste before transport in tightly covered containers. 3. Cover transport receptacles or carts. Tape covering unless solid lid 4. Vacuum work area with HEPA filtered vacuums. 5. Wet mop area with disinfectant. 6. Remove isolation of HVAC system in areas where work is being performed.

Detailed Description of Required Infection Control Precautions by Class

Class One Activity

Maintenance Staff & Contractors

Dust Control

- Immediately replace tiles displaced for visual inspection.
- Vacuum work area.

Plumbing

- Schedule water interruptions during low activity (such as in the evenings if possible).
- Flush water lines prior to reuse.
- Watch for discoloured water.
- Ensure water temperature meets the standards set by the health care facility.
- Ensure gaskets and items made of materials that support the growth of Legionella are not being used.
- Ensure tap aerators are not installed or used.
- Maintain as dry an environment as possible and report any water leaks that occur to walls and substructures.

Environmental Services

Plumbing

- Report discoloured water and water leaks to maintenance and ICP.

Medical/Nursing Staff

Risk Reduction

- Minimise patient exposure to construction/ renovation area.
- Report discoloured water and water leaks to maintenance and ICP.

Class Two Activity

The following specifications are to be considered in addition to Class I. Class II specifications must be followed if dust will be created during the Type A construction activity.

Maintenance Staff & Contractors

Dust Control

Execute work by methods that minimise dust generation from construction or renovation activities.

- Wet mop and/or vacuum as necessary.
- Provide active means to minimise dust generation and migration into the atmosphere.
- Use drop sheets to control dust.
- Control dust by water misting work surfaces while cutting.
- Seal windows and unused doors with duct tape.
- Seal air vents in construction/renovation areas.
- Place dust mat at entrance to and exit from work areas.

Ventilation

- Disable the ventilation system in the construction/renovation area until the project is complete.
- Monitor need to change and/or clean filters in construction or renovation area.

Debris Removal & Cleanup

- Contain debris in covered containers or cover with a moistened sheet before transporting for disposal.

Plumbing

- Avoid collection tanks and long pipes that allow water to stagnate.
- Consider hyperchlorinating stagnant potable water (especially if Legionella is already present in potable water supply).

Environmental Services

Dust Control

- Wet mop and vacuum area with a HEPA filtered vacuum as needed and when work is complete.
- Wipe horizontal work surfaces with a disinfectant.

Medical/Nursing Staff

Risk Reduction

- Identify high-risk patients who may need to be temporarily moved away from the construction zone.
- Ensure that patient care equipment and supplies are protected from dust exposure.

Class Three Activity

The following specifications are to be considered in addition to Class I and II

Maintenance Staff & Contractors.

Risk Reduction

Ensure that ICP consultation has been completed and infection prevention and control measures have been approved.

Dust Control

- Erect an impermeable dust barrier made of plasterboard or plywood from true ceiling (includes area above false ceilings) to the floor.
- Ensure that windows, doors, plumbing penetrations, electrical outlets and intake and exhaust vents are properly sealed with plastic and duct taped within the construction/ renovation area.
- Vacuum air ducts and spaces above ceilings if necessary.
- Ensure that construction workers wear protective clothing that is removed each time they leave the construction site before going into patient care areas.
- Do not remove dust barrier until the project is complete and the area has been cleaned thoroughly and inspected.
- Remove dust barrier carefully to minimise spreading dust and other debris particles associated with the construction project.

Ventilation

- Maintain negative pressure within construction zone by using portable HEPA equipped air filtration units.
- Ensure air is exhausted directly outside and away from intake vents or filtered through a HEPA filter before being recirculated.
- Ensure ventilation system is functioning properly and is cleaned if contaminated by soil or dust after construction or renovation project is complete.

Debris Removal & Cleanup

- Remove debris at the end of the work day.
- Erect an external chute if the construction is not taking place on ground level.
- Vacuum work area with HEPA filtered vacuums daily or more frequently if needed.

Plumbing

- Flush water lines at construction or renovation site and adjacent patient care areas before patients are readmitted.

