Using a Aerosol Sealant to Reduce Multifamily Envelope Leakage

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Center for Energy and Environment

2016 Energy Design Conference

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"This educational offering is recognized by the Minnesota Department of Labor and Industry as satisfying **1.5 hours** of credit toward Building **Officials and Residential Contractors code /1 hour** energy continuing education requirements."

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What We Do

- Energy Program Design & Delivery
- Engineering Services
- Lending Center
- Public Policy
- Innovation Exchange
  - Research
  - Education and Outreach

Multifamily Experience

- Facility assessments of over 2,000 buildings in Minnesota
- Completed over 20 research projects

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Current Multifamily Research Projects

PROJECT	ANTICIPATE FINDINGS
• Condensing boiler optimization	Early 2016
• Multifamily ventilation optimization	Early 2016
• Multifamily aerosol envelope air sealing	Mid 2016
• Indoor pool optimization	Late 2016
• Demand controller recirculation loop	Mid 2017

The Conservation Applied Research and Development (CARD) grant program is funded by MN ratepayers, and administered by the Minnesota Department of Commerce, Division of Energy Resources

Opportunity:

- **Existing.** Thousands of leaky units – reduce air infiltration with limited or no added ventilation.

- **New Construction**. Moderately tight with ventilation – seal to nearly eliminate air infiltration and air transfer.

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Challenge:

- **Existing.** No/difficult/costly access to distributed air leaks. 10% to 25% reduction is challenging.

- **New Construction**. Single family approaches only recently starting to carry over to multifamily buildings.

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Envelope Tightness Requirements:

- **Code.** 1 to 3 story buildings must meet 3.0 ACH50 residential requirement. 4+ story buildings - typically use tight materials or assembly to meet prescriptive requirement – not whole envelope test.

- **Green Communities (MHFA)**. EPA ENERGY STAR for multifamily high rise = 0.3 cfm50/sf (4 – 8 ACH50).

- **No requirements prior to 2015.**

Envelope Aerosol Sealing

- Pressurize apartment
- Spray air sealing fog
- Sealant particles build up on gaps as they flow through the leaks

Similar to process used for aerosol duct sealing

How does it do that?

No, really?

(animation video here)

Sealant is GREEN Guard Gold Certified for use in California school and health care facilities

Benefits:

- **Reduced air infiltration energy costs**
- Reduced odor transfer & improved IAQ
- Improved comfort
- Reduced noise transmission
- Simultaneous air leakage testing documents results
- Potential savings for avoided conventional air sealing (?)

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Study Objectives:

Demonstrate sealing capability and evaluate commercialization

- Refine sealing technique – measure leakage and noise transmission reduction & identify sealing locations
- How to incorporate into sealing strategy – preseal “large” leaks and protect horizontal surfaces as necessary
- Time estimates
- Model energy savings and effect on ventilation

1. Sealed 18 units in 3 new construction buildings
2. Sealed 9 units in 3 existing buildings

Aerosol Sealing Process:

Design Visit – Before Construction

1. Identify air tightness goal
2. Describe aerosol sealing process
3. Review air barrier details
4. Specify that leaks with gap width > 3/8” must be sealed or reduced to 3/8”
5. Determine when aerosol sealing will be applied in construction process
6. Discuss “conventional” sealing that may not be necessary (consider fire code)

This is ideal process

Aerosol Sealing Process:

All In One Visit

1. Walk thru to identify pre-sealing & protection requirements (prior to sealing visit?)
2. Pre-seal large gaps & temporary sealing as necessary
3. Site work prep – cover horizontal surfaces
4. Set up sealing equipment
5. Perform sealing
6. Remove coverings
7. Clean surfaces (if necessary)
8. Post-sealing air leakage test
9. Air leakage test when unit finished?

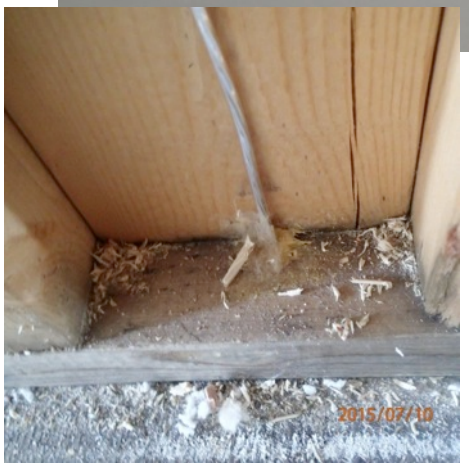
Site Work Prep: pre-seal wide gaps

Sprinkler head

Plumbing penetration

Site Work Prep: pre-seal wide gaps

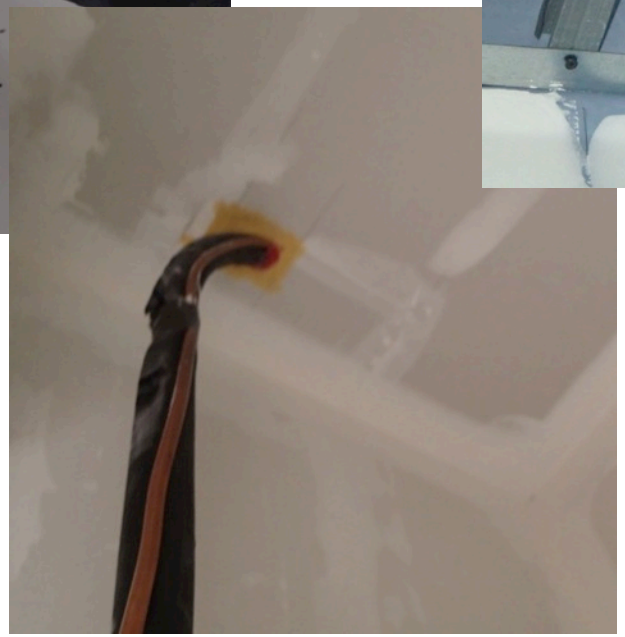
Range electric line



Low-voltage wiring

Site Work Prep: pre-seal wide gaps

AC Line set



Duct – narrow enough to leave?

Site Work Prep: pre-seal wide gaps

Construction	Plumbing	Electrical	Mechanical
Floor wall connection	Showerhead penetration	Range plug	Line sets for HVAC
Sprinkler penetration	Sink penetrations	Electric baseboards	Vent duct penetrations
	Waste line penetrations	Low voltage wiring	Fresh air duct penetration
	Clothes washer connections	Additional wiring penetrations	Combustion and exhaust air penetrations
	Toilet water connection		PTAC wall penetration
	Kitchen water connection		Gas line penetrations (range, HVAC, laundry)

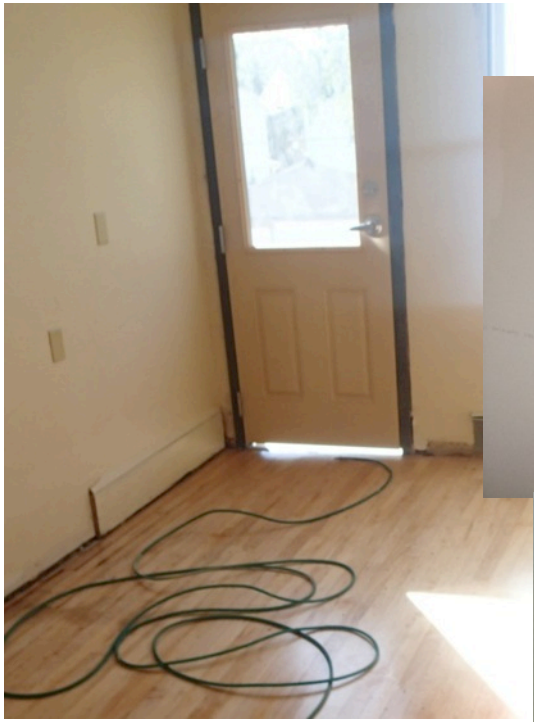
1 to 2 hours/unit

Site Work Prep: baseboards

Seal before quarter round, caulk after?

What about leaky wood floors?

Site Work Prep: temporary sealing

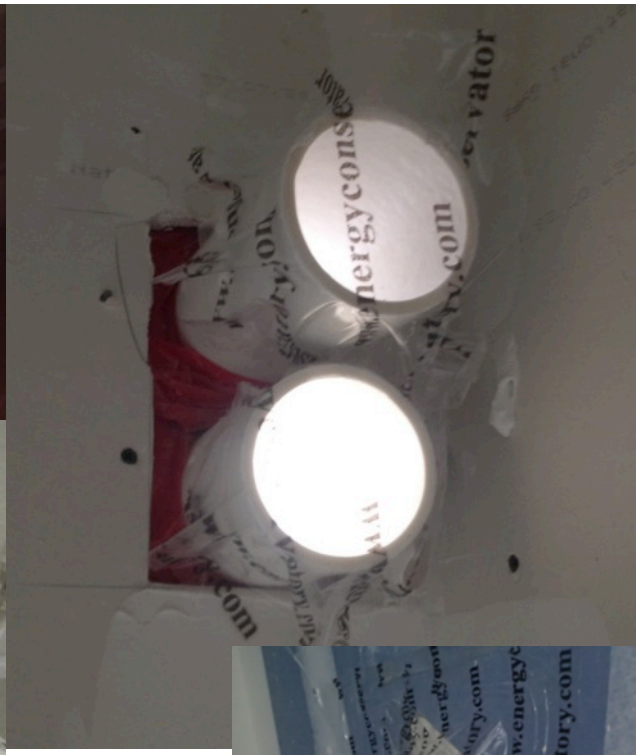


Exterior doors

Exhaust fan ducts

Plumbing penetrations

Combustion vents



Shower handles

Fill traps or cover waste line openings

Site Work Prep: temporary sealing

Construction	Plumbing	Electrical	Mechanical
Door frames	Bathroom handles	Intercom	Bath fan
Floors (i.e. finished hardwood)	Drains	Low voltage outlets	Kitchen fan
Exterior doors (not used for fan frame)	Waste lines	Smoke detectors	Additional ventilation
Large holes/openings in the envelope		Alarms	Combustion and exhaust air
Windows (leaky)		Sprinkler heads	PTAC openings
			Outdoor air intakes
			Forced air registers
			Forced air returns

