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# Building Science

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Adventures In Building Science

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# Build Tight - Ventilate Right

Build Tight - Ventilate Right  
How Tight?  
What's Right?

# Air Barrier Metrics

Material	0.02 l/(s-m <sup>2</sup> ) @ 75 Pa
Assembly	0.20 l/(s-m <sup>2</sup> ) @ 75 Pa
Enclosure	2.00 l/(s-m <sup>2</sup> ) @ 75 Pa
	0.35 cfm/ft <sup>2</sup> @ 50 Pa
	0.25 cfm/ft <sup>2</sup> @ 50 Pa
	0.15 cfm/ft <sup>2</sup> @ 50 Pa

Getting rid of big holes	3 ach@50
Getting rid of smaller holes	1.5 ach@50
Getting German	0.6 ach@50

Best

As Tight as Possible - with -

Balanced Ventilation

Energy Recovery

Distribution and Mixing

Source Control - Spot exhaust ventilation

Filtration

Material selection

Worst

Leaky - with – Nothing

Spot Ventilation in Bathroom/Kitchen

Exhaust Ventilation – with – No Distribution  
and No Mixing

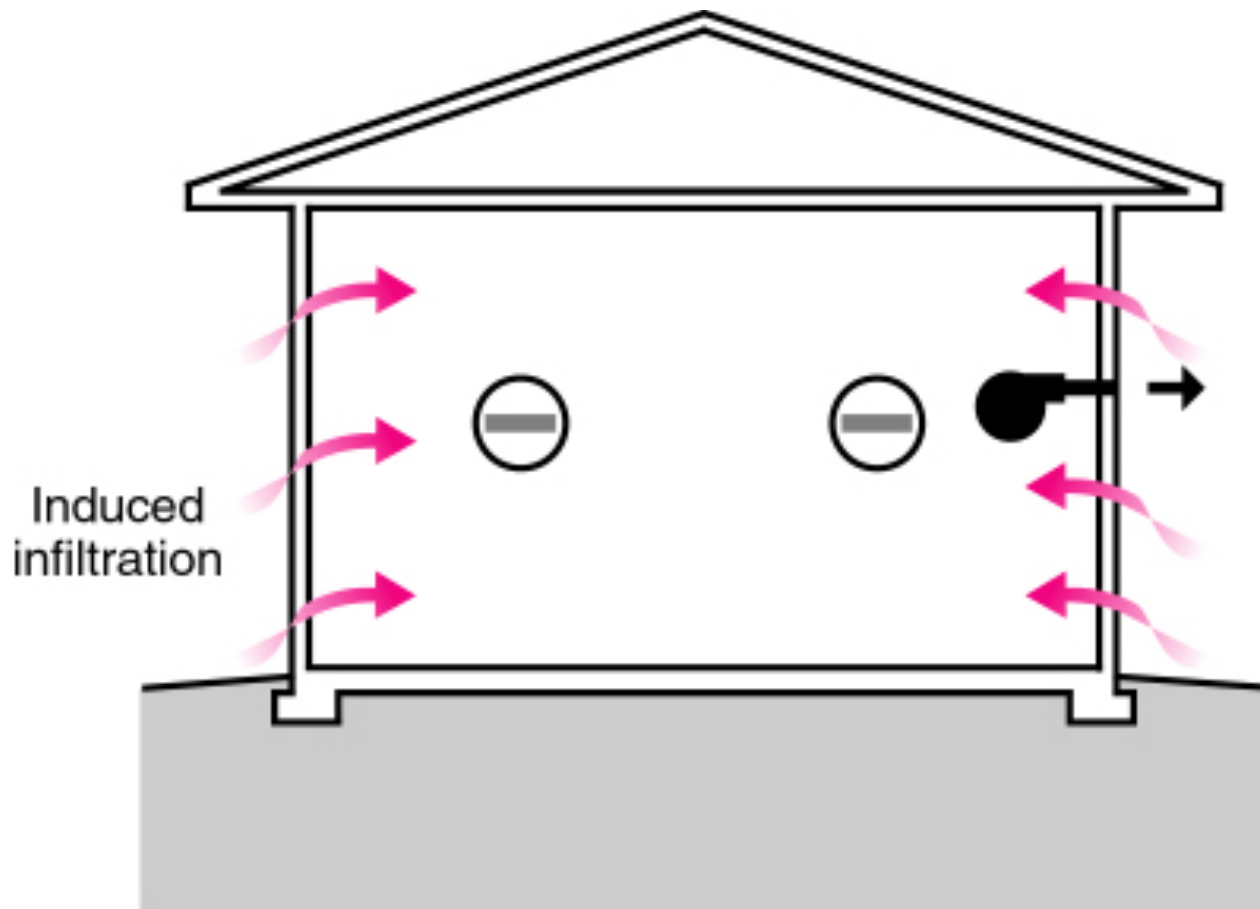
# Three Types of Controlled Ventilation Systems

