

Joseph Lstiburek, Ph.D., P.Eng, ASHRAE Fellow

Building Science

Where We Were and Where We Are
Going....

www.buildingscience.com

Competition for Air

Pressure

Humidity Control in Cold Climates

Humidity Control in Hot-Humid Climates

Ventilation

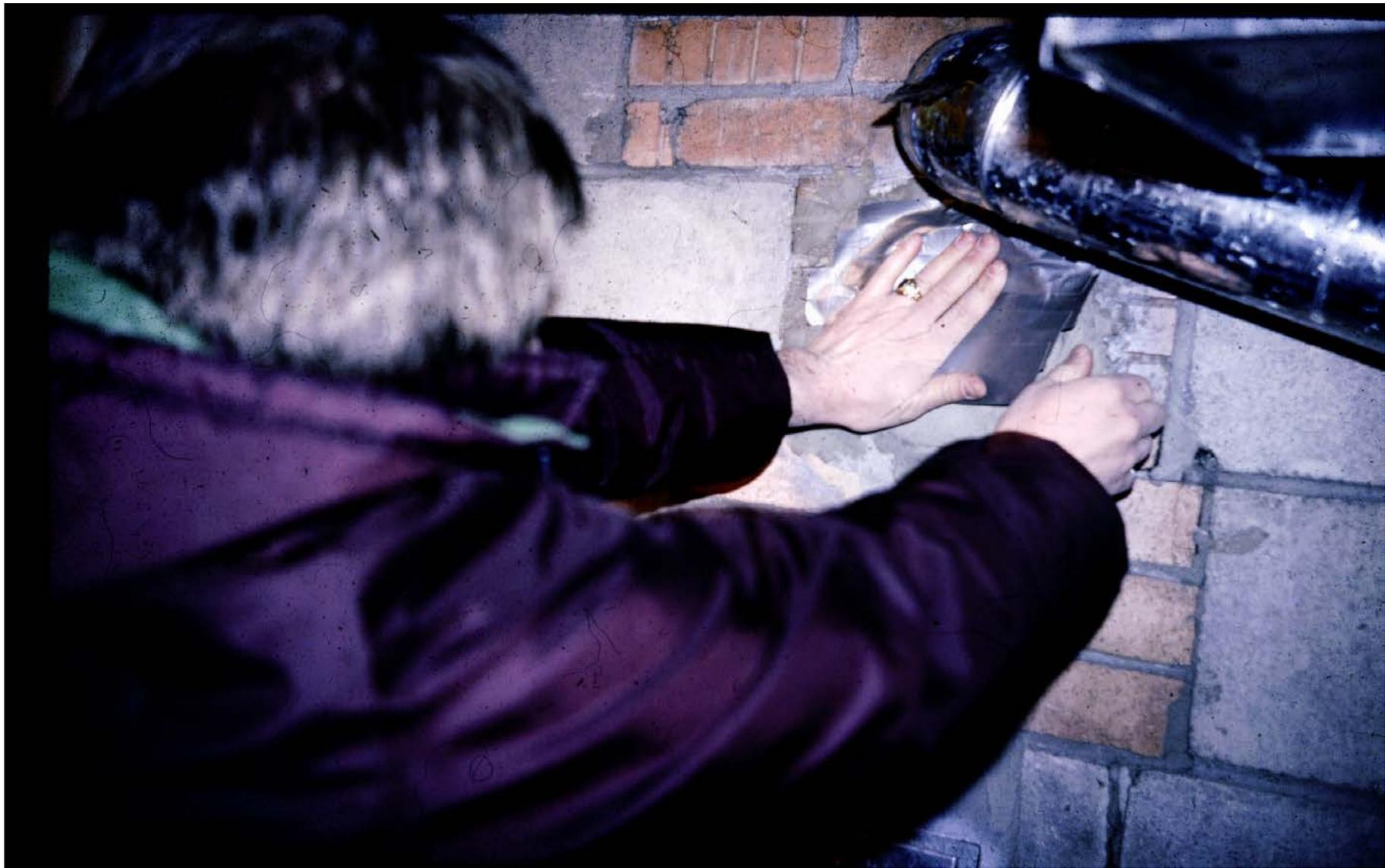














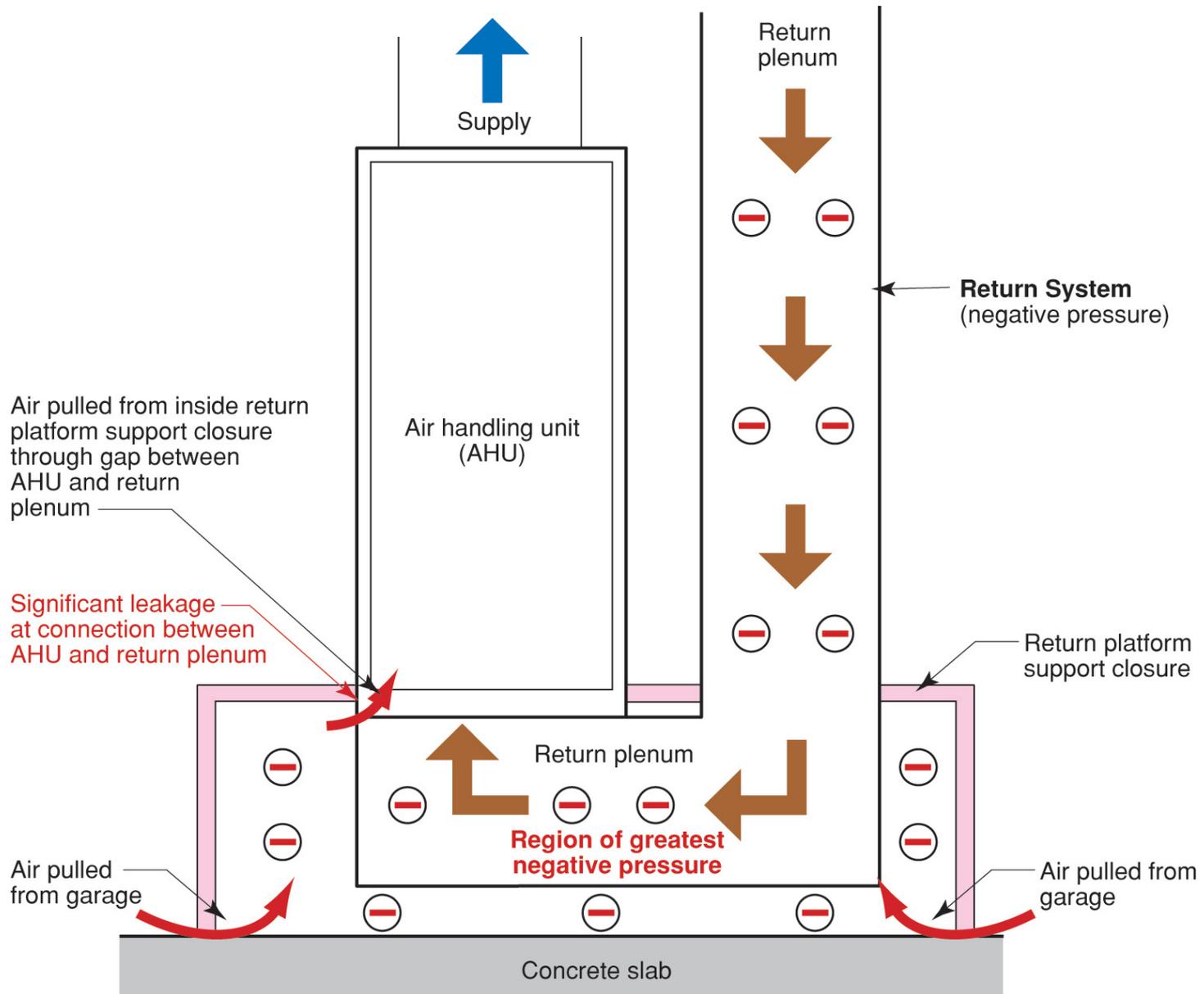












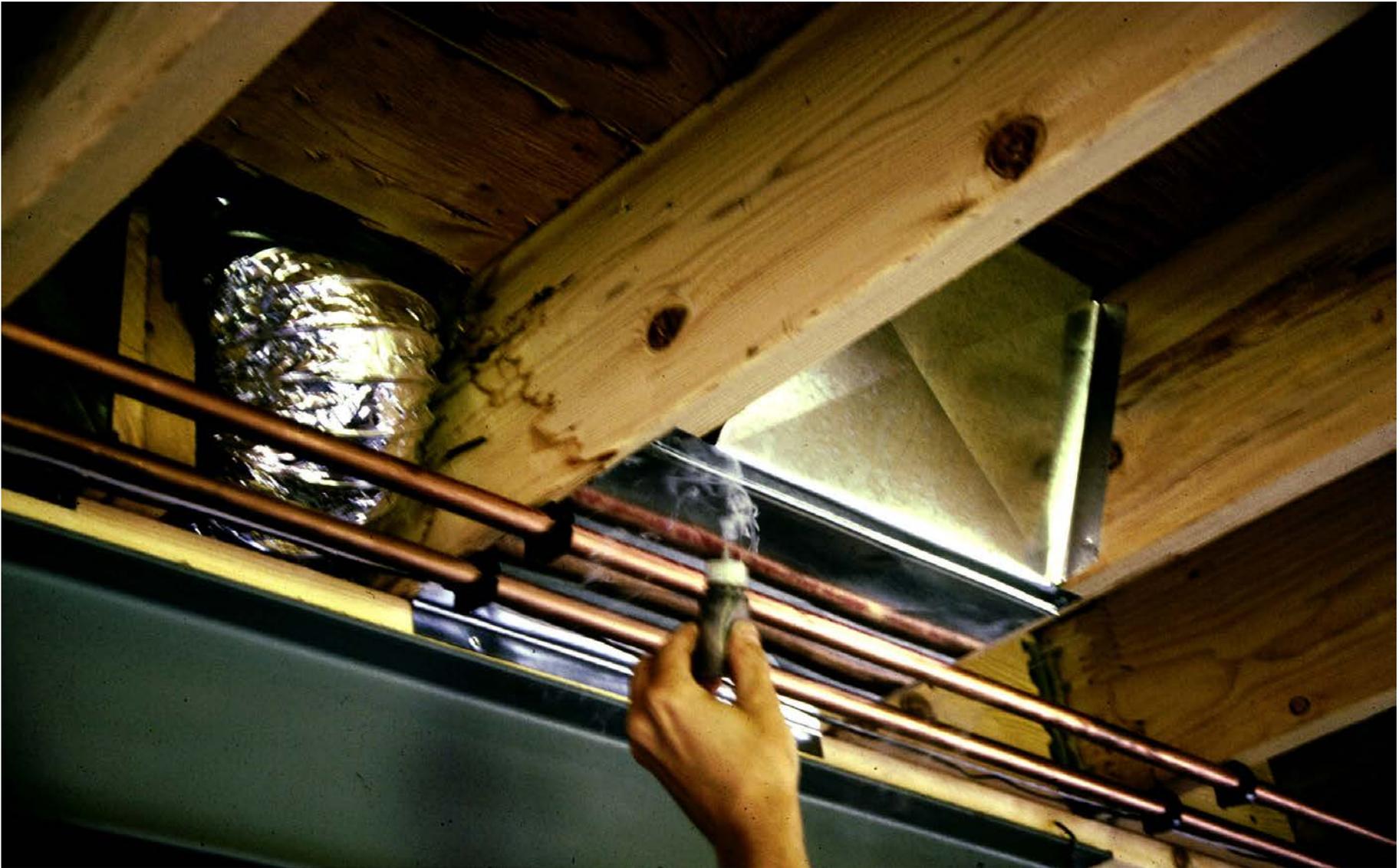






