Environmental Infectious Disease Management in Healthcare Facilities

Dr. Andrew Streifel, University of Minnesota

A Webber Training Teleclass

Environmental Infectious Disease Management in Healthcare Facilities

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Guidelines for Environmental Infection Control in HCF

- Seven major areas covered:
  - Air
  - Water
  - Environmental Services
  - Environmental Sampling
  - Laundry and Bedding
  - Animals in Healthcare Facilities
  - Regulated Medical Waste
- MMWR 6-03 was partial document
- 249 pg. with >1400 citations
- Appendices A – F

Guideline for Environmental Infection Control Centers for Disease Control & Prevention Heating, Ventilation & Air Conditioning

- Air handling systems in health care facilities
- Construction, renovation, remediation, repair and demolition
- Infection control and ventilation requirements for protective environments
- Infection control and ventilation requirements for airborne infection isolation
- Infection control and ventilation requirements for operating rooms

Ventilation Control in Hospital

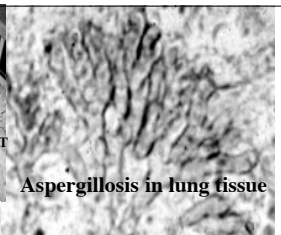
- Airborne Infection Isolation & Protective Environment
  - outage control (planned or emergency)
  - ventilation assurance
    - air changes per hour - (6 to 15)
    - HEPA filtration - (90% to 99.97%)
    - -pressurization - (2.5 Pascal's = 0.01"wg)
    - -monitoring
- Construction barriers
  - external project protection
  - internal barrier types
  - controlled airflow direction
  - monitoring

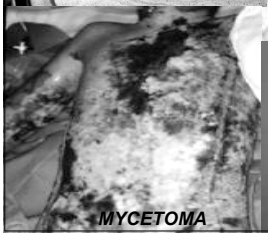
Human Source Airborne Infectious Diseases

•Tuberculosis
•Chicken pox
•Disseminating H. zoster
•Measles
•Smallpox

Droplet nuclei <5µm particles

EMERGENT DISEASES
SARS
MONKEY POX
ANTIBIOTIC RESISTANT MICROBES





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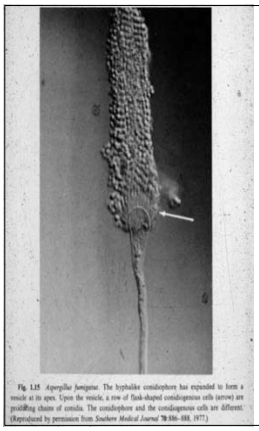
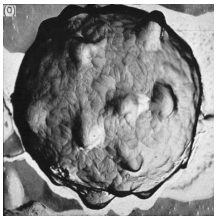
Fungi in the World
- >100,000 species
- about 100 human pathogens
- mostly skin pathogens
- small spores penetrate lungs
- essential to our survival



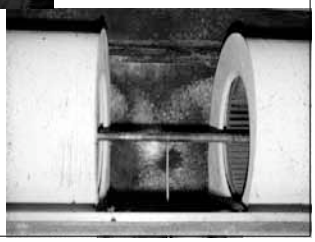
Aspergillus fumigatus
- prolific spore production



Aerodynamic spore
2-4μm diameter

Mold digests cellulose for a source of cellulose. Add water to most organic material and mold will grow with water content >25% and a RH >95%

Common material such as gypsum board will grow mold. Some species are opportunistic infectious agents
-Aspergillus species
--A.fumigatus, A.flavus,
--A.terreus and A.niger



Costs of Aspergillosis

- In 1996 dollars, average cost $62,426
  - Range $52,670 - $72,181
- Often as a secondary diagnosis (73%)
  - Respiratory, neoplastic and HIV most common primary diagnosis
- Increased length of stay
  - Average hospitalization 17.3 days
  - Range 16.1 – 18.6 days
- Costs don't include mortality

Dasbach et al, *Clinical Infectious Diseases* 2000;31:1524-8

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Highest Concentration Patient Risk

- **Oncology and bone marrow transplant**
- **solid organ transplant**
- **burn unit**
- **operating rooms**
- **labor and delivery, neonatal ICU**
- **ICU-surgery and medicine**
- **dialysis**
- **cardiac catheterization and recovery**
- **endoscopy**
- **pharmacy admixture**