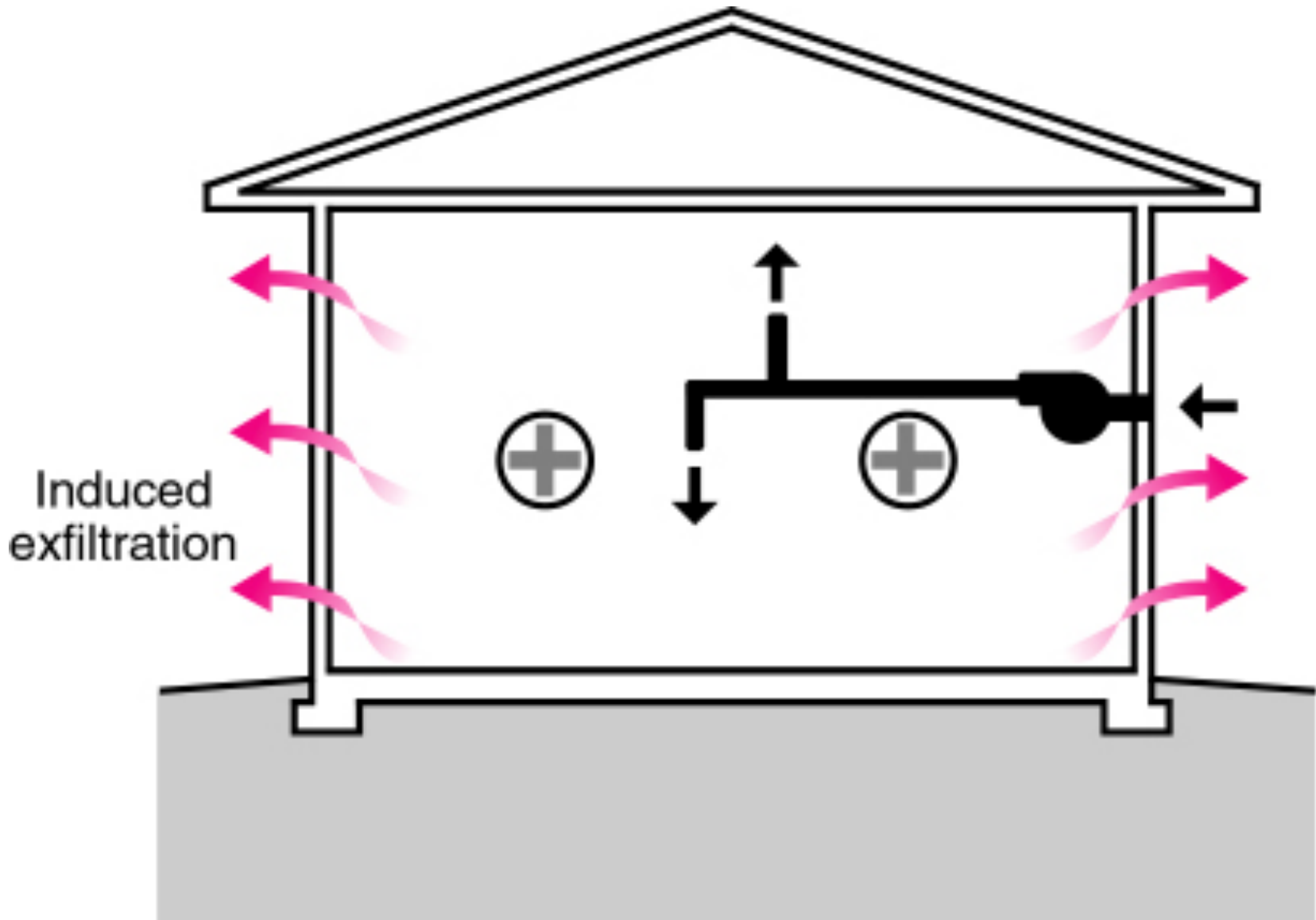
Exhaust Ventilation

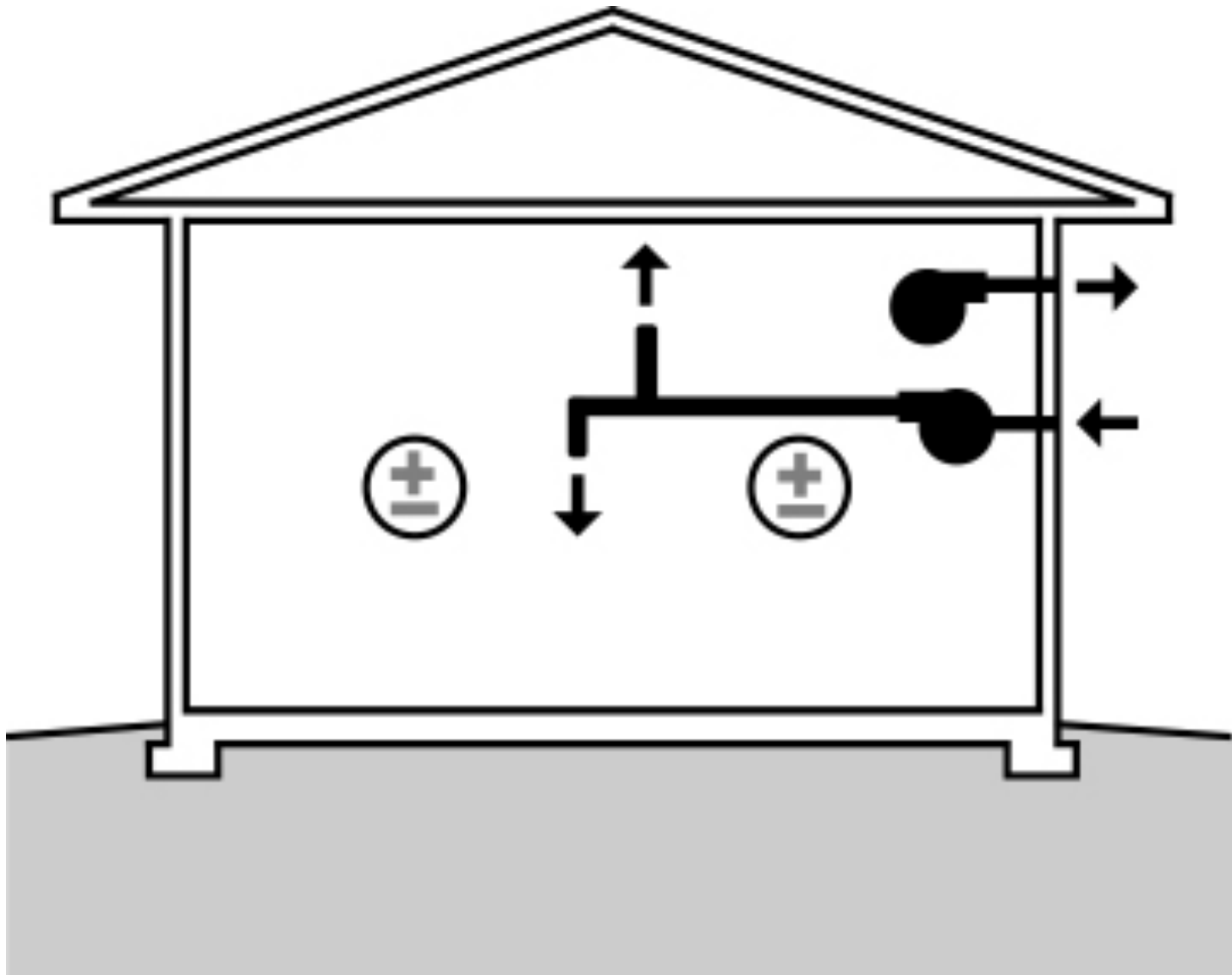
Supply Ventilation

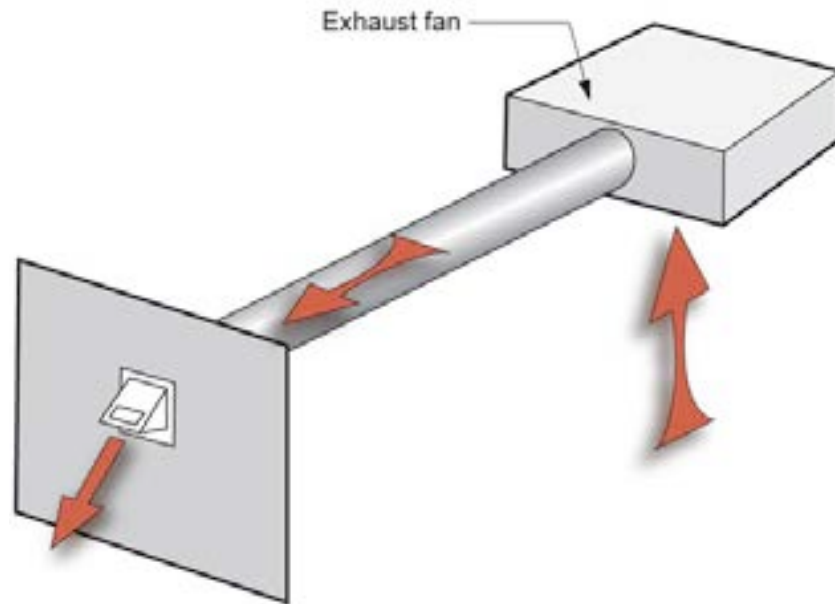
Balanced Ventilation

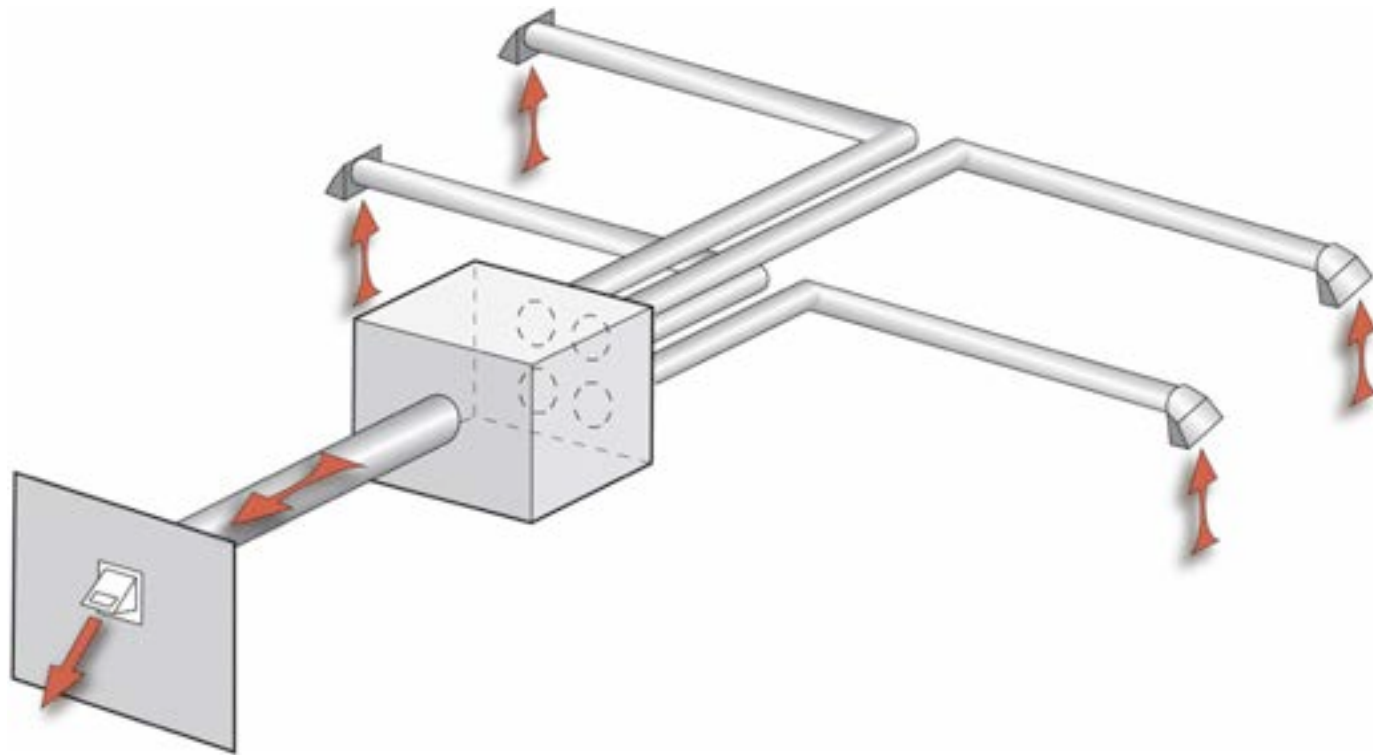


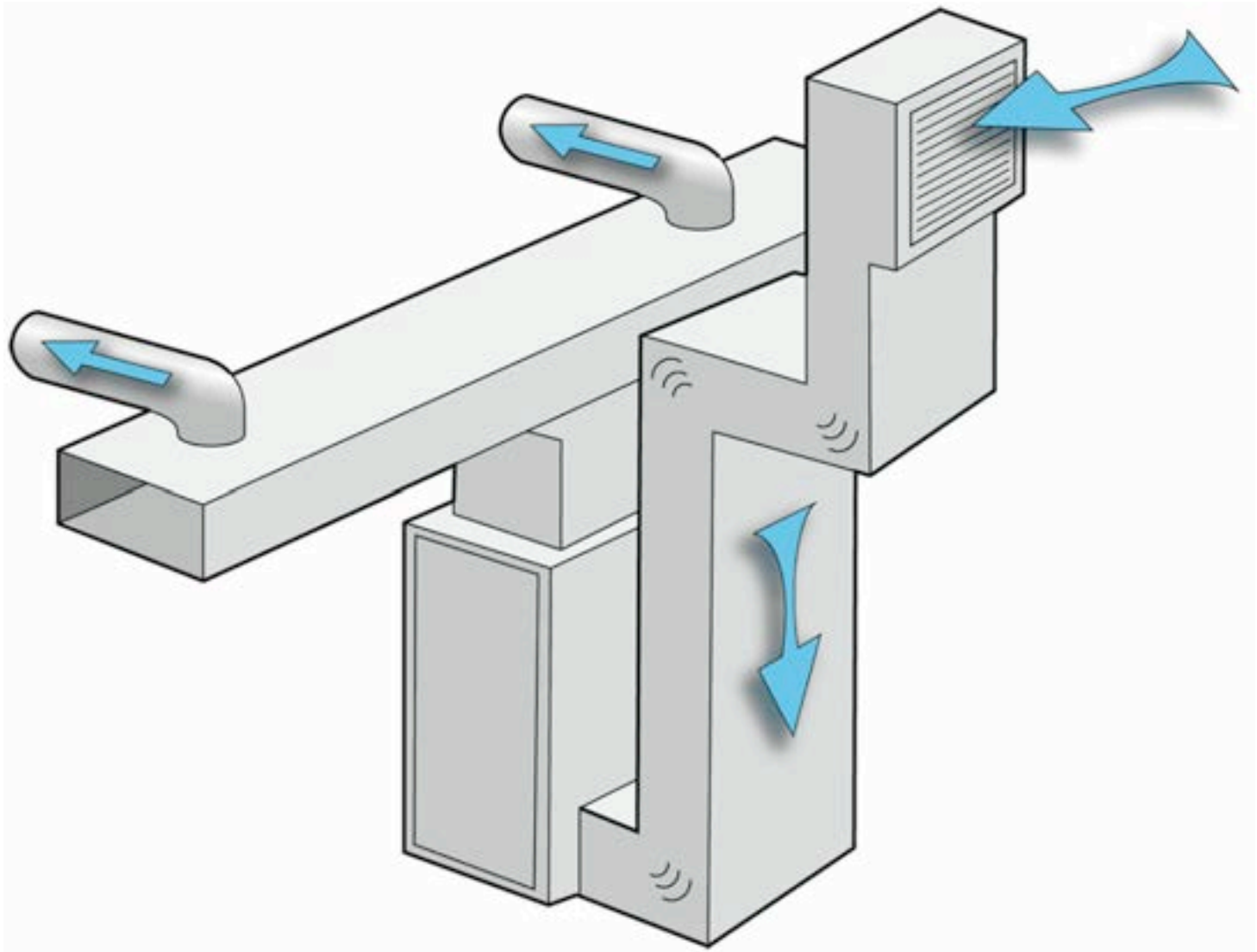


