"Trust but Verify"
Design, Build and Validation for Infection Control Acceptance

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www.webbertraining.com December 2, 2010

Ventilation Management in Healthcare

- Temperature and Relative Humidity Control
  - ASHRAE
- Smoke Control
  - NFPA
  - Building Codes
  - ASHRAE
- Infectious Disease Control
  - Airborne spread-TB, Measels, Chicken Pox, Aspergillosis
  - AIA, CDC, OSHA, ASHRAE

Infection Control Air Flow Management

- Airflow ventilation control with offset:
  - supply versus exhaust/return
  - clean to dirty airflow
  - greater exhaust = negative
  - greater supply = positive
- Pressure differential
  - airflow in or out of area (AIA 1996)
  - 0.01 inch water gauge (AIA 2001)
  - air flow velocity about 400 fpm
  - consistent airflow necessary for control

Why Validate?

- Existing Conditions of Ventilation Systems
  - Area control
    - Comfort and moisture management
    - Fire management
    - Infection control needs for:
      - Airborne spread infectious diseases
      - Surge of unknown infectious patients
        - » Infectious disease event
      - Construction aerosol control
        - » Potentially infectious
        - » Environmental microbes
    - Functional performance testing
      - Safety management
        - » Patient
        - » Employee
        - » visitor

CDC Environmental Infection Control Guidelines 2003

Microorganisms associated with airborne transmission

	Fungi	Bacteria	Viruses
Numerous reports in health-care facilities	*Aspergillus* spp. *Mucorales* (*Rhizopus* spp.)	*Mycobacterium tuberculosis*	Measles (rubeola) virus Varicella-zoster virus
Atypical, occasional reports	*Acremonium* spp. *Fusarium* spp. *Pseudoallescheria boydii* *Scedosporium* spp. *Sporothrix cyanescens*	*Acinetobacter* spp. *Bacillus* spp. *Brucella* spp. *Staphylococcus aureus* Group A *Streptococcus*	Smallpox virus (variola) Influenza viruses Respiratory syncytial virus Adenoviruses Norwalk-like virus
Airborne in nature; airborne transmission in health care settings not described	*Coccidioides immitis* *Cryptococcus* spp. *Histoplasma capsulatum*	*Coxiella burnetii* (Q fever)	Hantaviruses Lassa virus Marburg virus Ebola virus Crimean-Congo virus
Under investigation	*Pneumocystis carinii*	—	—

Droplet nuclei <5µm particles

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

EMERGENT DISEASES
SARS
MONKEY POX
ANTIBIOTIC RESISTANT MICROBES

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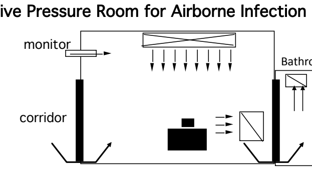
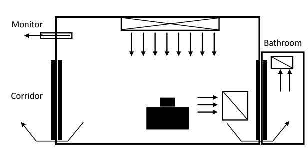
Negative Pressure Room for Airborne Infection Isolation



Positive Pressure Room for Protective Environment



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CDC EIC MMWR JUNE 6, 2003

Table 6. Engineered specifications for positive- and negative pressure rooms*

	Positive pressure areas (e.g., protective environments [PE])	Negative pressure areas (e.g., airborne infection isolation [AII])
Pressure differentials	> +2.5 Pa§ (0.01" water gauge)	> -2.5 Pa (0.01" water gauge)
Air changes per hour (ACH)	>12	≥12 (for renovation or new construction)
Filtration efficiency	Supply: 99.97% @ 0.3 µm DOP¶ Return: none required**	Supply: 90% (dust spot test) Return: 99.97% @ 0.3 µm DOP¶ ⊥
Room airflow direction	Out to the adjacent area	In to the room
Clean-to-dirty airflow in room	Away from the patient (high-risk patient, immunosuppressed patient)	Towards the patient (airborne disease patient)
Ideal pressure differential	> + 8 Pa	> - 2.5 Pa

* Material in this table was compiled from references 35 and 120. Table adapted from and used with permission of the publisher of reference 35 (Lippincott Williams and Wilkins).
§ Pa is the abbreviation for Pascal, a metric unit of measurement for pressure based on air velocity; 250 Pa equals 1.0 inch water gauge.
¶ DOP is the abbreviation for dioctylphthalate particles of 0.3 µm diameter.
** If the patient requires both PE and AII, return air should be HEPA-filtered or otherwise exhausted to the outside.
⊥ HEPA filtration of exhaust air from AII rooms should not be required, providing that the exhaust is properly located to prevent re-entry into the building.

AIA & ASHRAE DESIGN GUIDELINES FOR VENTILATION

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Environmental Risk Factors for TB Transmission

- Exposure to TB in small enclosed places
- Inadequate local/general ventilation
- Recirculation of air containing infectious droplet nuclei
- Inadequate cleaning and disinfection of medical equipment
- Improper specimen handling procedures
- Unrecognized patient

(CDC MMWR, 12/30/05)

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What ways do we have to monitor airflow and pressure?

