PARTICLE FILTRATION WITH CENTRAL AIR HANDLERS: FOLLY OR OPPORTUNITY

HP Regional Education Series
New England

Find this presentation here:
http://rocis.org/past-rocis-events

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ROCIS (*Rock-us*) or (*Raucous*)
Reducing Outdoor Contaminants in Indoor Spaces
WWW.ROCIS.ORG
WHAT IS ROCIS?

Our MISSION

A Southwestern Pennsylvania initiative to reduce the impact of exterior pollution in indoor spaces.
Why??

Most of our exposure to outdoor pollution happens IN buildings

http://www.iaqscience.lbl.gov
Focus on Particles

Also referred to as Particulate Matter (PM)
PM$_{2.5}$: Particulate matter $<2.5$ µm in diameter

ROCIS LCMP Dylos: Particles $> 0.5$ µm

(1/100 of human hair!)
Health Concerns - Particles

- Particles differ in toxicity
- Can be adverse synergy with other co-pollutants
- Fine & Ultra-Fine particles can be vehicles to increased exposure of toxic contaminants such as SVOCs & metals
- Our premise: “Precautionary principle” – avoid or minimize exposure

Outdoor Plus Indoor!
Outdoor Particles (PM) & Human Health

“Our best estimates of the US mortality burden associated with total PM$_{2.5}$ exposure in 2012 range from ~230,000 to ~300,000 deaths.”

Health Concerns (<PM10)

Established PM-associated diseases: cardiovascular disease, asthma, & lung cancer

Recent associations with PM exposure include: idiopathic pulmonary fibrosis, type 2 diabetes, Alzheimer’s disease, & decreased cognitive function as well as premature birth

Loxham, M., & Nieuwenhuijsen, M. J. (2019). *Particle and fibre toxicology*
4 Strategies to Reduce Indoor Particles

• **Reduce air exchange from outside**
  - Close windows
  - Tighten home or building

• **Reduce indoor sources**
  - Use an effective ducted kitchen hood!
  - Use induction cook top & other good practices w/ cooking

• **Reduce resuspension**
  - HEPA vacuum; thoroughly clean hard surfaces
  - Walk-off mats
  - Get rid of carpets, old upholstered furniture

• **Filter the air**
  - Portable air cleaners
  - DIY Fan Filters
  - Central air handler (furnace, AC, or ventilation)
4 Strategies to Reduce Indoor Particles

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- **Filter the air**
  - Portable air cleaners
  - DIY Fan/Filter
  - MERV 13 filter in central air handler (furnace, AC, or ventilation)
Indoor Particle Distribution – All Sites

More than 20 to 1 difference!
Median: ~1/2 Fair; ~1/2 Good / Very Good

Majority of sites in “very good - excellent” range use continuous filtration: either portable or central air handler

50% of observations are within each vertical box
Particles 0.5+ μm (Dylos small)
Dylos Corporation scale (on right)
ROCIS
Air Handler/High MERV Inquiry

http://rocis.org/air-handler-inquiry
High MERV Filter - Air Handler (Filter/AHU) Inquiry

Initial Question…

Is there an easy way to determine if I can use a high MERV filter with a longer air handler run-time without causing problems ($, equipment durability, performance, or GHG emissions)?

NO !!

Diagnostic Screen is Required
Big Issues with 24/7 High MERV Filter

**Air handler (AHU) energy use** can be high due to 500 to 1,500 watt-draw

- High cost of running air handler continuously
  
  \[(360 \text{ kWh to } 1080 \text{ kWh/month } = \sim \$500 \text{ to } \$1500/\text{year}\]^{1}

**Wrong blower speed**

- Seldom set in field
- Often defaults to high speed, not low, in continuous mode
- Higher energy cost, less effective filtration

**Ductwork issues** introduce additional problems

- Static pressure too high (can lead to equipment failure)
- Duct leaks (energy waste & pressure-related problems)

^{1} $0.12/\text{kWh}
Air Handler Operation

Thermostat usually set to “Auto”, not “On”

Average annual run-time is ~15%

Inadequate for filtration

Call for heat & cool does not align with need for filtration

With smart thermostats more control of “on time”
Air Handler, or Air Handling Unit

(often abbreviated to AHU), is a device used to regulate and circulate air as part of a heating, ventilating, & air-conditioning (HVAC) system.

Includes: ductwork, blower/motor, filter, coil, & controls

1 Wikipedia
Blower / Motor

ECM (electronically commutated motor)
This multi-speed model also allows us to set up a very low continuous movement of air for filtration, ~400 - 700 CFM, @120 - 180 Watts of power.