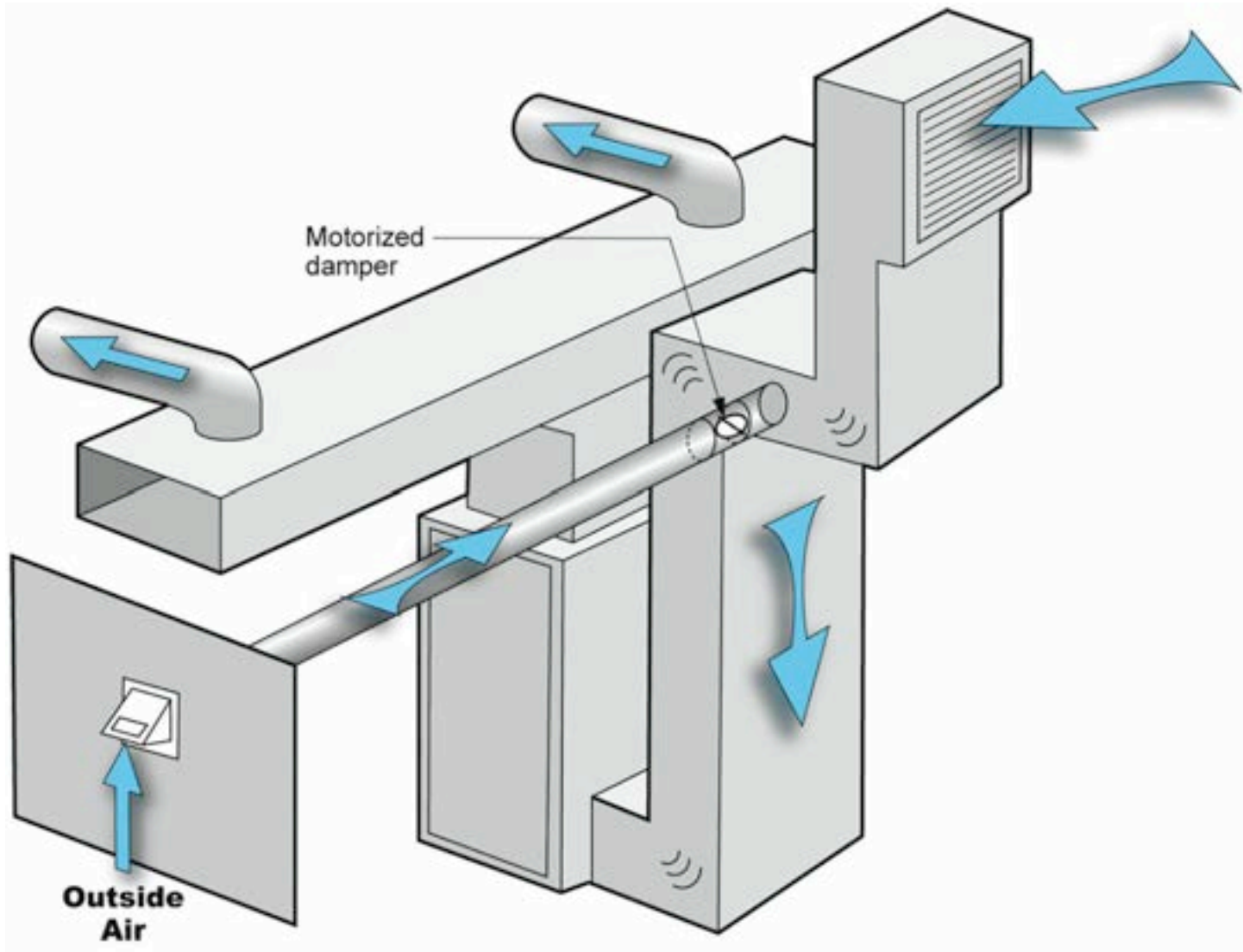


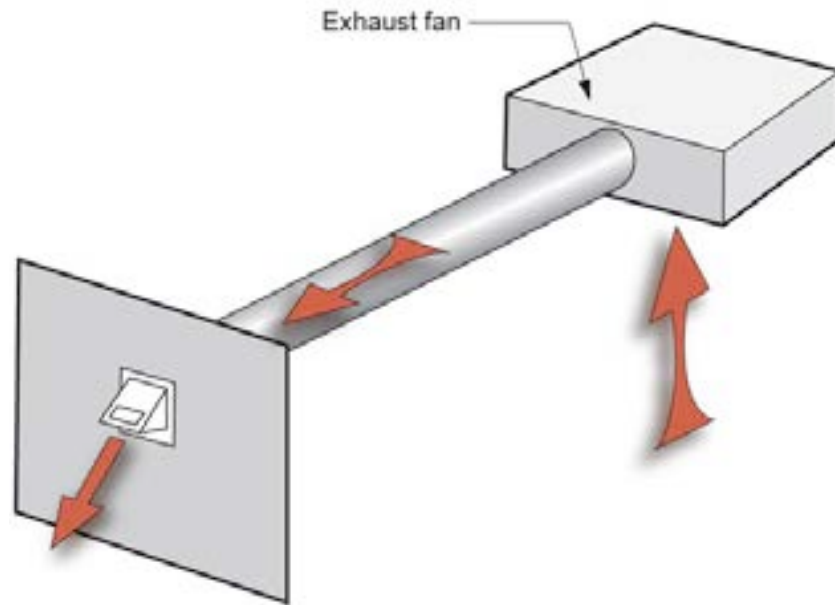




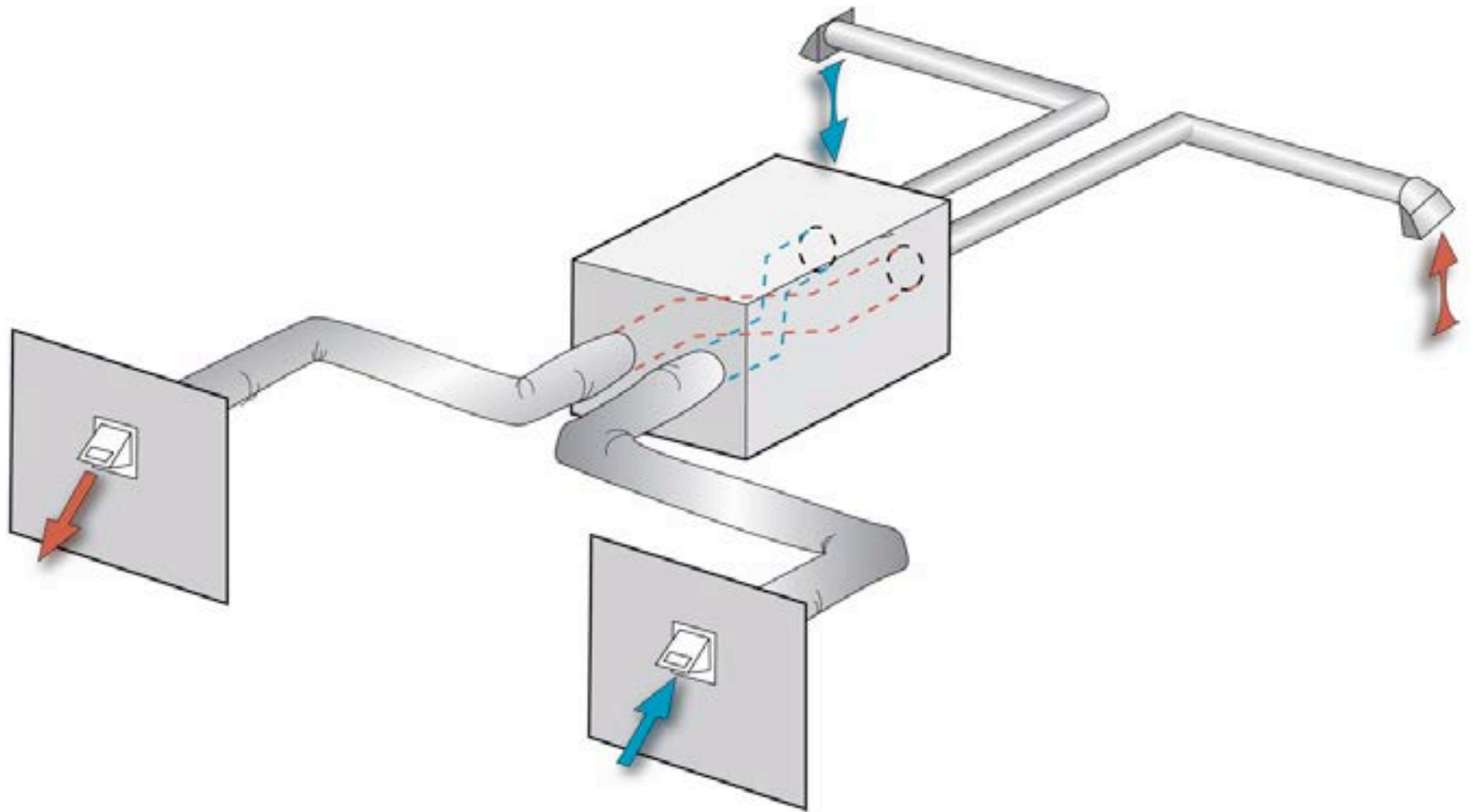












# Ventilation Rates Are Based on Odor Control

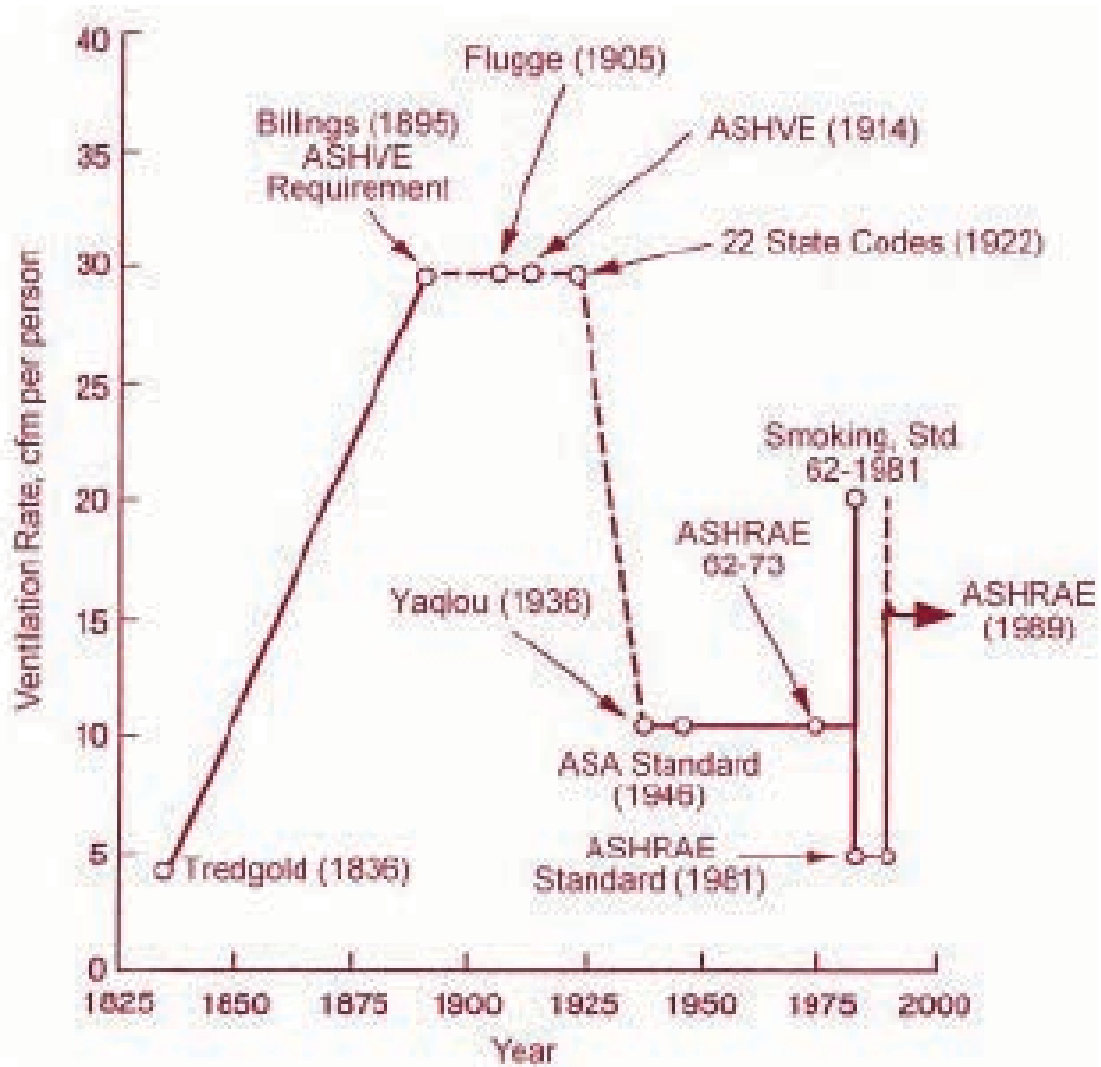