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Airborne Infectious Diseases

Patient/Visitor	Environmental
TB	Aspergillous
VZV	Fusarium
Measles	Mucorales
RSV	Legionella
	Bacillus sp.
	Gram negative bacteria

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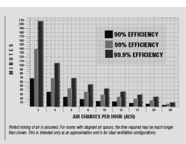
Figure 2. Particle mist created upon sneezing. (Davidhazy, 2007)

Airborne Droplet Nuclei

ACH	90% EFFICIENCY	99% EFFICIENCY	99.9% EFFICIENCY
2	69	138	207
4	35	69	104
6	23	46	69
8	17	35	52
10	14	28	41
12	12	23	35
15	9	18	28
20	7	14	21
50	3	6	8

Modified from Table B.1, CDC Guidelines for Environmental Infection Control in Health-Care Facilities, 2003.[5]



Perfect mixing of air is assumed. For rooms with stagnant air spaces, the time required may be much longer than shown. This is intended only as an approximation and is for ideal ventilation configurations.

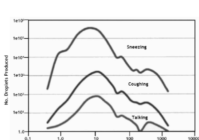


Figure 1. Size distribution of droplets formed upon sneezing (blue), coughing (pink) and talking (green) * Note: log scale (Kowalski & Bahnfleth, 1998)

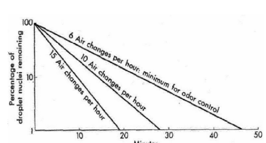


Figure 3. Effect of air exchange on droplet nuclei distribution in air. (Riley & O'Grady, 1961)

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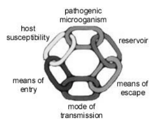
Objective for sampling

- Interpretation guidelines
  - What are we trying to accomplish?
  - What should the data show?
- Baseline data
  - Functional performance of infection control system
- Epidemiology study
  - Determine if the environment source of disease
  - Source detection
- Validation of controls
  - Assure control systems are maintaining baseline

Breaking the Chain of Infection

- Negative Pressure Isolation
  - Isolate infectious microbe to eliminate the mode of transmission
- Source Mangement
  - Direct removal of infectious pathogen from reservoir
  - Change of pathogenic reservoir environment in order to inhibit and prevent it's growth



Hospital survey summary of Airborne Infection Isolation Capability

- 678 rooms surveyed using survey and site visit objective analysis
- Most rooms do not meet AIA/CDC criteria
- Inadequate pressures in a large % of rooms checked
- Filtration analysis less than specification in a high % of air handlers checked
- Lack of written plans for negative pressure machines and surge management

A Performance Assessment of Airborne Infection Isolation Rooms,

AJIC, Vol 35:5, p324-331, 2007

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Airborne Infection Room Criteria

Table 1. Critical parameters for benchmarking AIIR performance.

All AIIRs should ...

1. Have a negative pressure differential between the isolation room and the surrounding areas of at least 2.5 Pa[4,5]
2. Have at least 12 air changes per hour[4,5]
3. Have self-closing doors leading into the isolation rooms[4,5]
4. Have a permanently installed pressure monitor[4]
5. Not have a system installed allowing the room to switch from negative to positive pressure or function as both an isolation room and a protective environment room[4,5]
6. Have ASHRAE dust spot tested filters of at least 90% efficiency installed in the supply air unit that serves the AIIR[4,5]

328 Vol. 35 No. 5 *Saravia, Raynor, and Streifel* AJIC

Table 3. Performance of AIIRs agent functional criteria

Functional criteria	Percentage of rooms meeting the functional criteria (n = number of rooms evaluated for a criterion)
Pressure differential between isolation room and surrounding areas greater (more negative) than 2.5 Pa	32% (n = 672)
At least 12 air changes per hour	51% (n = 370)
Permanently installed pressure monitor	76% (n = 566)
Ventilation system does not allow room to be used for infectious isolation and protective isolation	90% (n = 560)
Self-closing doors are installed	36% (n = 621)
Final filters are rated at ≥90% efficient	93% (n = 403)

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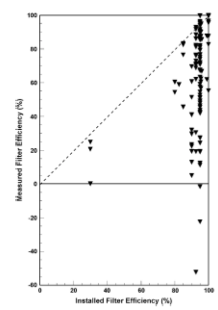

Fig 4. Triangles represent measured filter bank efficiency in air-handling units serving AIIRs versus dust spot efficiency reported by manufacturers. The dashed line is a 1:1 relationship between measured efficiency and manufacturer-reported efficiency.