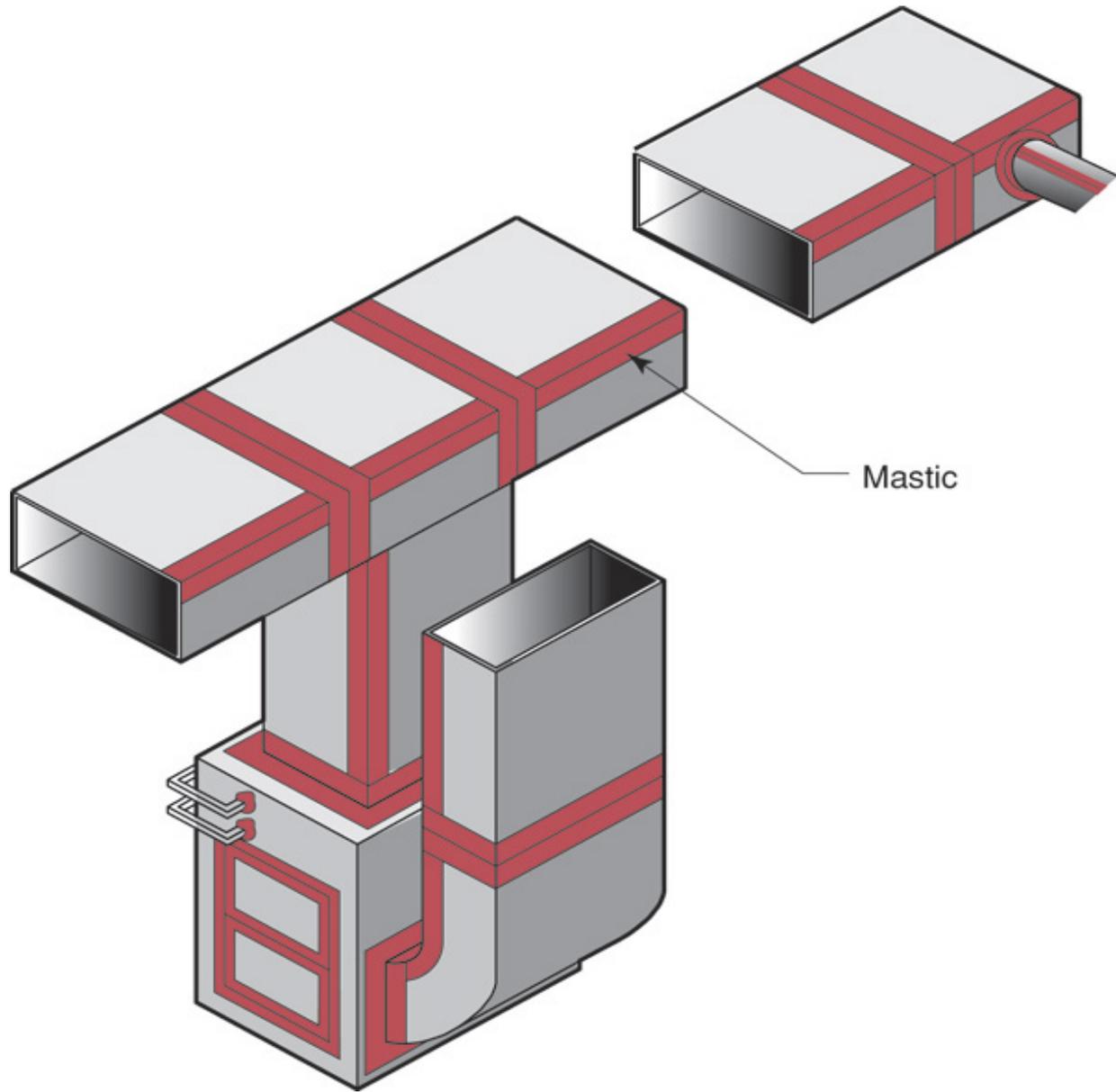


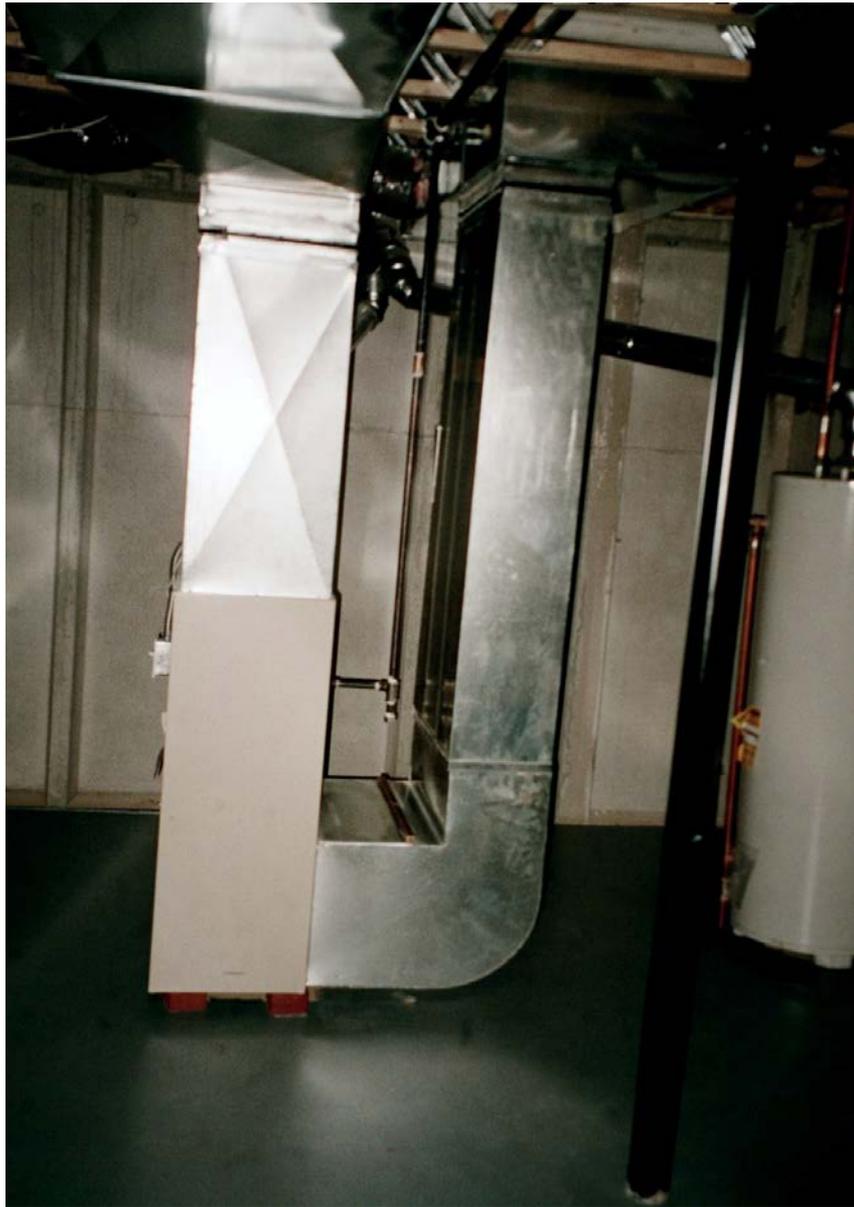




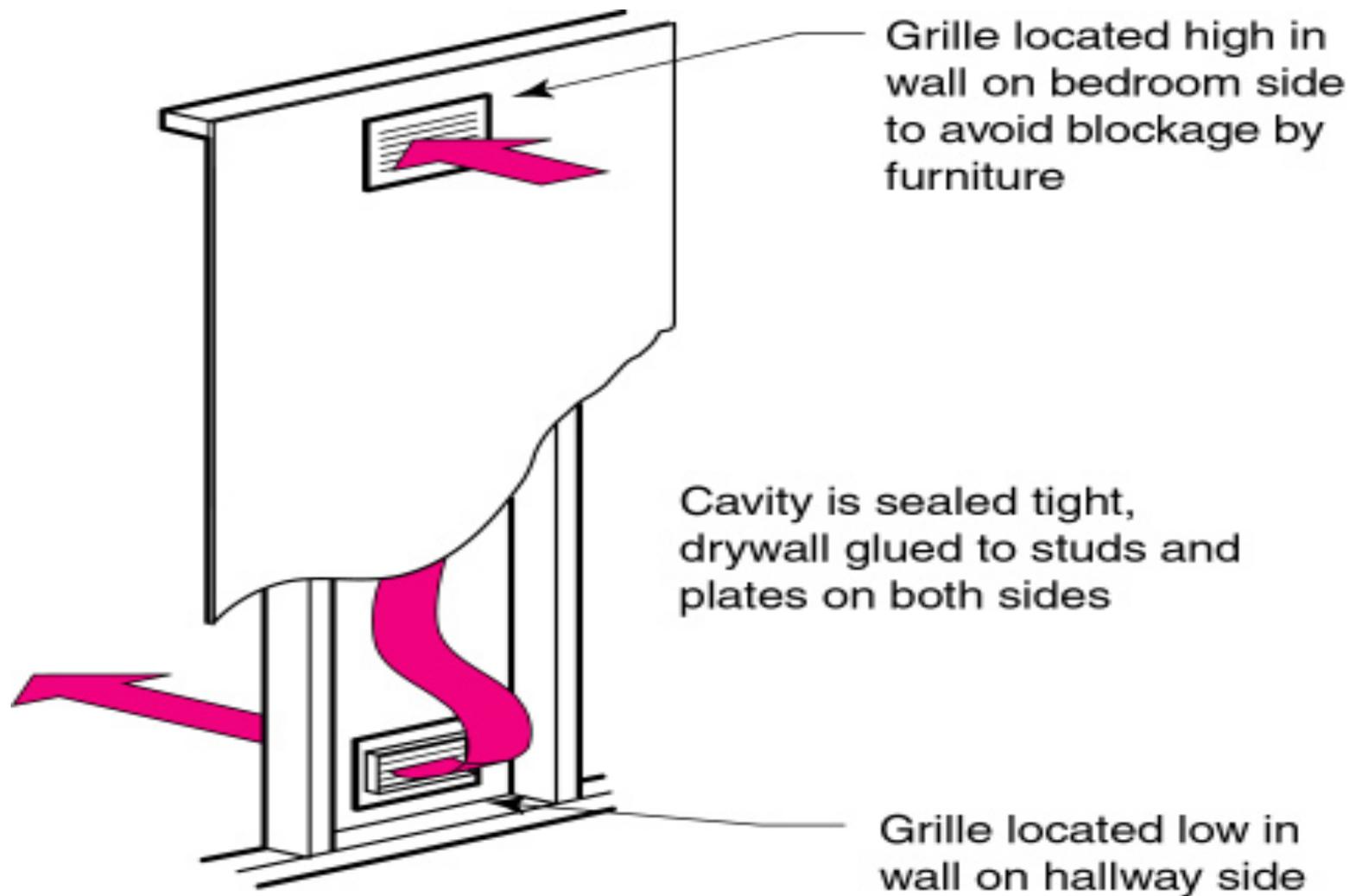




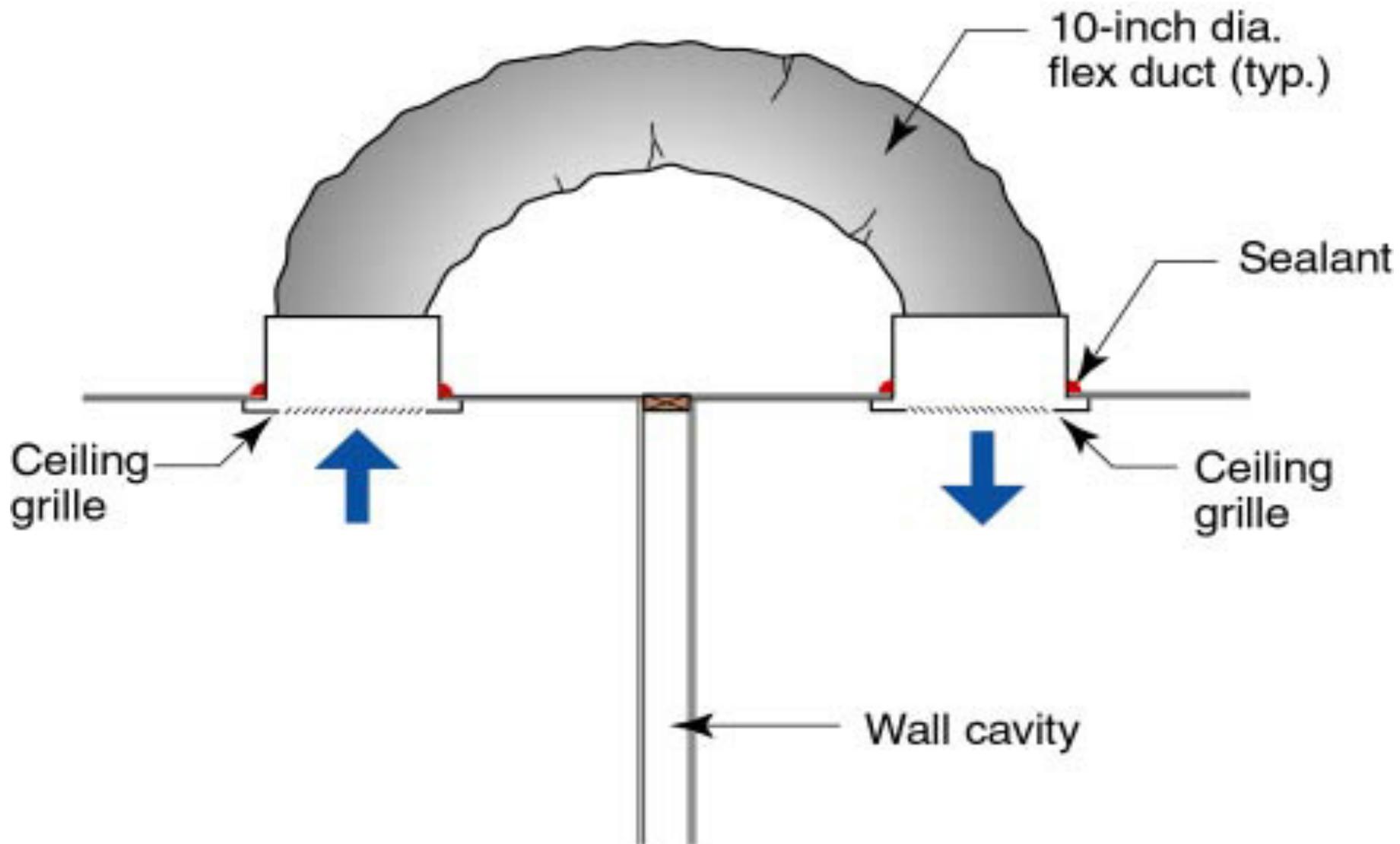








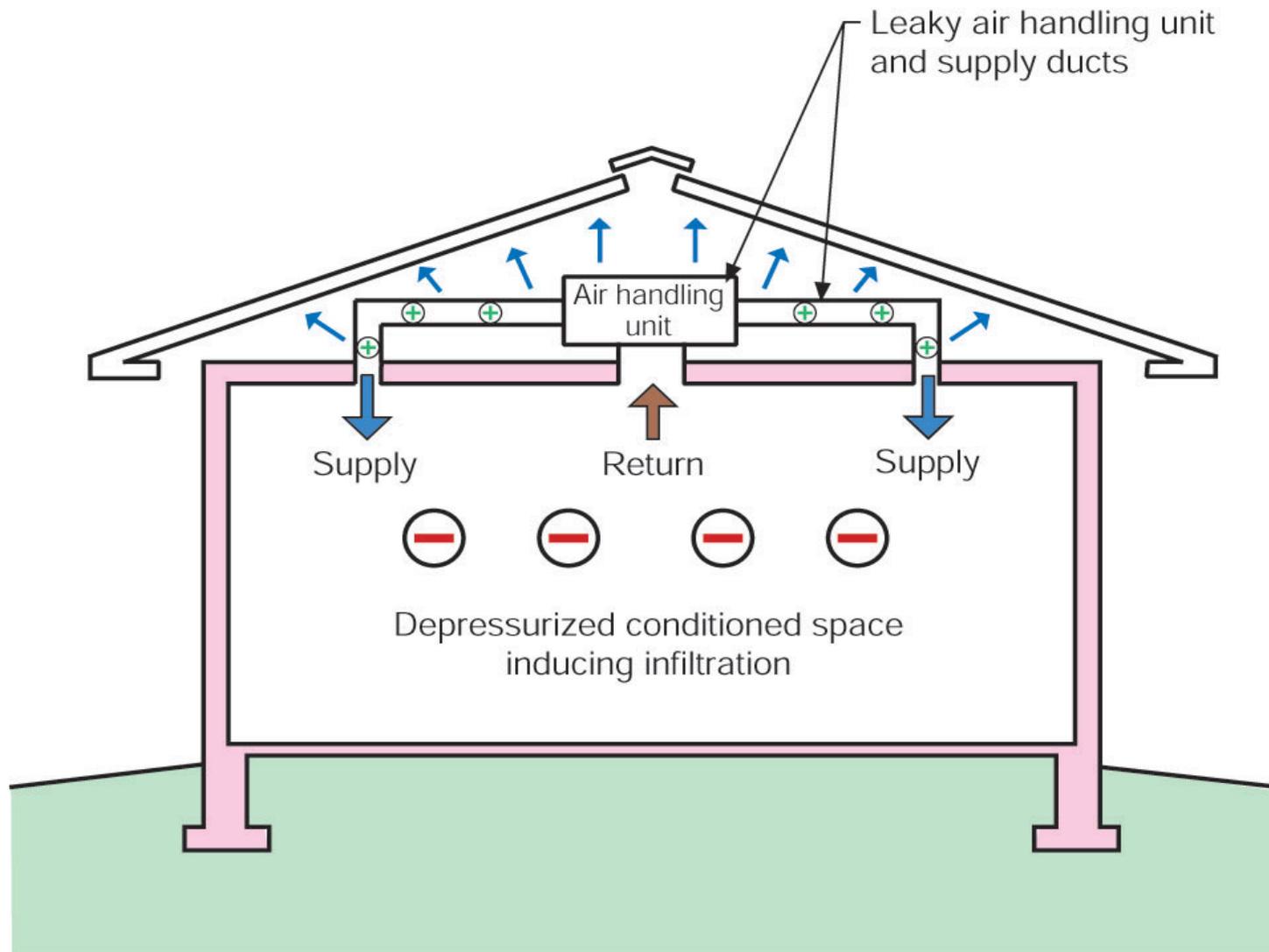










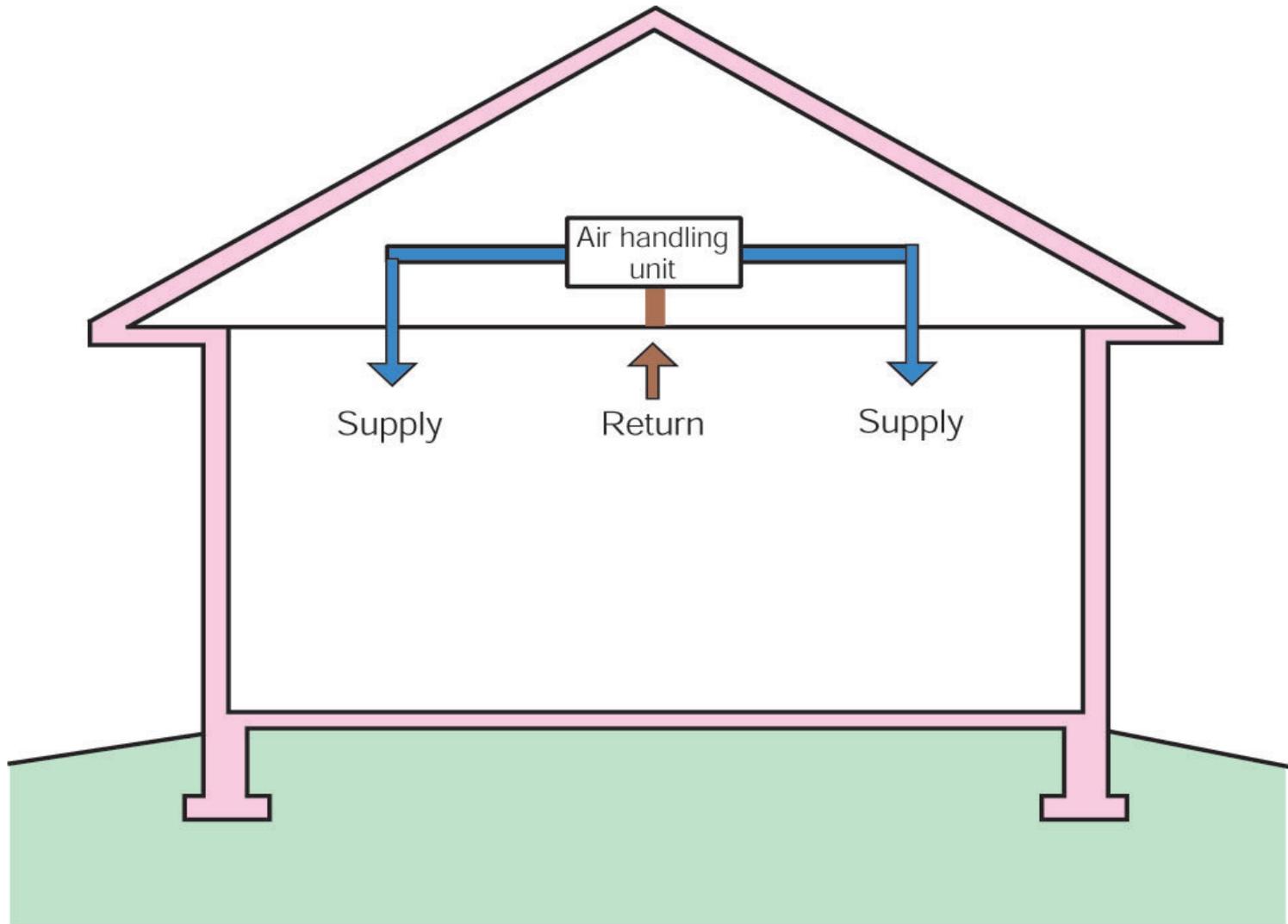


Note: Colored shading depicts the building's thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.

