Identification and Resolution of IAQ Problems

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Indoor Air Quality

• Sick building
• HVAC issues
• Odors
• Renovations
• Processes- photocopiers, printers, plants
NIOSH Review of IAQ causes 1983

• 50 % ventilation problem
• Process internal – regular / periodic
• Building itself or contents
• Process external
• Smoking - Vaping
• 10% No resolution
• Water infiltration / Fungi / allergen
Indoor Air Quality Investigation

- Energy conservation
- IH needed to learn new skills
- Typically non industrial area- office etc
- Complaints typically eye irritation, nasal congestion, sinus problems, headaches
- Individual or Sick Building
Employee Complaints - Productivity

Who
What – Symptoms, odor
When
How often
How long

Ask questions – Create Log - Questionnaire
IAQ - Major Components

• Outside air - CO2- ASHRAE – 700 above outside
• Temp, Humidity, Breezes (doors, vents)
• Formaldehyde
• Carbon monoxide
• Fungi
• VOC’s
• Dust
IAQ Other - Common allergens

- Pollen – Seasonal - Tree, weeds
- Cat Dander
- Dust Mite proteins
- Latex proteins
- Dog, mouse, rat, cockroach Dander
- Fungi
Allergy Symptoms

• Itchy watering eyes
• Running nose - congestion
• Rashes - Hives
• Can effect breathing – Swelling - Asthmatics
• 99.9 % temporary
• Anaphylaxis – Shock - Antihistamines
Acceptable levels? GREAT Latitude

• ASHRAE
• OSHA
• TLV – Ozone?
• Target Indoor Air Levels - Background
• Non Industrial 1/10 TLV
• LEED
Carbon Dioxide  ppm

• OSHA  5000
• TLV  5000 TWA  30000 STEL
• NIOSH IDLH  50000

• ASHRAE  700 over outside  WHY??
• Background  1990 350  2019 400
<table>
<thead>
<tr>
<th></th>
<th>Formaldehyde  ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OSHA</strong></td>
<td>0.75 TWA</td>
</tr>
<tr>
<td><strong>TLV</strong></td>
<td>0.30 Ceil (Sen)</td>
</tr>
<tr>
<td><strong>ASHRAE</strong></td>
<td>0.10  makeup air</td>
</tr>
<tr>
<td><strong>USGBC</strong></td>
<td>0.025 4 hr</td>
</tr>
<tr>
<td><strong>NIOSH REL</strong></td>
<td>0.016 TWA</td>
</tr>
<tr>
<td><strong>Background</strong></td>
<td>0.005-0.030</td>
</tr>
<tr>
<td><strong>2 STEL</strong></td>
<td>0.1 ppm TWA</td>
</tr>
<tr>
<td><strong>0.1 STEL</strong></td>
<td></td>
</tr>
</tbody>
</table>
Ventilation

• Rooftop units
• Unit ventilators or Heat pumps
• Radiators
• Combination – VAV boxes - electric
• Air plenum or direct duct returns
• Outdoor air or not – open or closed
• Fans – Auto/Constant on
• 20 cfm / person outdoor air
HVAC Evaluation – Building Science Corp – Joe Lstiburek
Temperature - Office

- ASHRAE- Table indicate range of temps based on humidity
- Summer  72.5 - 81 F
- Winter  68 - 76 F
- 20% dissatisfied no mater what – Set at 70-74 F and let people cloth appropriately
- Over 75-76 F will have complaints
- Expectations Home verses office inconsistency

- My home is 68-72 and 74-76
Humidity

• 30-60% optimal
• <30 % dry and irritation – Northeast Winter
• >70% condensation and mold possible

• Recommend Humidification?
Employee solutions

• Plants-

• Keep Warm – turn up thermostat or space heater

• Filter the dust/air - DO NO HARM
NIOSH Review of IAQ causes  1983

• 50 % ventilation problem
• Process internal – regular / periodic
• Building itself or contents
• Process external
• Smoking
• 10% No resolution
• Water infiltration / Fungi / allergen
Workplace examples – Impact - Take action

• Employee compliant of stuffy and discomfort at work
• Employee complaints over 6 months – others now agree- results in building evacuation
• Occasional odors in recently renovated outpatient clinic- Summa - 1,2 Dichlorethene and pentafluoropropane
• Employee complaints of burn like odors and headaches in afternoon
Insulation - UFFI, Fibrous glass, Isocyanates

- Energy Conservation
- Saves Money on heating - cooling
- Tighter- less air exchanges
- Potential for higher Formaldehyde and other VOC’s
- Potential for off gas of foam itself
- TRADE OFF
Isocyanates

- OSHA NEP
- Used in paints and foams – Blowing agents
- Resp Sensitizer (skin)
- TDI used less than MDI and now HDI
- Use less monomer and more oligomer
- 5ppb TLV  20ppb OSHA STEL
Homeowners cases

• Builder indicates wife experiencing fatigue at home.

