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Submitted On: 11/4/2026
Docket Number: 25-BSTD-03

HPWH Installation Provisions for Health and Safety-Part 2

I was only able to attach one document for Part 1. This attachment is a presentation that has been given to the HPWH manufacturers explaining the health and safety risks associated with improper HPWH installations.

Thank you for considering my comments. Gary Klein

Additional submitted attachment is included below.

The Ins and Outs of Installing Air-Source Heat Pump Water Heaters

AHRI Guideline U Committee
October 15, 2026

Gary Klein

gary@garykleinassociates.com

916-549-7080

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Do You Know Anyone Who…

- Has installed an integrated (unitary) air-source Heat Pump Water Heater (HPWH)?
- Has inspected the installation of this type of water heater?
- Has wondered if the HPWH will perform properly in the location it was installed?
- Is curious to know if there are any unintended consequences of installing these units inside a building?
- Would like to understand how to install these units in a way that protects the health and safety of the building and its occupants and so that they will operate efficiently?

Why HPWHs? The Opportunity & Challenge

HPWH Benefits

- ✅ High efficiency – up to 3-4x more efficient than electric resistance storage water heaters
- ✅ Supports decarbonization & electrification goals
- ✅ Growing adoption across residential & commercial markets

The Challenge

- ❌ Mismanagement of the cold exhaust air → condensation & mold risks
- ❌ Poor installations → moisture damage, lost efficiency, and discomfort

🚨 **Getting installations right is critical!**

The Big Problem:
Poor Installations Have Consequences

📌 Unintended issues from poor HPWH installation

Health and Safety Risks

❌ Cold air impacts surface → condensation, moisture damage & mildew and mold on surface
❌ Cold air trapped → condensation & mold inside building cavities

Lower Operating Efficiency

❌ Limited airflow → reduced efficiency & higher costs
❌ Cold inlet air temperatures→ reduced efficiency & higher costs

Real-World Case Studies…

From 2025: https://buildingscience.com/documents/building-science-insights/bsi-150-alice-cooper-does-heat-pump-hot-water-heatersc
https://heatinghelp.com/systems-help-center/air-source-heat-pump-water-heaters/

Garage Install Failure

Richmond, VA
Resulted in Mold Growth

- ✅ Plenty of air exchange
- ❌ Cold discharge air impacts air handler and ductwork
- ❌ Humid garage air condensed on air handler and supply ductwork, causing mold
- ❌ Equipment was removed

🚨 **Lesson Learned: Plan exhaust direction & airflow carefully!**

***Issue**: Installation instructions say that the space volume is large enough. <u>However, the instructions do not address</u> where the exhaust air is directed, or the potential to create condensation on exposed surfaces.*



Indoor Closet Install Failure

Richmond, VA
Resulted in Mold Growth

- ✅ Plenty of air exchange through louvered door
- ❌ Cold discharge air impacts back wall
- ❌ Humid air condenses on back wall
- ❌ Dehumidifier was added as part of the mold mitigation effort

🚨 **Lesson Learned: Don't cool surfaces below the dew point!**

***Issue**: Installation instructions say that the full louvered door provides enough airflow and require minimum spacing to the back wall, which appears to have been met. However, the instructions do not address the high humidity/dewpoint of the incoming air.*



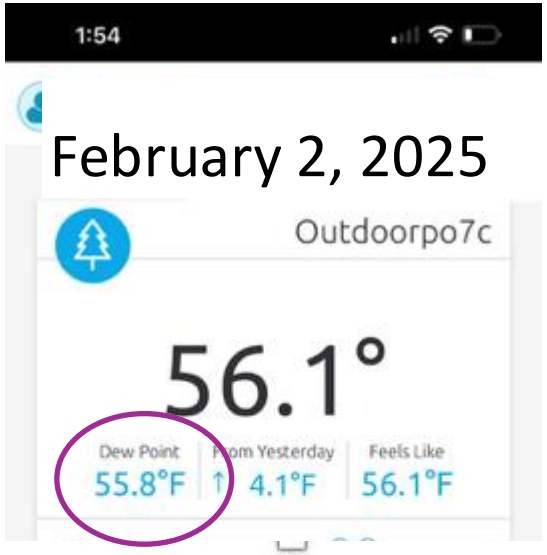
Garage Installation

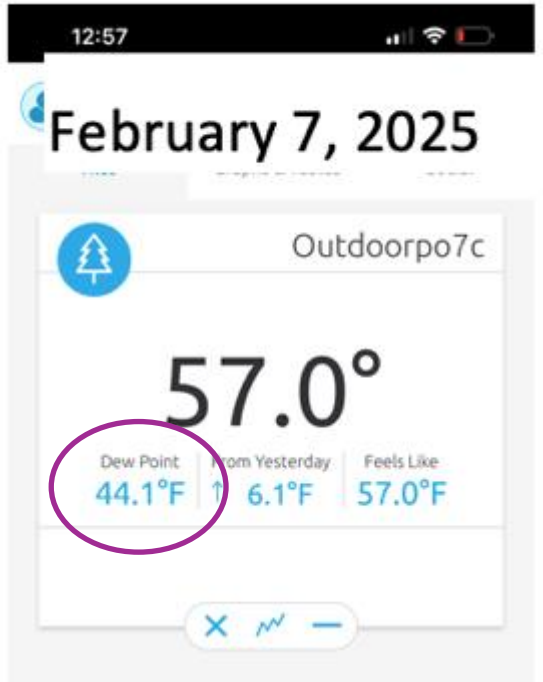
Sacramento, CA



Condensation on the outside of the duct







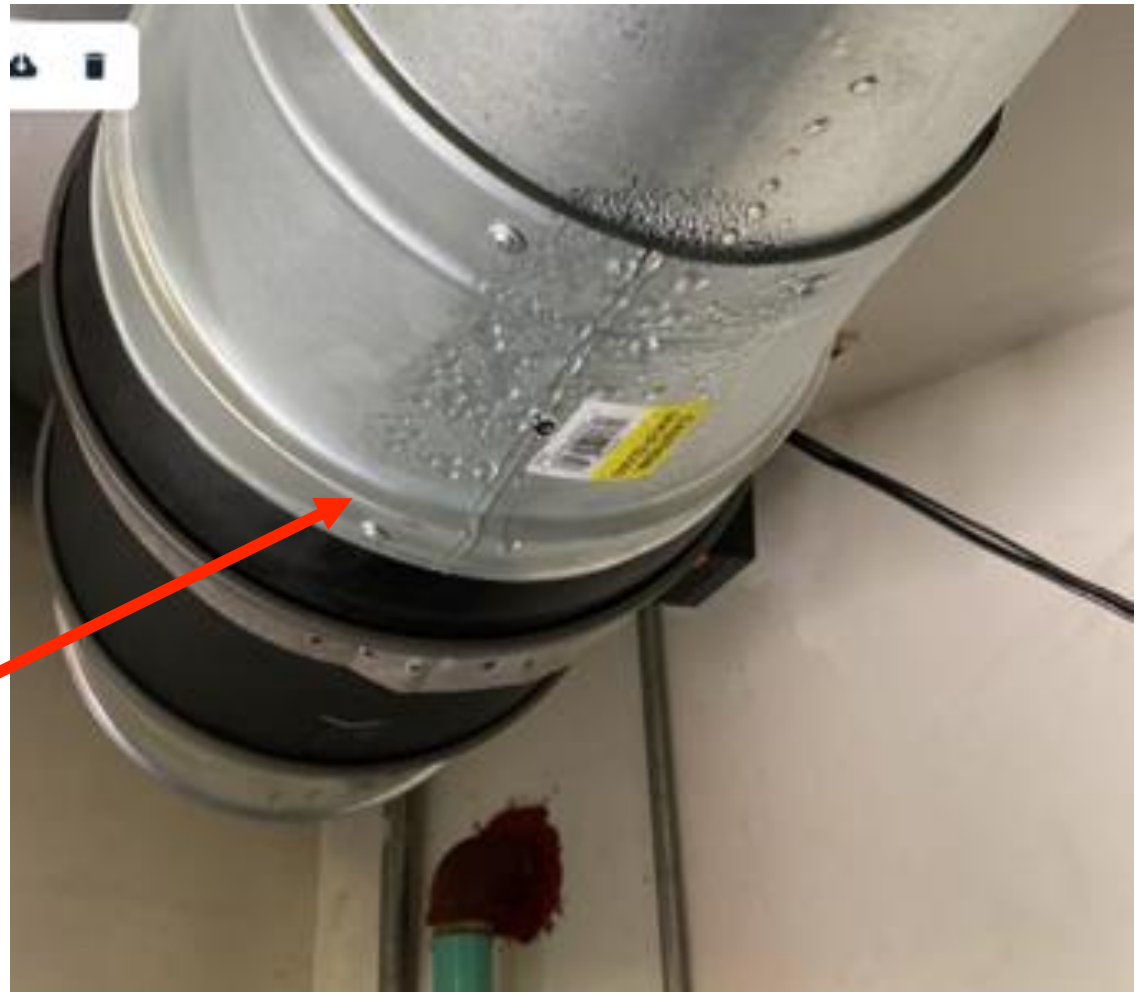
Mechanical Room

Los Angeles, CA

Hotel

- Room temperature in the 40-50ºF range
- Condensation on cold air exhaust pipe

Condensation on the outside of the duct



External Closet

Sacramento, CA

Garden apartment complex

Needs much larger openings

Intake and Exhaust Air Flows:
need to match <u>and</u> be proportional to the number of water heater and the CFM of the blowers.



Collar



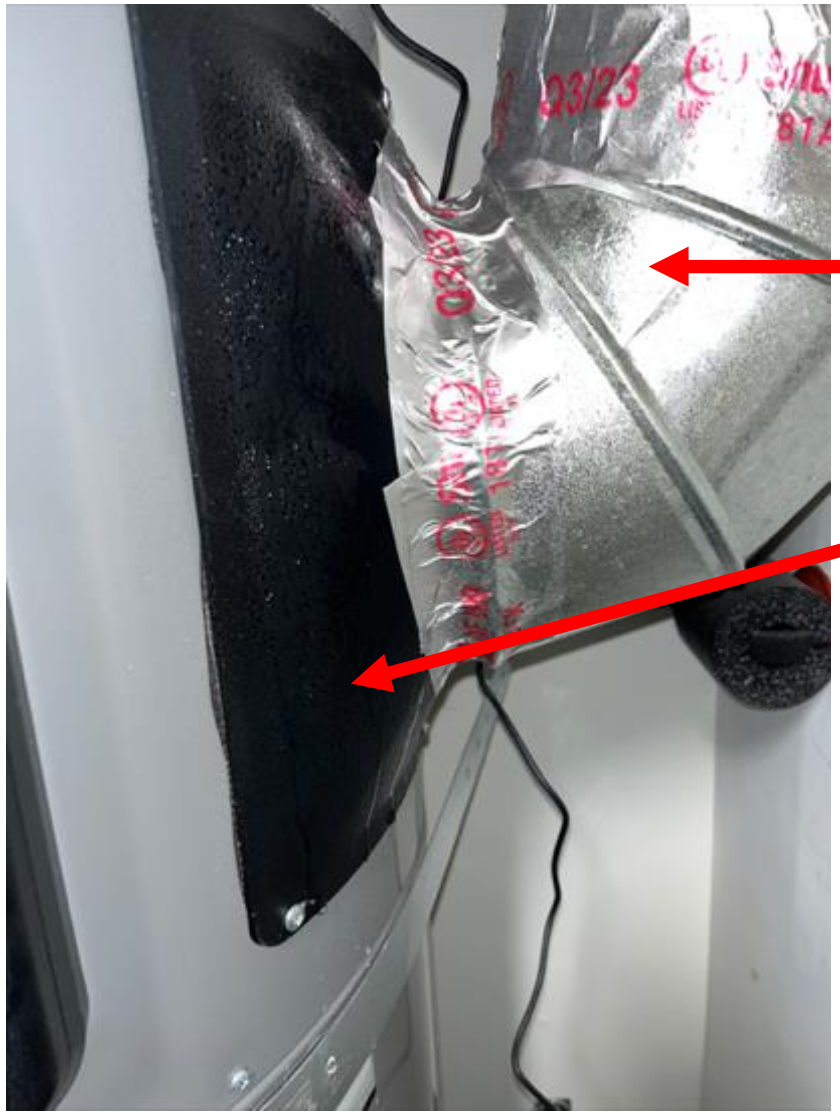
Intake



Exhaust

Internal Closet

Rancho Cucamunga, CA



Condensation on the Duct and on the Take-off boot



"We are continuing to have condensation issues with the exhaust duct kit, which sweats at certain times of the year, creating water that runs downhill, hits the water heater, and goes into drain pan, which then shuts down the water heater. " Apartment Building Owner



FIGURE 5. IMAGES OF SHRINKING ROOM INSTALLATION

Construction of the Amazing Shrinking Room

Thanks to PGE! Many images come from:

Final Project Report
Laboratory Testing of Heat Pump Water Heater Performance: Impact of Airflow and Space Configurations
CR22PGE1901-1

ASR Data provided by Ben Larson

Plan View of the Amazing Shrinking Room

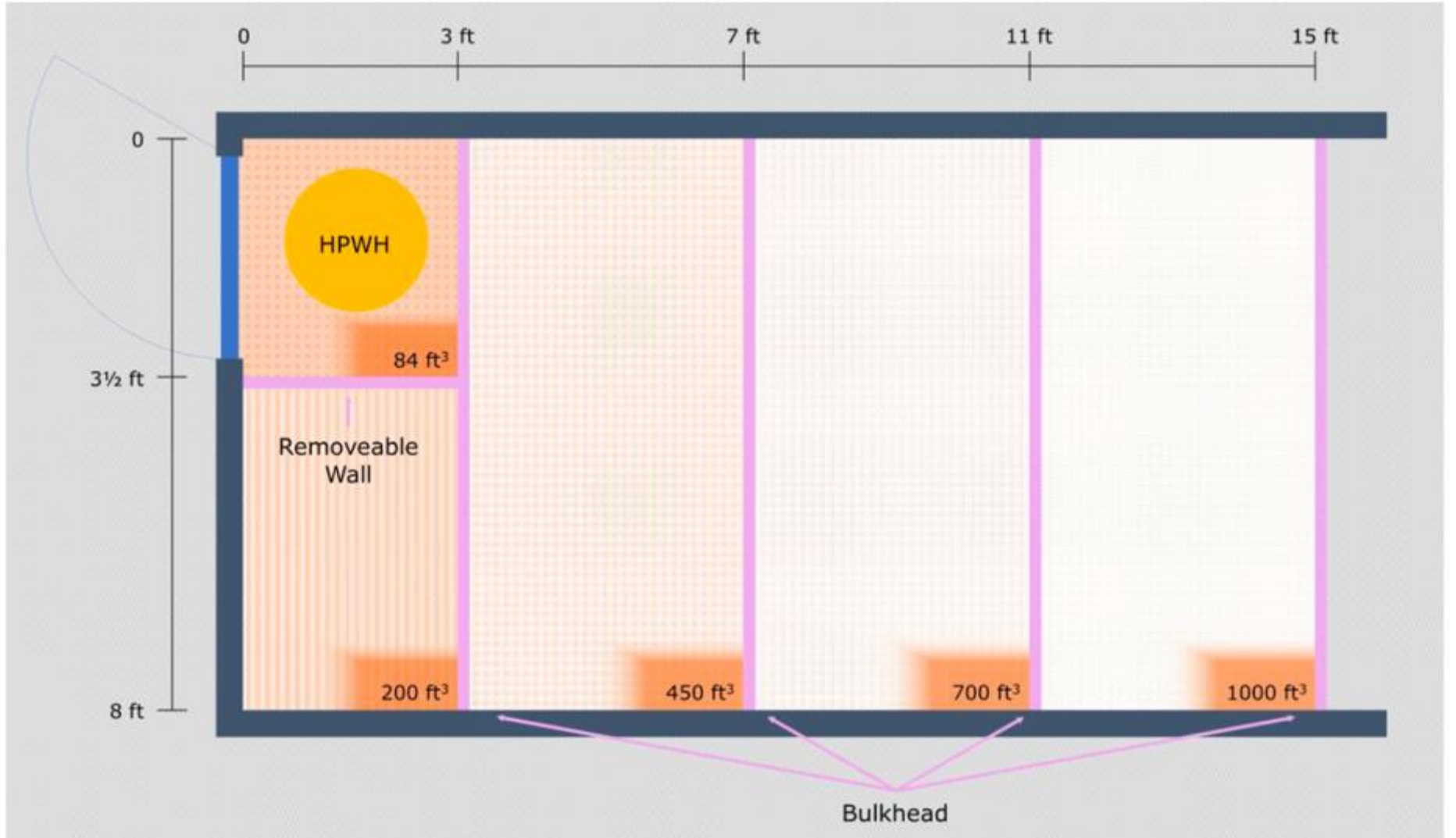


FIGURE 6. DIAGRAM OF SHRINKING ROOM CONFIGURATIONS

HPWH Installed in Interior Enclosure

Limited access to new thermal resources. No new intake and exhaust stays in the room. New energy can only get into the enclosure via conduction.