Performance Evaluation of Filtration in Air Handling Systems

- Filtration at 90% rating: consider evaluation of filter bank when when the measured efficiency is below 80%.

$$\eta_{filter} = 100 \times \left(\frac{C_{pre} - C_{post}}{C_{pre}} \right)$$

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Common causes of filter leaks are:

- Loose filters
- Missing gaskets
- Missing or damaged filters
- Incorrect filters installed
- High air velocity
- Overloaded filters

Journal of Hospital Infection (2007) 67, 35–41
Available online at www.sciencedirect.com
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Ten-year air sample analysis of *Aspergillus* prevalence in a university hospital

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Received 19 September 2006; accepted 8 June 2007
Available online 27 August 2007

KEYWORDS
Aspergillus;
Ventilation;
Environmental air sampling;
Immunocompromised host; Fungal sources;
Hospital-acquired infections;
Aspergillosis

Summary Airborne fungal samples were collected on a monthly basis for 10 years, from 1995 to 2005, at a tertiary university hospital. Paired samples were cultured at 25 and 37 °C. Data were interpreted according to the air filtration systems serving each location. Samples cultured at 37 °C from the patient care areas had a mean recovery of 18% of the mean recovery from outdoor air (22 versus 122 cfu/m^3). Recovery of *Aspergillus* spp. at 37 °C in the high-efficiency particulate air (HEPA)-filtered locations was positive for *Aspergillus* spp. approximately one-third of the time; the rest of the patient care areas were positive half of the time and the outdoor samples were positive 95% of the time. We found 48 sporadic bursts at 37 °C which produced counts >3 SD above the mean. Hospital-acquired infection was related to high recovery of *Aspergillus fumigatus* on at least one occasion. We have found it impossible, without implementing impractical measures, to provide an environment completely devoid of *Aspergillus* spp. We conclude that routine air sampling is not an effective means of predicting hospital-acquired infections. However, a transient spike, or burst, may be useful in identifying an in-house source of contamination and may be used to consider additional interventional treatments for patients at risk. Emphasis should be placed on maintaining high-efficiency filtration of the outside air and on ensuring that other environmental control methods are used to prevent dissemination of environmental opportunistic fungal spores.

Table I Ventilation in each location sampled

Location	Filtering efficiency of fan (%)	ΔP[a]	Air changes per hour
BMT suite (32 rooms)	99.97	0.03	12
Patient care units	90—95	[b]	3
Intensive care unit	90—95	[b]	6
Indoor reference	65	NA	NA
Lobby	90—95	NA	NA

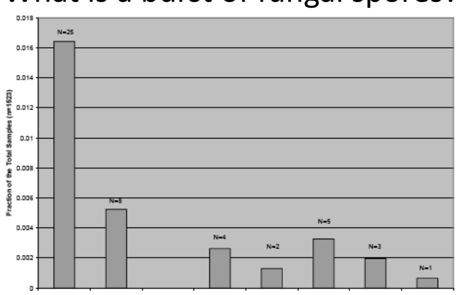
BMT, bone marrow transplant; NA, not applicable.
[a] Pressure differential of patient's room, with the door closed.
[b] Open door, no ΔP maintained.

Table II Colony-forming units per cubic meter sampled from fan-specific locations (10 years)

Location (Fan #)	Samples (N)	Total fungal counts at 25° C			Total fungal counts at 37° C		
		Mean	Median	Range	Mean	Median	Range
Adult BMT (S-11)	122	18	11	0-320	3.2	1.4	0-25
Pediatric BMT (S-9)	127	22	14	0-158	16	2.8	0-784
Patient Care Area "B" (S-11)	123	46	27	2.8-1120	16	4.2	0-1008
Hospital lobby	126	97	66	7-582	21	11	1.4-428
Outdoors	129	848	406	17-5830	122	50	0-2540

Highlights-
-range of cfu from 0 to 1008 for 37C fungi.
-control of sources more effective than searching for burst.

What is a burst of fungal spores?



A burst is >3 standard deviations above the average?
1243 SAMPLES INDOORS WITH 48 "BURSTS" EVENTS

Air Quality Surveillance
University of Minnesota Medical Center-Fairview

Airborne Fungi and Ventilation Parameters

Filtration local	cfu/m^3	Temp	% filtration
–U of MN 1962	706	35C	none
–U of MN 1982	82	35C	40
–U of MN 2002	3.6	35C	90

Infection Control Ventilation Parameters

- Air exchanges
- Pressure differential
- Airflow direction
- Particle management

IC CONSIDERATION EXAMPLES
Commissioning issues

Functional Performance Testing of Special Ventilation Rooms

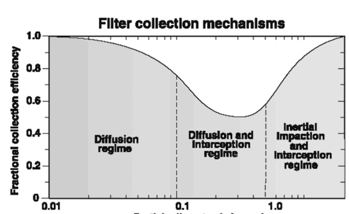
Optical particle counters

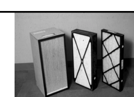
Microbial sampler high volume portable

- Air sampling devices need interpretation guidelines before sampling begins.
- Providing existing conditions information for ventilation is essential.

