2020 Managing Your HVAC Systems to Help Mitigate the Spread of SARS-CoV-2 In Buildings

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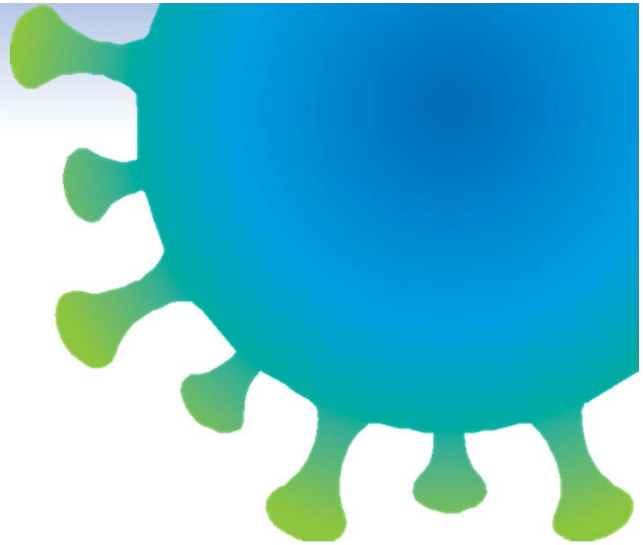
Learning Objectives

- Assess a building's HVAC system(s) ability to respond to an Infectious Aerosol event
- Create an effective Building Readiness Plan
- Explain desirable HVAC system characteristics beneficial to mitigating the spread of Infectious Aerosols
- Apply the guidance to operating a building during an event
- Discuss how this may affect future HVAC design criteria

Agenda



- Introduction
- Building Readiness Intent
- Epidemic Conditions in Place (ECiP)
- Steps to Re-occupy Your Building
- Considerations for Future Design
- Conclusions
- Questions

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The Importance of Indoor Air Quality
"Buildings are for People, not for Saving Energy"

- People are the most valuable/expensive part of a building
- 1:10:100:1000 rule (order of magnitude)
  - $1 of design cost
  - $10 of construction cost
  - $100 of operating cost (energy, water,…)
  - $1000 of occupant cost (salary, benefits…)
- Indoor air quality (IAQ) affects
  - Safety (chronic and acute toxicity)
  - Comfort (odor perception)
  - Productivity/Learning
  - Health
    - Allergies and asthma
    - Cardiopulmonary disease
    - Infectious diseases

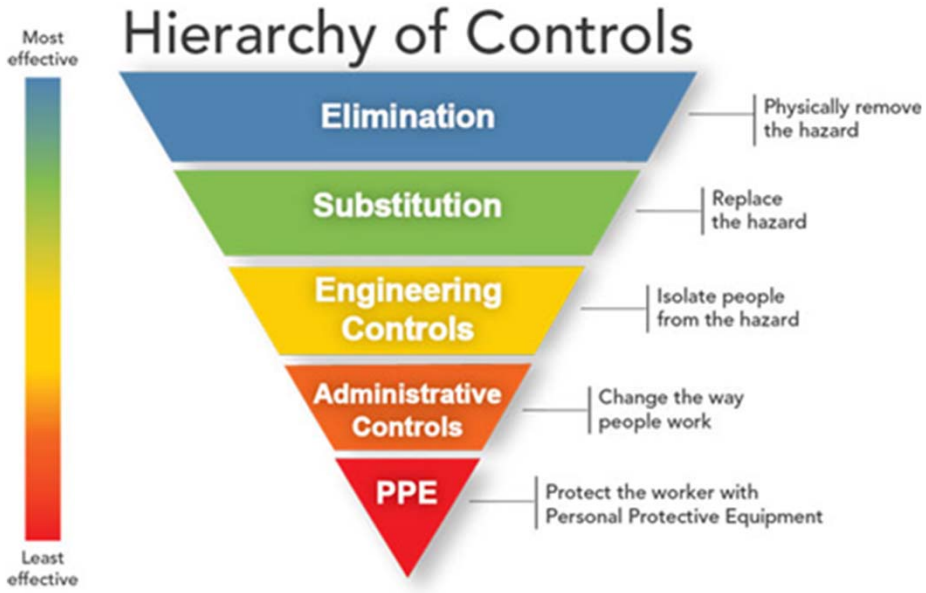
IAQ Control is Control of Contaminants

Transmission Modes

- Airborne
  - Large droplet/short range
  - Aerosol
- Fomite – intermediate surface
- Water/food
- Physical contact
- Insect/animal vector

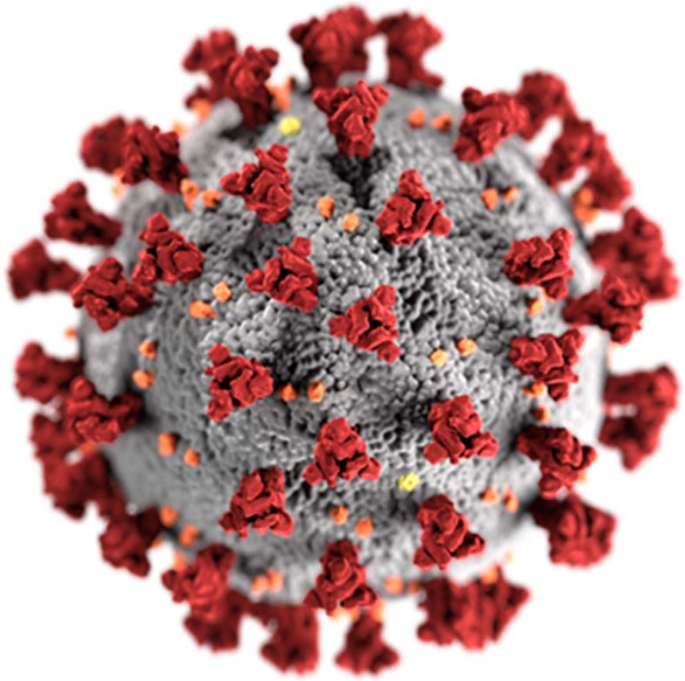
…HVAC mainly impacts aerosol and fomite transmission – only part of a solution

Control Hierarchy



SARS-CoV-2

- Coronavirus related to the one that causes SARS
- RNA virus with lipid envelope
- Diameter » 120 nm (0.12 µm)
- Not determined
  - Shedding rate
  - Infectious dose
- Survival of hours in air, days on surfaces