Environmental Services

- Increase frequency of cleaning in areas adjacent to the construction zone while the project is under way.
- In cooperation with ICP ensure that the construction zone is thoroughly cleaned when work is complete.

Infection Prevention and Control Personnel

Risk Reduction

- Move high-risk patients who are in or adjacent to the construction area.
- In cooperation with environmental services ensure that construction zone is thoroughly cleaned when work is complete.
- Inspect dust barriers.

Traffic Control

- In cooperation with the facility project manager designate a traffic pattern for construction workers that avoids patient care areas and a traffic pattern for clean or sterile supplies and equipment that avoids the construction area.

Plumbing

- Consider hyperchlorinating stagnant potable water (especially if Legionella is already present in potable water supply).

Medical/Nursing Staff

Risk Reduction

- Move high-risk patients who are in or adjacent to the construction area.
- Ensure that patients do not go near the construction area.
- In cooperation with environmental services and ICP ensure that construction zone is thoroughly cleaned when work is complete.

Class Four Activity

The following specifications are to be considered in addition to those in Class I, II and III.

Maintenance Staff & Contractors

Dust Control

- Before starting the construction project erect an impermeable dust barrier that also has an anteroom.
- Place a walk-off mat outside the anteroom in patient care areas and inside the anteroom to trap dust from the workers' shoes, equipment and debris that leaves the construction zone.
- Ensure that construction workers leave the construction zone through the anteroom so they can be vacuumed with a HEPA filtered vacuum cleaner before leaving the work site; or that they wear cloth or paper coveralls that are removed each time they leave the work site.
- Direct all personnel entering the construction zone to wear shoe covers.
- Ensure that construction workers change the shoe covers each time they leave the work site.
- Repair holes in walls within eight hours or seal them temporarily.

Ventilation

- Ensure negative pressure is maintained within the anteroom and construction zone.
- Ensure ventilation systems are working properly in adjacent areas.
- Review ventilation system requirements in the construction area with ICP to ensure system is appropriate and is functioning properly.

Evaluation

- Review infection control measures with other members of the planning team or delegate to evaluate their effectiveness and identify problems at the end of the construction project.

Plumbing

- If there are concerns about Legionella, consider hyperchlorinating stagnant potable water or superheating and flushing all distal sites before restoring or pressurising the water system.

Environmental Services

Evaluation

- Review infection prevention and control measures with other members of the planning team or delegate to evaluate their effectiveness and identify problems at the end of the construction project.

Infection Prevention and Control Personnel

Risk Reduction

- Regularly visit the construction site to ensure that preventive measures are being followed. Wear coveralls and shoe covers when visiting the site.

Evaluation

- Review infection control measures with other members of the planning team or delegate to evaluate their effectiveness and identify problems at the end of the construction project.

Medical/Nursing Staff

To reduce the possibility of transferring fungal spores staff are not permitted to visit the construction site.

Evaluation

- Review infection control measures with other members of the planning team or delegate to evaluate their effectiveness and identify problems at the end of the construction project.

Plumbing

- Consider using another source of potable water for patients who are at greatest risk until potable water has been cleared of signs of Legionella after major plumbing installation/repairs.

Appendix No 4: Infection Control Construction Approval Checklist Form

Directions:

1. The top portion of this form is to be completed by the Project Coordinator then sent to the Infection Control Department.
2. After review of the proposed project, the responsible infection control representative will complete the recommendation and return to the Project Coordinator.

Location of Construction:	Project Start Date:
Project Coordinator:	Estimateed Duration:
Contractor Performing Work:	
Supervisor:	Telephone:

Type I	Inspection and non-invasive activities: These include, but are not limited to, activities that require removal of ceiling tiles for visual inspection (limited to one 600 mm^2 tile per 15 m^2), painting but not sanding, wall covering, electrical work, minor plumbing that disrupts water supply to a localised patient care area [e.g. one room] for less than 15 minutes, and other maintenance activities that *do not* generate dust *or* require cutting of walls *or* access to ceilings other than for visual inspection.
Type II	Small scale, short duration activities that create minimal dust. These include, but are not limited to, activities that require access to duct spaces, cutting of walls or ceilings where dust migration can be controlled for the installation or repair of minor electrical work, ventilation components, telephone wires or computer cables, and sanding of walls for painting or wall covering to *only repair* small patches. It also includes plumbing that requires disruption to the water supply of more than one patient care area (> two rooms) for less than 30 minutes.
Type III	Any work that generates a moderate to high level of dust or requires demolition or removal of any fixed building components or assemblies such as counter tops, cupboards, and sinks. These include, but are not limited to, activities that require sanding of walls for painting or wall covering, removal of floor coverings, ceiling tiles, new wall construction, minor duct work or electrical work above ceilings, major cabling activities, and any activity that *cannot be completed* within a single work shift. It also includes plumbing that requires disruption to the water supply of more than one patient care area (> two rooms) for more than 30 minutes but less than one hour.
Type IV	Major demolition, construction and renovation projects. These include, but are not limited to, activities that involve heavy demolition or removal of a complete cabling system and new construction requiring consecutive work shifts to complete. It also includes plumbing that results in disruption to the water supply of more than one patient care area (> two rooms) for more than one hour.

Type of Project	Type I	Type II	Type III	Type IV
Infection Control Recommendations				

Requested by: Date:	Authorised by: Date:

Appendix No 5: Daily Site Safety Checklist

Job: _____ Date: _____

Activity	Month _____	Mon	Tue	Wed	Thur	Fri	Sat	Sun
1	All employees and Sub-contractors have received induction training.	☐	☐	☐	☐	☐	☐	☐
2	Check condition of equipment & that Safe Working Methods are being followed for:							
	Manual Handling	☐	☐	☐	☐	☐	☐	☐
	Traffic Management	☐	☐	☐	☐	☐	☐	☐
	Earth Moving Machinery	☐	☐	☐	☐	☐	☐	☐
	Safety Barriers	☐	☐	☐	☐	☐	☐	☐
	Electric Power Tools	☐	☐	☐	☐	☐	☐	☐
	Explosive Power Tools	☐	☐	☐	☐	☐	☐	☐
	Mobile Scaffolds (including assembly)	☐	☐	☐	☐	☐	☐	☐
	Ladders	☐	☐	☐	☐	☐	☐	☐
	Working Adjacent to Edges	☐	☐	☐	☐	☐	☐	☐
	Roof / Shaft / Penetration Work	☐	☐	☐	☐	☐	☐	☐
	Elevated Work Platforms	☐	☐	☐	☐	☐	☐	☐
	Oxy Acetylene / Arc Welding gear	☐	☐	☐	☐	☐	☐	☐
	Live Power / Overhead Power Lines	☐	☐	☐	☐	☐	☐	☐
	Compressors / Pneumatic Equipment	☐	☐	☐	☐	☐	☐	☐
	Equipment Maintenance	☐	☐	☐	☐	☐	☐	☐
	Dangerous Chemicals	☐	☐	☐	☐	☐	☐	☐
3	Infection control daily compliance survey completed	☐	☐	☐	☐	☐	☐	☐
4	All employees and Sub-contractors are wearing correct Safety / Protective gear.	☐	☐	☐	☐	☐	☐	☐
5	Work areas are clean & free of debris etc. If considered unsafe report to Safety Rep.	☐	☐	☐	☐	☐	☐	☐
6	Area clean ups have been conducted.	☐	☐	☐	☐	☐	☐	☐

Unsafe Conditions Noted: _____

_____

_____

Corrective Action Taken: _____

_____

_____

_____

_____

Conducted By: _____ Period Ending: _____/_____/_____

Appendix No 6: Infection Control Daily Compliance Survey

Project Title:

Project No: Time: Date: Inspector:

Location:

Contractor:

	YES	NO	CORRECTED
I. Construction Barricade			
Barriers sealed, no penetrations			
Walk off mats in place and clean			
Barrier doors have closers and they are working			
Door frames have gaskets, doors close and seal properly			
Signs posted informing about spread of dust			
Adjacent ceiling areas intact			
Adjacent floor is clean and no dust is tracked			
Comments:			
2. Negative Air			
Negative pressure at barrier entrance			
All windows and doors closed behind barrier			
Negative air units or exhaust fans running			
Negative air units filters clean			
Negative air units discharge ducts intact			
Comments:			
3. Jobsite			
Project area is clean and debris removed daily			
Debris removed in suitable containers			
Debris removed at time specified			
Comments:			
4. Occupied Areas			
Work authorised and scheduled			
Barrier in place and properly sealed			
Ceiling access sign posted			
Surrounding areas are clean			
Comments:			

cc: Infection Control & General Contractor.