Site Work Prep: cover horizontal surfaces

Site Work Prep: cover horizontal surfaces

Ideal: drywall mud/tape no other finishes (bare floor better)

Not ideal: ready for occupancy

Site Work Prep: cover horizontal surfaces

Construction	Plumbing	Electrical	Mechanical
Floors	Tub or shower surrounds and floors	Ceiling Fans	Top surface of baseboard heating
Window sills	Toilets, sinks, other bathroom pieces	Light switches	
Window meeting rail and muntins	Plumbing fixtures	Light fixtures	
Door tops and hardware	Sprinkler heads		
Top surface of baseboards, trims, and molding			
Horizontal surfaces of cabinets and built-ins			

Temporary seals & covers: 3 to 7 hours/unit

Site Work:

Set-up, Seal & Breakdown

- Blower door and nozzles
- 100Pa pressurization
- ~ 90% RH maintained
- Open windows & purge

6 to 7 hours/unit

Remove Covers & Pack-up

- Care to not disturb seals
- Minimal clean-up

1.5 to 3.5 hours

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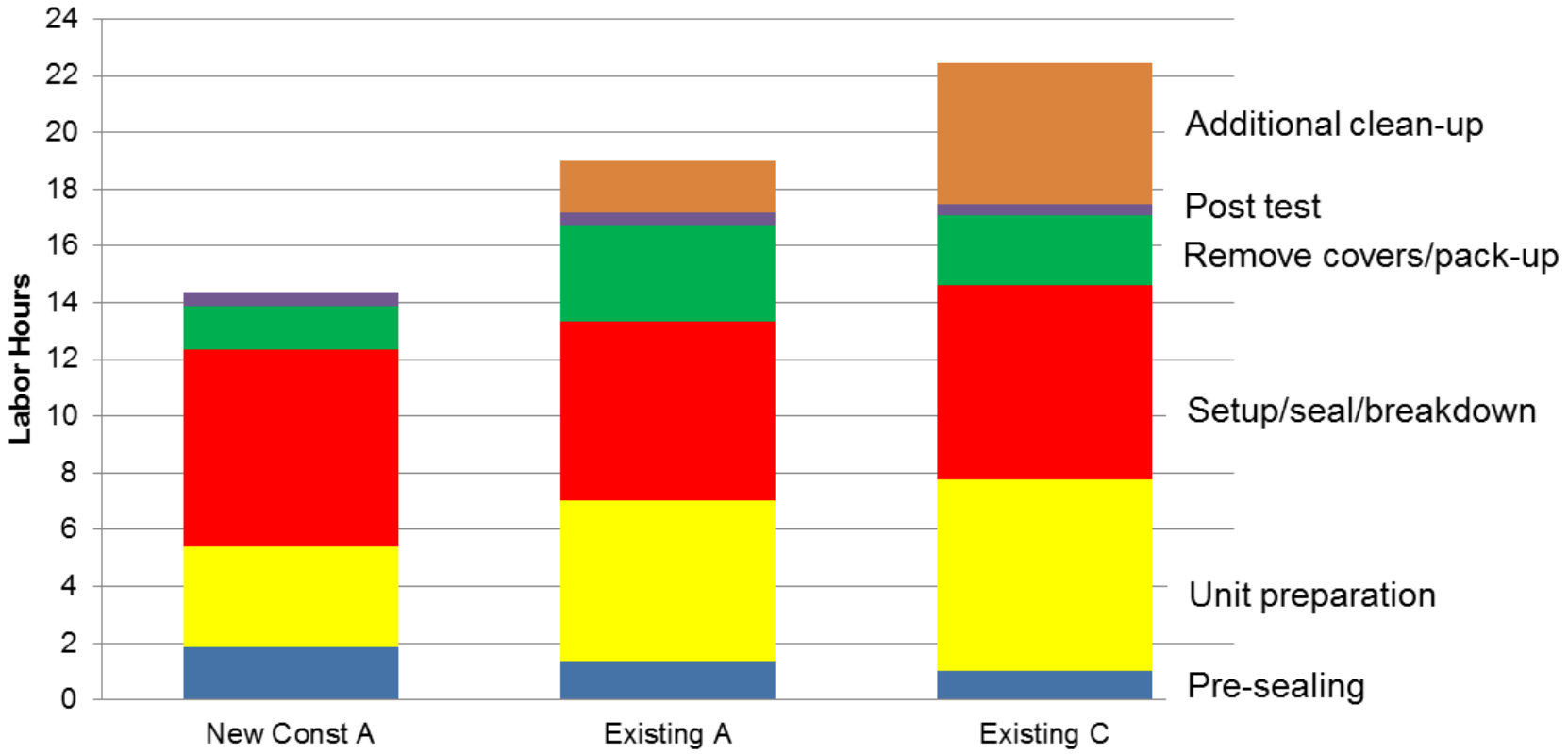
Site Work Prep: how long does it take?



14 – 22 hours: still learning

Site Work Prep: reduce time

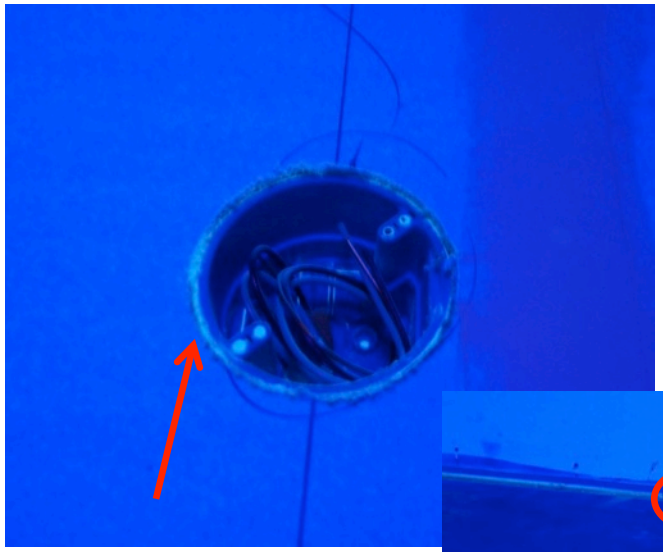
Opportunities to reduce labor time

- Pre-sealing: new construction – GC or sub completes
- Unit preparation: select time during construction when
  - Minimum horizontal surfaces to protect
  - Leaks are accessible
  - Seals will be durable
- Sealing time: new generation of more portable equipment is being developed & stop when no longer cost effective
- Breakdown/clean-up: minimize surfaces to cover and better positioning of spray nozzles