Selected Aspergillosis References

- Arnow
  - 1978 - internal construction with little control
  - 1991- lack of maintenance with internal sources
- Sarubbi
  - 1984 -external construction/defective air system
- Rhame
  - 1984 - natural ventilation
- Patterson
  - 1999 - Dumb weighter construction minimal barriers
- Thio
  - 2000 - depressurized protective rooms & building
- Hahn
  -- 2002-differences in filter efficiencies & moldy material

Refinements of Environmental Assessment During an Outbreak Investigation of Aspergillosis Leukemia & BMT Unit. Thio,C. et al, ICHE. 2000

- 21 cases of invasive aspergillosis
- Depressurized oncology rooms 12/25 (-0.1 to -5.8 Pascal's)
- Sampling air did not detect A.flavus with 160 liters but 10/40 high volume samples(1400 liters) did detect
- Interventions:N95masks, wet buffing, pressure management, portable filtration
- Ventilation not the source but construction due to:
  - Doors, poorly sealed windows
- Recommendation: novel protection, assess environment, >1000 liter/sample, comparison samples

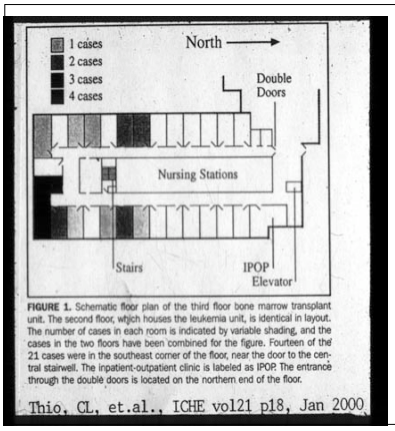

FIGURE 1. Schematic floor plan of the third floor bone marrow transplant unit. The second floor, which houses the leukemia unit, is identical in layout. The number of cases in each room is indicated by variable shading, and the cases in the two floors have been combined for the figure. Fourteen of the 21 cases were in the southeast corner of the floor, near the door to the central stairwell. The inpatient-outpatient clinic is labeled as IPOP. The entrance through the double doors is located on the northern end of the floor.

Thio, CL, et.al., ICHE vol21 p18, Jan 2000

Depressurized building and patient rooms
21 cases Aspergillosis

Efficacy of HEPA Filtration in Preventing Aspergillosis in Immunecompromised Patients… Hahn T. et al. ICHE. 2002

- 10/55 pts July to December 1992 developed invasive aspergillosis compared to 0/36 pts January to June 1992
- Leukemia patients not on BMT ward but regular rooms
- High volume (1700 l) detected Aspergillus in air of regular rooms but not on BMT ward
- Regular room @ 90% filtration yet >150 cfu/M^3 total fungi
  - compared to < 4 cfu/m^3 on BMT ward BMT had 99.97% filters
- Contamination source on non BMT was wet insulation which developed and infected patients
- Conclusion was to use HEPA filtration and maintain protective conditions albeit not as stringent as the BMT patient

Summary of Outbreak Analysis

- Environmental disruption causes release of opportunistic microbes
- Lack of adequate ventilation
- Point source of microbial contamination
- Minimal protective measures
- Institution of protective measures reduces infection:construction management, masking, filtration, pressure control and procedural practice
- Infection Control Risk Assessment is necessary for patient risk reduction

INFECTION CONTROL RISK ASSESSMENT

•RECOGNIZES RISK TO PATIENTS FROM ONGOING CONSTRUCTION, RENOVATION AND MAINTENANCE

•IMPLIMENTS SAFETY MEASURES TO PREVENT EXPOSURE TO COMMON ENVIRONMENTAL HAZARDS

•PROVIDES GUIDANCE FOR SURVEILLANCE OF PROJECT AND PATIENTS

•MULTIPLE METHODS SITUATION DEPENANT TO COMPLY WITH SAFETY MEASURES FOR INFECTION CONTROL

Using an ICRA Matrix

1. Type of Project Activity
2. Patient Risk Groups ☑
   - Immunocompromised ☑
   - Invasive procedures/devices ☑
3. Class of IC Precautions based upon parameters ☑