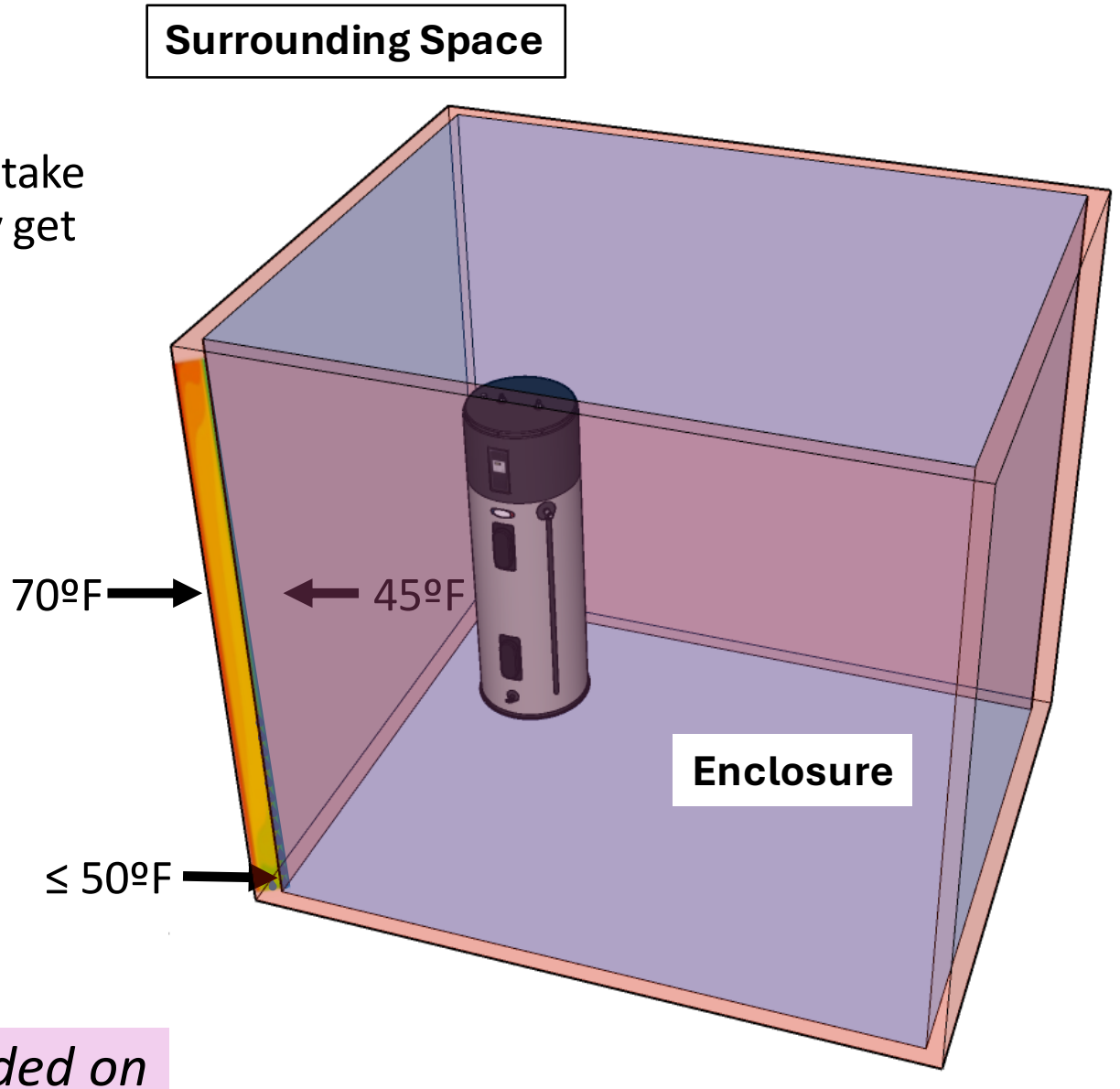
Surrounding Space Air Conditions:

- Dry Bulb Temp: 70ºF
- Relative Humidity: 50%
- Dew Point Temp: 50.5ºF

Enclosure Air Conditions:

- Dry Bulb Temp: 45ºF
- Relative Humidity: Low
  - HPWH removes moisture from the air

Best case is that this enclosure is surrounded on all 6-sides by other rooms at 70ºF or higher. This is very rarely the case!



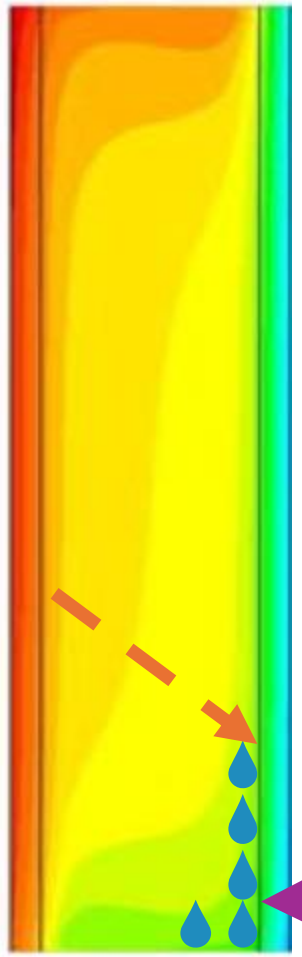
Temperature Gradient

The **temperature** differential has the Potential to Create Condensation on Surfaces that Results in Moisture Damage and Mold Growth

Surrounding Space Air Conditions:

- Dry Bulb Temp: 70ºF
- Relative Humidity: 50%
- Dew Point Temp: 50.5ºF

Temperature: High



Enclosure Air Conditions:

- Dry Bulb Temp: 45ºF
- HPWH removes moisture from the air

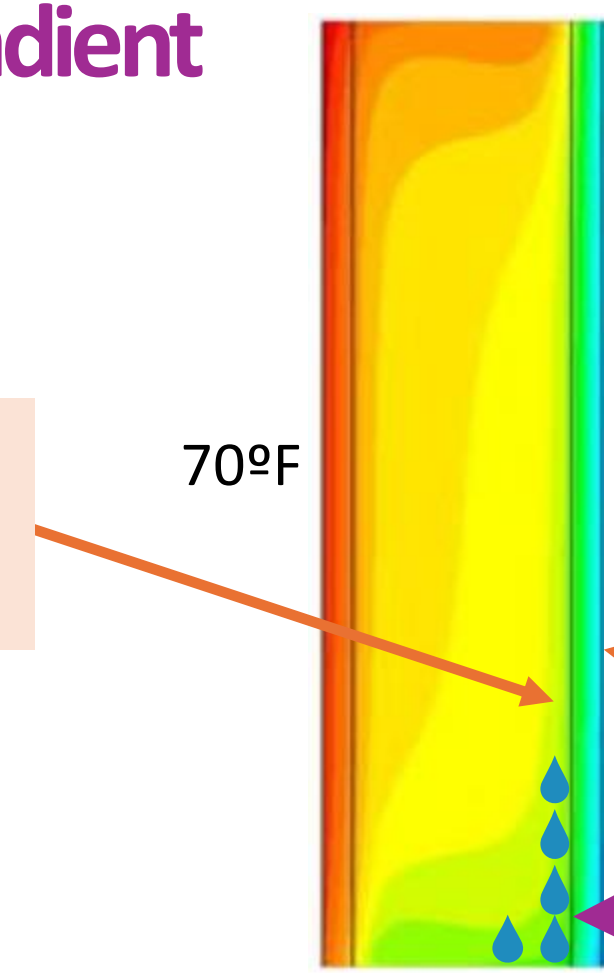
Temperature: Low

***Issue**: Installation instructions do not address the potential for moisture to condense on surfaces inside the walls, floors and ceilings.*

Recommended Reading: The Perfect Wall by Joseph Lstiburek.
https://buildingscience.com/documents/insights/bsi-001-the-perfect-wall

Vapor Pressure Gradient Part 1

The **vapor pressure** differential **<u>also</u>** has the Potential to Create Condensation on Surfaces that Results in Moisture Damage and Mold Growth



2nd Surface is <u>in the cavity</u> that surrounds the HPWH enclosure

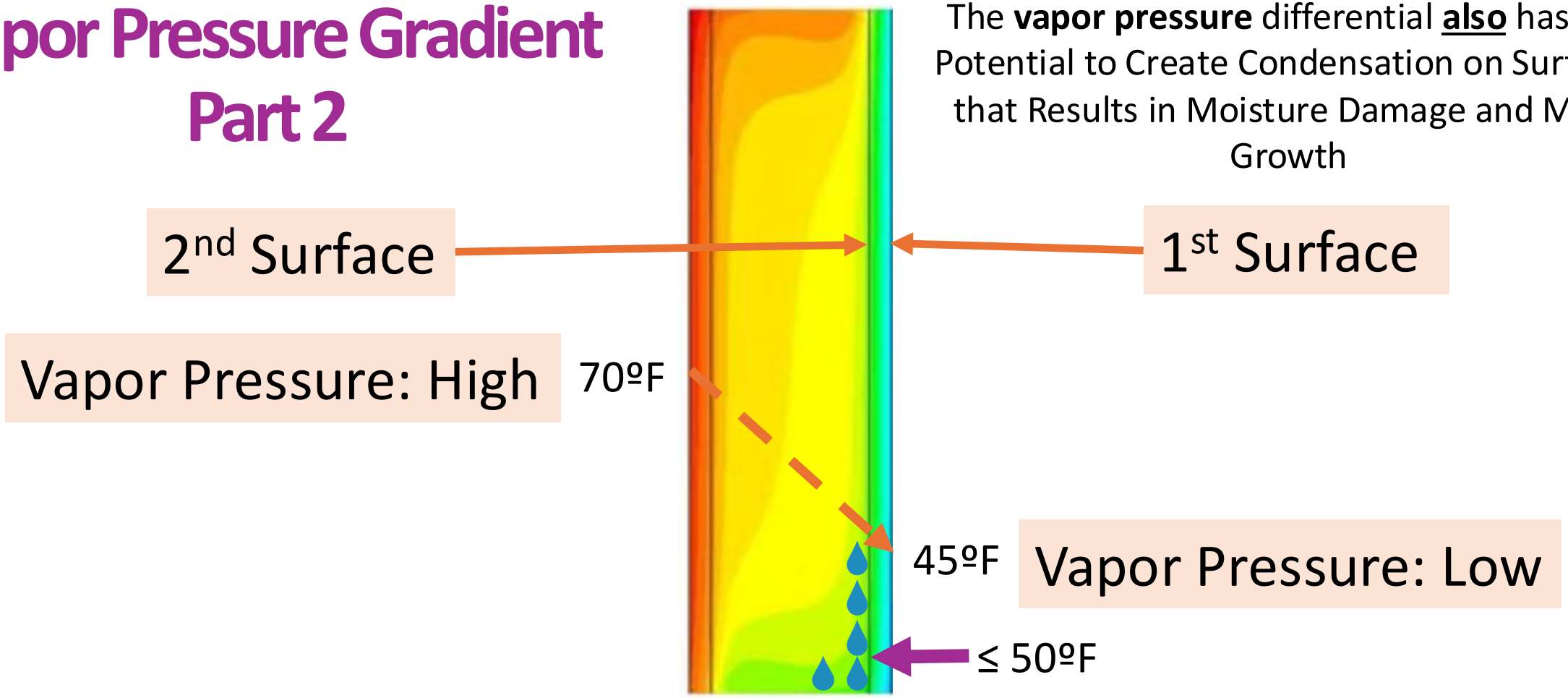
1st Surface is <u>inside</u> the HPWH enclosure

When a surface temperature is below the dew point, moisture vapor will:

1. condense on solid surfaces, not on fibrous insulation in the cavity.
2. condense on the coldest surface it sees.

Vapor Pressure Gradient Part 2

The **vapor pressure** differential **<u>also</u>** has the Potential to Create Condensation on Surfaces that Results in Moisture Damage and Mold Growth



Moisture vapor always goes from regions of high vapor pressure to regions with low vapor pressure. Transport mechanisms include:

1) air that enters the enclosure
2) diffusion through the materials of the enclosure's envelope

Location of Temperature Sensors



Air temperature sensors are on a string very close to the wall.

Upper Wall

Mid Wall

Lower Wall

Steps to Assess the Risk of Moisture Damage, Mildew, and Mold

1. Start with the temperature plot.

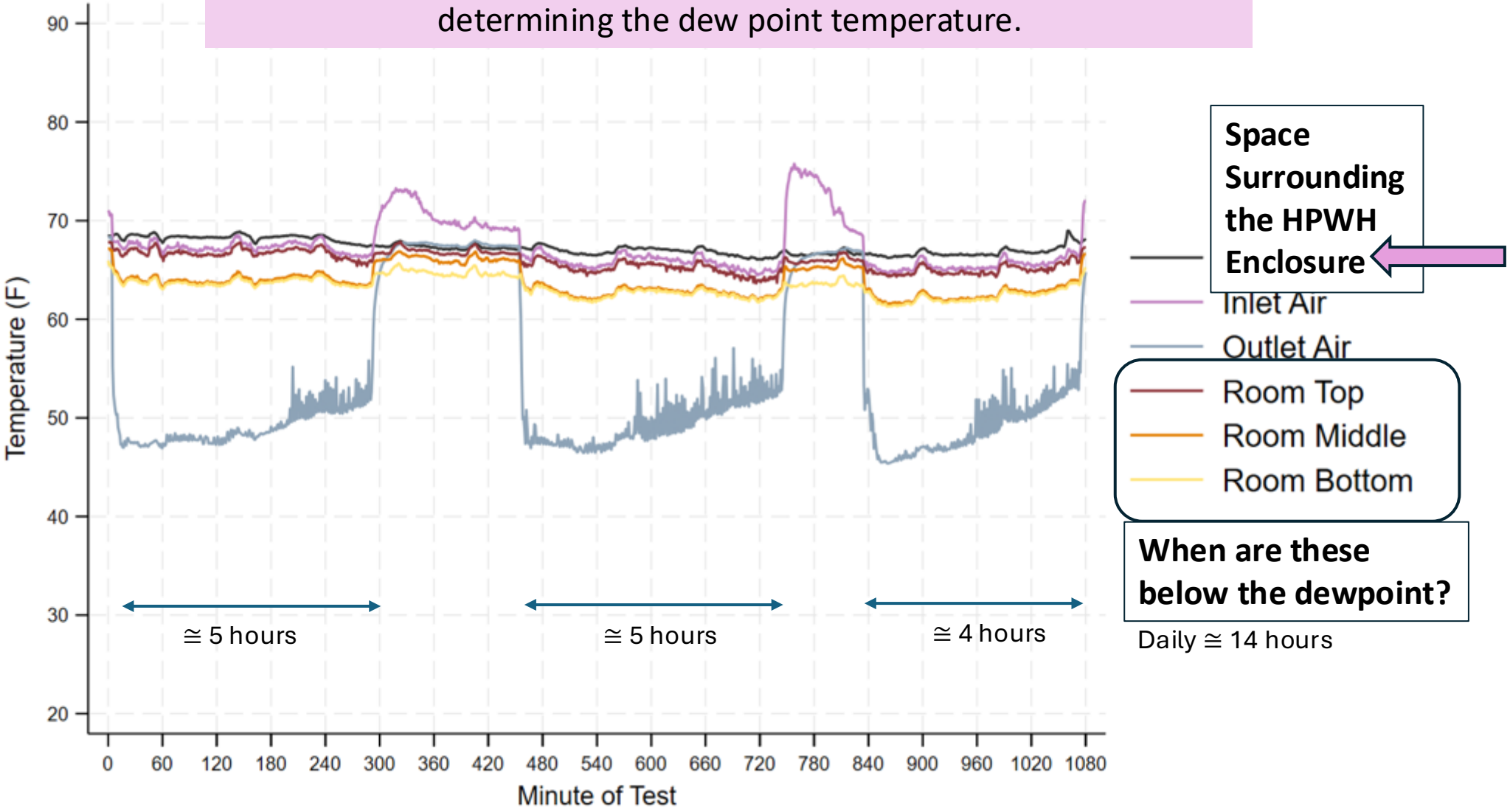
2. Overlay a range of dew point temperatures.

3. Evaluate at what relative humidity can surface temperatures drop below the dew point temperature.

4. Determine the daily hours of operation in heat pump mode.

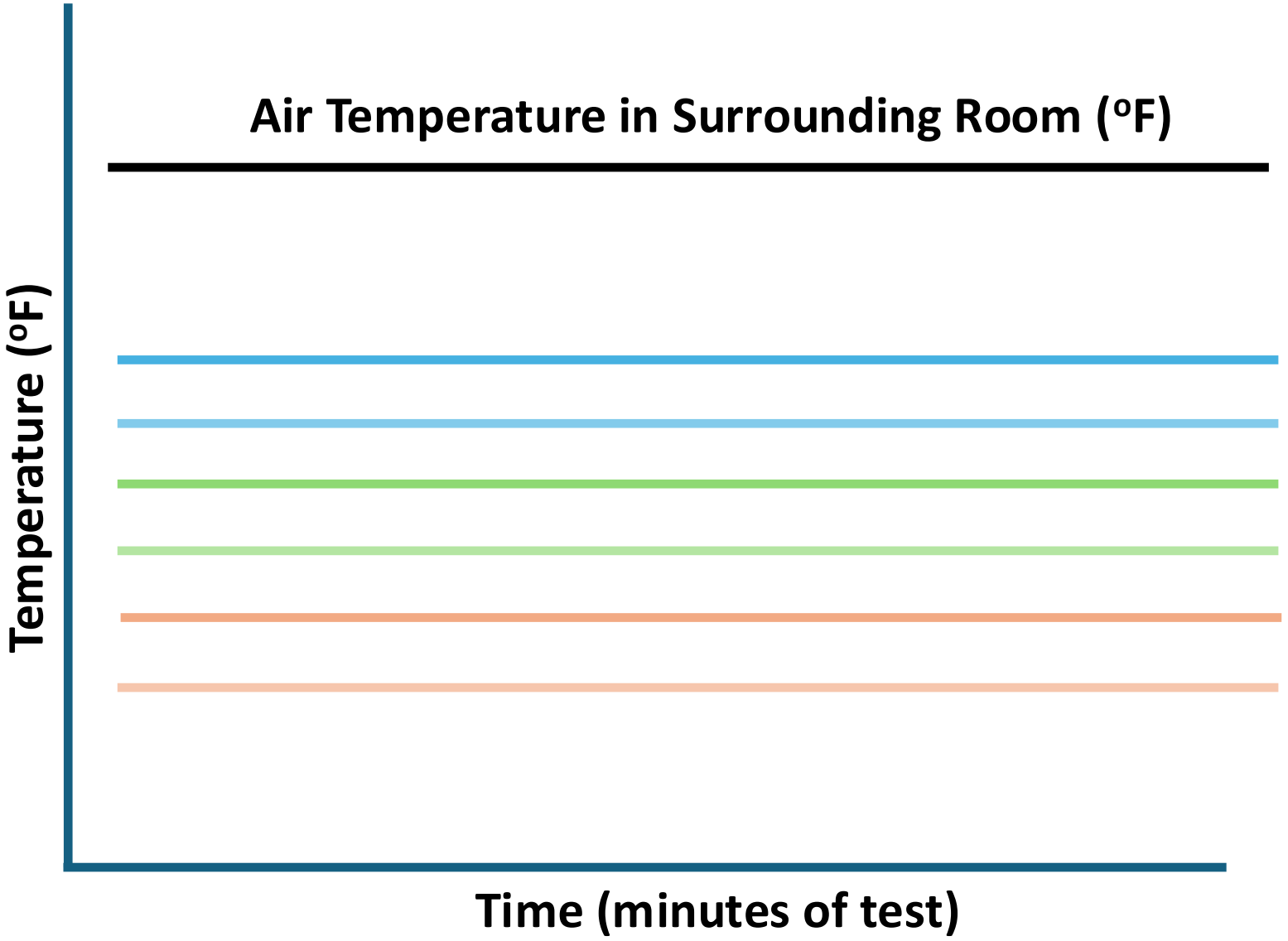
What is the Potential for Moisture to Condense?

