How to Enhance IAQ

Remediation

Source – Pathway - Stakeholders

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President
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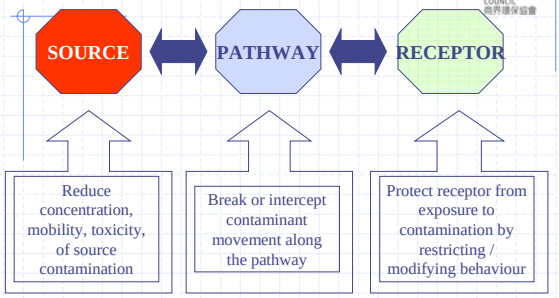
Pollutant Pathway

Source: Environmental-Agency, UK



Source Control

- Reduce concentration, mobility & toxicity, of source of contamination
- Outdoor
- Indoor

Pollutant Pathway

- "The direction through which a stream of contaminants travels. Most commonly, an air pathway or water pathway" *1
- "Airflow patterns in buildings result from the combined action of mechanical ventilation systems, human activity, and natural forces." *2

Source: *1 The Ecology Programme, Olympic Co-ordination Authority, Sydney 2000.
*2 EPA

Pollutant Pathway

- Air distribution zones (AHU $^{1...n}$)
- Partition Walls (non-concrete)
- Ceiling Plenum
- Elevator Shafts
- Stair cases
- Any cracks and openings and channels

Pollutant Pathway

- What moves pollutants via pathways
  - Pressure differential (design or faulty sy.)
  - Human movement
  - Obstructions (filing cabinets, partition walls)
  - Stack effect (hot air rises)
  - Wind (transient)

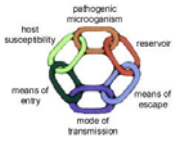
Pollutant Pathway

- Pressure differential creates:
  - Closed circulation of pollutant in a room
  - Air movement into adjacent spaces with pollutant
  - Re-circulation of air / pollutant within zones where return systems overlap
  - Infiltration of outdoor air or reentry of exhaust air

Pollutant Pathway

- Human movement
- Obstructions (filing cabinets, partition walls)
- Stack effect
  - movement from lower to upper floors of the building
- Wind
  - creating local areas of high /low pressure

Break the Chain / Pathway



University of Minnesota, Department of Environmental Health and Safety.

Remediation

- Solutions for As-built IAQ Problems
- i.e. SBS "medication"
- Cure not Prevention
- Design-built = Prevention
- O&M = Prevention

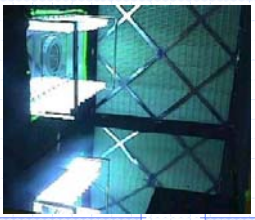
Agenda

- Three Prong Approach – Office/Public Places
  - National Energy Management Institute
    - Pollutant Source Control
    - Dilution
    - Air Treatment
  - STANLEY A. MUMMA, Ph.D., P.E., ASHRAE Fellow
    - DOAS
- Mold Remediation
- More Contaminants & Solutions
- Three Prong Approach – Healthcare Facilities
  - Douglas Kosar
    - Dilution
    - Filtration
    - UVGI

In-duct UVGI installation

UVGI lamps are installed inside an air duct to disinfect air.

- **The number and spacing of the lamps is selected to ensure that air in the duct is exposed to sufficient radiation.**
- **The exposure depends on the intensity of the radiation and the time of exposure.**



IAQ Solutions

- National Energy Management Institute
  NEMI found that 75% of all IAQ investigations recommend HVAC system repairs or replacements as key solutions.

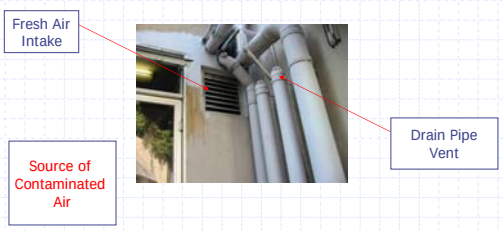
Three Basic Strategies

- Every IAQ investigation is unique and the solutions are always tailored to solve the specific problem
  1. Control pollutants at the source
  2. Dilution (i.e., improve ventilation)
  3. Treatment (e.g., filtration)

1 Control Pollutants at Source

- Local, dedicated exhaust systems remove concentrated pollutants before they can spread.
- Remove and replace the offending product or material, if possible.
- Replace equipment or processes, if possible.
- Limit the locations of certain activities to specific areas.
- Improve accessibility of HVAC ductwork and equipment for maintenance and cleaning.

FA Intake & Drain Pipe Vent



2 Improve Ventilation (Dilution)

- " Dilution/removal is a common ventilation principal. "

Adequate Ventilation

- Maintaining the air quality at an acceptable level for optimum human comfort and health throughout a building
- Standards for ventilation established under ASHRAE Standard 62, based on the maximum possible number of occupants in the building
- how to avoid wasting energy by unnecessarily overventilating
- solution to this problem is found in the methods used to control the ventilation, such as time-based ventilation or demand-based ventilation using CO2 sensors and mixed gas sensors

Treat the Air Stream

- To remove offensive impurities
- To some degree, most buildings already treat air to improve its quality to comfort: cooling coils remove hear and humidity, and filters remove particles
- UVGI
- Others

Treat Air Stream?

