PROTECTING BUILDING OCCUPANTS FROM SMOKE DURING WILDFIRE AND PRESCRIBED BURN EVENTS

- Balance Engineering LLC – David Ryan PE

WHAT WE WILL BE COVERING

- Indoor Environmental Quality overview/ Air Conditioning
- Indoor sources of pollution
- Ventilation and Filtration
- Why we are concerned with wildfire smoke
- What kind of facility/ space do we need for a shelter
- How to prepare for a smoke event (Readiness Plan, "Normal Operation")
- What to do during a smoke event ("Smoke-Ready Mode")

Balance Engineering LLC – dave@balanceengineer.com – 406 490 6233

WHAT WE WILL BE COVERING

- Specifics of Guideline 44-2024 (if anyone is still awake and we have time).

INDOOR ENVIRONMENTAL QUALITY OVERVIEW

- Temperature
- Humidity
- Ventilation
- Filtration
- Air Movement
- Noise
- Lighting
- Pests

Not quite the same thing as comfort

Mechanical systems are called “HVAC” – Heating Ventilation and Air Conditioning systems

INDOOR ENVIRONMENTAL QUALITY OVERVIEW

WHAT IS AIR CONDITIONING?

- Heating
- Cooling
- Humidification
- Dehumidification
- Ventilation
- Filtration
- Air Movement

- Seven processes that we use to maintain comfort

- To some extent we can change one condition to affect discomfort caused by a different condition - example is using a fan in summer (air movement) to improve discomfort from high temperature.

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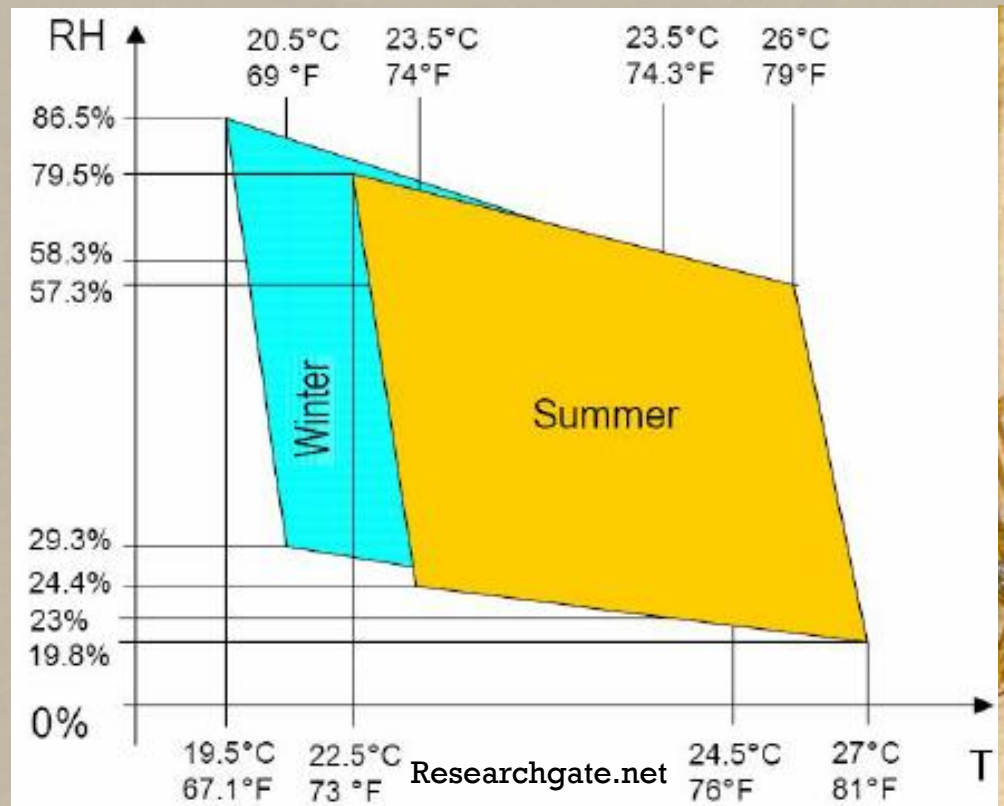
INDOOR ENVIRONMENTAL QUALITY OVERVIEW

- Too cold
- Too Warm
  - What is "Just Right"?
- We can use mechanical systems to either warm the space or cool the space
- We can add humidity and we can take water out of the air



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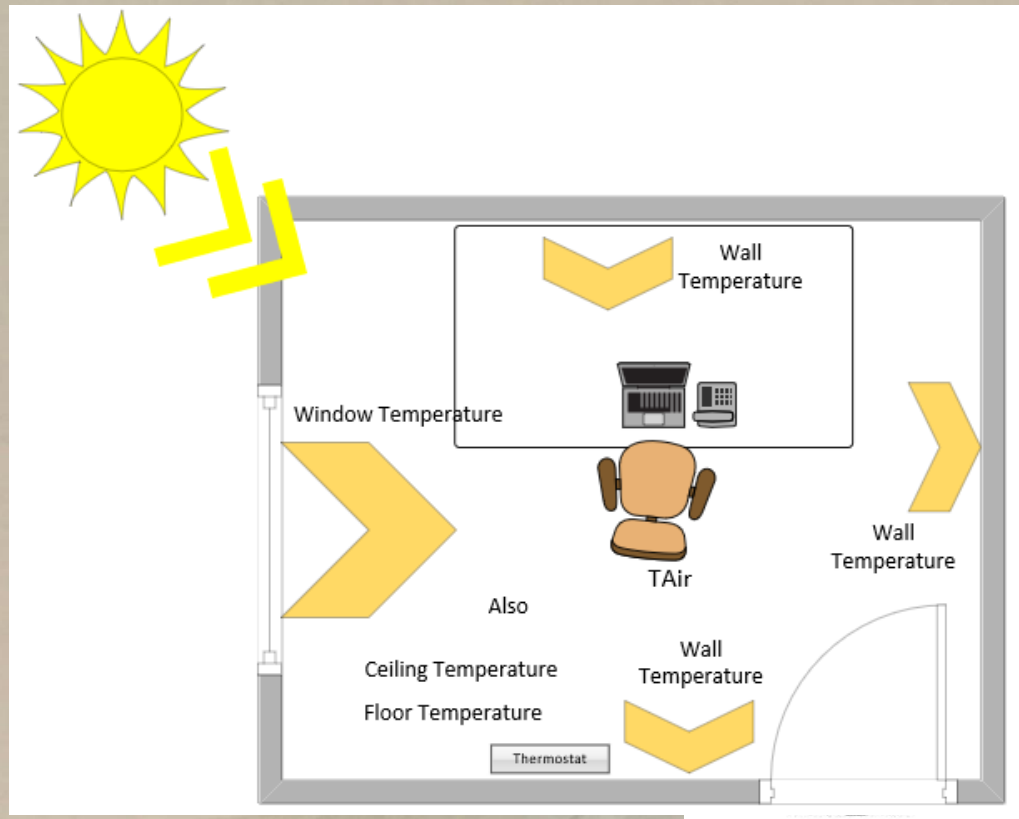
- Too Moist – Muggy or Clammy
- Too Dry – Sinus and eye irritation, aggravates asthma, skin conditions
- Air is Never completely dry