The temperature of the space surrounding the room where the unitary (integrated) HPWH is installed the starting point for for determining the dew point temperature.



Temperature, Relative Humidity, and Dew Point

Air Temperature in Surrounding Room: 67.5 F	
% RH	Dew Point (F)
90	64.5
80	61.1
70	57.4
60	53.1
50	48.2
40	42.3
30	35.0
20	25.0
10	9.0



Increased Energy Efficiency Cannot Come at the Expense of Protecting Public Health and Safety

		Protect Health and Safety of the Building and Its Occupants	
		High	Low
Energy Efficiency	High	Yes!	Why gamble?
	Low	Why gamble?	Absolutely not!

To protect health and safety,
HPWH installations need to minimize the potential for moisture to condense on surfaces inside the building.

Doing so minimizes the risk of moisture damage, mildew , and mold.

Hot Water Draw Profiles

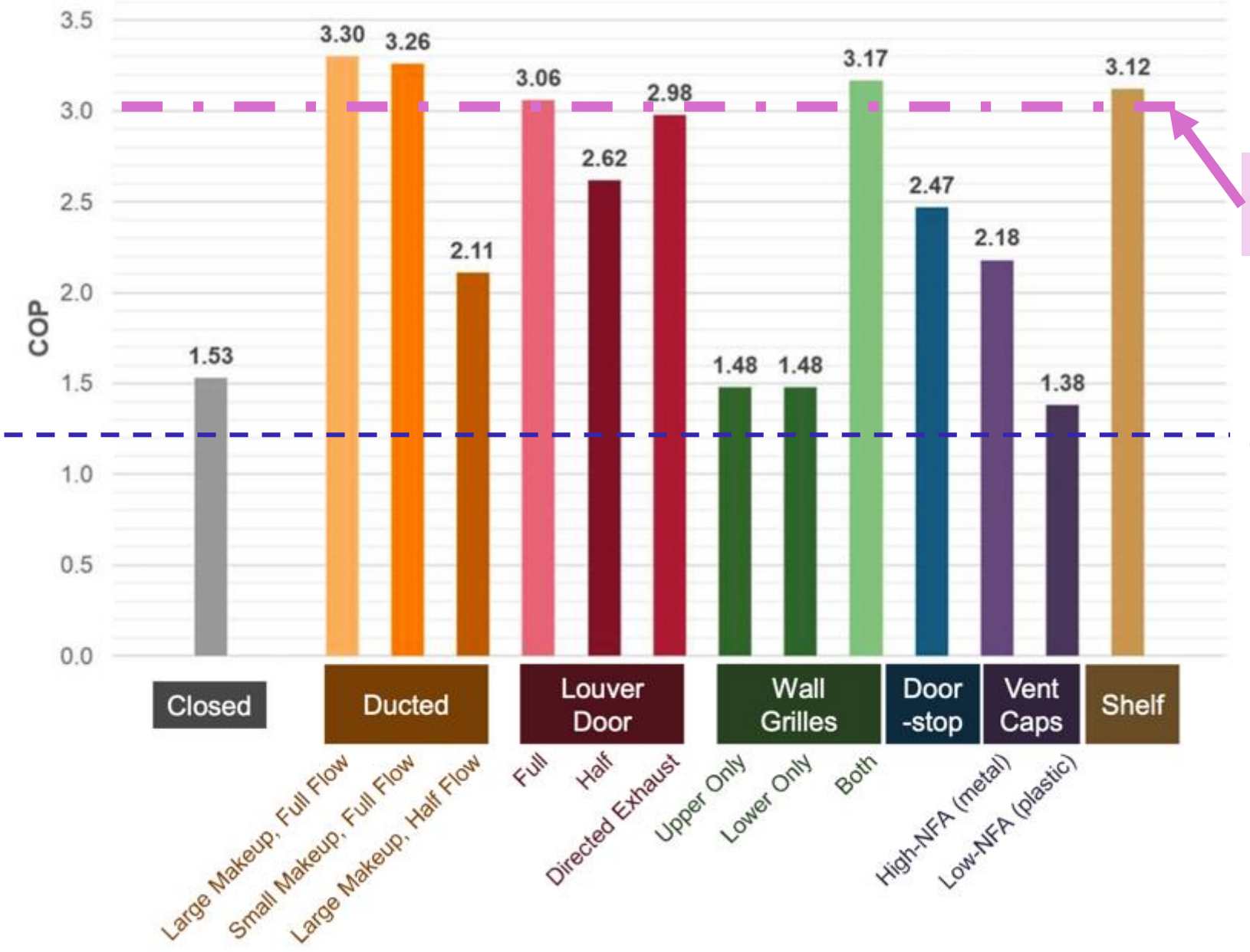
TABLE 4: HOT WATER DRAW PROFILES						
Test Time (hr:min)	**Medium (55 gal)[3]**		**High (84 gal)**		**X-High (135 gal)**	
	Volume (gal)	Flow Rate (GPM)	Volume (gal)	Flow Rate (GPM)	Volume (gal)	Flow Rate (GPM)
00:00	15	1.7	27	3.0	43.2	3.0
00:30	2	1.0	2	1.0	3.2	1.0
00:40	--	--	1	1.0	1.6	1.0
01:40	9	1.7	9	1.7	14.4	1.7
07:30	9	1.7	15	3.0	24.0	3.0
08:30	3	1.7	5	1.7	8.0	1.7
09:00	1	1.0	1	1.0	1.6	1.0
09:45	1	1.0	1	1.0	1.6	1.0
09:50	1	1.0	1	1.0	1.6	1.0
13:00	1	1.0	2	1.0	3.2	1.0
13:15	2	1.0	2	1.0	3.2	1.7
13:30	--	--	2	1.7	3.2	1.7
13:45	2	1.7	2	1.7	3.2	1.7
14:00	9	1.7	14	3.0	22.4	3.0

Summary of COPs

Closed Spaces		
Location	**Daily Hot Water Use (GPD)**	**COP**
Large Room (conditioned)	55 84 135	3.7 3.5 3.1
1,000 ft^3 Closed	55 84 135	3.2 2.6
700 ft^3 Closed	55 84 135	3.2 2.9
450 ft^3 Closed	55 (50 gal HPWH) 84 (50 gal HPWH) 84 (80 gal HPWH)	3.3 2.7 3.3
200 ft^3 Closed	55 84 135	2.3 1.9

Small Closets		
Location	Daily Hot Water Use (GPD)	COP
84 ft^3 Closed	55 84 135	1.2 1.1
84 ft^3 Closed, Down Elbow	55 84 135	1.1
84 ft^3 Fully Louvered Door	55 84 135	3.1
84 ft^3 High-Low Grilles	55 84 135	3.2
84 ft^3 Ducted Exhaust	55 84 135	3.3

84 ft³ Closets: Effect of Ventilation Strategies



3.45 – Open

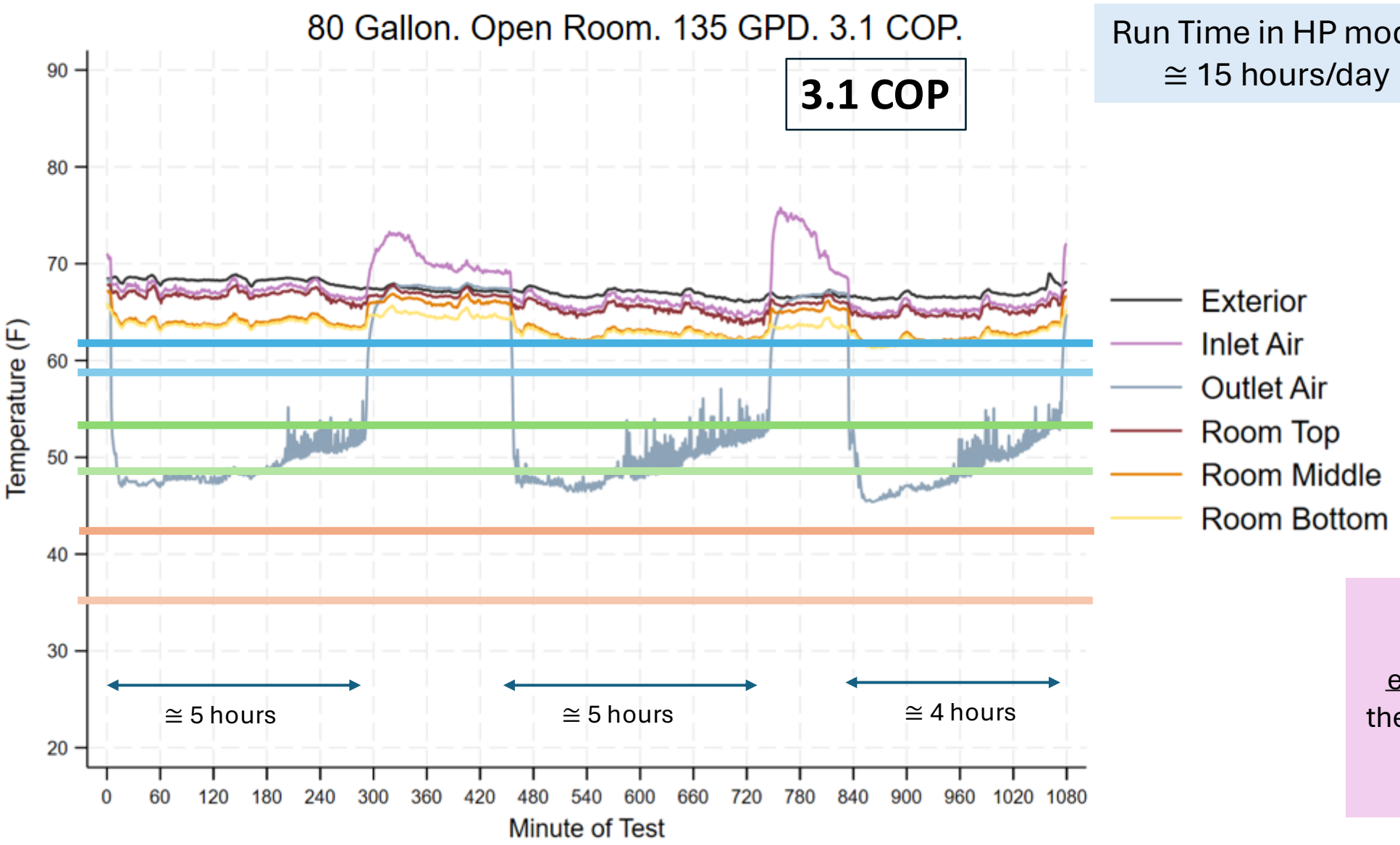
COP with unlimited air

3.0 – Minimum CoP Target

1.2 – Closed

COP at 84 ft³ without intervention

Large Room (Conditioned) – 135 GPD

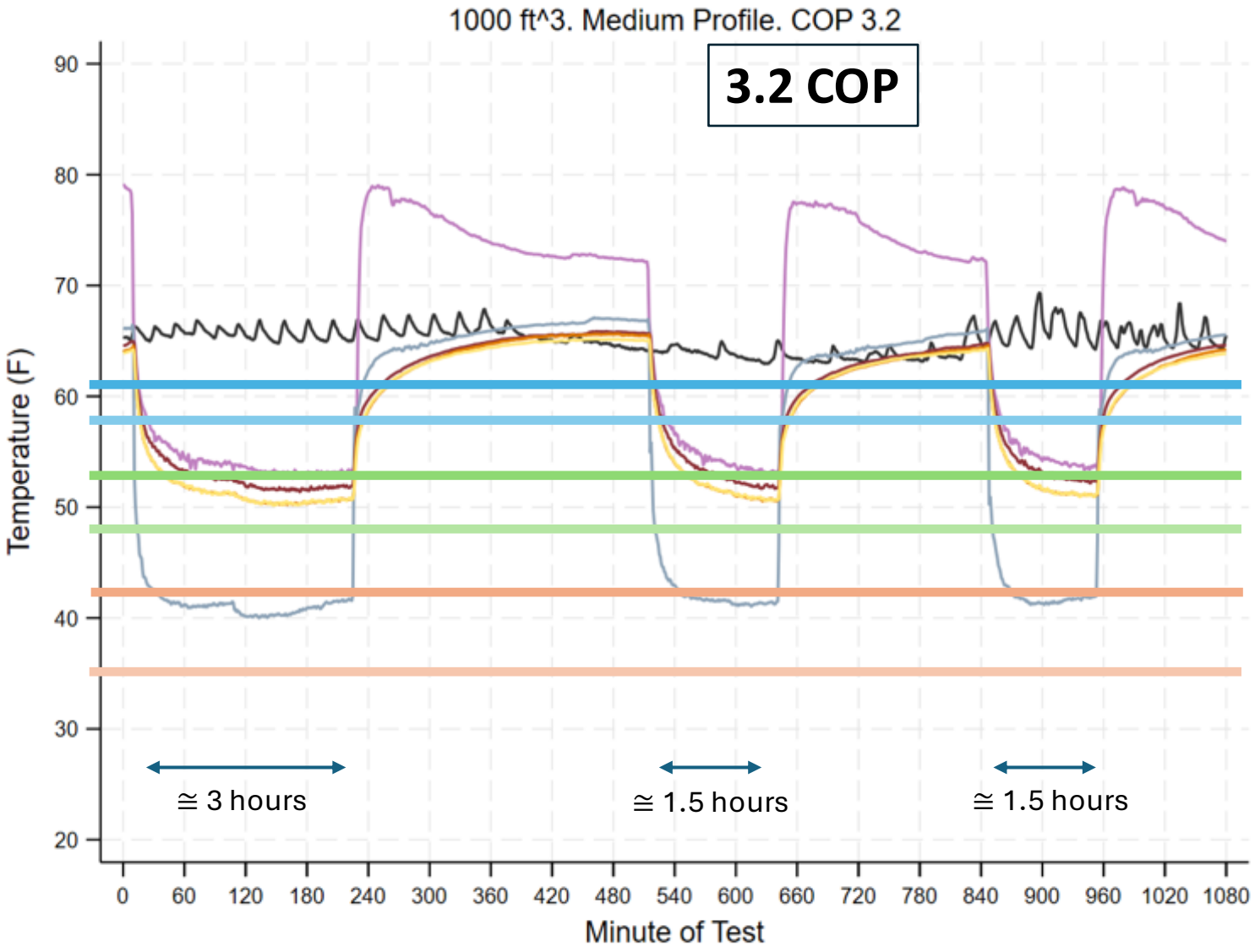


Run Time in HP mode:
≅ 15 hours/day

Dew Point (F) @ 67.5F
61 (80% RH)
58 (70% RH)
53 (60% RH)
48 (50% RH)
42 (40% RH)
35 (30% RH)

When the room is conditioned, and the exhaust air is well mixed, the surfaces of the room are not at risk unless RH is greater than 80%

1,000 ft^3 Closet – Closed, 55 GPD



Why is the inlet air temp so warm?