"IC Permit" assists documentation

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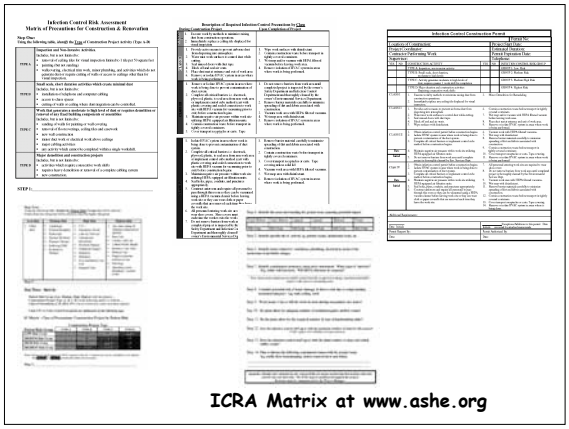
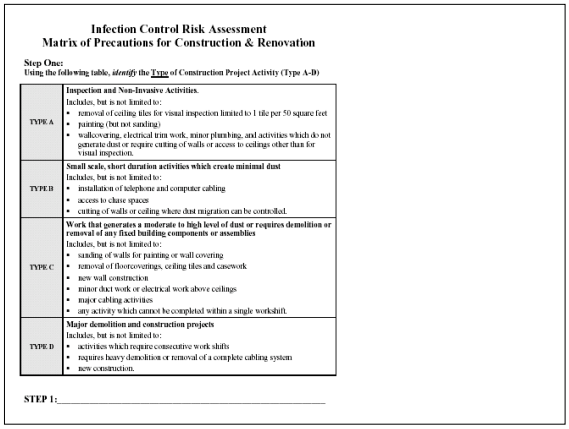


ICRA Matrix at www.ashe.org

Sample ICRA Matrix

PATIENT Risk Group	TYPE A	TYPE B	TYPE C	TYPE D
LOW Risk Group	I	II	II	III / IV
MEDIUM Risk Group	I	II	III	IV
HIGH Risk Group	I	II	III / IV	IV
HIGHEST Risk Group	II	III / IV	III / IV	IV

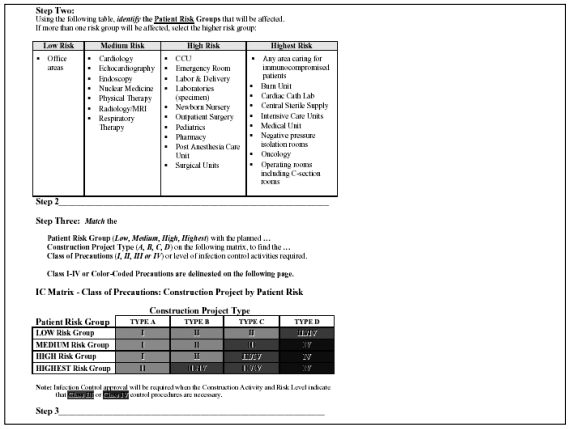


Infection Control Risk Assessment
Matrix of Precautions for Construction & Renovation

Step One:
Using the following table, *identify* the Type of Construction Project Activity (Type A-D)

TYPE A	**Inspection and Non-Invasive Activities.** Includes, but is not limited to: ▪ removal of ceiling tiles for visual inspection limited to 1 tile per 50 square feet ▪ painting (but not sanding) ▪ wallcovering, electrical trim work, minor plumbing, and activities which 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 which create minimal dust** Includes, but is not limited to: ▪ installation of telephone and computer cabling ▪ access to chase spaces ▪ cutting of walls or ceiling where dust migration can be controlled.
TYPE C	**Work that generates a moderate to high level of dust or requires demolition or removal of any fixed building components or assemblies** Includes, but is not limited to: ▪ sanding of walls for painting or wall covering ▪ removal of floorcoverings, ceiling tiles and casework ▪ new wall construction ▪ minor duct work or electrical work above ceilings ▪ major cabling activities ▪ any activity which cannot be completed within a single workshift.
TYPE D	**Major demolition and construction projects** Includes, but is not limited to: ▪ activities which require consecutive work shifts ▪ requires heavy demolition or removal of a complete cabling system ▪ new construction.

