Dwelling Unit Cross-Contamination in Multi-Family Buildings

The Impact of Compartmentalization and Ventilation System Type

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ENERGY TECHNOLOGIES AREA
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Agenda

- Background
  - Research Questions
  - Methods
- Results
  - Inter-Unit Air Flow
  - Inter-Unit Contaminant Transport
- Conclusions
- Questions

Background

- Dwelling unit compartmentalization aims to reduce inter-unit air and contaminant transport
- Many codes/standards, including ASHRAE 62.2, have performance-based compartmentalization targets for multi-family dwellings (Section 6.1.1)

Research Questions

1. Is the current compartmentalization requirement in ASHRAE 62.2 adequate for controlling cross-contamination in multi-family buildings?
2. Are different ventilation system types more or less sensitive to compartmentalization?

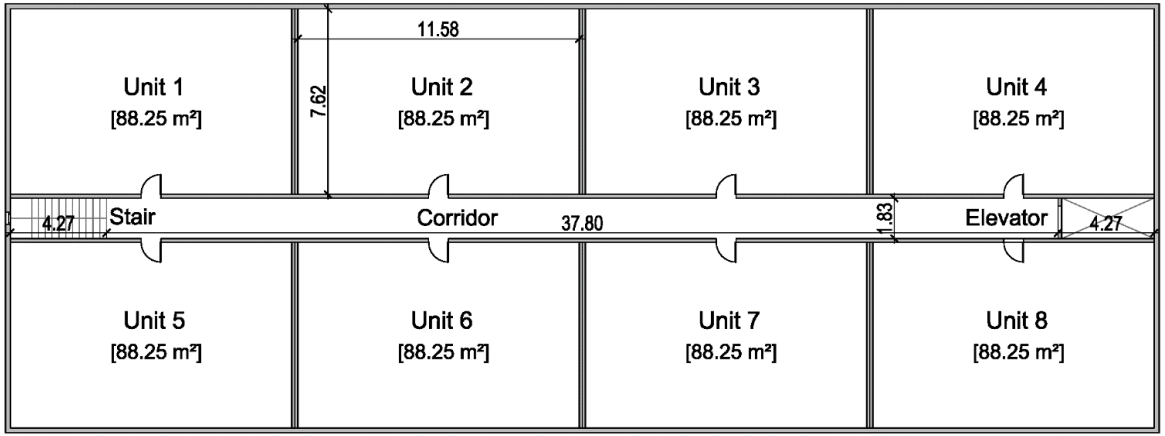
Methodology

- Coupled CONTAM-EnergyPlus simulations
  - Annual simulations, 3-min time-steps
- Parametric Variables
  - Building typology
  - Climate zone
  - Ventilation system
  - Dwelling unit air leakage
- Contaminant emissions

Building Typology and Climate

Building Typology

- 4, 20 storeys
- Floor plan adapted from DOE prototype models



Climate Zones

- 2A Hot Humid
- 2B Hot Dry
- 3C Warm Marine
- 4A Mixed Humid
- 7 Very Cold

Ventilation System Design

1. Unit-Level Balanced Heat Recovery Ventilators
2. Unit Exhaust with Corridor Supply (Pressurized Corridor)
3. Unit Supply
4. Unit Exhaust with Trickle Vents
5. No Ventilation

Corridors

- Ventilated to meet ASHRAE 62.1

Local Exhaust Fans

- Sized to meet ASHRAE 62.2
- Kitchen, bath, laundry exhaust fans operated on fixed schedules

Dwelling Unit Air Leakage

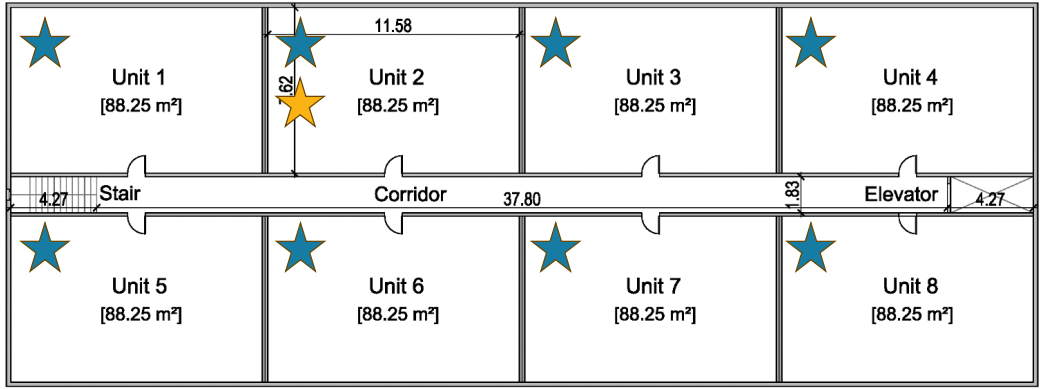
Leakage Class	Leakage ($L/s/m^2$ at 50Pa)	Leakage (cfm_{50}/ft^2)
Typical	5.1	1.0
Current Practice	1.5	0.30
Moderate	1.0	0.20
Tight	0.50	0.10
Super Tight	0.25	0.05