- Performance testing should be conducted where ventilation critical for infectious disease management. The parameters include: location, monitoring, offset, air exchanges, pressure, room size and filtration. This data serves owner with baseline information.

FILTRATION EFFICACY





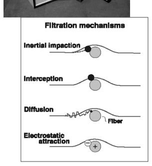


Figure 3. Four primary filter

- Impaction occurs due to inertia collision of particle with fibers
- Interception occurs due to size and the collision of particles with fibers
- Diffusion occurs from random motion causes particle contact with fiber
- Electrostatic attraction due to electrostatic force

Are aerosols preferentially removed?

Do biological particles have an electrical charge that is different than ionic crystals used to test filters?

COMMERCIAL FILTER EVALUATION USING OUTSIDE AIR: FUNGAL CFU

Filters	Efficiency	Test Method	% Fungal Particle Efficiency: Total CFU 37ºC	% Fungal Particle Efficiency: Aspergillus fumigatis
American Air Filter(AAF)	90-95%	dust spot	99.92	- -
Farr Rigi Flow 200	90-95%	dust spot	99.6	99.8
AAF - Biocel	95%	0.3µ	99.8	100.0
Air Guard M-500	95%	0.3µ	99.99	99.99
AAF - Magna Media	99.97%	0.3µ	99.99	99.98
Astrocel I	99.97%	0.3µ	99.99	99.99
Air Guard M-1220	99.97%	0.3µ	99.99	99.99

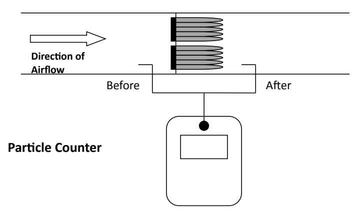
Collection of biological and non-biological particles by new and used filters made from glass and electrostatically charged synthetic fibers, Raynor, P., et al, Indoor Air 2008; 18: 51–62

Reality Check!

While the filter bank of bag filters looks good?

You might not be able to see it all.....
When filters oscillate they wear & tear.

Removal Efficiency In-Situ by Particle Size and Resistance to Flow



Depiction of particle counts before and after filtration in air handling system

Sample log for measuring particle counts APPENDIX I

This log can be used for testing portable HEPA filters as well as whole building air filters.

"PC INITIAL" and "PC FINAL" refer to the initial and final particle counts, respectively.
For testing a HEPA filter, PC INITIAL refers to the particle count at the air intake, and PC FINAL refers to the particle count at the air output of the HEPA filter.
When testing a whole building air filtration system, PC INITIAL can refer to either the particle count outside or before the filter, and PC FINAL can refer to the particle count inside or after the filter.

DATE	FAN	PC INITIAL (HEPA: Outside room; Building Air Filter: Outside/Before Filter)	PC FINAL (HEPA: Output of Filter; Building Air Filter: Inside/After Filter)	EXPECTED PERCENT REDUCTION	ACTUAL PERCENT REDUCTION ($\frac{PC_I - PC_F}{\div PC_I}$)	COMMENTS

Before filter
12176 p/ft^3

After filter
40 p/ft^3

>99% reduction

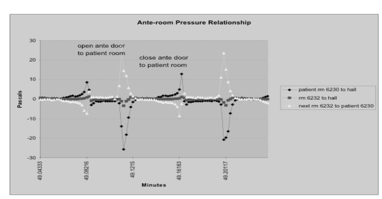
DATA DEMONSTRATE PERCENT REDUCTION OF AIRBORNE PARTICLES

Optical PC*	Before filter PC	After filter PC	Percent reduction
MERV** 12 filters	120000	24000	80
MERV 14 filters	120000	12000	90
MERV 16 filters	120000	36	99.97

Note Optical Particle Counts Are Report As Particles Per Cubic Foot.
* PC = particle counts **Particles >0.5 µm**
**MERV = minimum efficiency rating value (current ASHRAE rating system).

Rank order reduction of particles from Clean to Cleanest will demonstrate the efficacy of local filtration.

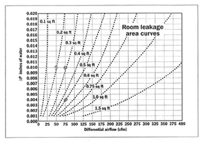
How the door swing affects pressure?



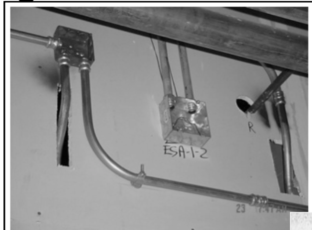
Door swing shows pressure flux depending on the seal on the room. How much air is moved with each swing?

