Construction and Renovation: Infection Control measures

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Developing a comprehensive team approach

- Multi-disciplinary participants including:
  - Construction Manager
  - The Owner
  - The Client
  - The Design Team (A/M/E/C)
  - The End User (Operator)
  - Third Party (Infection Control Practitioners)

Objectives

- Control dust generation
- Prevent dust from infiltrating occupied (or completed) areas
- Prevent generation of aerosols from contaminating water sources
- Prevent mold and bacteria growth
- Prevent dust infiltration into HVAC systems
- Maintaining ambient interior temperature and humidity controls and controlling or preventing dust and debris build up, a future source of nutrients for spores and bacteria is minimized.
- Turn-over of the completed facility would be sooner, with less need to address final deficiencies, such as, re-cleaning duct work, or addressing expansion or shrinkage of sensitive finish material installations.

Pre-construction: Pre-emptive planning for building works

- Risk profile should be carried out during the preplanning stage as part of a robust risk management programme
- At a minimum, the risk profile should
  - identify the location of high-risk patients within the site,
  - identify ventilation system types and their potential impact; determine air monitoring requirements, methodology and frequency and
  - take air samples to establish baseline values and identify possible contaminants and their locations (e.g. ceiling dust, service shafts, sprayed-on fire retardants and bird droppings)

Negative air flow is ideal

- Move air from clean to dirty
- Stay within excess HVAC system capacity (not too negative)
- Maintain 0.1” to 0.001”
- HEPA filter
- Exhaust outdoors

Open ducts are dangerous

- Isolate and seal all open construction area ducts

Open ceilings are a no-no!

Barriers help to contain dust

- Construct physical barriers to keep dust in and people out
- Gypsum wallboard, melamine panels, and plastic sheeting

Responsibilities of the Project Officer i/c project

- Inform Infection Control of project
  - dates, location, type of renovation work
  - as soon as a project is planned, or at least prior to the start date of scheduled projects
- Complete the Infection Control Risk Assessment (ICRA) Matrix

Infection control risk assessment matrix

IC Matrix - Class of Precautions – Project Type by Patient Risk

Patient Risk Group	Construction Project Type			
	TYPE A	TYPE B	TYPE C	TYPE D
LOW	I	II	II	III / IV
MEDIUM	I	II	III	IV
HIGH	I	II	III / IV	IV
HIGHEST	II	III / IV	III / IV	IV

Note: Notification to Infection Control will be required when the Construction Activity and Risk Level indicate that **Class III** or **Class IV** control procedures are necessary.

IC Precautions

- Class I
  - minimize dust production
  - replace any displaced tiles
  - maintain as dry an environment as possible
  - clean work area upon completion of task

IC Precautions

- Class II
  - prevent air-borne dust from dispersing
  - seal window and unused doors with dust tape
  - water misting work surfaces while cutting
  - block off and seal air vents in construction area
  - dust mat at entrance and exit of work site
  - contain debris in covered containers or cover moistened sheet before transporting for disposal

IC Precautions

- Class III
  - complete all construction barriers before construction begins
  - maintain negative pressure within work site by using portable HEPA equipped filtration units or other methods
  - ensure ventilation system is functioning properly and cleaned if contaminated by soil or dust after renovation is over

Responsibilities of the Project Officer i/c project

- Communicate to contractors the infection control requirements e.g. HEPA filtration unit and HEPA filtered vacuum cleaner
- Brief and train contractors of required infection control measures and audit
- Verify audit performed by contractors
- Verify and follow up with contractor for corrective actions when non-compliance is reported

Responsibilities of the Contractor

- Provide HEPA filtration unit if available
- Provide HEPA filtered vacuum cleaner for cleaning at the site
- Provide effective hoarding and clear signboard
- Ensure workers' compliance and safety
- Conduct infection control audit and safety inspection according to the frequency specified by project officer in-charge
- Implement action plan for non-compliance

Responsibilities of Infection Control Unit

- Receive and verify the checklist and notification forms from project officer in-charge
- Suggest additional measures if necessary
- Conduct random audit
  - dust and debris;
  - traffic control;
  - barriers; and
  - cleanliness of adjacent sites.