ASHRAE 62.2 - 2019
Compartmentalization Requirement (6.1.1)

ASHRAE 62.2 - 2022
Compartmentalization Requirement (6.1.1)

Indoor Contaminants

- **Contaminant Species**
  - Carbon Dioxide
  - Formaldehyde
  - $PM_{2.5}$



- **Contaminant Types**
  - ★ Global contaminants (modelled in ALL dwelling units)
  - ★ Shadow contaminants (modelled in Unit 2 on Levels 1, 11, 20)

Results

Inter-Unit Air Flow

Annual Average "From Unit" Air Flows (L/s)
(1.0L/s/m^2 (0.2cfm$_{50}$/ft^2))

ASHRAE 62.2 Dwelling Unit Supply Air Flow Rate = 27.5 L/s

Building-Level Maximum "From Unit" Air Flow

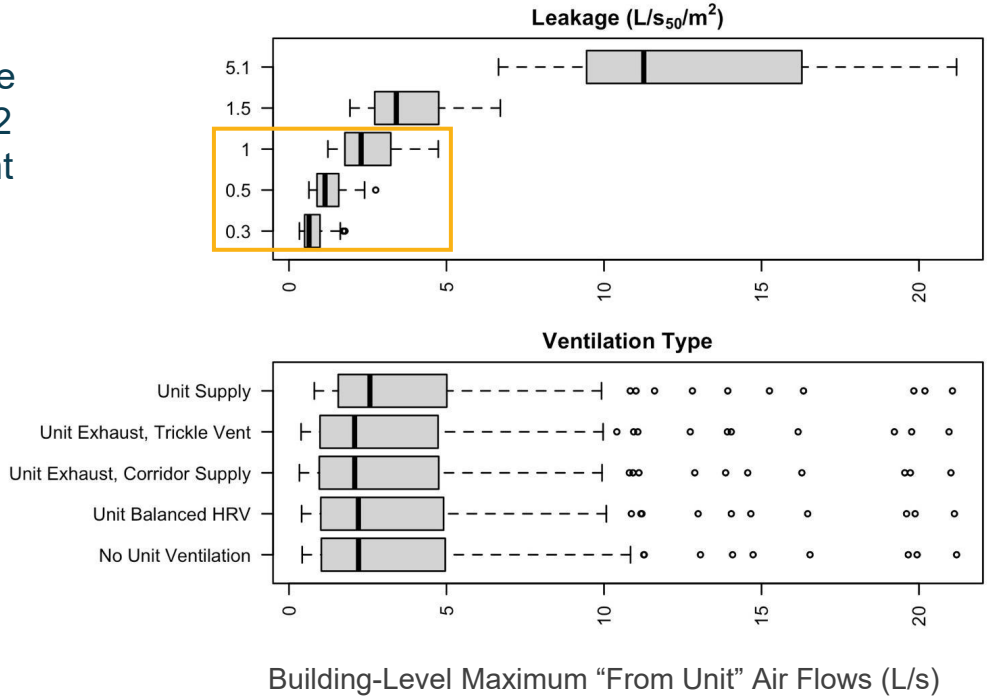
	Apt 1	Apt 2	Apt 3	Apt 4	Elv	Cor	Str	Apt 5	Apt 6	Apt 7	Apt 8
Level 20	3	3	3	3	0	1	0	3	3	3	3
Level 19	2	3	3	3	0	1	0	3	3	3	3
Level 18	3	3	3	3	0	1	0	3	3	3	3
Level 17	3	3	3	3	0	1	0	3	3	3	3
Level 16	3	3	3	3	0	1	0	3	3	3	3
Level 15	3	3	3	3	0	1	0	3	3	3	3
Level 14	3	3	3	3	0	1	0	3	3	3	3
Level 13	3	2	3	3	0	1	0	3	3	3	3
Level 12	2	2	2	2	0	1	0	2	2	3	2
Level 11	2	2	2	2	0	2	0	2	2	2	2
Level 10	2	2	2	2	0	3	0	2	2	2	2
Level 9	2	2	2	2	0	3	0	3	3	3	3
Level 8	3	2	2	2	0	4	0	3	3	3	3
Level 7	3	2	3	3	0	5	0	3	3	3	3
Level 6	3	2	3	3	0	6	0	3	3	3	3
Level 5	3	3	3	3	0	6	0	3	3	3	3
Level 4	3	3	3	3	0	7	0	3	3	3	3
Level 3	3	3	3	3	0	8	0	3	3	3	3
Level 2	2	2	2	2	0	6	0	2	2	2	2
Level 1	0	0	0	0	0	6	0	0	0	0	0

50
40
30
20
10
0

Inter-Unit Air Flow, cont.