SARS-CoV-2 Transmission Debate

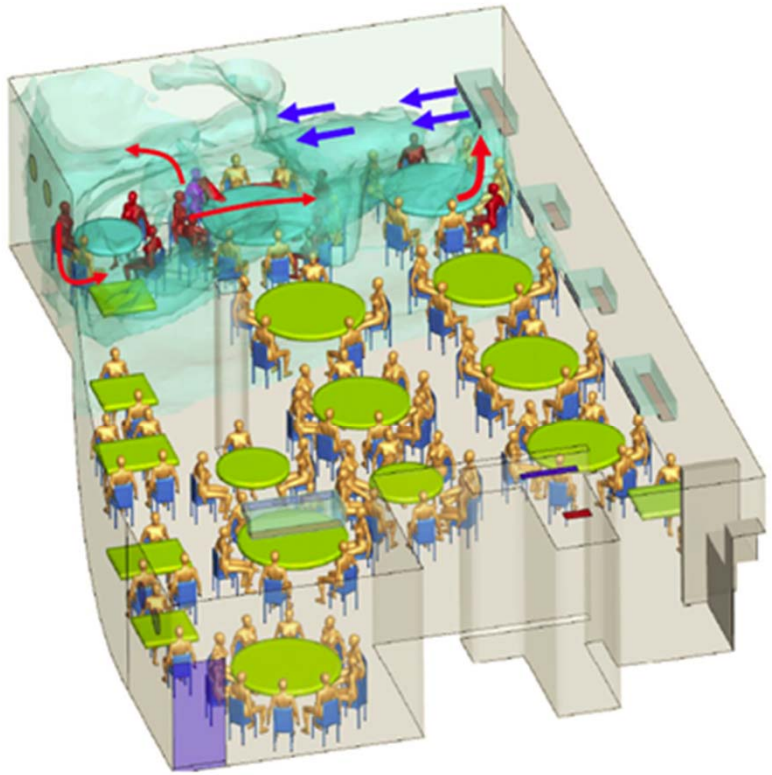
- Health organizations (WHO, CDC)
  - Evidence points to predominantly large droplet transmission at short range
  - Other modes not ruled out
  - Tend to rely on evidence from healthcare environments
- Possible explanations
  - Virus mostly in large droplets
  - Infectious dose is large
  - Exposure reduced by environmental factors
- Unexplained COVID-19 “community spread” incidents cast doubt on claimed insignificance of airborne transmission, e.g.
  - Skagit Valley, WA choir rehearsal - 47 of 60 participants infected despite following distancing and hygiene guidelines
  - Guangzhou, CHN restaurant – 10 of 21 diners at three adjacent tables infected by one person at distances of up to 5 m
- Documented airborne transmission of SARS also suggests possibility for COVID-19

Fundamental Assumptions

ASHRAE leadership has approved the following two statements regarding SARS-CoV-2.

AIRBORNE TRANSMISSION

Transmission of SARS-CoV-2 through the air is sufficiently likely that airborne exposure to the virus should be controlled. Changes to building operations, including the operation of heating, ventilating, and air-conditioning systems, can reduce airborne exposures.



Li, et al. (2020) https://doi.org/10.1101/2020.04.16.20067728

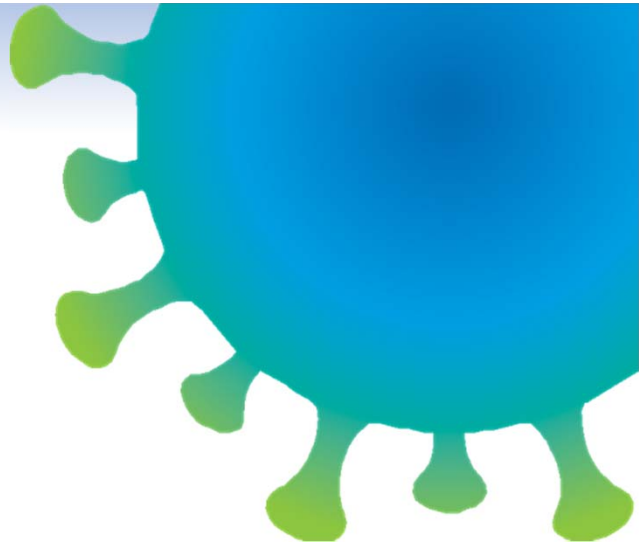
Fundamental Assumptions

ASHRAE leadership has approved the following two statements regarding SARS-CoV-2.

OPERATION OF HVAC SYSTEMS

Ventilation and filtration provided by heating, ventilating, and air-conditioning systems can reduce the airborne concentration of SARS-CoV-2 and thus the risk of transmission through the air. Unconditioned spaces can cause thermal stress to people that may be directly life threatening and that may also lower resistance to infection. ***In general****, disabling of heating, ventilating, and air-conditioning systems is not a recommended measure to reduce the transmission of the virus.*

ASHRAE Documents



- Position Document:
  - Infectious Aerosols (4/14/20)
    https://www.ashrae.org/file%20library/about/position%20documents/pd_infectiousaerosols_2020.pdf

- Emerging Issue Brief:
  - Pandemic COVID-19 and Airborne Transmission
    https://www.ashrae.org/file%20library/technical%20resources/covid-19/eiband-airbornetransmission.pdf

- Epidemic Task Force

  https://www.ashrae.org/technical-resources/resources

Building Readiness: Intent

Building Readiness is meant to create practical guidance for how your building is operating, should be operating and how to practically check its operation.

Building Readiness modes of operation for the building should include the following:

- Epidemic Conditions in Place (ECiP)
  - Occupied- at pre-epidemic capacity
  - Occupied- at reduced capacity
  - Unoccupied temporarily, and
  - Operation during building closure for indefinite periods

- Post-Epidemic Conditions in Place (P-ECiP)
  - Prior to Occupancy
  - Operational Considerations once Occupied

Building Readiness: Team

The Building Readiness Team could include professionals and licensed and certified individuals and companies that can perform the analysis, testing, design, construction, control programming, balancing, commissioning, maintenance and operation services required to make the adjustments and achieve the performance included in these recommendations.