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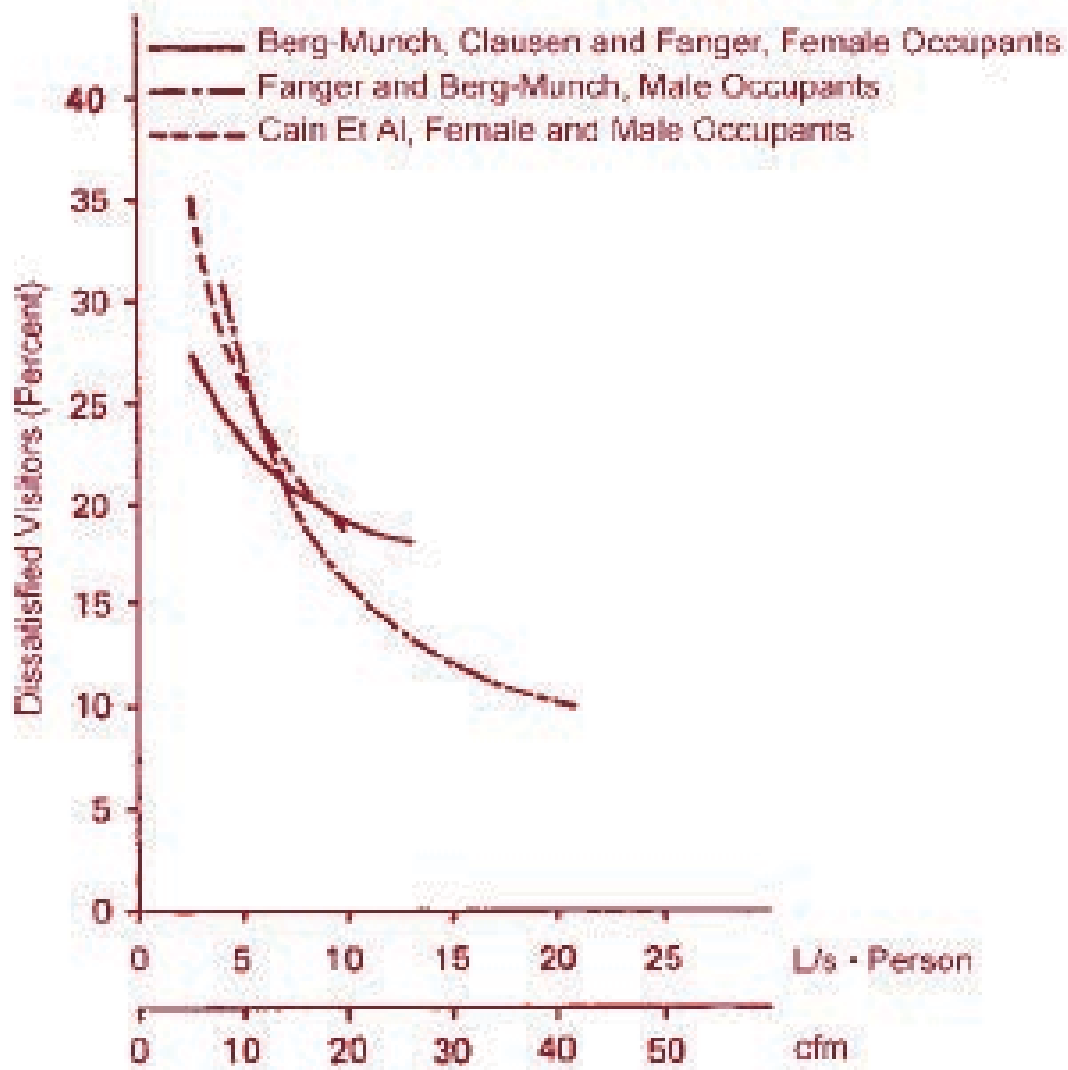
Ventilation Rates Are Based on Odor Control  
Health Science Basis for Ventilation Rates is  
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Almost Nothing Cited Applies to Housing