1. Diminishing returns for air leakage rates below current ASHRAE 62.2 compartmentalization requirement

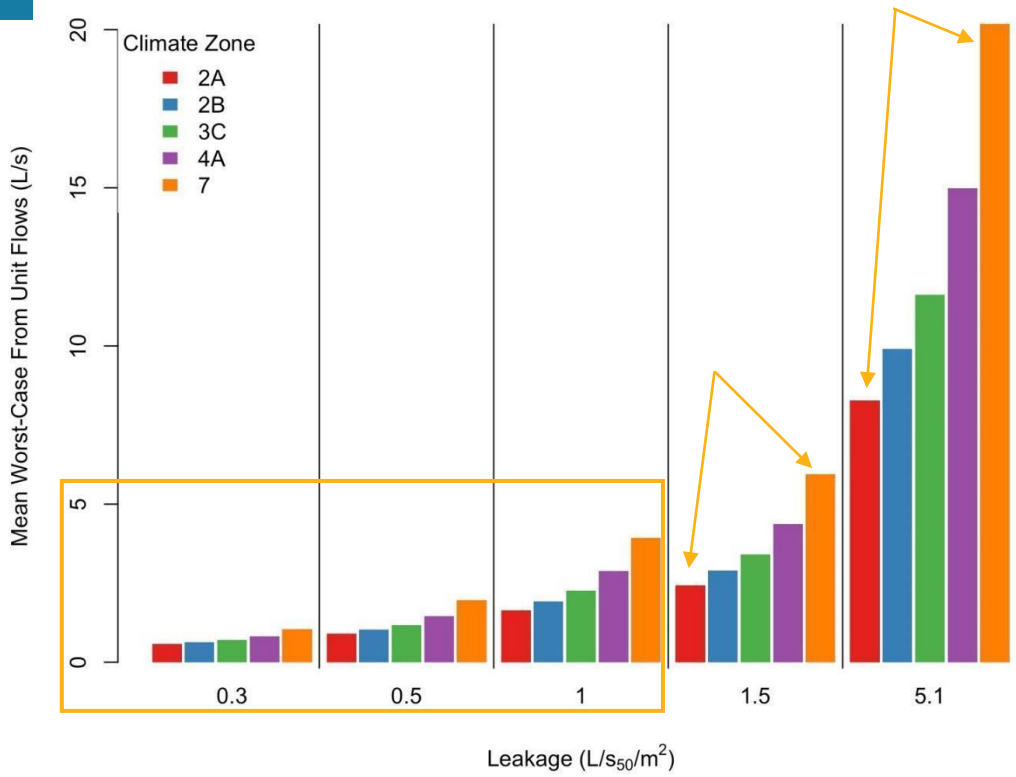
2. No significant difference between ventilation system types



Building-Level Maximum “From Unit” Air Flows (L/s)

Climate vs. Unit Air Leakage

Climate doesn't really matter….unless you have a leaky building



Contaminant Transport (shadow contaminants)

Annual Average Zone CO_2 Concentration (ppm) from Single Source Unit (Shadow Contaminant)
(1.0L/s/m² (0.2cfm$_{50}$/ft²))