Responsibilities of the Manager or nurse manager of the construction / renovation / maintenance area

- Identify whether patients of high-risk groups, e.g. immunocompromised patients, are involved
- Arrange for relocating of patients if necessary
- Assist in ensuring minimal dust migration and inform project officer and infection control nurse if non-compliance is found

Responsibilities of Housekeeping

- Ensure the corridor and areas adjacent to the site are clean and free from dust
- Responsible for final cleanup at the completion of the project

IC Precautions

- Class IV
  - cover adequately gaps, holes or opening to prevent dust migration
  - construct anteroom
    - workers remove overalls each time they leave work site
    - change shoe covers
    - wet mop room and remove debris daily

Pre-construction

- Assessment of risk
  - Patients
  - Staff
  - Process
  - Facility
- Storage of building materials
- Contractors' access to occupied area
- Above ceiling access in occupied area
- Travel paths for contractors and deliveries
- Contractor education

Patient area risk assessment

- Criteria for emergency work interruptions (stop and start process)
- Patient placement or relocation
  - Does the unit need to be closed for duration?
- If yes, who will authorise this and how should communication be done

Staff education

- General
  - Closure of doors, windows
  - Housekeeping
  - Look out for potential lapses in infection control that staff should report to IC Department

Process or logistics

- Traffic flow for patients, staff, workers, visitors
- Waste handling
  - Who is responsible?
  - Transport path and manner

Facility

- Air handling needs
- Water system
- Plumbing
- Emergency preparedness plans for utility failures

Others

- Expectations for contractor accountability in event of breaches in infection control practices and related written agreements
- Education – for whom and by whom
- Occupational health expectations for subcontractors and staff before start

Construction workers education

- Why and how to adhere to infection control measures
- Potential environmental risks e.g. fungal contamination for plumbers
- Use of particulate respirators or other PPE
- Risk prevention for safety issues e.g. noxious fumes or asbestos
- How to seek help and report exposures

Construction worker education

- Training before site entry
  - Group or self study guides
- Documentation of training

During construction monitoring: safety measures

- Signage
- Entry and exit paths
- Dust containment
- Housekeeping
- Water sampling or air sampling indicated if there is suspicion of an associated outbreak or outbreak is identified

External projects - Keep the dust *out*

- Water mist the soil or wall before excavation or demolition
- Wet dust surfaces
  - Truck, equipment path
- Keep windows and doors closed as much as possible
- Keep the facility air pressure positive to the outside
  - Ensure sufficient air supply and exhaust
- Regular filter maintenance to ensure intake of clean air

Hoarding at the source

Window netting for non air-conditioned areas (including corridors)

Regular maintenance: vacuum + wash weekly

Cover up the soil to minimize dust migration

Internal projects – keep the dust *in*

Internal projects – keep the dust *in*

- Hoarding
- Negative pressure within the worksite
- Site cleanliness and waste management
- Traffic control
- Additional measures for patient protection
- Monitoring for compliance
- Post-procedure cleanup

Hoarding

- Physical control barriers, minimizes dust migration to adjacent areas
- Types of hoarding depend on the duration and extensiveness of the project
- Must be dust-tight
- Must remain until all dust generating work is complete, walls and ceiling closed, sanding done, and area cleaned

Plastic sheets hoarding

- Projects with minimal dust
- Sealed at full ceiling height
- Minimal 60-cm overlapping flaps for access to entry

“Sarong” hoarding for small projects (e.g., removal of 1 – 2 ceiling tiles for access)

Plaster board hoarding

- Projects with moderate to high level dust
- Rigid, dust-proof fire-rated barrier walls (plywood, drywall)
- Caulked seams tightly sealed

Anteroom

- Large, dusty projects (Type D)
- Allows workers to change to clean attire, or removing the dust from their boots before leaving the site
- Anteroom with gasketed door frames
- Full perimeters of walls tightly sealed