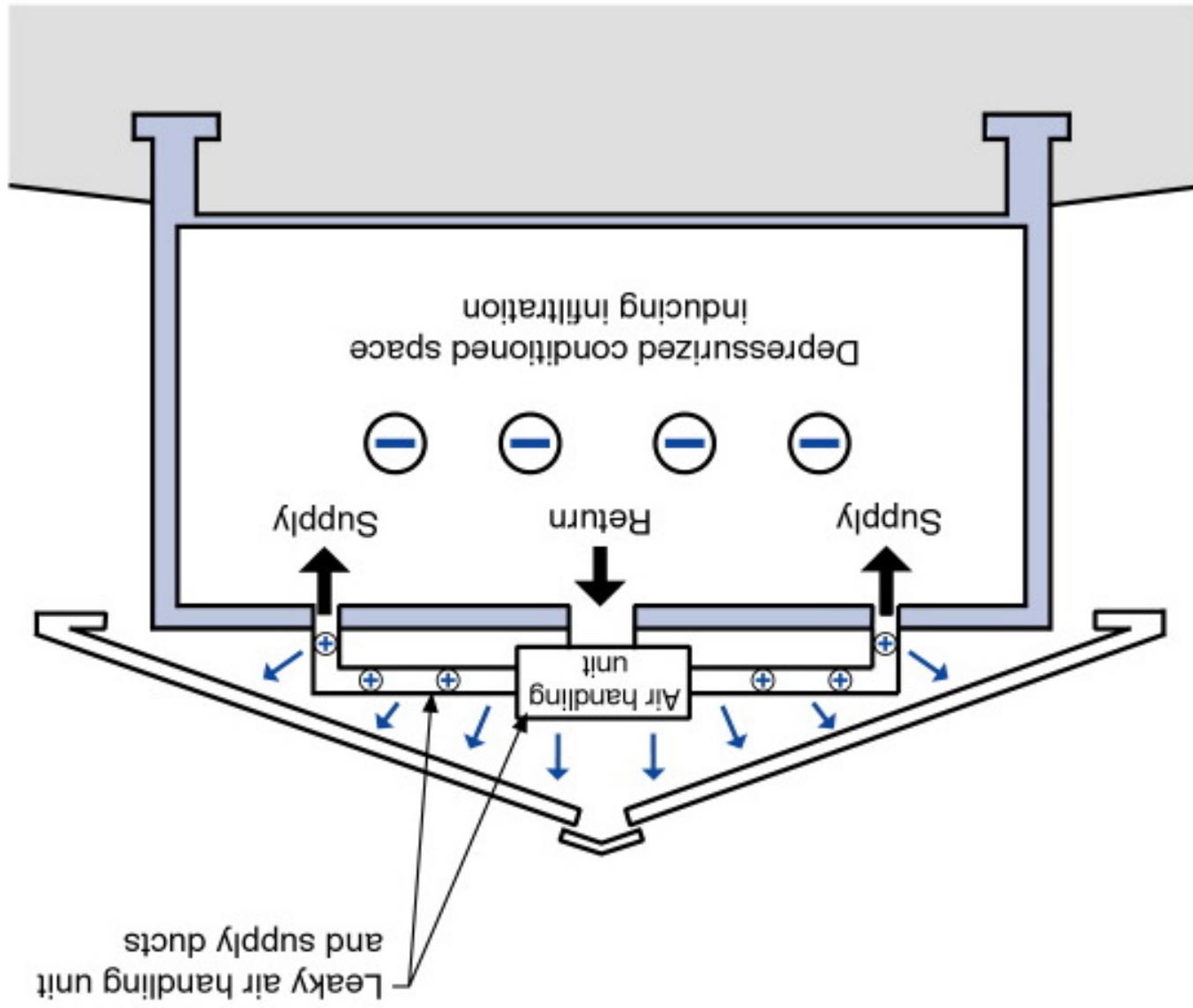


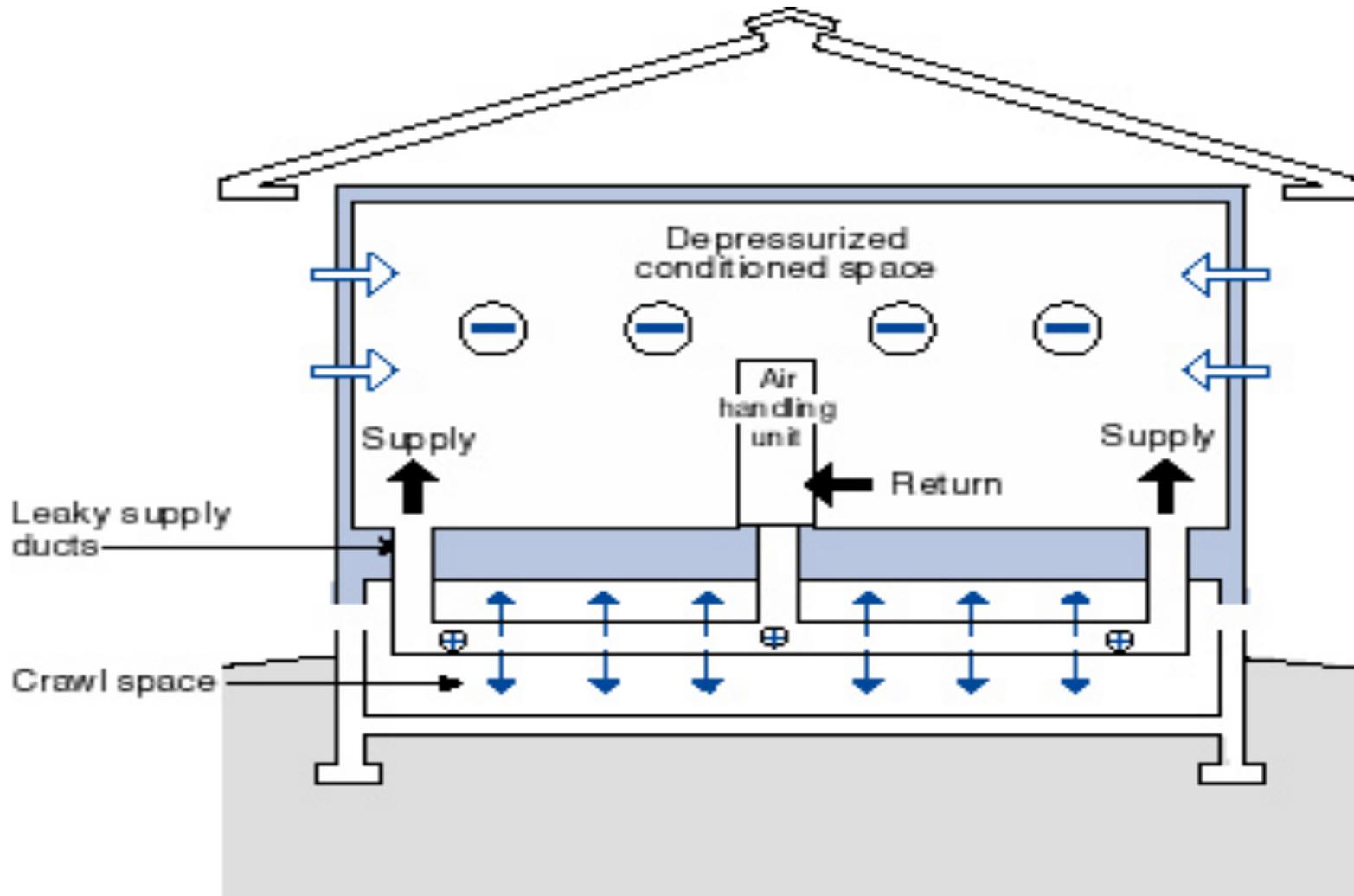




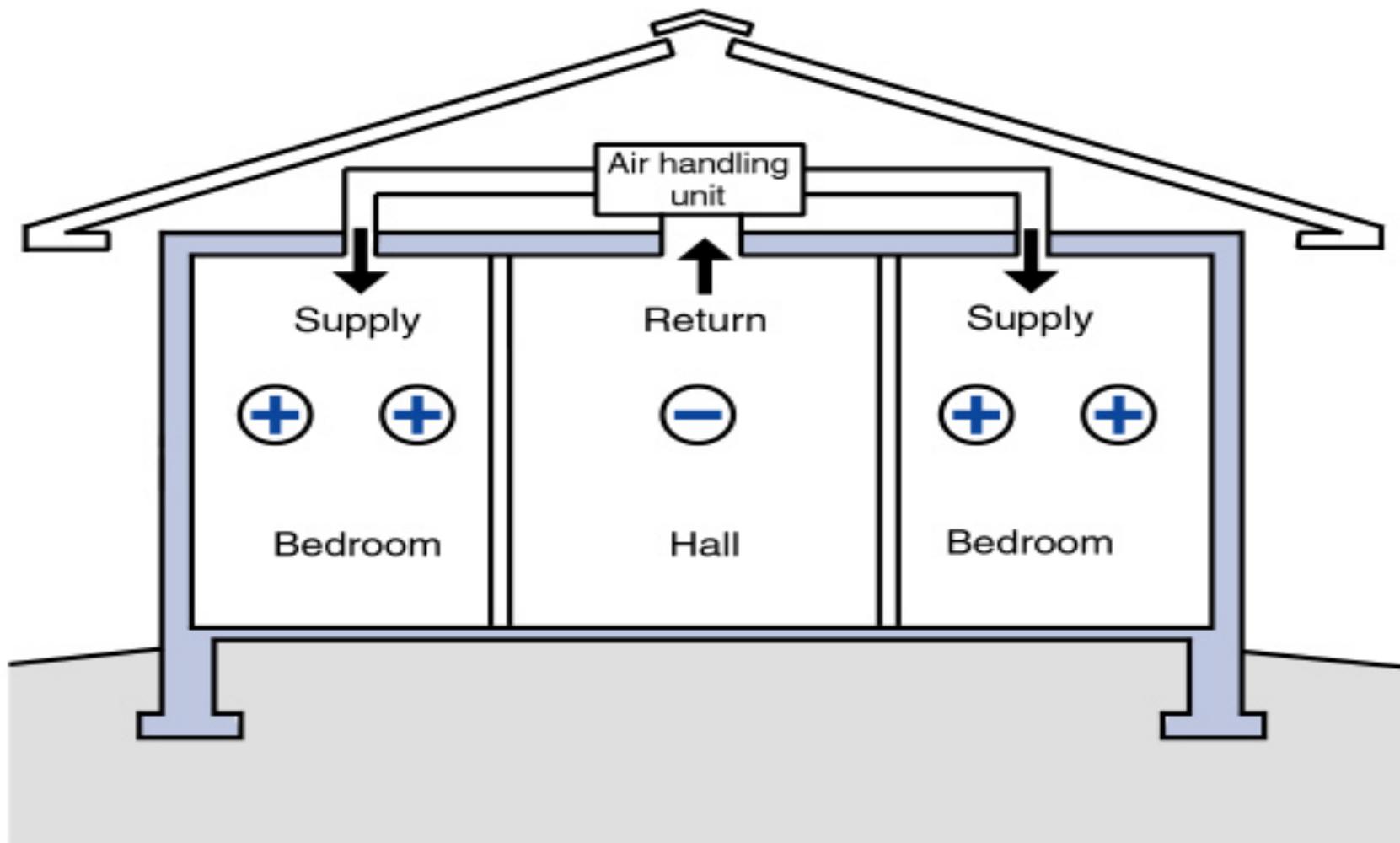


Note: Colored shading depicts the building's thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.













Duct Leakage Should Be Less Than 5% of
Rated Flow As Tested by Pressurization To
25 Pascals





ENERGY STAR[®] Qualified
In All 50 States

THIS PRODUCT IS ENERGY STAR QUALIFIED FOR THE FOLLOWING UNCLIMATED ZONES:
ALL ZONES

 **MW PATRIOT**
NC 2800 DOUBLE HUNG WINDOW
VINYL FRAME DOUBLE GLAZE
LOW E GLASS CONTOUR GRID
Product Type: VERTICAL SLIDER 95357

ENERGY PERFORMANCE RATINGS

U-Factor (U.S./I-P)	Solar Heat Gain Coefficient
0.34	0.31

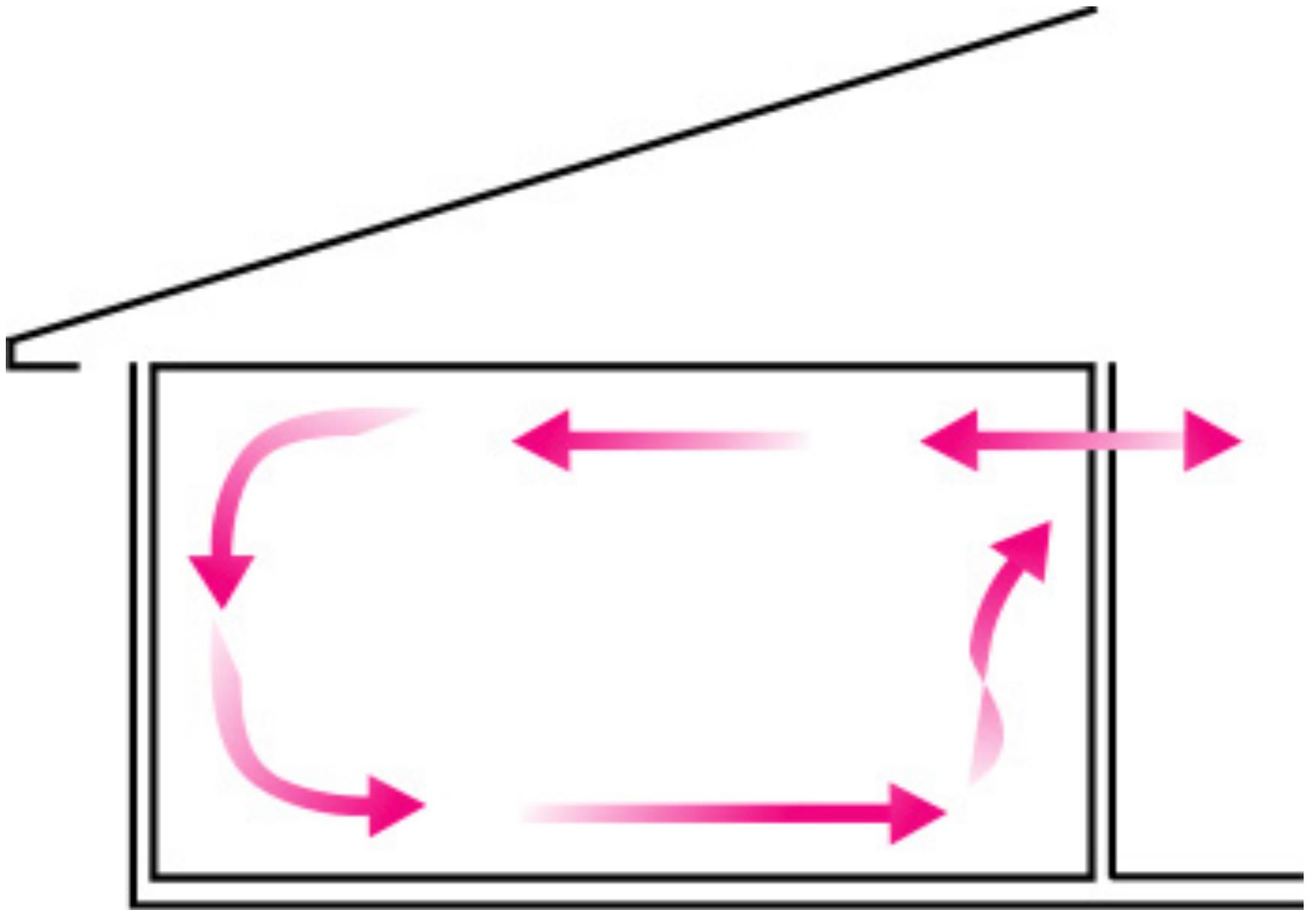
ADDITIONAL PERFORMANCE RATINGS

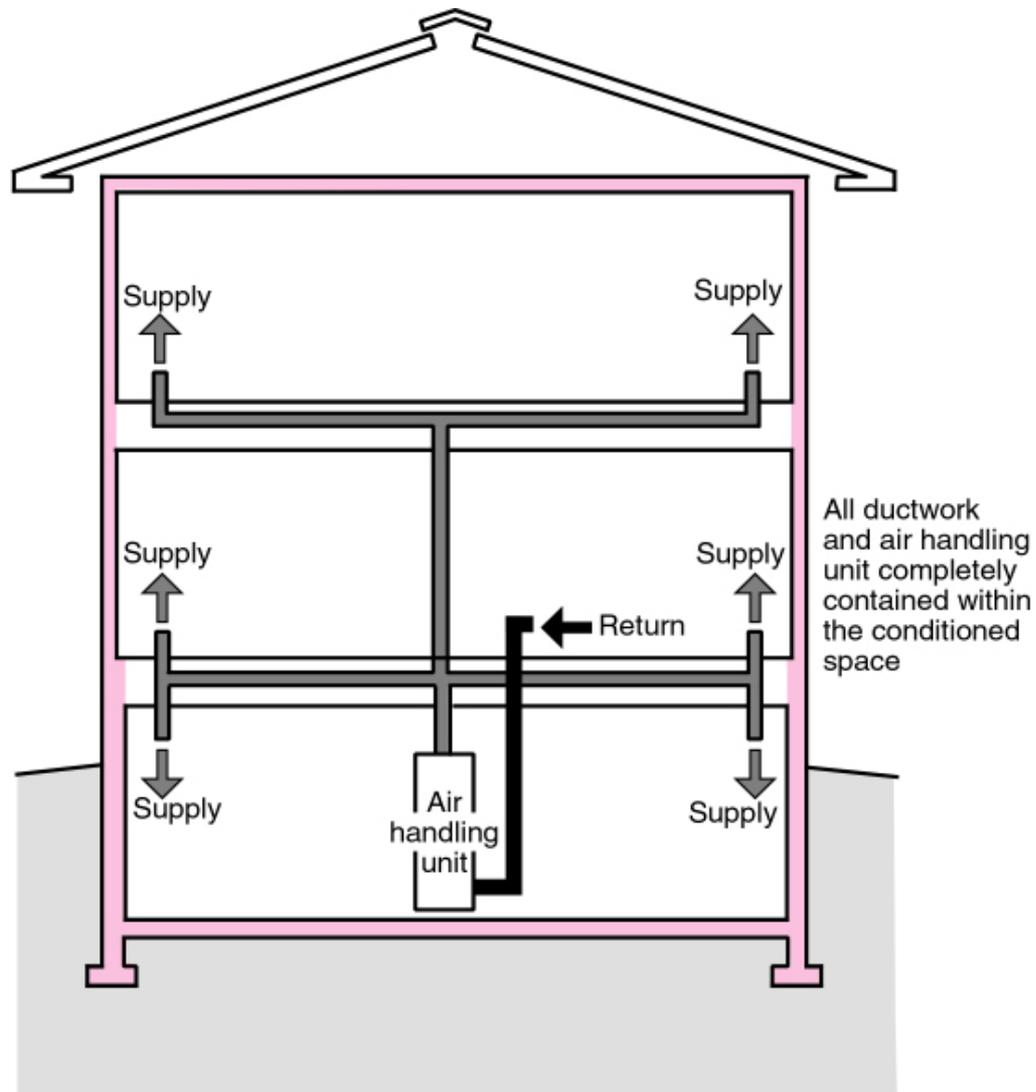
Visible Transmittance	
0.42	

Manufacturer stipulates that these ratings conform to applicable NFRC procedures for determining whole product performance. NFRC ratings are determined for a fixed set of environmental conditions and a specific product size. Consult Manufacturer's literature for other product performance information.
www.nfrc.org

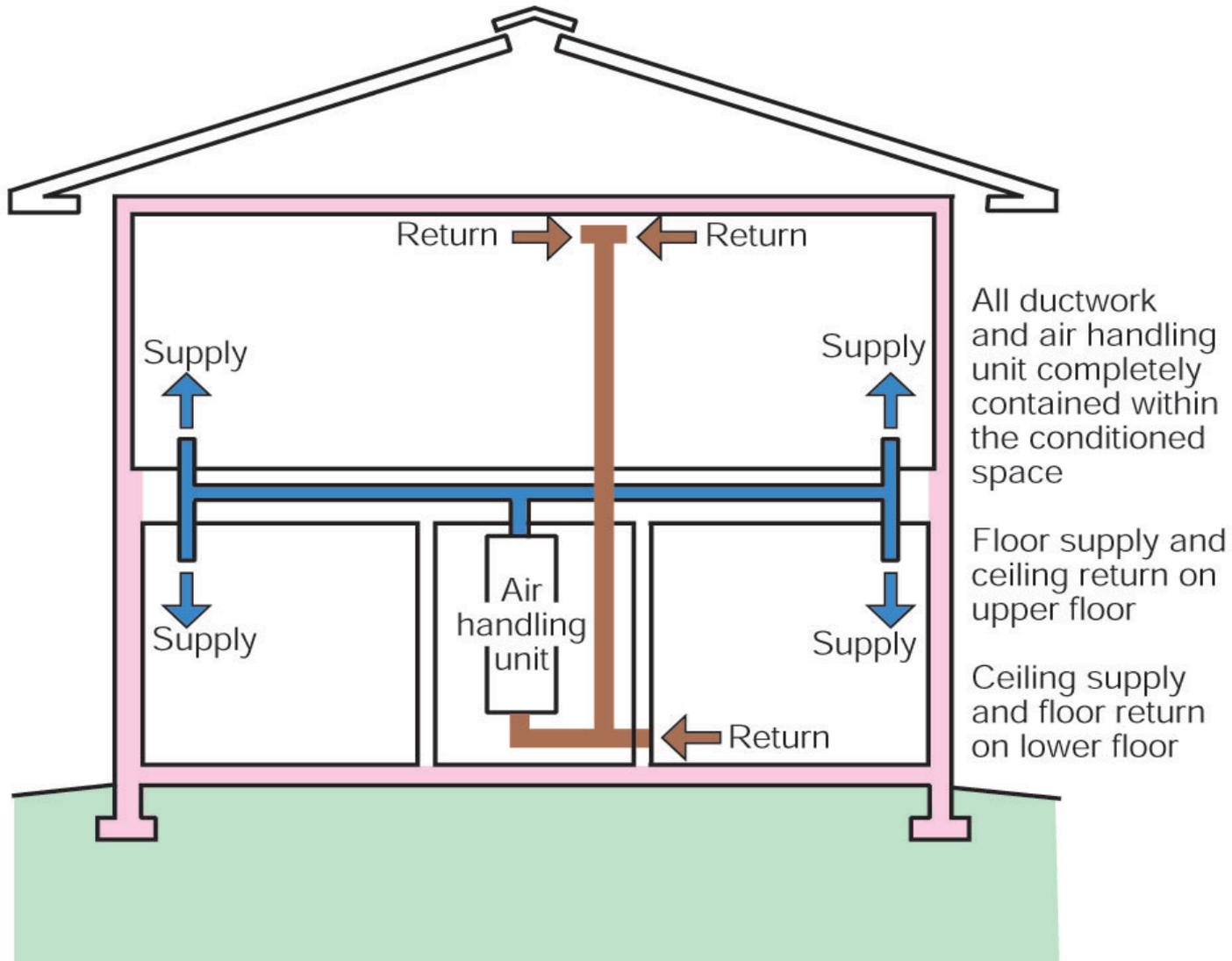
DP035 RATING
Tested in accordance with ASTM/NUGD 101.1.5.2-97