The following are the typical service providers that may be required:

- Commissioning Provider (CxP)
- Test and Balance Company (TAB)
- Building Automation Systems (BAS) Company
- Contractors
- Architect and/or Engineer (AE)
- Owner's Facility Staff
- Building Operations

Guiding Principles

- Do No Harm
- ASHRAE Infectious Aerosols Position Document
- ASHRAE Environmental Health COVID-19 Emerging Issues Brief
- ASHRAE COVID-19 Preparedness Resource Website
- Use your Resources, Education and Experience

Epidemic Conditions in Place (ECiP)

"Houston, we have a problem"

(Erroneous quote attributed to Jack Swigert, Apollo 13)

Epidemic, Pandemic or Disaster Conditions Have Been Declared or Recognized to Exist

ECiP - Building Readiness Plan Systems Evaluation

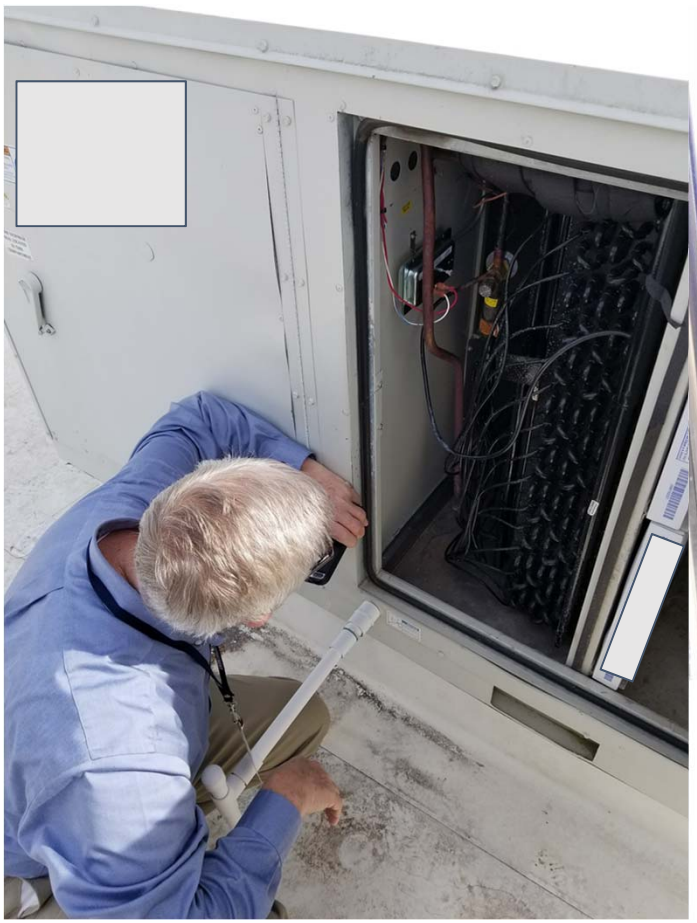
Gather as much documentation on the building as possible, such as:

- Most recent design documents, specifically HVAC and Plumbing systems
- Record documents, such as as-builts and specifications
- Equipment submittals
- Building Automation System (BAS) reports
- Recent TAB or Commissioning reports

ECiP - Building Readiness Plan Workflow

- Walk the facility with stakeholders
- Consult insurers, legal counsel as necessary
- Consult local, state and federal regulators, as necessary

ECiP - Building Readiness Plan
Inspect Components & Systems

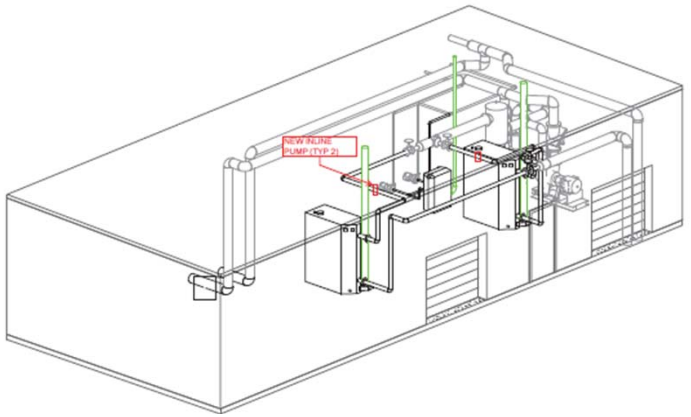


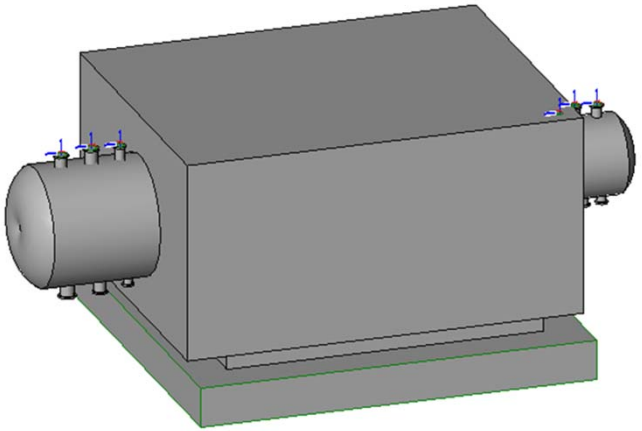
ECiP - Building Readiness Plan Inspect Components & Systems

- Air Handling Equipment
  - Coils
  - Filters
  - Air cleaning devices
  - Dampers
- Air Distribution Devices
- Chillers
- Boilers
- Water Distribution Systems