The Applicable Studies Focus on Dampness



**Figure 1: Minimum ventilating rate history.**



**Figure 2: Odor acceptance.**

# House

**2,000 ft<sup>2</sup>**

**3 bedrooms**

**8 ft. ceiling**

**Volume: 16,000 ft<sup>3</sup>**

.35 ach    93 cfm

.30 ach    80 cfm

.25 ach    67 cfm

.20 ach    53 cfm

.15 ach    40 cfm



# House

2,000 ft<sup>2</sup>

3 bedrooms

8 ft. ceiling

Volume: 16,000 ft<sup>3</sup>

## Ventilation Rates

.35 ach	93 cfm	62 - 73	5 cfm/person	20 cfm
.30 ach	80 cfm		10 cfm/person	40 cfm
.25 ach	67 cfm	62 - 89	15 cfm/person	60 cfm
.20 ach	53 cfm		.35 ach	90 cfm
.15 ach	40 cfm	62.2 - 2010	7.5 cfm/person + 0.01	50 cfm
		62.2 - 2013	7.5 cfm/person + 0.03	90 cfm

# Office

## Occupant Density

15/1000 ft<sup>2</sup> (67 ft<sup>2</sup>/person)  
15 cfm/person

62 - 89

5/1000 ft<sup>2</sup> (200 ft<sup>2</sup>/person)  
17 cfm/person

62.1 - 2007

# Correctional Facility Cell

## Occupant Density

20/1000 ft<sup>2</sup> (48 ft<sup>2</sup>/person)  
10 cfm/person

62.1 – 2007

# C.P. Yaglou

Harvard School of Public Health

1936

1955

150 ft<sup>3</sup> → 20 cfm/person

300 ft<sup>3</sup> → 12 cfm/person

# C.P. Yaglou

Harvard School of Public Health

1936

1955

150 ft<sup>3</sup> → 20 cfm/person 18.75 ft<sup>2</sup> 106 occupants

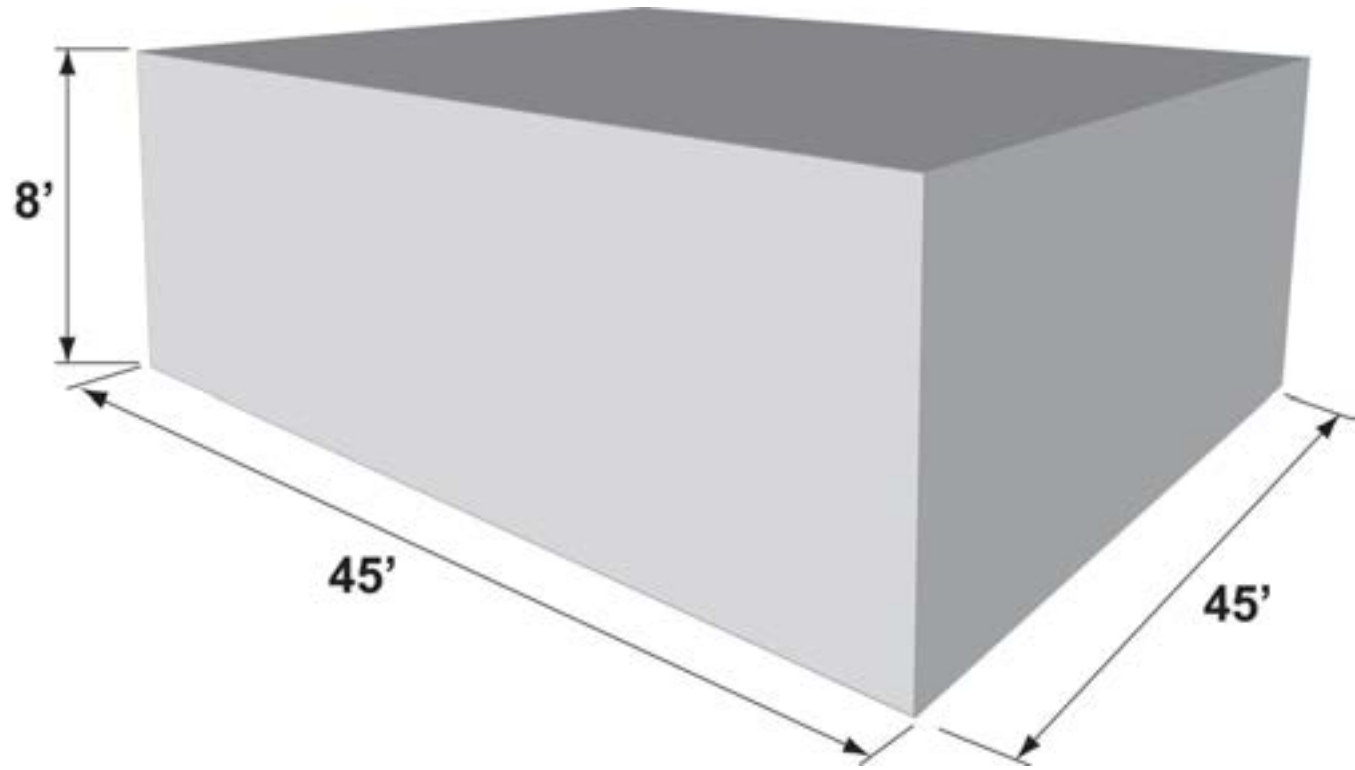
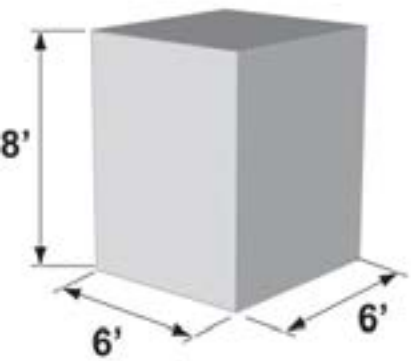
300 ft<sup>3</sup> → 12 cfm/person 37.5 ft<sup>2</sup> 53 occupants