Appendix No 7: Access & Work Permit

1. WORKER IDENTIFICATION & LOCATION

Work location

.....

Work types this permit applies to

.....

.....

.....

Employees (recipients) signed onto this permit

.....

.....

.....

Contractors (recipients) signed onto this permit

Company .....

Supervisor.....

Employees .....

.....

.....

.....

2. DESCRIPTION OF WORK TO BE UNDERTAKEN

.....

.....

.....

.....

3. PERMITS ON ISSUE

- ☐ Hot work
- ☐ Fire protection isolation
- ☐ Confined spaces
- ☐ Environmental disturbance control
- ☐ Lock out / tag out
- ☐ Roof access

4. ISOLATIONS REQUIRED TO PERFORM WORKS

- ☐ Fire protection/alarms
- ☐ Pipelines
  - ☐ water
  - ☐ steam
  - ☐ gas
  - ☐ medical gases
- ☐ Mechanical / electrical drives
- ☐ Electrical services
- ☐ Radiation source
- ☐ Sludges/deposits/waste
- ☐ Harmful/hazardous materials

Location of isolations .....

.....

.....

.....

.....

Authorised person.....

Date .....

5. HOT WORK PRECAUTIONS

- ☐ All combustible materials removed or made safe
- ☐ No flammable liquids, vapours, or gases present
- ☐ Extinguishers/hose reels provided on site
- ☐ Operator trained in fire appliance use
- ☐ Operator knows location of fire alarms/telephone
- ☐ Site inspected on completion of work
- ☐ Alarms isolated. Permit completed

6. FIRE PROTECTION ISOLATION

- ☐ Alarms circuits identified and isolated
- ☐ Fire panel tagged and log filled in
- ☐ Security & plant supervisor notified
- ☐ Period of isolation __/__/__ to __/__/__
- ☐ AIU / ASE isolated

7. ENVIRONMENTAL DISTURBANCE CONTROL

- ☐ Risk assessment completed
- ☐ Construction area sealed off
- ☐ Predetermined traffic routes
- ☐ Site cleaning procedures in place
- ☐ Negative pressure air within construction area
- ☐ HEPA filtered vacuum cleaner to be used
- ☐ Area access control to be implemented
- ☐ Partitioning and/or temporary wall to be installed
- ☐ Environmental microbial sampling to occur

8. LOCK OUT TAG OUT

- ☐ Plant safety tagged
- ☐ Plant locked out with appropriate device
- ☐ Plant supervisor notified
- ☐ Log completed

9. ROOF ACCESS

- ☐ Harness checked and correctly setup
- ☐ Observer in place
- ☐ Code of practice requirements fulfilled

10. WORK COMPLETED

Recipients signed
off and Date.....

.....

.....

.....

11. PERMIT CANCELLED

Workplace has been checked and cleared as safe. All permit conditions have been withdrawn.

Authorised by .....

Date .....

Appendix No 8: Sample Specification Clauses

1. POLICY

Aspergillosis and related nosocomial fungal infections are caused through inhalation by immunocompromised patients of Aspergillus spores, or other related spores that can be present in the construction environment. The spores are known to be prolifically present in construction dust, debris and earthwork excavation dust. Control of construction dust, debris and excavation dust, as required in this section, is imperative to help prevent outbreaks of aspergillosis or related nosocomial fungal infections in immunocompromised patients.

- Inhalation of *Aspergillus* spores or other fungal spores by immunocompromised patients can lead to serious complications and death.
- *Aspergillus* and other related spores are present in the natural environment and thus are not a risk to healthy construction workers.
- All construction workers are required to attend an orientation session.

