Using an Aerosol Sealant to Reduce Multifamily Envelope Leakage

Russ Landry PE | Senior Mechanical Engineer

Center for Energy and Environment

2017 MEEA Energy Codes Conference

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Project Team & Funding

- Center for Energy and Environment
  - Dave Bohac, Ben Schoenbauer and Jim Fitzgerald
  - Kirk Kolehma and Megan Hoye
- UC Davis Western Cooling Efficiency Center
  - Curtis Harrington
  - Mark Modera and Jose Garcia
- The Energy Conservatory

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CEE - What We Do

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

Benefits:

- Reduced air infiltration energy costs
- Reduced odor transfer & improved IAQ
- Improved comfort from reduced drafts
- Reduced noise transmission (neighbors and outside)
- Improved envelope durability
- Reduced stack effect

Envelope Sealing Challenges:

- **Existing buildings.** No/difficult/costly access to distributed air leaks. 10% to 30% reduction is challenging.

- **New Construction**. Single family approaches only recently starting to carry over to multifamily buildings. How can we do this more effectively for both exterior leakage and compartmentalization?

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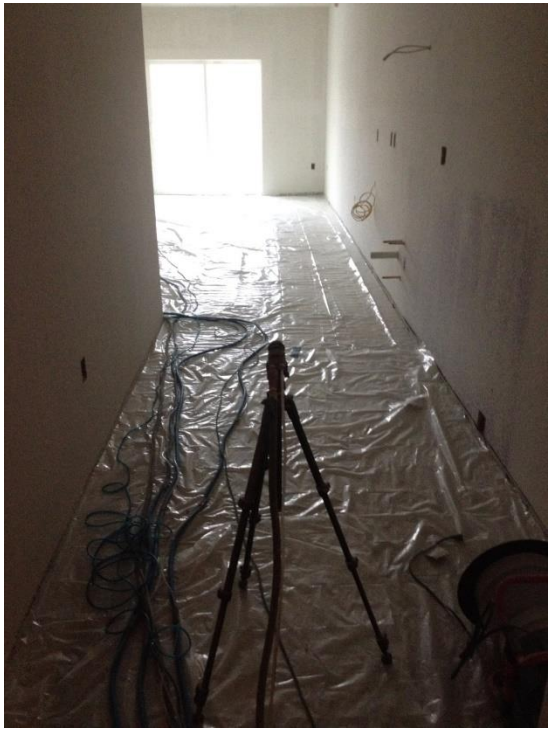
Envelope Tightness Requirements:

- **Minnesota Energy Code (2015).**
  - SF and 1 to 3 story MF: 3.0 ACH50
  - 4+ story MF: 0.4 cfm75/sf
    typically met by either **Materials** (0.004 cfm75/sf) or **Assemblies** (0.04 cfm75/sf) prescriptive options
- **Green Communities (MHFA)**. EPA ENERGY STAR for multifamily high rise = 0.3 cfm50/sf (4 – 8 ACH50)
- **LEED**.
  - Prerequisite. 1-3 story: 3.0 ACH50; 4-8 story: 0.3 cfm50/sf; 9+ story: continuous air barrier.
  - Secondhand smoke. 9+ story prereq. & credits

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 a synthetic acrylic – typically rolled or sprayed on for monolithic, elastomeric exterior air barrier. Diluted for aerosol application.

Sealant is low VOC: GREEN Guard Gold Certified for use in California school and health care facilities.

Aerosol Benefits:

- Automatically finds and seals leaks
- Very effective at sealing small, diffuse leaks
- Continuous update of leakage during sealing
- Reliably meet air tightness requirements
- 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:

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?

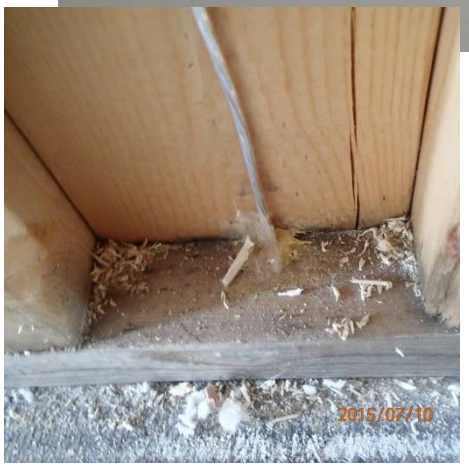
Site Work Prep: pre-seal wide gaps

Sprinkler head

Plumbing penetration

Site Work Prep: pre-seal wide gaps

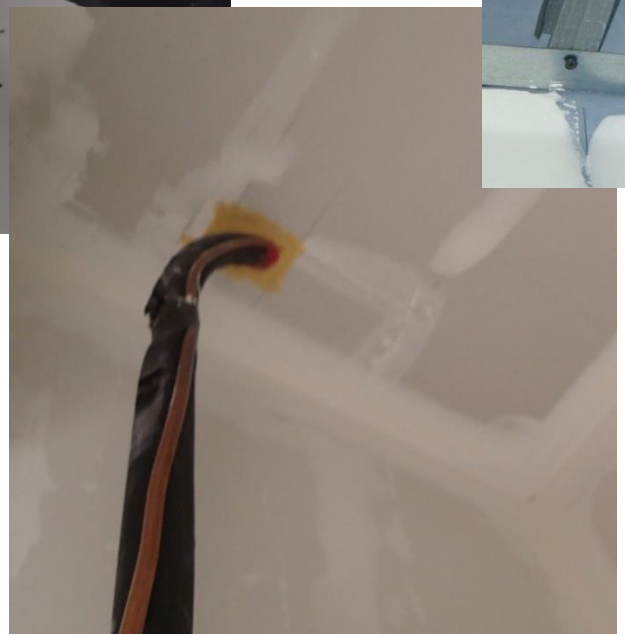
Range electric line



Low-voltage wiring

Site Work Prep: pre-seal wide gaps

AC Line set



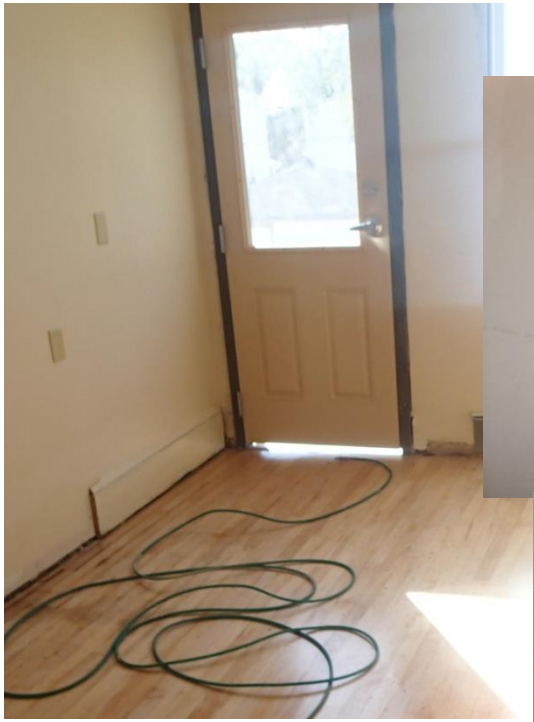
Duct – narrow enough to leave?