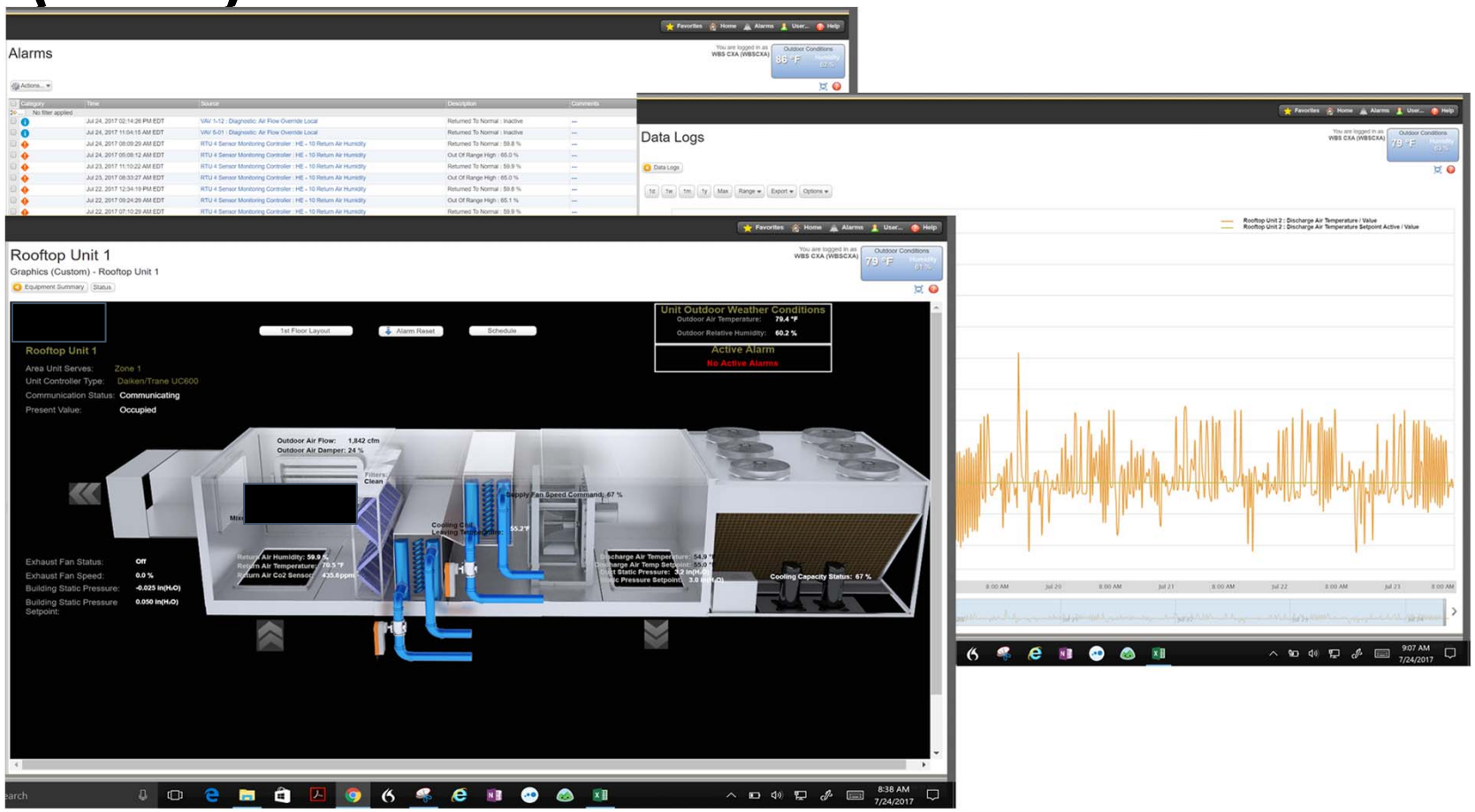
ECiP - Building Readiness Plan HVAC System Types

- Single Zone
  - Split Systems
  - Packaged Rooftop
- Multizone
  - Variable Air Volume (VAV)
  - Variable Refrigerant Flow (VRF)
  - Fan Coil Units
- All Air
- Chilled Water
- Heating Hot Water and Steam
- Dedicated Outdoor Air Systems
  - Energy Recovery





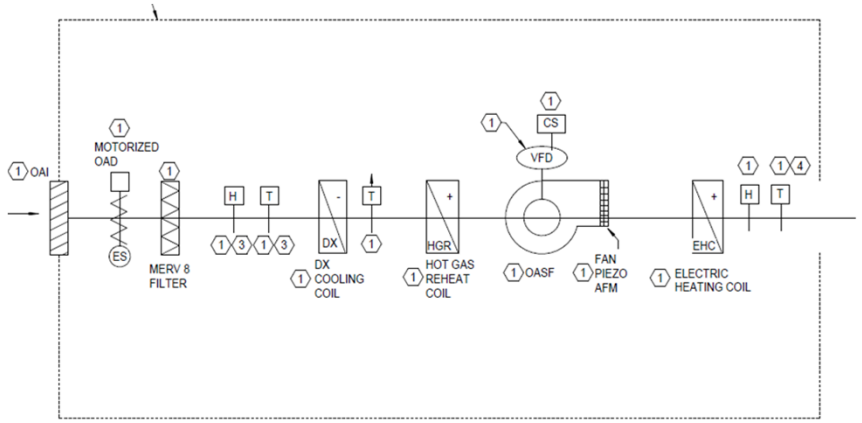
ECiP - Building Readiness Plan Building Automation Systems (BAS)



ECiP - Building Readiness Plan BAS (cont'd)

- Print out current values set points and adjustable values from BAS (hard copy and PDF) prior to changes
- Perform complete backup of BAS and equipment controller settings and history prior to changes
- Store backups offsite and in secure Cloud Storage
- Setup and verify remote access to BAS is working and secure (work with IT, if appropriate)

ECiP - Building Readiness Plan
BAS- Sequences of Operation



INPUT/OUTPUT SUMMARY
VAU-1 THROUGH VAU-4

	INPUTS									OUTPUTS				FEATURES								
	DIGITAL			ANALOG						DIGITAL			ANALOG	ALARM			ENERGY MGMT					
	UNIT GRAPHIC DISPLAY	STATUS (PERCENT SPEED)	END SWITCH	CURRENT SENSING RELAY	TEMPERATURE	RELATIVE HUMIDITY	AIR FLOW	RUN TIME	SUPPLY FAN VFD FEEDBACK	START/STOP	OPEN/CLOSE	BAS CONTROL	DAMPER POSITION	FAN SPEED	STATUS/INTERLOCK	HIGH/LOW LIMIT	RUN TIME TOTALIZATION	FAULT (VFD)	OPTIMUM START/STOP	DAY/NIGHT SETBACK	OCCUPIED/UNOCCUPIED	BAS TREND	FAILURE MODE (SEE NOTES 1 AND 2)	NOTES
OUTSIDE AIR DAMPER	X		X								X		X									X	C	2
OUTDOOR AIR SUPPLY FAN START/STOP	X									X									X	X	X	X	O	
OUTDOOR AIR SUPPLY FAN STATUS	X	X		X				X						X	X							X		
OUTDOOR AIR SUPPLY FAN VFD	X								X			X						X				X	C	2
FAN PIEZO AFM AIRFLOW	X						X															X		
OUTSIDE AIR TEMPERATURE	X				X																	X		
OUTSIDE AIR RELATIVE HUMIDITY	X					X																X		
COOLING COIL LEAVING AIR TEMPERATURE	X				X										X							X		
UNIT DISCHARGE RELATIVE HUMIDITY	X					X									X							X		
UNIT DISCHARGE AIR TEMPERATURE	X				X										X							X		
UNIT DISCHARGE AIR DEW POINT TEMP (CALCULATED)	X														X							X		
GLOBAL CO2 LEVEL/OA TEMP/RH	X																					X		
COMPRESSOR UTILIZATION	X	X										X				X		X	X			X	C	2

- Develop Sequences of Operation for
  - Normal Occupied Mode
  - Normal Unoccupied Mode
  - Emergency shutdown
  - Partial shutdown
  - Starting back up after an event – re-occupancy
  - Alarms