STEP 1:_____



Step Two:
Using the following table, *identify* the Patient Risk Groups that will be affected.
If more than one risk group will be affected, select the higher risk group:

Low Risk	Medium Risk	High Risk	Highest Risk
▪ Office areas	▪ Cardiology ▪ Echocardiography ▪ Endoscopy ▪ Nuclear Medicine ▪ Physical Therapy ▪ Radiology/MRI ▪ Respiratory Therapy	▪ CCU ▪ Emergency Room ▪ Labor & Delivery ▪ Laboratories (specimen) ▪ Newborn Nursery ▪ Outpatient Surgery ▪ Pediatrics ▪ Pharmacy ▪ Post Anesthesia Care Unit ▪ Surgical Units	▪ Any area caring for immunocompromised patients ▪ Burn Unit ▪ Cardiac Cath Lab ▪ Central Sterile Supply ▪ Intensive Care Units ▪ Medical Unit ▪ Negative pressure isolation rooms ▪ Oncology ▪ Operating rooms including C-section rooms

Step 2_____

Step Three: ***Match*** **the**

Patient Risk Group (*Low, Medium, High, Highest*) with the planned …
Construction Project Type (*A, B, C, D*) on the following matrix, to find the …
Class of Precautions (*I, II, III or IV*) or level of infection control activities required.

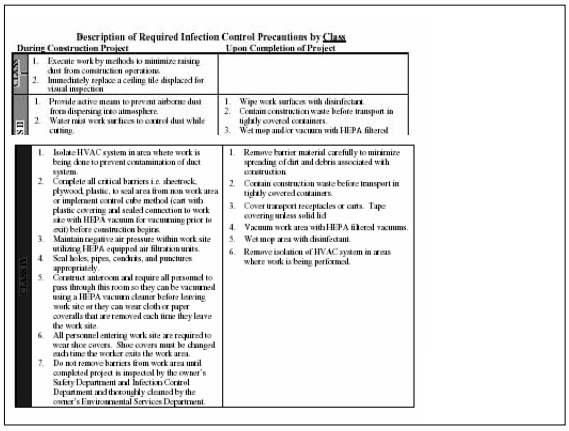
Class I-IV or Color-Coded Precautions are delineated on the following page.

IC Matrix - Class of Precautions: Construction Project by Patient Risk

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

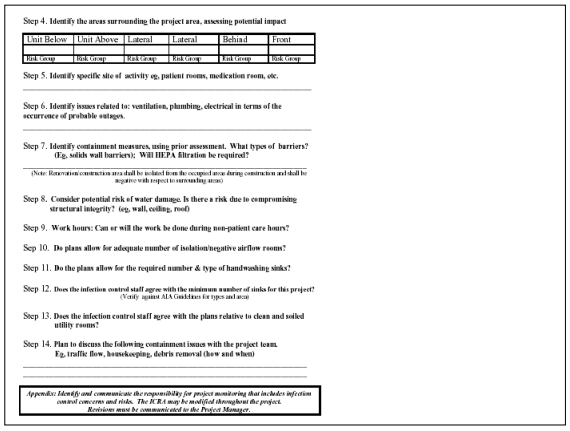
Note: Infection Control approval will be required when the Construction Activity and Risk Level indicate that Class III or Class IV control procedures are necessary.

Step 3_____



Description of Required Infection Control Precautions by Class

	During Construction Project	Upon Completion of Project
CLASS I	1. Execute work by methods to minimize raising dust from construction operations. 2. Immediately replace a ceiling tile displaced for visual inspection	
CLASS II	1. Provide active means to prevent airborne dust from dispersing into atmosphere. 2. Water mist work surfaces to control dust while cutting.	1. Wipe work surfaces with disinfectant. 2. Contain construction waste before transport in tightly covered containers. 3. Wet mop and/or vacuum with HEPA filtered
CLASS III	1. Isolate HVAC system in area where work is being done to prevent contamination of duct system. 2. Complete all critical barriers i.e. sheetrock, 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 utilizing 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 changed each time the worker exits the work area. 7. Do not remove barriers from work area until completed project is inspected by the owner's Safety Department and Infection Control Department and thoroughly cleaned by the owner's Environmental Services Department.	1. Remove barrier material carefully to minimize 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.
CLASS IV		



Step 4. Identify the areas surrounding the project area, assessing potential impact

Unit Below		Unit Above		Lateral		Lateral		Behind		Front	
Risk Group		Risk Group		Risk Group		Risk Group		Risk Group		Risk Group	

Step 5. Identify specific site of activity eg, patient rooms, medication room, etc.

Step 6. Identify issues related to: ventilation, plumbing, electrical in terms of the occurrence of probable outages.

Step 7. Identify containment measures, using prior assessment. What types of barriers? (Eg, solids wall barriers); Will HEPA filtration be required?

