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Multifamily Ventilation Strategies and Compartmentalization Requirements

Sean Maxwell, CEM

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Improving the Built Environment Since 1972

Previous Research

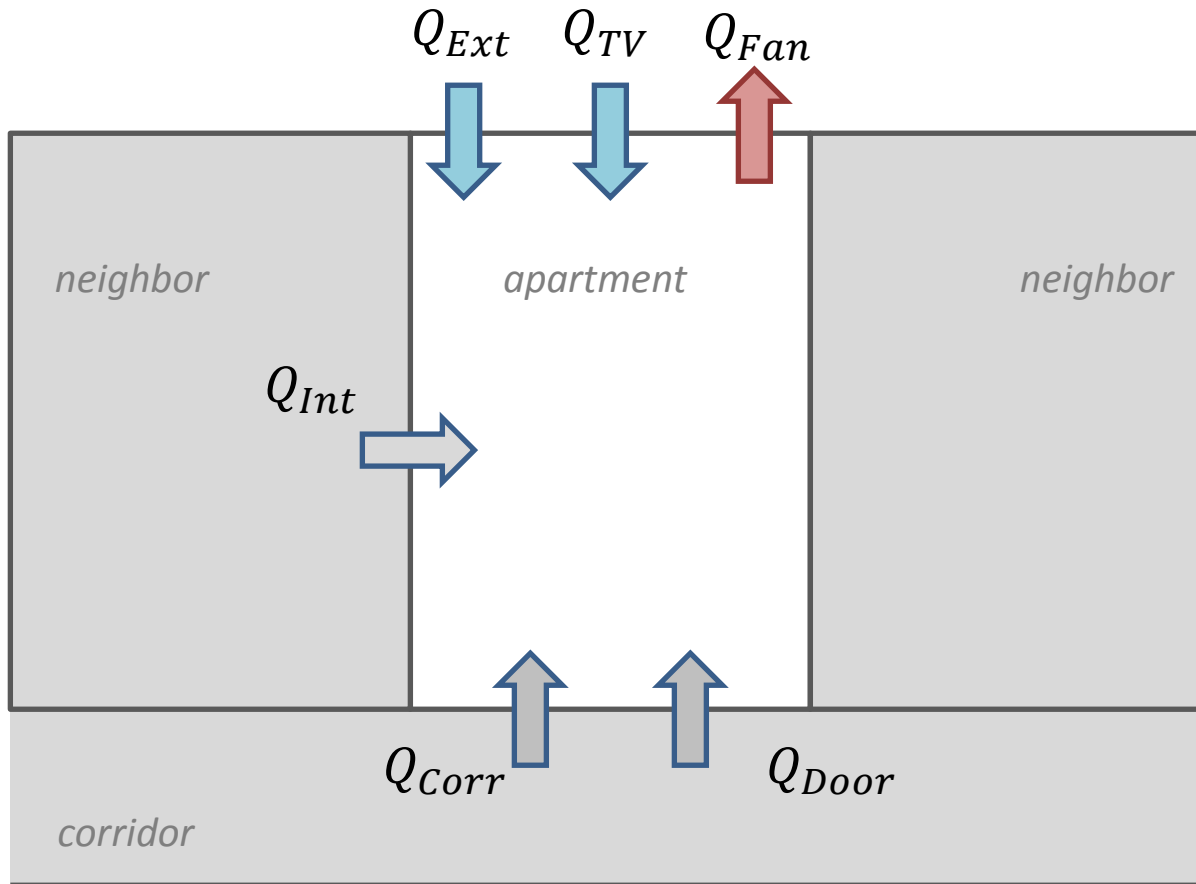- Where does makeup air come from?

Simple example
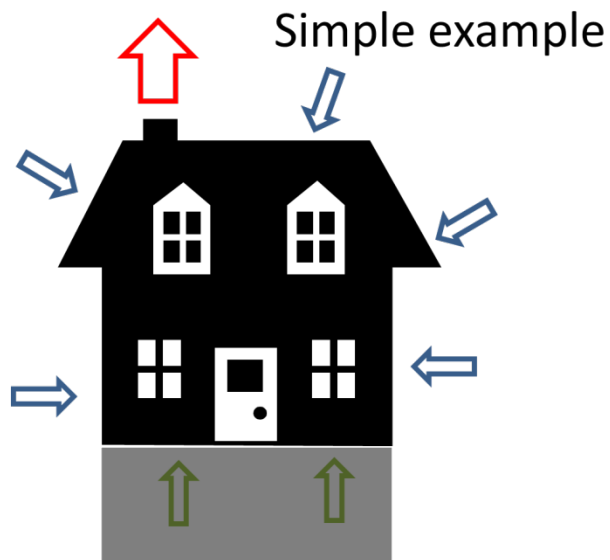
- Centrally- ducted supply
- Door undercuts
- PTAC "fresh air kit"
- Passive vents (including trickle vents)

6

Airflows within an apartment

Q_{Fan} = apartment exhaust flow

Q_{TV} = supply airflow from trickle vents

Q_{Ext} = air leakage from exterior envelope

Q_{Int} = air leakage from other apartments through interior partitions (demising walls, ceiling, floor)

Q_{Corr} = air leakage from corridor walls

Q_{Door} = air leakage from corridor door

$$Q_{Fan} = Q_{TV} + Q_{Ext} + Q_{Int} + Q_{Corr} + Q_{Door}$$

Quantifying airflows

Q_{Fan} = apartment exhaust flow = **good**

Q_{TV} = supply airflow from the trickle vents = **good**

Q_{Ext} = air leakage from exterior envelope= **good**

Q_{Int} = air leakage from other apartments through interior partitions = **bad**