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: temporary sealing

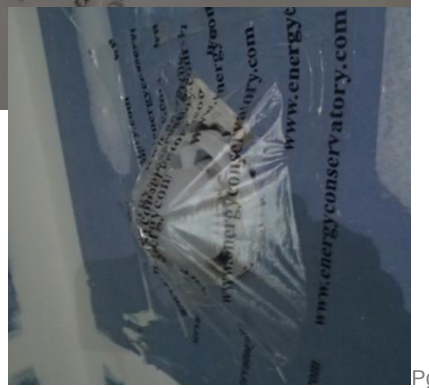


Exterior doors

Exhaust fan ducts

Plumbing penetrations

Combustion vents



Shower handles

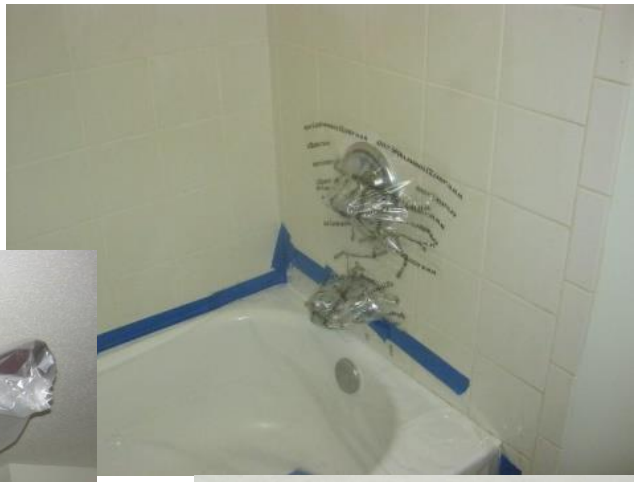
Fill traps or cover waste line openings

Site Work Prep: cover horizontal finished surfaces

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

Not ideal: ready for occupancy

Site Work Prep: cover horizontal finished surfaces



Site Work Prep: cover horizontal finished surfaces

Construction	Plumbing	Electrical	Mechanical
Finished 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

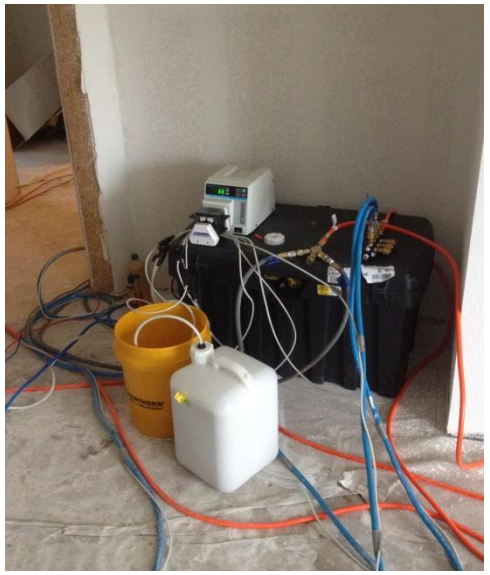
- Blower door and nozzles
- 100Pa pressurization
- ~ 90% RH maintained
- Open windows & purge

6 to 7 person-hours/unit

Remove Covers & Pack-up

- Care to not disturb seals
- Minimal clean-up

1.5 to 3.5 hours



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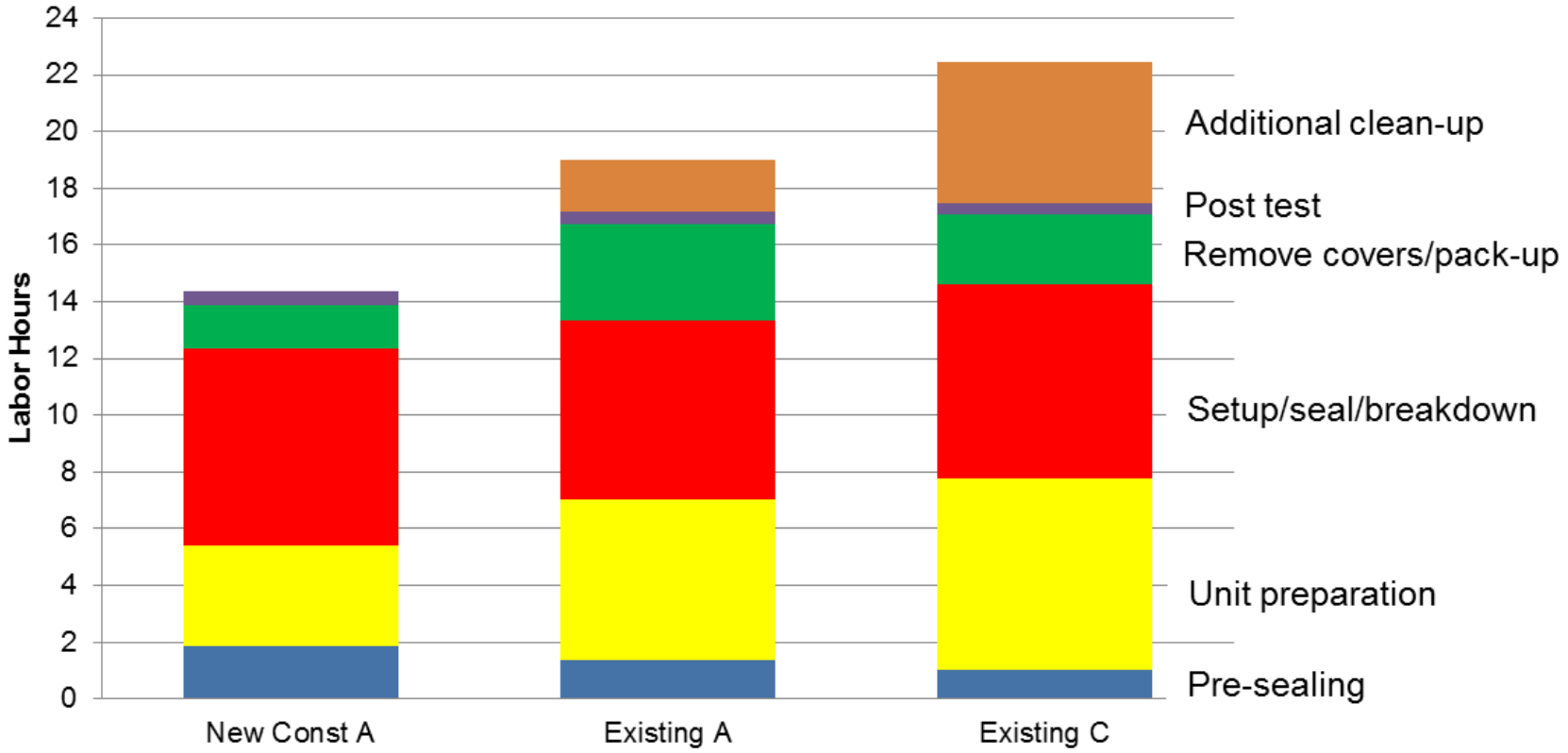
Site Work Prep: how long does it take?