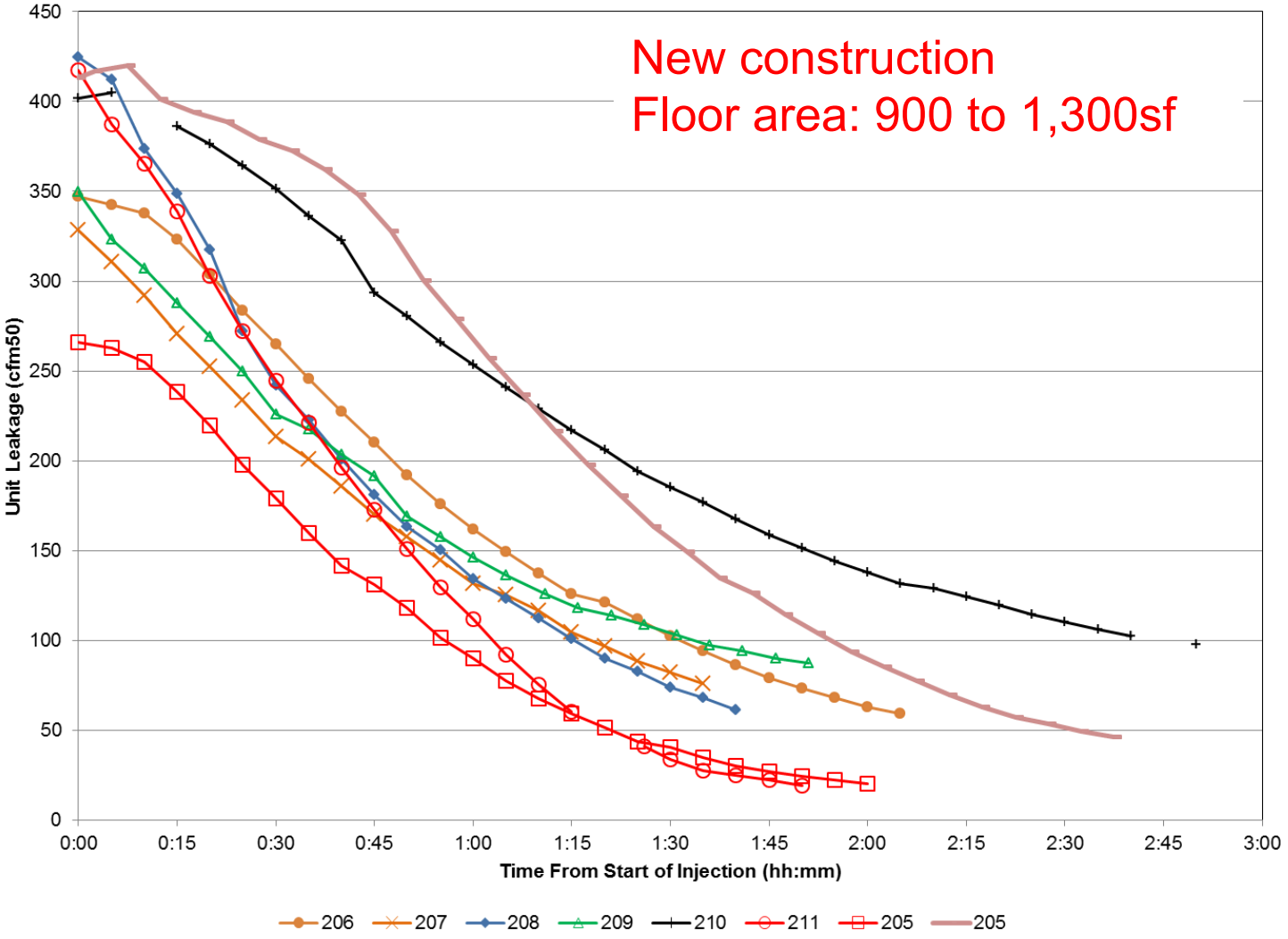
Sealed Penetrations

Sealed Penetrations

Site Work Prep: black light photos

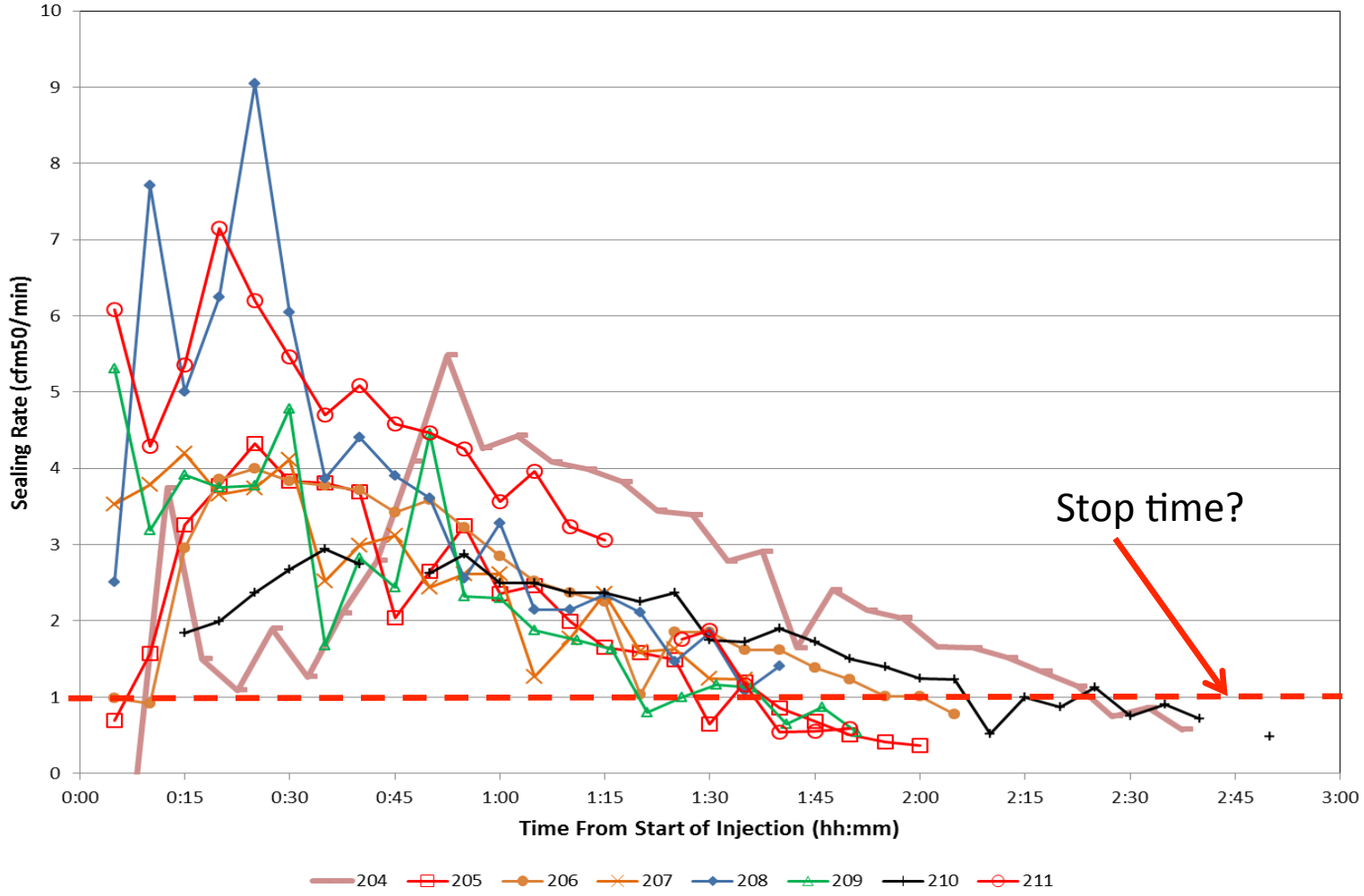


Leakage Reduced Over Injection Period



ACH50 pre: 2.0 – 2.9, post: 0.2 – 0.7; 71% to 94% reduction

Sealing Rate



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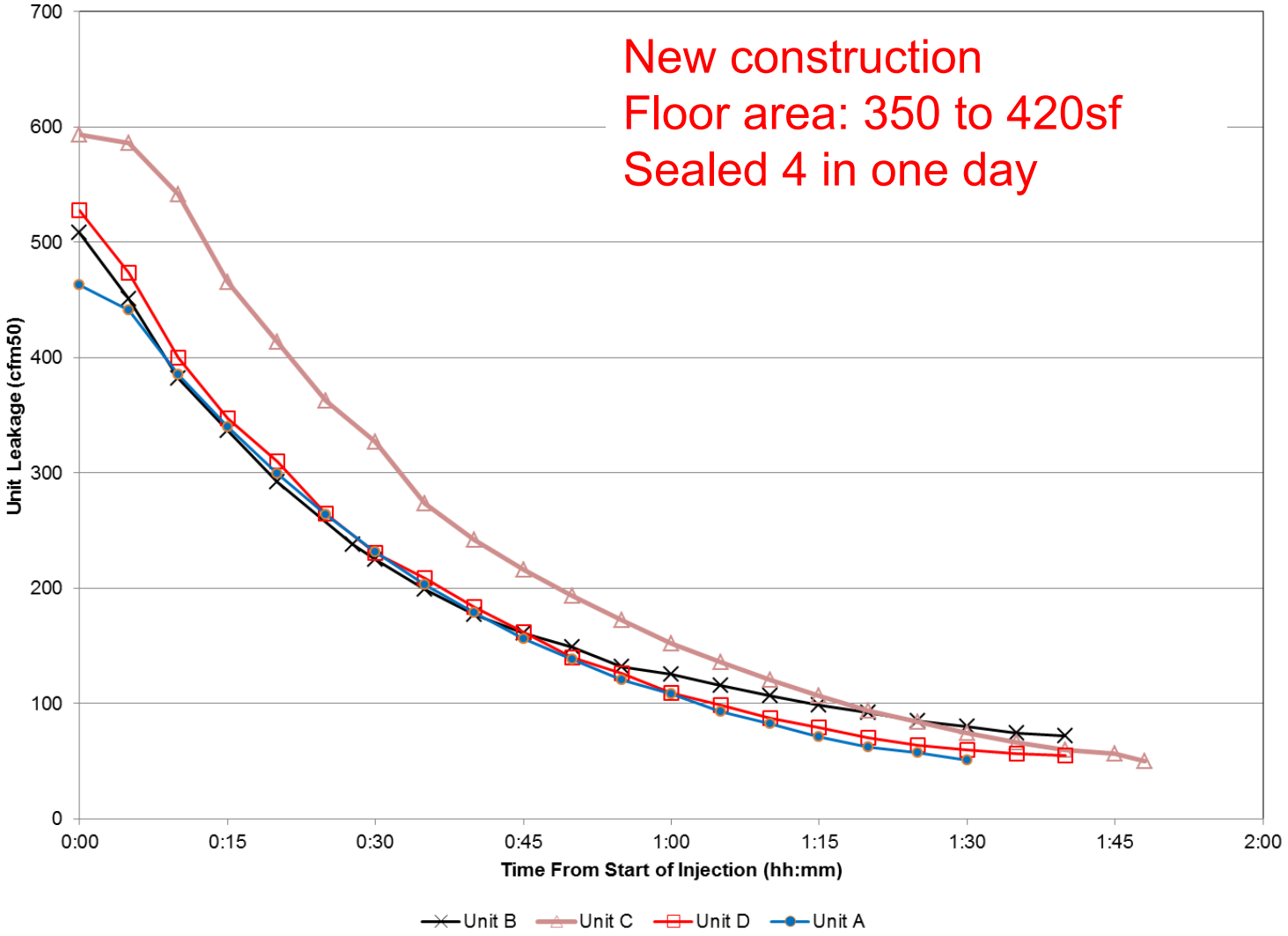
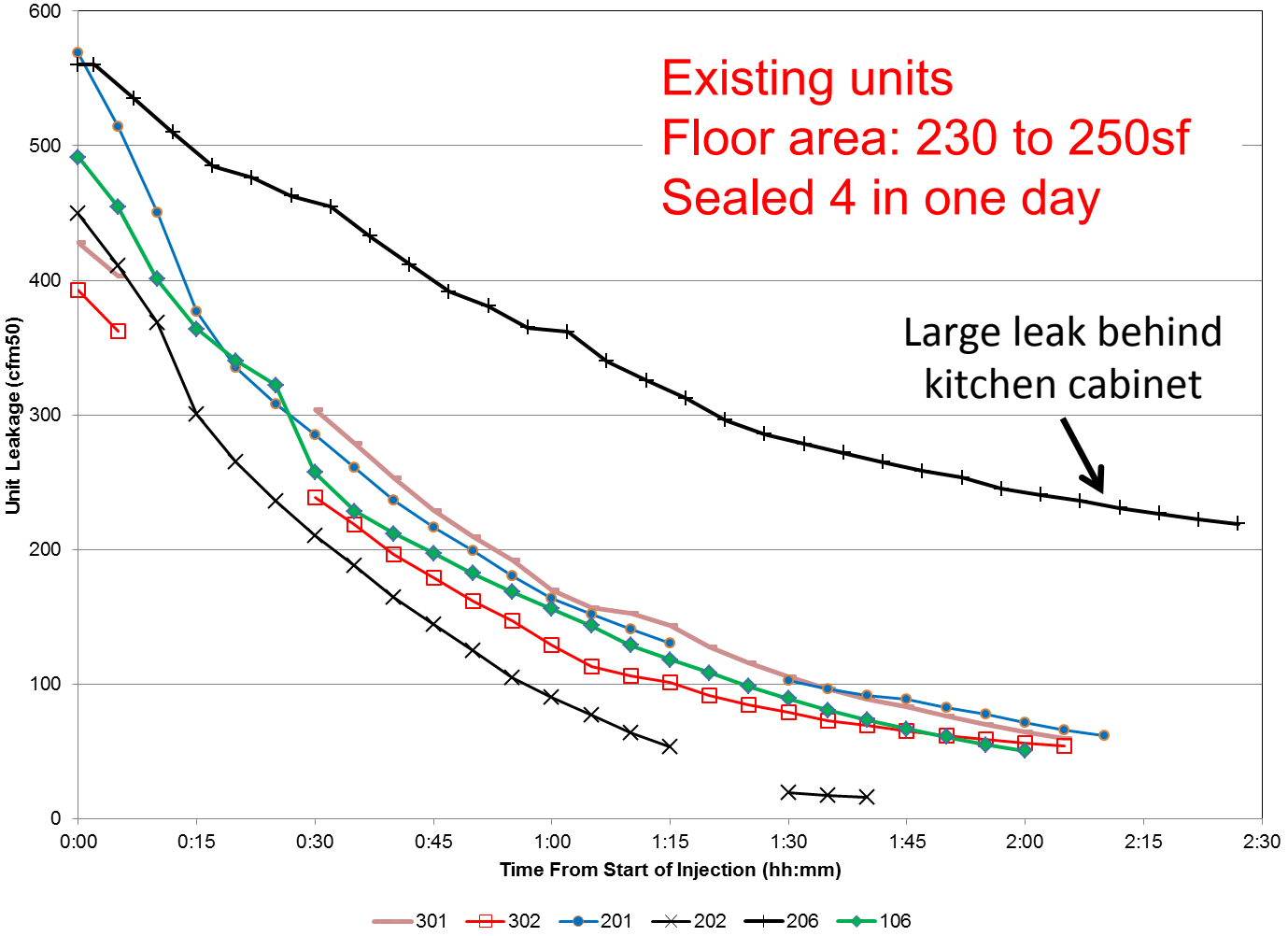