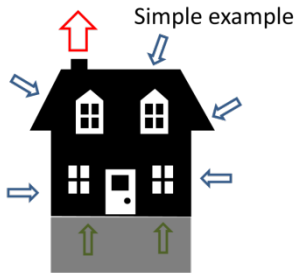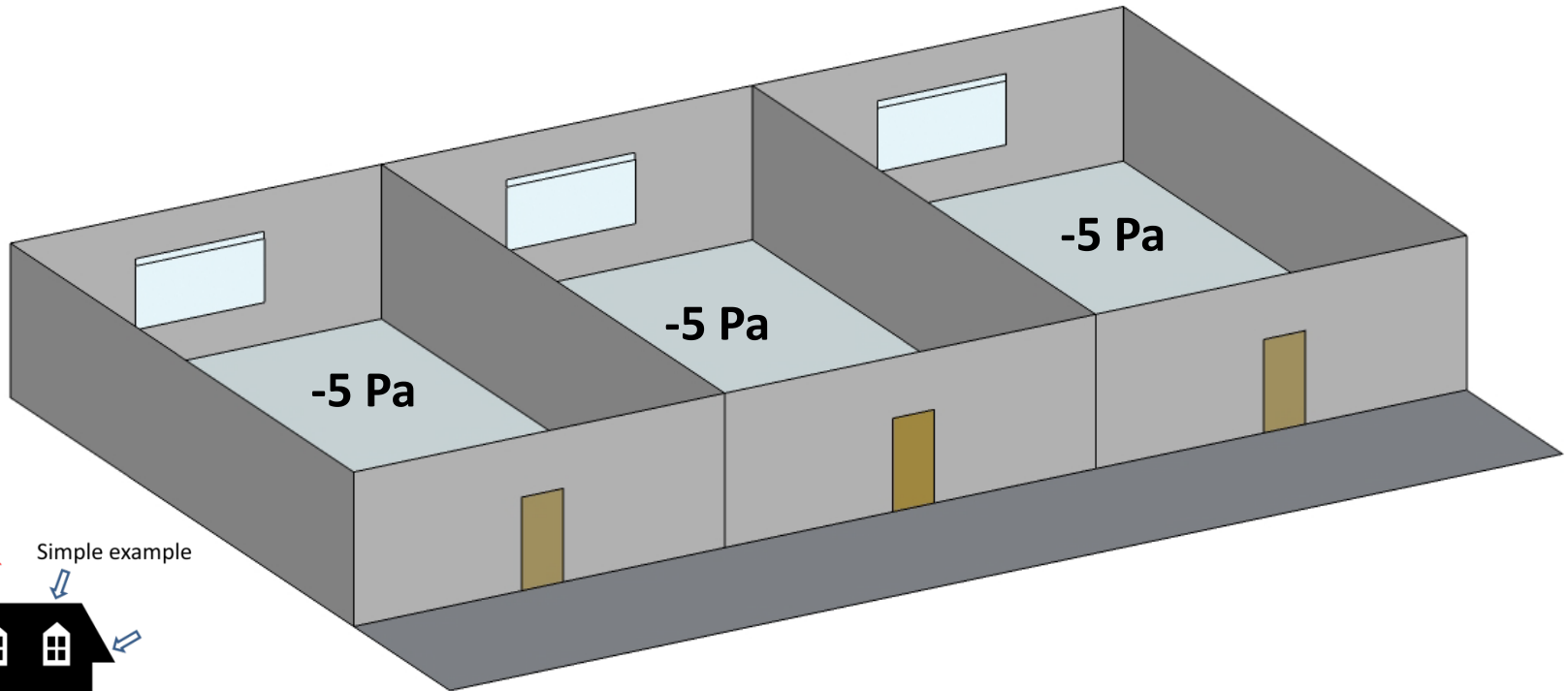Q_{Corr} = air leakage from corridor walls = **bad**

Q_{Door} = air leakage from corridor door = **bad**

$$\frac{Q_{TV}}{Q_{Fan}} = \text{controlled makeup air fraction}$$
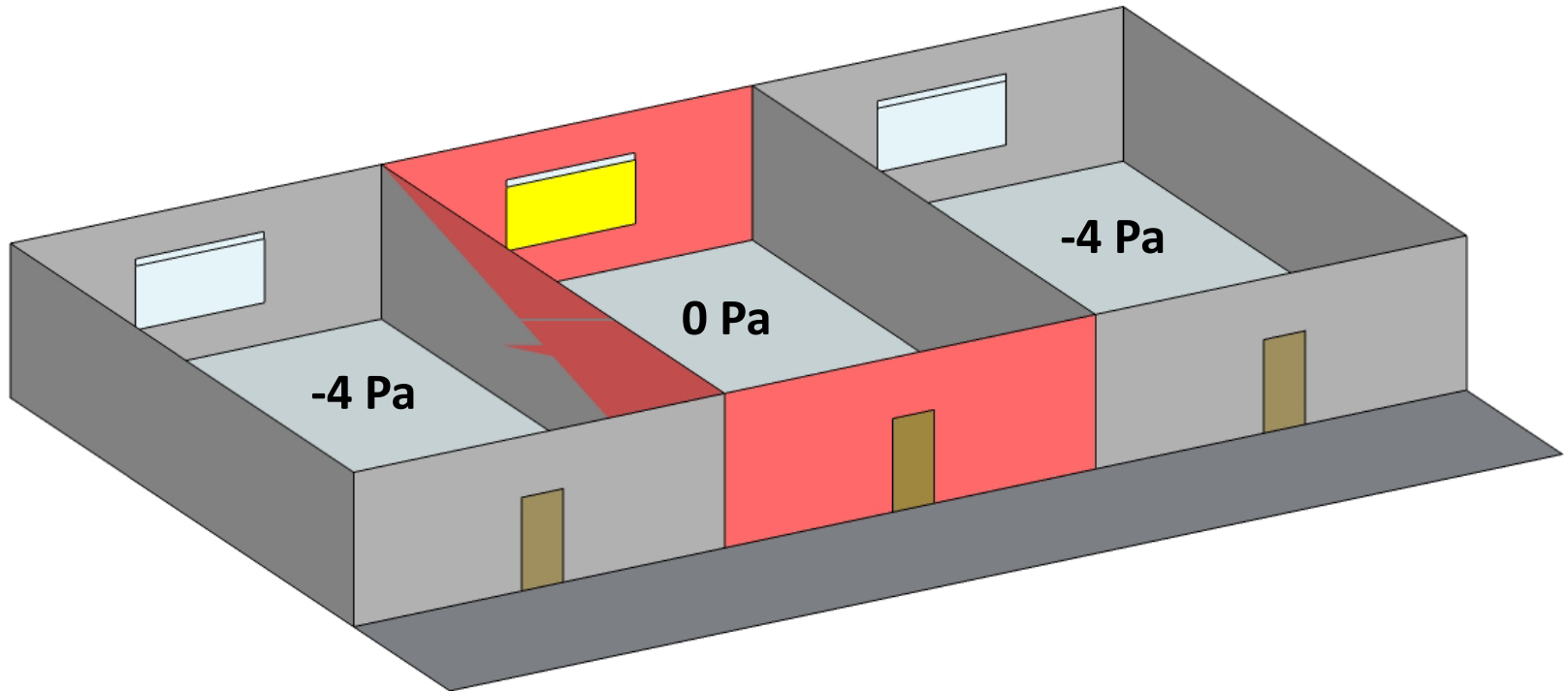
Greater than 50% = **good?**