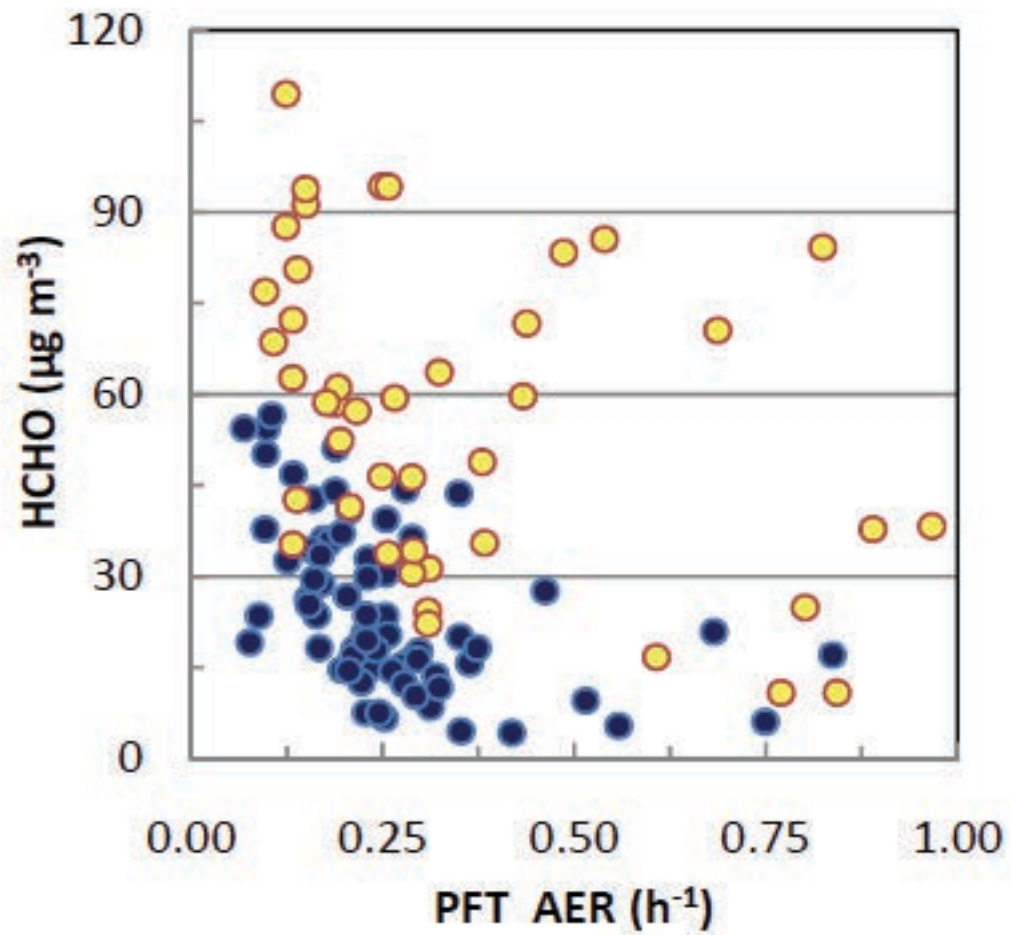
## Experiment

470 ft<sup>3</sup> → 59 ft<sup>2</sup>

200 ft<sup>3</sup> → 25 ft<sup>2</sup>

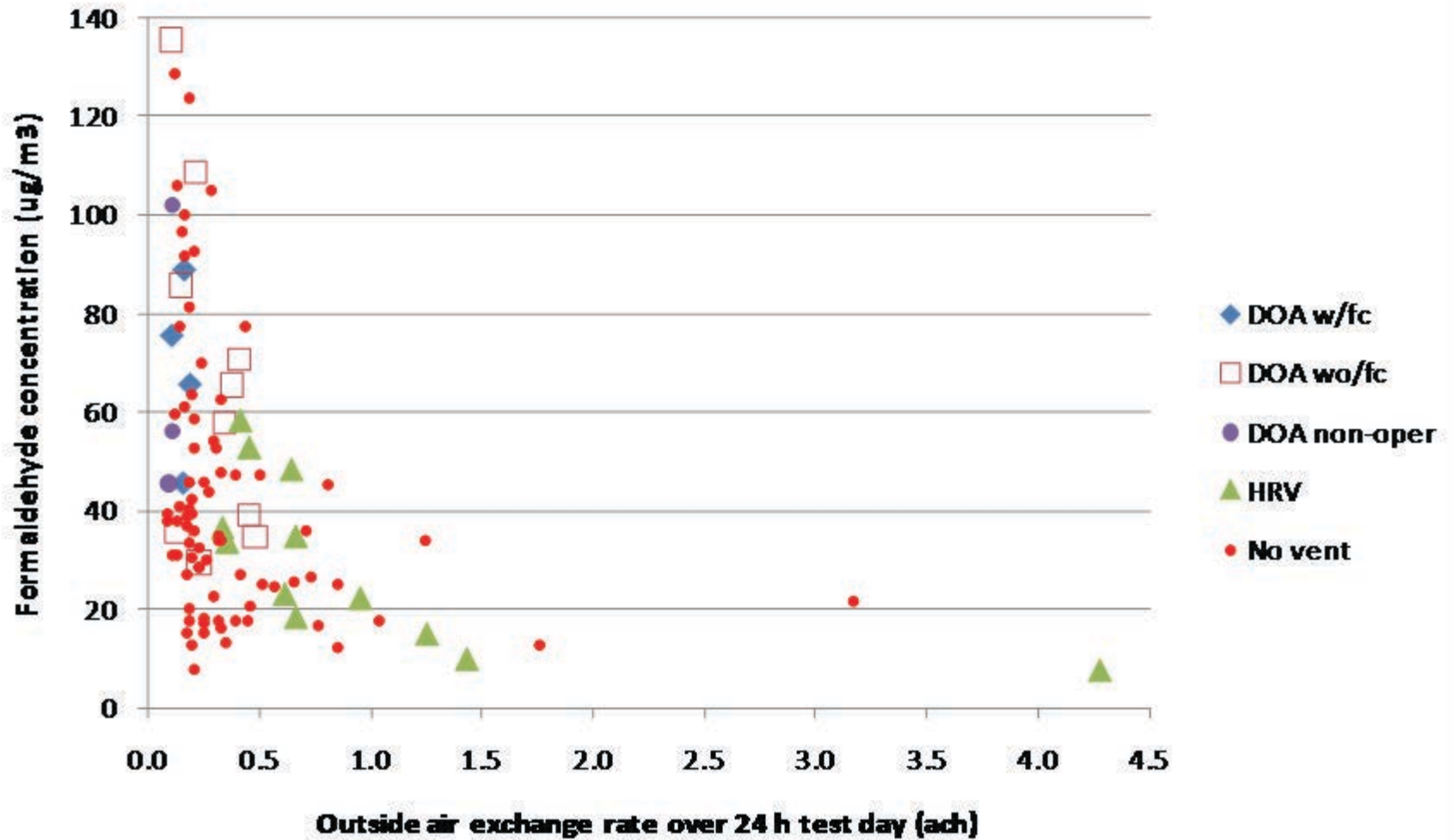
100 ft<sup>3</sup> → 12 ft<sup>2</sup>





Aubin, D., Won, D.Y., Schleichinger, H., 2010

## Formaldehyde sample concentration versus PFT measured outside air exchange rate over the test day



ASHRAE Standard 62.2 calls for 7.5 cfm per person plus 0.03 cfm per square foot of conditioned area

Occupancy is deemed to be the number of bedrooms plus one



ASHRAE Standard 62.2 calls for 7.5 cfm per person plus 0.03 cfm per square foot of conditioned area

Occupancy is deemed to be the number of bedrooms plus one

Outcome is often bad – part load humidity problems, dryness problems, energy problems

IRC 2015 and 2018 calls for 7.5 cfm per person plus 0.01 cfm per square foot of conditioned area