ECiP- Document the Plan

- Correct deficiencies between existing systems' operation and design intent
- Bring deferred maintenance up to date, if it can be done safely
- Detail any design modifications or component additions needed
- List all changes being proposed to BAS and only make one change at a time
- Existing alarm settings may need to be adjusted for the "new" normal

ECiP - Document the Plan

Log All Deficiencies

Issue Log		
Tag	Issue	Date Repaired
RTU-1	Broken Condensate Drain Line	TBD
RTU-1	OA Damper Frozen Closed	TBD
AHU-1	Upgrade Filters to MERV 13	TBD
Nurses Office	Balance to a negative pressure	TBD

ECiP - Document the Plan
Develop a Repair Strategy

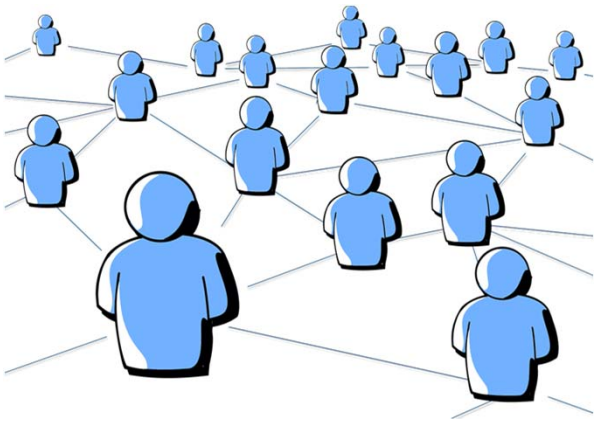
Plan		
Tag	Issue	Priority
RTU-1	Broken Condensate Drain Line	3
RTU-1	OA Damper Frozen Closed	1
AHU-1	Upgrade Filters to MERV 13	2
Nurses Office	Balance to a negative pressure	1

ECiP - Document the Plan Work Orders

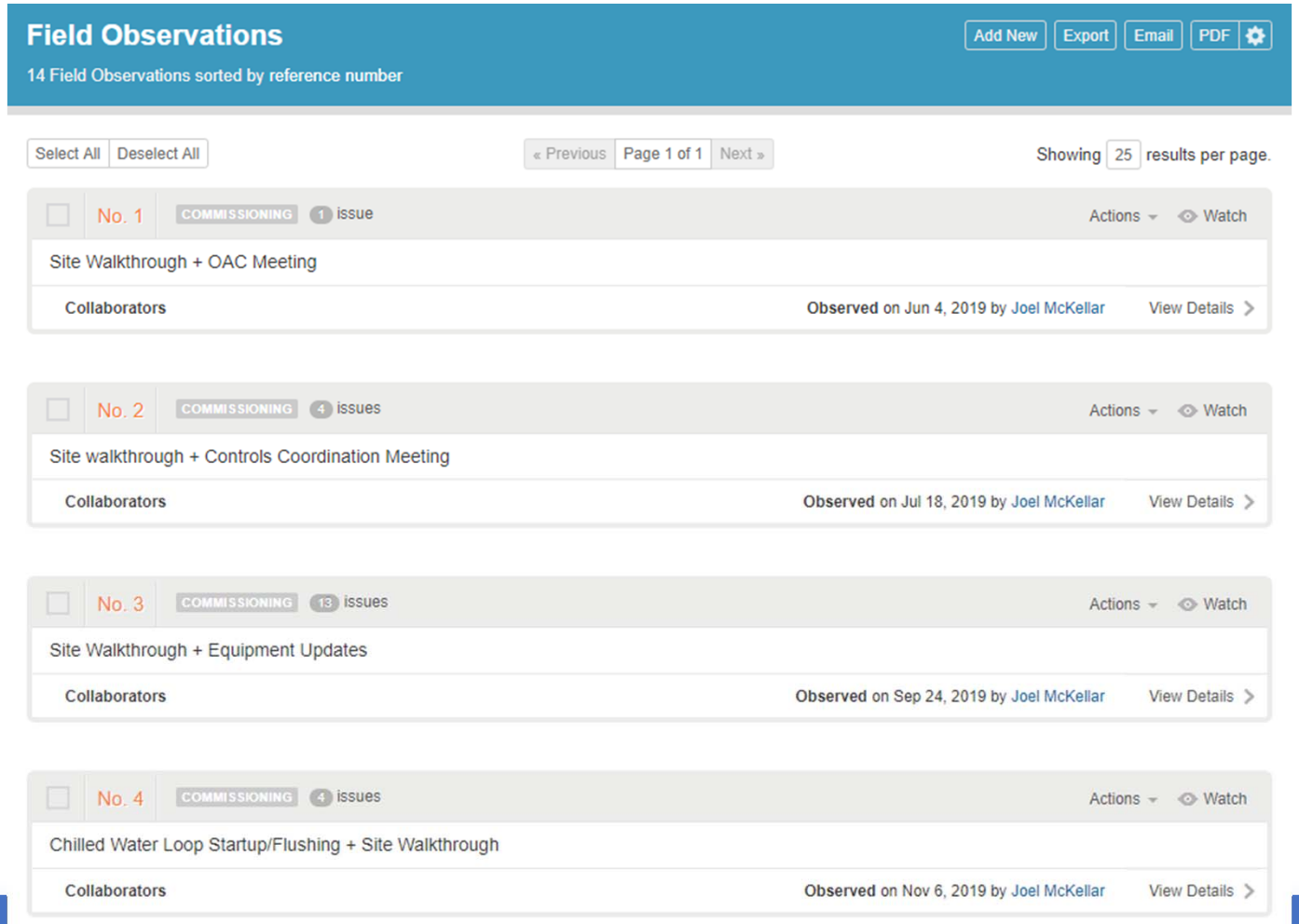
- Collaborate with stakeholders to plan for modifications to operations
- Make small changes at a time
- Continue routine and scheduled maintenance

ECiP - Communicate the Plan!