Room Leakage Areas

- Airflow leakage occurs around:
  - plumbing connections
  - medical gases
  - electrical/video connection
  - lighting
  - ceilings
  - windows/doors
  - door cracks
  - in wall mounted fixtures



Differential room airflow vs. differential pressure for various room leakage areas. Small changes in differential airflow make drastic presssure differences in a very "tight" room. Source: Landis & Staefa.

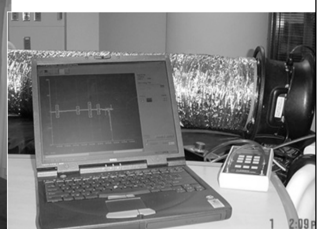


In new construction will the contractor plug these holes to control airflow?

MAYBE NOT EVERYWHERE BUT WHERE SPECIFIED FOR FIRE AND INFECTION CONTROL

HOW DO WE FIND THESE HOLES FOR AIRFLOW MOVEMENT IN A BUILDING?

Duct Blaster evaluation of AII room



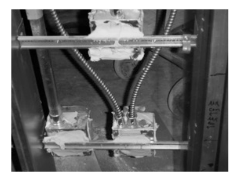
Depressurize room and record air flow volume to determine room leakage. Four AII rooms evaluated with average of 22 inch^2/100ft^2; two sealed rooms 3.1 in^2/100ft^2.

AIR TIGHT HOUSES STANDARD AT 2.5 inch^2 /100ft^2

Leakage defined as x cfm @ x pressure Pascal's or WC

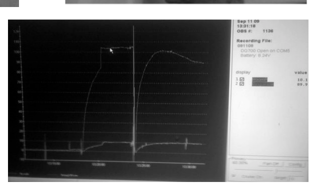
Room Seal Necessary for Special Ventilation Management

- Cracks can result in room air leakage.
- Supply air volume differential allows for airflow direction control.
- Low pressure differential can result in airflow reversal.
- Substantial room pressure design should provide a sealed "vessel".
- Design criteria are necessary for control.



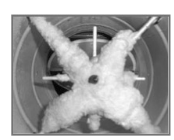
Finding leakage points in rooms helps assure consistent pressure management

Design for airborne infection isolation rooms the size at UMMC when sealed will move 84 cfm air at 10 Pascal's pressure to achieve 2.5 in^2/100ft^2 surface area. Leakage at about 0.1 cfm/ft^2.



Causes of Ventilation Deficiencies

- Plugged Filters
- Plugged Temperature Control Coils
- Duct Leakage
- Dust on Fan Blades
- Fan Belt Slippage
- Uncalibrated Control Equipment
  - Digital Controls
  - Pneumatic Controls
    - Plugged sensors



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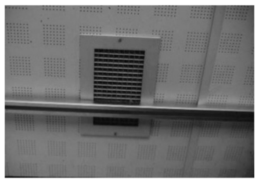
Ventilation deficiencies can affect airflow direction

Flexible duct not properly installed caused condensation & mold

What is wrong with this picture??



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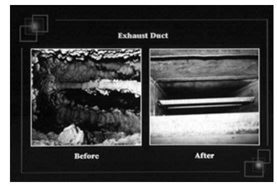
Buildings age when the ventilation is turned on.

Which side moves more air??



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Age of Air Concept for particle movement

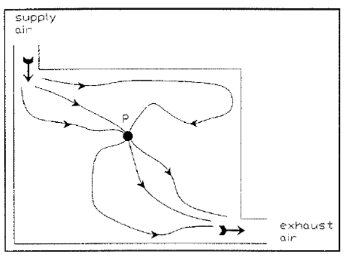

Figure 1. Diagram to illustrate the concept of "age of air." Parcels of air starting at the supply (top left) may reach the point "P" by many possible routes and take different times to get there; so, the age of individual parcels of air arriving at P may be described by a statistical distribution function.

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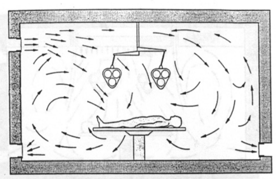


Figure 5 Conventional wall supply (turbulent).

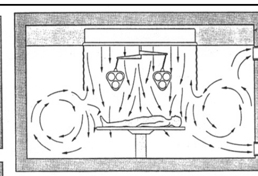


Figure 11 Unidirectional downflow with curtains (Schmidt 1987).

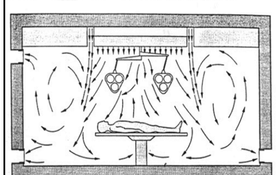
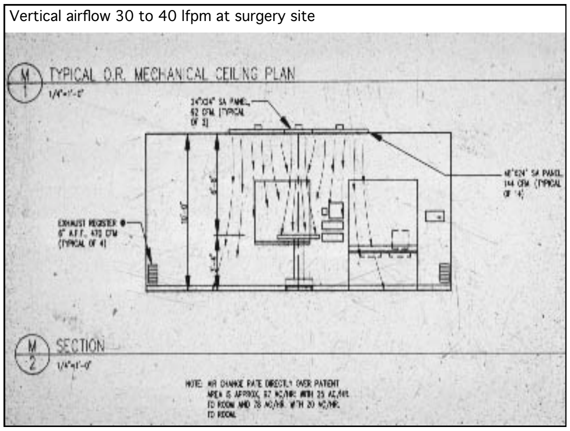


Figure 9 Air curtain around the working area (Schmidt 1987).