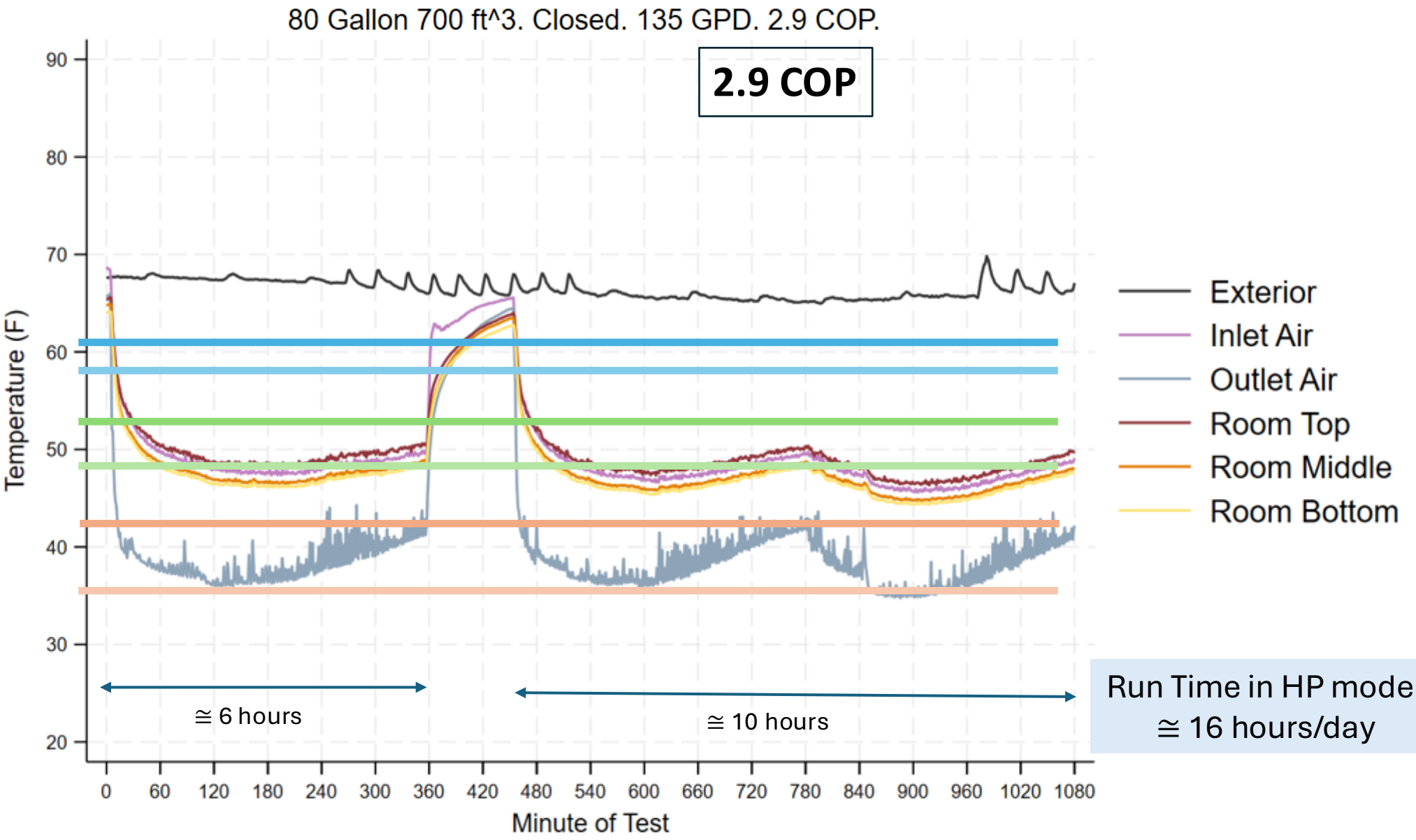
Standby heat loss from HPWH?

Dew Point (F) @ 67.5F
61 (80% RH)
58 (70% RH)
53 (60% RH)
48 (50% RH)
42 (40% RH)
35 (30% RH)

Run Time in HP mode:
≅ 6 hours/day

Surfaces at risk when RH is above 55%.

700 ft^3 Closet – Closed, 135 GPD

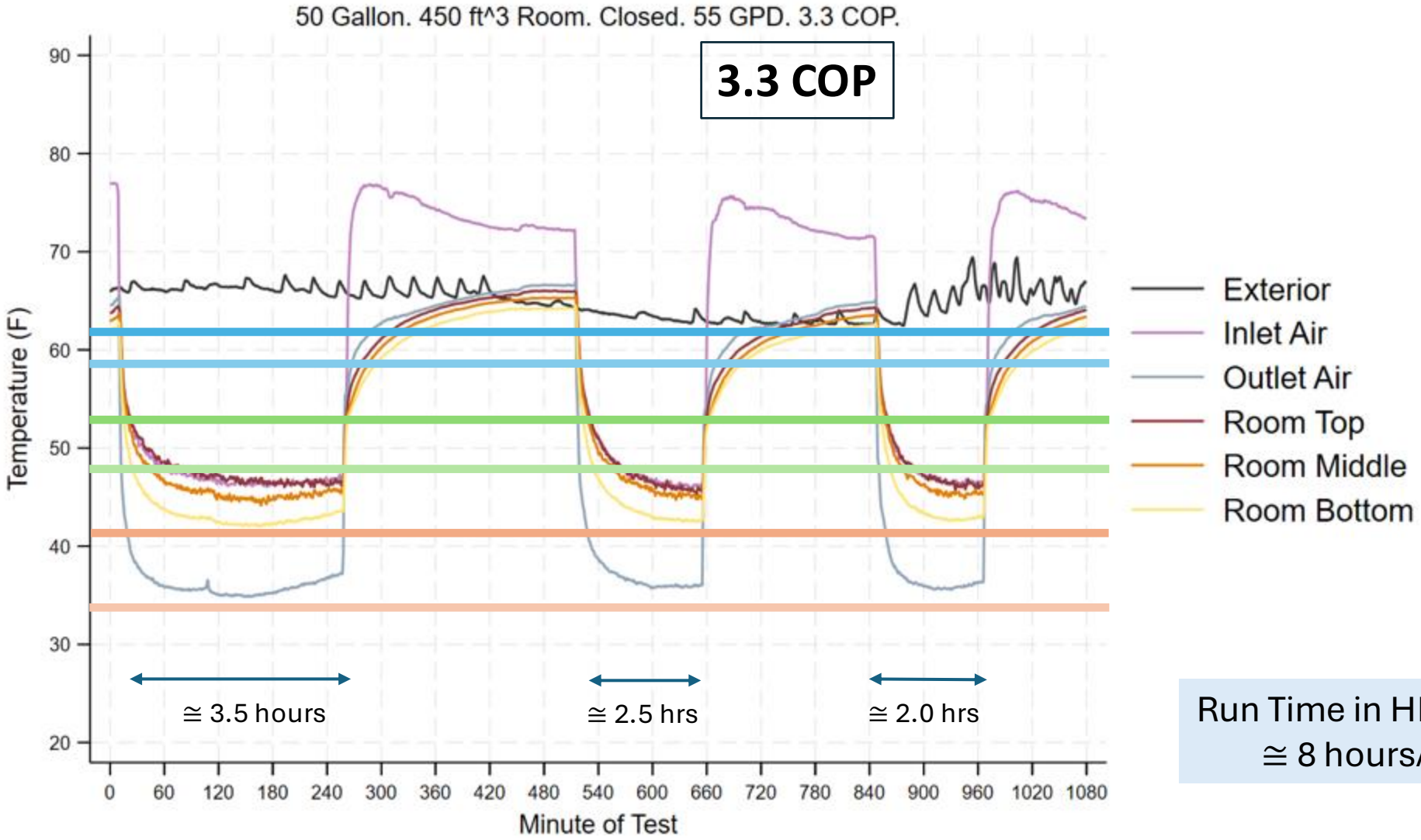


Dew Point (F) @ 67.5F
61 (80% RH)
58 (70% RH)
53 (60% RH)
48 (50% RH)
42 (40% RH)
35 (30% RH)

Run Time in HP mode:
≅ 16 hours/day

Surfaces at risk when RH is above 45%

450 ft^3 Closet – 55 GPD

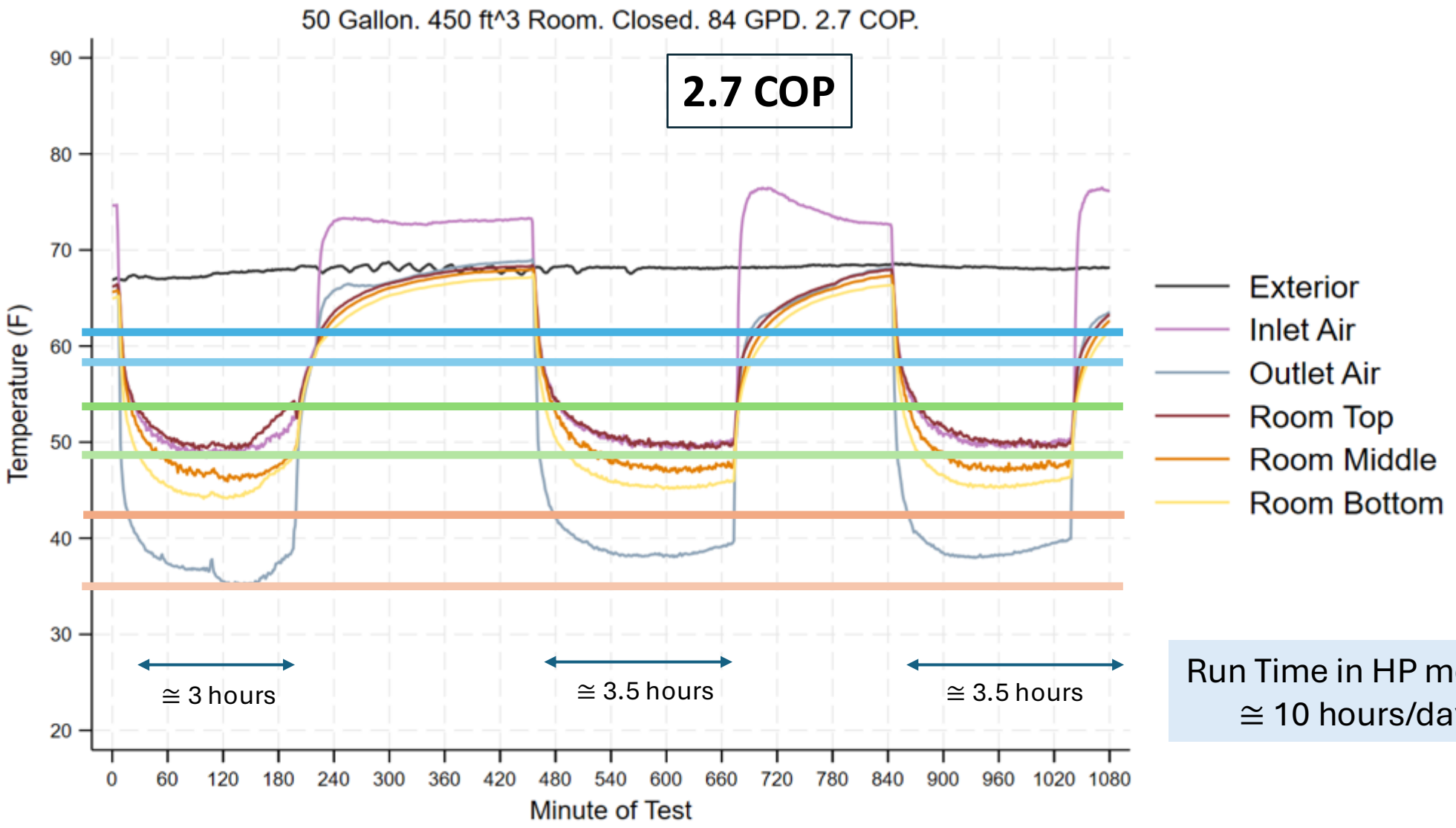


Dew Point (F) @ 67.5F
61 (80% RH)
58 (70% RH)
53 (60% RH)
48 (50% RH)
42 (40% RH)
35 (30% RH)

Run Time in HP mode:
≅ 8 hours/day

Surfaces at risk when RH is above 40%

450 ft^3 Closet – 84 GPD

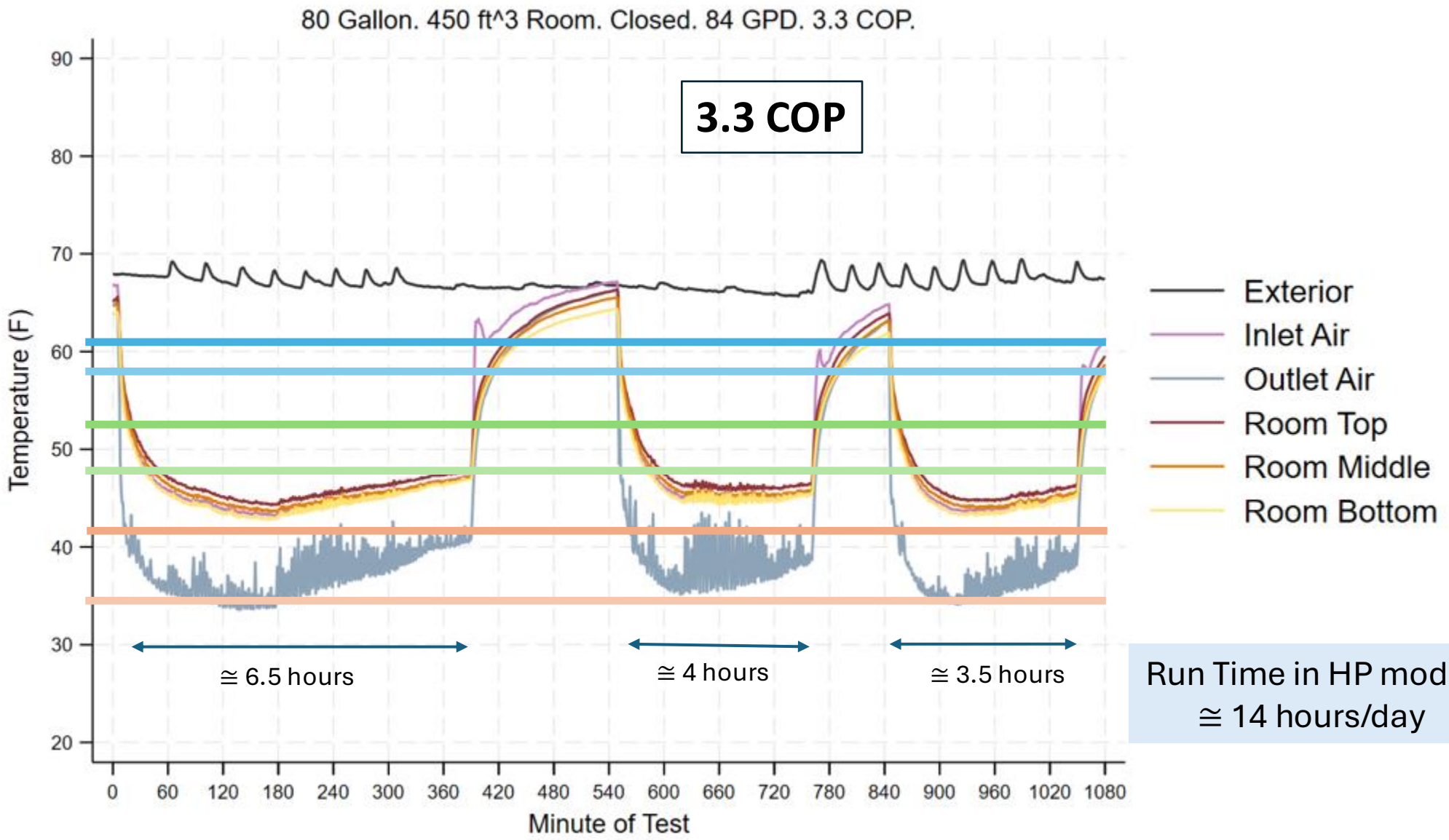


Dew Point (F) @ 67.5F
61 (80% RH)
58 (70% RH)
53 (60% RH)
48 (50% RH)
42 (40% RH)
35 (30% RH)

Run Time in HP mode:
≅ 10 hours/day

Surfaces at risk when RH is above 45%

450 ft³ Closet – 84 GPD

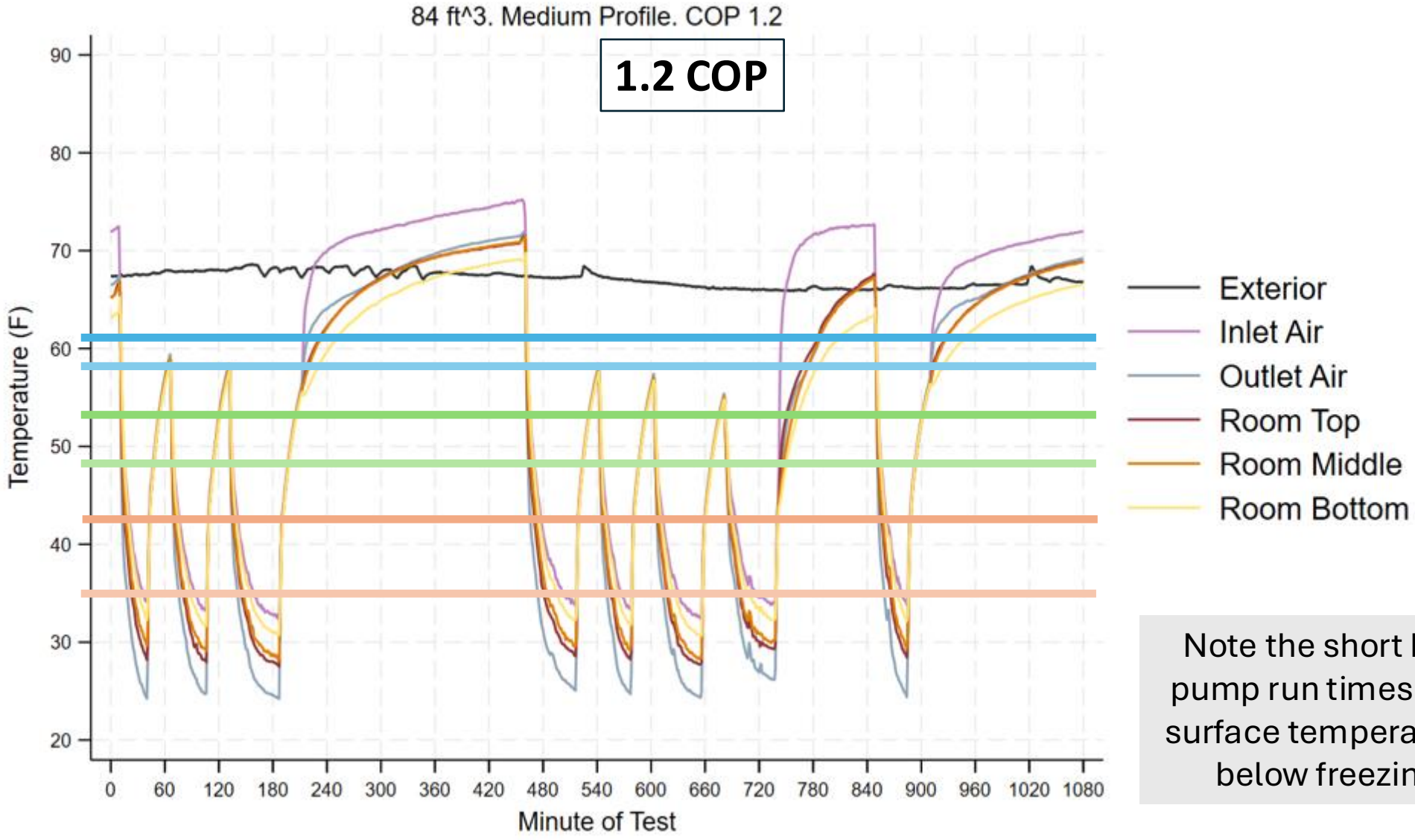


Dew Point (F) @ 67.5F
61 (80% RH)
58 (70% RH)
53 (60% RH)
48 (50% RH)
42 (40% RH)
35 (30% RH)