28R50916U6-AI03

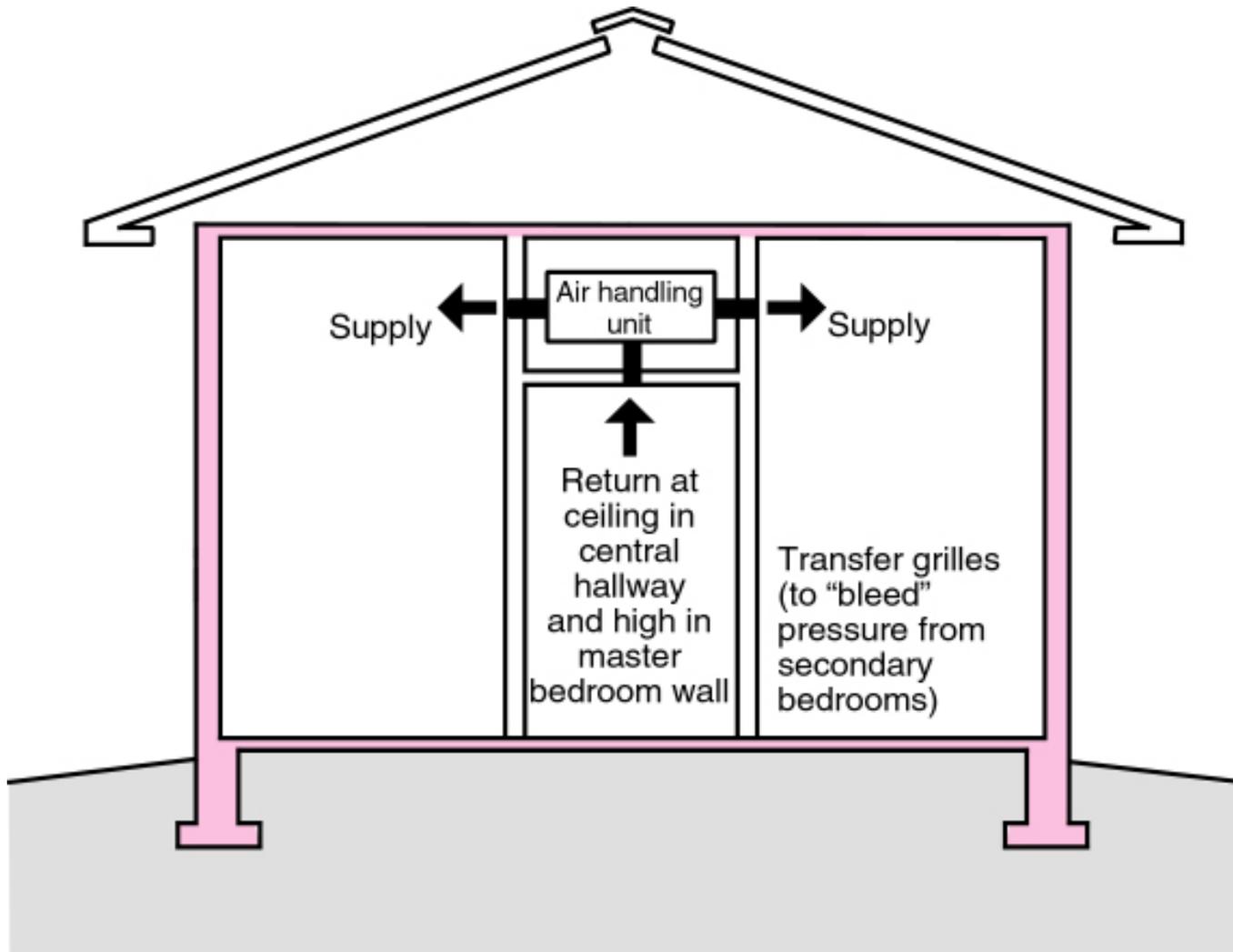




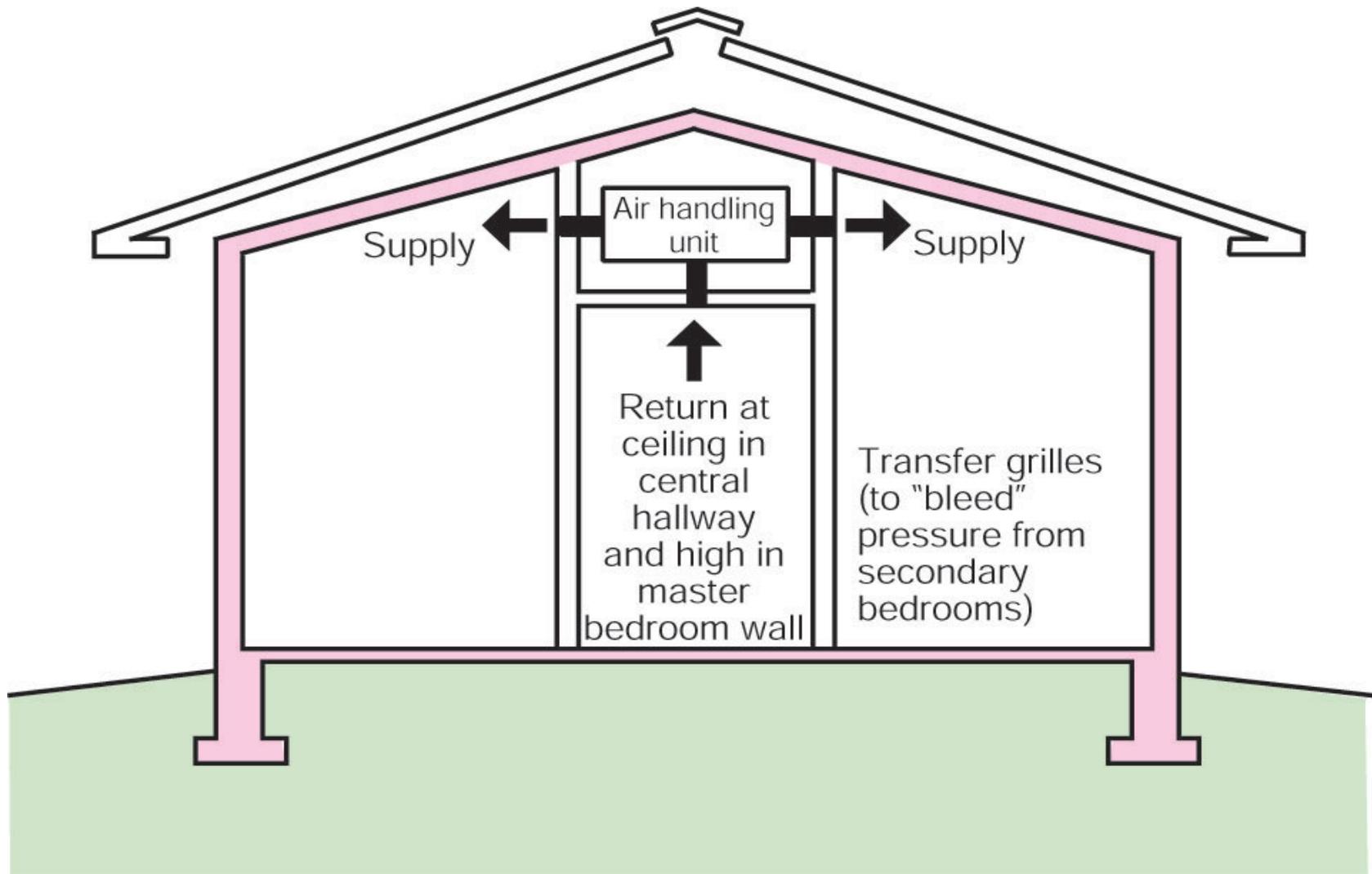
Note: Colored shading depicts the building's thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.



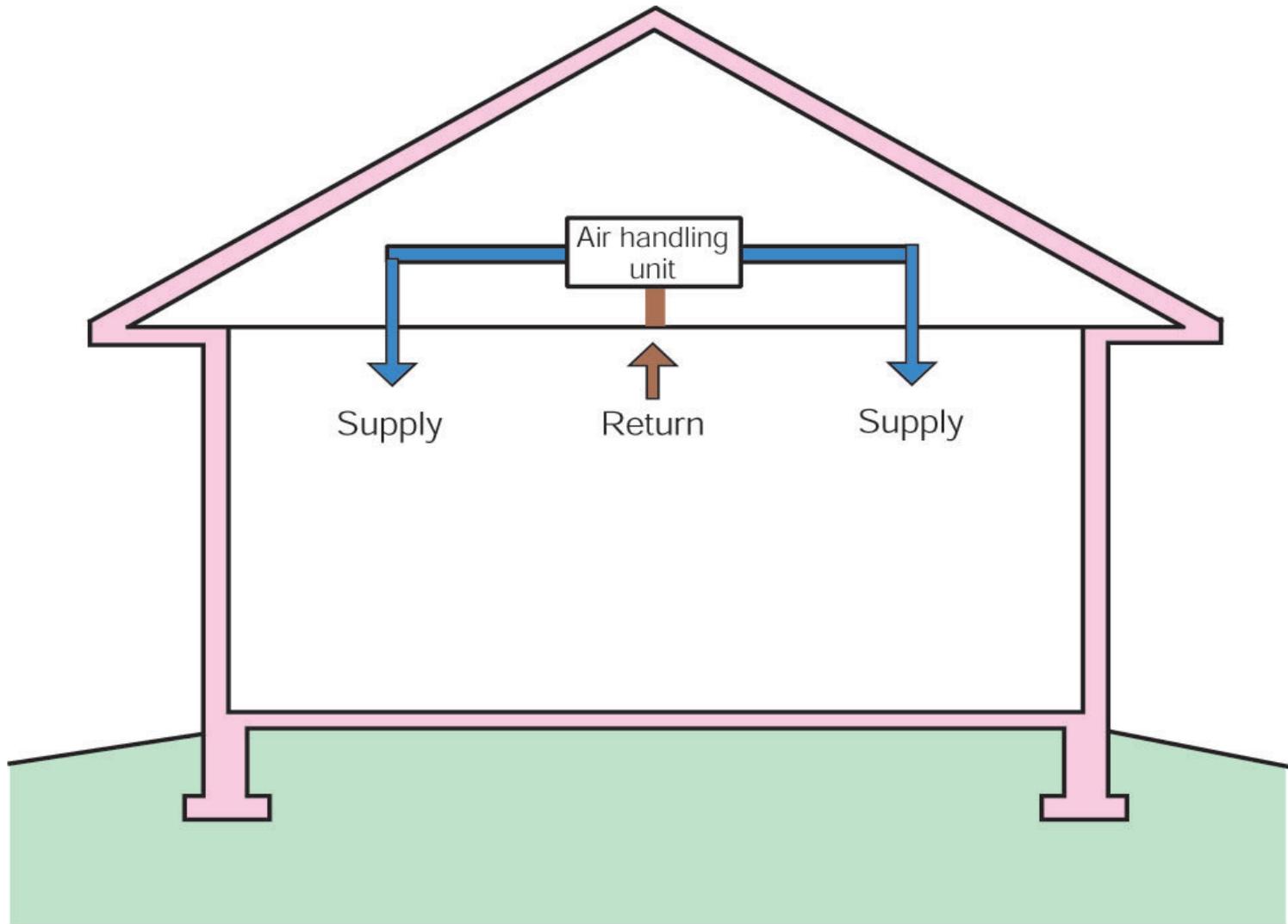
Note: Colored shading depicts the building's thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.



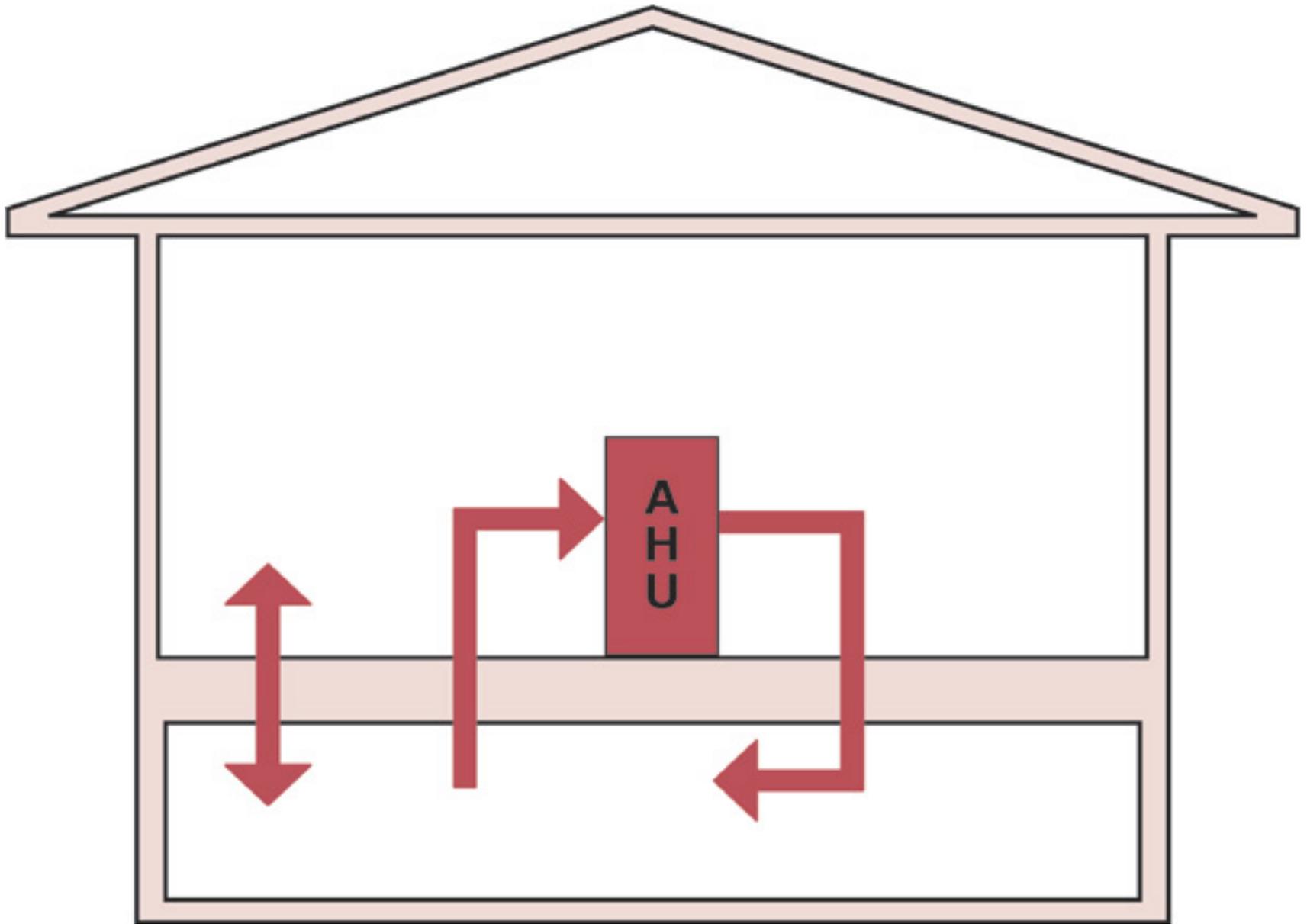
Note: Colored shading depicts the building's thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.



Note: Colored shading depicts the building's thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.

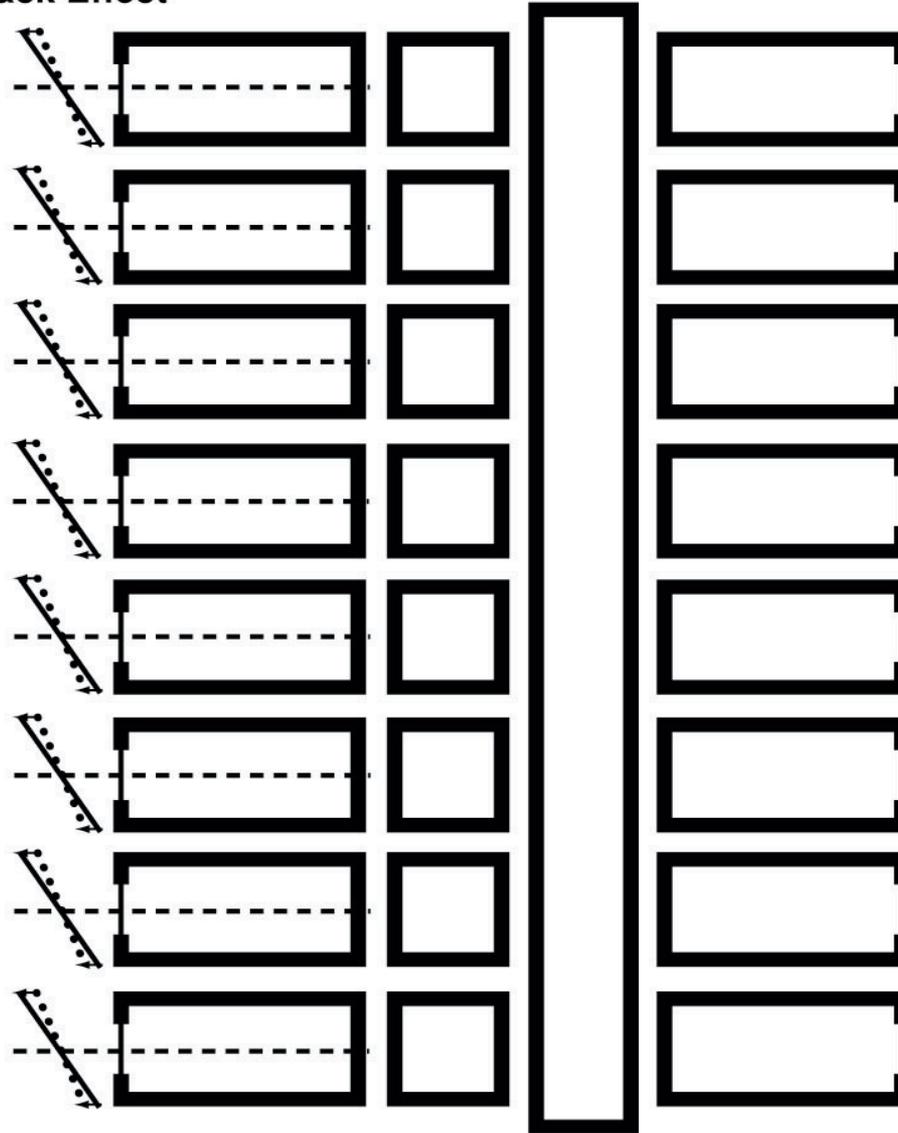


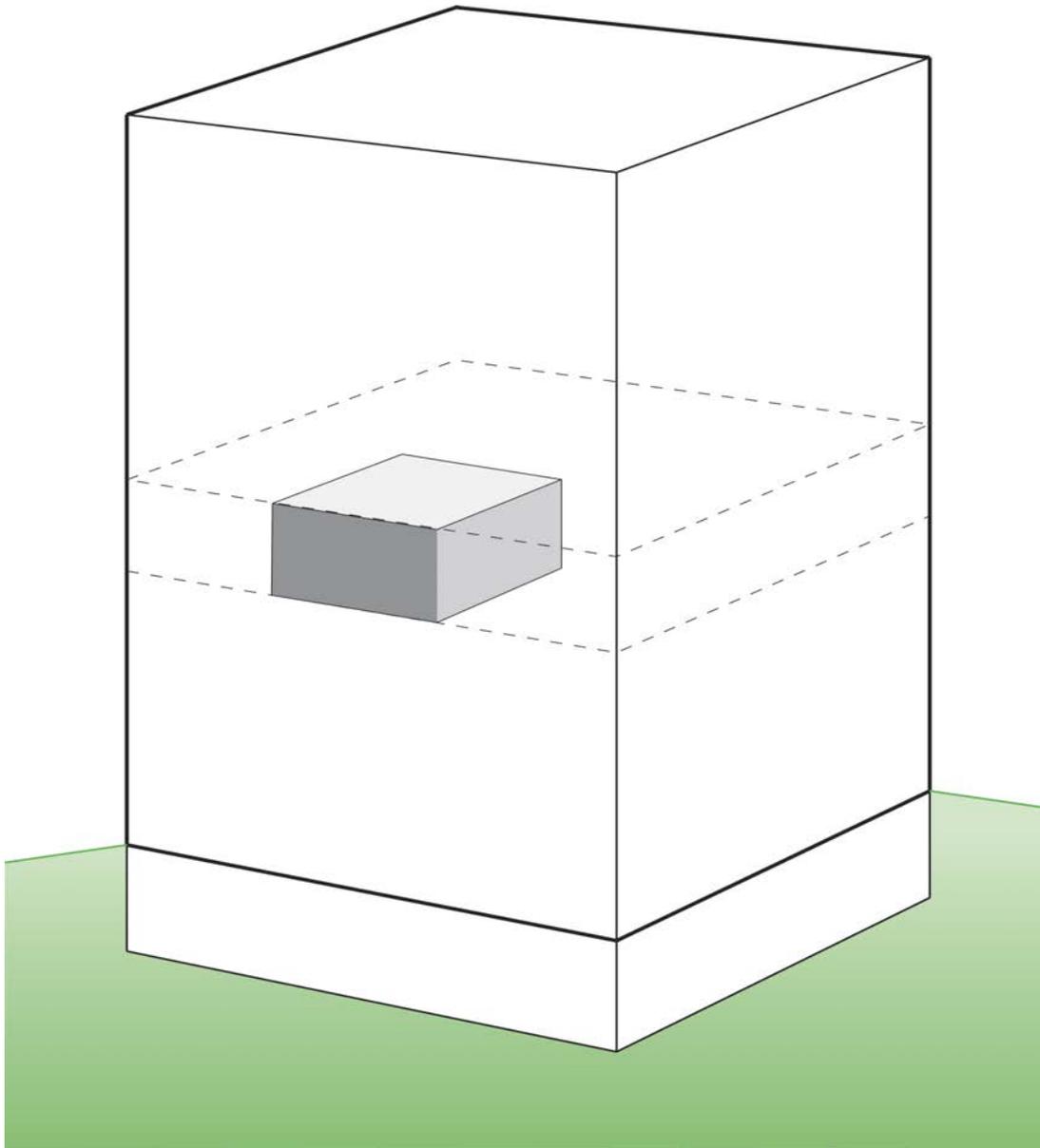
Note: Colored shading depicts the building's thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.