The airflow pattern in OR's must overcome thermal buoyance and maintain a down ward flow of air

Vertical airflow 30 to 40 lfpm at surgery site



Operating room issues:

Smoke from:
- -electro-cautery
- -laser

Aerosol from:
- -saws
- -blood spatter

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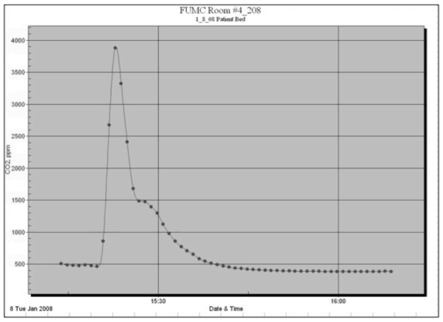

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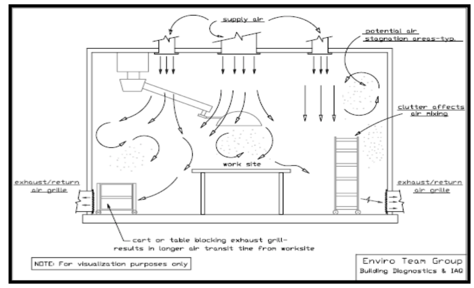

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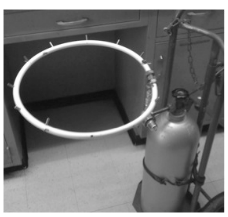
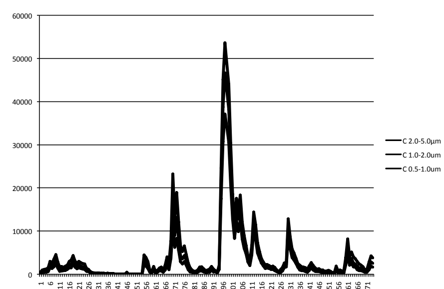
Advances in airflow evaluation in operating rooms



Airflow can be demonstrated when timing the release of gas or particle to the extractor grill. Then covering extractors and allowing gas to build to higher concentration and when extractors uncovered measure rate of decrease.

Surgical Smoke Generated During Hip Resection



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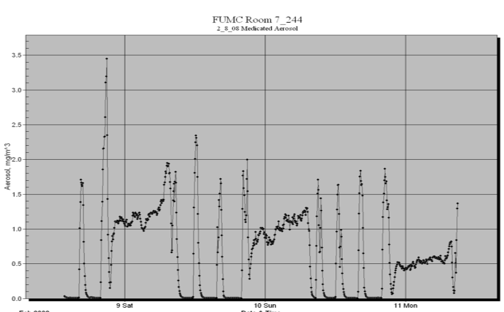

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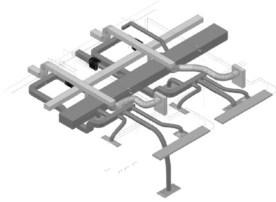
Interpretation of Data

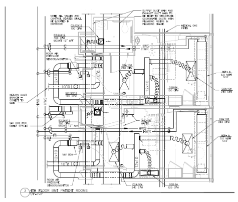
Particle Counters & Construction

- Particle counts compared to outside
  - Per cent reduction approximation
  - Particle size and construction
  - Stop work guidance
- Local controls when sampling
  - Set up levels of project expect high counts
    - Know the aerosol
  - Critical to operation rooms, bone marrow transplant, oncology, neonates, burn unit
    - Lowest levels before and after
  - Ventilation management controlling dirty air
    - Exhaust ventilation out of space
    - Recirculation of HEPA filter
    - Negative pressure

CEILING REAL ESTATE

CEILING PROPERTY FILLS UP FAST TO PROVIDE MULTI FUNCTION OF THE CEILING COMPONENTS





SCHEMATIC DESIGN DOES NOT ALLOW FOR CEILING COMPONENT UNLESS PREPLANNING OCCURS

Ceilings are more difficult to seal especially with lifts being installed in patient rooms.

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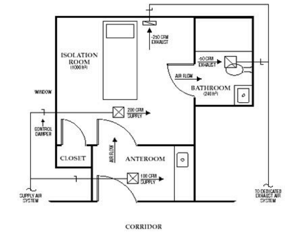
AIR BALANCE VALIDATION

Special Ventilation Rooms: AIIR, PE, OR & Procedure Rooms



-Supply and exhaust/return location
-validate volumes
-seal room for efficiency
-validate pressure differential
-assure filter installation
-determine air exchanges/hour
-if necessary; age of air for room particle removal

Ante Rooms are not required as a minimum except in certain states.