INDOOR ENVIRONMENTAL QUALITY OVERVIEW "MEAN RADIANT TEMPERATURE"

- We usually control space conditions based on air temperature, but radiation has a great effect
- "Mean Radiant Temperature" MRT is the average temperature of air and all surrounding surfaces
- "Don't put thermostat in direct sunlight"
- Because windows have relatively less insulation, they have a greater effect on radiant temperatures



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OTHER AIR CONDITIONING PROCESSES

- Air movement – when the space is warm, air movement cools us
- Air movement – even when cool, contributes to comfort
- Filtration – both Return Air and Outdoor Air can be filtered
  - MUCH more to come
- Ventilation – Outside (Outdoor) Air brought into building
  - MUCH more to Come

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FILTRATION

- Filtration – Location
  - On your face – respirator
  - In the room – in-room HEPA filters, box fan filters
  - In the HVAC system – "furnace" filters, on intake and return
- Mechanisms
  - Mechanical – Filter media – particles stick to fibers in the filter media
  - Electrostatic – particles charged by static electricity are attracted to opposite charged filter
    - Washable
    - Low MERV ratings
  - Adsorbent – activated carbon

MERV	(µm) PSE (%)	0.30-1.0	1.0-3.0	3.0-10	Airflow Rate (CFM) Débit d'air (pi³/min)	410	615	820	102
12		54	83	90	Initial Resistance (IWC) Résistance initiale (IWC)	0.09	0.15	0.22	0.3

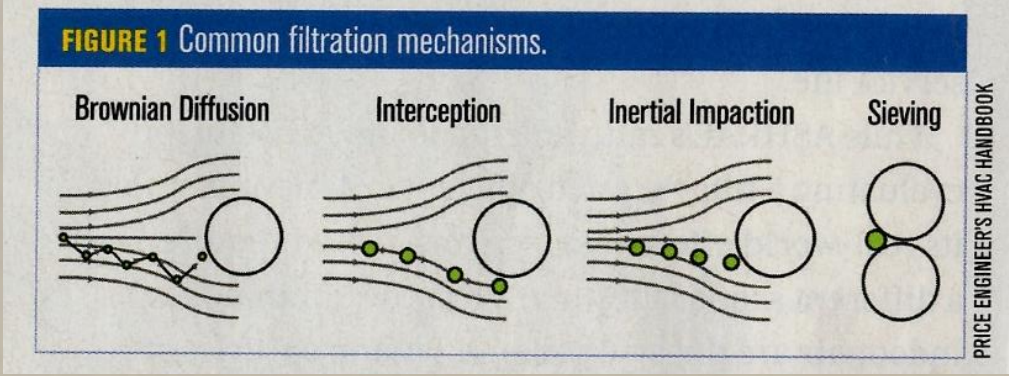
FILTRATION

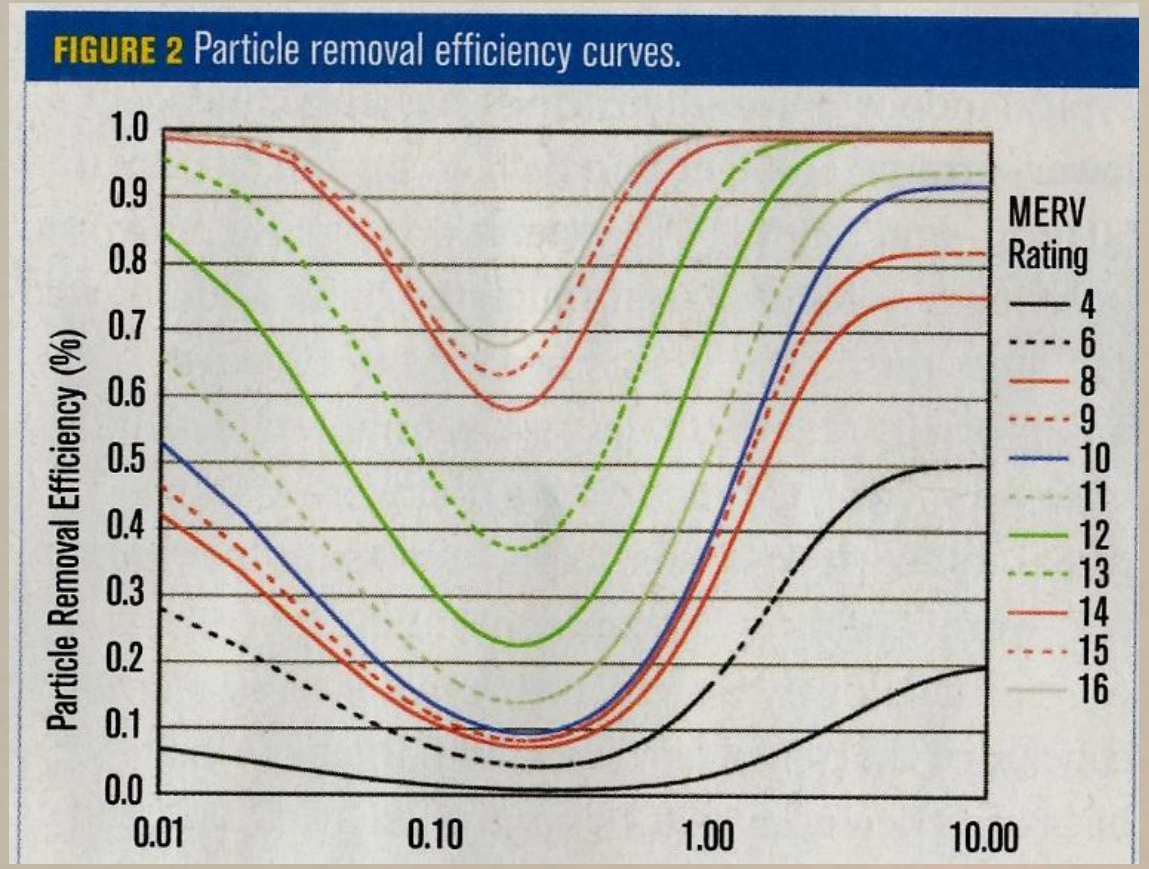
- Particles - Minimum Efficiency Reporting Value MERV
  - How efficient the filter is at capturing what percentage of particles in a size range
  - For example, a MERV 13 filter will capture over 75% of particles 0.3 to 1.0 Microns, 90% of particles bigger than 1.0 Micron
  - Can't get it all, so we rely on multiple passes through air filter – reduce concentration to <20% of OA concentration
- Filtration – Particles - High Efficiency Particulate Air HEPA filters
- Filtration – Gases – Need an activated carbon or other adsorbent filter
  - Volatile Organic Compounds VOCs
  - Body Odors BOs
  - Radon
  - NOT CO