Calcium silicate hoarding

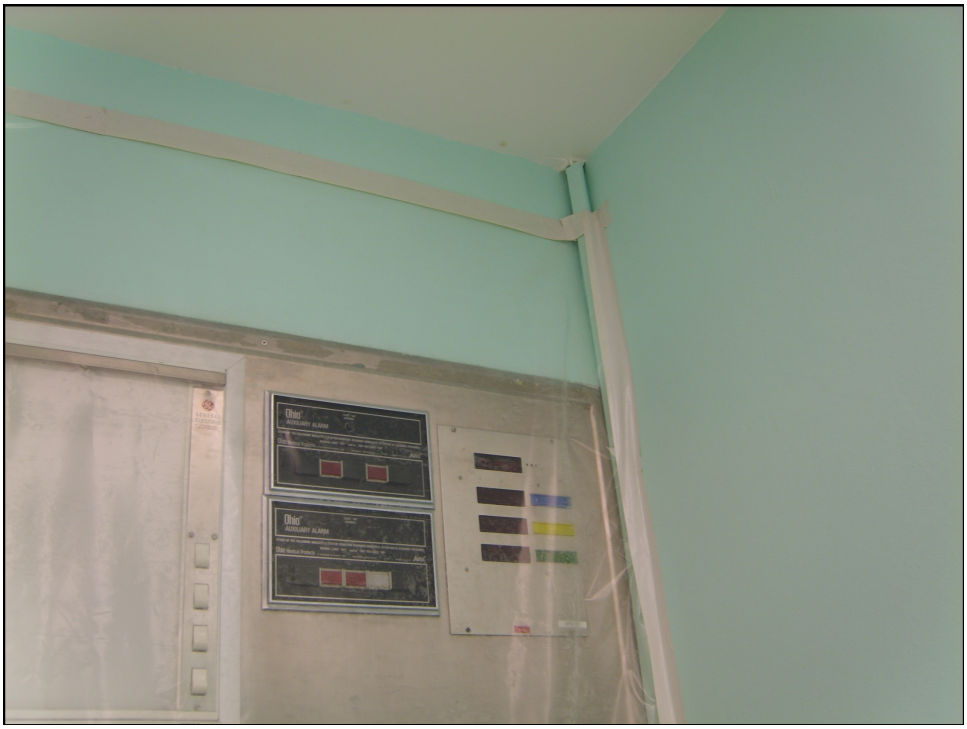
- Cheaper than metal hoarding
- Easier to construct / amend
- Durable
- Exposure to sun and rain - ok
- Less lasting than metal hoarding

Metal hoarding

- Solid material
- Could withstand long term exposure to sun and rain
- Concrete supporting structure
- Costly
- Could be technically difficult to fix

Use heavy-duty materials for taping

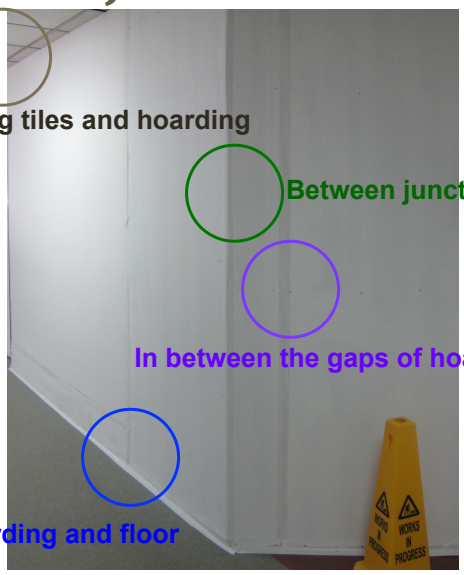
Look into the details



When hoarding extends through interstitial space ..

ensure all holes, pipes, conduits and punctures are tightly sealed

Ensure all junctures are taped



Continuous taping – to ensure no gaps

Taping – common challenges

Juncture between ceiling and hoarding material – most neglected area

Taping – common challenges

Taping – common challenges

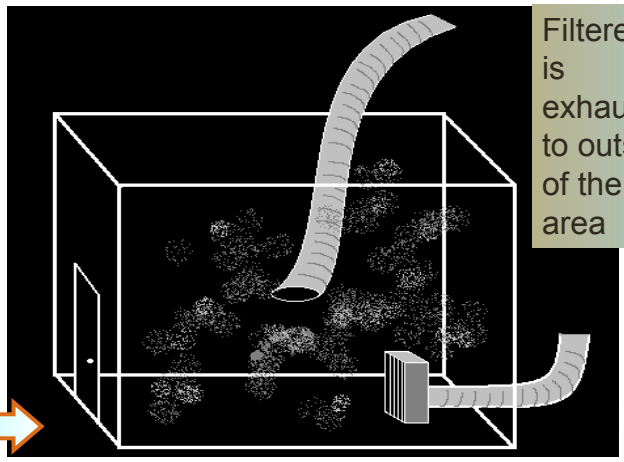
Poor taping practice

Is this acceptable?