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Functional Performance Testing

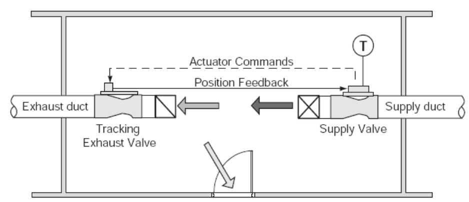
Baseline Data for Future Reference

Unit	Room # FMG	Actual Room #	Room Name	BAS MONITORING ONLY	LOCAL DISPLAY WITH ALARM	AC/HR	dif.pres sure	off-set	ROOM POSITIVE/ NEGATIVE	SQ. FT.	S CFM
ED	A1547	8	INFECTIOUS Negative Airflow Rm	Monitored by BAS only	***	22	-.006	-125	(-)	135	350
ED	A1549	9	INFECTIOUS Negative Airflow Rm	Monitored by BAS only	***	25	-.006	-125	(-)	120	350
ED-OBS	A1602	B	INFECTIOUS Negative Airflow Rm	***	Local display and alarm	17.7	-.002	-100	(-)	150	300
ED	A1663	38	PROTECTIVE Positive Airflow Rm	Monitored by BAS only	***	17.7	.001	125	+	130	500
ED	A1661	39	PROTECTIVE Positive Airflow Rm	Monitored by BAS only	***	17.7	.001	125	+	135	500
ED	A1649	40	PROTECTIVE Positive Airflow Rm	Monitored by BAS only	***	17.7	.001	130	+	150	500
OR	A2536	1	OR 1 Positive Airflow	***	Local display and alarm	27.3	.015		+	435	1980
OR	A2542	2	OR 2 Positive Airflow	***	Local display and alarm	28.7	.025		+	460	1980
OR	A2544	3	OR 3 Positive Airflow	***	Local display and alarm	29	.017		+	425	2090
OR	A2548	4	OR 4 Positive Airflow	***	Local display and alarm	29	.030		+	430	2090
OR	A2587	5	OR 5 Positive Airflow	***	Local display and alarm	29	.022		+	425	2090
PICU	A3955	4	PROTECTIVE Positive Airflow Rm	***	Local display and alarm	13.5	.006	200	+	260	525
PICU	A3965	5	PROTECTIVE Positive Airflow Rm	***	Local display and alarm	13.5	.001	200	+	260	525
PICU	A3880	14	PROTECTIVE Positive Airflow Rm	***	Local display and alarm	17.9	.001	E VAV	+	260	700
PICU	A3870	15	PROTECTIVE Positive Airflow Rm	***	Local display and alarm	17.9	.002	E VAV	+	260	700
PICU	A3975	6	INFECTIOUS Negative Airflow Rm	***	Local display and alarm	20.9	no test	patient	(-)	255	600
PICU	A3985	7	INFECTIOUS Negative Airflow Rm	***	Local display and alarm	19	-.010	-300	(-)	280	600
Kidney Center	A4095	?	INFECTIOUS Negative Airflow Rm	***	Local display and alarm	15	-.004	-150	? supposed to be (-)	175	400
NICU	A4355	50	PROTECTIVE Positive Airflow Rm	Monitored by BAS only	***	8.5	.001	100	+	235	300
NICU	A4365	51	PROTECTIVE Positive Airflow Rm	Monitored by BAS only	***	8.5	.001	100	+	235	300
NICU	A4930	1	INFECTIOUS Negative Airflow Rm	***	Local display and alarm	21.2	-.014		(-)	235	550
NICU	A4940	2	INFECTIOUS Negative Airflow Rm	***	Local display and alarm	21.2	-.014		(-)	235	550
7 - Onc	A7370	704	PROTECTIVE Positive Airflow Rm	Monitored by BAS only	***	14.7	.073		+	240	530
7 - Onc	A7485	712	PROTECTIVE Positive Airflow Rm	Monitored by BAS only	***	15.5	.016		+	220	530
7 - Onc	A7475	713	PROTECTIVE Positive Airflow Rm	Monitored by BAS only	***	15.3	.056		+	230	530
7 - Onc	A7465	714	PROTECTIVE Positive Airflow Rm	Monitored by BAS only	***	14.7	.054		+	240	530
7 - Onc	A7445	715	PROTECTIVE Positive Airflow Rm	Monitored by BAS only	***	14.7	.043		+	240	530
7 - Onc	A7313	with 724	ANTE ROOM	***	Local display and alarm	24	-.115		(-)	81	100
7 - Onc	A7315	724	INFECTIOUS Negative Airflow Rm	***	Local display and alarm	20	.078		* +	210	650
7 - Swing beds	A7380	705	PROTECTIVE Positive Airflow Rm	***	Local display and alarm	14.7	.043		+	240	530
7 - Swing beds	A7420	706	PROTECTIVE Positive Airflow Rm	***	Local display and alarm	14.7	.091		+	240	530
7 - Swing beds	A7430	707	PROTECTIVE Positive Airflow Rm	***	Local display and alarm	14.7	.074		+	240	530
7 - BMT	A7440	708	PROTECTIVE Positive Airflow Rm	***	Local display and alarm	14.7	.056		+	240	530
7 - BMT	A7460	709	PROTECTIVE Positive Airflow Rm	***	Local display and alarm	14.7	.030		+	240	530
7 - BMT	A7470	710	PROTECTIVE Positive Airflow Rm	***	Local display and alarm	15.3	.024		+	230	530
7 - BMT	A7474	with 711	ANTE ROOM	***	Local display and alarm	23.5	-.12		(-)	85	100
7 - BMT	A7480	711	INFECTIOUS Negative Airflow Rm	***	Local display and alarm	20	.068		* +	240	725