Airborne contaminants control is critical in all hospital areas. The Contractor shall limit dissemination of airborne contaminants produced by construction-related activities, in order to provide protection for: immunocompromised and other patients; staff; sensitive procedures or equipment, and diagnostic operations from possible undesirable effects of exposure to such contaminants.

- Dust in ceilings and construction debris contains fungus spores. Construction activities causing disturbance of existing dust, or creating new dust, or other airborne contaminants, must be conducted in tight enclosures cutting off any flow of particles into patient areas.
- Ceilings and walls in Protection areas and other areas in Hospitals, as indicated on drawings, must be secure at all times. If access into the ceiling in occupied areas is required, procedures as described in this Section shall be followed.

2. DEFINITIONS

Contaminant Producing Activities include, but are not limited to:

1. Demolition and removal of walls, floors, ceilings, and other finish materials.
2. Demolition of plumbing, mechanical and electrical systems and equipment.
3. Finish operations such as sanding, painting, and application of special surface coatings.
4. All routine construction activity that can generate dust.
5. Sitework operations.

Containment Areas

Containment Areas are determined by the Owner's Representative and are as shown on the drawings. Containment Areas include area of construction; adjacent staging and storage areas, and passage areas for Contractors, supplies and water; includes ceiling spaces above and adjacent to construction, if shown.

Protection Areas

Protective areas are determined by the Owner's Representative and are as shown on the drawings. Protection areas include hospital areas adjacent to the Containment Area, either occupied or passage, as well as areas connected to the construction area by mechanical system air intake, exhaust and ductwork.

Minor Ceiling Access

Minor ceiling access is defined as visual observation, minor adjustments or other activity that does not disturb dust. Acoustical panels shall be replaced or access panel shall be closed immediately when the Contractor leaves the work site.

Major Ceiling Access

Major ceiling access is defined as other access not defined as "minor".

Thorough Cleaning

Thorough cleaning of surfaces that become exposed to dust shall be accomplished by the use of either a HEPA-filtered vacuum cleaner or a wet mop.

Negative Air Unit

Negative air units are portable mechanical units to provide a negative air pressure in the Containment Areas, as specified in this Section.

3. PROTECTION

If work is being done above a lay-in ceiling and work must be performed while the space below is occupied, provide temporary work surfaces to provide a safe working platform and protect the ceiling and the spaces below from falling objects and materials. Take all necessary precautions to protect the people and spaces below from injury due to the Contractor's operations.

Exercise caution when handling fluids, particularly heating water, in the interstitial space. When working with fluids provide a watertight barrier beneath the work area to catch and retain all spillage before it reaches the ceiling below.

Notify the Owner's Representative at least 48 hours, or greater if requested by the Owner's Representative, prior to commencing work in ceiling or interstitial spaces above occupied areas. This will allow at-risk patients to be relocated or protected.

4. SUBMITTALS

Progress Schedules

Submit work areas and procedure schedules for containment of airborne contaminants.

Work Plan

Submit drawings and details of construction of necessary temporary barriers, and description of procedures to be used to achieve and maintain control of construction-related airborne contaminants.

5. PRELIMINARIES

Dust Control and Sealing Work Area

The Building Contractor shall seal the work areas to Infection Control requirements, which may include, but are not limited to:

1. Maintain Positive Pressure in the Occupied Areas. The supply air ducts are to be sealed in the work areas.
2. Create a Negative Pressure in the Construction Areas. The Construction Manager shall arrange for the Air Filtration Units to be delivered to the work area. The Building Contractor shall be responsible for the units until the project is complete and return them in working order to the Construction Manager.
3. Supply and erect temporary walls (including access doors and 'kick-out' emergency escape panels for patient safety). Demolish walls and make good all surfaces on completion. Refer to the drawings for the locations of the proposed temporary walls.
4. All doors surrounding and enclosing a work area should remain closed during the execution of the work.

Each Contractor shall provide HEPA filter vacuum cleaners: refer to each trade specification. Sweeping is prohibited.