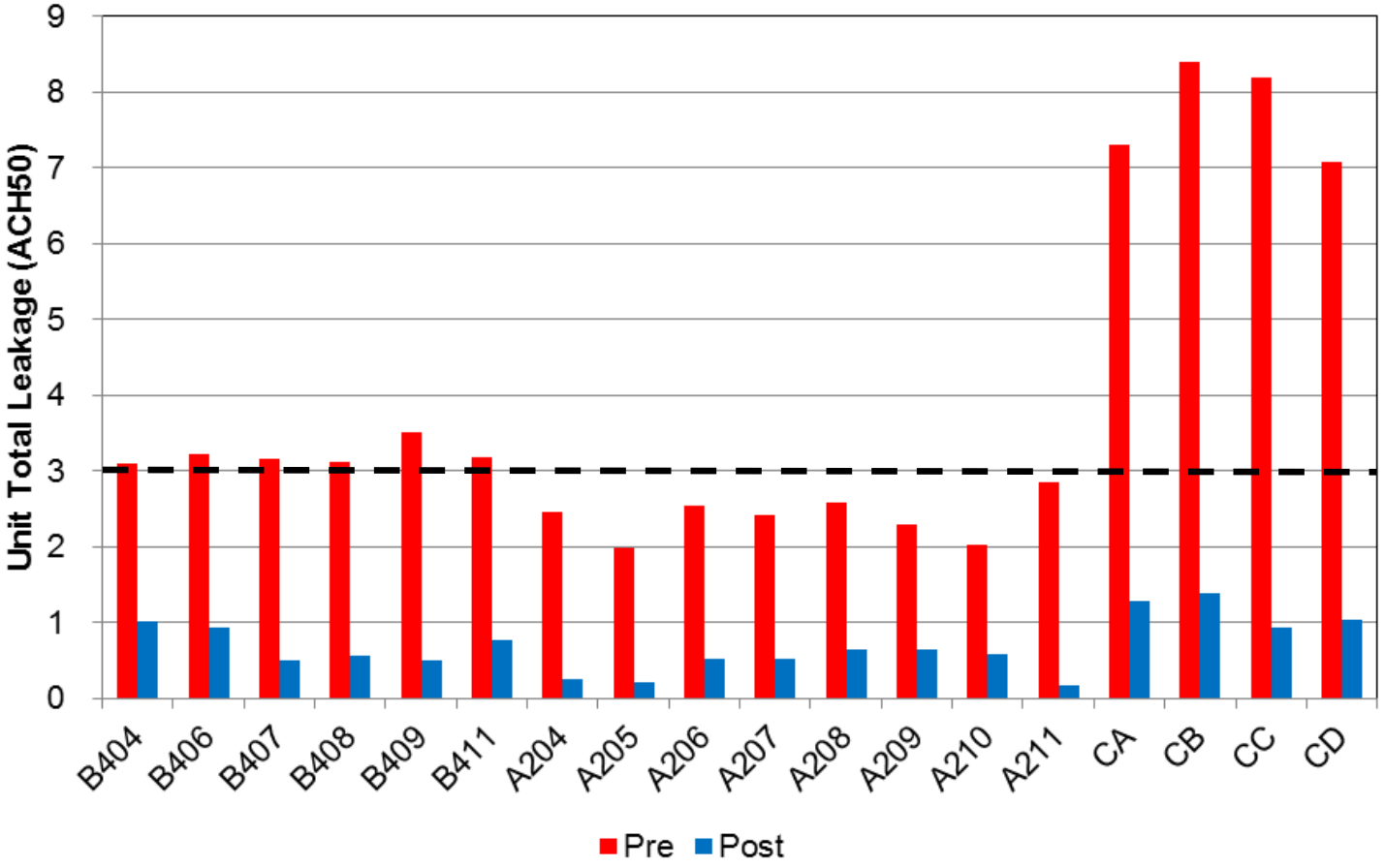
ACH50 pre: 7.1 – 8.4, post: 0.9 – 1.4; 82% to 89% reduction

Leakage Reduced Over Injection Period



ACH50 pre: 12.0 – 17.2, post: 1.4 – 10.5; 39% to 88% reduction

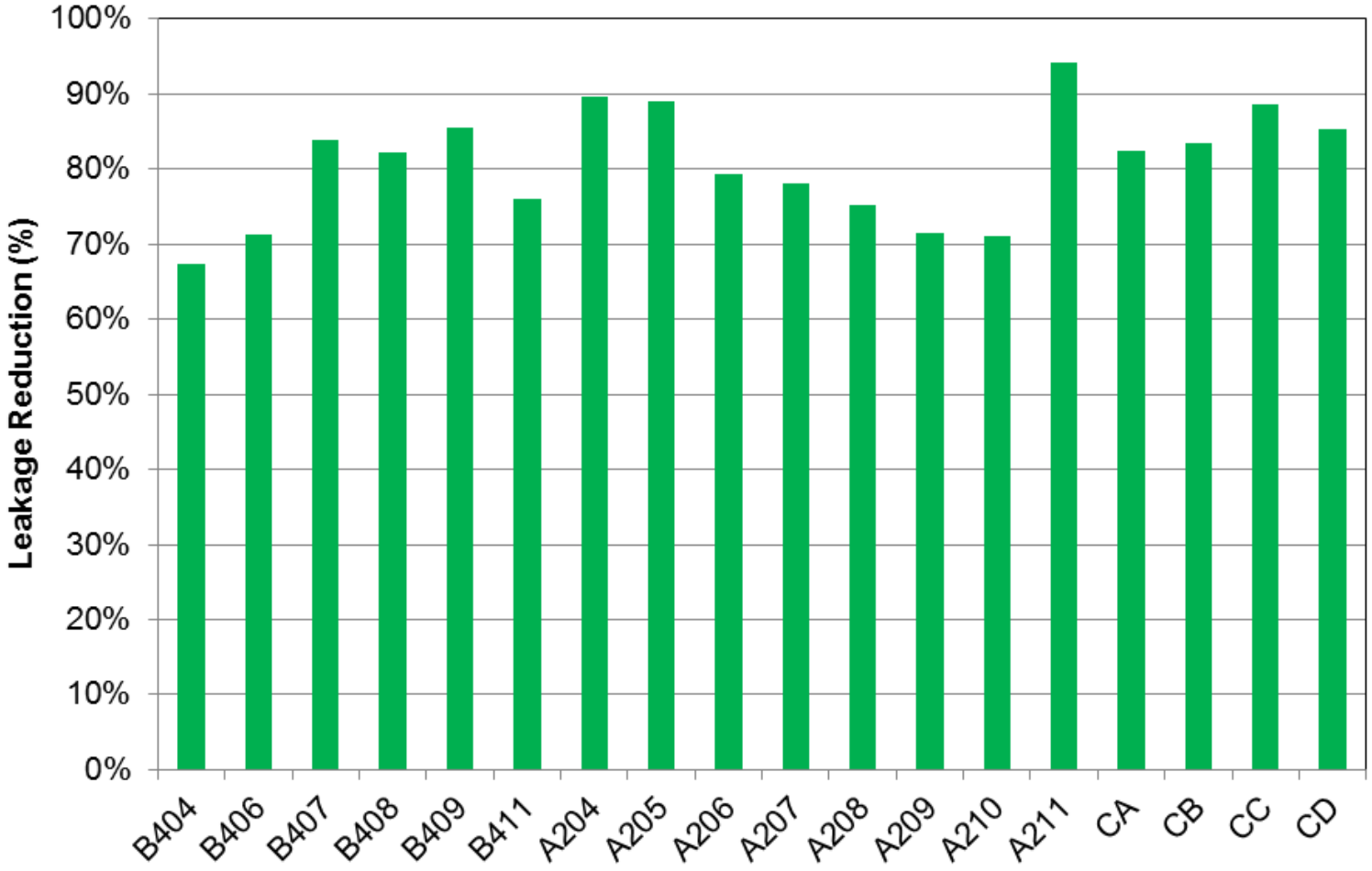
Leakage Results: 18 New Construction Units