Exhaust-only apartments

Simple example

-5 Pa

-5 Pa

-5 Pa
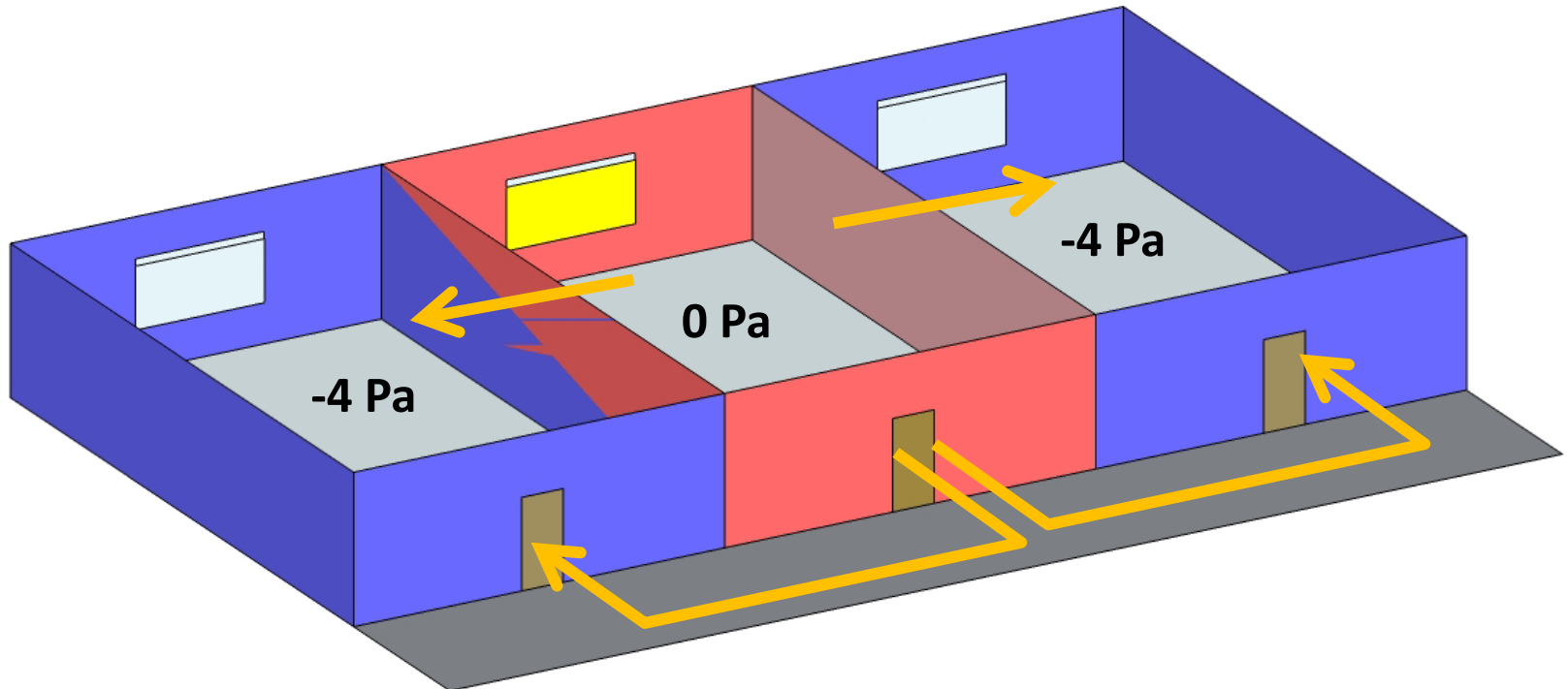
- Apartments all equally depressurized

Open windows

- Someone burns a grilled cheese sandwich
- They open the window, the apt. drops to 0 Pa WRT outside
- Air moves freely in and out of apartment from outside

Other apartments receive pollution

- One apartment drops to 0 Pa WRT outside
- Air moves out of apartment into corridor
- Airflow from corridor into apartments
- Net pollutant transfer to other apartments