• Buyer of home felt slight irritation similar to carpet store irritation – her and daughter sensitive

• Semiretired engineer renovated area above garage. Energy credit but wife cannot stay in room.
Incidents

• Furnace Blow back -
• Water damage and repair -
• Fire damage - smoke, soot, chemicals, water damage
Flagrances – Do not make things worse

• Masking agents- cover up
• Pinene - pine/turpentine – 20 ppm TLV
• Limonene – lemon, citrus – 30 ppm WEEL
• Benzaldehyde – Almond – 2 ppm WEEL
• Cinnamaldehyde – cinnamon - ????
• Diacetyl – butter odor
Global Markets – Relearn past solutions

• Historical Knowledge gets lost (lead, mercury, UFFI now Isocyanates)
• Lead in toys, consumer products
• CPSC new reg on Lead in consumer products
• Sourcing – cheapest, quality, still meets spec, change origin of chemical
Global Markets – Rapid Demand

• Latex allergy – Blood Bourne Pathogens
• FEMA Trailers – Formaldehyde
• Container Shipments – Formaldehyde, VOCs
• Plant openings – Plant closings
• Chinese Drywall – Sulfur
Fungi Evaluation

• Look for moisture- stains, discolored tiles
• Determine if mold present – sticky tape, swab
• Note material type, length of time wet, condition
• Wood, chipboard, particle board, sheetrock
• Mold Candy
• Collect indoor and outdoor/ non problem samples
• Construction sites- water protection
IAQ - CO₂ measurement

• Direct reading - Interferences

• Drager tubes
Passive Sampling

- NO PUMPS - Easy

- Diffusion

- Vapors / Gases

- Colorimetric (active / passive)

- Direct Read vs Lab Analyzed
Classic IH pump-and-tube sampling

- Sample train:
- Solvents or gases captured and recovered from charcoal or other solid sorbent media
- Formaldehyde, phenol and others require a special tube
Benefits of Canisters, EPA TO15

Pumpless Sample Collection
- Can regulate flow from 5 sec to 1 day
- No flow rates to adjust or calculate in field

Ease of Use
- Single Connection or valve
- Non technical person can collect samples

Wide Application Range
- Polars/Alcohols
  - Gases, Freons
  - No multiple tubes
  - No special tubes
- Formaldehyde
Environmental sampling (ppb)
Water, soil vapor, indoor air
Fungi

• Fungi – reproduce by spores
• Spores like seeds
• Germinate to produce new mold colony
• Diverse but same for a specific genus
Fungi defenses - byproducts

• Yeast + sugar = ethanol + 1000 chemicals
• Odors
• Antibiotics – penicillin
• Mycotoxins – Stachybotrys – 1930 animals/poor
• Aflatoxins – Corn – 2005 Diamond Pet food
Fungi – Bacteria Needs

• Fungi - Water activity > 0.65
• Bacteria – Water activity > 0.90
• Food – carbohydrates, cellulose
• Temperature – refrigerate, hot water
Fungi Health Effects

• Predominately allergy irritant type symptoms (5%)

• At high levels potential of Anaphylaxis (Asthma)

• Immune compromised (AIDS/Hosp) – lung infection (asp fumigatus/pen marneffei)

• Toxic effects – mycotoxins (stachy), aflatoxin (corn)
Viable vs non viable

- Non Viable (spore trap)
  - Collects all allergens
  - Results in 1-3 days
  - One media collects all
  - Cannot speciate
  - Can overload with dust

- Viable
  - Only living will grow
  - Results in 6-14 days
  - Multiple plates needed
  - Can speciate
  - Colonies overgrow
Other mold tools

- Moisture meter –
- Conductivity and IR capabilities
- Boroscope
- IR scanners/meters
Bulk sample collection

• Sample of bulk material -- destructive

• Sticky tape/slide – direct exam

• Swab -- direct exam and/or culture
Spore trap impaction

Flow rate dependant
Viable sampling
ID by size, color, shape

- *Penicillium*
- *Curvularia*
## Typical Fungi Genus

<table>
<thead>
<tr>
<th>Indoor</th>
<th>Outdoor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asp/pen</td>
<td>Cladosporium</td>
</tr>
<tr>
<td>Cladosporium</td>
<td>Basidiospores</td>
</tr>
<tr>
<td>Stachy</td>
<td>Ascospores</td>
</tr>
</tbody>
</table>
Water Intrusion molds