(Note: Renovation/construction area shall be isolated from the occupied areas during construction and shall be negative with respect to surrounding areas)

Step 8. Consider potential risk of water damage. Is there a risk due to compromising structural integrity? (eg, wall, ceiling, roof)

Step 9. Work hours: Can or will the work be done during non-patient care hours?

Step 10. Do plans allow for adequate number of isolation/negative airflow rooms?

Step 11. Do the plans allow for the required number & type of handwashing sinks?

Step 12. Does the infection control staff agree with the minimum number of sinks for this project?
(Verify against AIA Guidelines for types and area)

Step 13. Does the infection control staff agree with the plans relative to clean and soiled utility rooms?

Step 14. Plan to discuss the following containment issues with the project team.
Eg, traffic flow, housekeeping, debris removal (how and when)

Appendix: Identify and communicate the responsibility for project monitoring that includes infection control concerns and risks. The ICRA may be modified throughout the project. Revisions must be communicated to the Project Manager.

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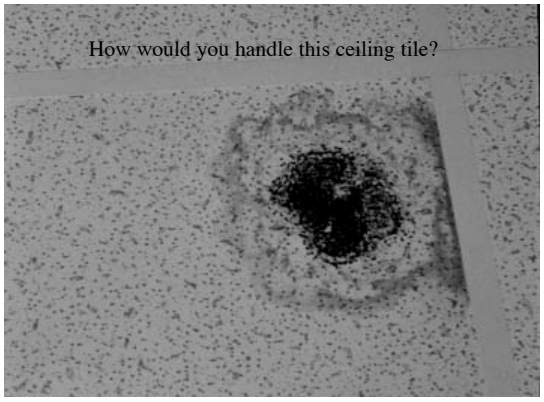
Internal Construction Risk Factor

- Dust containment, removal and moisture control
  - Educate construction workers and staff
  - Prepare the site
  - Notify staff, visitors, patients re: precautions
  - Relocating patients and moving staff as needed
  - Monitoring for adherence to infection control
  - HVAC system maintenance; water system
  - Daily clean-up and removal of debris

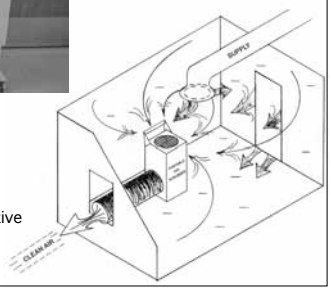
Control: Dust Containment



Portable containment on BMT unit

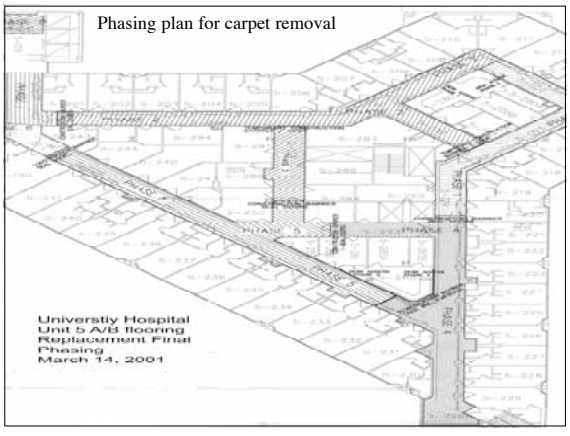
Filter verification

Portable filters
-airflow direction
-noise levels
-adaptability



Goal is to provide pressure differential and dilution ventilation to control respective airborne hazards.

Phasing plan for carpet removal



Filter in barrier
•dilution vent
•depressurization

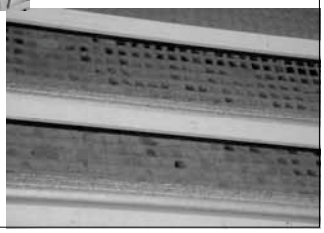
Negative pressure machine

A good idea may not work if the window is not sealed.