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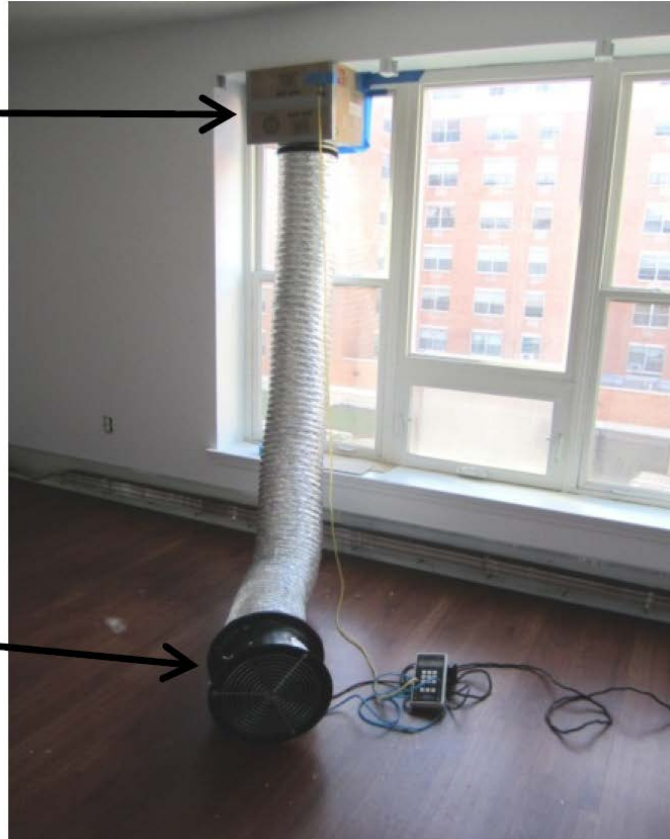
Passive Vent Tests

Trickle Vents

Wall Vents

Passive vents

Capture hood
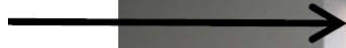
Fan

Trickle Vent Tests

Trickle Vent Installed Performance vs. Lab Tests

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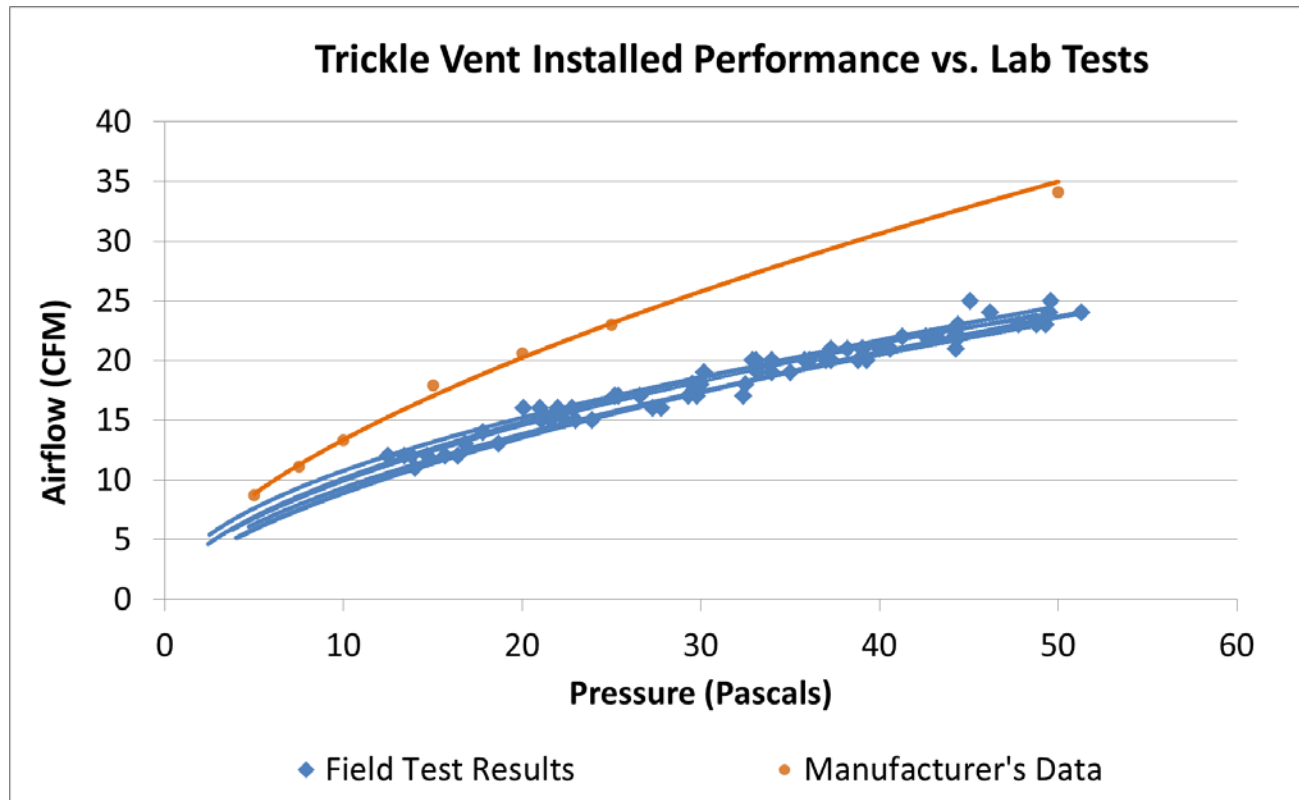
Trickle vent performance

Performance affected by installation

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How to specify passive vents

- To specify properly, must know
  - Airtightness of apartment
  - Airtightness of door
  - Flow rate of exhaust
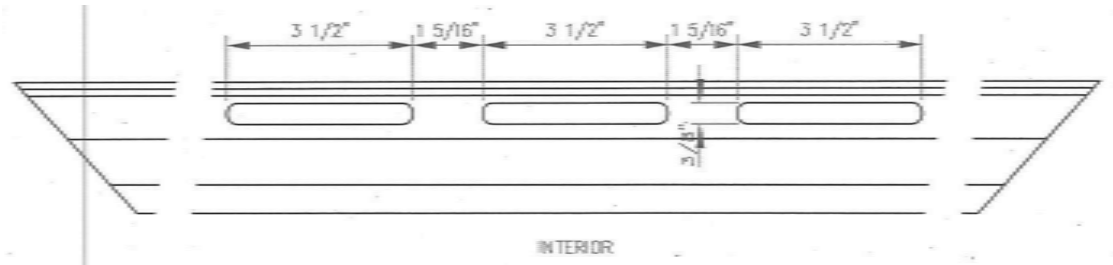 - Performance of trickle vent

- Standard procedure = 1 vent per room
- Common trickle vent = 4 in^2 nominal opening per vent
- Common apartment = 70 in^2 total leakage, not including vents or door

Overview of two buildings

Summary table	Building 1	Building 2
ACH50	2.5	6.7
Exhaust	41 CFM	53 CFM
Supply from passive vents	11.5 CFM	4.3 CFM
Passive vent type	Trickle vents	Airlet®

Some super-tight apartments

CFM50

564	**158***	**127***
579	356	**167***
585	**180***	375

CFM50/SF

0.26	**0.08***	**0.06***
0.27	0.17	**0.08***
0.27	**0.09***	0.18

*enhanced sealing

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What level is realistic?