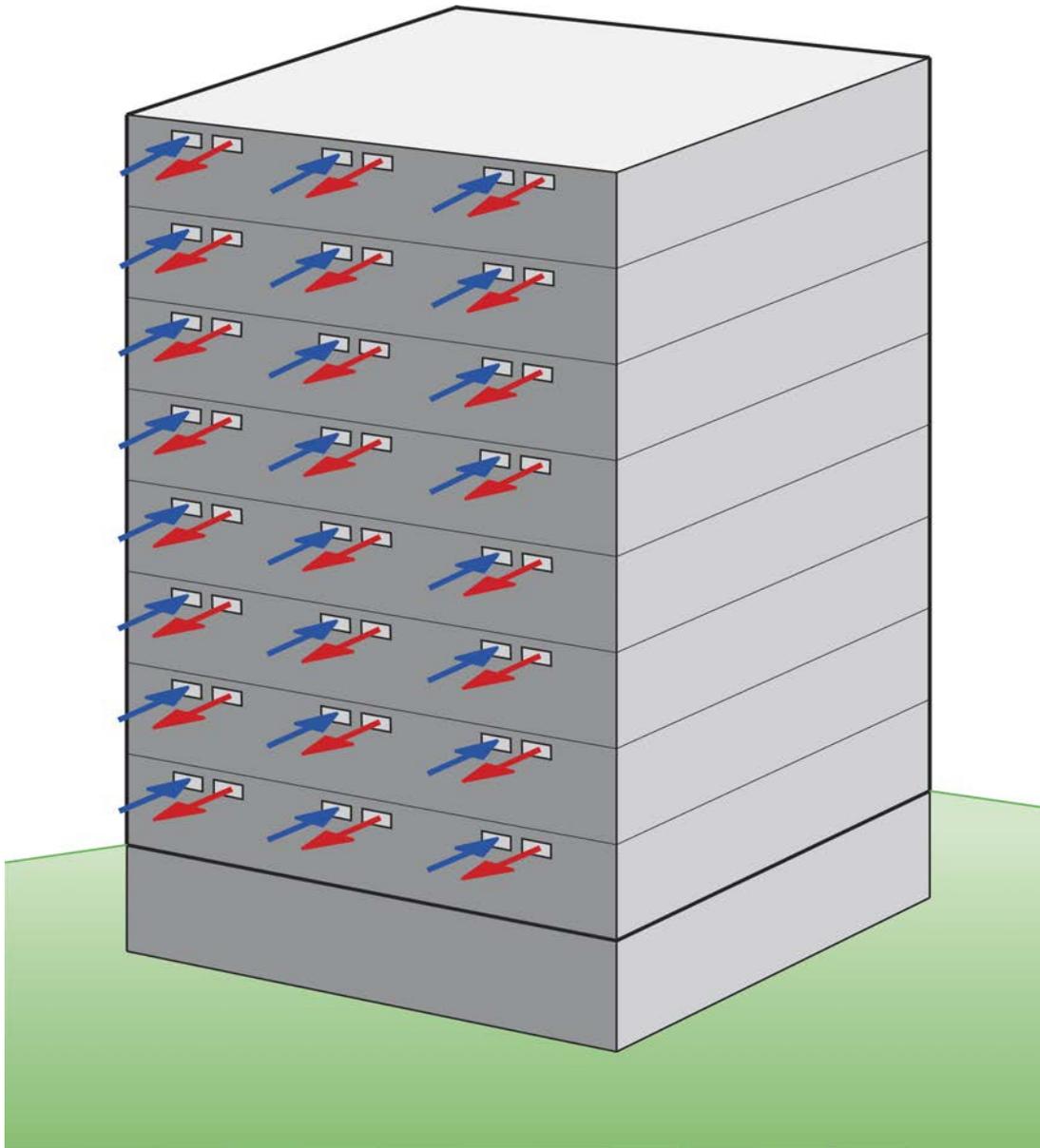




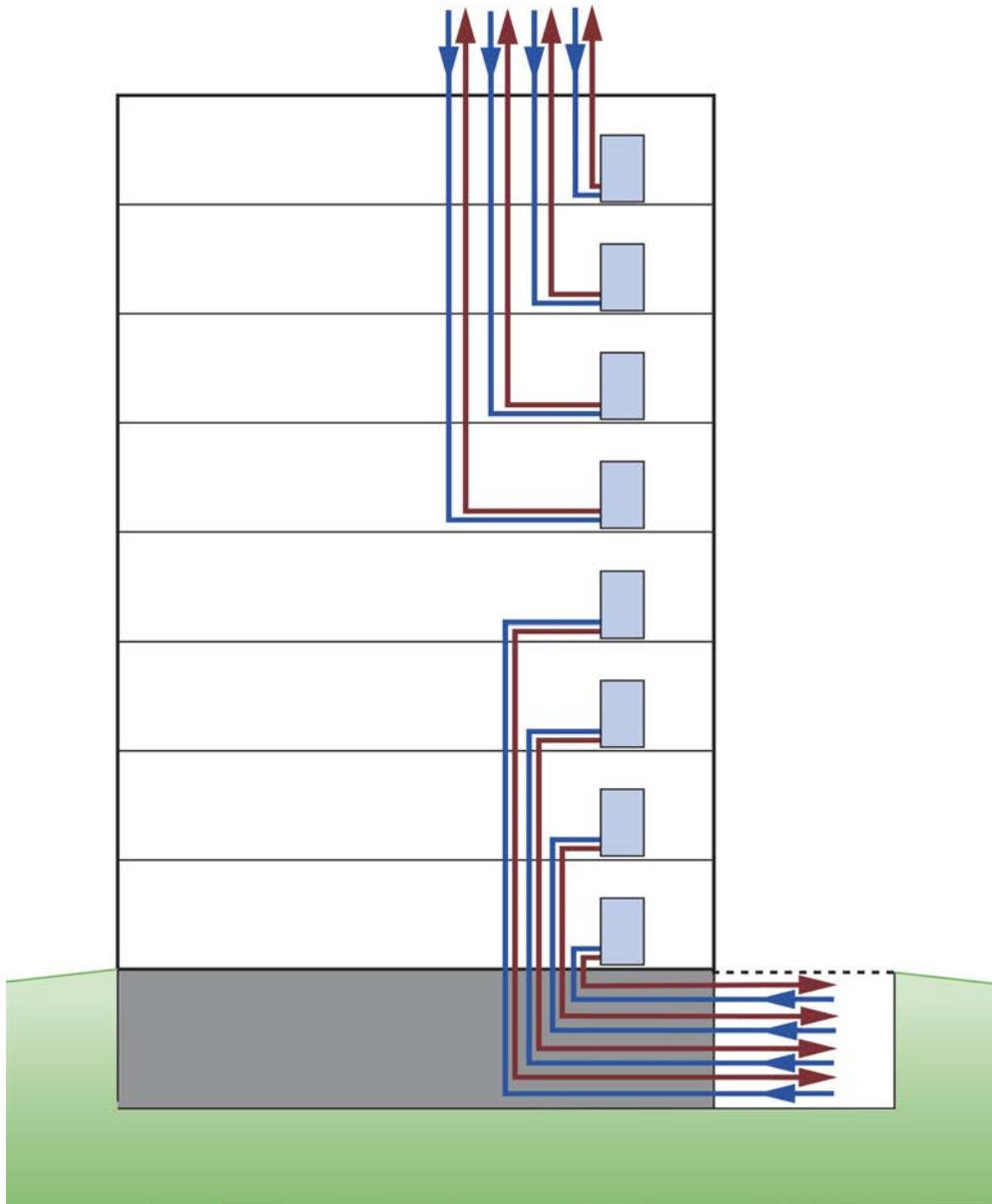
Reduced Individual Unit Stack Effect

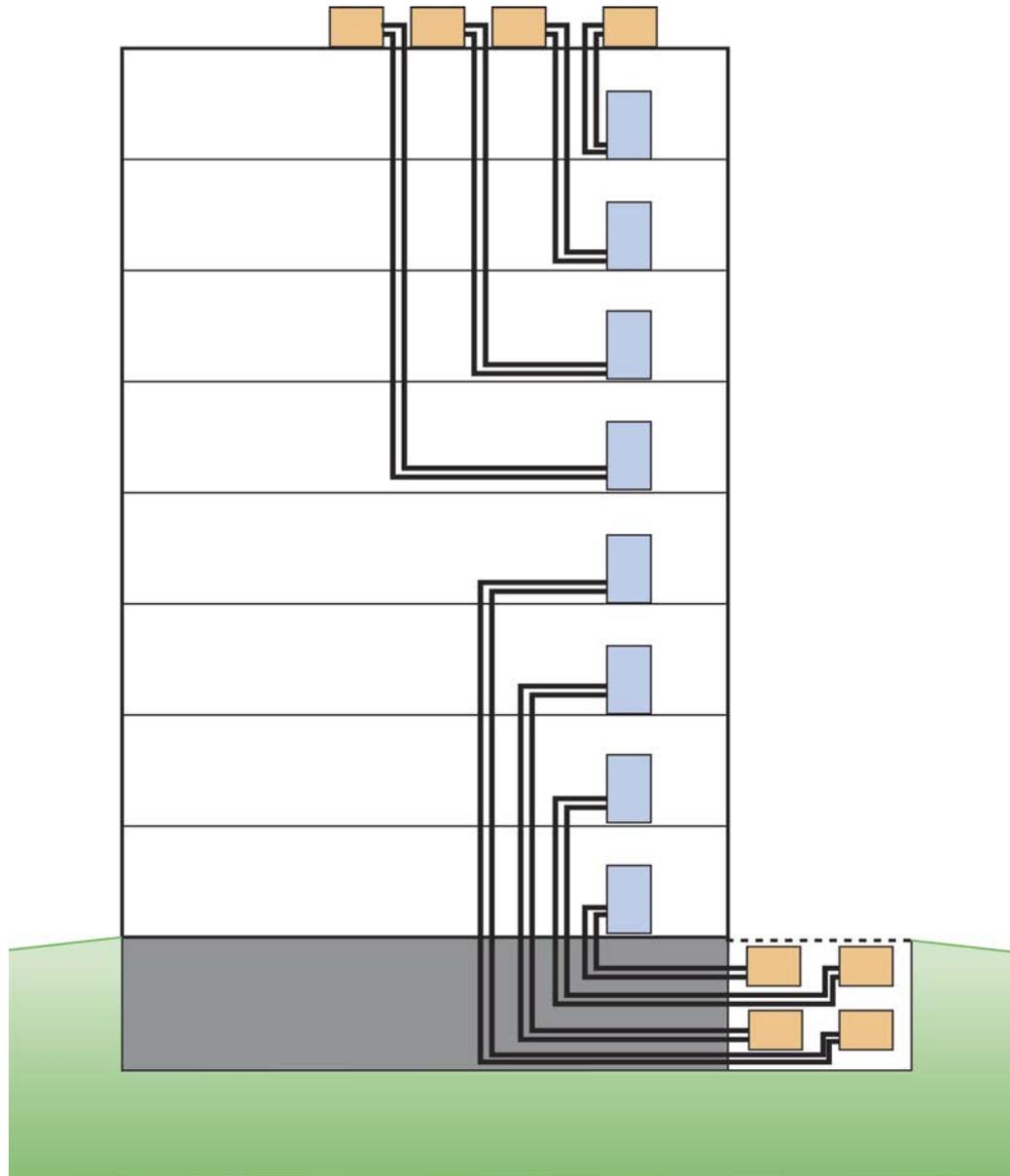


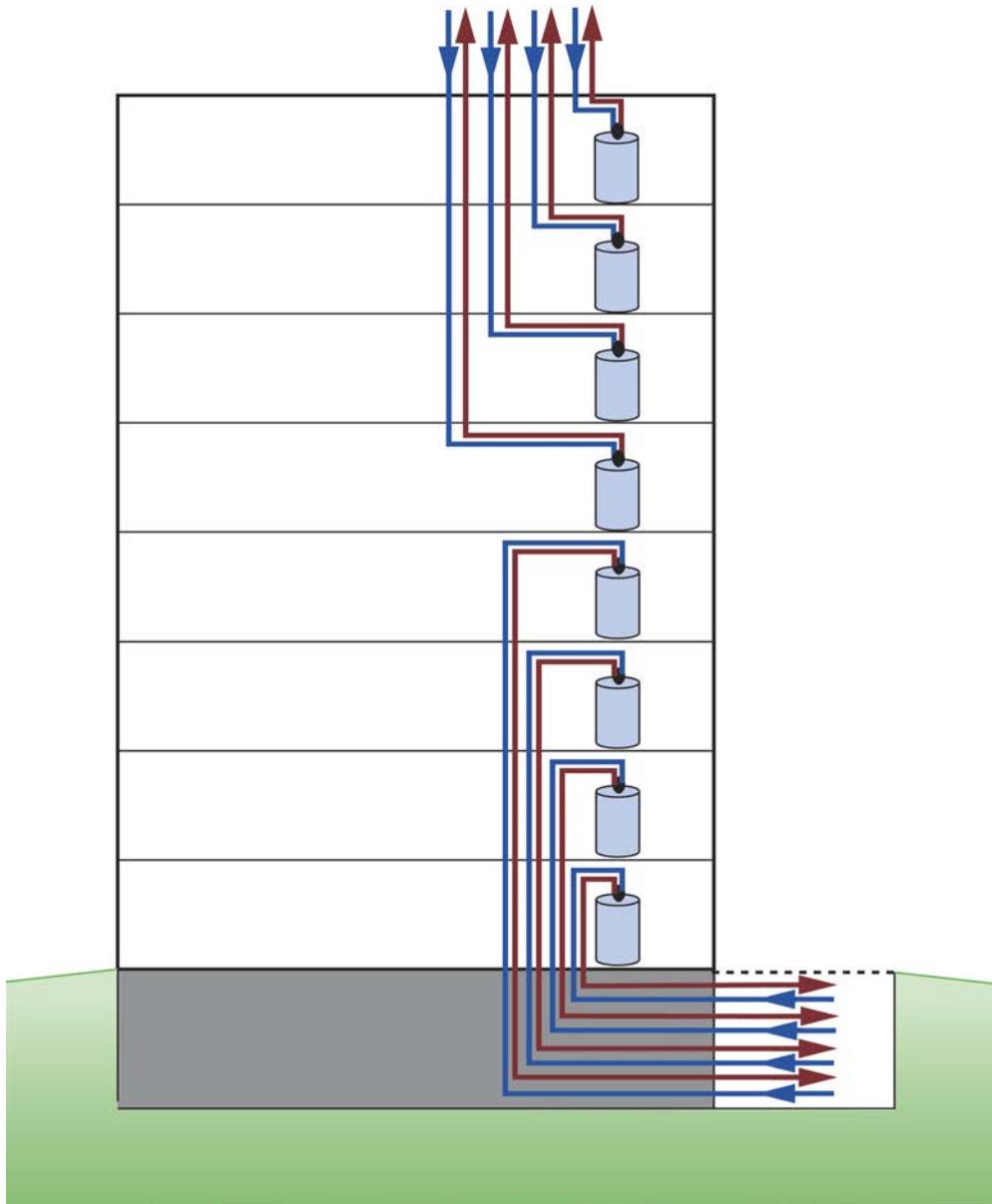














Build Tight - Ventilate Right

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

Air Barrier Metrics

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

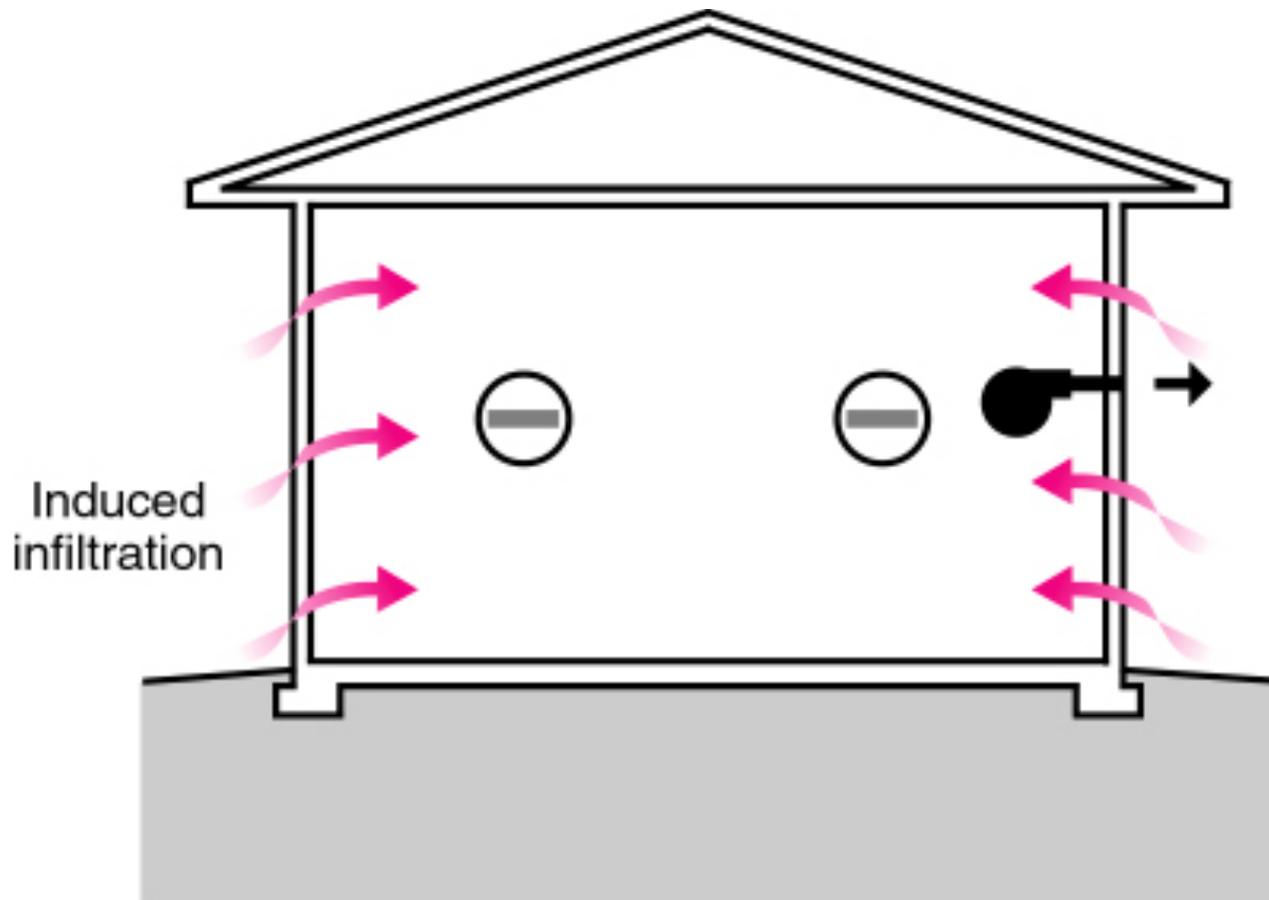
Exhaust Ventilation – with – No Distribution
and No Mixing

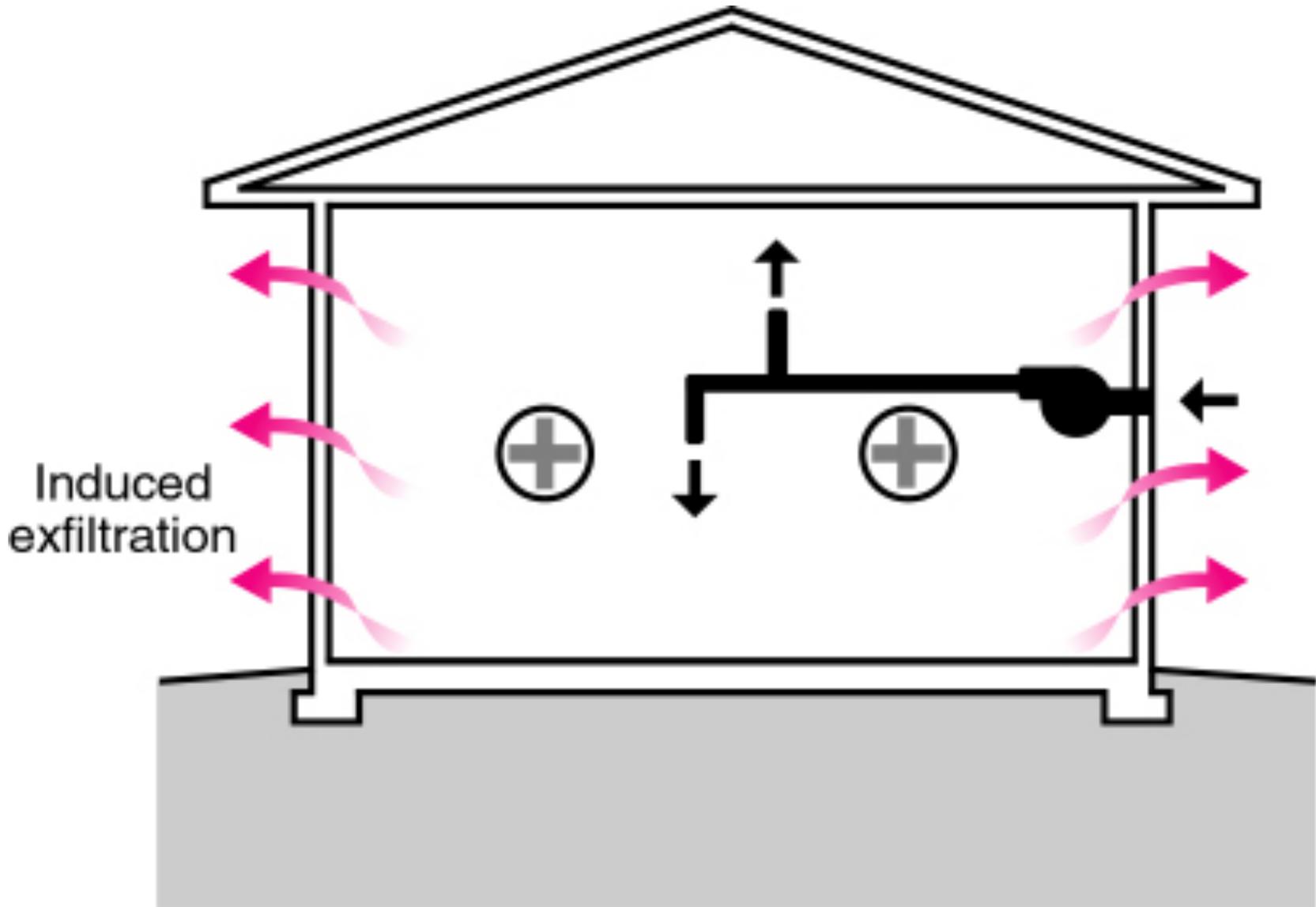
Three Types of Controlled Ventilation Systems