EXERNAL CONSTRUCTION MANAGEMENT

- Verification of existing protective ventilation
- Control of building entrances
- Window infiltration
- Utility tunnel access to construction
- Building tie-ins
- Employee training
- Street cleaning
- Emergency response

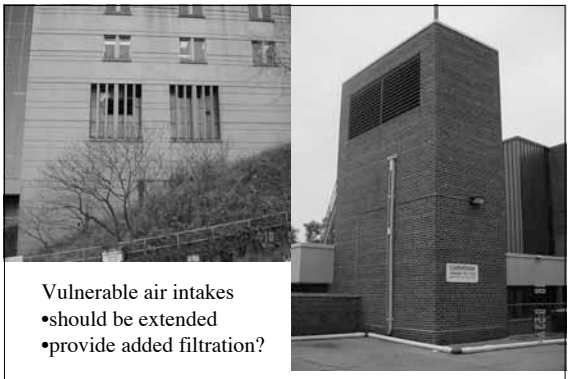
Filters not set in housing leak allowing particle bypass



Plugged air intake causes? decreased airflow

Building tie-ins can be problematic
•noise & vibration
•relocate patients
•air infiltration
•barrier management

Solutions for issues
•fan outage during penetration
•worker access control
•airflow control
•communication



Vulnerable air intakes
•should be extended
•provide added filtration?

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Ventilation Outage Planning

– Planned maintenance outages
- critical areas - time limits
- combining tasks for efficiency
- patient protection

– Emergency Outages
- backup motors, fan belts, bearings, etc.
- redundant systems in critical areas
- portable filtration contingencies

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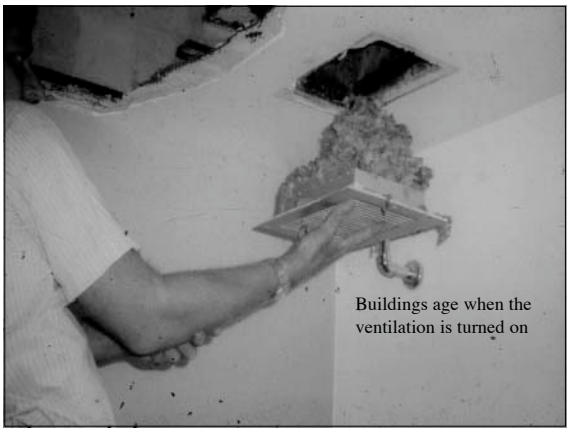
Emergency Planning for Physical Plant Disruption

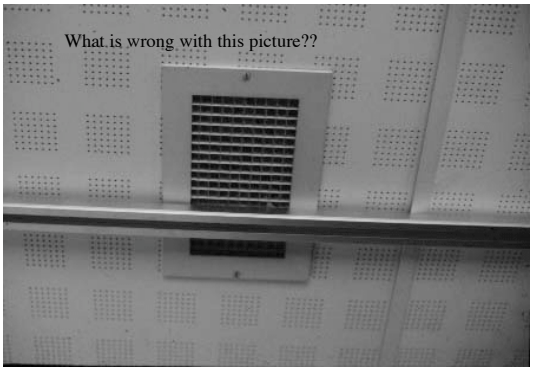
- Develop contingencies for:
  – critical ventilation
  – water supply
  – loss of steam
- Water damage control
  – notification process
  – drying time < 72 hours
  – remediation precautions if moldy
  – certification after clean-up in critical areas



Buildings age when the ventilation is turned on

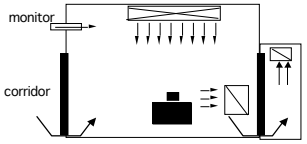
CAUSES OF VENTILATION DEFICIENCIES

PLUGGED FILTERS
PLUGGED TEMP CONTROL COILS
DUCT LEAKAGE
DUST ON FAN BLADES
FAN BELT SLIPPAGE
UNCALIBRATED CONTROL EQUIPMENT
- DIGITAL CONTROLS
- PNEUMATIC CONTROLS
  - TEMP SENSORS
  - THERMOSTAT
  - HUMIDITY SENSOR
  - RECIEVER CONTROL



What is wrong with this picture??

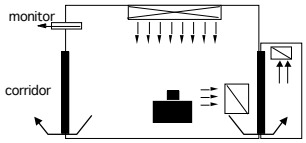
Negative Pressure Room for Airborne Infection Isolation



- negative pressure greater exhaust than supply air volume
- pressure differential @ 2.5 Pascal's or 0.01"w.g
- airflow differential >125 cfm
- sealed room, with about 0.5 sq. feet leakage
- clean to dirty, airflow
- >12 air exchanges per hour new or 6 ac/hr renovation
- monitoring
- exhaust to outside or HEPA filtered if recirculated

Intended usage's:
+procedure/treatment rooms
+bronchoscopy rooms
+autopsy
+emergency rooms

Positive Pressure Room Control for Protection From Airborne Environmental Microbes