14 to 22 hours: researchers still learning

Site Work Prep: reduce time

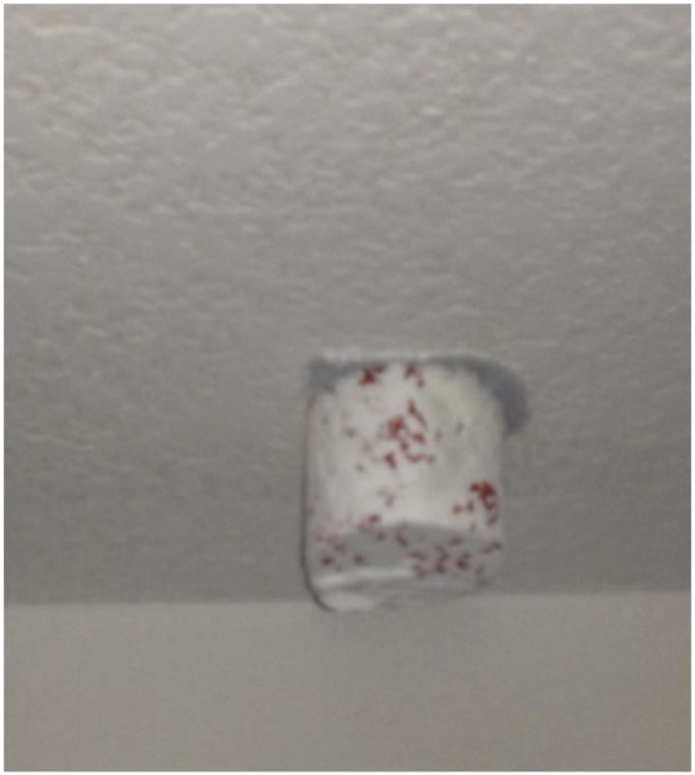
Opportunities to reduce labor time

- 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

Plumbing Penetrations

Sealed Penetrations



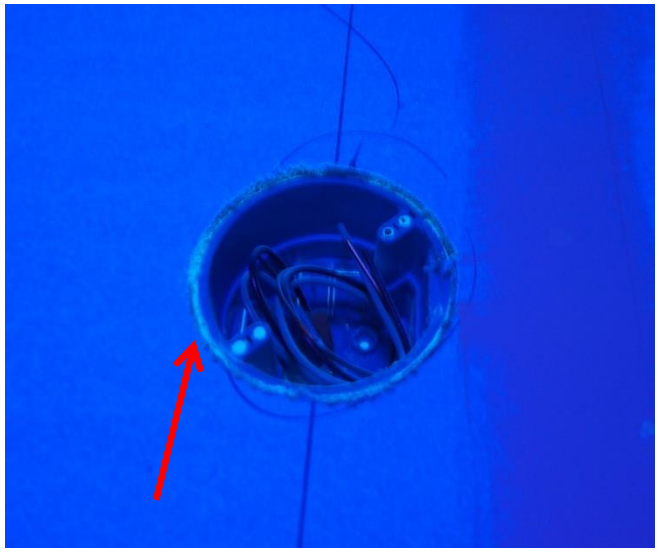
Sprinkler Head

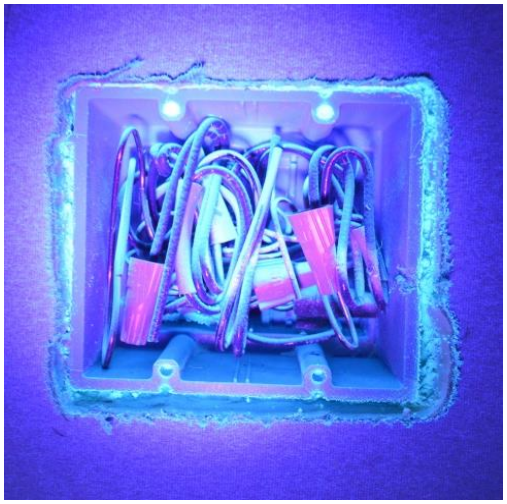
Kitchen exhaust fan

Sealed Penetrations