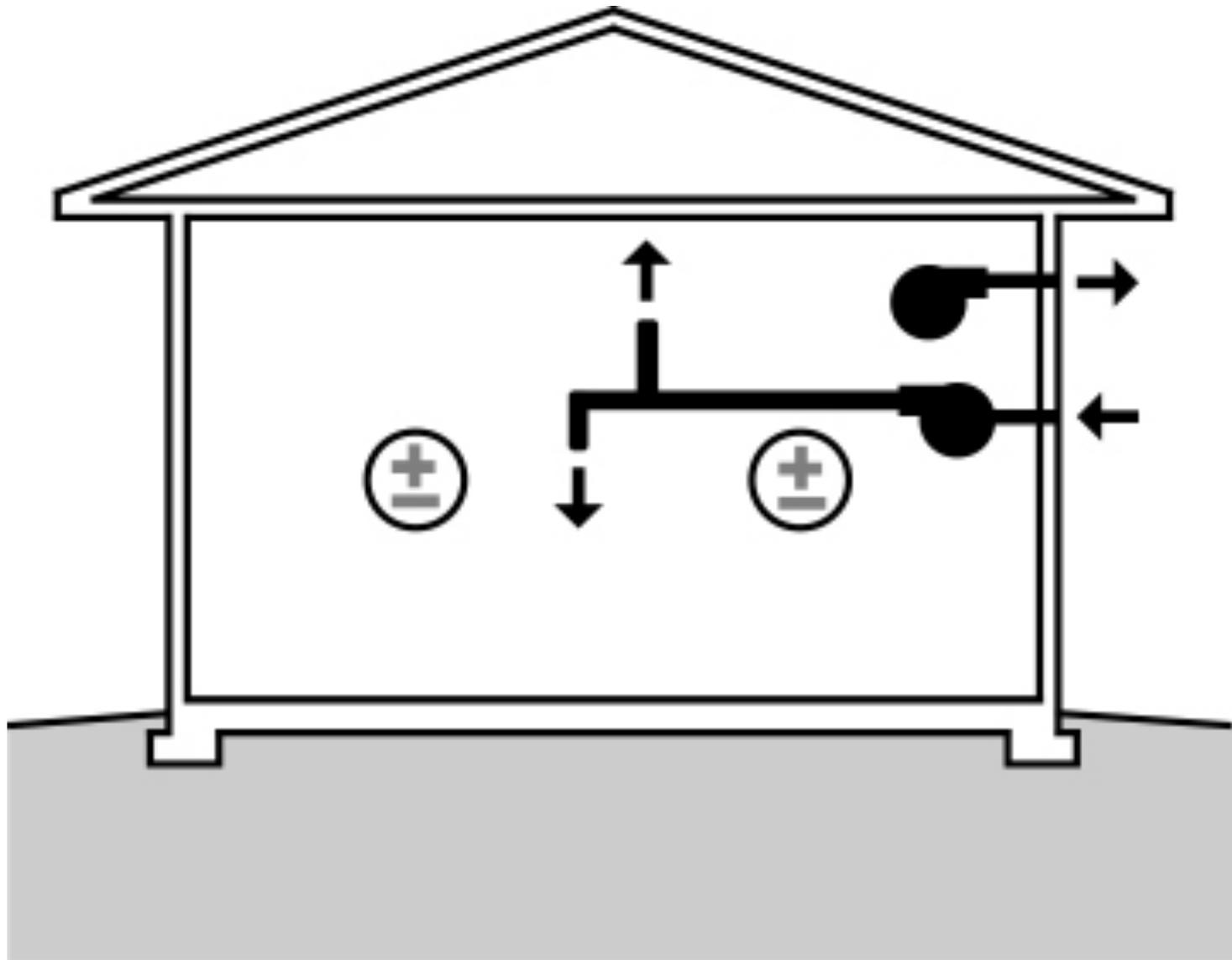
Exhaust Ventilation

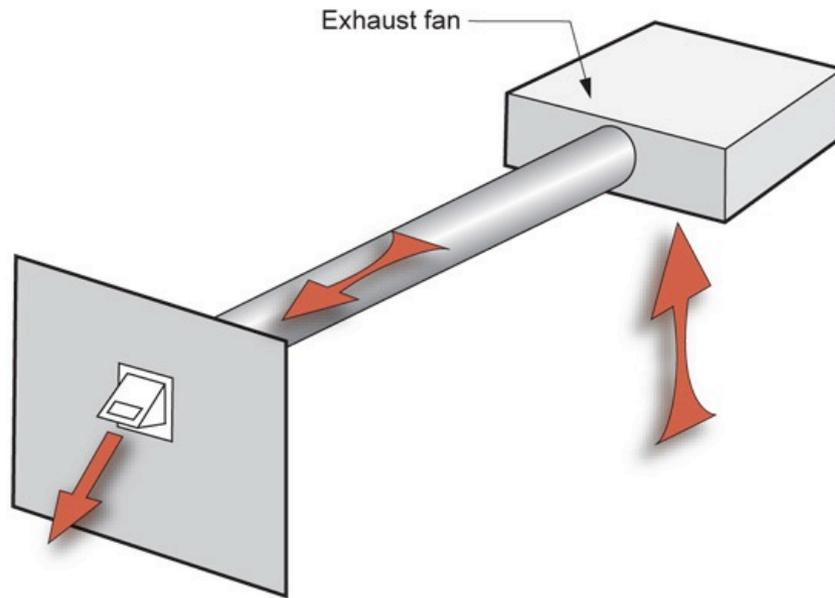
Supply Ventilation

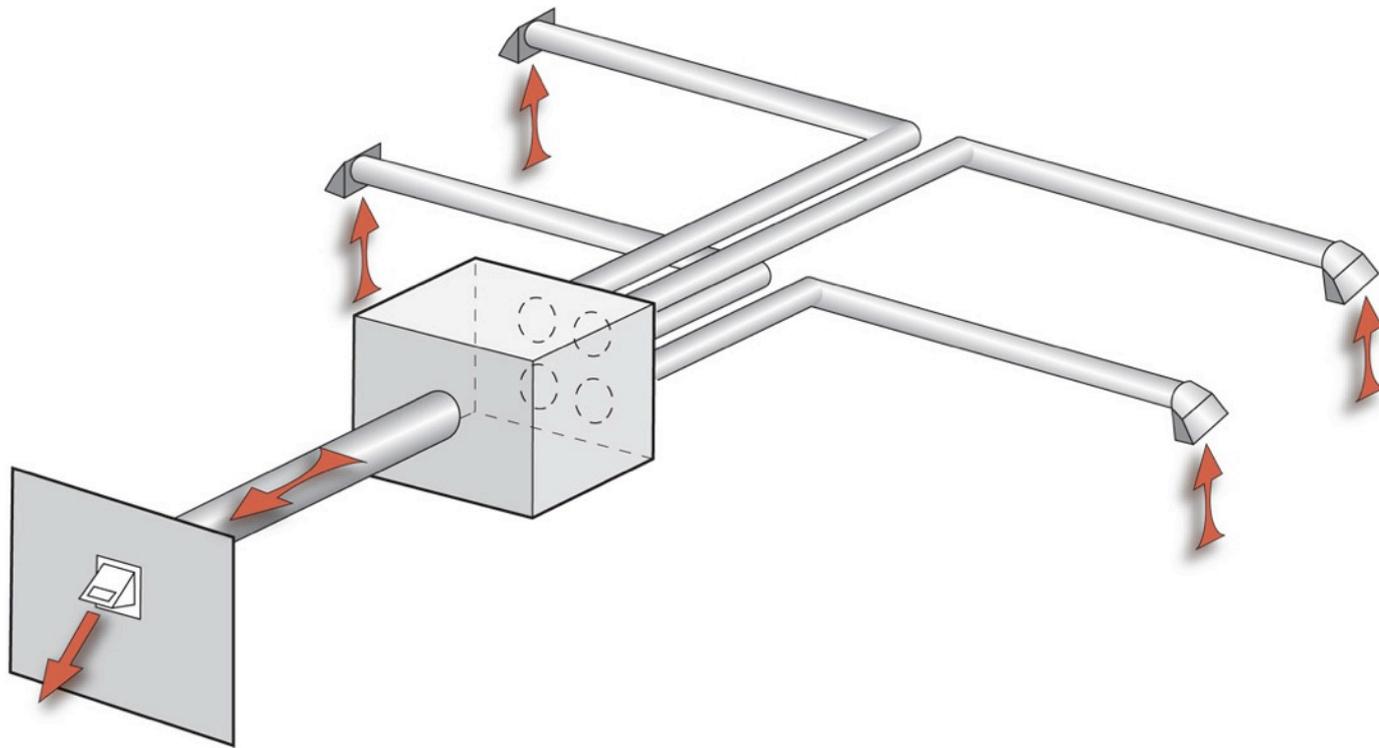
Balanced Ventilation

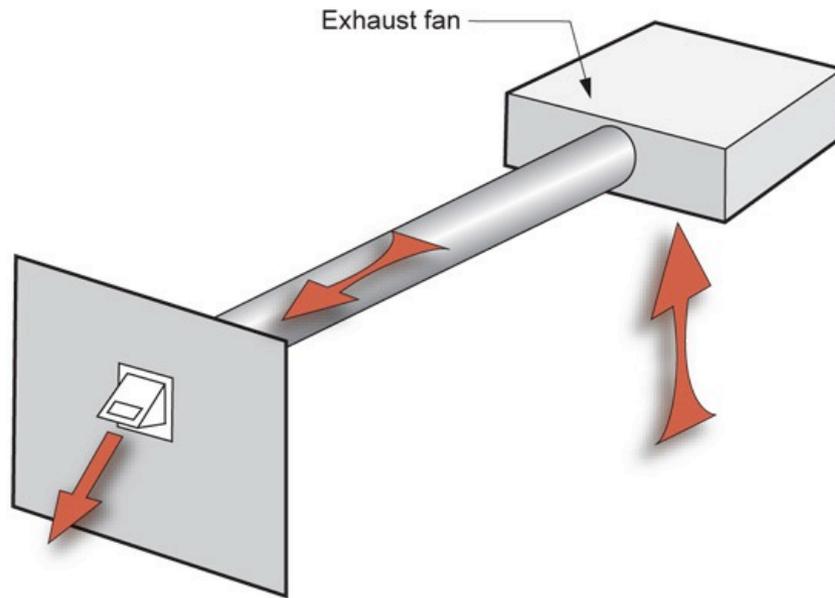


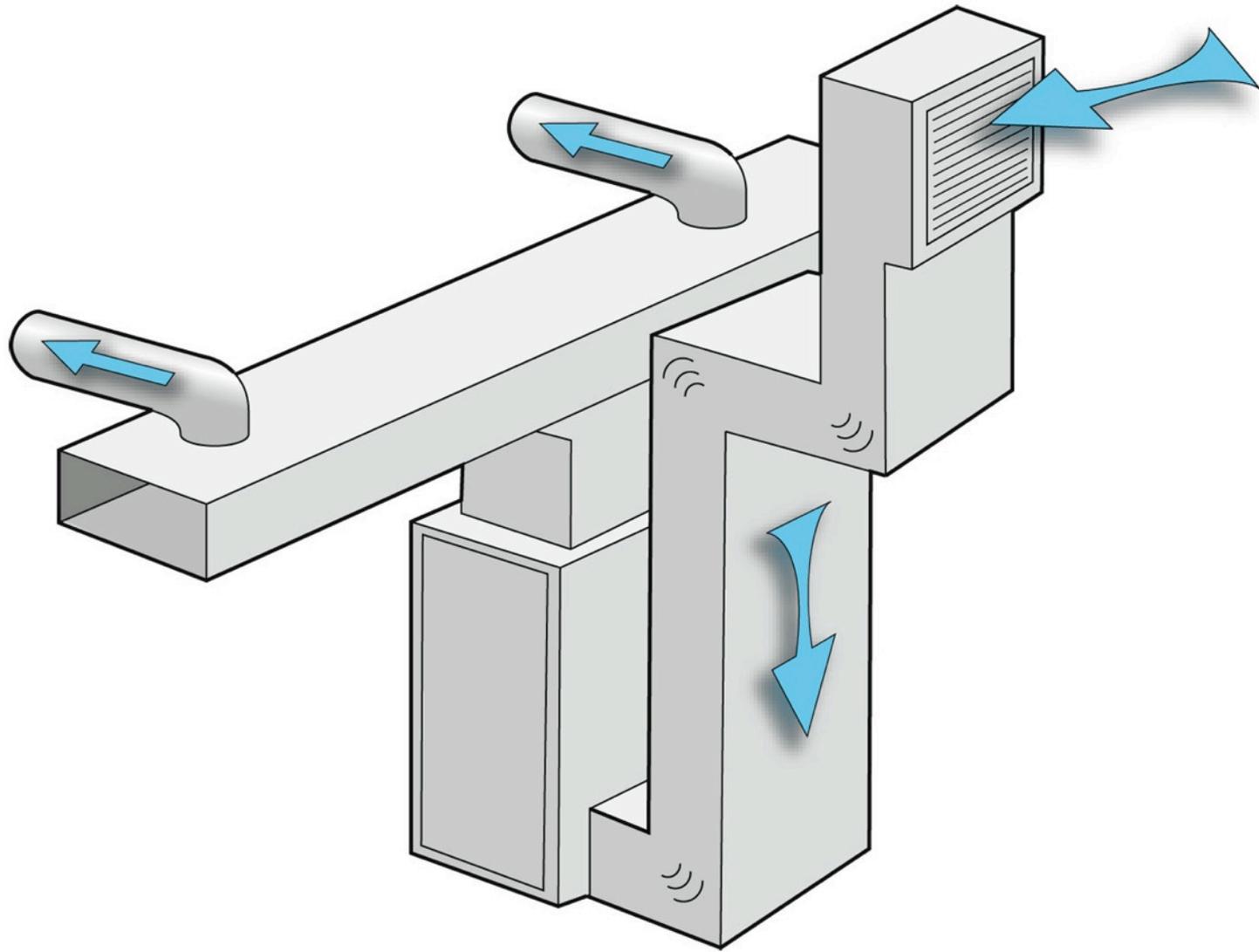


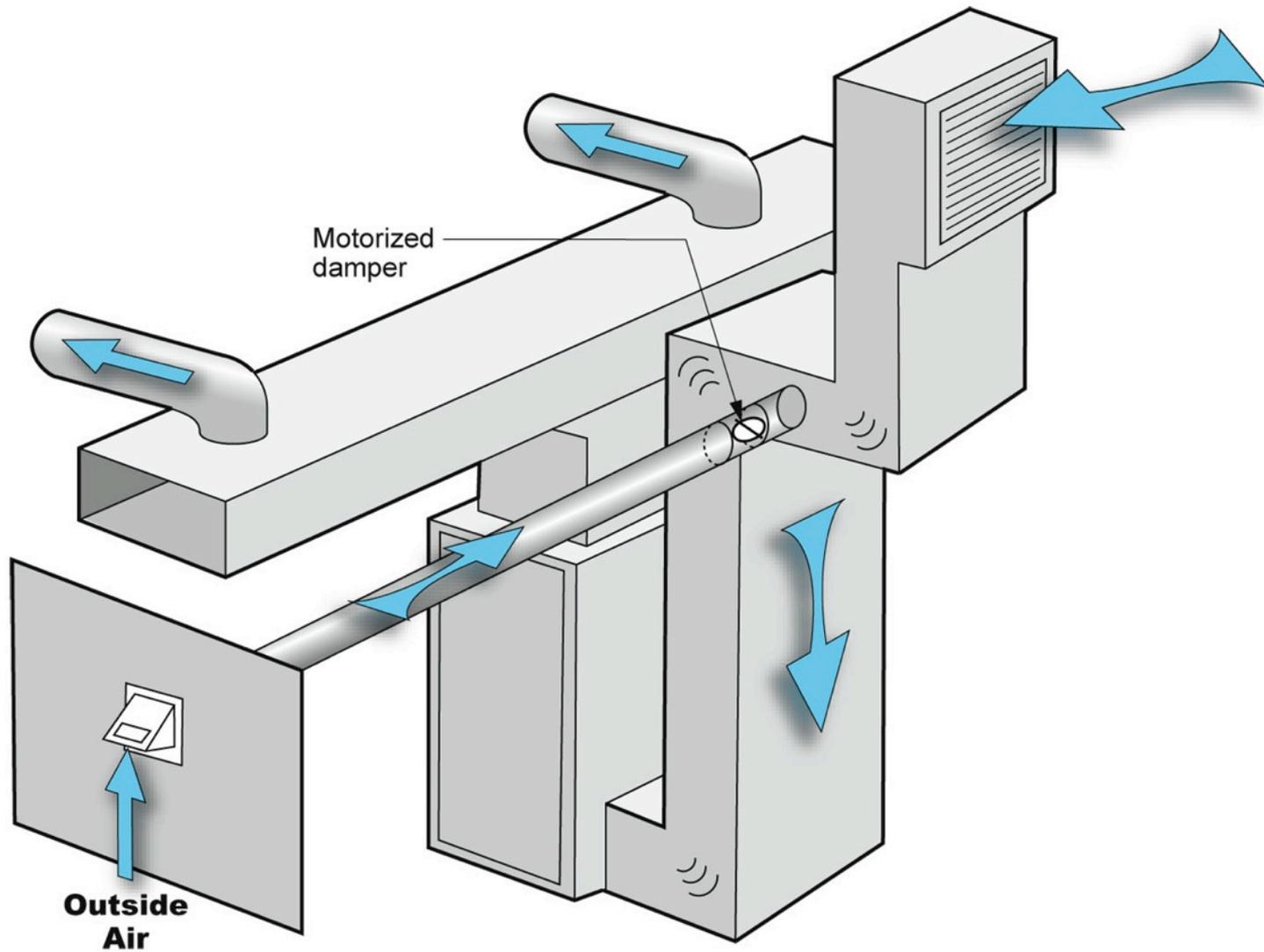


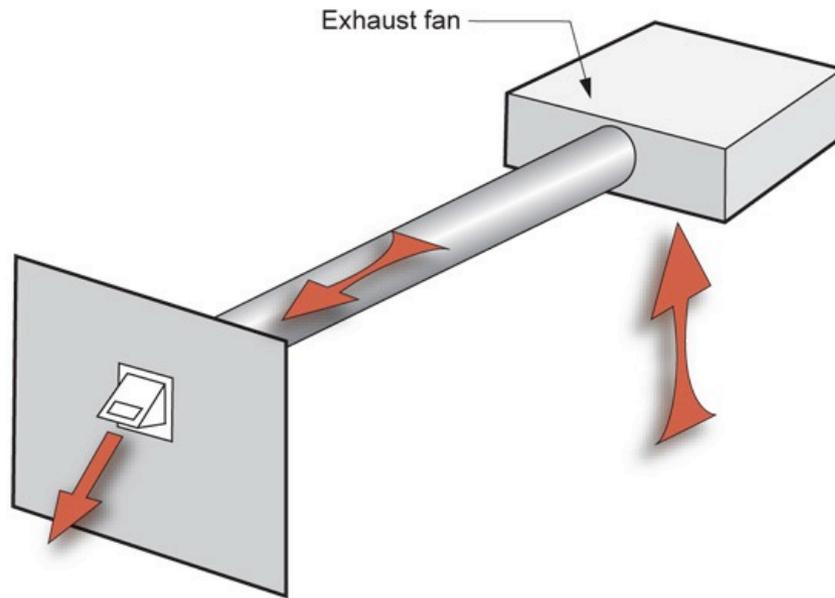


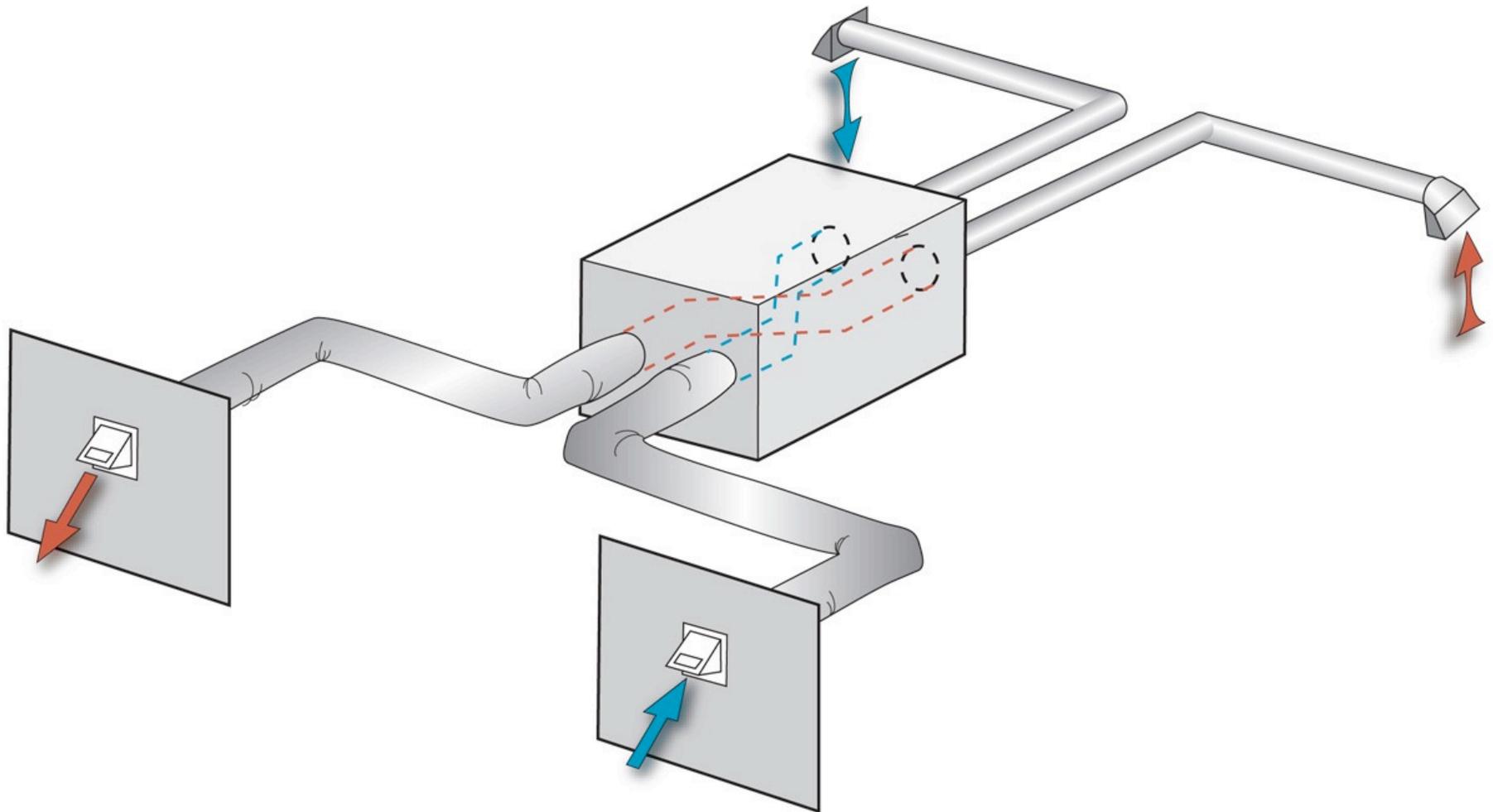












Ventilation Rates Are Based on Odor Control

Ventilation Rates Are Based on Odor Control
Health Science Basis for Ventilation Rates is
Extremely Limited

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

Ventilation Rates Are Based on Odor Control
Health Science Basis for Ventilation Rates is
Extremely Limited

Almost Nothing Cited Applies to Housing