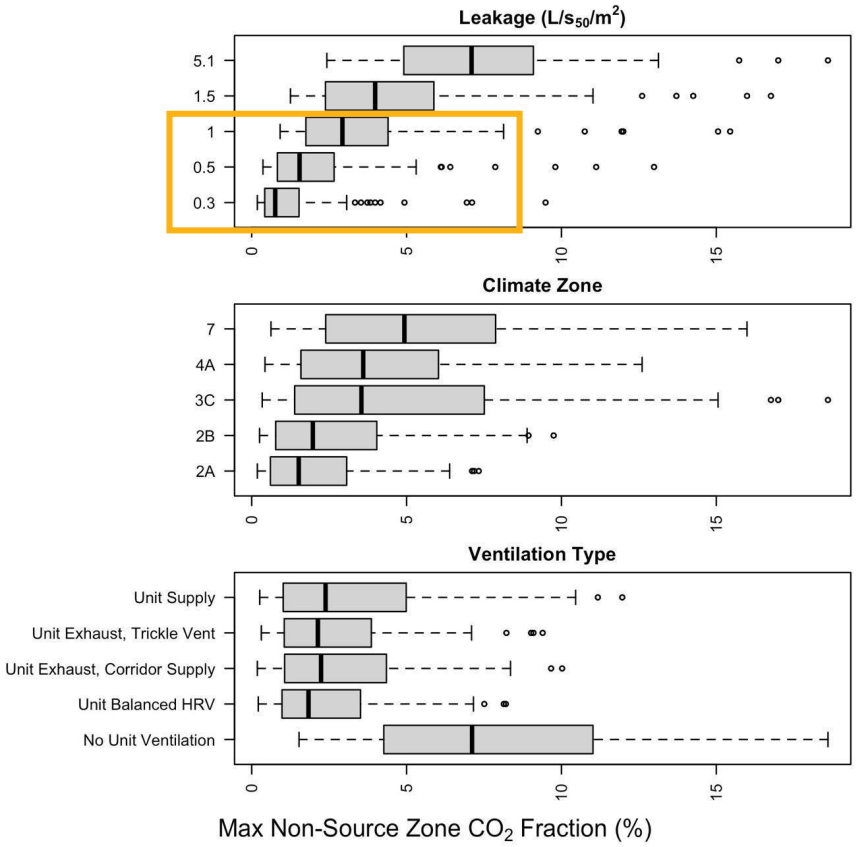
	Apt 1	Apt 2	Apt 3	Apt 4	Elv	Cor	Str	Apt 5	Apt 6	Apt 7	Apt 8
Level 20	0.3	0.3	0.3	0.3	0.7	0.4	0.7	0.3	0.3	0.3	0.3
Level 19	0.3	0.3	0.3	0.3	0.7	0.3	0.7	0.3	0.3	0.3	0.3
Level 18	0.3	0.3	0.3	0.3	0.7	0.3	0.7	0.3	0.3	0.3	0.3
Level 17	0.3	0.3	0.3	0.3	0.7	0.3	0.7	0.3	0.3	0.3	0.3
Level 16	0.3	0.2	0.2	0.3	0.7	0.3	0.7	0.3	0.3	0.3	0.3
Level 15	0.2	0.2	0.2	0.2	0.7	0.3	0.7	0.3	0.3	0.3	0.3
Level 14	0.2	0.2	0.2	0.2	0.7	0.3	0.7	0.2	0.2	0.2	0.2
Level 13	0.2	0.2	0.2	0.2	0.7	0.2	0.7	0.2	0.2	0.2	0.2
Level 12	0.1	0.1	0.1	0.1	0.7	0.2	0.7	0.1	0.2	0.2	0.2
Level 11	0.1	0.1	0.1	0.1	0.7	0.1	0.7	0.1	0.1	0.1	0.1
Level 10	0	0	0	0	0.7	0	0.7	0	0	0	0
Level 9	0	0	0	0	0.7	0	0.7	0	0	0	0
Level 8	0	0	0	0	0.8	0	0.8	0	0	0	0
Level 7	0	0	0	0	0.9	0	0.9	0	0	0	0
Level 6	0	0	0	0	0.9	0	0.9	0	0	0	0
Level 5	0	0.1	0	0	1.1	0	1.1	0	0	0	0
Level 4	0	0.7	0	0	1.3	0	1.3	0	0	0	0
Level 3	0	5.5	0	0	1.7	0	1.7	0	0	0	0
Level 2	[illegible]	46.9	0	0	2.4	0.4	2.4	0.2	0.2	0.2	0.1
Level 1	1.7	618.6	0	0.3	4.3	4.3	4.3	0.9	1.1	1.1	0.8

Highest Non-Source Zone

1000
800
600
400
200
0

Contaminant Transport (shadow contaminants)

Highest Non-Source Zone CO_2, as a Fraction of Total Zone CO_2 (%)



Formaldehyde

- Climate variability

$PM_{2.5}$

- Low fractions (deposition, penetration)

Conclusions

1. **Is the current compartmentalization requirement in ASHRAE 62.2 adequate for controlling cross-contamination in multi-family buildings?**
    - Maximum From-Unit Flows did not exceed 5L/s, assuming current 62.2 compartmentalization target
    - Increasing compartmentalization provided diminishing returns (inter-unit air flow and contaminant transport)
2. **Are different ventilation system types more or less sensitive to compartmentalization?**
    - Ventilation systems performed comparably
    - “Build Tight, Ventilate Right”

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