Electrical Boxes

Site Work Prep: black light photos

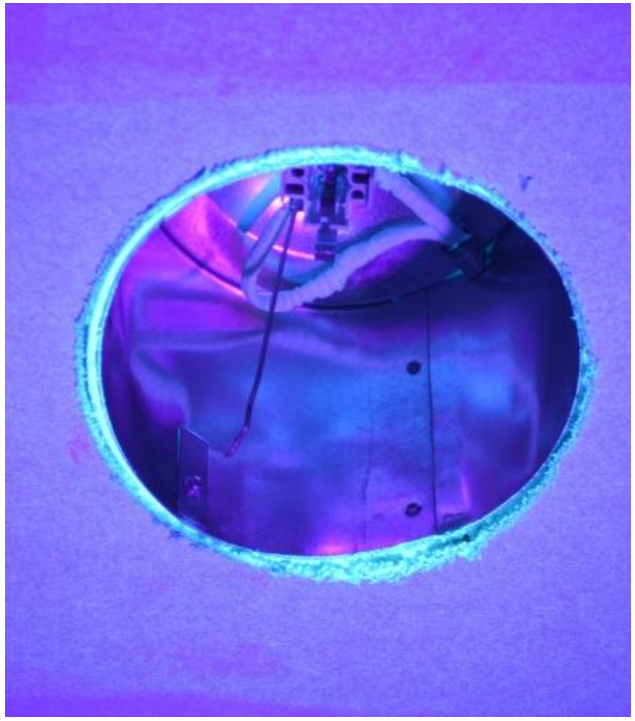




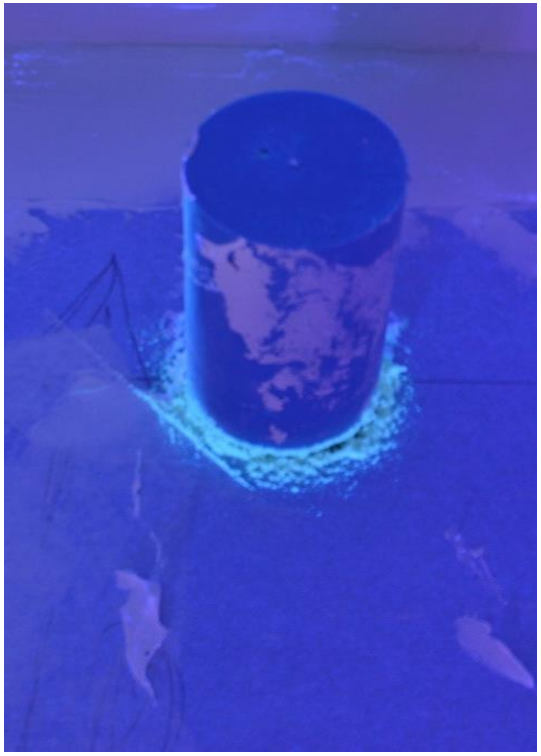
Electrical Boxes

Floor/wall Joint

Site Work Prep: black light photos

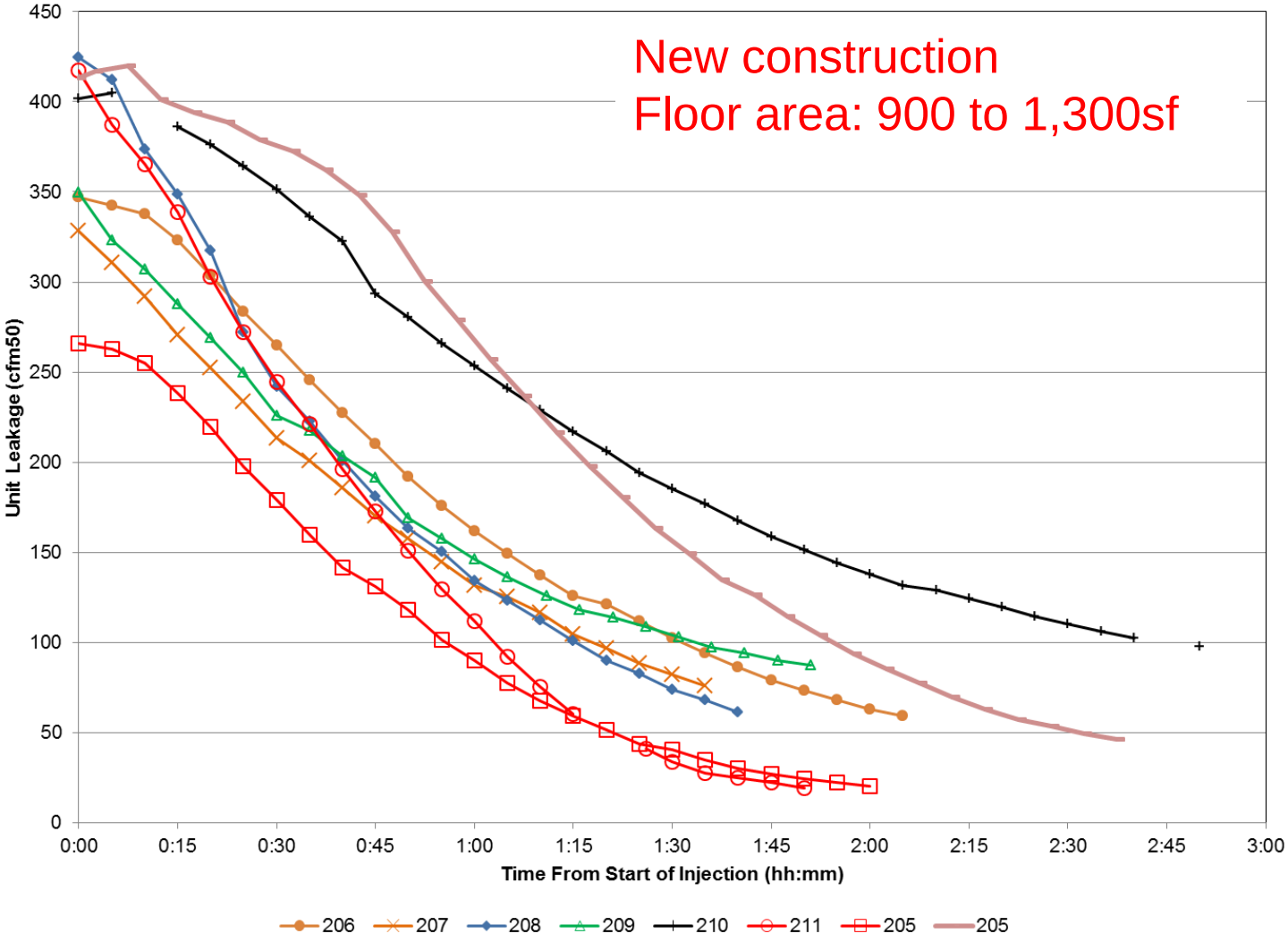


Recessed Light



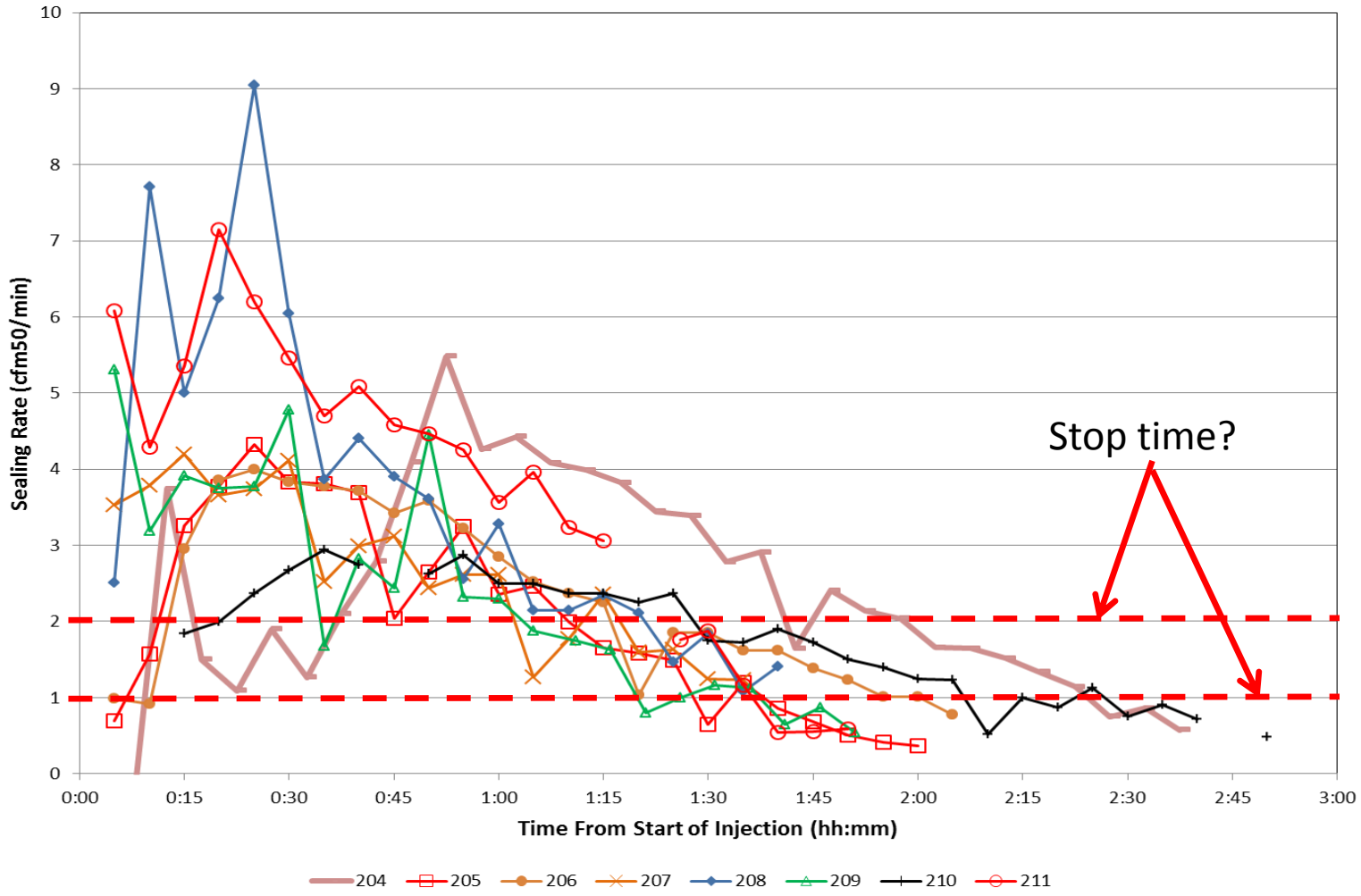
Sprinkler Head

Leakage Reduced Over Injection Period