Run Time in HP mode:
≅ 14 hours/day

Surfaces at risk when RH is above 45%

84 ft^3 Closet – Closed, 55 GPD

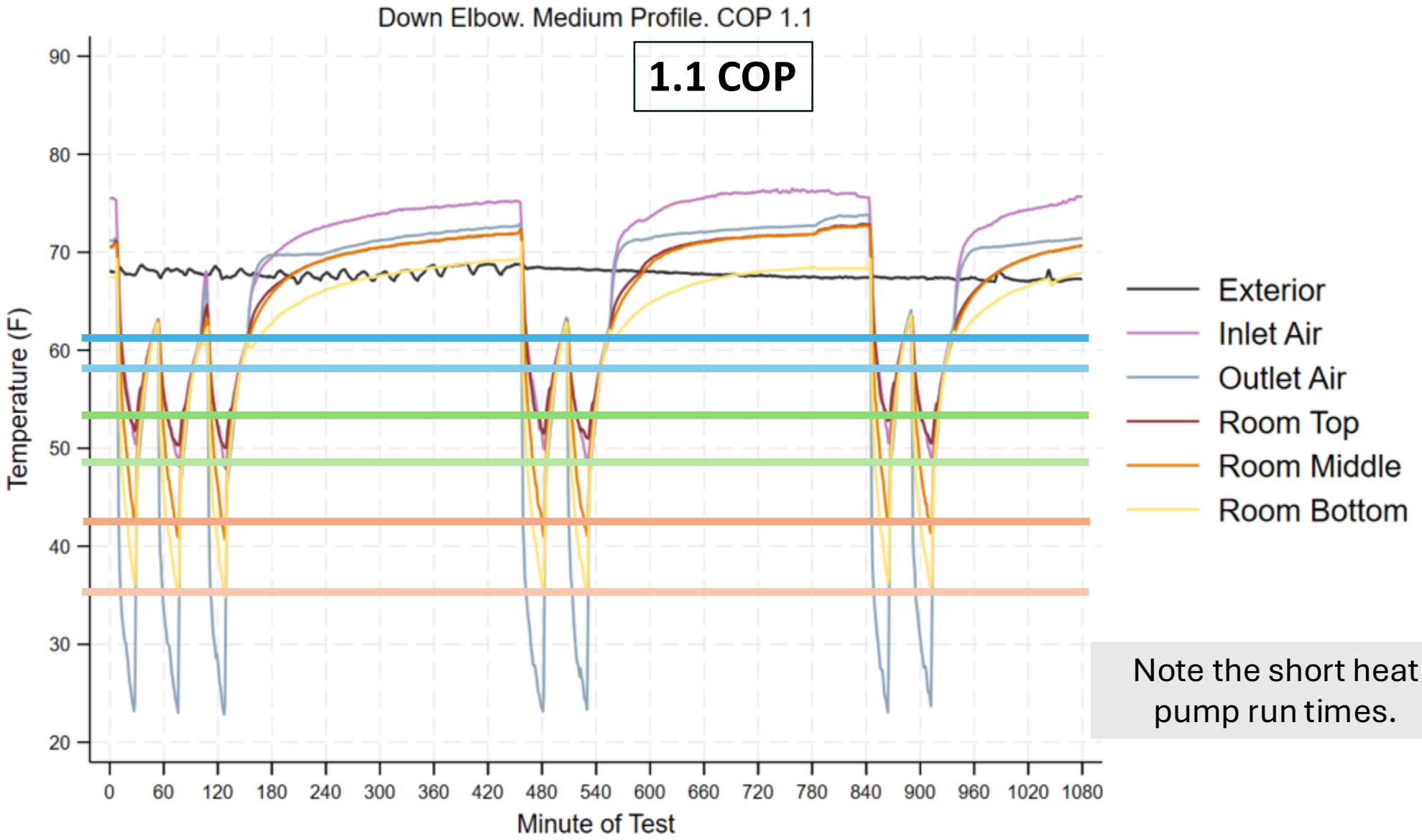


Dew Point (F) @ 67.5F
61 (80% RH)
58 (70% RH)
53 (60% RH)
48 (50% RH)
42 (40% RH)
35 (30% RH)

Note the short heat pump run times. And surface temperatures below freezing.

Surfaces at risk when RH is above 20%.

84 ft^3 Closet – Closed, Down Elbow, 55 GPD

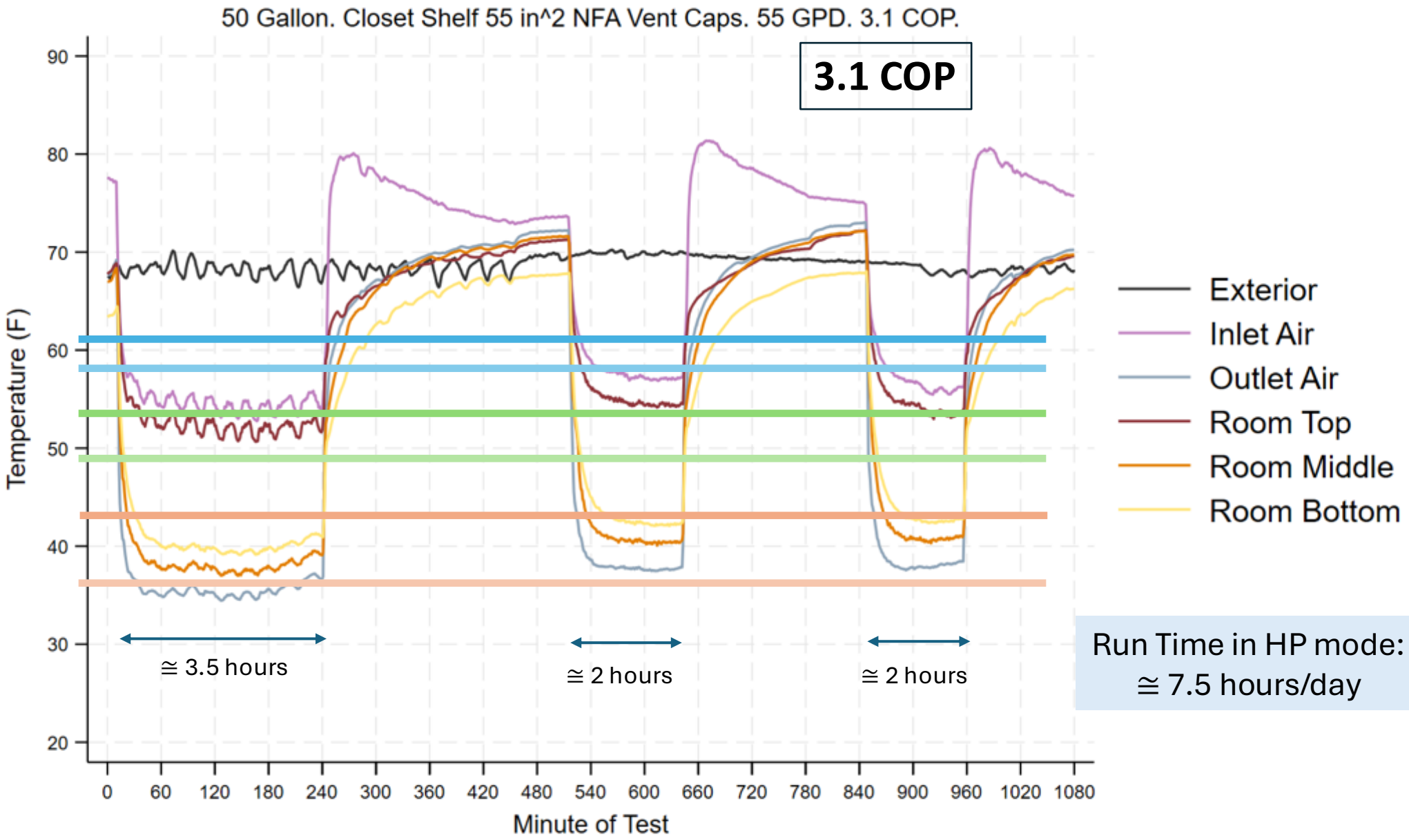


Dew Point (F) @ 67.5F
61 (80% RH)
58 (70% RH)
53 (60% RH)
48 (50% RH)
42 (40% RH)
35 (30% RH)

Note the short heat pump run times.

Surfaces at risk when RH is above 30%.

84 ft³ Closet – Shelf and 55in² vent caps, 55 GPD

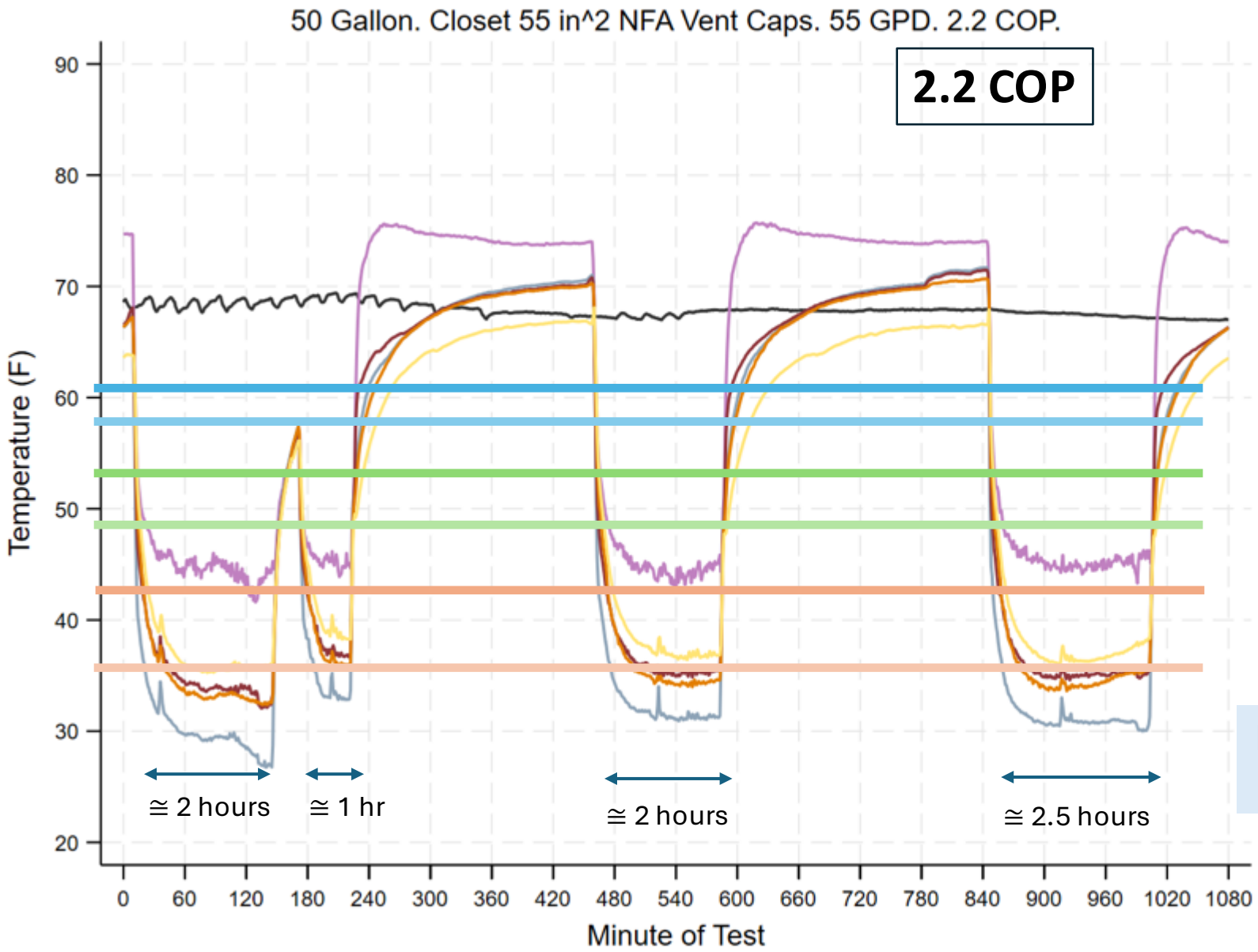


Dew Point (F) @ 67.5F
61 (80% RH)
58 (70% RH)
53 (60% RH)
48 (50% RH)
42 (40% RH)
35 (30% RH)

Run Time in HP mode:
≅ 7.5 hours/day

Lower surfaces at risk when RH is above 30%, upper at 60%

84 ft^3 Closet – 55in^2 vent caps, 55 GPD

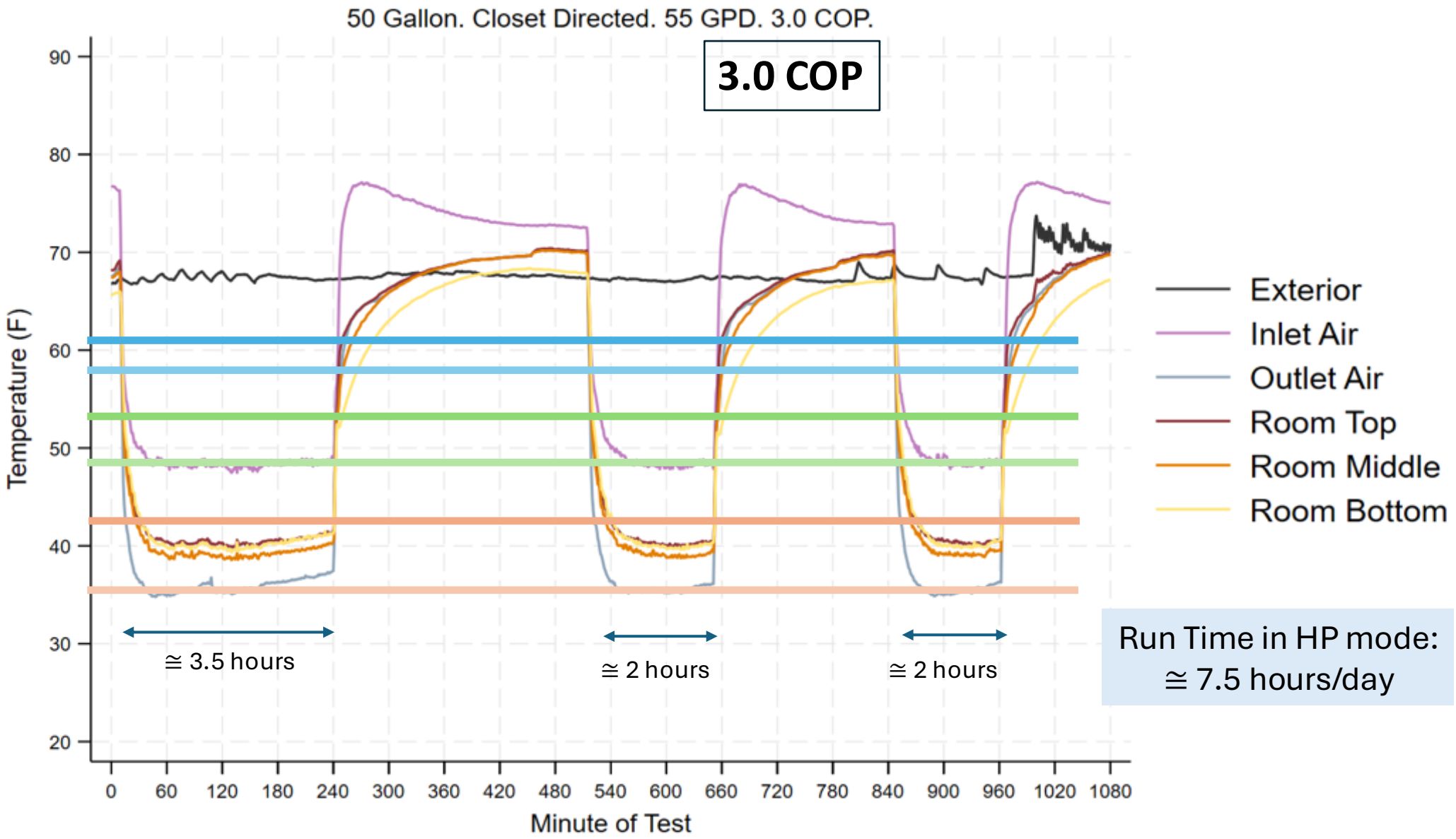


Dew Point (F) @ 67.5F
61 (80% RH)
58 (70% RH)
53 (60% RH)
48 (50% RH)
42 (40% RH)
35 (30% RH)

Run Time in HP mode:
≅ 7.5 hours/day

Surfaces at risk when RH is above 25%.