Aspergillus/Penicillium
Stachybotrys
Chaetomium
Ulocladium/Stemphylium
Interpreting Air Samples

• NO OSHA STD or TLV
• Genus/species of organisms inside/outside
• Rank order / number
• If good HVAC then inside should be < outside
• Looking for building related source
Recommendations

• Remove/resolve water source problem
• Remove porous materials wet > 24-48 hrs
• Remove with plastic enclosure with neg pressure
• Isolate or cap HVAC systems
• Workers wear protection
• Clearance air sampling
Fungi

• FUNGI Questions?
Bacteria (WA >90)

Metal working fluids – Hypersensitivity pneumonitis (endotoxin)
Legionella – Legionella pneumophila
  Hot tubs – Showers
  Drinking water
  Cooling towers
# Legionnaires Disease vs. Pontiac Fever

<table>
<thead>
<tr>
<th>Legionnaires Disease</th>
<th>Pontiac Fever</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-10% attack rate</td>
<td>90% attack rate</td>
</tr>
<tr>
<td>10-15% mortality</td>
<td>No Mortality</td>
</tr>
<tr>
<td>Incubation 2-14 days</td>
<td>Incubation 1-3 days</td>
</tr>
<tr>
<td>Fever (102-105 F)</td>
<td>Flu Like</td>
</tr>
<tr>
<td>Headache, muscle aches</td>
<td>Fever</td>
</tr>
<tr>
<td>Pneumonia</td>
<td></td>
</tr>
<tr>
<td>Antibiotics</td>
<td></td>
</tr>
</tbody>
</table>
## Significant Legionella Outbreaks

<table>
<thead>
<tr>
<th>Location of outbreak</th>
<th>Infected</th>
<th>Deaths</th>
<th>Source - Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Philadelphia, PA (1976)</td>
<td>240</td>
<td>34</td>
<td>Cooling Tower - Hotel</td>
</tr>
<tr>
<td>Lo Que Pas, Az (1995-1997)</td>
<td>7</td>
<td>1</td>
<td>Potable - Hospital</td>
</tr>
<tr>
<td>Woodbridge, NJ (1995-1997)</td>
<td>3 (2)</td>
<td>1 (1)</td>
<td>Potable - Motel</td>
</tr>
<tr>
<td>Madrid, Spain (1995)</td>
<td>230</td>
<td>16</td>
<td>Cooling Tower</td>
</tr>
<tr>
<td>Christianburge, VA (1995)</td>
<td>23</td>
<td>3</td>
<td>Spa – Store display</td>
</tr>
<tr>
<td>Culver City, CA (1999)</td>
<td>11</td>
<td>1</td>
<td>Cooling Tower</td>
</tr>
<tr>
<td>Bovenkarspel, Holland (1999)</td>
<td>233</td>
<td>22</td>
<td>Spa – Flower Show display</td>
</tr>
<tr>
<td>Melbourne, Australia (2000)</td>
<td>104</td>
<td>4</td>
<td>Cooling Tower - Aquarium</td>
</tr>
<tr>
<td>Cleveland, OH (2001)</td>
<td>4</td>
<td>2</td>
<td>???</td>
</tr>
<tr>
<td>Murcia, Spain (2001)</td>
<td>638</td>
<td>2</td>
<td>Cooling Tower</td>
</tr>
<tr>
<td>Barrow in furnace, UK (2004)</td>
<td>123</td>
<td>3</td>
<td>Cooling Tower</td>
</tr>
</tbody>
</table>
Cooling Towers
Prevalence

• 8,000-18,000 cases/yr in US
• Fraction are reported
• 23% are nosocomial (healthcare associated)
• 10%-20% can be linked to outbreaks
• 10-15% mortality, nosocomial much higher
Prevention

• Dead legs, design, rotation of backup
• Eliminate aerosols
• Maintain treatment systems
• Eliminate biofilms and protozoa
• Testing
• Water temperature
Prevention - Cooling towers vs potable

• Aerosol transmission
• Filtration
• Water treatment
• Testing
• Corrosion
• Sediments

• Water temperature
• Water treatment
• Storage and dead legs
• Aerators
• Handicap shower heads
• Recycle backup systems
• Testing
Chemical Treatment

• Oxidizers - Cl, Br, O₃
• Concentration, pH, shock, change, corrosivity
• Quats and dithiocarbamates NG
• Non oxidizers - system volume
  – Gluteraldehyde
  – Bromopol
  – Kathon
Guidelines

• British and Australia
• CDC guidelines for JACOH
• Culver City
• OSHA – prompt/immediate action
  – Humidifier 1 and 10 CFU/ml
  – water 10 and 100 CFU/ml
  – tower 100 and 1000 CFU/ml
Bacteria

• Bacteria Questions?