1-3 story code requirement

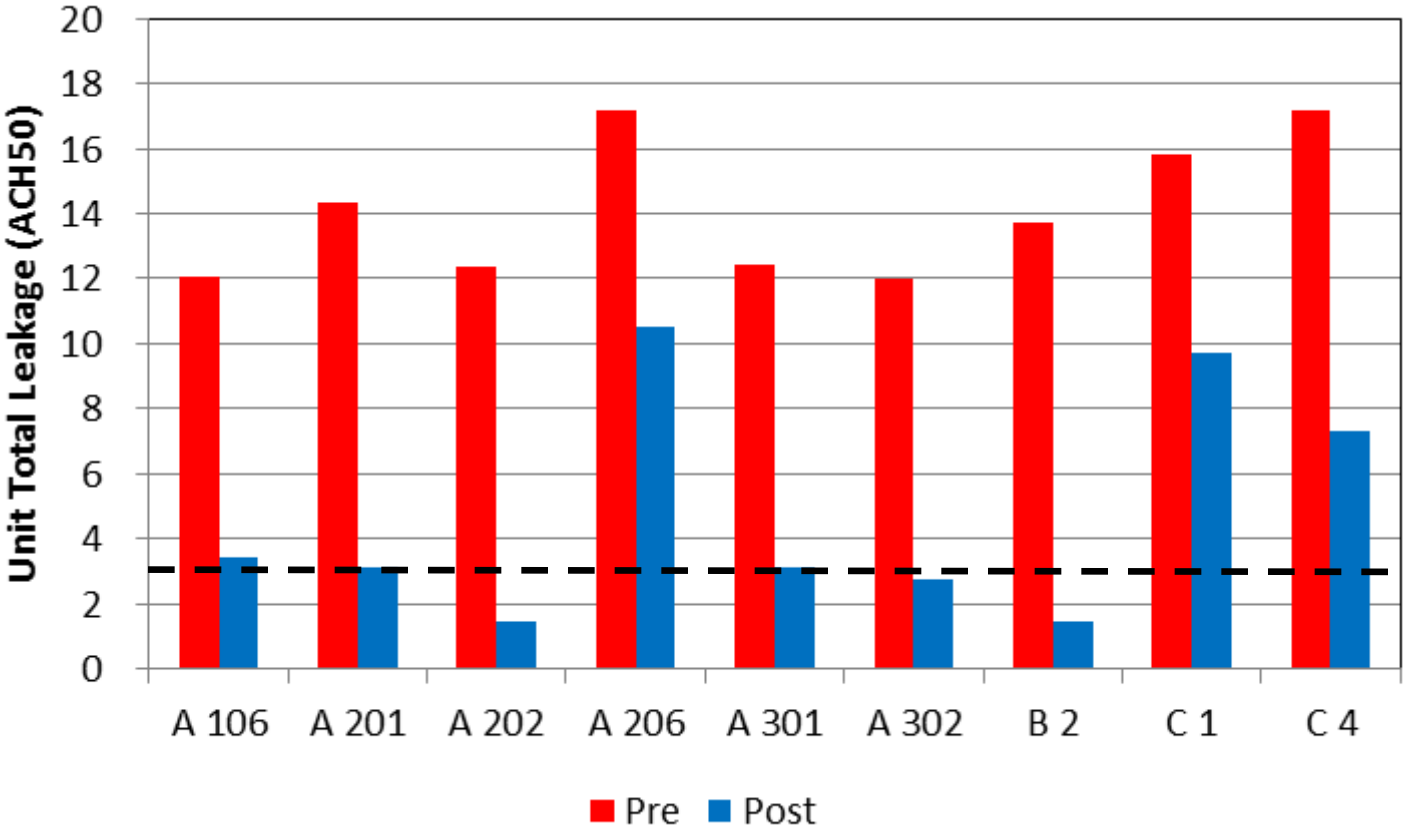
Average leakage: pre= 3.9 ACH50, post= 0.7 ACH50
54% to 95% below code requirement, average= 77%

Leakage Results: New Construction



Reduction: 67% to 94%, average = 81%

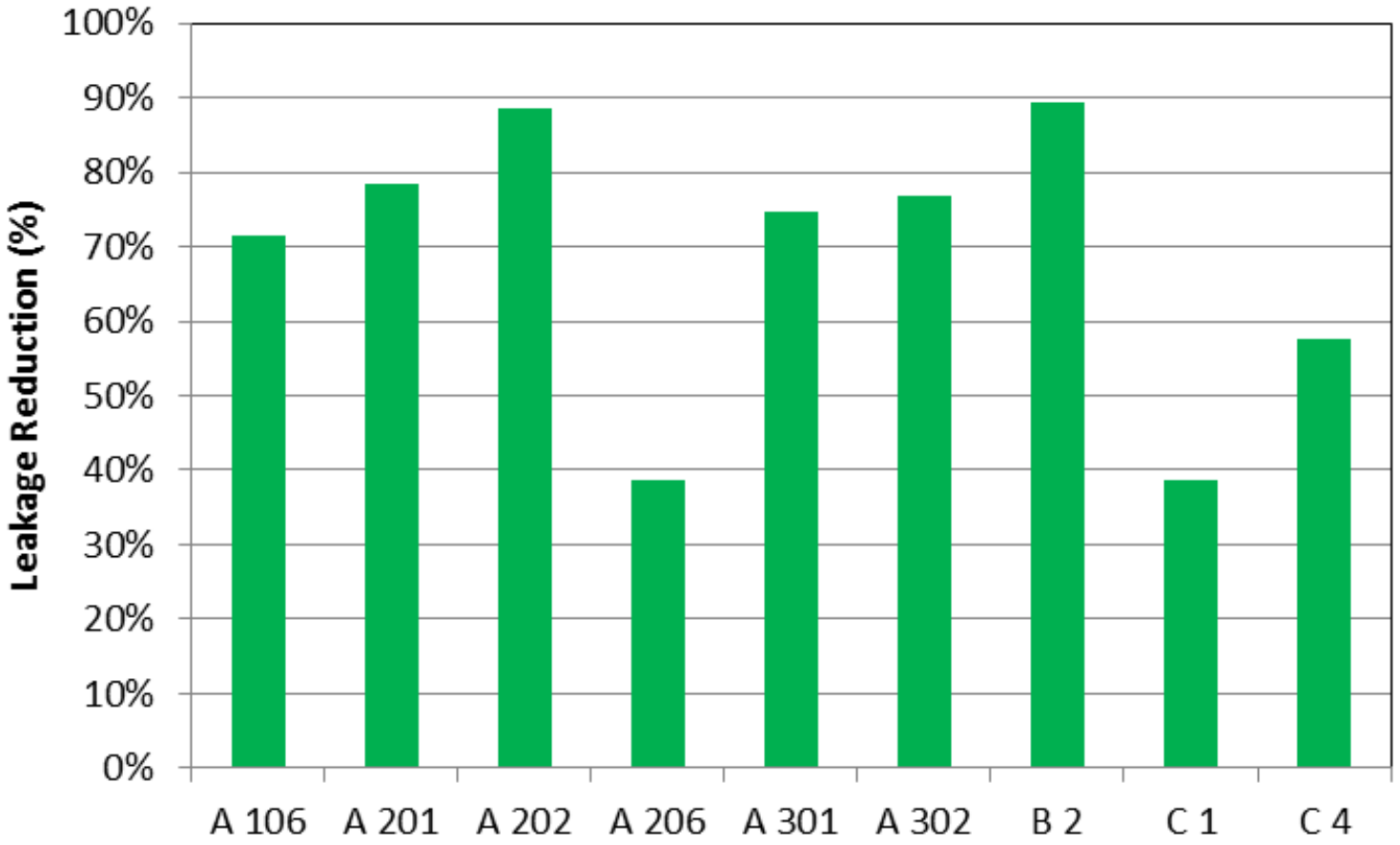
Leakage Results: 9 Existing Units



1-3 story code requirement

Average leakage: pre= 14.1 ACH50, post= 4.8 ACH50
6 of 9 within 15% of new construction code requirement

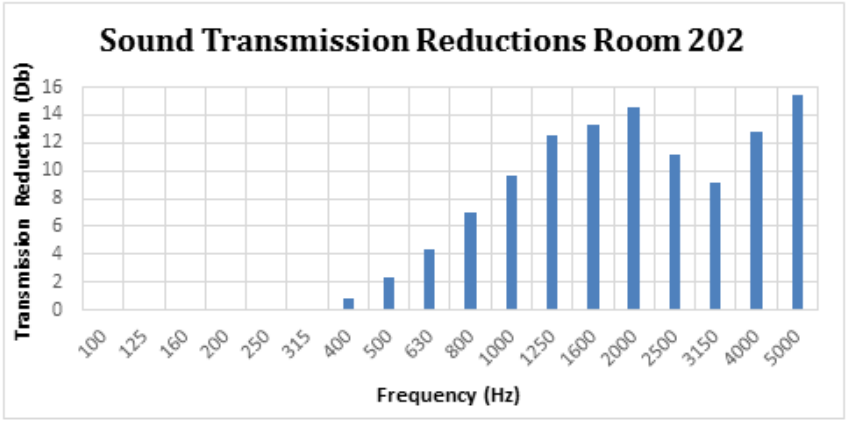
Leakage Results: Existing Units

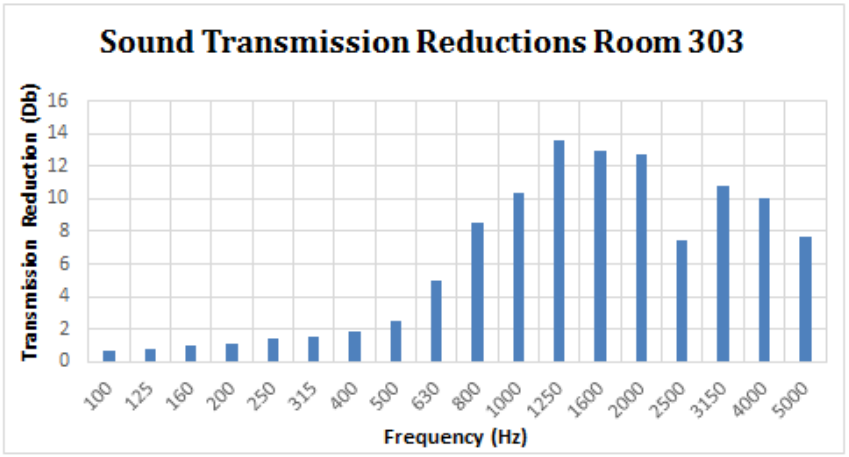


Reduction: 39% to 89%, average = 68%

Reduced Noise Transmission

- Sound transmission testing was conducted in a MF building in NY
- Protocol based on ASTM E90
- Seal was an effective sound barrier between 800-5000 Hz
- Human voice frequency falls between 300-3000 HZ
- Helps to meet Building Code (IBC) requirement of 50 STC