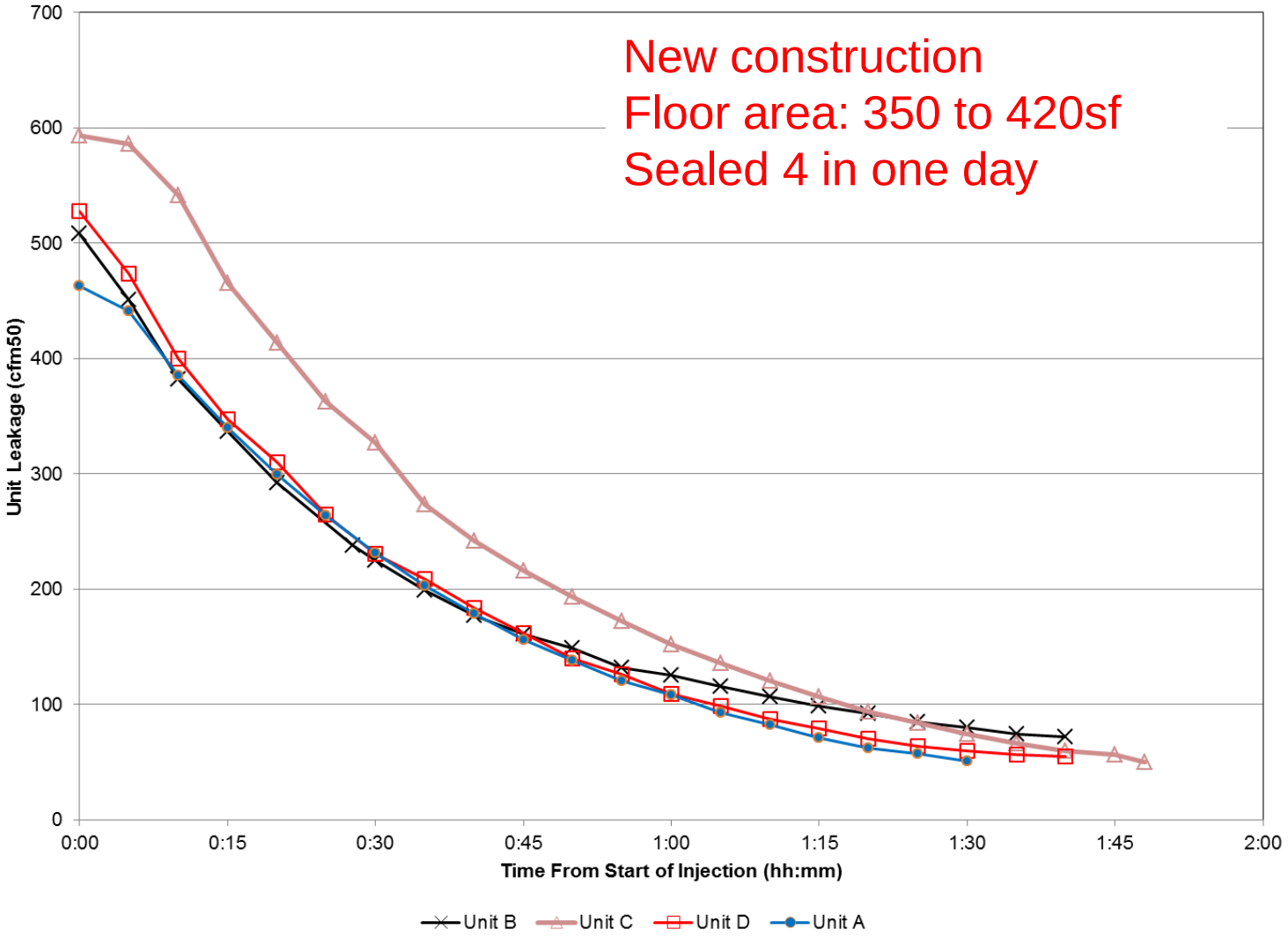


ACH50 pre: 2.0 – 2.9, post: 0.2 – 0.7; 71% to 94% reduction

Sealing Rate

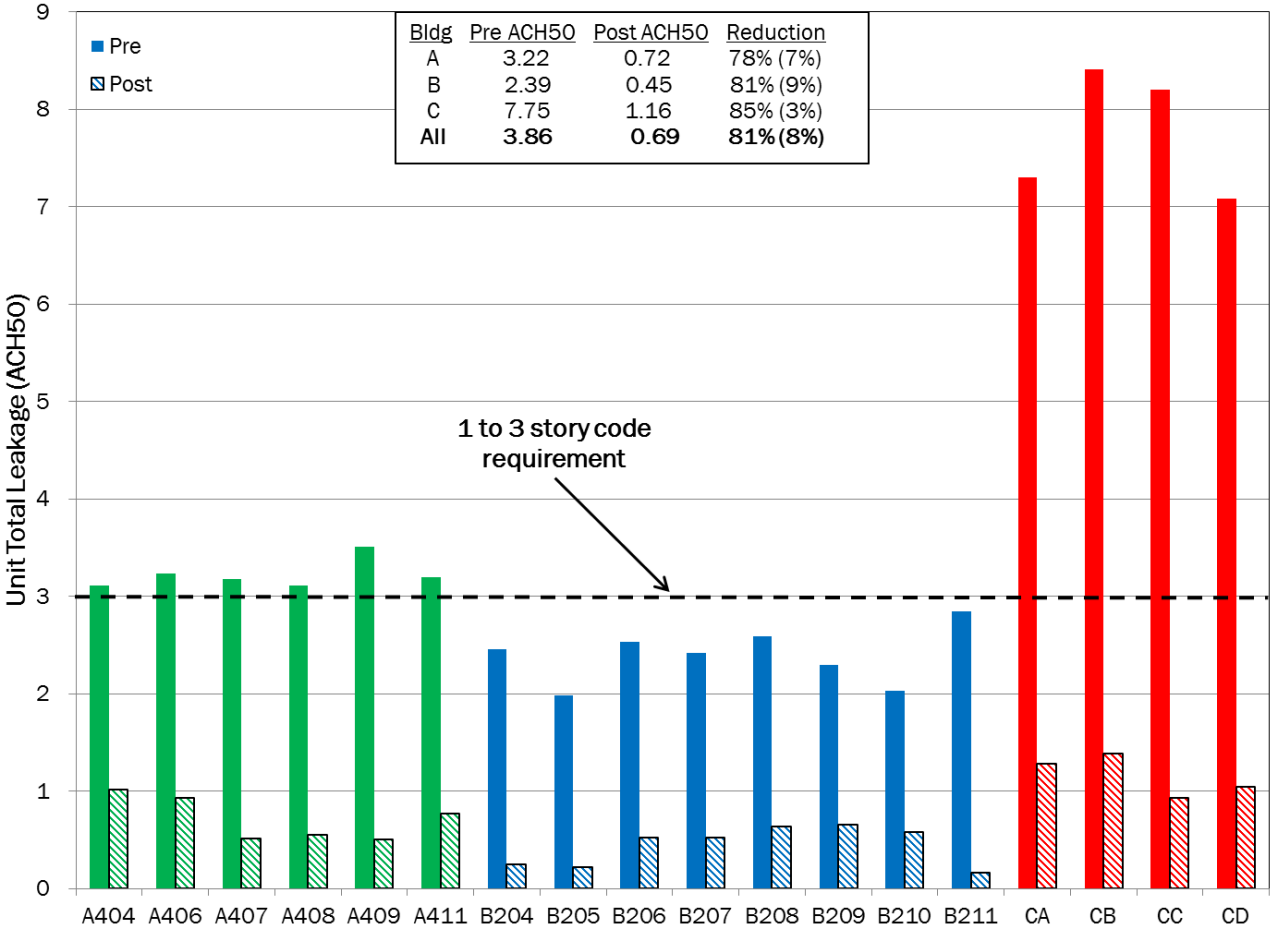


Leakage Reduced Over Injection Period



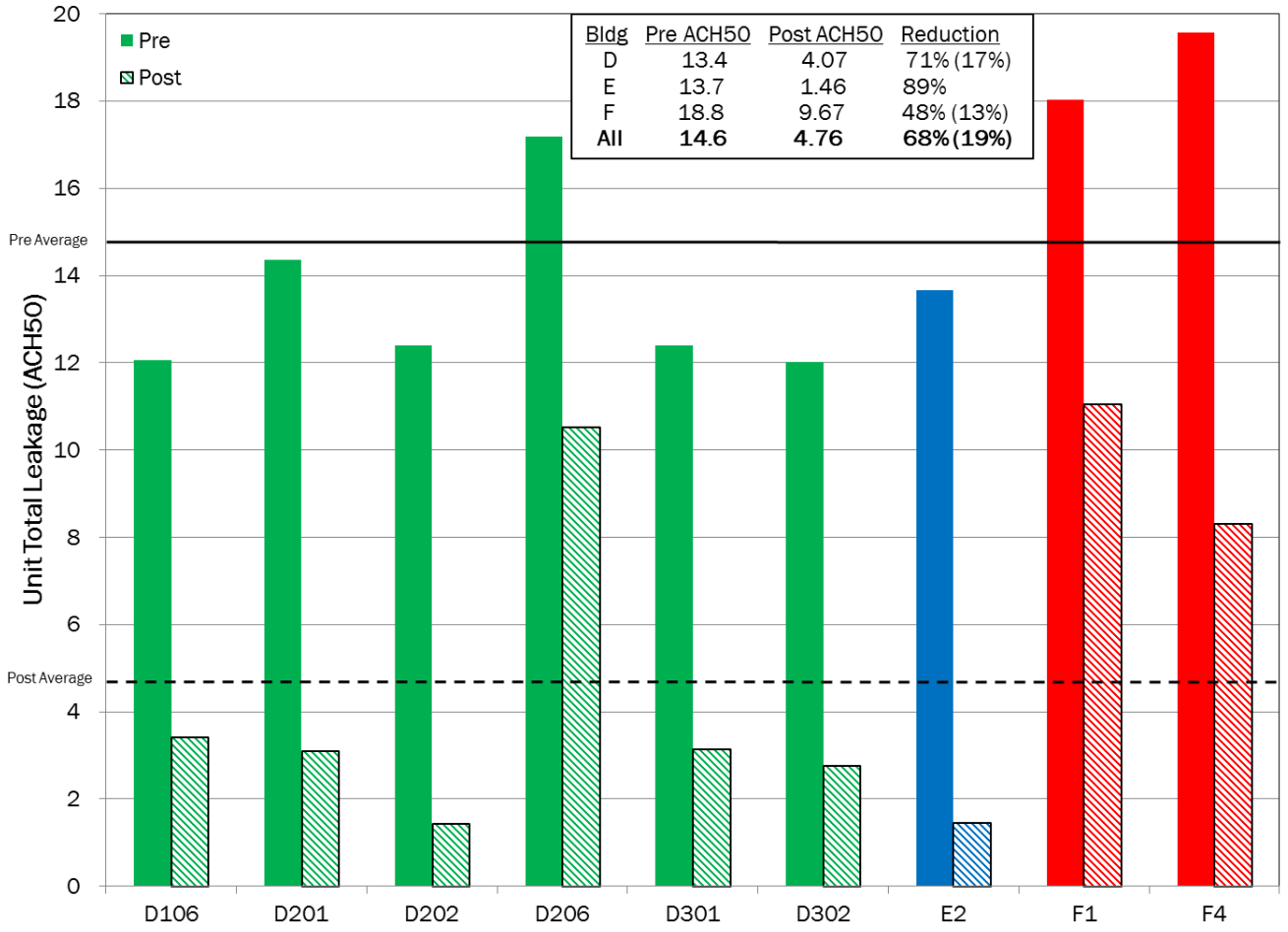
ACH50 pre: 7.1 – 8.4, post: 0.9 – 1.4; 82% to 89% reduction

Leakage Results: 18 New Construction Units



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