Results of 600+ SWA MF Blower Door Tests

Chart axes: Count (y-axis, 0 to 250); Airtightness (CFM50/SF) (x-axis, 0 to 0.6)

Annotations:
- Study apartments (~0.1)
- LEED-NC (~0.21)
- Study apartments (~0.26)
- ENERGY STAR® MFHR, LEED-H (~0.3)
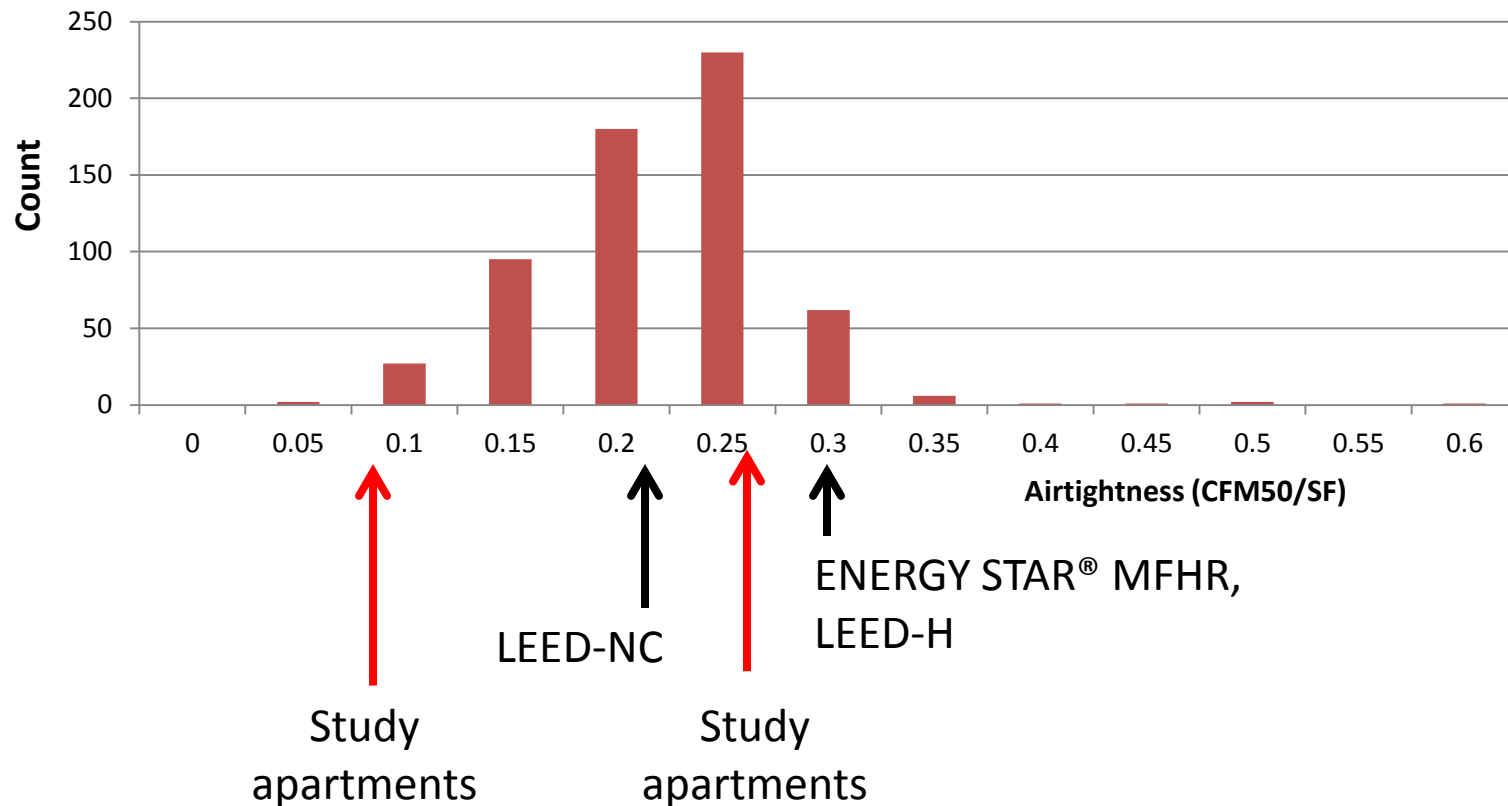
Operating Pressures