84 ft³ Closet – Directed Exhaust, 55 GPD

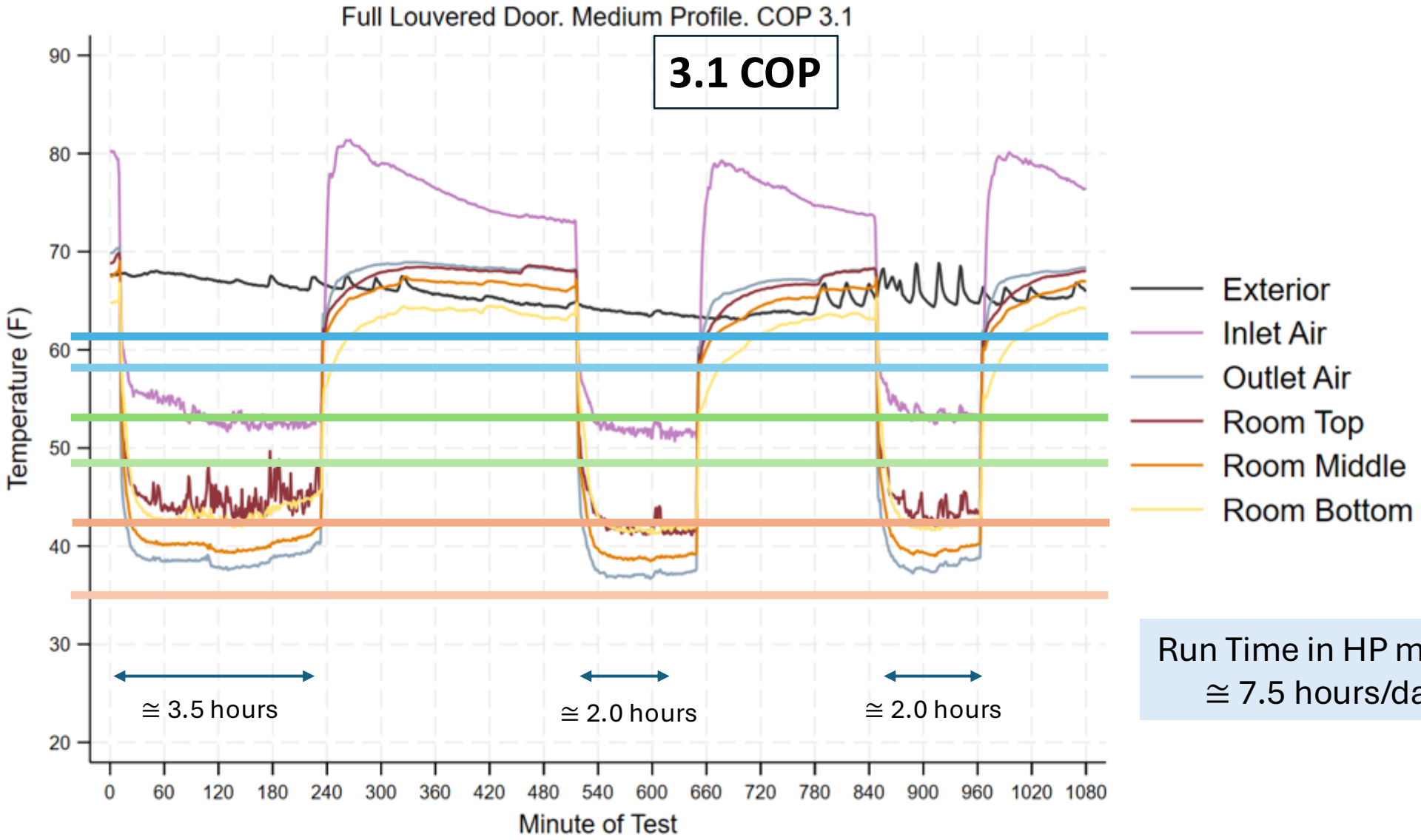


Dew Point (F) @ 67.5F
61 (80% RH)
58 (70% RH)
53 (60% RH)
48 (50% RH)
42 (40% RH)
35 (30% RH)

Run Time in HP mode:
≅ 7.5 hours/day

Surfaces at risk when RH is above 35%.

84 ft³ Closet – Fully Louvered Door, 55 GPD

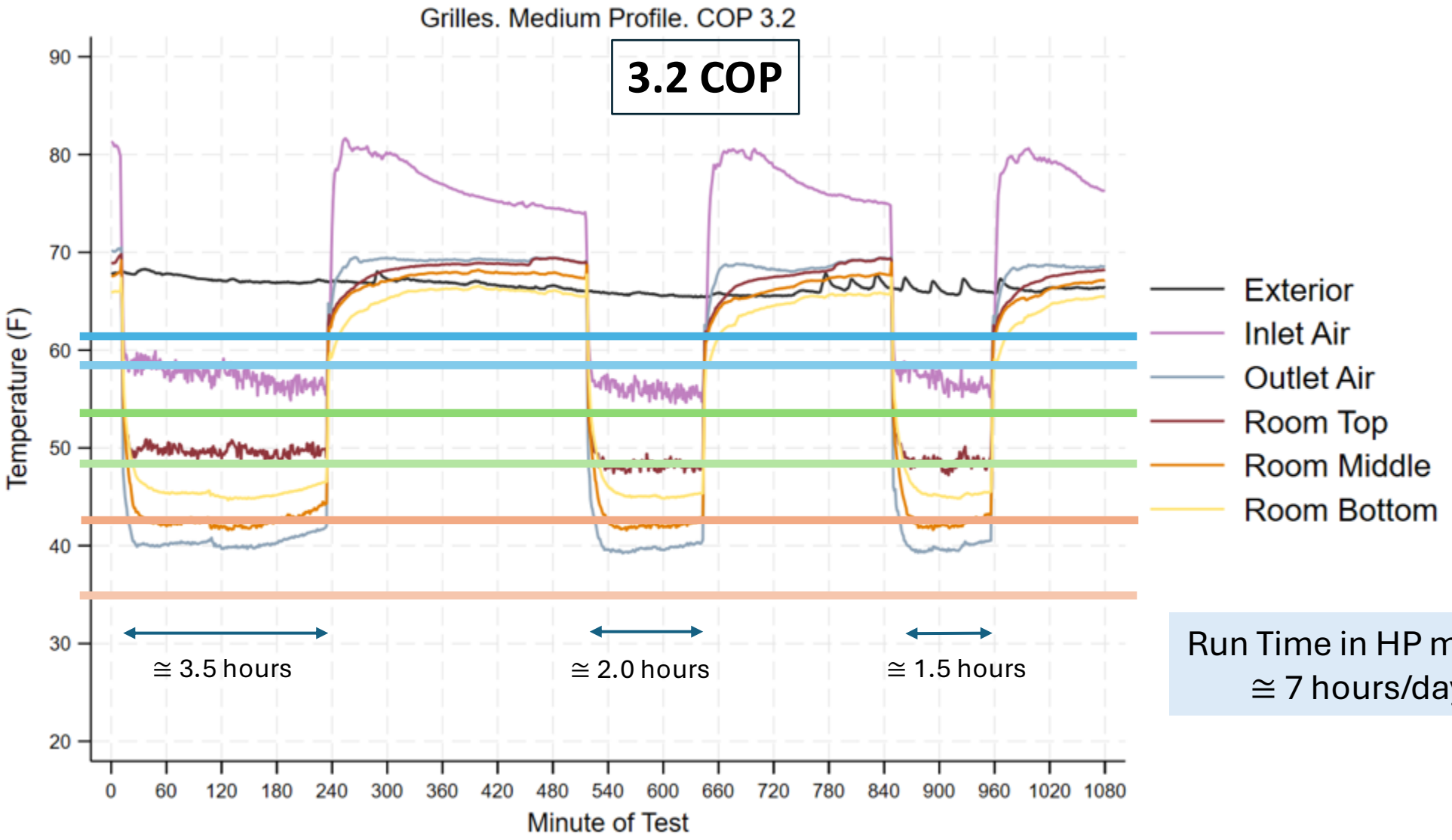


Dew Point (F) @ 67.5F
61 (80% RH)
58 (70% RH)
53 (60% RH)
48 (50% RH)
42 (40% RH)
35 (30% RH)

Run Time in HP mode:
≅ 7.5 hours/day

Surfaces at risk when RH is above 35%.

84 ft³ Closet – High and Low Grilles, 55 GPD

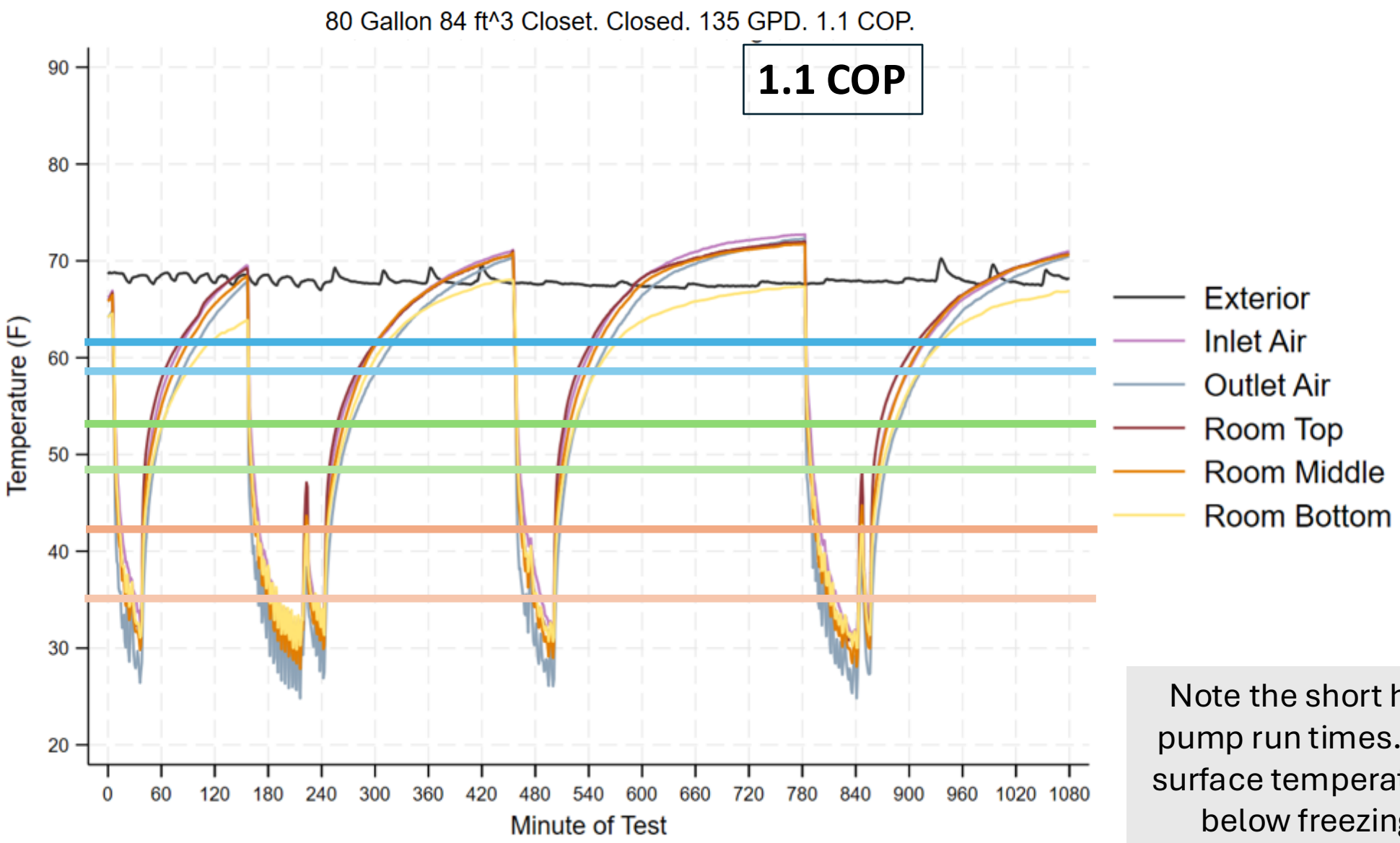


Dew Point (F) @ 67.5F
61 (80% RH)
58 (70% RH)
53 (60% RH)
48 (50% RH)
42 (40% RH)
35 (30% RH)

Run Time in HP mode:
≅ 7 hours/day

Surfaces at risk when RH is above 40%.

84 ft^3 Closet – Closed, 135 GPD

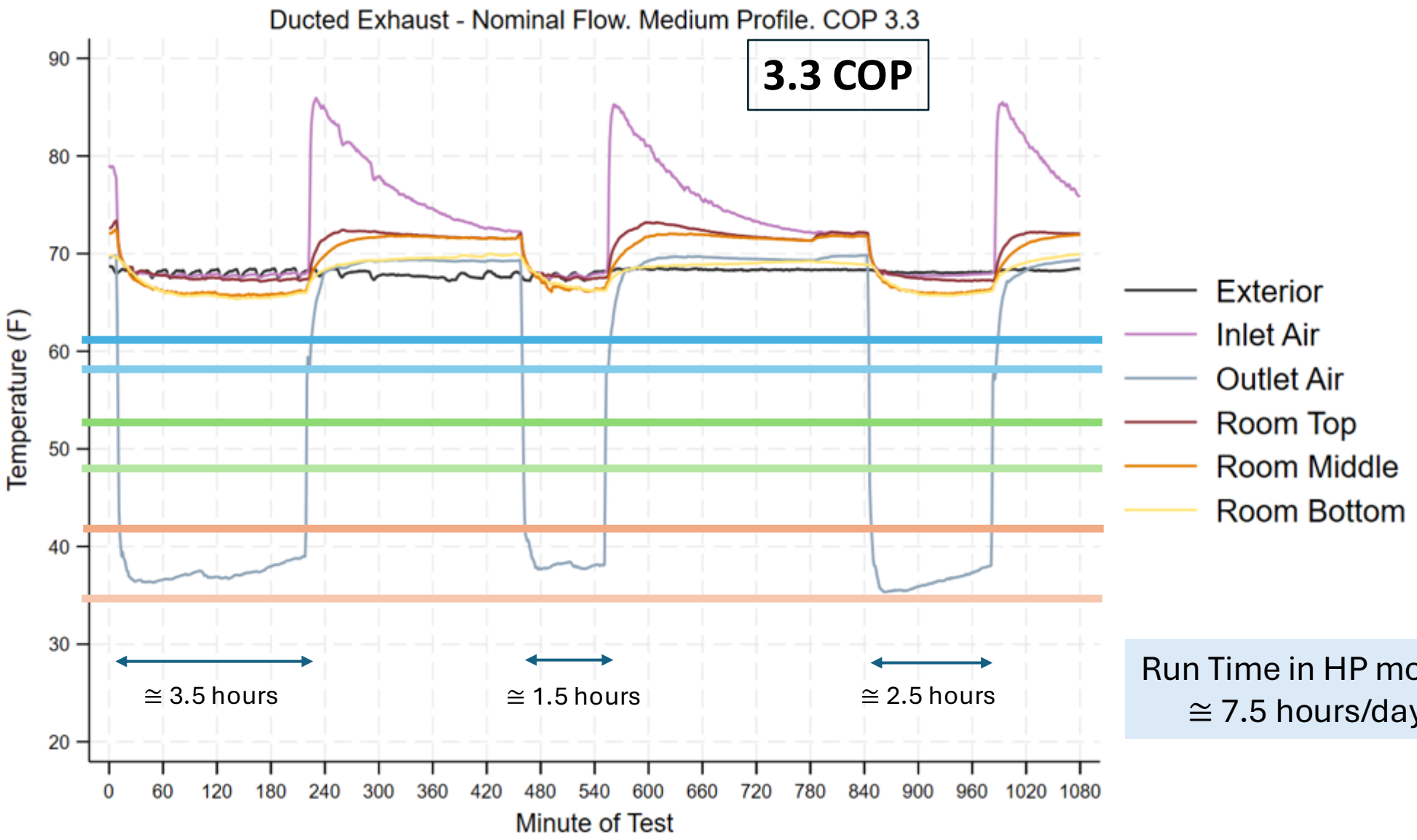


Dew Point (F) @ 67.5F
61 (80% RH)
58 (70% RH)
53 (60% RH)
48 (50% RH)
42 (40% RH)
35 (30% RH)

Note the short heat pump run times. And surface temperatures below freezing.