MERV	(µm) PSE (%)	0.30-1.0	1.0-3.0	3.0-10	Airflow Rate (CFM) Débit d'air (pi³/min)	410	615	820	1025	1390*	*Max Rated Airflow *Débit d'air nominal max
12		54	83	90	Initial Resistance (IWC) Résistance initiale (iWC)	0.09	0.15	0.22	0.31	0.46	

MERV Rating	Air Filter Will Trap Particles Sized .3 To 1.0 Microns	Air Filter Will Trap Particles Sized 1.0 To 3.0 Microns	Air Filter Will Trap Particles Sized 3.0 To 10 Microns	Filter Type & Particles Removed
MERV 1	<20%	<20%	<20%	**Fiberglass and Aluminum Mesh** pollen, dust mites, spray paint, carpet fibers, pet dander
MERV 2	<20%	<20%	<20%	
MERV 3	<20%	<20%	<20%	
MERV 4	<20%	<20%	<20%	
MERV 5	<20%	<20%	20%-34%	**Disposable Filters** mold spores, kitchen aerosols, hair spray, furniture polish, household cleaning sprays
MERV 6	<20%	<20%	35%-49%	
MERV 7	<20%	<20%	50%-69%	
MERV 8	<20%	<20%	70%-85%	
MERV 9	<20%	>50%	85% or better	**Home Box Filters** lead dust, flour, auto fumes, welding fumes
MERV 10	<20%	50%-64%	85% or better	
MERV 11	<20%	65%-79%	85% or better	
MERV 12	<20%	80%-90%	90% or better	**Commercial Filters** bacteria, wildfire smoke, respiratory drops
MERV 13	>75%	90% or better	90% or better	
MERV 14	75%-84%	90% or better	90% or better	
MERV 15	85%-94%	95% or better	90% or better	
MERV 16	95% or better	95% or better	90% or better	
MERV 17	99.97%	99% or better	99% or better	**HEPA and ULPA** viruses, carbon dust
MERV 18	99.997%	99% or better	99% or better	
MERV 19	99.9997%	99% or better	99% or better	
MERV 20	99.99997%	99% or better	99% or better	

MERV EXPLAINED





- Very small particles – Brownian motion
- Larger particles – Sieving
- Filters work in a combination of mechanisms.
- Remember, the particle has to make it to the filter before it can be filtered!

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FILTRATION

- Filtration – both Return Air and Outdoor Air can be filtered
  - HVAC units with outdoor air should be filtered
  - For wildfire smoke filtration use MERV 13 or higher
  - Pre-filter with MERV 8 filter
- Filtration changes how the fans move air
  - Restriction
  - Maintenance
- Room air filters -
  - HEPA Personal Air filters

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OTHER AIR CONDITIONING PROCESSES

- Ventilation – Bringing in outdoor air - "Acceptable" – 80% don't complain, for wildfire smoke event keep AQI at 20% of Outdoor conditions
  - International Mechanical Code 2021 refers to ASHRAE 62.1-2022
    - Three paths:
    - IAQ procedure
    - Ventilation rate procedure
    - Natural ventilation rate procedure
- Watch out for entrained exhaust, local sources of pollution
  - Trucks and cars exhaust – loading docks
  - HVAC system exhaust, relief location near intake
- ASHRAE Standard 62 ≈15 CFM per person (Don't quote me on this)

Different standard for residential
ASHRAE 62.2-2022
Health care facilities ASHRAE 170

Air Quality Index (AQI) is calculated for four pollutants, particulates, sulfur dioxide, ozone, and carbon monoxide

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VENTILATION

- Ventilation – IAQ Procedure
  - Dilution
  - Specify low emission building elements carpets, wall coverings, furniture
  - Use air cleaning strategies
  - Evaluate occupant comfort
- Ventilation – Ventilation Rate Procedure
  - Based on number of occupants, activity level
- Ventilation – Natural Ventilation Rate Procedure
  - Open windows
  - Verify ventilation at least as good as VRP

VENTILATION

- Ventilation –
  - For high indoor air pollutant levels, increase ventilation
  - For wildfire smoke conditions, decrease ventilation to minimum
  - Impacts cooling ability of HVAC system

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INDOOR SOURCES OF POLLUTION

- Burning Non-Electric fuels Indoors
  - Cooking Fuels
  - Naturally aspirated water and space heating appliances
  - Unvented space heaters "catalytic" heaters
- Our Smelly Bodies
  - Not enough cologne
  - Too much cologne
  - CO_2 emitting
  - Bring in food
  - Bring in waste
  - Smoking
  - Bring Contaminants in with them
    - Bugs
    - Bacteria
    - Viruses
    - Wildfire smoke
- New Stuff
  - Paint
  - Carpet
  - Furniture
- Cleaning
  - Vacuums
  - Dusting
  - Cleaning Chemicals
- Activities
  - Sedentary adults kick up less pollution than active youngsters
- Mold