Not as efficient (or expensive) as the variable speed ECMs in many new heating & air conditioning systems.
Problems identified in 60 diagnostic inspections of SW PA air handlers

- High TESP: 80%
- High Static (Filter): 68%
- High Static (Return): 67%
- AC Oversized: 48%
- High Airflow: 52%
- High Static (Coil): 30%
- HVAC Oversized: 27%
- Space Constraints: 17%
Time for a ROCIS Video!
And Rhett’s presentation
Elements for 24/7 Operation of AHU

ECM (electronically commutated motor) Blower

Increase control to optimize (& lower) air flow

Drops electricity use, but only if static pressure is low/correct

4” Pleated MERV 13 filter – ideally also larger area

Lower air flow thru filter increases reduction of smaller particles

4” deep filter longer life without clogging

Option for 2 filter (pre or post)

Good Duct System

Minimal leaks to outside

Air flow & TESP within name plate specifications

NOT RECOMMENDED:

1” pleated MERV 11 or 13 filter (equivalent) without performance testing for TESP, air flow, & watt-draw
Case 2  Pre & Post Particles
Air Handler Retrofit

Week ending 5-24-2017 (windows open) vs. 7-31-2017, poorer outdoor counts

**INTERVENTION:**
ECM blower (lower air flow & energy cost on continuous setting)
New return (larger 20” x 25” MERV 13 filter & pre-filter)
**Cost – labor & materials:** $1,000

**RESULTS:** Lower CO₂ in bedroom  **24/7 annual operating cost:** $131.40
PARTICLE LEVELS IN AND AROUND YOUR HOUSE

Roamer hallway - Small

Inside living room - Small

outside - Small

Location

0% 25% 50% 75% 100%
Proportion of time

Excellent
Very Good
Good
Fair
Poor
Very Poor

LCMP Top Performer
Air Handler 24/7 – MERV 13 Filter

Indoor tracks outdoor
Indoor uniform – 2 locations
Also – 2nd fl portable air cleaner

Continuous Mode: $12/month
Post: 110 watts; 500 CFM
(Pre-Post: 400 watt reduction)

Dylos small (0.5+ microns) (#/1/100 ft³)

Green – Outdoor; Blue Living Room; Yellow – 2nd Floor Hallway
ROCIS 24/7 Air Handler Checklist

http://rocis.org/air-handler-inquiry

Reducing Outdoor in Indoor

ROCIS Mission
Selected ROCIS Intervention Homes
Pre-Post Median Particle Count

85% Reduction in Particles!!

Use above code (w2i9) to view data on ROCIS LMCP Data Explorer
http://rocis.org/rocis-data-explorer
Air Handler Interventions

Pre-Post Continuous Watt-Draw

Use these codes (w2i9) to view particle data on ROCIS LMCP Data Explorer
http://rocis.org/rocis-data-explorer
Big Opportunity at HVAC Replacement

- *Downsize HVAC to reduce static pressure!!*
- Incorporate return drop modification & option for larger, deeper filter
- Set blower speeds for optimal performance
- Address duct system shortcomings

To ponder…
- Could potential filtration health & comfort benefits add impetus to getting HVAC systems designed & installed correctly?
Bottom Line – Air Handlers
24/7 w High MERV Filtration

- Can be very effective!
- Do not operate air handler 24/7 without confirming
  - Fan cost (electricity)
  - Minimal duct leakage to outside (big issue w/attic ducts)
  - Static pressure within operating range
- NOTE: One-inch pleated filters can be very restrictive
Air Hander Filtration not an Option?
DIY Fan Filters
Fan/Filter Intervention: Low Cost, MERV 13

4” MERV 13 filter ($35) on 20” x 20” box fan (~$20)
Box fan in room or in window
UL-rated fan with overheat protection
Indoor Fan/Filter 24/7 Impact

http://rocis.org/rocis-data-explorer (k4x3)
Fan/Filter Options
20” Box Fan w High MERV Filters

- Some use multiple filters (2 in V, or 4 in box)

Image Credit: Comparetto Comfort Solutions
Summary
Filter Essentials

- Use large filter (surface area)
- Use deep filter (we prefer 4”)
- Use low resistance filter (check label on filter)
- Minimize filter bypasses

- Use MERV 13 to reduce 0.3 to 0.5 μm particles (MERV is like R-Value; performance depends on installation/operation)

- Provide adequate run/on time (if system passes diagnostic screening)
Filter Bypass

...Relatively Common in Homes
Conclusions

Insight to Date re Interventions

- Air filtration can significantly reduce particle counts if the application is appropriate
- Low cost monitors reinforce use of filtration as well as source control
- Tighter the house, the greater the impact of filtration
- But, tighter the building, the more critical it is to control indoor sources
- In some cases, shift focus from building exposure to human exposure (i.e. bedroom safe room)
Bottom Line!

Integrated solutions are needed to enhance health, resilience, energy efficiency, comfort, & durability (engagement, building tightness, source control, operation & maintenance)

Ideally, improve outdoor air quality!
SEND US YOUR QUESTIONS & COMMENTS

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Filtering Air with Forced Air Home Heating & Air Conditioning Systems

Simultaneously…

- **Significant missed opportunity** to reduce particles

- **Major liabilities** (energy use, energy cost, equipment life, & performance)

*Our solutions reduce fine particles by 50-80% while minimizing risk*