Surfaces at risk when RH is above 25%

84 ft³ Closet – Ducted Exhaust, 55 GPD

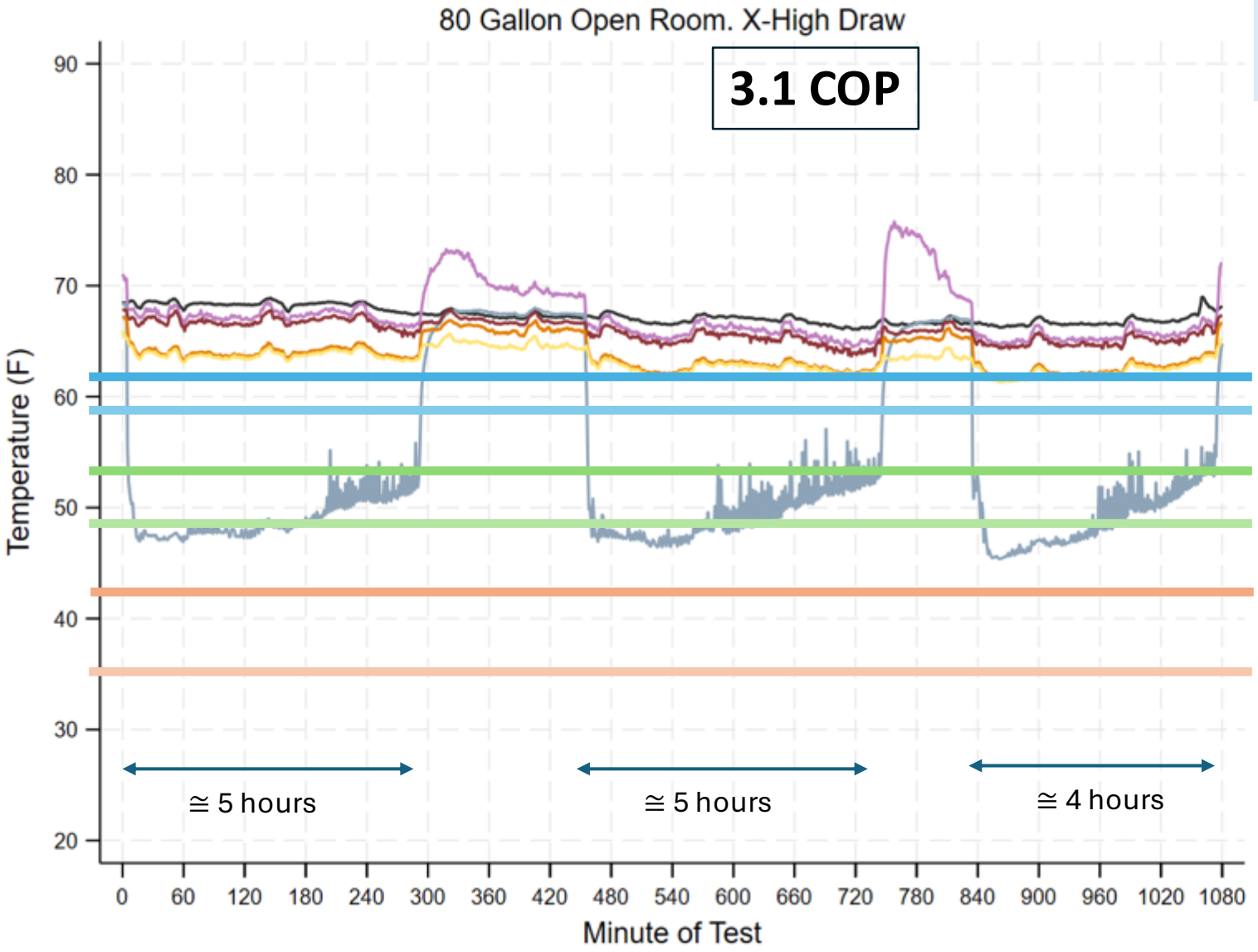


Dew Point (F) @ 67.5F
61 (80% RH)
58 (70% RH)
53 (60% RH)
48 (50% RH)
42 (40% RH)
35 (30% RH)

Run Time in HP mode:
≅ 7.5 hours/day

Surfaces of the HPWH enclosure are not at risk.

Large Room (Conditioned) – 135 GPD



Run Time in HP mode:
≅ 15 hours/day

Dew Point (F) @ 67.5F
61 (80% RH)
58 (70% RH)
53 (60% RH)
48 (50% RH)
42 (40% RH)
35 (30% RH)

When the room is conditioned, and the exhaust air is well mixed, the surfaces of the room are not at risk unless RH is greater than 80%

Two Installation Methods Protect Public Health and Safety, and Increase Efficiency

Closed Spaces

Location	Daily Hot Water Use (GPD)	COP	Run Time (hrs/day)
Large Room (conditioned)	55 84 135	3.7 3.5 3.1	 15
1,000 ft^3 Closed	55 84 135	3.2 2.6	6
700 ft^3 Closed	55 84 135	3.2 2.9	 16
450 ft^3 Closed	55 (50 gal) 84 (50 gal) 84 (80 gal)	3.3 2.7 3.3	7.5 10 14
200 ft^3 Closed	55 84 135	2.3 1.9	

Small Closets

Location	Daily Hot Water Use (GPD)	COP	Run Time (hrs/day)
84 ft^3 Closed	55 84 135	1.2 1.1	
84 ft^3 Closed, Down Elbow	55 84 135	1.1	
84 ft^3 Fully Louvered Door	55 84 135	3.1	7.5
84 ft^3 High-Low Grilles	55 84 135	3.2	7
84 ft^3 Ducted Exhaust	55 84 135	3.3	7.5

When Conditioned:

1. **Any** room volume **and**
2. up to 24-hour runtimes in heat pump mode

There is No Conflict:
Protecting Public Health and Safety and Increased Energy Efficiency Go Together!

		Protect Health and Safety of the Building and Its Occupants	
		High	Low
Energy Efficiency	High	Yes!	Why gamble?
	Low	Why gamble?	Absolutely not!

To protect health and safety,
HPWH installations need to minimize the potential for moisture to condense on surfaces inside the building.

Doing so minimizes the risk of moisture damage, mildew , and mold.

Public Health and Safety are Protected When:

Integrated air-source HPWHs are installed so that

1. The exhaust air is not allowed to short circuit into the intake, **and**
2. The exhaust of the HPWH is well mixed and warmed up above the dew point before it reaches any surface in the room
3. The HPWH is installed in a **conditioned space** (65F or warmer), **or**
4. The HPWH is installed in an unconditioned space **and**
    1. the exhaust of the HPWH is ducted out of that enclosure to a location that is **space conditioned** (65F or warmer)

Operating Efficiency will be High Too!

How to Get Installations Right, Part 1:

Manage the Cold Exhaust Air to Protect Health and Safety and Increase Efficiency

✅ Manage the Cold Exhaust Air to Prevent Moisture Issues

- Never trap the HPWH exhaust air in (small) enclosed spaces
- Raise the cold exhaust air above the dewpoint temperature as quickly as possible.
  - Strategies include reheating, mixing or ducting to a safe location
- Keep the air in the room well-mixed; cold air settles, increasing the risk near the floor
- Insulate ducts, duct kits, boots and collars with R-8 insulation, and ensure that the insulation wrap is vapor tight

How to Get Installations Right, Part 2:

Manage the Cold Exhaust Air to Protect Health and Safety and Increase Efficiency

✅ Provide Sufficient Warm Air

1. Prevent the cold exhaust air from short circuiting into the intake.
2. Never trap the HPWH exhaust air in (small) enclosed spaces
3. A thermal resource is essential.
    1. It must be in the room or be brought into the room for use by the HPWH.
    2. To enable 24-hour operation, the thermal resource must be greater than or equal to the capacity of the heat pump.
        1. For example, if the CoP is 4, and the capacity of the heat pumps is 4,000 BTU/hour, the air must provide 3,000 BTU/hour. This is approximately 1 kW/hour.
    3. Conduction into the space with the HPWH is not sufficient
4. If the intake air temperature will be below 40F for long periods of time, select a unit that has a defrost cycle

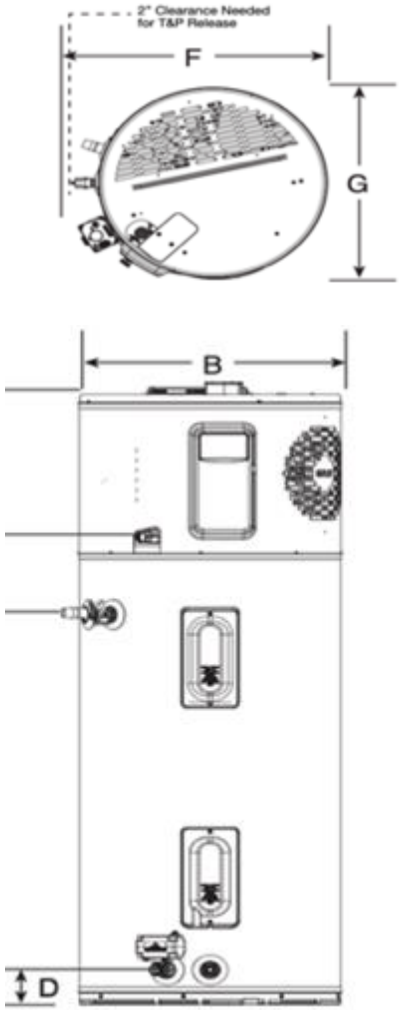
Possible Locations of HPWH Intakes and Exhausts

Intake	Exhaust
Top	Top
Side	Side
Back	Back

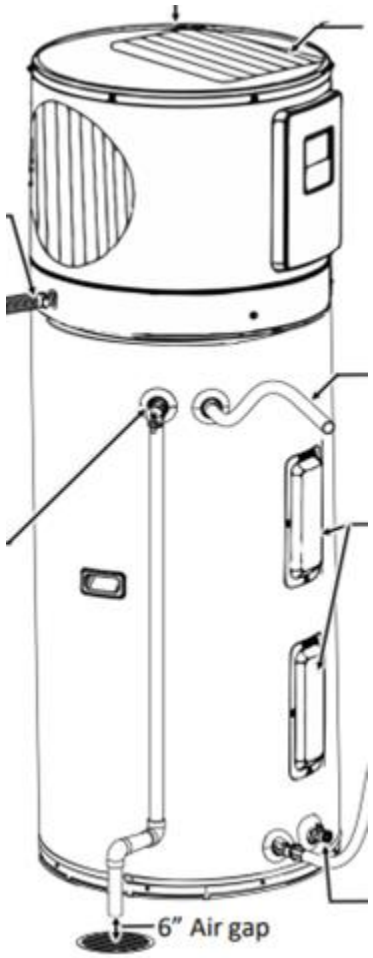
Which combination is best suited for the application?

Examples of HPWH Intake and Exhaust Locations

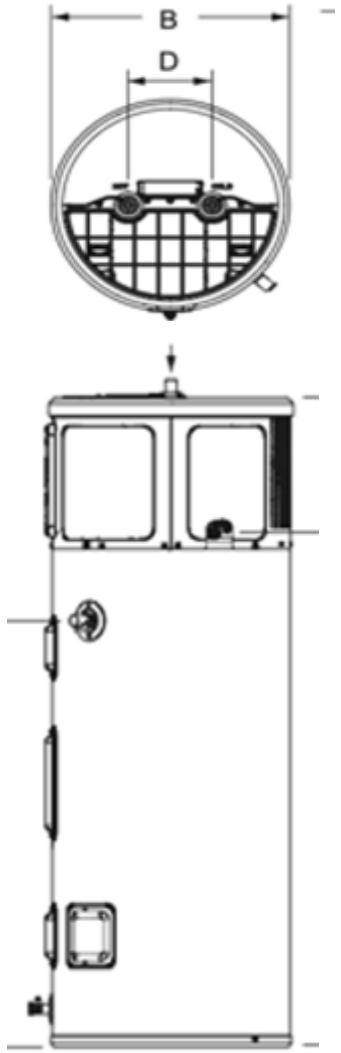
Top Intake
Side Exhaust



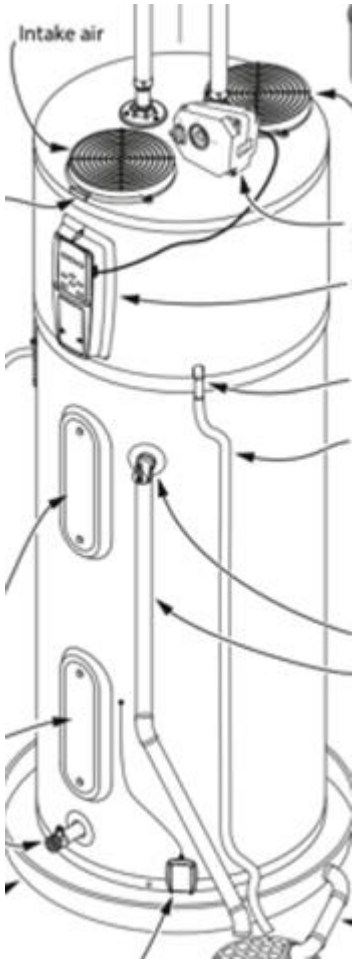
Top Intake
Side Exhaust



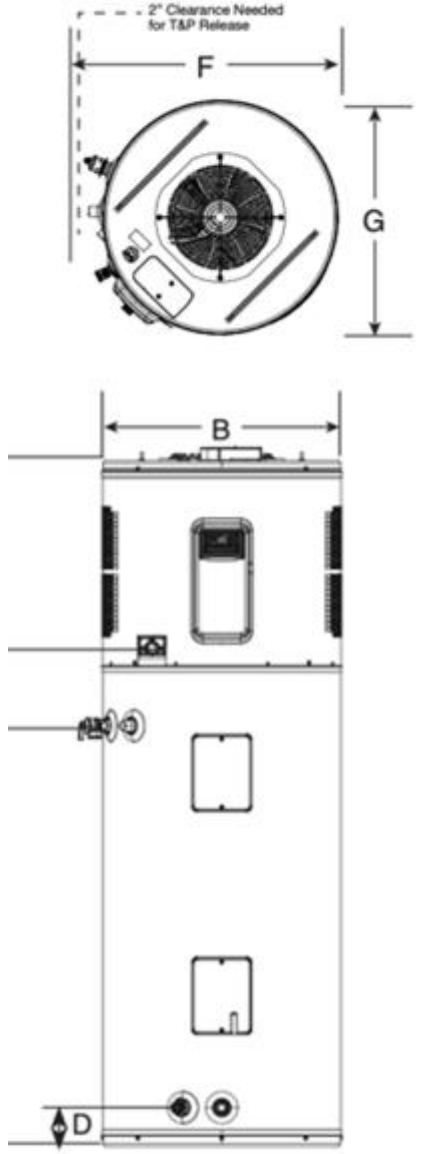
Top Intake
Rear Exhaust



Top Intake
Top Exhaust



Side Intakes
Top Exhaust



Typical Water Heater Locations

Basement
Garage
Attic
Mechanical Room
Laundry Room
Restroom
Closet
Crawl Space
Podium
Others?

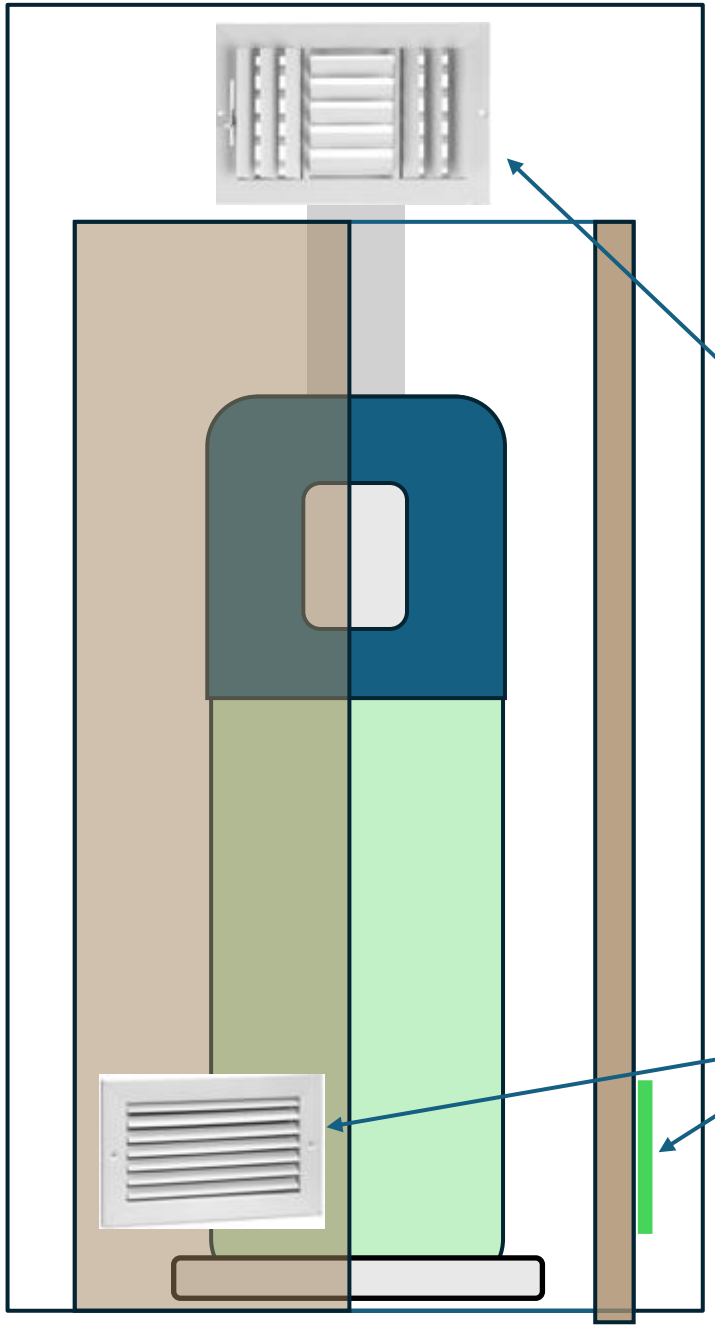
Ensuring the safe discharge of the cold exhaust air in the most confined locations while simultaneously providing warm intake air needs to be our focus.

Protecting health and safety will lead to increased efficiency.