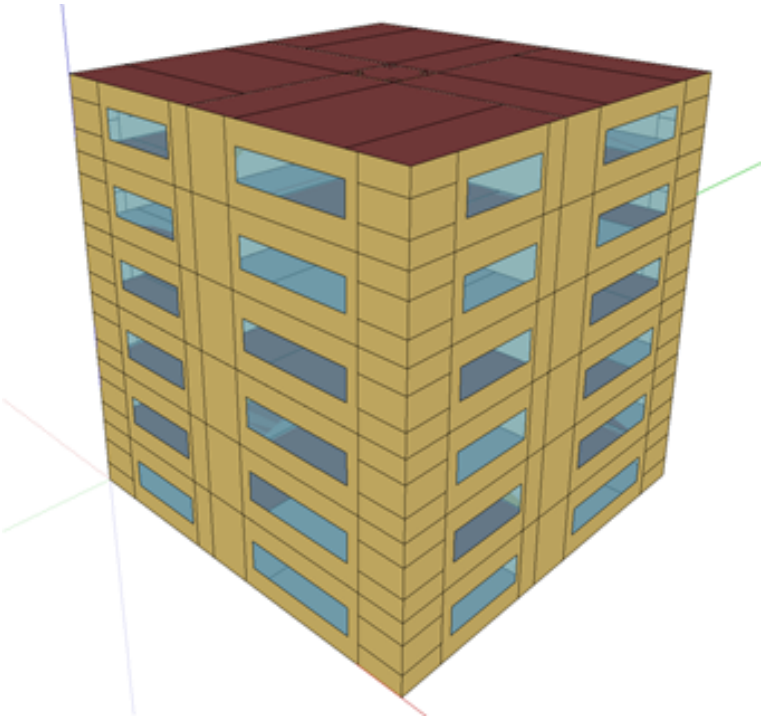




Energy & Ventilation Modeling

- EnergyPlus model: air flows **computed** from leakage paths and wind/stack/ventilation imbalance
- Three levels of tightness:
  - 9.5 ACH50 (leaky/existing)
  - 3.0 ACH50 (new code)
  - 0.6 ACH50 (aerosol sealed)
- Ventilation systems (0.35ach = 70cfm rqd):
  - balanced
  - exhaust only
  - supply = half of exhaust
  - none

6 story, 4 units/floor
1,200sf/unit

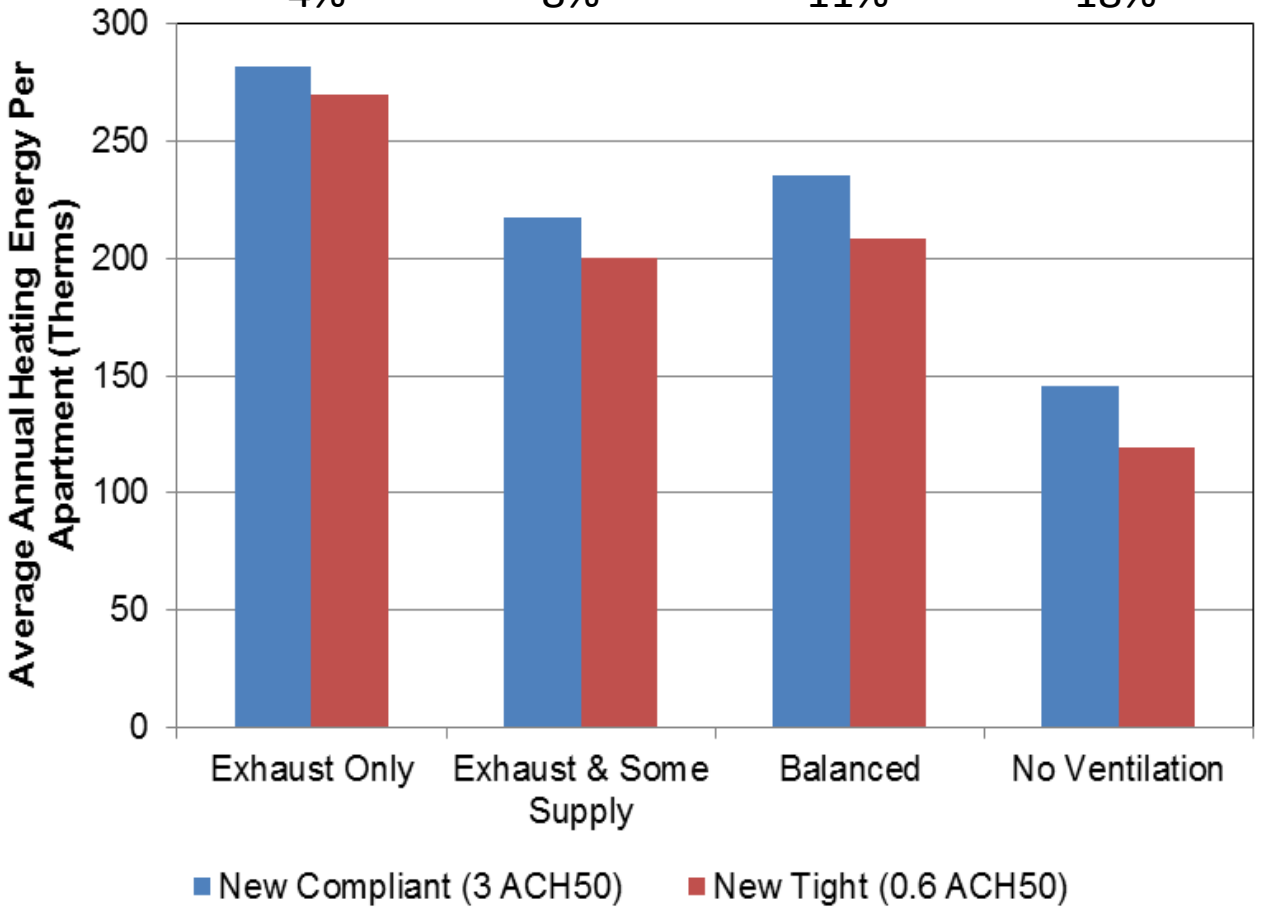


Leakage Distribution
Exterior = 28%
Hallway = 51%
Adj Unit = 16%
Ceiling = 5%

Energy & Ventilation Modeling

New Construction

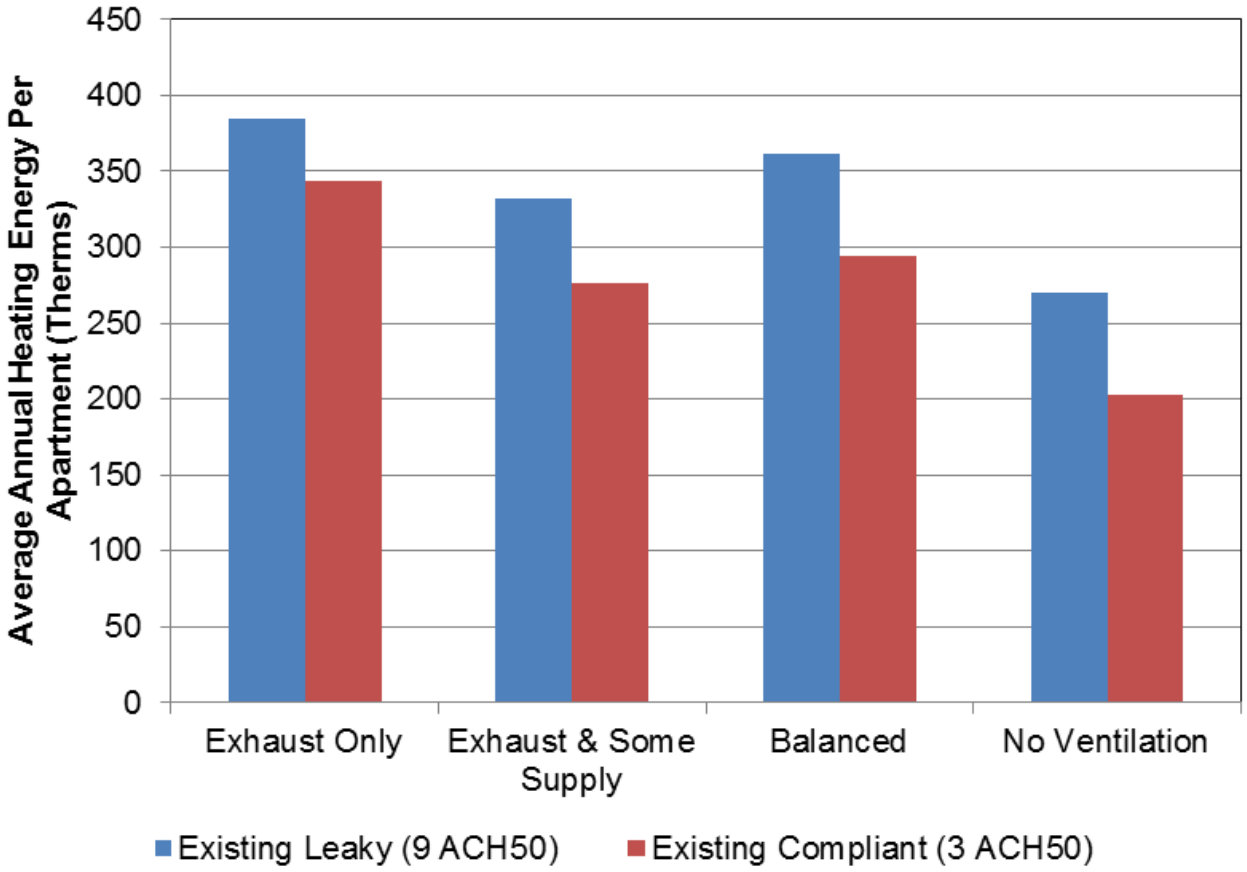
Therm/yr	12	17	27	26
$/yr	$7	$10	$16	$15
	4%	8%	11%	18%