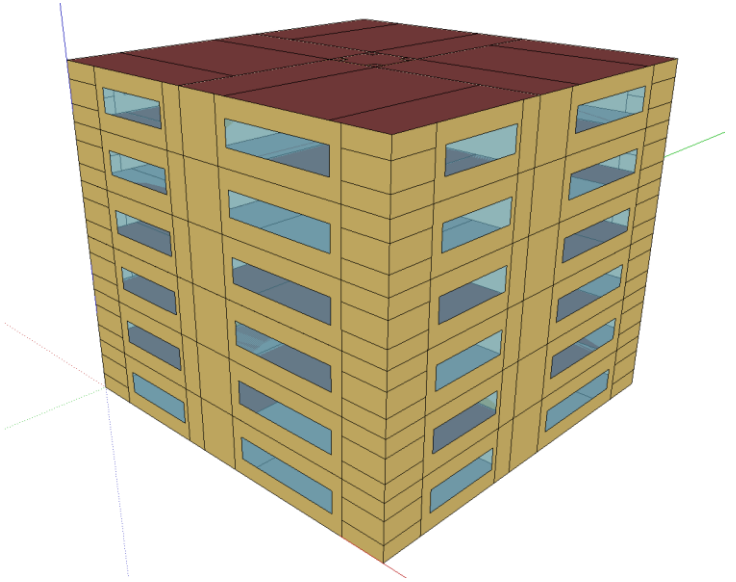
Leakage Results: 9 Existing Units



Average leakage: pre= 14.6 ACH50, post= 4.8 ACH50
6 of 9 within 15% of new construction code requirement

Model

- **EnergyPlus**

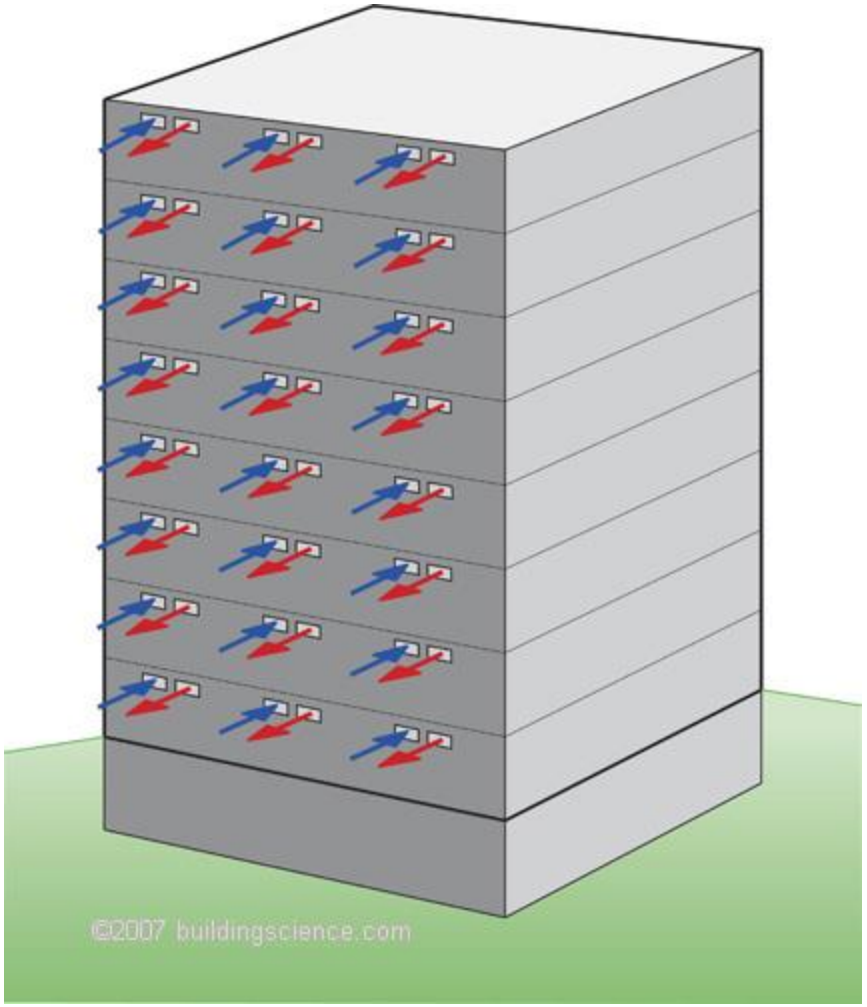


  - **Ventilation model**: Airflow network
    - Calculates inter-zone flows
    - Accounts for wind and stack effects