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INDOOR SOURCES OF POLLUTION

- Waste – Smelly and Maybe Toxic
  - Rest Rooms
  - Printing
  - Manufacturing
  - Glue
  - Solder
- Processes
  - Welding
  - Woodworking
- Recreation
  - Gyms
  - Pools
  - Spas

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INDOOR SOURCES OF POLLUTION

- Occupants add heat and humidity to the space
- Be aware of HVAC system capacity compared to the actual number of occupants
- Estimate the ventilation air you need (ASHRAE 62)
- Sedentary Adults – 220 Btu per hour sensible heat, 280 Btu per hour latent heat
- Active Adults – 580 Btu per hour sensible heat, 870 Btu per hour latent heat

Level of Activity	Typical	Heat Gain / Person btuh	
	Application	SHG (qs)	LHG (ql)
Seated at rest	Theater	245	105
Seated, light work	Office	245	155
Moderate office work	Office	250	200
Standing, walking slowly	Retail Sales	250	250
Light bench work	Factory	275	475
Dancing	Nightclub	305	545
Heavy work	Factory	580	870

Energy –Models.com "ASHRAE Table 8.19"

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OTHER INDOOR ENVIRONMENTAL QUALITY FACTORS

- Noise – Increased Fan Use = More Noise
  - Building Level HVAC Fan Noise
  - In-Room HEPA Filter Units Fan Noise
- Lighting – Probably the Last We Will Hear of This One
  - Until people have a burning question about lighting
- Pests -Probably the Last We Will Hear of This One
  - Until people complain about bugs or rodents

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BALANCE ENGINEERING

HVAC EQUIPMENT - PREPARATION

- Air side equipment
  - Fans – Track motor amperage, clean fans
  - Filters – Track room temperatures
  - Coils – Clean
  - Coils – Comb condenser fins
- Direct Expansion equipment
  - Track temperatures (ΔT) 20F, Minimum Supply Temperature 55F
- Water side equipment
  - Chillers – Track flow rates, (ΔT)
  - Coils – Clean
  - Maintain water treatment

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HVAC EQUIPMENT – DURING SMOKE EVENT

- Air side equipment
  - Fans – Track motor amperage – operation in service factor?
  - Filters – Track pressure drop across filters
- Direct Expansion equipment
  - Track temperatures (ΔT) 20F, Minimum Supply Temperature 55F
- Water side equipment
  - Chillers – Track flow rates, (ΔT)

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WHY ARE WE CONCERNED ABOUT WILDFIRE SMOKE?

- We consider outdoor air, (ambient air, ventilation air) to be generally cleaner than indoor air
- Smoke negatively affects the quality of ambient air (outdoor air, ventilation air)
- We use outdoor air to dilute indoor air pollutants
  - Smoke is not just from burning vegetation, it is also from human sources (think burning buildings and Human Made Stuff)

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WILDFIRE SMOKE POLLUTANTS

- Standards exist for "Criteria Pollutants" Tested in ambient air
- $PM_{2.5}$, PM_{10}, O_3, No_x, SO_x, CO
- Other pollutants "Toxic Pollutants" Tested at their source
- VOCs, PAH, Lead, other metals

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$PM_{2.5}$

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WILDFIRE SMOKE POLLUTANTS

$PM_{2.5}$

- Most concern is $PM_{2.5}$
- $PM_{2.5}$ is of concern because these particles penetrate deep into lungs
- $PM_{2.5}$ particles pick up other pollutants (VOCs, PAHs)by adsorption
- Causes a wide variety of human ills not just respiratory, but systemic inflammation can effect other organs including immune system, heart, brain, kidneys, and increase in cancer rates.
- Causes an increase in hospital visits and higher healthcare costs.
-

WILDFIRE SMOKE PENETRATES BUILDINGS

- Infiltration is uncontrolled air leaking into the building
- Ventilation is controlled outdoor air pushed or pulled into the building by ventilation equipment
- $PM_{2.5}$ infiltration coefficients above 20% in all studied cases during smoke events
- Outdoor $PM_{2.5}$ Can be much higher during a smoke event
- We can increase indoor $PM_{2.5}$ by bringing in smoky outdoor air
- Keep $PM_{2.5}$ levels no more than 20% of outdoor levels

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WHAT KIND OF FACILITY DO WE NEED TO USE FOR A SMOKE SHELTER?

- Have the ability to operate building differently during smoke event
- Good building envelope integrity
  - Sealing and weatherstripping to decrease infiltration
  - Mechanical ventilation and air conditioning systems
    - OA Filtration
    - RA Filtration
  - Vestibules
  - Qualified HVAC staff or contractors
    - Readiness to make quick, temporary changes to OA
  - Get rid of soft surfaces
  - Do not vacuum during smoke event

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WHAT IF YOU DON'T HAVE AN IDEAL FACILITY TO USE FOR A SMOKE SHELTER?

- Seal and weatherstrip to decrease infiltration
  - Focus on keeping smoky outdoor air out
- Turn outdoor air to minimum
- Filter outdoor and return air to MERV 13
- Track pressure drop across filters
- Use box fan filters
- Use HEPA room air filter (Personal Air cleaner)

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HOW TO PREPARE FOR WILDFIRE SMOKE OR PRESCRIBED BURN EVENTS

- Have a Smoke Readiness Plan
- Recognize the need to operate the building differently during a smoke event