The Building Contractor shall be responsible for maintaining the dust control methods during the construction period.

Any variation to the above shall be reported to a Hospital representative.

If a penetration through the perimeter wall is required the Construction Manager shall be notified prior to any such works commencing. An appropriate local dust containment strategy shall be advised.

Maintain a sealed work area at all times to contain and exhaust dust by:

1. Keeping all supply ducts sealed
2. Ensuring the permanent extraction system is not interrupted

3. Keeping the plastic airlock doors shut at all times.

6. DUST CONTROL

Scope

The work of this section comprises the supply and fabrication of all miscellaneous items and all fastenings and fittings necessary for the proper building-in of articles specified to attain an airtight seal to Construction Site area to the extent as noted on Locality/Site Plan.

General

Work shall conform to all clauses within this specification.

Adjoining Properties

Take the utmost care so as not to cause any damage to adjoining properties, or adjacent buildings on the site. Any damages shall be made good at the Contractor's expense.

All dust control measures shall be carried out in a careful and systematic manner. Before commencing, submit evidence that:

1. Requirements of the Hospital and any authorities relating to the work under the contract have been ascertained
2. Permission to start has been obtained from the appropriate authority
3. A scaffolding permit has been obtained from the appropriate authority (if scaffolding is proposed to be used).

Carry out an investigation of the structure, services and the site, then prepare and document a work plan in accordance with the statuary regulations, Hospital rules and relevant Australian Standards. Include in the work plan the following additional information:

1. The method of protection of existing structures, services and site
2. The method of minimising dust
3. Locations and details of necessary service deviations and terminations.

Extent of Works

Build an airtight seal to perimeter of the Construction Site to the extent as noted on the Site Plan

Temporary Walls

Provide and install temporary walls where indicated on the drawings. Walls shall be constructed from F5 pinus, 90 x 45 mm studs at 450 mm centres, 16 mm thick plasterboard or plywood adhered to the existing walls. Seal all joints with aluminium foil tape to stop dust transferral and minimise noise transferral.

Above ceiling

- Techscrew 70 x 35 F5 Pine bottom plate to top of existing wall.
- Bolt 70 x 35 F5 Pine top plate to existing concrete slab over.
- Provide 70 x 35 F5 Pine vertical trimmers at 600 centres.

Staple Heavy Duty Reinforced Sisalation to top and bottom plate.

Cut around services and seal all gaps with Heavy Duty Aluminium Reinforced Lagging Tape.

Hoarding

Build slab to slab hoarding corridors where noted using:

- 70 x 35 F5 Pine frame at 450 centres.
- Screw fix heavy-duty Ply sheets to full height wall.
- Note: All sheets to be cut off site.
- Seal all gaps with Heavy Duty Aluminium Reinforced Lagging Tape.

Allow for emergency push out panel to East/West corridor hoarding.

Doors

The Hospital is to lock all doors on perimeter where applicable.

Securely fix and permanently shut all doors that do not have a locking mechanism. Ensure all gaps to existing doors on the perimeter are sealed with Heavy Duty Aluminium Reinforced Lagging Tape.

Windows

Remove two window panels to North facing wall and replace with temporary Pyneboard Infill. Cut board to allow tight fitting of extraction fan by others. Seal all gaps.

Airlock

Provide an airlock to North/South corridor leading to Proposed Construction Lift using two plastic swing doors (provided by Hospital) in locations to be determined.

Make Good

Allow for making good of any disturbance caused by the alterations and additions.

7. PROVISIONAL SUMS

Allow the Provisional Sum of $2,000 for purchase of a HEPA filter vacuum cleaner to hospital specifications. This vacuum cleaner is to remain on site and in the control of the Contractor for the duration of the Contract. It shall be handed over at no additional cost to the Proprietor at Practical Completion.

Allow the Provisional Sum of $6,500 for the purchase of a HEPA filter negative air unit to hospital specifications. This unit is to remain on site and in the control of the Contractor for the duration of the Contract. It shall be handed over at no additional cost to the Proprietor at Practical Completion.