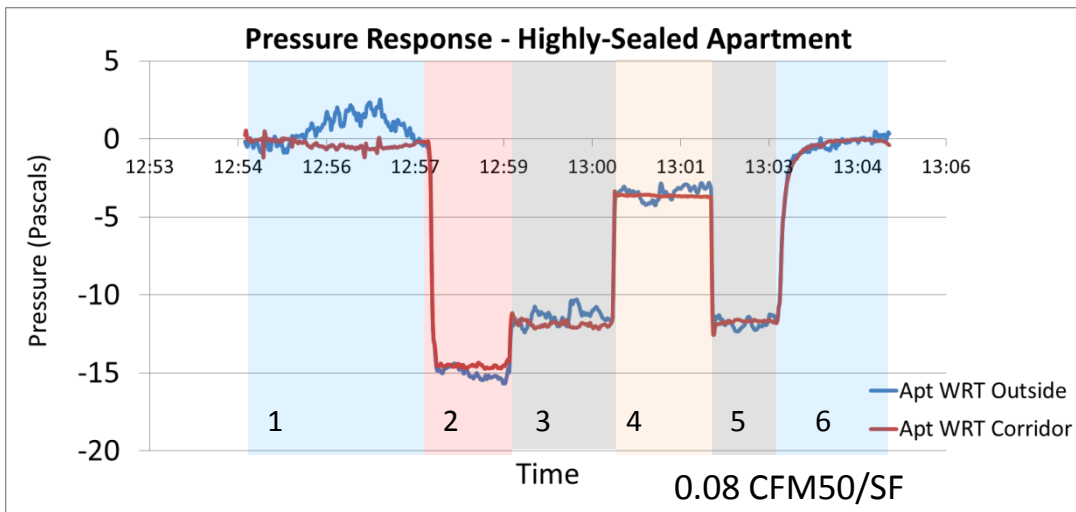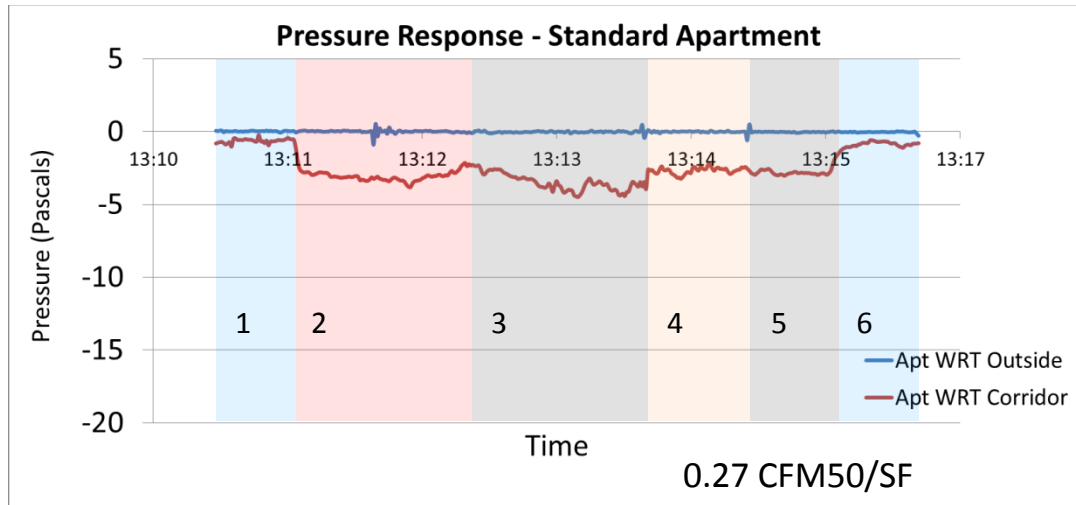|		
-5.7	-15.8*	-14.5*
0.6	-12	-4*
-3.3	-10.4*	-4.9

*apts received enhanced sealing

- Trickle vents open
- Bath fan running
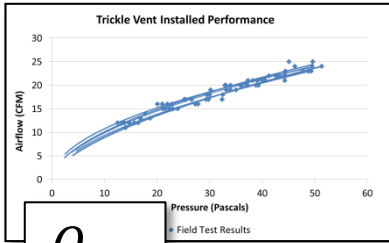- Door closed
- Windows closed

Comparison – sealed vs. unsealed

Pressure Response - Standard Apartment

0.27 CFM50/SF

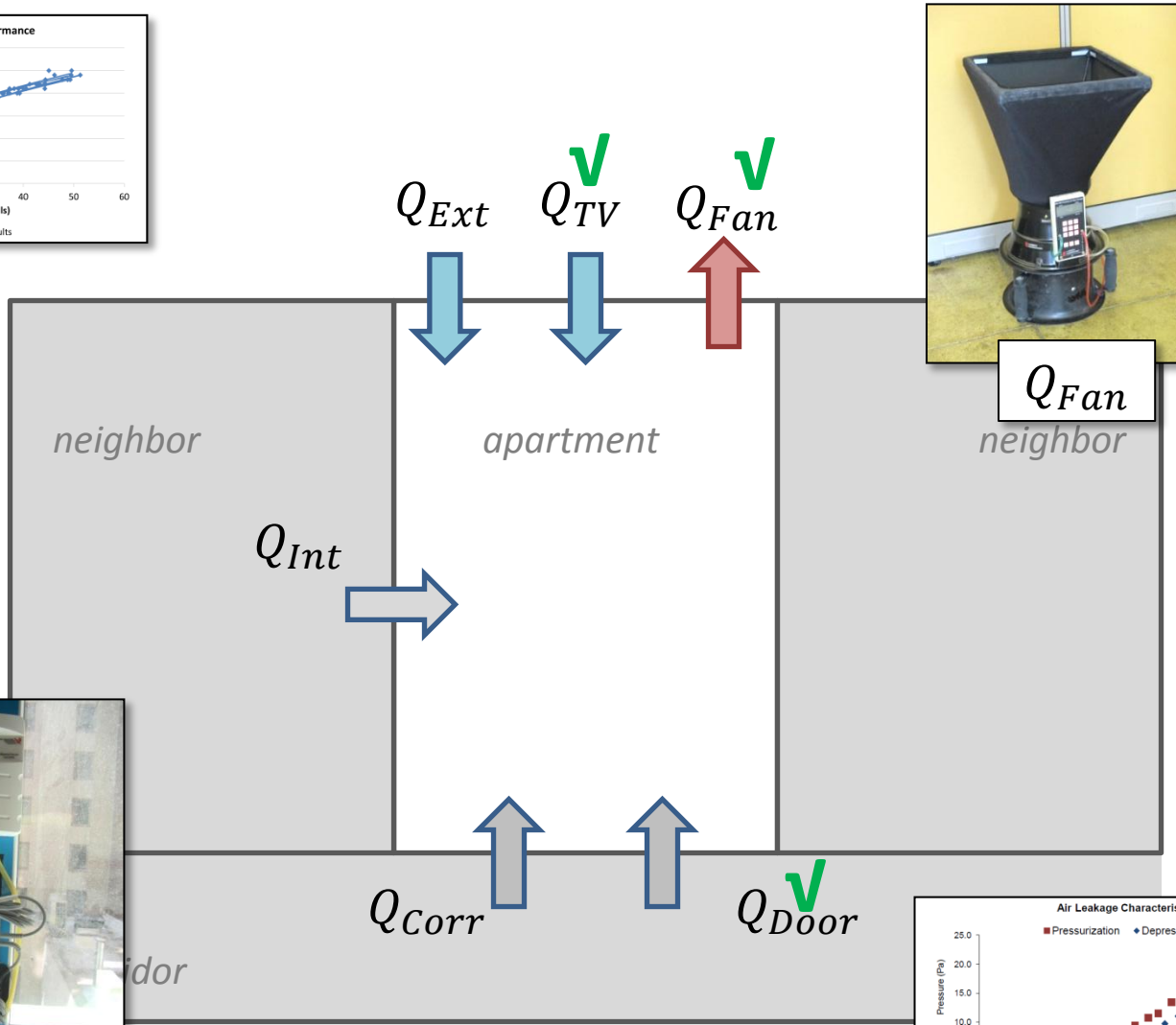Pressure Response - Highly-Sealed Apartment