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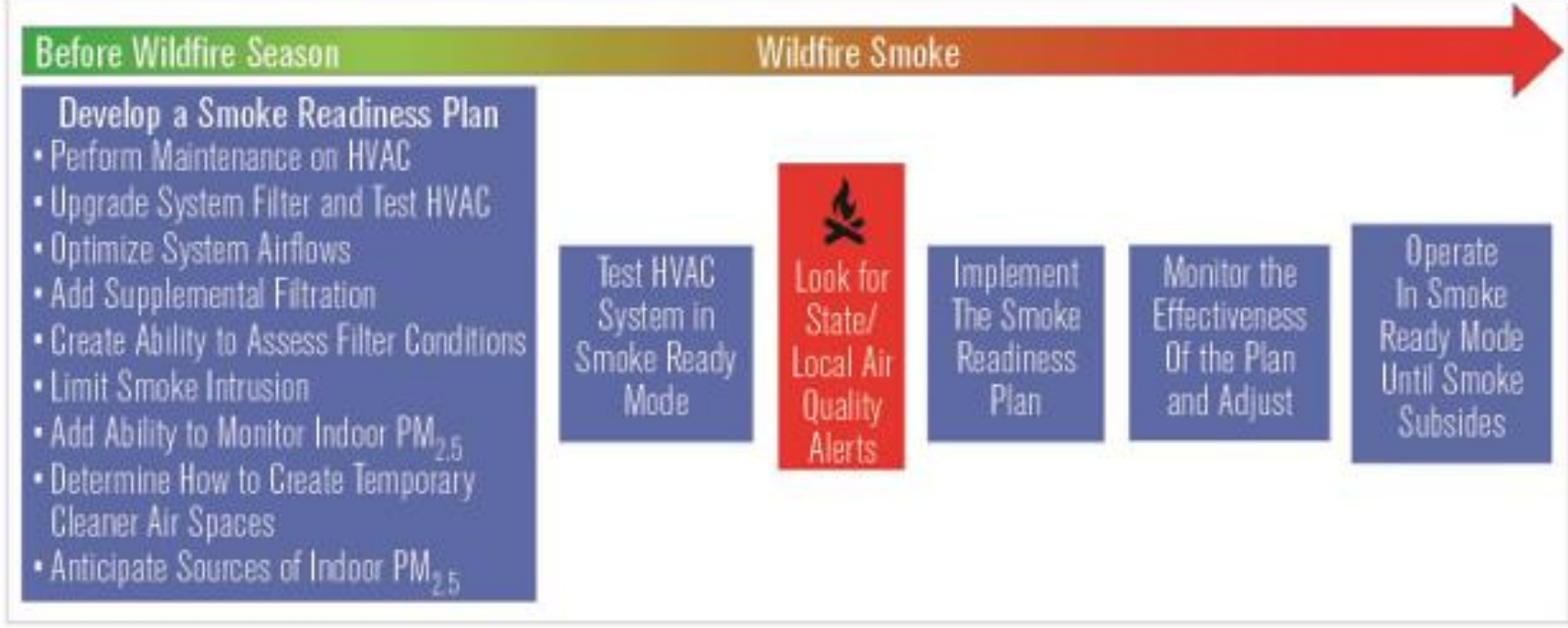
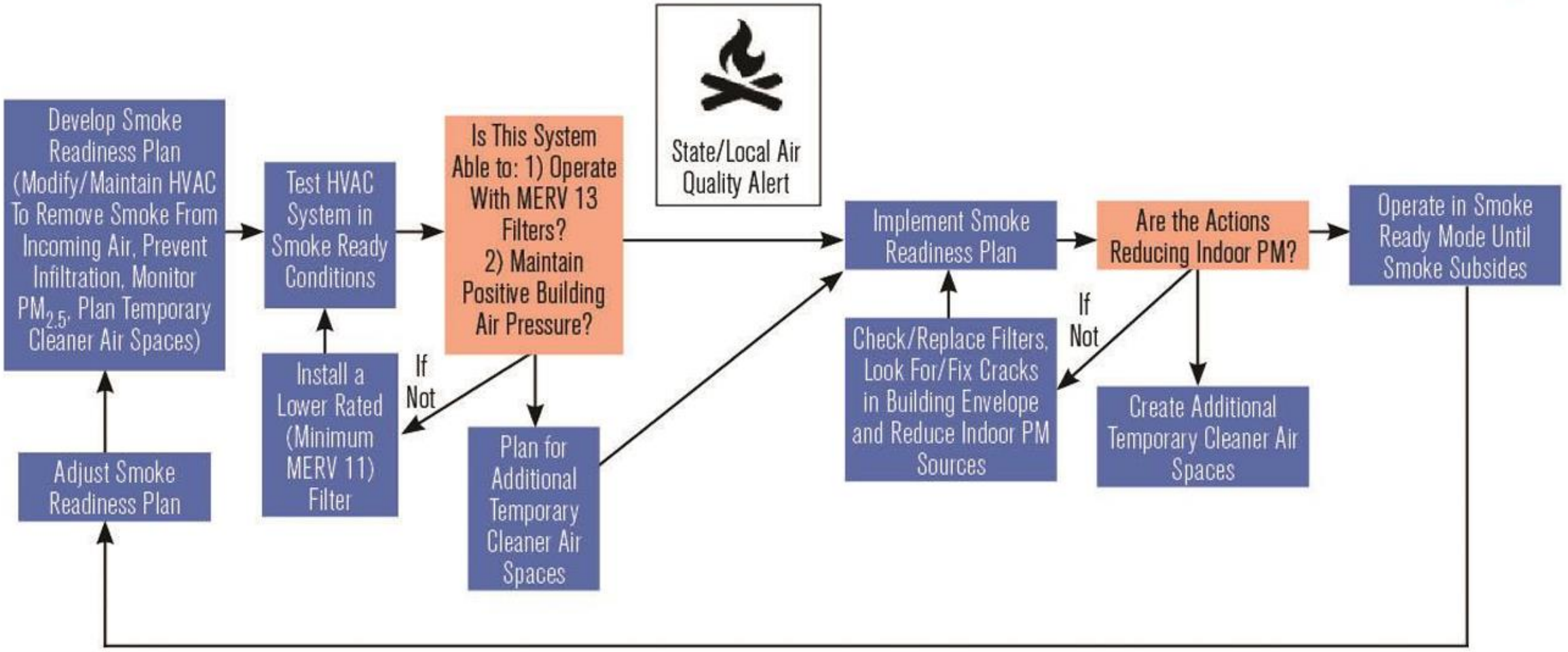
SMOKE READINESS PLAN

FIGURE 1 Process for making a building smoke ready.