Occupancy is deemed to be the number of bedrooms plus one

3 Bedroom House – 2,500 ft<sup>2</sup>

30 cfm plus 75 cfm

105 cfm

3 Bedroom House – 2,500 ft<sup>2</sup>

30 cfm plus 25 cfm

55 cfm

# The Cult of The Blower Door



# Blower Door Can't Get You The True ACH On A Short Term Basis – Hour, Day, Week

Don't Know Where The Holes Are

Don't Know The Type of Holes

Don't Know The Pressure Across The Holes

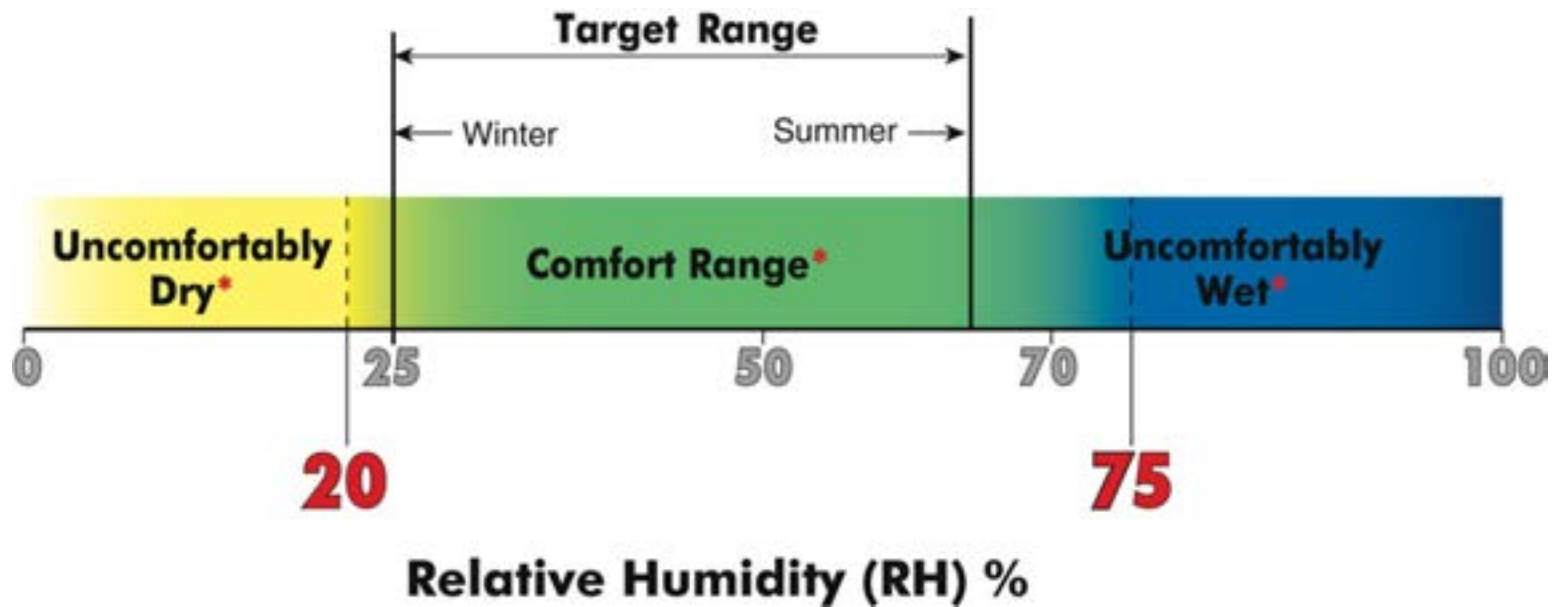