  - **HVAC Equipment:**
    - Based on MN multifamily building stock
      - Heating provided by baseboard radiant heaters
      - Cooling provided by window air conditioners

Model – Ventilation Method

- Four ventilation strategies investigated
  - Exhaust only
  - Exhaust with some supply
  - Balanced
  - No ventilation
- Individual unit exhaust fans and balanced ventilators



Model – Leakage

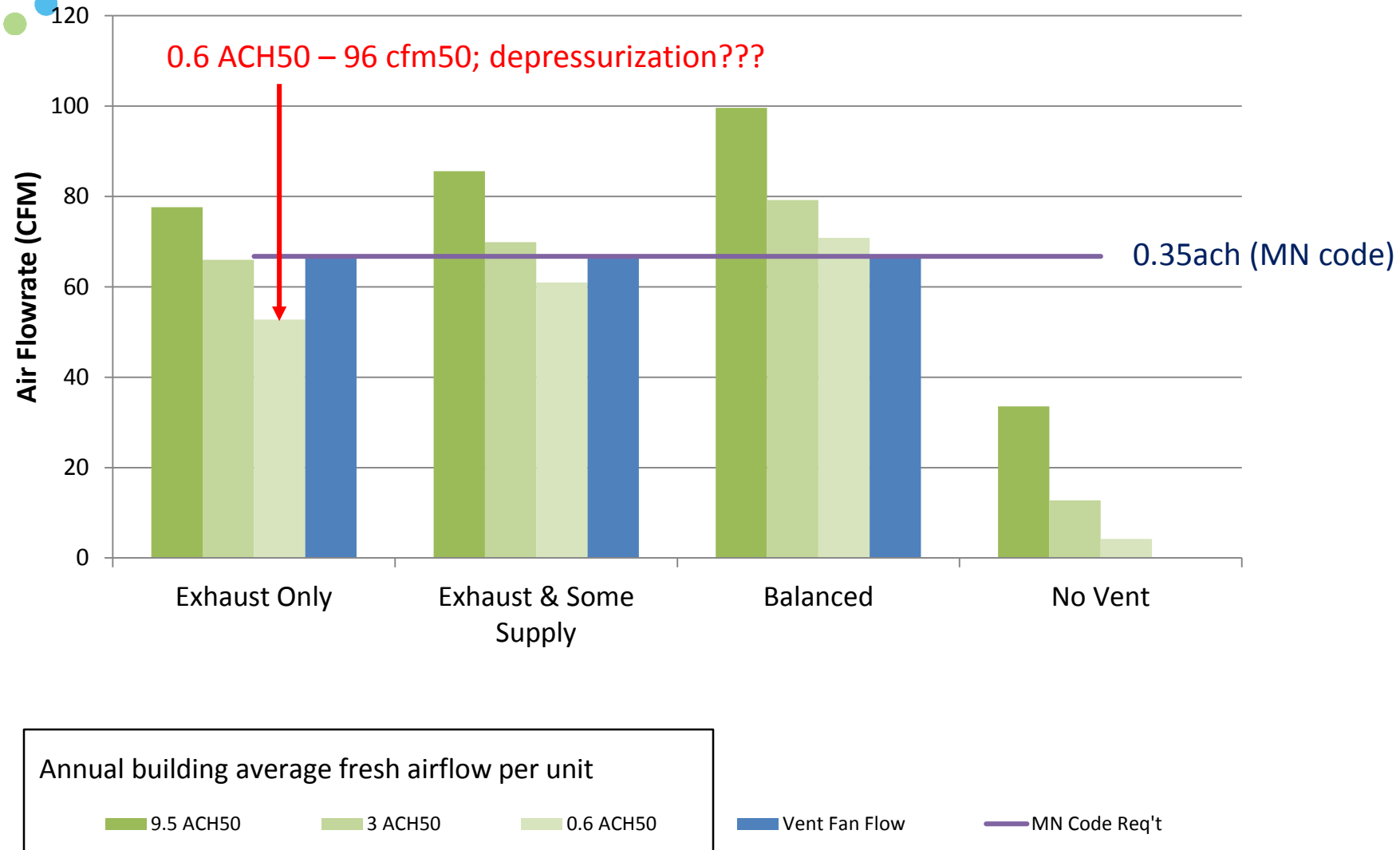
Envelope leakage (total):

- Existing Building
  - Leaky: 9.5 ACH50 (existing data)
  - Sealed: 3 ACH50 (MN code)
- New Building
  - Compliant: 3 ACH50 (MN code)
  - Tight: 0.6 ACH50 (Passive House)

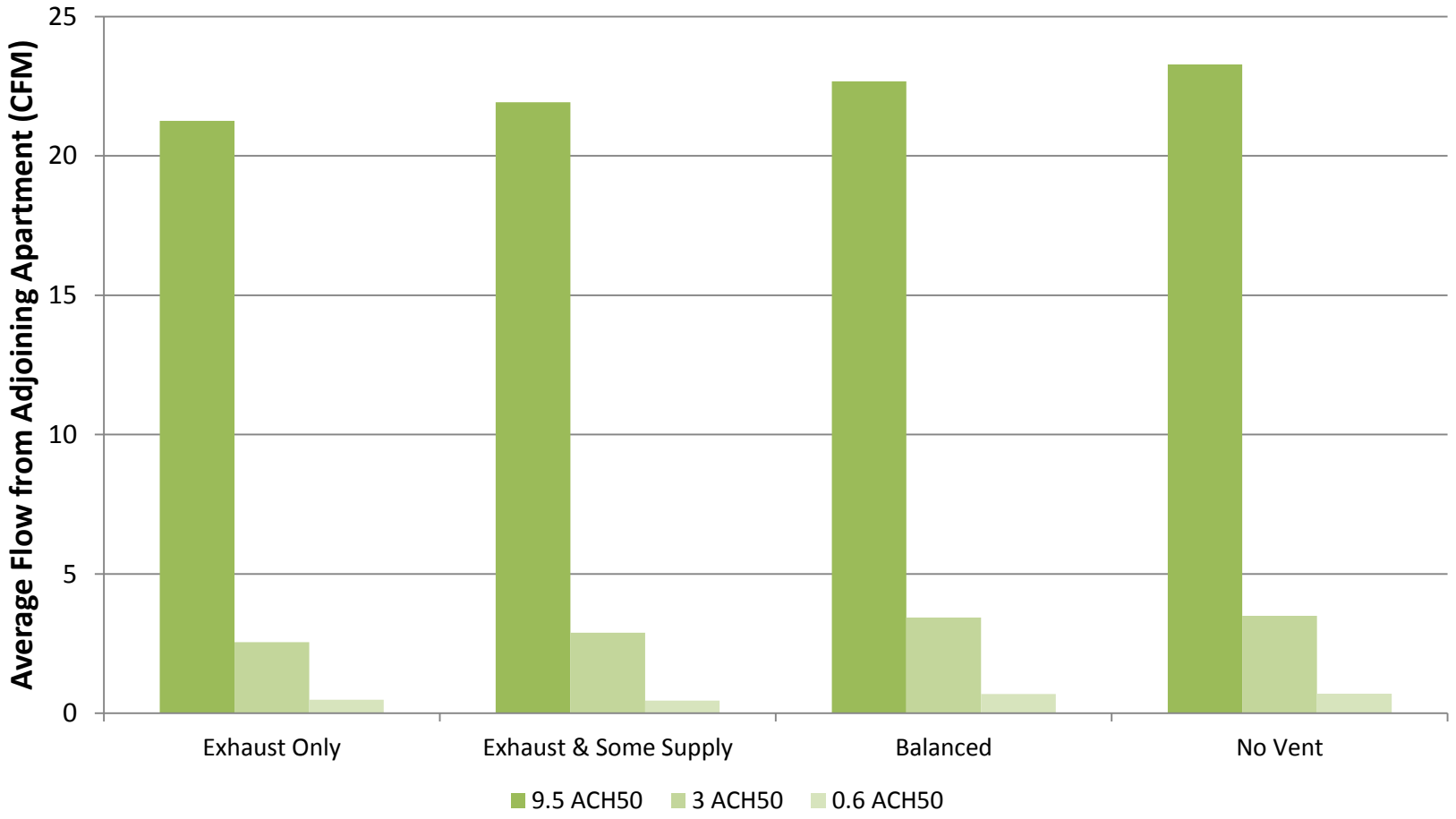
ACH50	Exterior	Interior	Floor/Ceiling	Door
9.5	43%	34%	13%	9%
3	47%	18%	5%	29%
0.6	47%	18%	5%	29%