Regardless of the type of hoarding, maintenance is the key to ensure the effectiveness of hoarding

NEGATIVE PRESSURE HEPA FILTER

Creating negative pressure at work site



Filtered air is exhausted to outside of the work area

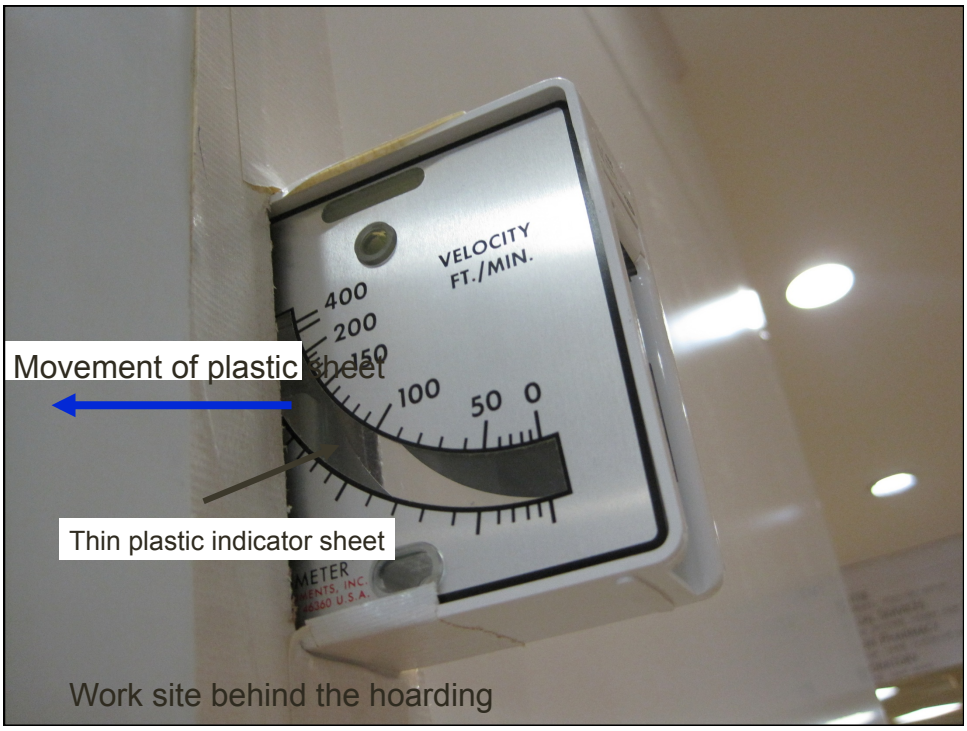
Air is drawn into the work site

With permission from John Marx, University of Wisconsin Hospital and Clinics

Negative pressure HEPA filter

- Capture particulates
- Create negative pressure at the site in relative to adjacent areas
- Filters are to be sealed and bagged securely at point of use before disposal

HOW DO WE KNOW WHETHER HEPA FILTER WORKS?



How do we know whether HEPA filter works?

Other measures to maintain negative pressure within the work site

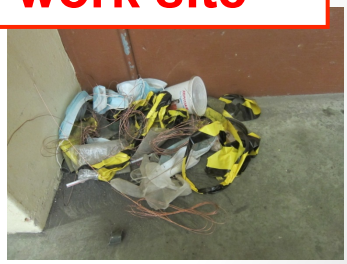
- Isolate HVAC
  - Seal air vents, air intakes, grills
  - Shut down HVAC system
  - Add filters

Ok to start!

Maintaining site cleanliness and waste management

Debris clearance – include debris created by workers


Food and drinks are not allowed at the work site

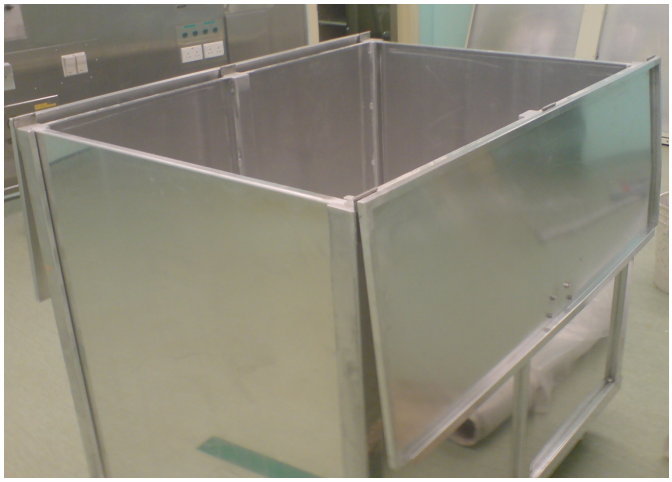



Designated route for debris transportation

Additional layer of vinyl flooring

Bag debris into securely tied bag and remove daily (at agreed hours – low traffic period)