- Communicate
  - Clear, concise, correct and complete
  - Prefer written- email or text
  - Phone (follow-up email)
  - Meetings
- Document
  - If It's Important - Write it down!
- Follow Up
  - Don’t set yourself up for failure

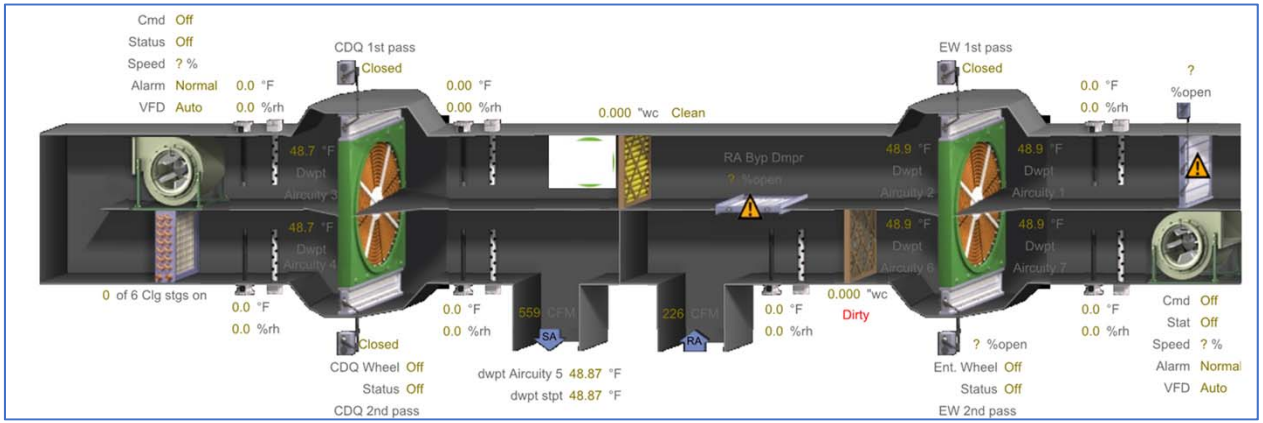


ECiP - Communicate the Plan Keep Good Records



ECiP- Engineering Controls

- Ventilation
- Filtration
- Temperature and humidity control
- Air distribution
- Disinfection

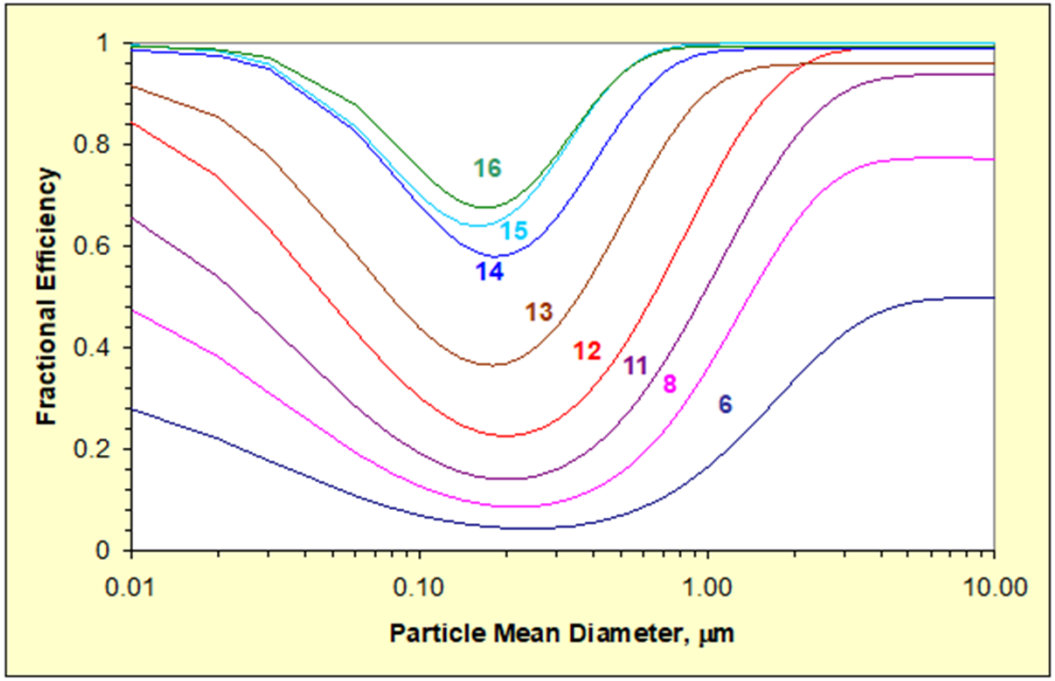


ECiP- Design Consideration
Can We Increase Ventilation?

- Encourage building owners/ operators to increase ventilation air, without causing new issues
- May be difficult in hot & humid climates
- Possibly let room design temperature setpoint slide a little, so more outside air can be distributed into the space
- Research indicates maintaining space relative humidity between 40-60% decreases virus infectivity
- Can add control programming at BAS

ECiP- Design Consideration
Can We Increase Filtration?

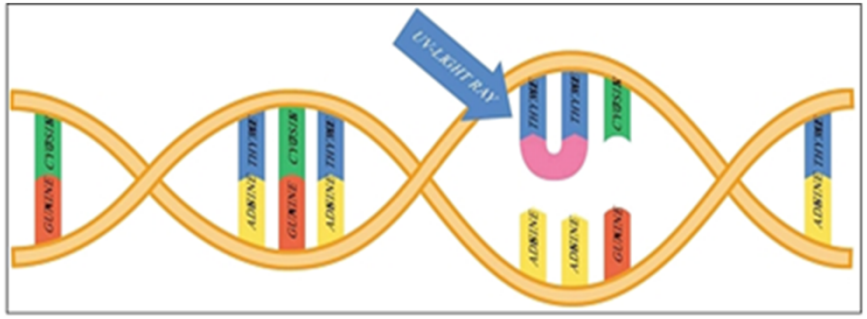
- Most buildings have MERV 6 or MERV 8 filters
- ASHRAE recommends using filters with a higher efficiency, preferably MERV 13 or MERV 14

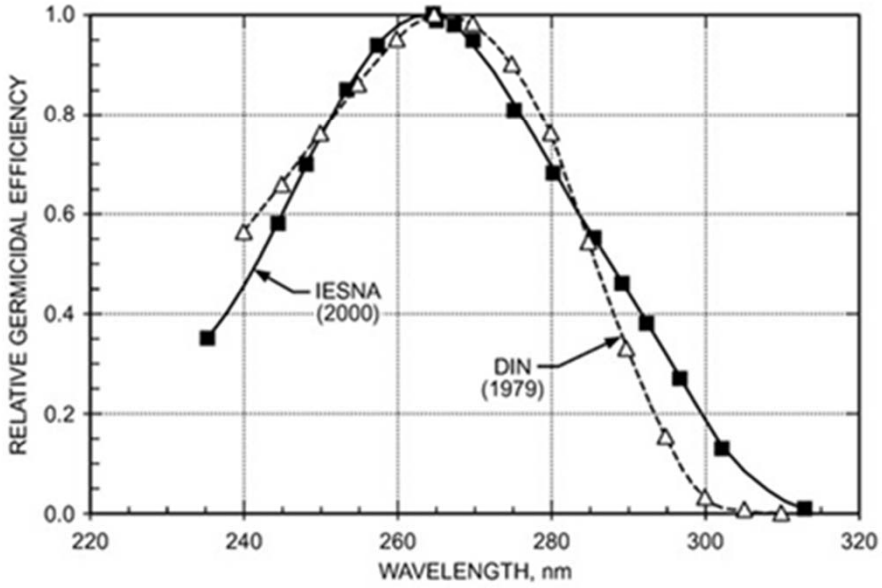


Representative MERV rated filter performance (Kowalski and Bahnfleth 2002)