0.08 CFM50/SF

Conditions:
1. Exhaust off
2. Maximum pressure (exhaust on, trickle vents closed)
3. Normal operation; (trickle vents open)
4. Door cracked
5. Normal operation; (trickle vents open)
6. Exhaust off

- Pressure across exterior in standard apartment is close to zero
- Pressure response in sealed apartment much greater
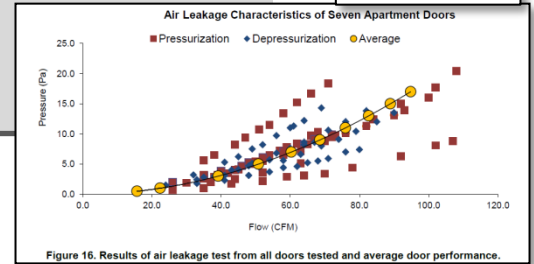- Inside and outside pressures track each other in sealed apt.

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Q_{TV}

Q_{Ext} $\checkmark$ Q_{TV} $\checkmark$ Q_{Fan}

Q_{Fan}

neighbor *apartment* *neighbor*

Q_{Int}

Pressure logging

Q_{Corr} $\checkmark$ Q_{Door}

Q_{Door}

Figure 16. Results of air leakage test from all doors tested and average door performance.

"Functional" leakage
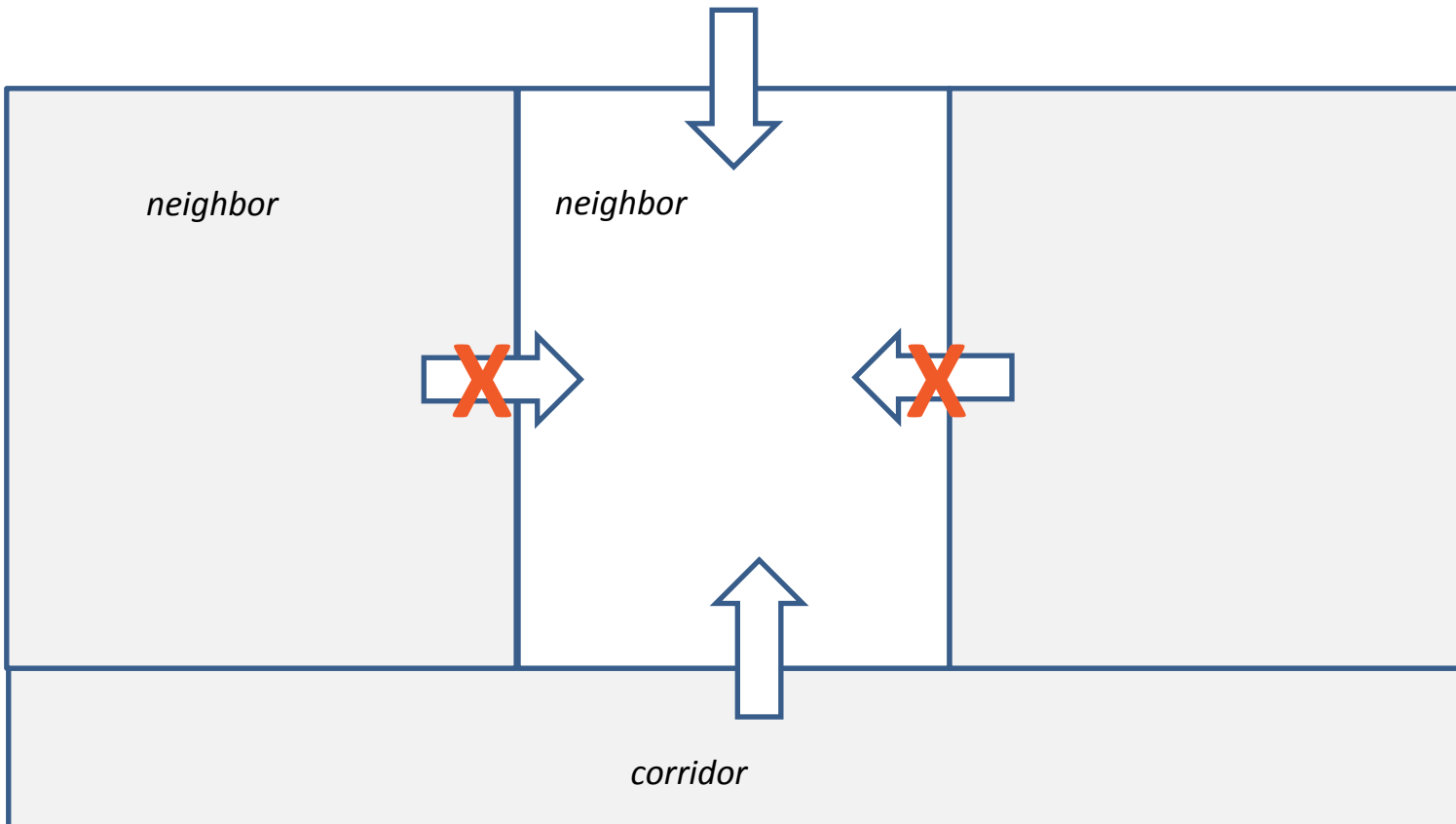
Airflows in an ideal (very tight) apartment

