Building Science

Ventilation
Lapse Rate
Figure 11.1: Building with no internal separations with opening at the bottom (Adapted from G.O. Handegord, 1998)
Figure 11.2: Building with no internal separations with opening at the top (Adapted from G.O. Handegord, 1998)
Figure 11.3: Building with no internal separations with openings at top and bottom (Adapted from G.O. Handegord, 1998)
Figure 11.4: Basic two storey house with vented attic
(Adapted from G.O. Handegord, 1998)
Figure 11.8: Stack effect pressures in high rise office building  
(Adapted from G.O. Handegord, 1998)
Figure 11.9: Multi-storey building with floor spaces isolated from vertical shafts (Adapted from G.O. Handegord, 1998)
Figure 11.12: Apartment building with tighter apartment entry doors (Adapted from G.O. Handegord, 1998)
Reduced Individual Unit Stack Effect
Build Tight - Ventilate Right
Build Tight - Ventilate Right

How Tight?
What’s Right?
Air Barrier Metrics

Material  \(0.02 \text{l/(s-m2) @ 75 Pa}\)
Assembly \(0.20 \text{l/(s-m2) @ 75 Pa}\)
Enclosure \(2.00 \text{l/(s-m2) @ 75 Pa}\)

- \(0.35 \text{ cfm/ft2 @ 50 Pa}\)
- \(0.25 \text{ cfm/ft2 @ 50 Pa}\)
- \(0.15 \text{ cfm/ft2 @ 50 Pa}\)
Getting rid of big holes 3 ach@50
Getting rid of smaller holes 1.5 ach@50
Getting German 0.6 ach@50
As Tight as Possible - with -
Balanced Ventilation
Distribution
Source Control - Spot exhaust ventilation
  Filtration
  Material selection
Energy Recovery
Flexible connection for vibration and sound control

Outside air duct

Motorized damper

Outside air filter

Air handler

Return air

Dehumidifier

Pressure relief grille to "bleed" pressure field from floor cavity

Additional sound and vibration control can be achieved with HVAC equipment supported independent of wall structure

Short return plenum ("sleeve")

Air handler filter

Full height louvered closet door for access, and for a return air pathway to the air handler and dehumidifier

Condensate overflow pan
Pressure relief grille to "bleed" pressure field from floor cavity

Motorized damper

Flexible connection for vibration and sound control

Expandable filter slot

Full height louvered closet door for access and to supply air for dehumidification

Air handler

Dehumidifier

Condensate overflow pan
Grille located high in wall on bedroom side to avoid blockage by furniture.

Cavity is sealed tight, drywall glued to studs and plates on both sides.

Grille located low in wall on hallway side.
Move cabinets farther apart

Hood wider than cook top and extended outboard past head space

Move hood up to provide headroom

Interlocked make-up air
Building Science Corporation

Return air
Dehumidifier
Supply air

Outside air
Exhaust air
Exhaust air

Bath
Kitchen

Interlocked kitchen hood make-up air
Motorized damper — typically closed (connected to fire control system)

Smoke and hot gas vent
(3 1/2% of shaft or 3 ft² per elevator car)

Constant airflow regulator

Exhaust from elevator shaft
Ventilation Rates Are Based on Odor Control
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Health Science Basis for Ventilation Rates is Extremely Limited
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Almost Nothing Cited Applies to Housing
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The Applicable Studies Focus on Dampness
Figure 1: Minimum ventilating rate history.
Figure 2: Odor acceptance.
House

2,000 ft²
3 bedrooms
8 ft. ceiling
Volume: 16,000 ft³

.35 ach  93 cfm
.30 ach  80 cfm
.25 ach  67 cfm
.20 ach  53 cfm
.15 ach  40 cfm
## House

- 2,000 ft²
- 3 bedrooms
- 8 ft. ceiling
- Volume: 16,000 ft³

### Ventilation Rates

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

Occupant Density

15/1000 ft$^2$ (67 ft$^2$/person)  
15 cfm/person  

5/1000 ft$^2$ (200 ft$^2$/person)  
17 cfm/person

Correctional Facility Cell

Occupant Density

20/1000 ft$^2$ (48 ft$^2$/person)  
10 cfm/person  

62.1 – 2007
C.P. Yaglou

Harvard School of Public Health
1936
1955

150 ft³  ➔  20 cfm/person
300 ft³  ➔  12 cfm/person
C.P. Yaglou

Harvard School of Public Health
1936
1955

150 ft$^3$  ➡  20 cfm/person 18.75 ft$^2$  106 occupants

300 ft$^3$  ➡  12 cfm/person 37.5 ft$^2$  53 occupants

Experiment

470 ft$^3$  ➡  59 ft$^2$

200 ft$^3$  ➡  25 ft$^2$

100 ft$^3$  ➡  12 ft$^2$
Aubin, D., Won, D.Y., Schleibinger, H., 2010
Formaldehyde sample concentration versus PFT measured outside air exchange rate over the test day.
Table 1. Summary of the air changes rates measured during the winter 2009-10 season in Quebec City

<table>
<thead>
<tr>
<th>Method</th>
<th>ACH (h⁻¹)</th>
<th>ACH standard deviation (h⁻¹)</th>
<th>number of measurements</th>
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<tr>
<td>SF₆ tracer decay</td>
<td>0.27</td>
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<td>perfluorocarbon tracer</td>
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<td>0.22</td>
<td>37</td>
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<tr>
<td>blower door at 50 Pa</td>
<td>4.16</td>
<td>2.64</td>
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