ECiP- Design Consideration UVGI/ Air Cleaning

- Ultraviolet light in UVC band
- 265 nm ideal, 254 nm produced by low pressure Hg vapor lamps is standard
- Disrupts microbial DNA/RNA, prevents reproduction
- Exponential dose response
- Coronavirus susceptibility is good
- Long record of application, CDC approved for tuberculosis control as adjunct to filtration

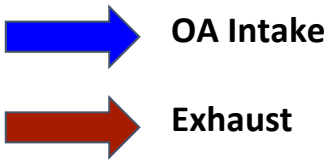


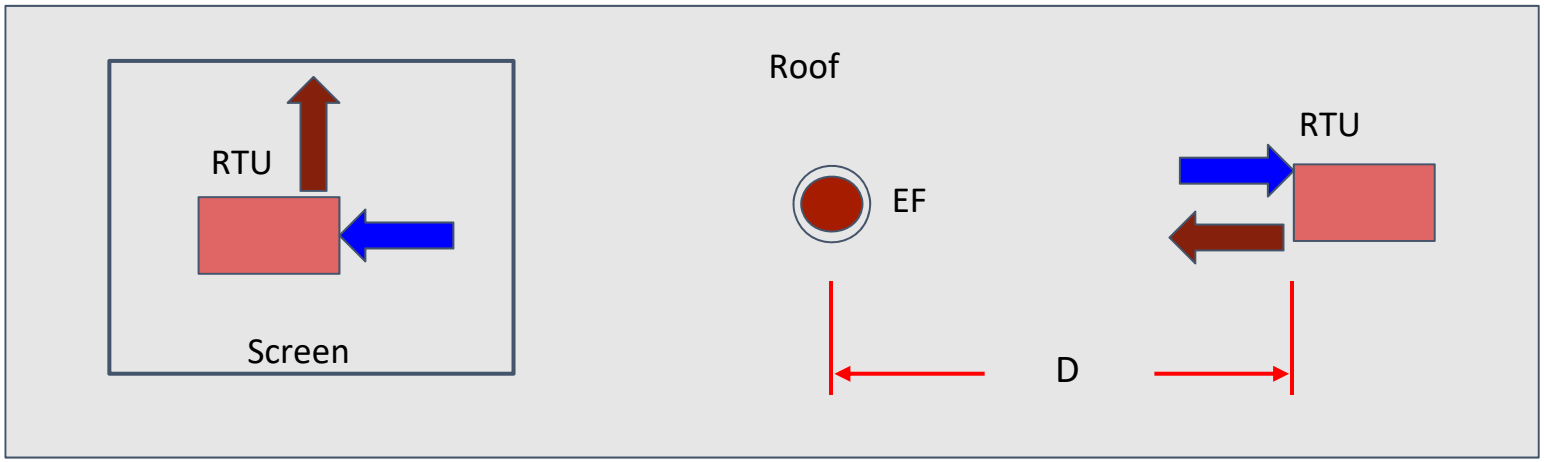


ECiP - Special Considerations Reentrainment

Conditions of Interest

- OA Intake Locations
- Exhaust Locations

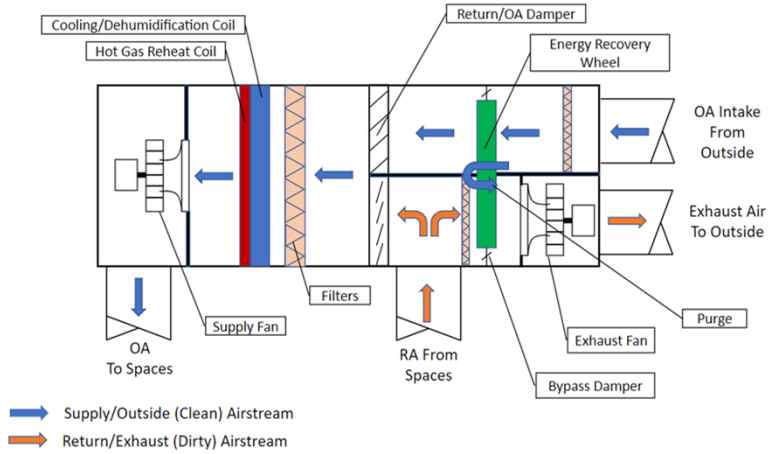


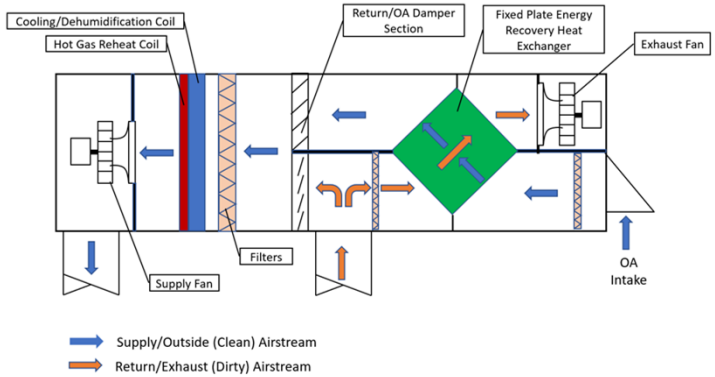


ECiP - Special Considerations DOAS & ERVs

Conditions of Interest

- Wheel/Plate Condition
- Filters
- Bypass Capability
- Cross Contamination Control
  - Fan Arrangement
  - Pressure Differential
  - Seals
  - Purge





ECiP- Combining Engineering Controls

- Combinations of controls can be synergistic
  - MERV rated filter + UV can approach HEPA performance
- Some combinations of controls are mutually exclusive
  - DOAS + central filtration for indoor contaminants
- Some are additive but trade off
  - Ventilation + air cleaning

- Air cleaner effectiveness – describes incremental effect of a control

$$\varepsilon = \frac{C_{uncontrolled} - C_{controlled}}{C_{uncontrolled}}$$

Nazaroff, W. 2000. Effectiveness of Air Cleaning Technologies. *Proc. of Healthy Buildings 2000*.