|			Flow at 50 Pa	Functional Leakage	Flow at 10 Pa
Blower Door Test	13.6 in^2	Q_{Ext} (20%)	22.0	Yes	9.8
	0.05 CFM50/SF	Q_{Int} (60%)	66.0	No	-
		Q_{Corr} (20%)	22.0	Yes	9.8
Door Leakage Test	2.5 in^2	Q_{Door}	20.0	No	8.9
Trickle Vent Test	8 in^2	Q_{TV}	64.8	No	29.0
Exhaust Flow Measurement			Q_{Fan}		58

$$Controlled\ makeup\ air\ fraction = \frac{Q_{TV}}{Q_{Fan}} = \frac{29}{58} = 50\%$$

Aerosol process (UC Davis)

Average at least 75% leakage reduction in 90 min.

- Sealing has an effect on neighbors
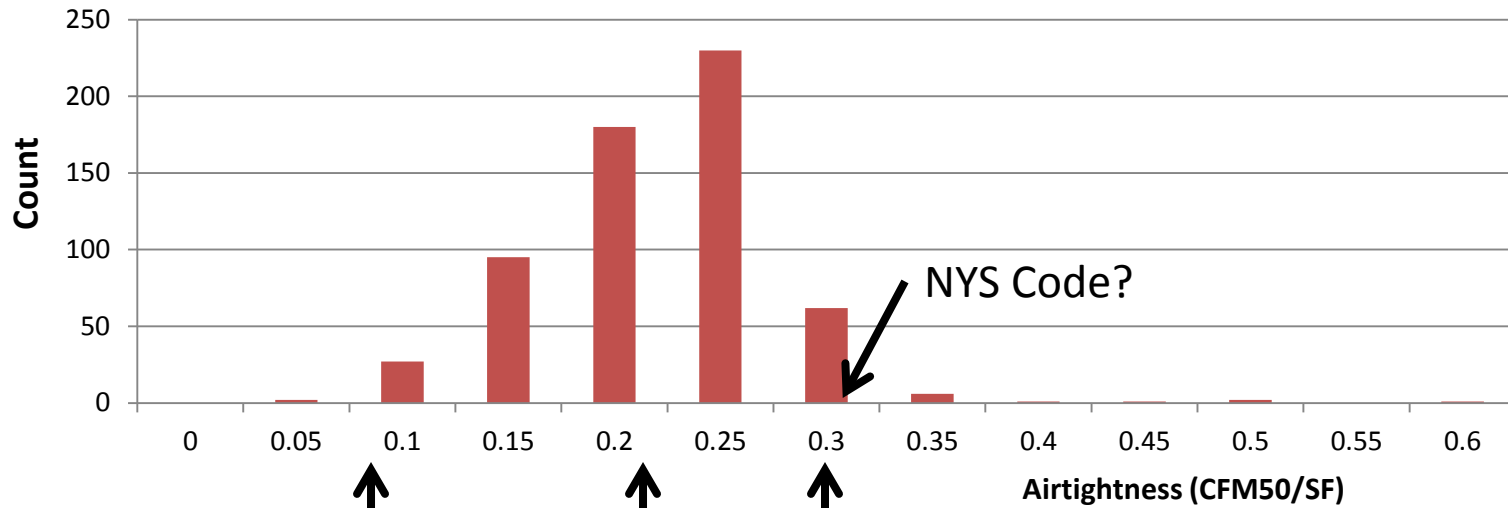- Complex air barriers – air seals created on interior surface
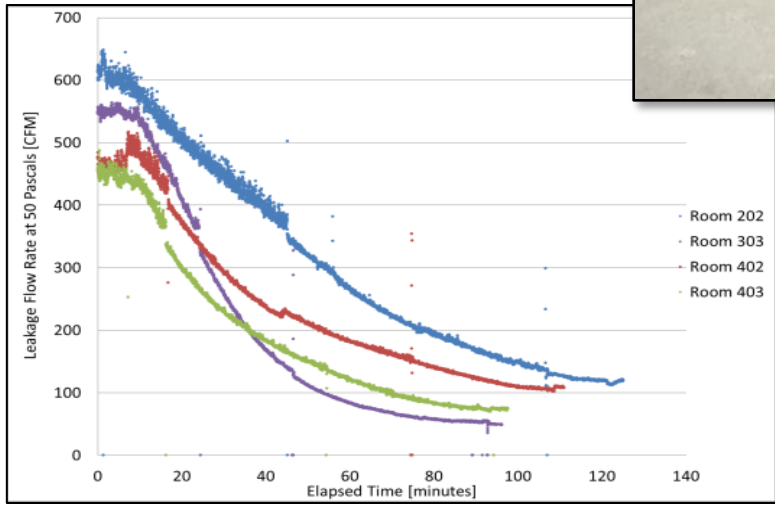
CFM50/SF

0.26	0.08*	0.06*
0.27	0.17	0.08*
0.27	0.09*	0.18

*aerosol sealing

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What level is realistic?

Results of 600+ SWA MF Blower Door Tests

Necessary for passive vents

LEED-NC

ENERGY STAR® MFHR, LEED-H

NYS Code?

Conclusions

- Compartmentalization is beneficial for airflow control

- Field evaluation of under real-world conditions for passive vents is important

- Passive vents can function in extremely tight apartments, most of the time

- Great majority of projects cannot achieve necessary airtightness

Are these conditions realistically achievable on a wide scale?

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