The Applicable Studies Focus on Dampness

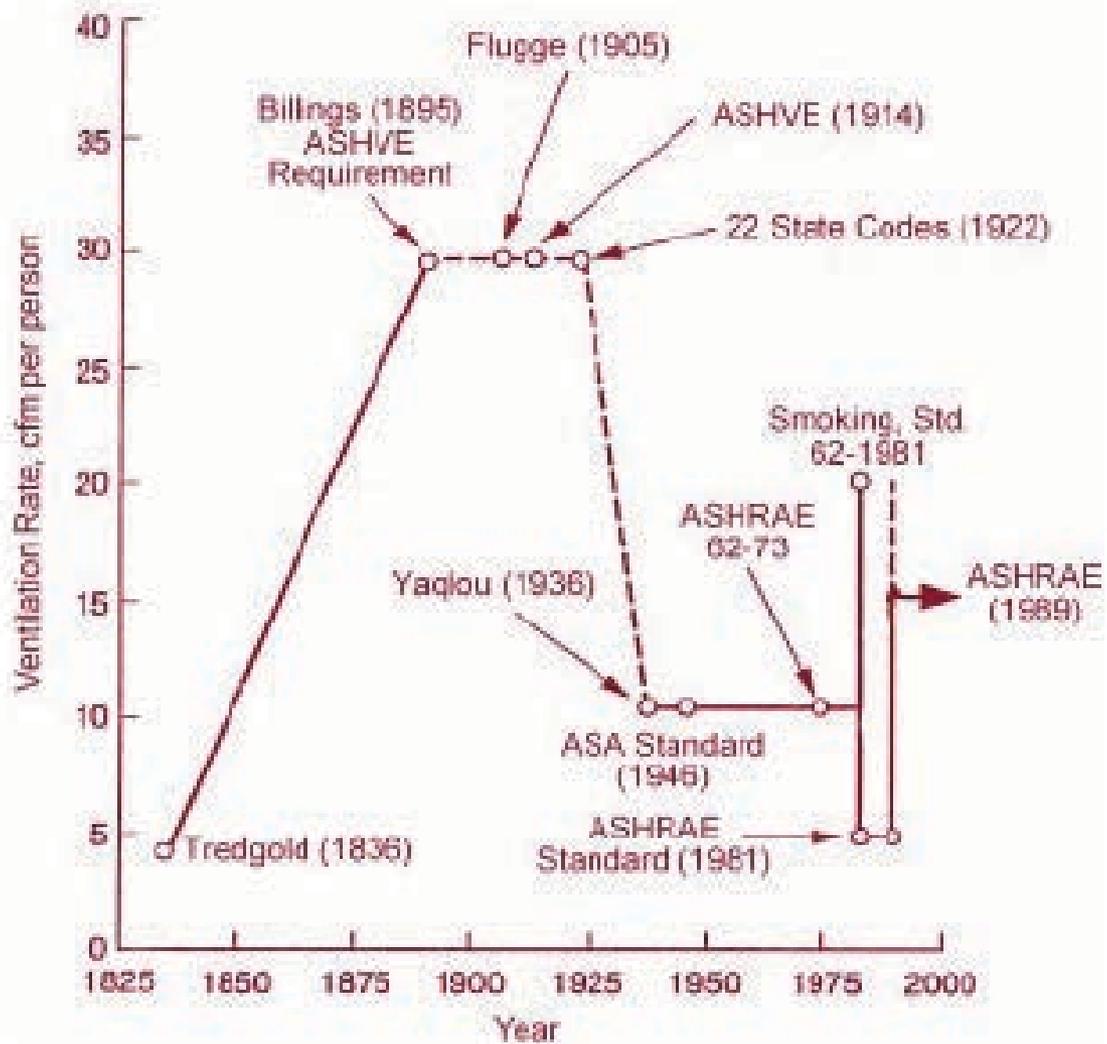
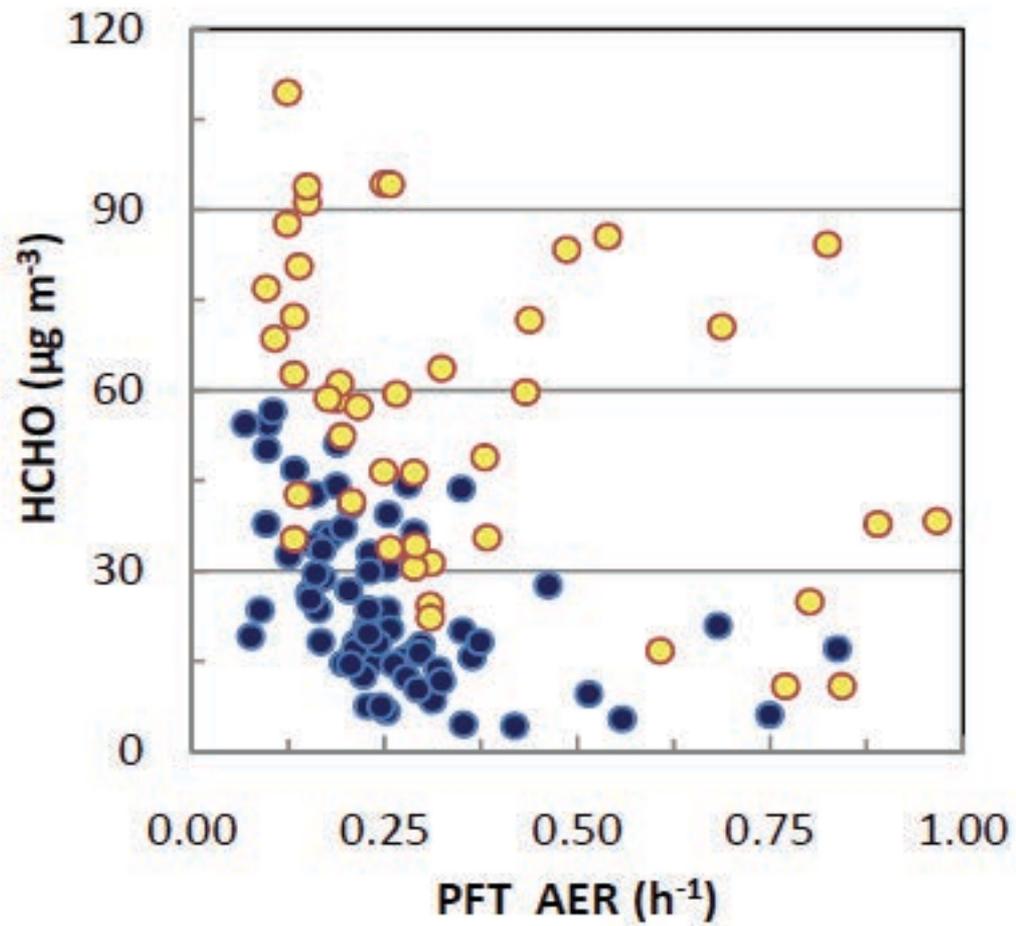
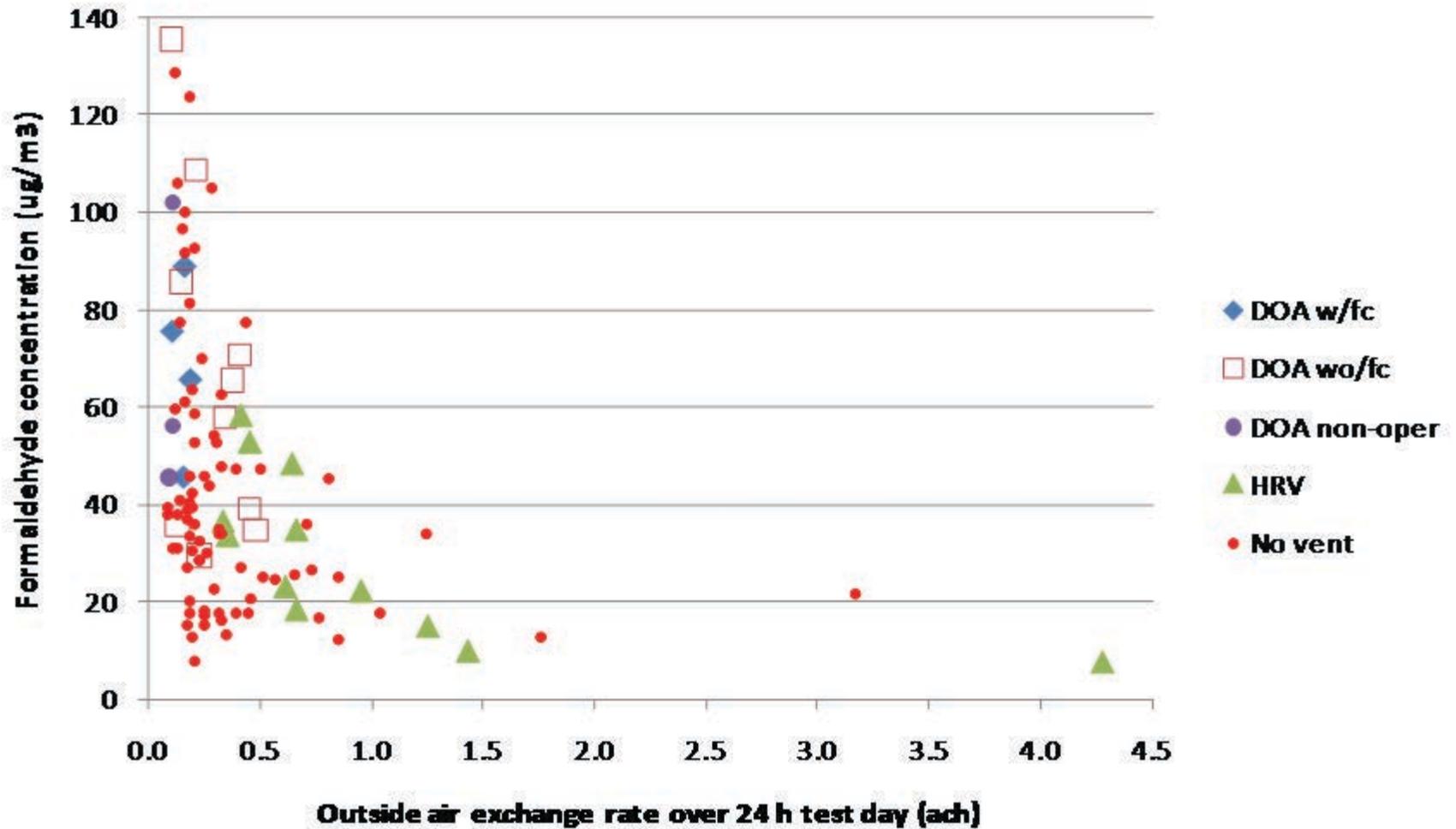


Figure 1: Minimum ventilating rate history.



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

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



Dilution Is Not The Solution To Indoor Pollution

Source Control

Dilution For People

Source Control For The Building

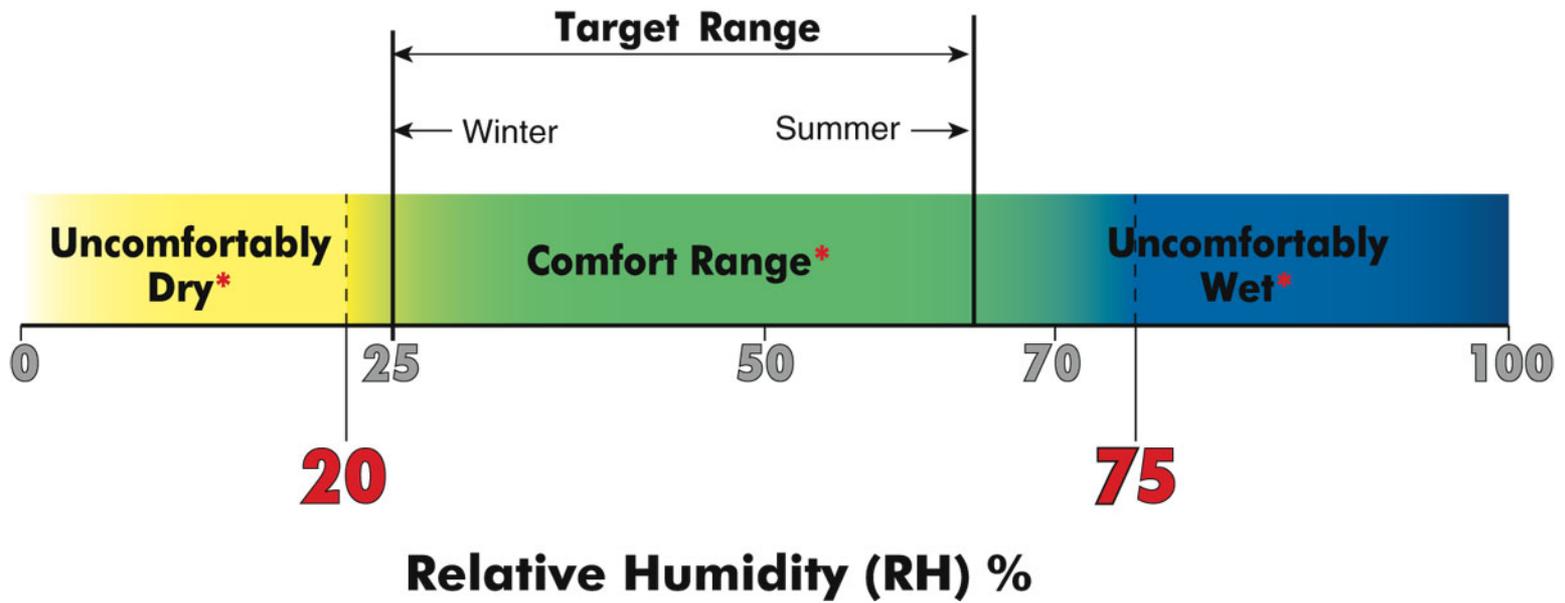
ASHRAE Standard 62.2 calls for 7.5 cfm per person plus 0.03 cfm per square foot of conditioned area

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

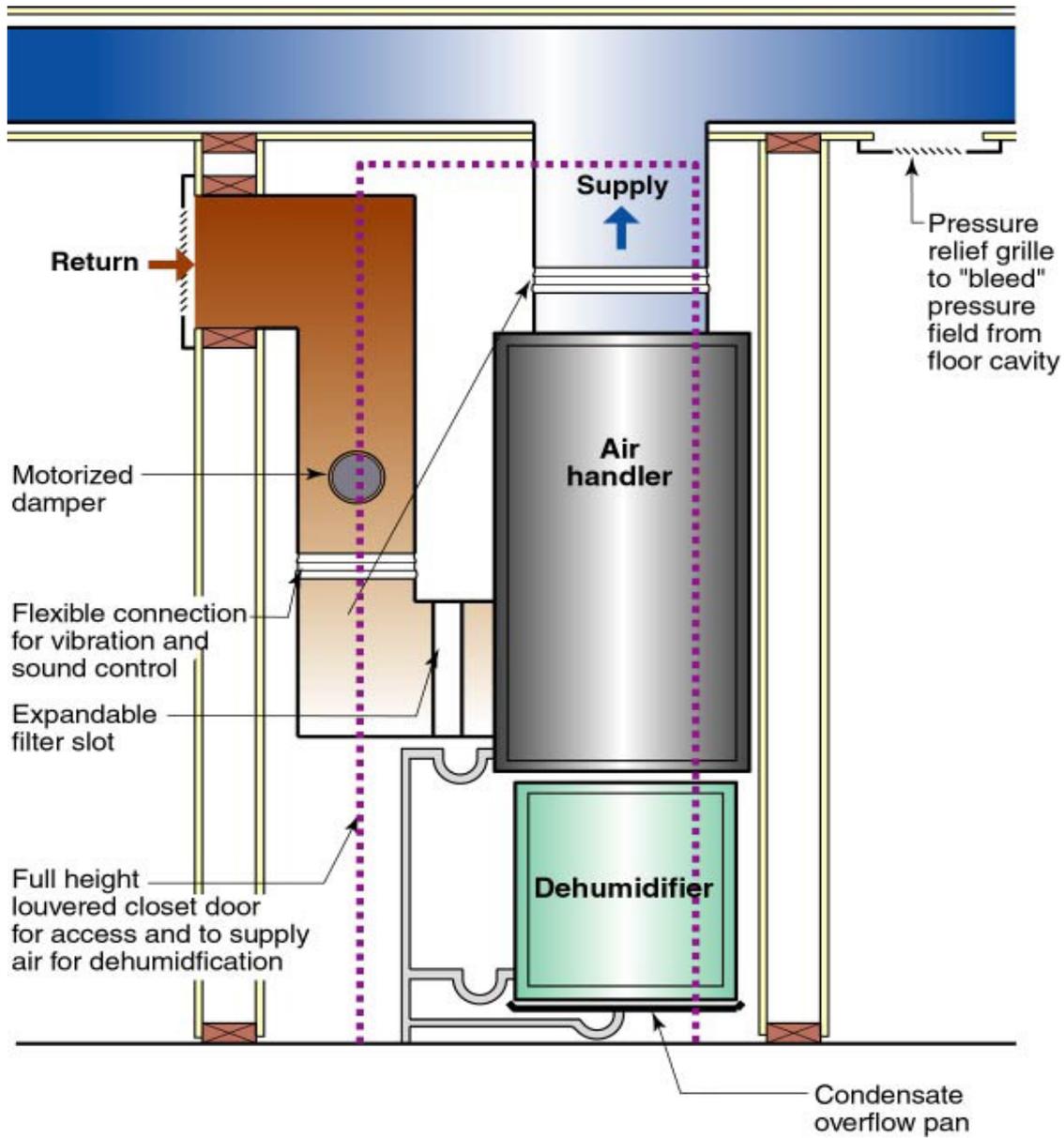
Outcome is often bad – part load humidity problems, dryness problems, energy problems