Table 1: Leakage distribution used in models

Results – Ventilation Flows



Results – Interior Flows



Results – Summary Table

- Impact of sealing air leaks in apartment buildings in Minneapolis

	New Buildings 80% reduction	Existing Buildings 68% Reduction
Heating Savings (therms/year)	60 - 75	40 - 200
Heating Savings ($/year)	$33 - $44	$23 - $120

Exterior leakage reduced from 3.0 ACH50 to 0.6 ACH50

Low savings: Total leakage reduced from 9.5 ACH50 to 3 ACH50

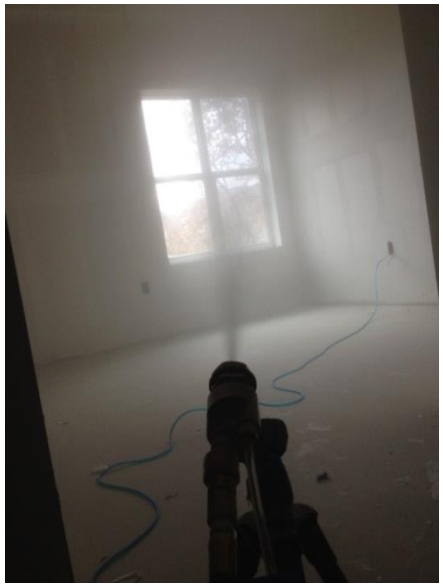
Little or negative impact on cooling energy

New construction: balanced ventilation
Existing buildings: exhaust only typically acceptable

Air Sealing at Lower Cost?

Aerosol

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



Vs.

Manual air sealing

i.e. caulking/foaming/tapes

- Architectural specification
- Labor
- Air leakage test

=> Uncertain results

Conclusions

- Not a solution for large air leak gaps > 5/8”
- When aerosol envelope sealing can be used
  - New construction
  - Rehab
  - Change in occupancy (higher cost)
- New construction
  - 81% reduction & 77% below code
  - Reduce to below code w/o excessive QC
  - Comply with code reliably
- Existing units
  - 68% reduction & 6 of 9 comply with new code (3 ACH50)
  - Heating savings= 40 - 200 therms/yr (Minnesota)
  - 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?

Ongoing Work

Large Building Sealing with Department of Defense

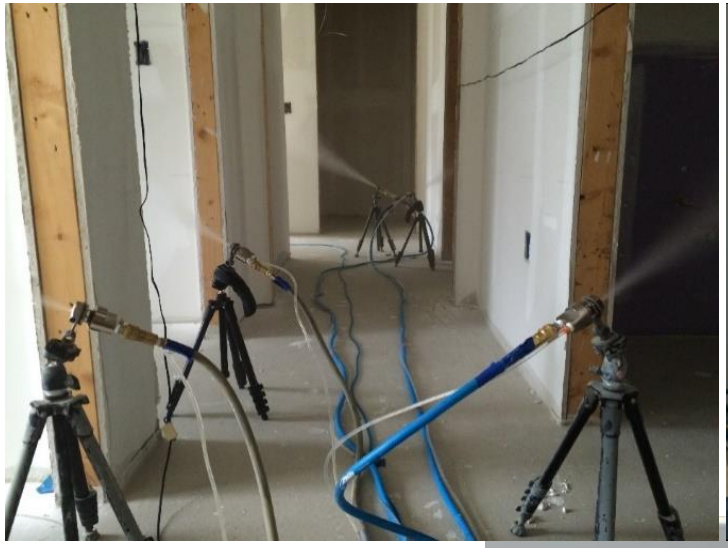
- UC Davis WCEC project with Aeroseal
- Sealing existing commercial buildings on military bases
- Lab testing of seal strength and durability

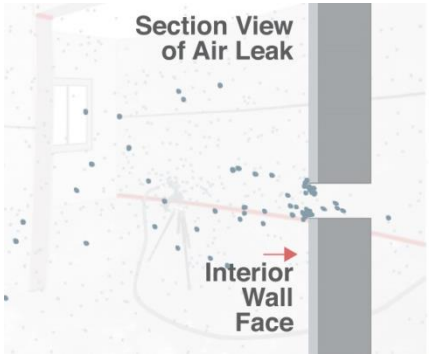
Aeroseal AeroBarrier Commercialization

- Announced at 2017 RESNET conference
- Currently has limited commercial service
- Developing partnership network in 2018

AEROSEAL

Aerosol Sealing in New Construction





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THANK *you!*

Dave Bohac
dbohac@mncee.org

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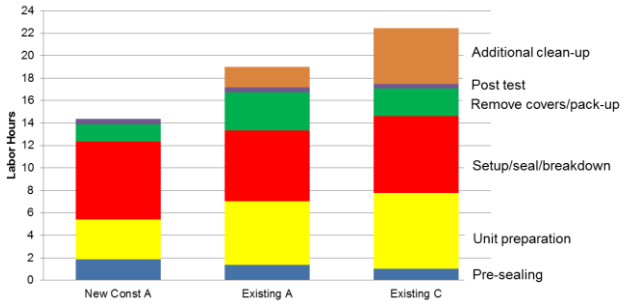
Approach

Key Issues:

- Previous Building America projects showed 60% to 95% improvements in envelope tightness.
- Sealing typically applied after drywall in place. No experience with ability to replace current sealing methods.

Approach:

- Iterative approach with multiple builders – when & what to eliminate
- Assess current sealing methods for a MN & CA builder and develop two approaches for each
- Net cost and tightness will be evaluated against standard methods
- Process repeated with second set of houses for first builders and a set of houses for additional builders.



Progress and Accomplishments

Lessons Learned (Builder Kickoff Meeting):

- Builders interested in sealing after mechanical penetrations/before insulation and drywall
- Eliminate 4 ml poly interior and use low perm paint for interior vapor retarder?
- Seal ducts from outside > in?
  - Ductwork exposed to interior
  - Plug duct boots & create opening to outside; protect furnace
- Change rim joist spray foam approach?
- Likely to need help working with code officials to approve some changes