Treatment [Cleaning]

Techno.	Application	Pro's: Effective	Con's
Dilution Ventilation	Purging of Indoor pollutants	Vs all Chem /Bio Pollutants	Need high ACH, [Energy] costly
Filtration	Remove airborne particulates	Vs large airborne particles	Effectiveness depends on efficiency, Costly
UVGI	Disinfection of airborne pathogens	Vs virus & many bacteria	High power requires for spores, costly
Carbon Adsorption	Removal of gases & vapor	Vs airborne chemical pollutants	Little effect on microbes

Filter Classification / Rating

- Dust Spot Efficiency [DSP] (%)
- Total Arrestance (%)
- EU Standard [EN 1822]
- Minimum Efficiency Reporting Value [insufficient data to rate all]

European Norm - EN 1822

- A two part test that identifies the particle size that penetrates the HEPA filter most easily, hence the name MPPS (Most Penetrating Particle Size)

EN 1822

- Released in the year 2000
- An advanced and stringent air filter standard for particulate filters

Filter Class	Overall Value	
	Efficiency (%)	Penetration (%)
H10	85	15
H11	95	5
H12	99,5	0,5
H13	99,95	0,05
H14	99,995	0,005
U15	99,999 5	0,000 5
U16	99,999 95	0,000 05
U17	99,999 995	0,000 006

BUSINESS ENVIRONMENT COUNCIL 商界環保協會

EN 1822 Class

Performance assessment of HEPA and ULPA filters.

E % @ 0.3 µm		E % @ MPPS
95	H10	85
98	H11	95
99.99	H12	99.5
99.997	H13	99.95
99.999	H14	99.995

E % @ 0.12µm		E % @ MPPS
99.9995	U15	99.995
99.99995	U16	99.99995
99.999995	U17	99.999995

E % = Mean fractional efficiency for HEPA & ULPA filters in the classification range H10 - U17.
MPPS = Most penetrating particle size.

What to Filter?

- **Fungal / Bacteria Spore size: 1-20 micron (µ m)**
- **Virus 0.2 – 2 µ m**

Pathogen	Group	Size Range [dia µ m]
Bacillus anthracis	Bacterial Spore	1-1.25
Legionella pneumophila	Gram–ve Bacteria	0.3-0.9 x 0.6-2
Stachybotrys chartarum	Fungal Spore	5.1-6.2

Filter types & rating [ASHRAE52]

Filter Type	Applicable Size Range	DSP Efficiency %	Total Arrestance %	MERV Rating [Estimate]
Dust Filters	> 10 µ m	< 20	<65	1
		< 20	65-70	2
		< 20	70-75	3
		< 20	75-80	4
High Efficiency	3-10 µ m	< 20	80-85	5
		< 20	85-90	6
		25-35	>90	7-8
	1-3 µ m	40-45	>90	9
		50-55	>95	10
		60-65	>95	11
		70-75	>98	12
	0.3-1 µ m	80-90	>98	13
		90-95	NA	14
		>95	NA	15

IDENTIFYING CULPRITS

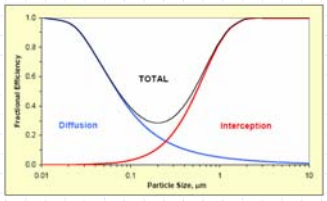
- IAQ problems are one area where one plus one might equal four
- No single method or piece of equipment can solve all IAQ problems

CULPRITS

Disconnected Fresh Air Intake

Compressor for Cooler

Summary: Dilution + Filtration

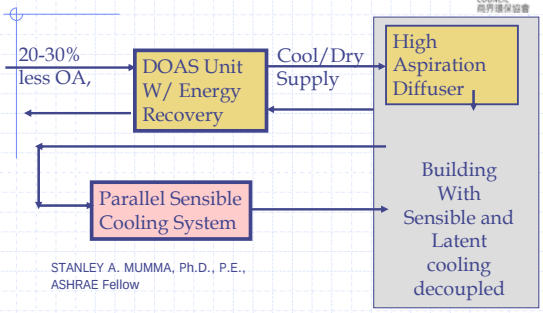


Generalized performance curve for a MERV 15 filter showing components.

Source: J.Kowalski

DOAS - New Paradigm

The New Paradigm Illustrated



STANLEY A. MUMMA, Ph.D., P.E., ASHRAE Fellow

Energy Saving

Table – U.S. Dept of Energy Top 15 Energy Saving Technologies

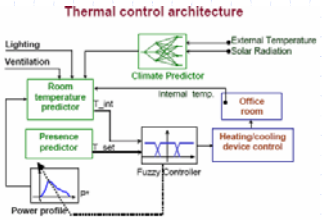
Technology	Status	Energy Savings in Quadrillion BTUs (quads)
Adaptive/fuzzy logic controls	new	0.23
Dedicated outdoor air systems (DOAS)	current	0.45
Displacement ventilation	current	0.20
Electronically-commutated Permanent magnet motors	current	0.15
Enthalpy/energy recovery heat exchangers for ventilation	current	0.55
Heat pumps for cold climates (zero-degree heat pump)	advanced	0.10
Improved duct sealing	current/new	0.23
Liquid desiccant air conditioners	advanced	0.2/0.06
Microenvironments/occupancy-based control	current	0.07
Microchannel heat exchanger	new	0.11
Novel cool storage	current	0.2/0.03
Radiant ceiling cooling/chilled beam	current	0.6
Smaller centrifugal compressors	advanced	0.15
System/component diagnostics	new	0.45
Variable refrigerant volume/flow	current	0.3

Fuzzy Logic Controls

- Fuzzy controller uses the current and predicted comfort levels to adjust the power profile
- Incorporates the information about presence and future presence of the user & follow very precisely the set-point temperature to avoid unnecessary heating or cooling when the user is away
- Anticipates the solar energy gains
- Contrarily to a classical controller, the user presence is also treated as a fuzzy variable, which fits very well with the reality of office hours

Fuzzy Logic Controls

Thermal control architecture



Fuzzy Logic 'logic'

- Valve position controlled by a set of rules that takes into account the current comfort level and the predicted future comfort level & corresponding fuzzy algorithm
- Rules generated by three "Predictors"
  - Climate
  - Room Temperature
  - Occupancy