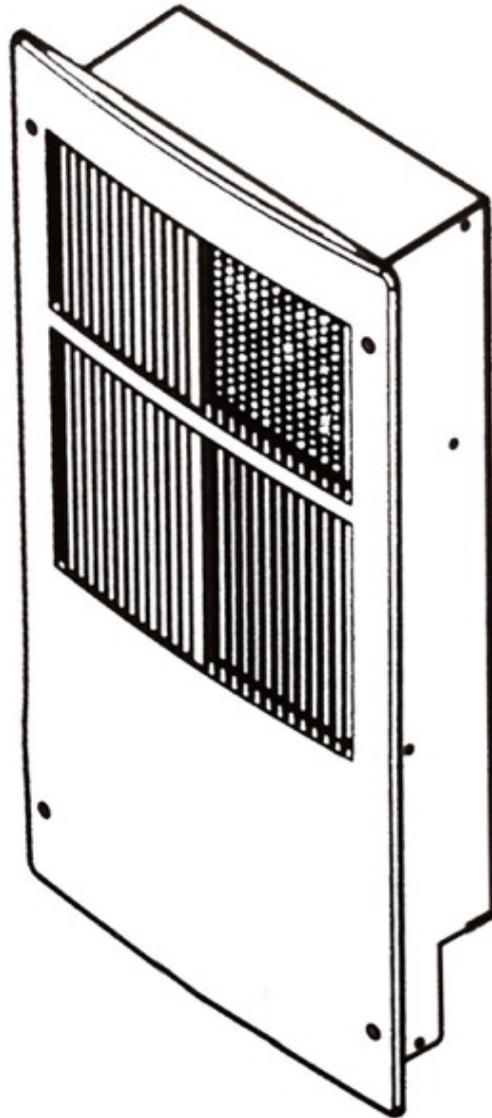
Recommended Range of Relative Humidity

Above 25 percent during winter

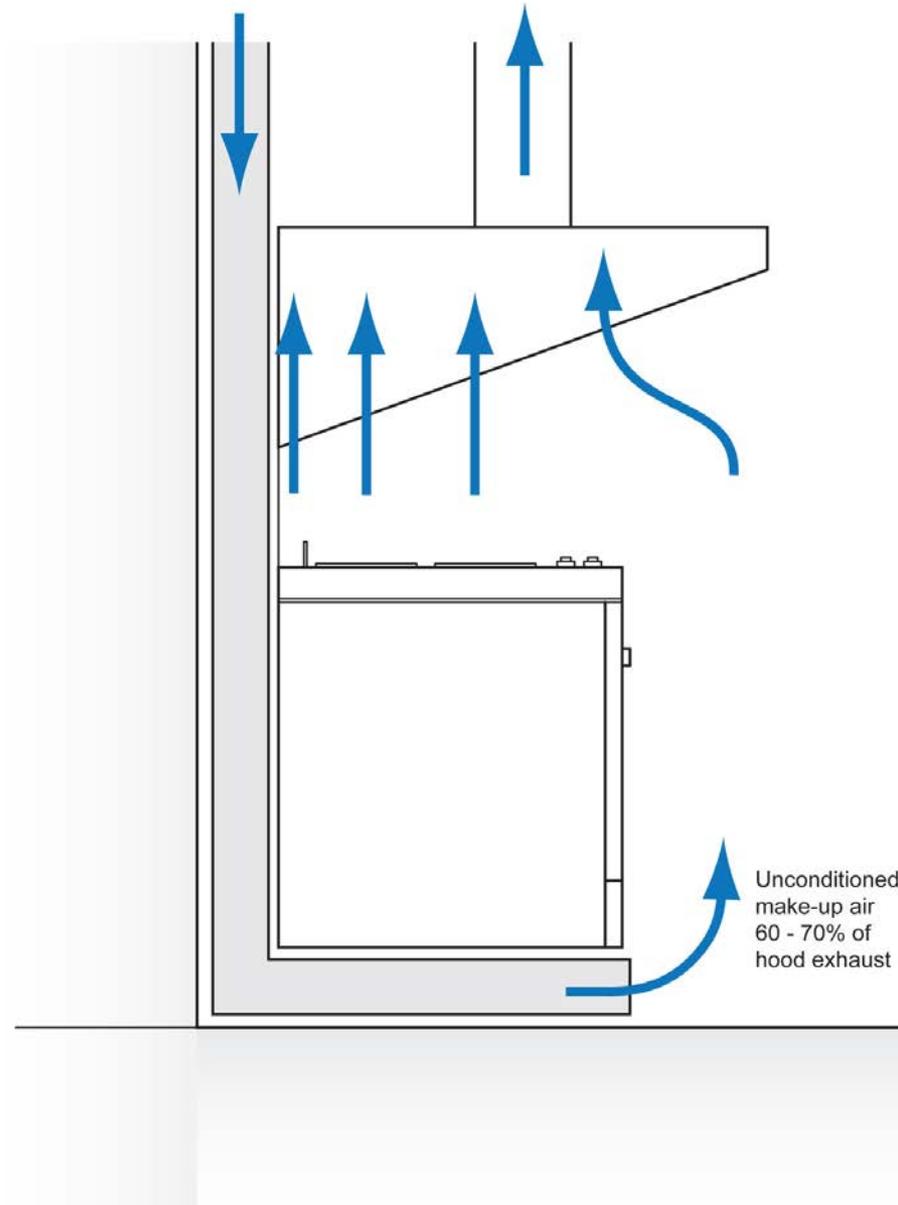
Below 70 percent during summer



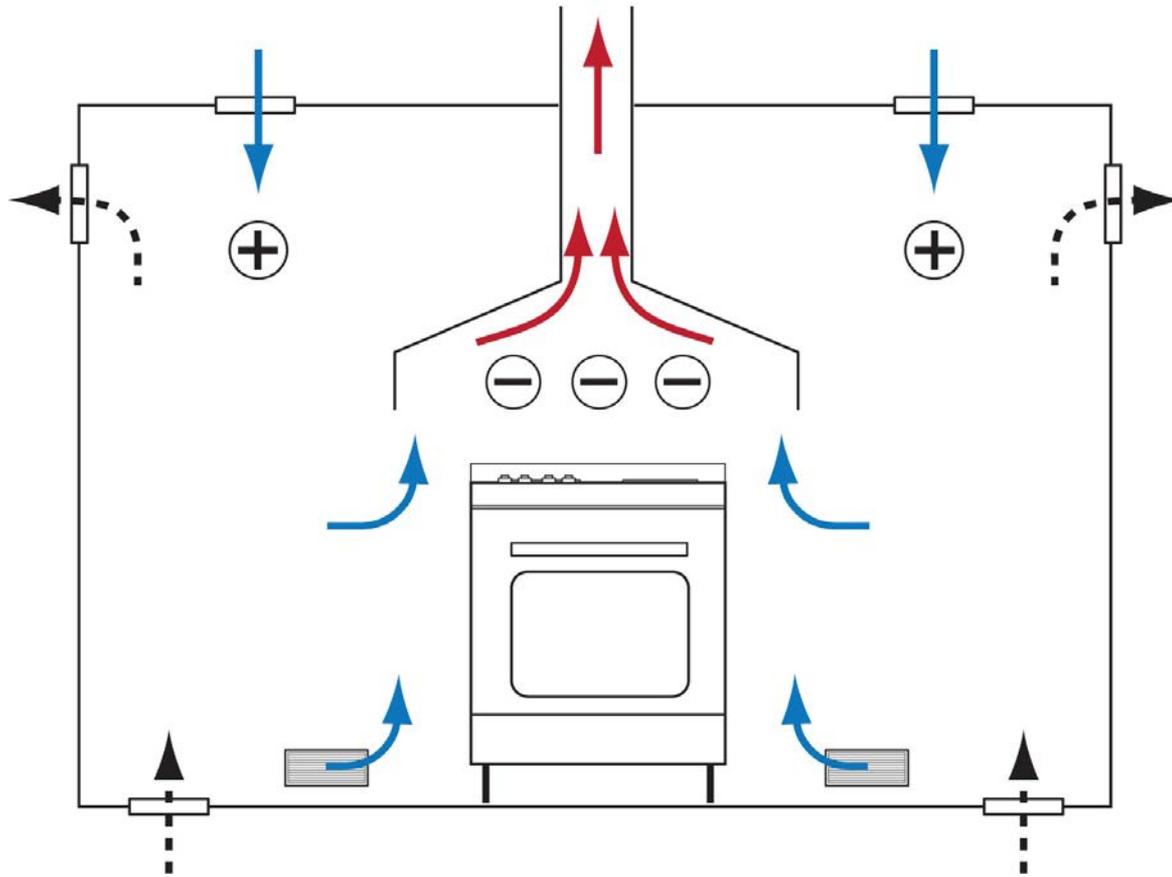


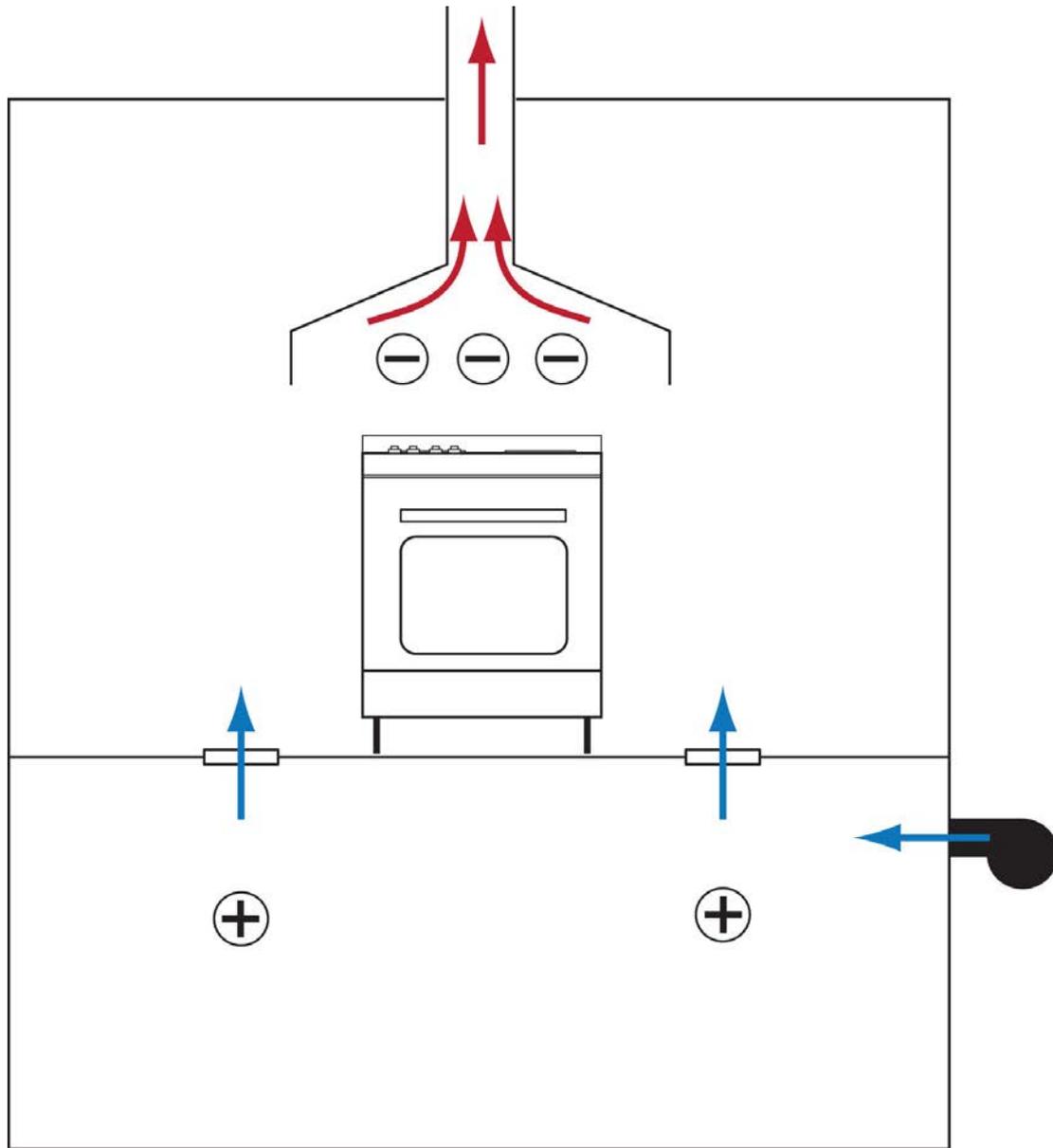


Kitchen Exhaust Hoods



















Clothes Dryers



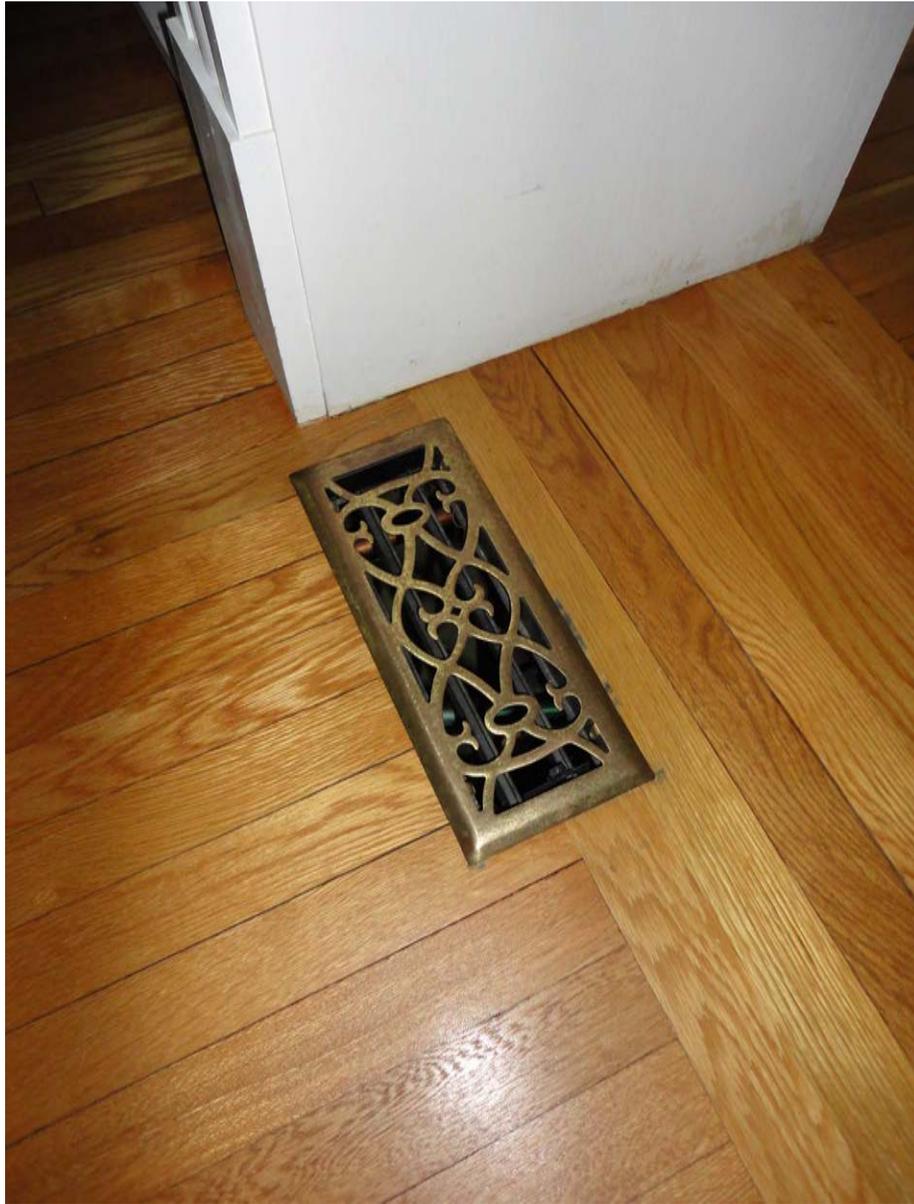


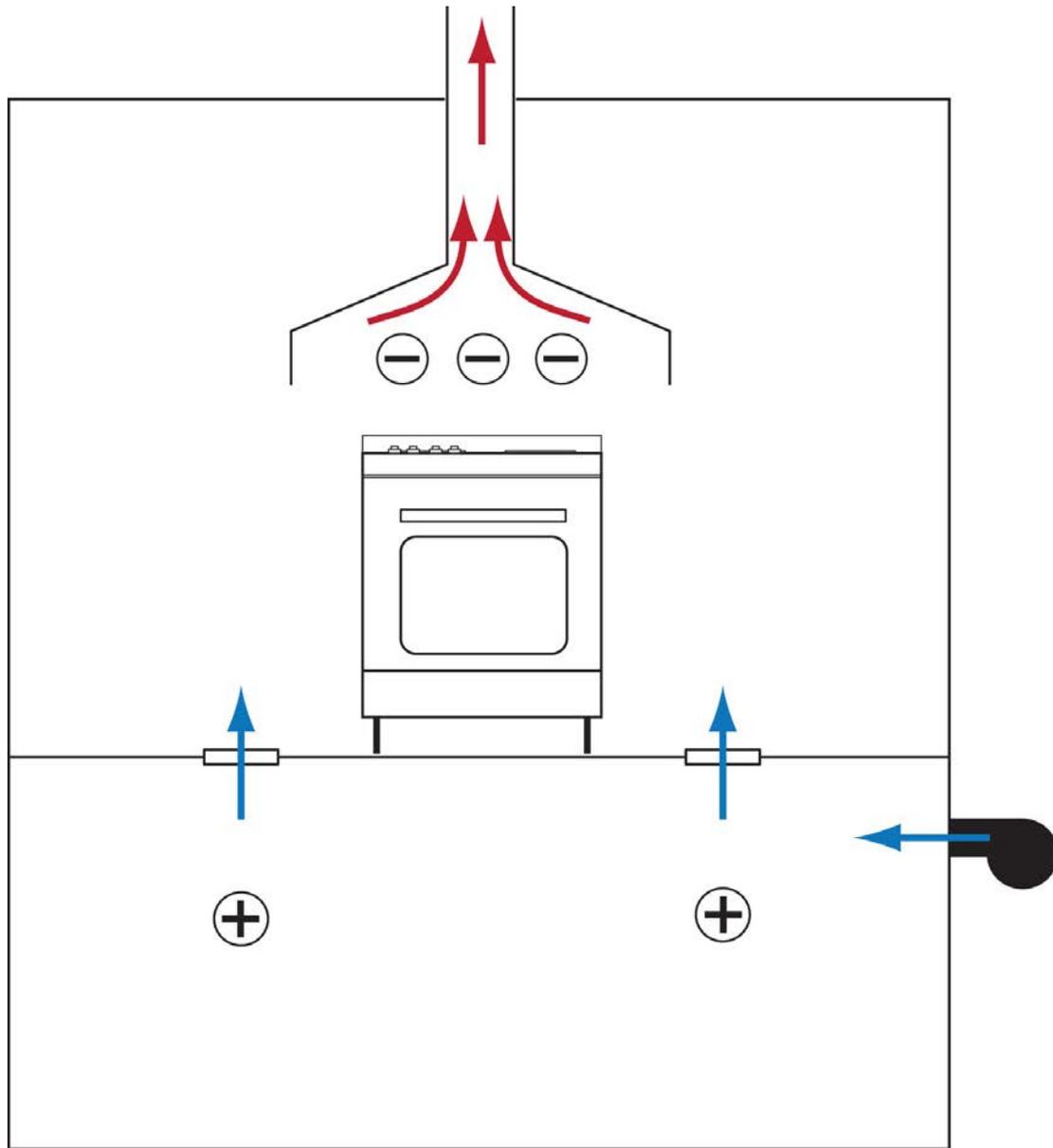
Fireplaces











Approaches