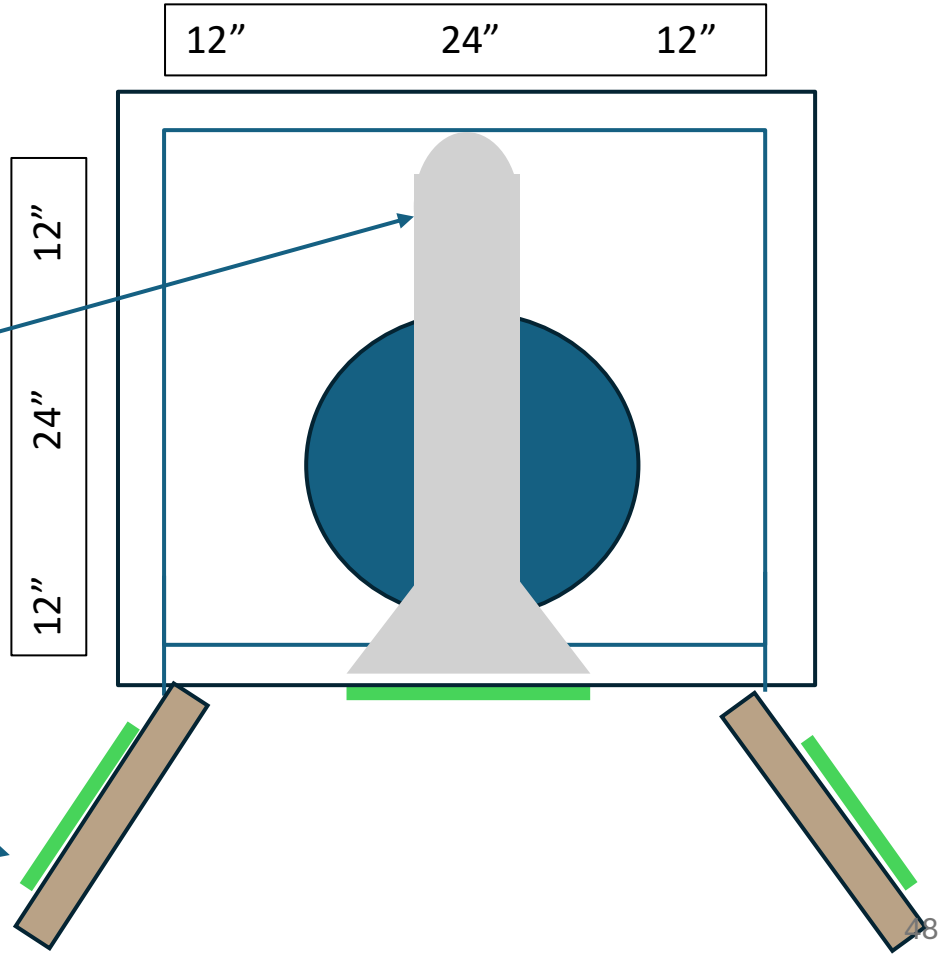
Closets, of any size, are the most confined locations.

Rear Exhaust: Interior of closet 4’ x 4’

- Side ports for plumbing, T&P, condensate
- Installation and service space
- Duct exhaust to a curved blade register
- Double door with filter grille on each door

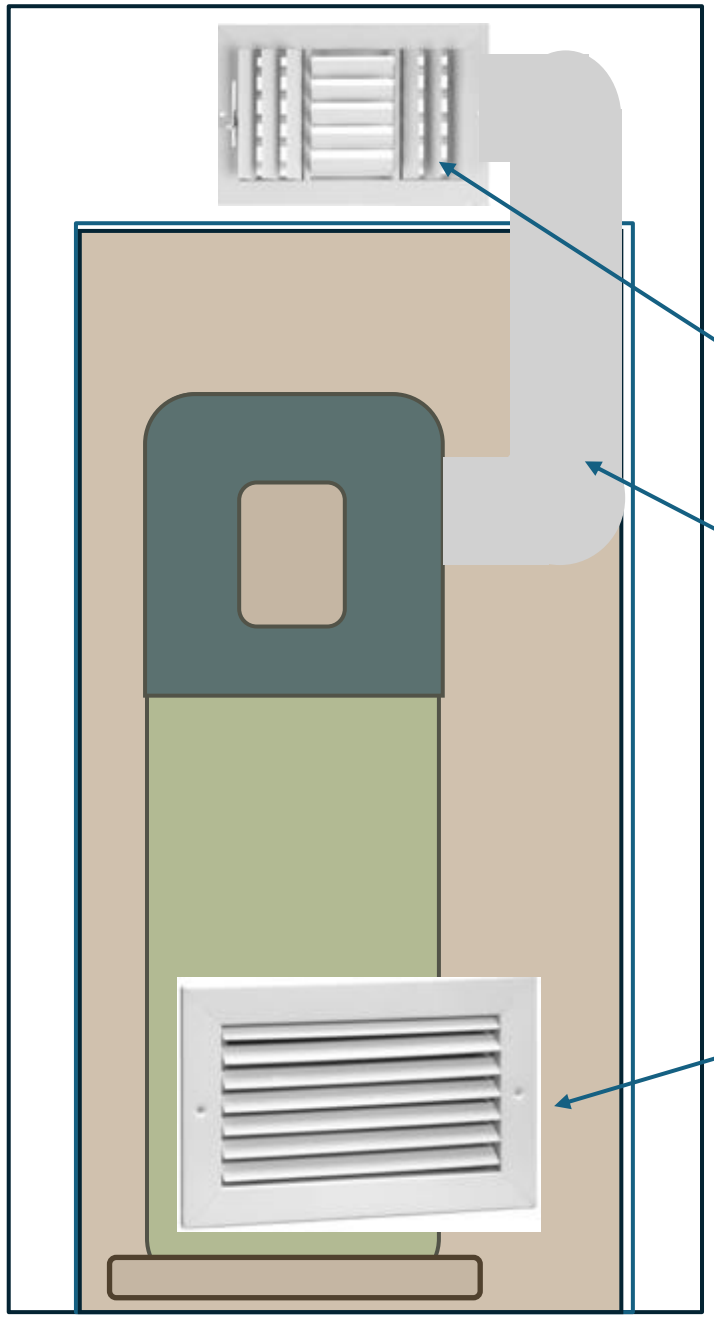


- HVAC Supply Register
- **Front View**
- Insulated Duct
- **Top View**
- HVAC Filter Grille

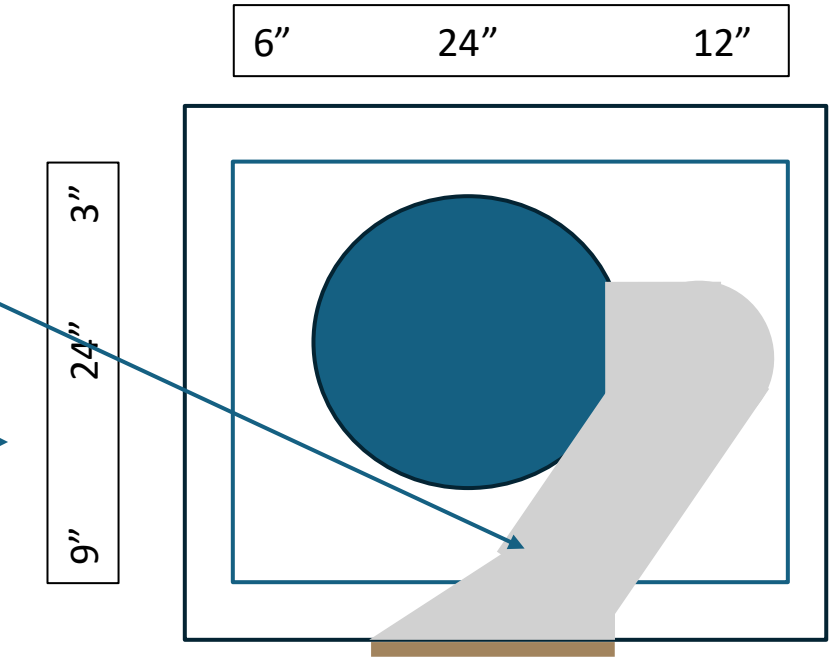


Side Exhaust: Interior of closet 3’ x 3.5’

- Side ports for plumbing, T&P, condensate
- Installation and service space
- Duct exhaust to a curved blade register
- Single door with large filter grille

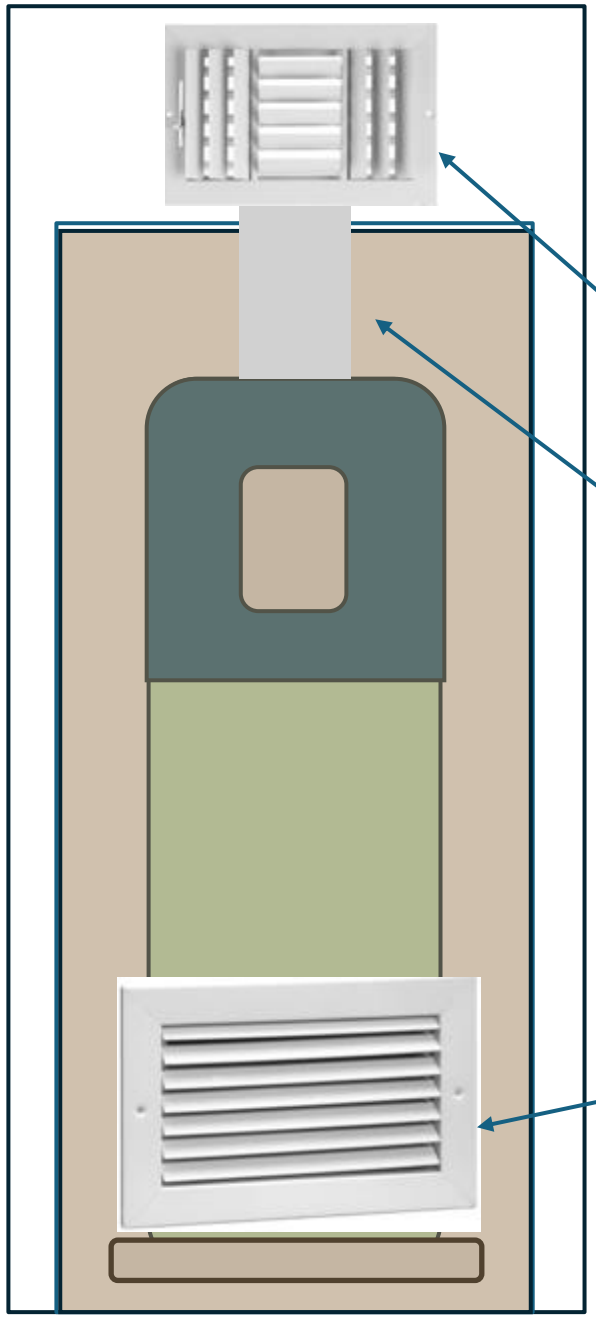


- HVAC Supply Register
- Insulated Duct
- **Front View**
- **Top View**
- HVAC Filter Grille

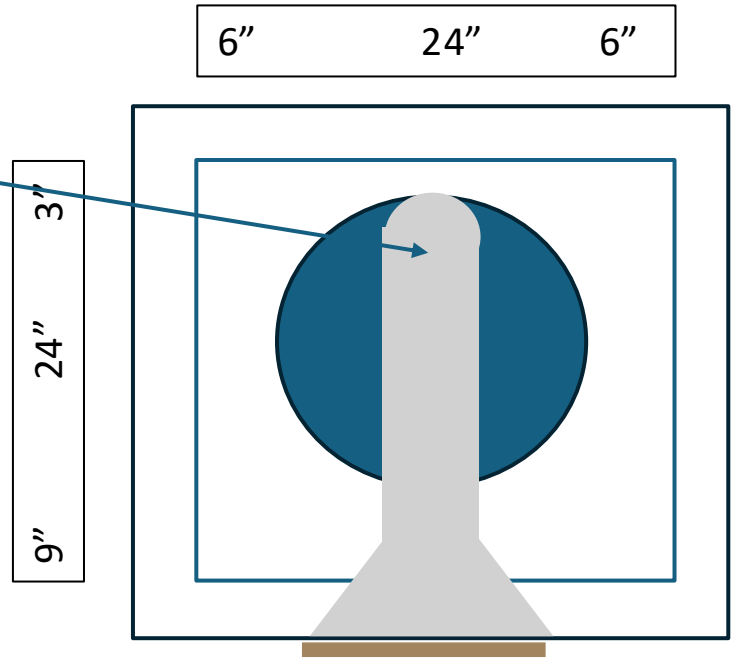


Top Exhaust: Interior of closet 3’ x 3’

- Top ports for plumbing,
- T&P and condensate drain on side
- Installation and service space
- Duct exhaust to a curved blade register
- Single door with large filter grille



- HVAC Supply Register
- Insulated Duct
- **Front View**
- **Top View**
- HVAC Filter Grille



Insulated and Vapor Tight Ducting







We need insulated and vapor-tight boots and takeoffs!





Currently available in 5-inch – 8-inch (125-200) mm diameters

Managing the Air Flow: Part 1

Large areas with full access to warm air

- Do not allow the exhaust air to short circuit into the intake
- Raise the cold exhaust air above the dewpoint temperature as quickly as possible.
- Discharge cold air away from surfaces.
- Ensure that the exhaust air is thoroughly mixed with surrounding air before it becomes intake air

Small areas with limited access to warm air

- Duct cold discharge air out of the enclosure into larger area to mix thoroughly before it becomes intake air
- Bring intake air back through a large filter grille. The surface area of the return grille needs to be 2-4 times the cross-section area of the inside diameter of the exhaust duct
- The lower the intake air temperature, the lower the CoP

Managing the Air Flow: Part 2

Install oversized MERV 13 filters for the intake air

- As part of a filter grille in the door or wall to the small enclosure; or
- In a filter box that is ducted to the intake of the HPWH
- Provides better protection for the coils and less frequent filter maintenance

Integrate the HPWH with the HVAC system

- Install an HVAC return to pull air through the HPWH.
  - Consider ducting the HPWH exhaust into the return plenum.
  - If needed, install a transfer grille into the space where the HPWH is located.
- Use the HVAC system to distribute and mix all air
- Run the HVAC fan at low watts and 150-200 cfm continuously or link the fan to come on whenever the HPWH is running

Access to New Energy, Intake Air Temperature and CoP

1. The volume of the space where the HPWH is installed is not relevant. What matters is the energy in the air in that space.
2. The CoP of the the HPWH is inversely proportional to the temperature of the intake air. For example, HPWH located in warm garages in summer can have a CoP greater than 5. In winter the CoP is often less than 2.
3. Adding energy to the air in that space at the rate needed by the HPWH enables the water heater to operate in heat pump mode 24/7, if needed due to the water heating requirements of the occupancy.
4. If the space is not “conditioned”, and if conduction the only way new energy gets into the air in space, for every hour the HPWH runs in heat pump mode, it needs at least another hour to recover the energy that was extracted. This limits the HPWH to roughly 12 hours per day in heat pump mode.
5. If outdoor air below about 40F is used as the intake air, the HPWH needs to have some means of defrosting the coil. Currently available unitary (integrated) HPWH do not seem to have this capability.

Installations in Other Typical Water Heater Locations

Location of HPWH	To Minimize Risk of Moisture Damage	To Maximize Operating Efficiency

Unconditioned
Garage
Basement
Attic
Podium
	1. Do not allow the exhaust air to bring surfaces in the space below the dew point
	  1. Raise the exhaust air temperature above the dew point
	  2. Direct the exhaust air diagonally across the space
		1. Do not allow the exhaust air to short circuit into the intake.
		2. Expect the CoP to vary seasonally.
		3. Expect the controls to switch to resistance mode when the space is below 55F and when the need for hot water is greater than ability of the heat pump to extract enough energy from the air.

Unconditioned Mechanical Room	1. Do not allow the exhaust air to bring surfaces in the space below the dew point.
	2. Duct the exhaust air out of the mechanical room and, using a louvered door, grille or duct either bring in new:
	• Conditioned air or
	• Unconditioned or outdoor air (HPWH needs to have defrost whenever this air is below 55F)
		1. Do not allow the exhaust air to short circuit into the intake.
		2. Duct the exhaust air out of the mechanical room
		3. When unconditioned or outdoor air is the intake, expect
		  • the CoP to vary seasonally
		  • the controls to switch to resistance mode when the space is below 55F and when the need for hot water is greater than ability of the heat pump to extract enough energy from the air.

Factors that Help Determine How Moisture Condensation on a Surface Results in Moisture Damage, Mildew and Mold

1. Time
   a. Consecutive time has greater risk than intermittent time
2. Temperature
   a. The temperatures found within buildings 40-104F are acceptable to the occupants and to the fungi
3. Food source
   a. Many, if not most of the materials used in construction provide a food source.
4. Moisture
   a. In or on a material,
      - Rot, mold, mildew, spalling, corrosion
      - 20% moisture content in wood
   b. RH in the air close to the material
      - The higher the RH near the food source the greater the risk
      - RH 80 and above
   c. Localized moisture condensation is not covered by whole building analyses

Key Takeaways

When Installing Integrated Air-Source HPWH

1. Prevent the cold exhaust air from short circuiting into the intake
2. Raise the temperature of the exhaust air above the dew point as quickly as possible
3. Don’t trap the cold exhaust air in a (small) enclosure
4. Don’t allow the cold exhaust air to bring surfaces below the dew point
5. Direct exhaust air to safe places
6. Ensure sufficient airflow & access to new thermal resources

Let’s get HPWH installations right –
for health and safety, efficiency, and comfort!

There is No Conflict:
Protecting Public Health and Safety and Increased Energy Efficiency Go Together!

		Protect Health and Safety of the Building and Its Occupants	
		High	Low
Energy Efficiency	High	Yes!	Why gamble?
	Low	Why gamble?	Absolutely not!

Q&A & Discussion

🎤 Questions?

What challenges have you encountered in HPWH installations?

Who wants to collaborate?



Contact information:

Gary Klein

gary@garykleinassociates.com

916-549-7080