Transport debris in a cart with lid



Wipe down the outer surface before leaving the work site

Use dust / tacky mat for dust containment

Damp mop the adjacent areas frequently

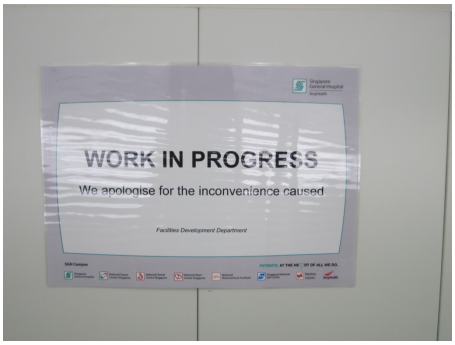
Traffic control

- Minimize procedure and waiting time near work zones

and ….

Use a separate route – away from patients and staff

Clear signage to alert visitors/ staff of the project and divert the traffic



No flow-through traffic in the work site

Door with security locking system and clean signage

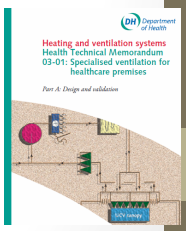
No entry to unauthorized personnel

Good references

- FGI (Facilities Guidelines Institute) Guidelines (USA)

- ASHRAE (The American Society of Heating, Refrigerating and Air Conditioning Engineers) Standards (USA)

- HTM 03-01 Specialised ventilation for Healthcare premises (by DHS, UK)



Audit checks

- Keeping construction area clean
  - Suppressing dust with wetting agents
  - Cleaning up immediately after activities producing high dust
  - Keeping duct ends sealed with plastic to reduce dust filtration into mechanical system when not in use
  - Intact hoardings
  - Construction waste is bagged and transported in covered carts
- Frequency of audits to be planned
  - Create a checklist

Singapore General Hospital
SingHealth

Construction & Renovation Infection Control On-site Checklist
for Class Precaution III

Location of project:																
Nature of project:																
Project start date:																
Contractor in-charge:																
Project officer in-charge:																
Date of assessment:																
A.	**Barriers**	Y	N	NA	Y	N	NA	Y	N	NA	Y	N	NA	Y	N	NA
1	All construction barriers are completed before construction begins.															
2	Correct type of barrier is used and the barriers erected effectively seal the work area from non-work area.															
3	Clear signboard is put up to direct pedestrian traffic away from construction area.															
B.	**Negative pressure**	Y	N	NA	Y	N	NA	Y	N	NA	Y	N	NA	Y	N	NA
1	Air vents are blocked off and sealed (if applicable).															
2	HVAC system is removed or isolated (if applicable).															
3	HEPA equipped air filtration units are utilized to maintain negative air pressure within the work site (if applicable).															
C.	**Dust control**	Y	N	NA	Y	N	NA	Y	N	NA	Y	N	NA	Y	N	NA
1	Windows at the site are closed when hacking is in process.															
2	Clean dust mat is placed at entrance and exit of work area.															
3	Work area is swept, wet mopped or vacuumed daily.															
4	Construction waste is contained and covered properly before transportation.															
D.	**Upon completion of project**	Y	N	NA	Y	N	NA	Y	N	NA	Y	N	NA	Y	N	NA
1	Construction waste is contained and covered properly before transportation.															
2	Barrier materials are wiped before removal and are removed carefully to minimize spreading of dust.															
3	All surfaces are wiped with disinfectant.															
4	Work area is vacuumed with HEPA filtered vacuum and wet mopped with disinfectant.															
5	Isolation of HVAC system is removed (if applicable).															
Endorsement by Project Officer																

Please place 'X' in the appropriate column ('Y', 'N' or 'NA')
Y = Compliance is observed
N = Non-compliance is observed*
NA = Non-applicable
*To inform Project Officer immediately when Non-compliance is observed

Particle counting

- IQAir Particle Scan Pro Airborne Laser Counter
- 0.3μm - 5μm

Air quality monitoring of HEPA-filtered hospital rooms by particulate counting

Particle counts of different locations

Location	Mean particle count (part/l)	Range	Number of measurements
13 HEPA-filtered patient rooms of adult HSCT ward	174	7-6309	daily for 12 weeks
Intensive care unit (children), 3 patient rooms	5750	1370-21300	6 separate days
Regular adult patient ward - patient room - hallway	 7450 20870	 3200-10600 12000-29000	hourly for one day
Outside air	173659	110806-292624	6 separate days

Anttila V-J, Nihtinen A, Kuutamo T, Richardson M. 2008.