Re-Occupying: Know Limitations

- Cannot make any claim or guarantee that compliance with our standards and guidance will provide health, comfort or occupant acceptability, but shall strive for those objectives, consistent with ASHRAE policy.
- Many infectious diseases (including SARS-CoV-2) are primarily transmitted through direct person-to-person contact or through large aerosol droplets exchanged at close range. Ensure those measures are being enforced by building owners.

Re-Occupying: General Recommendations

- Use your Building Readiness Plan
- Notify relevant people of the opening
- Follow local, state, and federal orders/regulations/guidelines
- Follow CDC and OSHA for PPE
- Perform Systems Analysis (if not done previously)

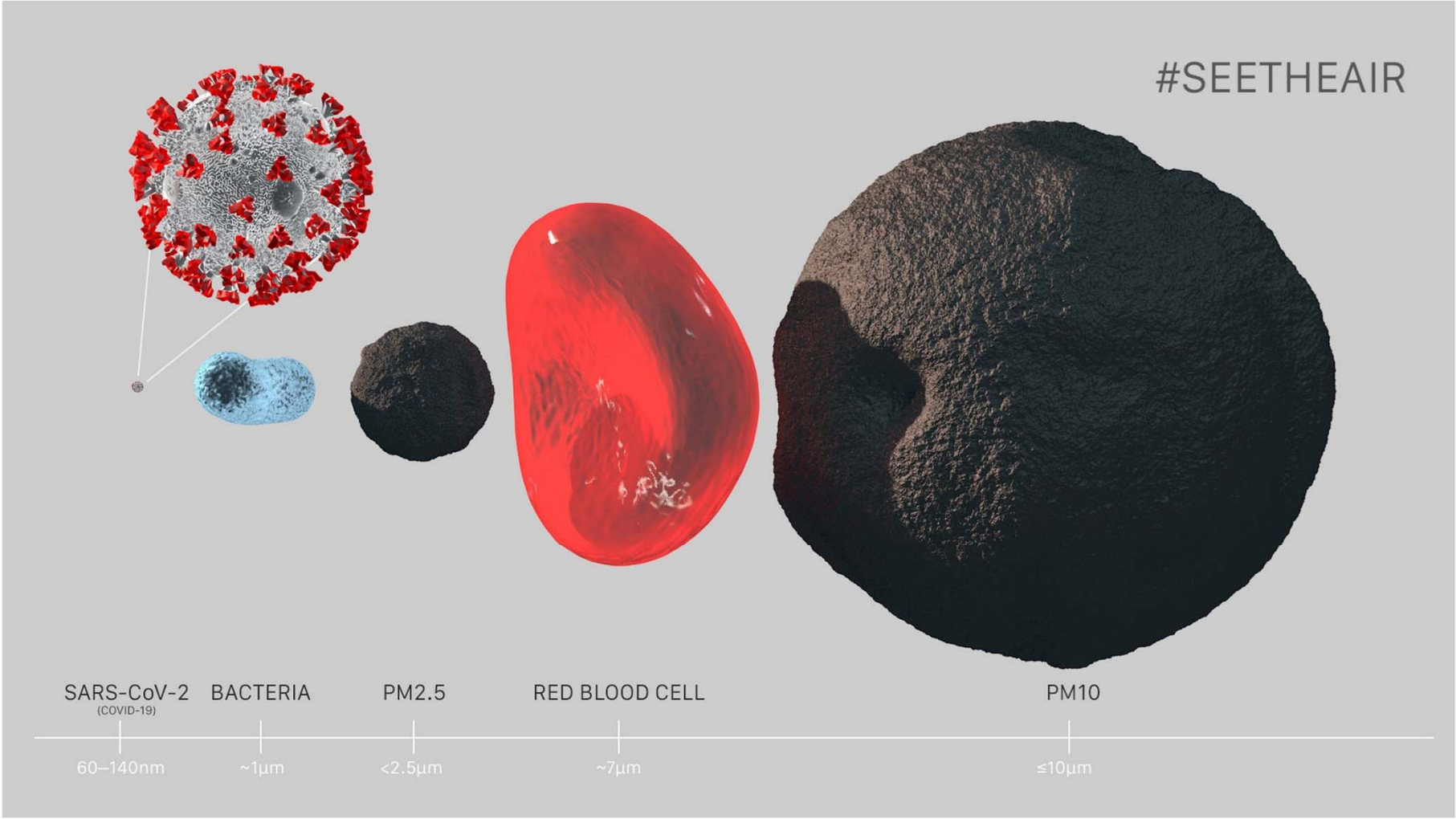
P-ECiP: Key Concepts

- Flush Building with as much fresh air as possible for 4 hours (or achieve 3 air changes)
- Flush your water systems and check water treatment
- Update BAS for any modifications that you are going to change (Schedule, DCV on, etc…)
- Operate the systems for 24 hours and monitor
- Review trends and check for issues
- Utilize the Building Readiness Guide for Post Epidemic Conditions in Place (P-ECiP) guide

P-ECiP: Post Event Activities

- Update your Systems Manual
- Evaluate your systems and think:
  - Did your maintenance program have any scheduled preventive maintenance periods missed because the building was unoccupied?
  - Did you have issues acquiring maintenance materials during the pandemic?
  - Were you able to continue daily or weekly rounds at the building?
  - Were there systems that were not able to be put into a setback mode?
  - Do the building mechanical systems have reset and ventilation control strategies to increase outside air back to normal?
  - Are there other lessons learned that need to be addressed within the building from this experience?

Future Proofing Your Building



Considerations for Future Design

- AHU capacity for increased ventilation
  - Fan, Coil, Chilled Water, Ductwork
- Filter Capabilities
  - “dirty” target in static pressure calculation
- Space air distribution effectiveness
- BAS Modes of Operation to include:
  - Occupied, Unoccupied, Extended Unoccupied, Epidemic / Pandemic
- Air disinfection strategies
- Water systems ability to drain
- Document the mitigation features for facilities

Conclusion

- Assess a building's HVAC system(s) ability to respond to an Infectious Aerosol event
- Create an effective Building Readiness Plan
- Explain desirable HVAC system characteristics beneficial to mitigating the spread of Infectious Aerosols
- Apply the guidance to operating a building during an event
- Discuss how this may affect future HVAC design criteria

Acknowledgements

- ASHRAE Epidemic Task Force
- ETF Building Readiness Team
- TC 5.5 Air-to-Air Energy Recovery
- Bill Bahnfleth, PhD, PE, The Pennsylvania State University
- Sotirios Papthanasiou, #seetheair

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