# Dilution Is Not The Solution To Indoor Pollution

## Source Control

# Dilution For People

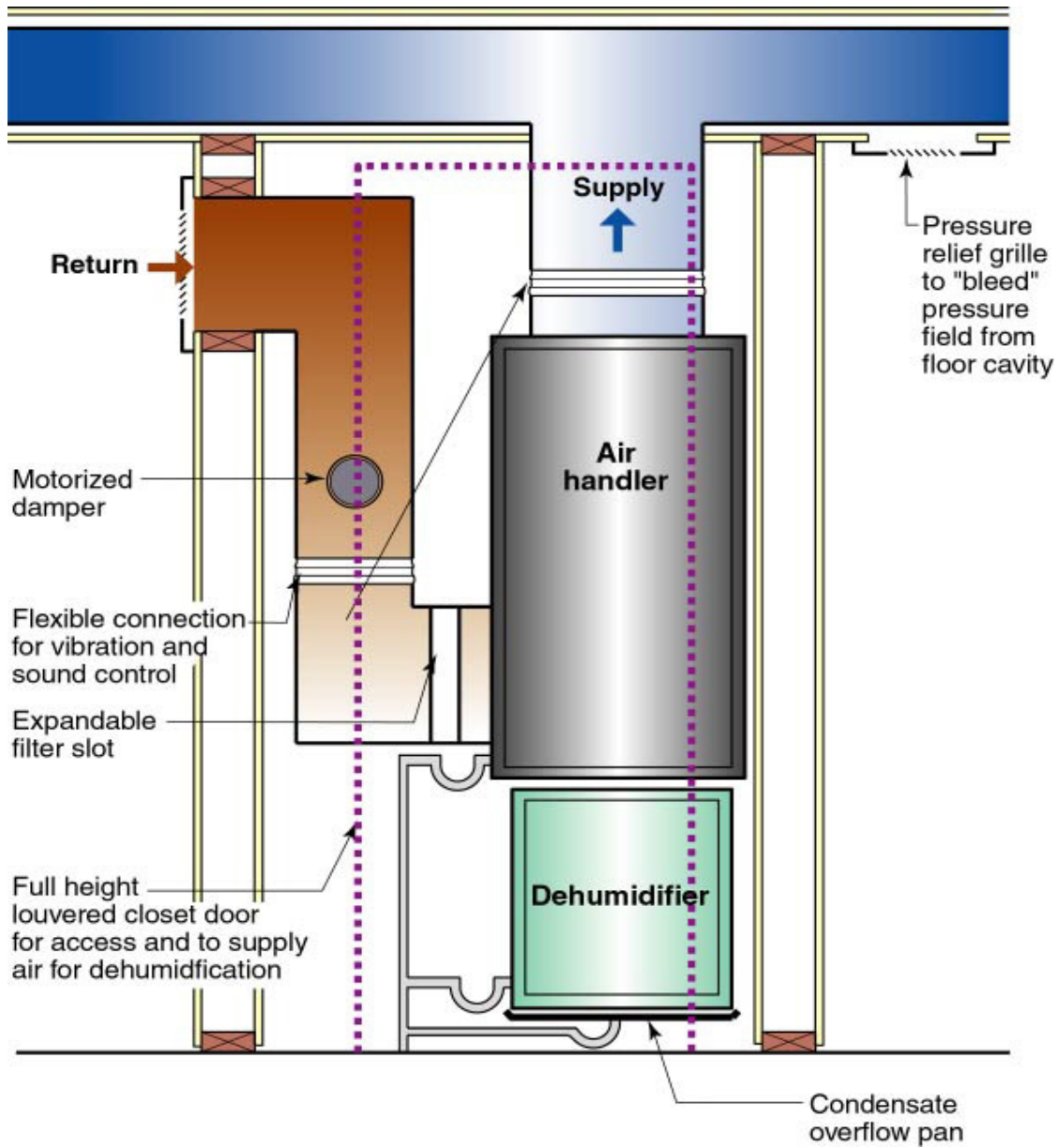
## Source Control For The Building



## Recommended Range of Relative Humidity

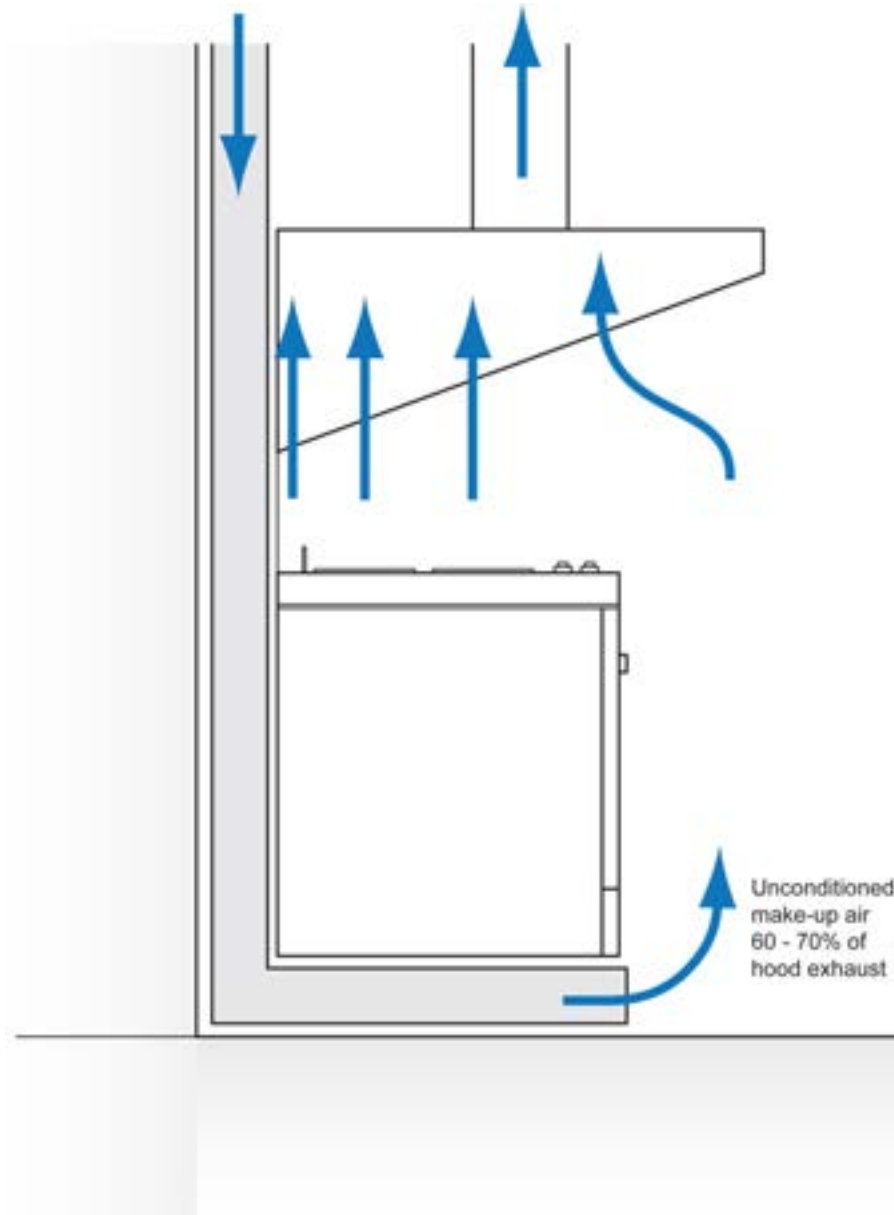
Above 25 percent during winter

Below 70 percent during summer



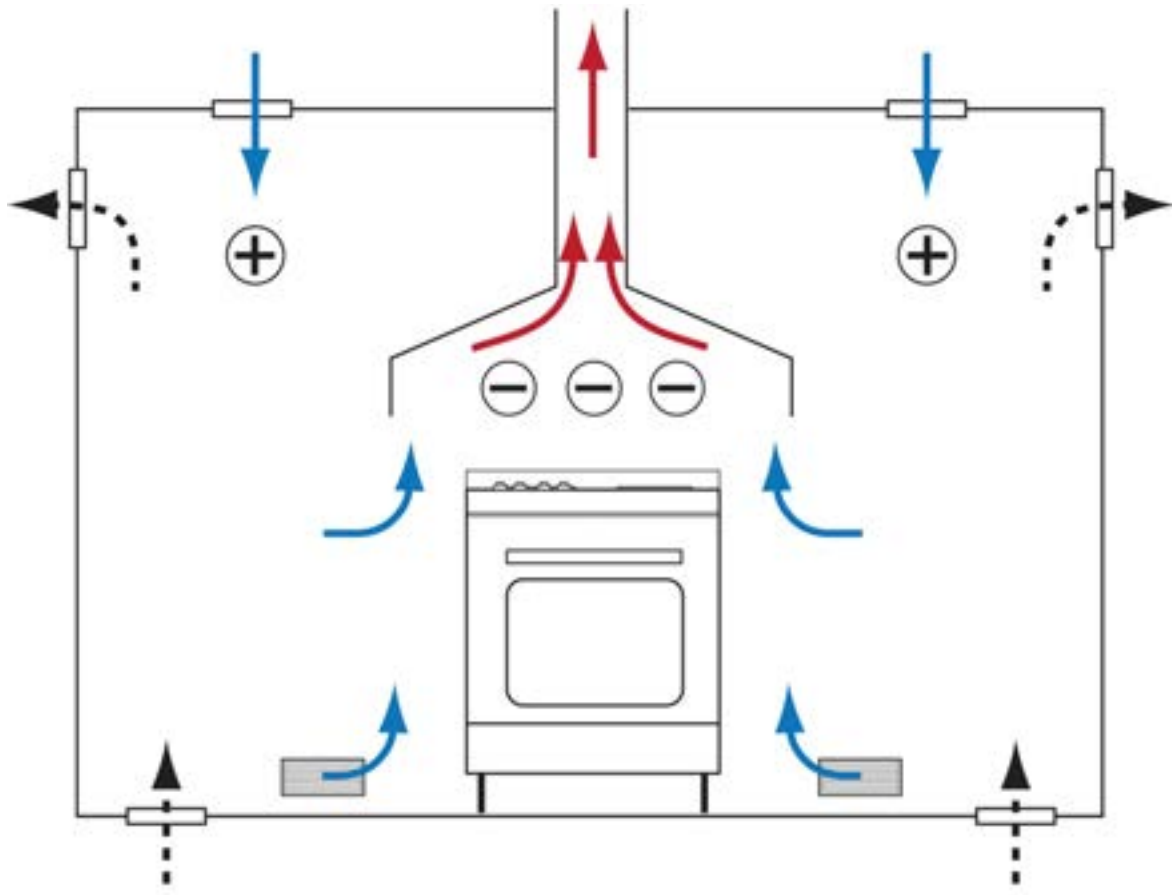


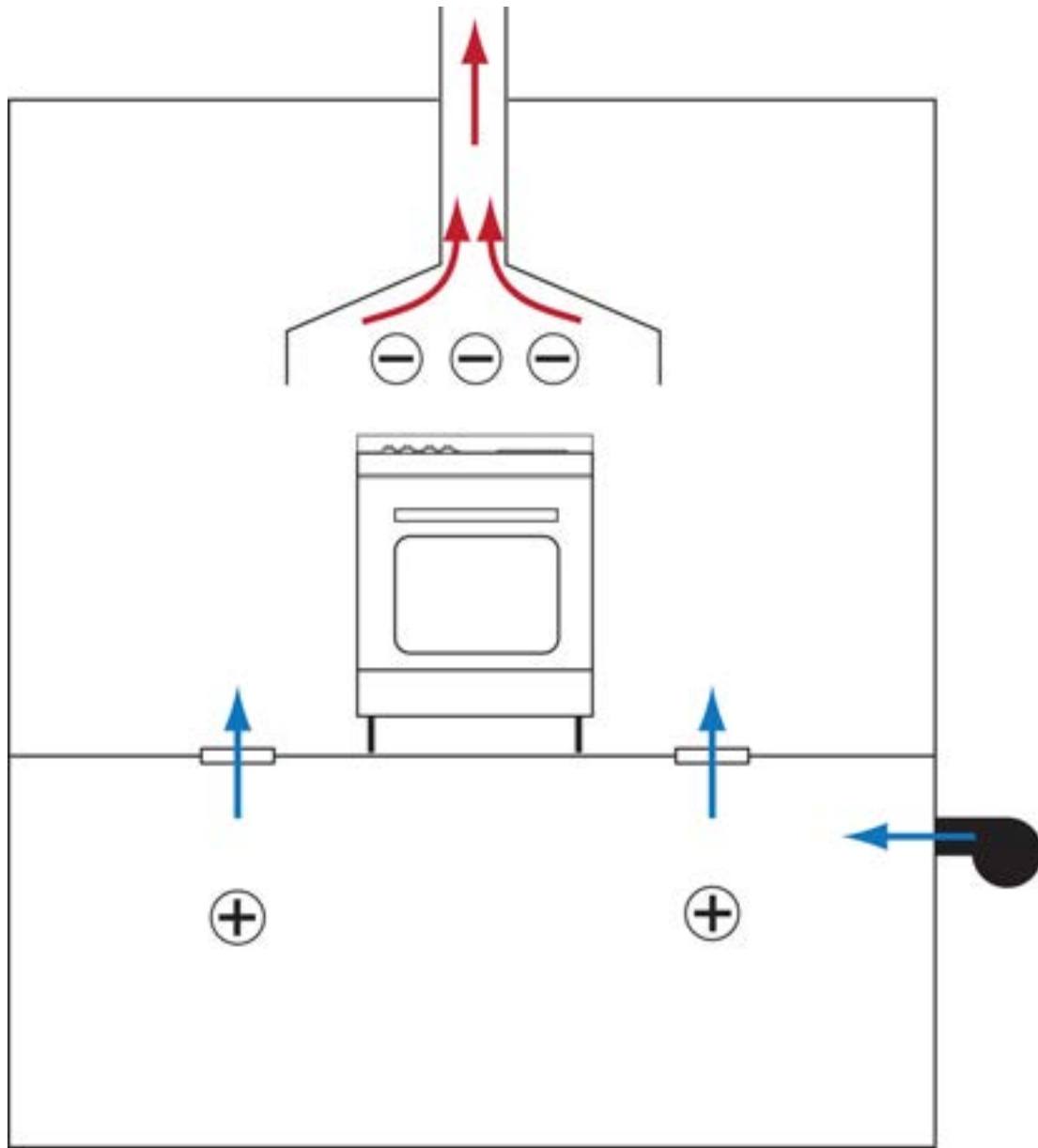
# Kitchen Exhaust Hoods























# Clothes Dryers





# Fireplaces







# Approaches