Energy & Ventilation Modeling

Existing Units

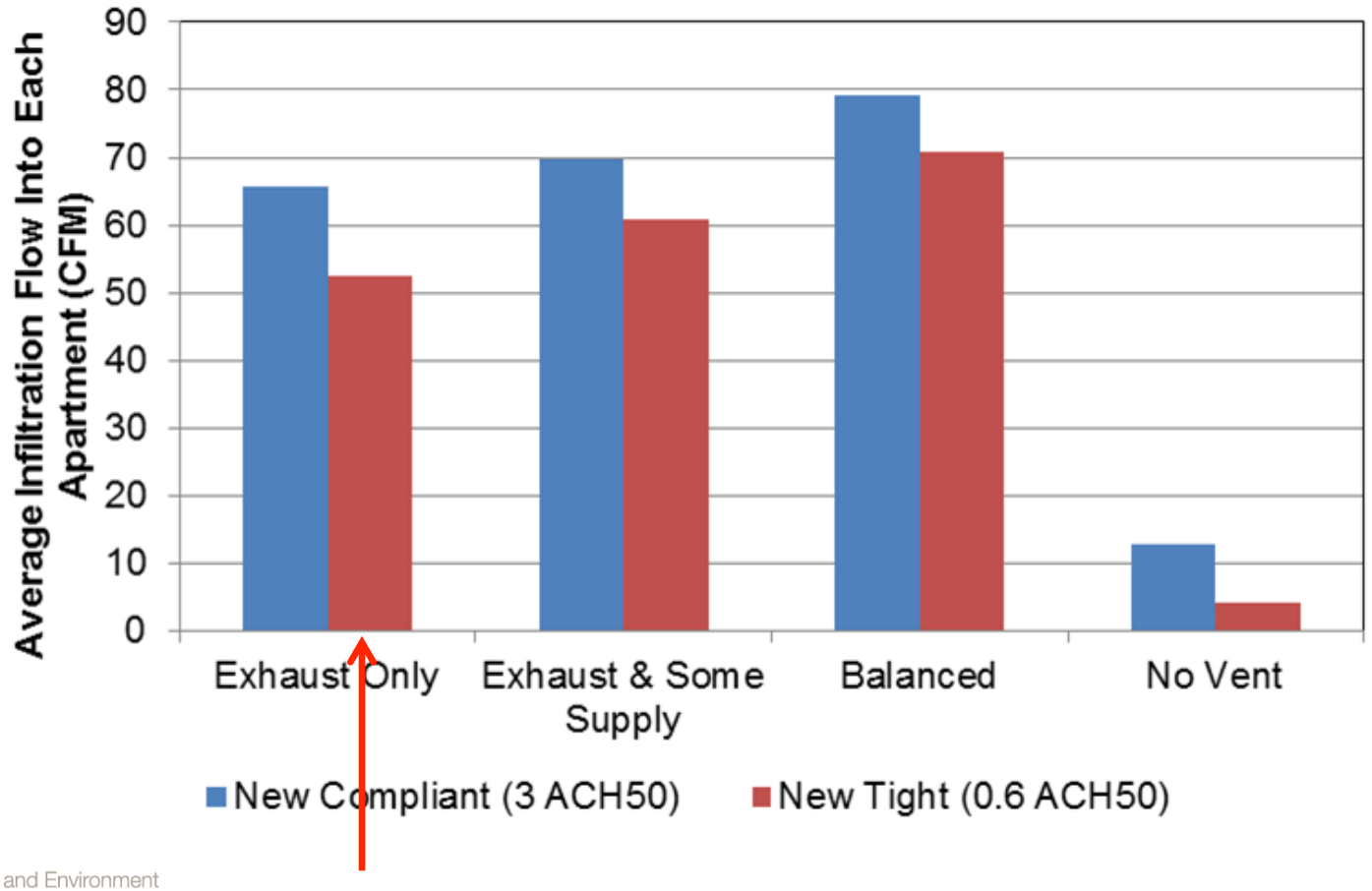
Therm/yr	41	56	67	68
$/yr	$24	$33	$39	$39
	11%	17%	19%	25%