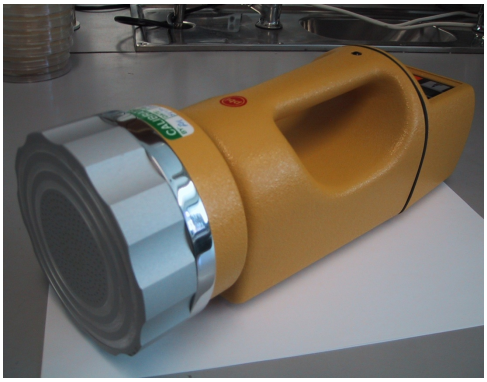
Fungal air sampling

- More accurate determination of indoor air quality compared to air particulate count

Air sampler for quantitation of viable fungal spores

Sampler type	Principle	Flow rate (litres/min)	Cut-off diameter (d50)(um)
Sieve impactor (Anderson)	Impaction on to agar plate	28·3	0·65–7·0
Slit sampler (e.g. Casella)	Impaction on to rotating agar plate	30–700	~0·5
Centrifugal Impactor (RCS)	Impaction due to centrifugal acceleration	40	4·0
Impingers (e.g. AGI)	Impingement into liquid	12·5	0·3
P.B.I. SAS Sampler (Single stage impaction)	Impaction on to agar plate	90/180	2·0
Settle plates	Gravity	Non-volumetric	N/A
Contact plates	Surface Sampling	Non-volumetric	N/A

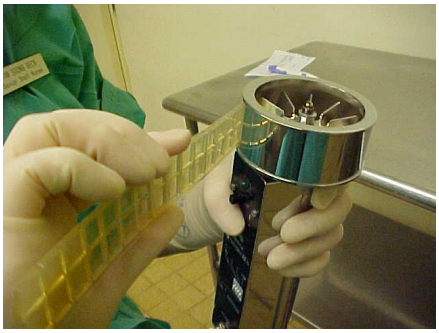
Air sampling: SAS Super 100 and Duo



Air sampler

Air sampler

Air sampling



Samplers: Andersen vs RCS

Table 1. Fungal genera most frequently isolated with the two air samplers.

Genera	Number of positive samples (%)	
	Andersen sampler	RCS
Penicillium	35 (83)	39 (92)
Aspergillus	33 (78)	18 (42)
Cladophialophora	31 (73)	20 (47)
Fusarium	21 (50)	–
Trichoderma	21 (50)	–
Rhodotorulla	15 (35)	–
Alternaria	15 (35)	–
Candida	–	14 (33)
Rhizopus	–	9 (21)
Number of samples	42	42

RCS: Reuter centrifugal air sampler.

Brazilian Journal of Medical and Biological Research (2003) 36: 613-616

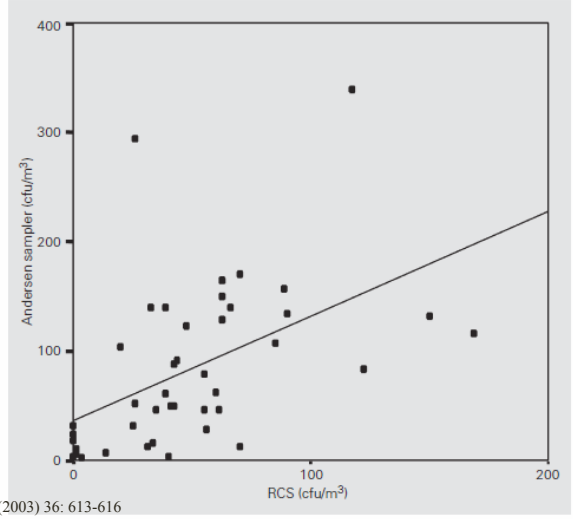


Figure 1. Correlation between fungal spore levels determined by measurement with the N-6 Andersen sampler and the Reuter centrifugal air sampler (RCS).