SMOKE READINESS PLAN



DURING A SMOKE EVENT

- Monitor indoor and outdoor $PM_{2.5}$
- Make sure doors and windows stay closed
- Do not vacuum
- Turn OA to minimum
- Check filters
- Maintain a slight positive pressure in the building

HOW TO BETTER CONTROL SMOKE IN BUILDINGS

KEEP THE SMOKE OUT

- Infiltration is uncontrolled air leaking into the building
- Make sure doors and windows stay closed
- Cover up large penetrations
- Seal and caulk smaller penetrations
- FILTER ventilation air
- Maintain a slight positive pressure in the building to minimize uncontrolled air

HOW TO BETTER CONTROL SMOKE IN BUILDINGS

USE HEPA FILTER UNITS FOR ROOM AIR CLEANING

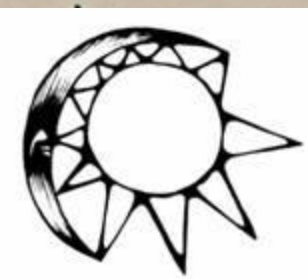
- Keep extra filters on hand

AIR CLEANING AND SENSOR TECHNOLOGIES

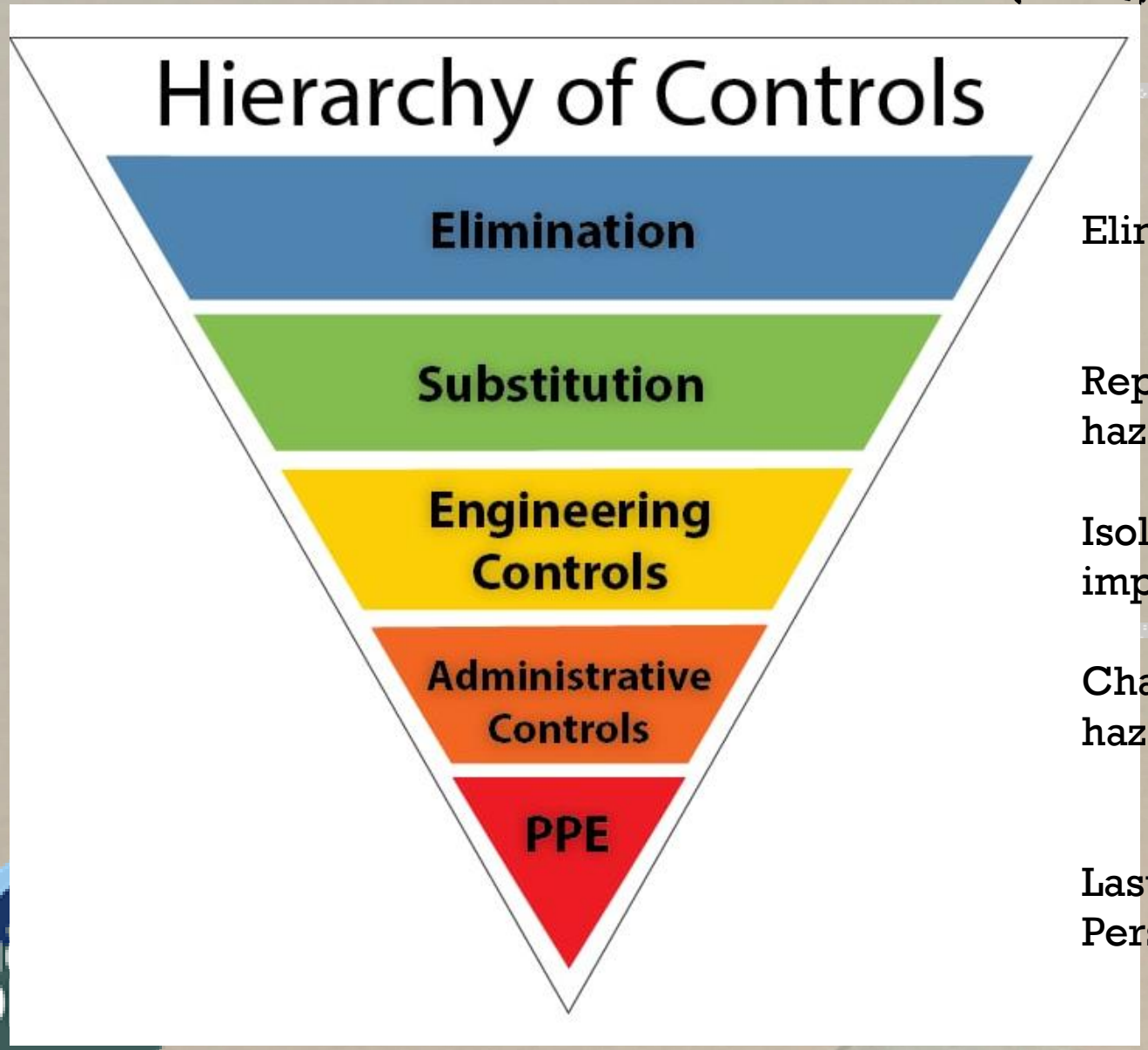
- Use to help inform Smoke Readiness Plan
- Sanitation
- Clean Drinking Water
- Safe Food

Considered to be traditional

- >>>Covid-19<<< Bringing about big changes in IAQ sensors and system philosophy
- Install sensors
- Trend Data



HIERARCHY OF CONTROLS (IAQ)



Eliminate the source of pollution

Replace a hazardous substance with a less hazardous one

Isolate people from pollution by HVAC improvements

Changing schedules around the use of hazardous materials

Last Resort – Protect the individual using Personal Protective Equipment

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- Be ready to:

Decrease OA, disable demand controlled ventilation, disable economizers

Filter OA and RA to MERV13 if possible, have extra filters on hand

Fans: Be aware of: surge (low flow condition) in centrifugal fans

Overloading of ECM fan motors

Overloading of VFD controlled fans

Low flow condition for inductive motor driven fans – freezing coils

DX Cooling: Check for: 55F discharge temp after 20 minutes of run time

Icing evaporator coils

Heating: Check for adequate flow across heat exchangers

!Know manufacturers recommendations!

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- Be Ready to:

Add supplemental air filters

Check pressure drop across filters, no more than 2X clean pressure drop

Use Portable Air Cleaners – buy PAC made to filter out particles (HEPA)

No ozone generators. (see Sec. 5.9 of Standard 62.1)

Correct size for room volume

Consider noise

Shoot for 20% of OA $PM_{2.5}$ level maximum

Deploy Do It Yourself Air Cleaners – Resources online

Follow fan manufacturer's recommendations

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- Be Ready to:

Make necessary changes to Building Automation System

Know BAS features that can help put the facility into Smoke Event Mode

Verify accurate sensor readings

Check fire suppression system status with fire department

Mitigate indoor air pollutant level increase

(Hey buddy how about a sponge bath?)