Energy & Ventilation Modeling

New Construction

Outside Air Ventilation & Infiltration

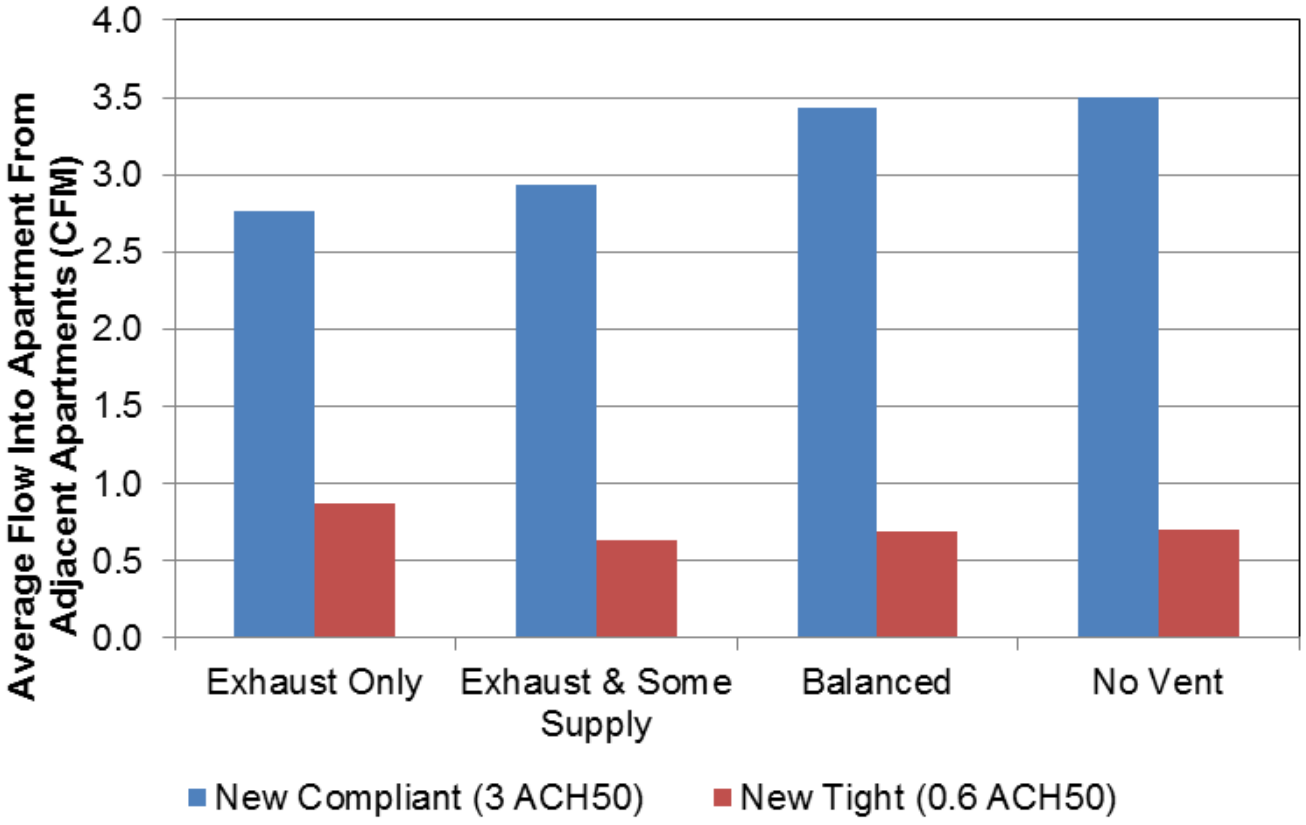


0.6 ACH50 = 96 cfm50; depressurization???

Energy & Ventilation Modeling

New Construction

Flow From Adjacent Apartment

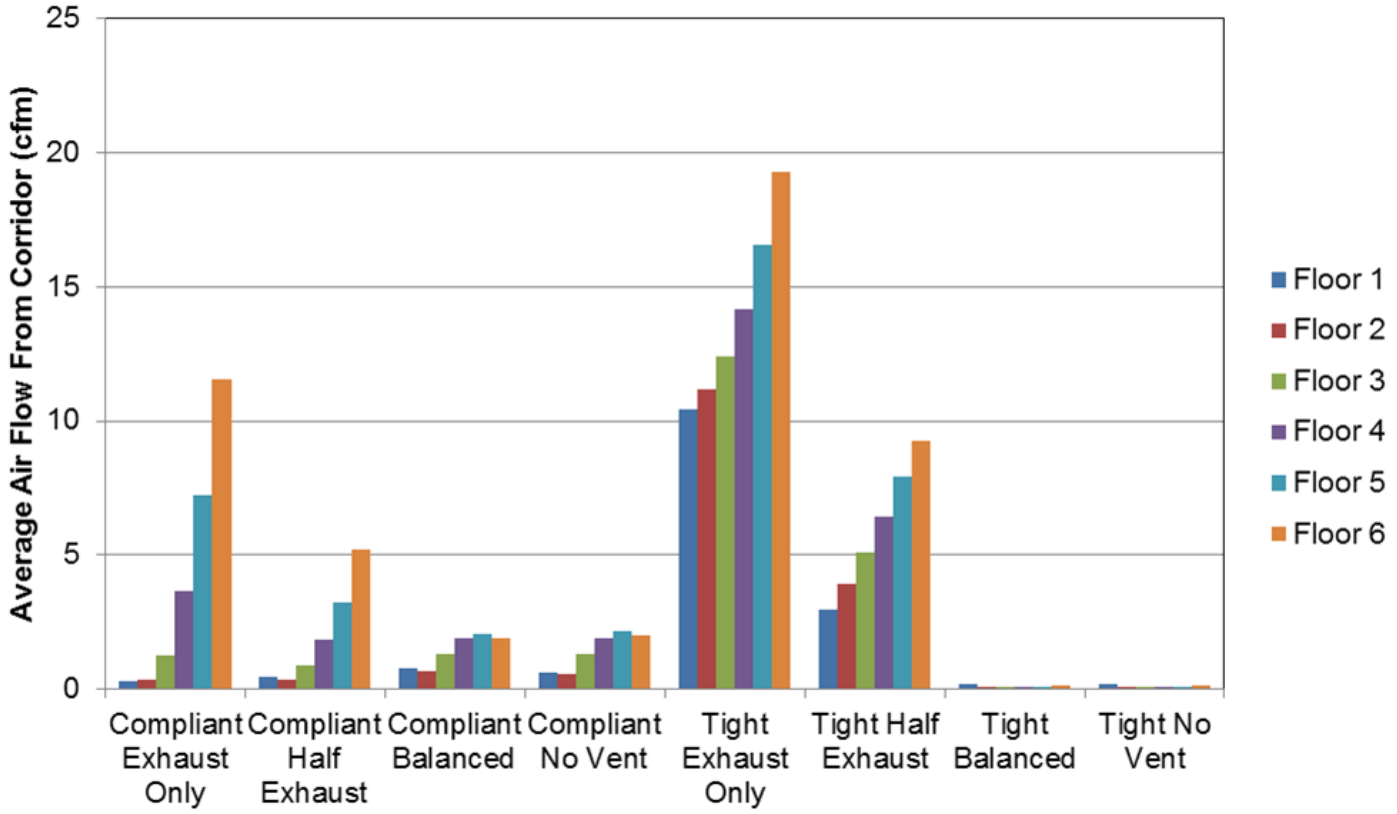


68 to 80% Reduction

Energy & Ventilation Modeling

New Construction

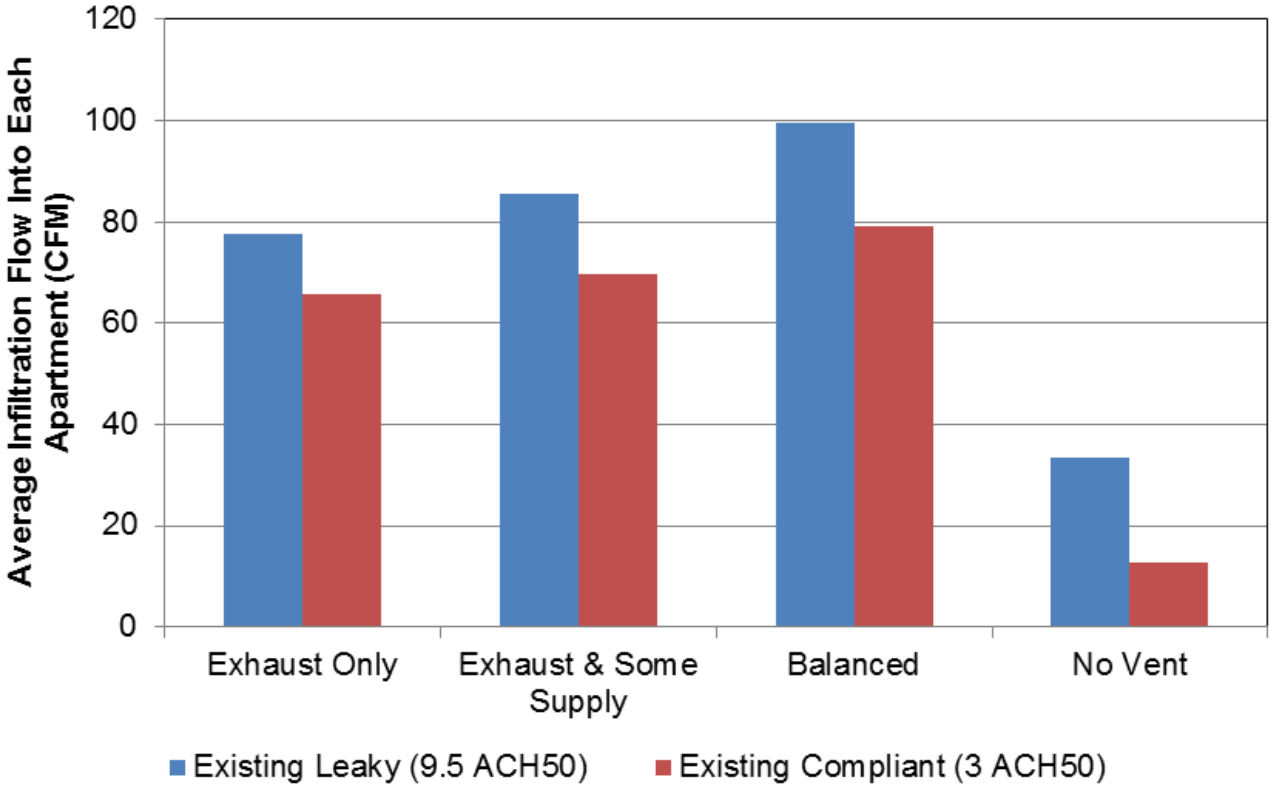
Flow From Corridor



Energy & Ventilation Modeling

Existing Units

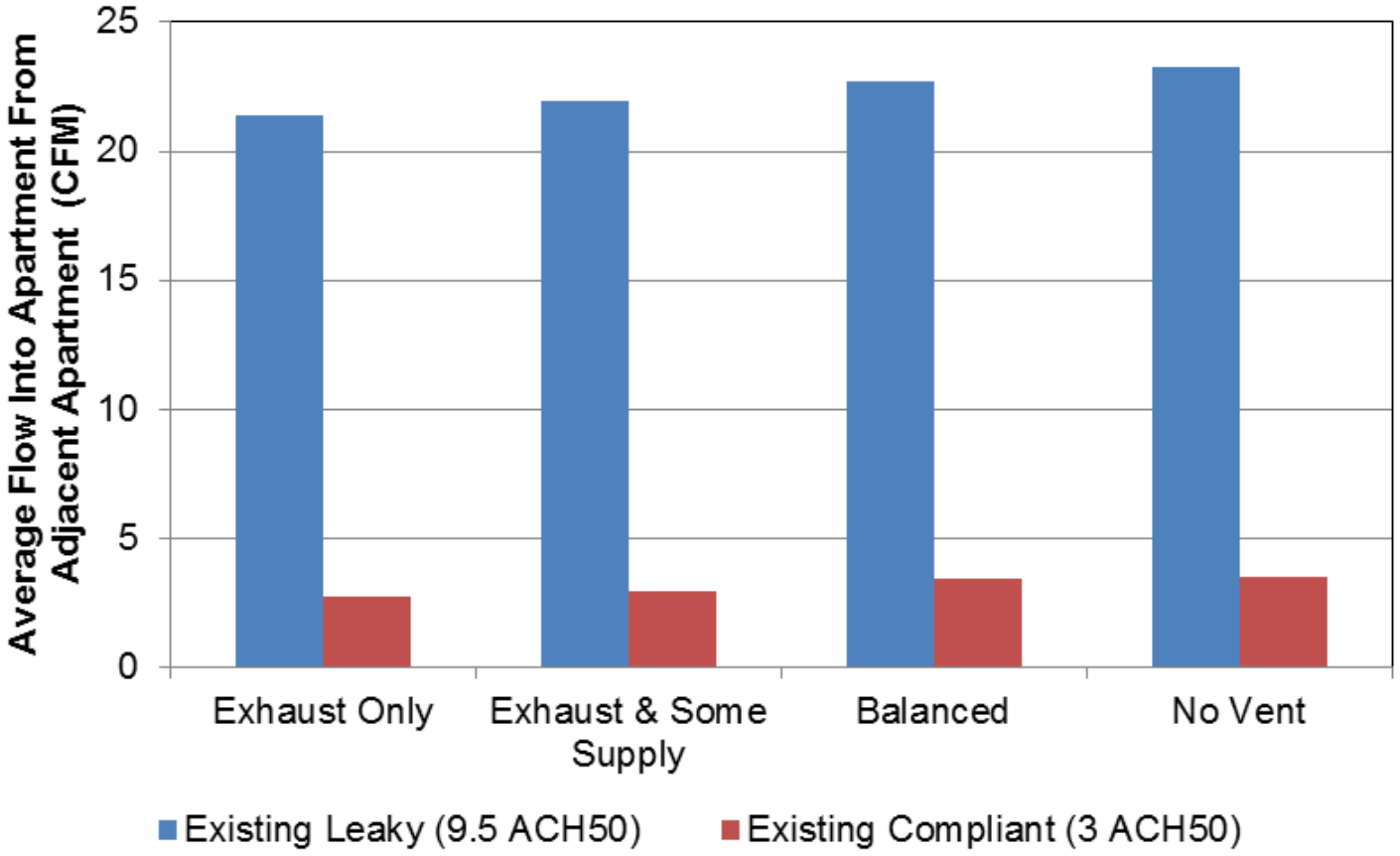
Outside Air Ventilation & Infiltration



Energy & Ventilation Modeling

Existing Units

Flow From Adjacent Apartment

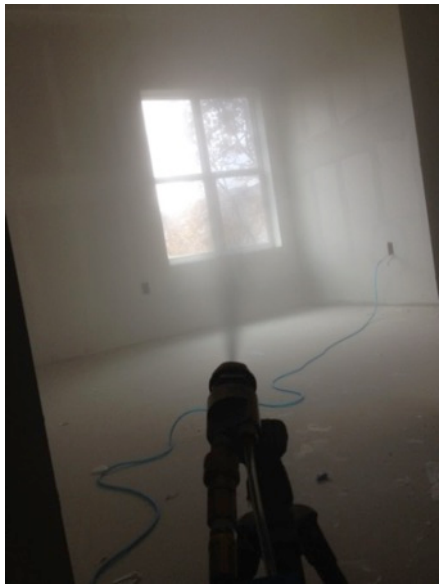


85% to 87% Reduction

Air Sealing at Lower Cost?

Aerosol

- Prep
- Sealing process
- Simultaneous air leakage testing ensures results



Vs.

Manual air sealing

i.e. caulking/foaming

- Architectural specification
- Labor
- Air leakage test

=> Uncertain results

Conclusions

- Not a solution for large air leak gaps
- When aerosol envelope sealing can be used
  - New construction
  - Rehab
  - Change in occupancy (higher cost)
- New construction
  - 81% reduction & 77% below code
  - Heating savings= 27 therms/yr, 11%
  - 80% reduction in flows from adjacent units
- Existing units
  - 68% reduction & 6 of 9 within 15% new code
  - Heating savings= 67 therms/yr, 19%
  - 85% reduction in flows from adjacent units
- Balanced ventilation is crucial for new construction, exhaust or supply OK for existing
- Can you eliminate some “conventional” sealing? If not, too costly?

THANK *you!*

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