Indications for sampling

- To monitor levels of contamination prior to occupancy of special controlled environments e.g. to determine efficiency of HEPA filters in laminar flow facilities
- To identify potential sources of nosocomial aspergillosis when a case has been identified
- To predict environmental spore contamination from outside sources
- To identify defects/breakdown in hospital ventilation/ filtration systems
- To correlate outbreaks of invasive aspergillosis with hospital construction or demolition work
- To monitor efficiency of procedures to contain hospital building wards where at-risk patients are managed

- Multiple air sampling over period of time is preferred to single sample

Interpretation of fungal counts

- Vary depending on:
  - Activity levels
  - Fluctuations in temperature
  - Fluctuations in humidity
  - Fluctuations in air flow
  - Changes in light level
- Outdoor air
  - Total = 103 to 105 cfu/m3
- HEPA filtered air (>95% efficiency and >10 ACH)
  - <0.1 cfu/m3
- No air filtration
  - 5 conidia/m3
- Total > 1cfu/m3 needs attention!

Airborne *Aspergillus* contamination during hospital construction works: Efficacy of protective measures

Isabelle Fournel, MD,[a] Marc Sautour, PhD,[b] Ingrid Lafon, MD,[c] Nathalie Sixt, MD,[b] Coralie L'Ollivier, PhD,[b] Frédéric Dalle, PharmD, PhD,[b] Pascal Chavanet, MD, PhD,[d] Gérard Couillaud, MD,[e] Denis Caillot, MD,[c] Karine Astruc, MD,[a] Alain Bonnin, MD, PhD,[b,f] and Ludwid-Serge Aho-Glélé, MD[a]
Dijon, France

	Before work		During work		
Air treatment system	**N**	**%**	**N**	**%**	***P***
None	58/93	62.4	53/95	55.8	.36
HEPA filtration	0/134	0	2/234	0.8	.54
Plasmair	42/248	16.9	85/497	17.1	.95
Aspergillus airborne contamination	100/475	21.1	140/826	16.9	.07

The impact of portable high-efficiency particulate air filters on the incidence of invasive aspergillosis in a large acute tertiary-care hospital

Zakir-Hussain Abdul Salam, MBBS, MS, MPH,[a] Rubiyah Binte Karlin, BHSc,[b] Moi Lin Ling, MBBS, FRCPA,[b] and Kok Soong Yang, MBBS, MMedPH[a]
Singapore

(Am J Infect Control 2010; 38:1-7.)

Table 1. Incidence rates and RRs of IA in different ward groups during the study period

Ward group	Ward type	Incidence rate (per 1000 patient-days) Period I (December 2005 to November 2006)	Period II (December 2006 to June 2008)	*P* value	RR (95% CI)
Group I	Wards with portable HEPA filters deployed December 2006	0.35	0.17	.013	1.98 (1.11-3.51)
Group II	Wards with only fixed HEPA filters during the entire study period	0.16	0.31	.061	0.51 (0.28-0.93)
Group III	Wards with no HEPA filtration	0.088	0.075	.623	1.17 (0.44-3.10)

End of construction checks

- Area is cleared, cleaned and decontaminated with disinfectant
- Work area is vacuumed with HEPA filtered vacuums
- Hoardings are removed and disposed properly
- Air and water testing, if ordered

Monitoring

- Air flow
- Air sampling
- Air particle counting
- Microbiological water testing
- Humidity

After construction monitoring

- Are sinks properly located and functioning?
- Do sinks in critical patient care areas have properly functioning fixtures?
- Are soap and towel dispensers filled and functioning?
- Are surfaces in procedure and service areas appropriate for use? (e.g. are they smooth, nonporous and water resistant?)
- Has air balancing been completed according to specifications? (air particle count, air microbial count, etc)
- Does air flow into negative pressure rooms and out of positive pressure rooms? (smoke test)

Portable digital pressure gauge

- Is used to monitor the differential pressure of a room with the adjacent areas.
- Could be used during or after renovation, or after construction of rooms with positive or negative pressure

Take home message

- Control dust
- Don't give mold a chance to grow
- If staff see something not quite right, call Infection Control
- Their prompt action may save a patient's life

THANK YOU