- pressure differential @ >2.5 Pascal's or 0.01"w.g. ideal at 0.03"wg or 8 Pascal's-range from 2.5 to 8.0 Pa
- positive pressure greater supply than exhaust air volume
- greater than 125 cfm airflow differential supply vs exhaust
- sealed room, about 0.5 sq feet leakage
- clean to dirty airflow,
- monitoring
- >12 air exchanges per hour
- recirculate air back through filters

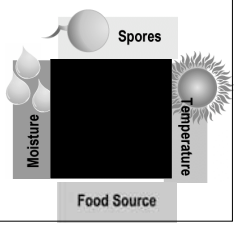
Intended usage's:
- **immune compromised patient rooms**
- **operating rooms**

- Particle counters tell the rank order
- Pressure gauges give air velocity
- Balancing hoods verify air exchanges

These parameters should be kept stable and should be checked when changes or adjustments are made in HVAC system

Water Damage Management

- Reactive
  - respond to water incident
  - determine extent of water damage
  - cut out or dry
- Proactive
  - water resistant material
  - preservative application
  - proper installation



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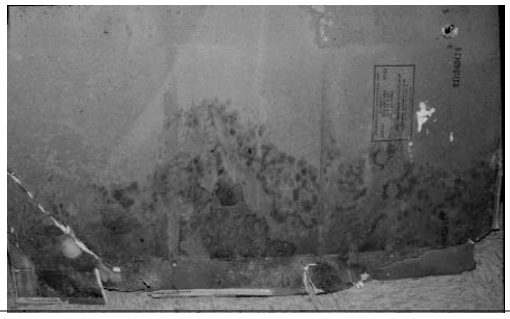
Moldy Sheetrock



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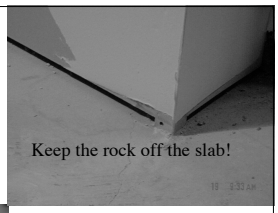
Mold Contaminated Wall Cavity

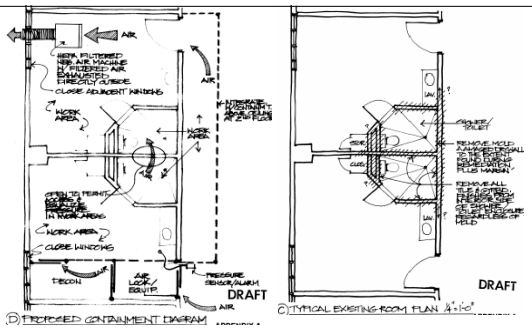
Water damage in relatively common in the janitor's closet. Water resistant materials will prove to be value added to construction and renovation. Inspections should evaluate these water damage issues.

Microbes recovered:

Even when rock is off the slab mold can grow when the water comes from above and is sealed behind the vinyl coving.



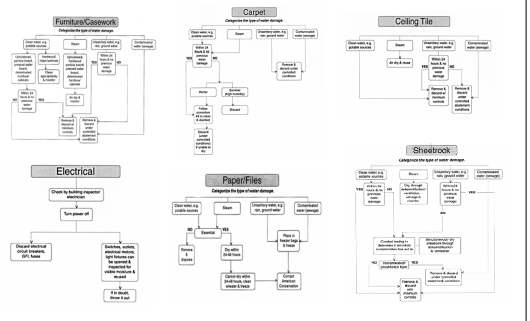
Flooding floors during cleaning & non integral coving causes sheet rock to get wet and promote mold.



Contamination area defined

Wet test meter
-decision maker
-find the wetness
-drying time
-<72 hrs
-<20% moisture content

Water Intrusion Algorithms



www.dehs.umn.edu/iaq

Moisture meters are useful decision makers for water damage mold prevention

- Keep moisture content <20%
- Maintain air movement
- Remove moisture
  - physical
  - evaporation

- Know which moisture meter to use
- Dry it out <72 hrs
- Move occupants if possible

Source management of infectious diseases

- Airborne spread infectious bacteria are relatively rare. Virus more common.
- Understand the difference of potential sources
- Environmental airborne fungi are common in some locations
- Immune compromised patients becoming more prevalent.
- Engineering controls help to minimize exposures to water bacteria and environmental mold.

Infectious Disease Management in Healthcare

•complex balance of mechanical and operational issues
•ventilation control essential to protect patients & personnel
•source management of infectious agents essential
•recognition of sources important for control
•protective measures needed for prevention of infection
•infection control risk assessment is a tool for proper means and methods in healthcare environment