Add activated carbon filters

Don’t vacuum during smoke event or use HEPA vacuum

Limit use of outside doors

Use Personal Protective Equipment (PPE)

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QUESTIONS??

- If we have time and we want to take a look at specifics in the guideline, we can keep going….

- (This is your chance to bail)

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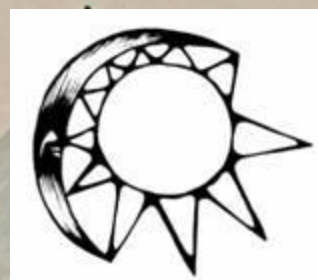
- In recent years, the incidence of wildland fires has increased in both the number of fires per year and the severity and duration of each event. In some cases, smoke events have lasted several weeks to months. The smoke produced from wildland fires can have a significant negative impact on ambient air quality, both local and distant, which in turn can negatively impact health. This guideline provides detailed information on the impacts of smoke on human health, with best practices in both building design and building operation to reduce the impact of prolonged smoke events on indoor air quality. The overall goal is to reduce exposure of occupants to wildland fire smoke, thereby protecting their health and wellbeing.



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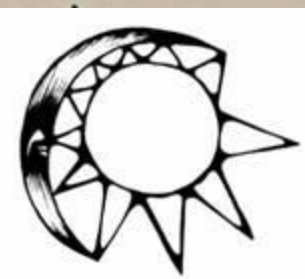
- Scope:
  - Commercial Buildings
    - For at-risk populations – elderly and children, active people
    - Design, installation, commissioning, operation, and maintenance of building envelope, ventilation, and air-cleaning systems.

- Note: the Guideline assumes that the HVAC systems in the building are well maintained and are working as designed in the building for which the smoke readiness plans are being developed.



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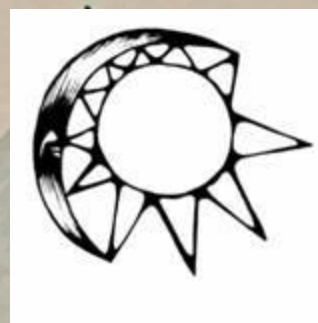
- 4. Background:
  - Wildfire smoke can contain anthropogenic pollution
  - A growing problem worldwide
  - Highly variable (wild?) concentrations of pollutants, only a few are measured
  - Focus on PM2.5
  - Health effects both acute and chronic, a particular concern to at-risk populations
  - Indoor Air Quality is an essential building service
  - Smoke infiltrates buildings – 20% to 80% OA PM2.5 concentration in commercial buildings
  - ALARA- As Low As Reasonably Achievable-
  - Emerging air cleaning and sensor technologies



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- 5. Design and Commissioning (Before smoke event)
  - Reduction of PM2.5 infiltration
  - Removal of PM2.5 in Indoor Air
  - Calculations
  - Design measures
    - Monitoring/Sensors – Indoor and Outdoor sensors
    - Building controls – Decrease OA, increase filtration
    - Increase SA runtime, check control sequences for damper coordination
    - Building pressure .02-.07 in. w.c. more than OA, or OA>1.1*EA
    - Tighten envelope
    - Use portable air cleaners
    - Disable natural ventilation
    - Commission systems

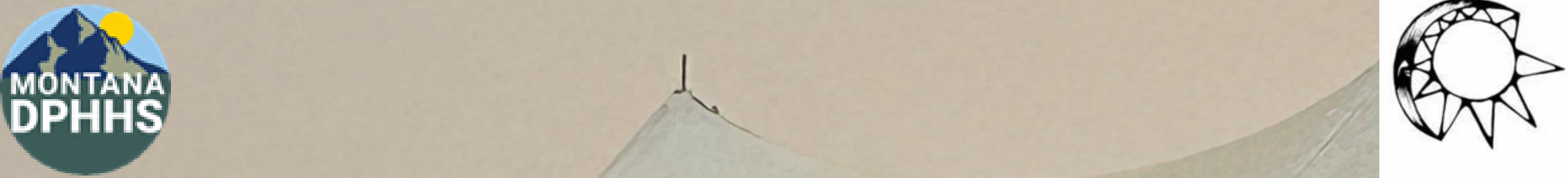

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Table 3 Application of Measures to Mitigate Wildfire Smoke

Measure	System							
	Large Chilled-Water AHUs with Supply VAVs	Large Chilled-Water AHUs with Supply VAVs and Return Airflow Control	Large Rooftop Package Units (more than 5 tons)	Small Rooftop Package Units (5 tons and smaller)	Radiant Systems with DOAS	Chilled Beams with DOAS	Ducted VRF with DOAS	Ductless VRF with DOAS
Add PM2.5 sensors	1	1	1	1	1	1	1	1
Add building pressure sensors	1	1	1	1	1	1	1	1
Reduce/shutdown outdoor air	1	1	1	2	2	2	2	2
Disable economizers and/or DCV	1	1	2	2	N/A	N/A	N/A	N/A
Maintain positive pressure between building and outside	1	1	1	1	1	1	1	1
Maintain positive pressure across zones inside building	3	1	3	3	3	3	3	3
Include vestibules/entryways	2	2	2	2	2	2	2	2
Add air curtains	1	1	1	1	1	1	1	1
Tighten duct and dampers after leak test	1	1	1	2	1	1	1	2
MERV 13 filters on recirculating and outdoor air	1	1	1	2	3	3	2	3
MERV 13 filters on outdoor air only	1	1	1	2	2	2	2	2
Fan sizing for filter loading	1	1	1	3	2	2	2	2
Add PACs	1	1	1	1	1	1	1	1