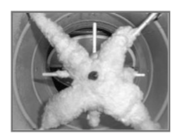
* Anteroom is negative to the hallway and the patient room is positive to the ante room.
RED is negative airflow room. BLUE is positive airflow room
BAS = Building Automation System (Centrally monitored)

List:
-patient care unit
-room number
-type of room
-monitoring system
-local display monitor
-AC/hr
-differential pressure
-offset
-airflow direction
-room size square feet
-supply volume
-return/exhaust volume

VAV Tracking Pair



Plugged airflow sensing devices will not function as designed which can affect infection prevention ventilation.



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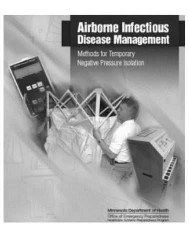
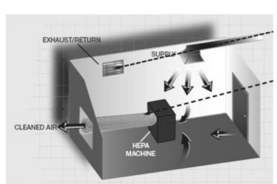
Contaminated air must be controlled





Training manual for temporary negative pressure isolation can be found at:
http://www.health.state.mn.us/oep/training/bhpp/airbornenegative.pdf

Proof of Containment

- Barriers for containment must show pressure differential (sides pull in as if under a vacuum)
- Differential pressure check with digital pressure gauge

How to Validate: Tools

- Pressure Gauges
  - Airflow management
    - Test locations
    - Intensity of airflow
    - Direction consistency
    - Interpretation
    - Velocity and pressure

IC CONSIDERATION EXAMPLES

Construction Management & Commissioning issues

Interpretation of Data Pressure

- •Develop baseline information
  - -before, during and after construction
- •Airflow direction and intensity
  - -clean to dirty airflow into construction site
  - -air velocity and pressure
    - •0.01 inch water column about 400 linear feet per minute
    - •ideal around 0.02 to 0.03 in. WC harder to achieve
    - •pressure gauge sensitive to 0.001inch water column
- •Airflow control in Surgery Projects
  - -keep operating rooms pressurized
  - -maintain consistent airflow
  - -know existing conditions
- •Return airflow and pressure to pre construction testing
  - -cooperation between contractor and user

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

THESE PARAMETERS DEMONSTRATE
EXISTING VENTILATION CONDITIONS

These parameters should be kept stable and should be checked when changes or adjustments in the HVAC system occur.

Source management methods for environmental disruption will help contain mold spores better than looking for the mold spores than wondering what to do.

Biological testing in USP 797 Pharmacy Manufacturing

Location	25C fungi	35C bacteria + fungi
Outdoors	700	80
Ante area	16	6
BSC	<2	<2
Fill area	18	8

Data Interpretation Guidelines
- •rank order (clean to cleanest)
- •Comparison data
- •qualitative
- •temperature

Realities:
- •culture results are too late
- •emphasis on training & asepsis
- •unusual event protocols

Interpretation of Owner's Acceptance Criteria

Air quality
- -clinical application
  - bone marrow, operating rooms, pharmacy

Water quality
- -clinical application
  - laboratory, dialysis, stagnant reservoirs
- -drinkable
  - not sterile

These require specific objective information for TJC and Baseline data

Cleaned surfaces
- -non porous

Control of the environment for patient safety
- -interdisciplinary team overview includes issues from slips to infectious diseases

Pressure Management in Healthcare

- Airborne infectious disease
  - Patient & procedure rooms
  - Surge capacity for emerging infectious diseases
- Fire & smoke
  - Will IBC affect ID management?
- Building pressure
  - Infiltration of moisture and other….
- Construction zone
  - Dust aerosol control
- What is an appropriate pressure gradient?
  - Air velocity to control particle movement.

Questions?

Amplatz Children's Hospital University of Minnesota-Fairview
March 26, 2011