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- 6. Smoke readiness plan

Table 4 Elements to Consider in the Smoke Readiness Plan

Preparing for Wildland Fire Smoke	
Example Questions to Address in Planning Phase	**Guidance in this Document**
What are any specific building design elements for controlling smoke?	• Section 5.5, "Design Measures" • Section 5.8, "Communication of the Smoke Readiness Plan to the Design and Operation Team"
Is the HVAC system in need of maintenance and repair?	• Section 6.2.1, "Mechanical Ventilation" • Checklist 1
Are the needed supplies on hand (including HVAC filters, personal protective equipment, portable air cleaners, etc.)? Where are they stored?	• Section 6.2.2, "Air Cleaning" • Section 6.2.7, "Administrative Controls"
Do building automation systems display the controls and settings that will need to be adjusted for smoke?	• Section 5.5.1, "Monitoring" • Section 5.5.2, "Building Controls" • Section 6.2.3, "Building Automation Systems"
Is an indicator such as a magnehelic gage or other sensor/procedure in place to identify when filter changes are needed?	• Section 5.5.1.3, "Building Pressure Sensors"
Have the gaps in the building envelope been sealed?	• Section 5.5.3, "Envelope Tightening" • Section 6.2.4, "Building Envelope"
Do dedicated cleaner air spaces with portable air cleaners need to be set up?	• Section 6.2.2, "Air Cleaning" • Section 6.2.5, "Dedicated Cleaner Air Spaces"
Are there concerns about maintaining space conditioning or reducing odors?	• Section 6.2.6, "Maintaining Space Conditioning and Reducing Odors"
Can indoor sources of air pollutants be identified and either reduced or eliminated?	• Section 6.2.7, "Administrative Controls"
Can smoke entry into the building be reduced by limiting use of certain entrances/exits?	• Section 6.2.7, "Administrative Controls"
Are indoor PM2.5 monitors available? What are the baseline PM2.5 concentrations?	• Section 5.5.1, "Monitoring" • Section 6.2.8, "Indoor and Outdoor PM2.5 Monitoring"
Are there special circumstances to address?	• Section 6.2.9, "Special Considerations for Health Care Facilities, Schools, and Other Institutions"
What are the criteria for implementing the plan and returning to normal operation?	• Section 6.4.2, "When to Implement the Smoke Readiness Plan" • Section 6.5, "Returning to Normal Operations"

Operational Testing	Implementing the Plan	Returning to Normal Operations
• Test any specific building smoke control measures.	• Take the steps in the plan. • Section 6.4.2 • Checklist 2	• Return HVAC to normal settings. • Section 6.5 • Checklist 3
• Test outdoor air damper settings that may be used to limit smoke entry. Ensure that positive building pressure is maintained. • Section 6.2.1	• Take the steps in the plan. • Section 6.4.2 • Checklist 2	• Return HVAC to normal settings. • Section 6.5 • Checklist 3
• Check that indoor PM2.5 monitors are working. • Section 6.2.8	• Check indoor PM2.5 monitors to ensure mitigation measures are working; make any adjustments. • Section 6.4.3	• Clean indoor surfaces. • Section 6.5

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ASHRAE GUIDELINE 44-2024

- 6. Smoke readiness plan

Checklist 1 Determine if the HVAC System is Ready for Smoke

- ☐ Review and check the building's smoke control design features.
- ☐ Do the outdoor air dampers function correctly? (Figure 3 shows a picture of a warped damper blade unable to close.)
- ☐ Are the damper blades, linkage, and edge seals in good condition?
- ☐ Does the building have a commercial thermostat or control system that allows the outdoor air dampers to remain closed when the system is set for an unoccupied state?
- ☐ Are there record drawings, blower door tests, commissioning reports, equipment installation, and service manuals or other information available?
- ☐ Does the outdoor air economizer work correctly?
- ☐ Can the minimum damper set point be changed and the economizer function be temporarily shut off? How is this accomplished for each air handler?
- ☐ Is it possible to disable or reduce the relief fan airflow?
- ☐ Does the demand control ventilation system work correctly?
- ☐ Can the unit use MERV 13 filters or higher? If the system cannot use MERV 13, use the highest MERV-rated filter possible. There are alternative filtration technologies that allow filtration at a range of pressure drops. See the "Upgrading and Improving Filtration" section of the ASHRAE Epidemic Task Force Building Readiness guide for more information.
- ☐ Has an HVAC or TAB technician evaluated whether installing MERV 13 filters will reduce airflow to an unsafe level? System characteristics, such as the duct configuration and dirt on air coils, can also affect airflow.
- ☐ Are all filters properly seated and edges sealed? Air leakage around the filters will greatly reduce their ability to clean the air. (Figure 4 shows a filter that is not seated correctly.)
- ☐ Have the filter and fan access doors been checked to confirm that they are fastened and sealed?
- ☐ Where are the exhaust fans and how are they controlled?
- ☐ Which exhaust fans are critical for safety? Examples may include exhaust fans serving isolation rooms, commercial kitchen hoods (if cooking is occurring), and locations where hazardous materials are handled (e.g., laboratories).
- ☐ Where are the locations of exhaust grilles? Can they be partially blocked to reduce the amount of filtered outdoor airflow?
- ☐ If the building has more than one air handler or rooftop air-conditioning unit, can some of them be set to recirculation and a small number used to provide filtered outdoor air?
- ☐ Does the building have an air-conditioning system or portable cooling units to prevent heat-related illness?

Table 5 Example of How to Capture Operational Settings in Normal Operations and Smoke-Ready Mode

Setting	Value under Normal Operations	Value During Smoke-Ready Mode	Notes (such as date changed)
Outdoor air damper setting			
Operating time schedule of HVAC system			
Filter size			
Quantity needed per filter replacement			
MERV rating of main HVAC unit filters			
Critical breaker and switch positions and locations			

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- Special considerations for:
  - Health care facilities
  - Schools

RESOURCES

- https://sftool.gov/learn/about/1/indoor-environmental-quality-ieq#:~:text=Indoor%20Environmental%20Quality%20(IEQ)%20is,over%20lighting%20and%20thermal%20comfort.
- https://www.epa.gov/sites/default/files/2018-07/documents/guide_to_air_cleaners_in_the_home_2nd_edition.pdf
- https://energy-models.com/internal-heat-gains-ihg#:~:text=Latent%20heat%20(moisture%20or%20water,a%20time%2Ddelayed%20cooling%20load.
- https://www.epa.gov/indoor-air-quality-iaq?utm_content=&utm_medium=email&utm_name=&utm_source=govdelivery&utm_term=
- https://www.epa.gov/sites/default/files/2018-07/documents/guide_to_air_cleaners_in_the_home_2nd_edition.pdf
- https://www.airnow.gov/sites/default/files/2018-04/aqi_brochure_02_14_0.pdf
- https://www.ashrae.org/technical-resources/bookstore/indoor-air-quality-guide

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