

# Air Distribution Retrofit Strategies for Affordable Housing

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# Overview

- Duct sealing can be difficult, costly and disruptive
- Two techniques compared in 40 homes
  - Manually-applied sealants
  - Injected aerosol sealant (Aeroseal®)



# Research Questions

- What is the cost and effectiveness of AeroSeal<sup>®</sup> compared to manual duct sealing?
- What logistical and technical issues might affect community-scale duct sealing retrofit productivity and effectiveness?



# OUTLINE

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FIELD STUDY

RESULTS

MODELING

BILLING ANALYSIS

LESSONS

CONCLUSION

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BILLING ANALYSIS

LESSONS

CONCLUSION

# Building Characteristics

- Two North Carolina public housing complexes
  - 50 years old
  - ~1,000 ft<sup>2</sup>
  - Central air conditioning
  - Natural gas forced air heating



# Unit Characteristics

Development	Unit type	Hand sealing	Aeroseal®
Terrace Park	1 story 2 bedroom	0	2
	1 story 3 bedroom	3	2
	2 story 3 bedroom	7	6
Berkshire Village	1 story 3 bedroom	7	7
	2 story 3 bedroom	3	3
Total		20	20

# Variety of Duct Configurations

	Terrace Park		Berkshire Village	
Unit type	1-story	2-story	1-story	2-story
Supply duct	Flex	Unknown (inaccessible)	Metal trunk, flex branches	Floor 2: Metal trunk, flex branches; Floor 1: Unknown
Supply location	Attic	Floor	Attic	Floor and attic
Return duct	Metal			
Return, A/H location	Conditioned space			
Returns	1	2 (1/floor)	1	2 (1/floor)



# Hand Sealing

- *Register boots* to the ceiling/floor with mastic or foil tape from below/above



# Hand Sealing

- *Return plenums* from the inside with mastic



# Hand Sealing

- *Air handler with mastic*



# Hand Sealing

- *Rigid trunk duct and trunk to flex duct connections in the attic with mastic – where accessible*



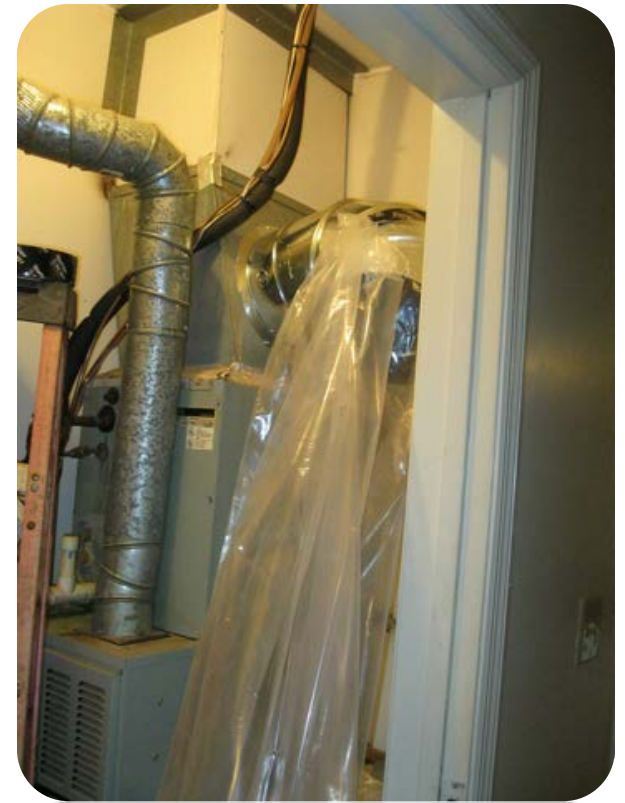
# Aeroseal®

- Invented at Lawrence Berkeley National Laboratory in 1994
- Internally seals duct leaks by injecting aerosolized sealant particles into a pressurized duct system
- Polymer particles stick first to the edges of a leak, then to each other until the leak is closed



# Aeroseal®

- Isolate registers and air handler from ducts
- Connect Aeroseal® system to supply duct



# Aeroseal®

- Injector system connected to heating element attached to 8-10 foot plastic tunnel



# Aeroseal®

- Airflow and leakage continuously monitored throughout sealing process





# Aeroseal®

- Hand-seal return plenum, air handler, junction between registers and wall/ceiling/floor



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FIELD STUDY

**RESULTS**

MODELING

BILLING ANALYSIS

LESSONS

CONCLUSION

# Results

- Aeroseal<sup>®</sup>-treated units improved more than in the units sealed solely by hand
- Return flow and supply register flows increased on average in most retrofit units

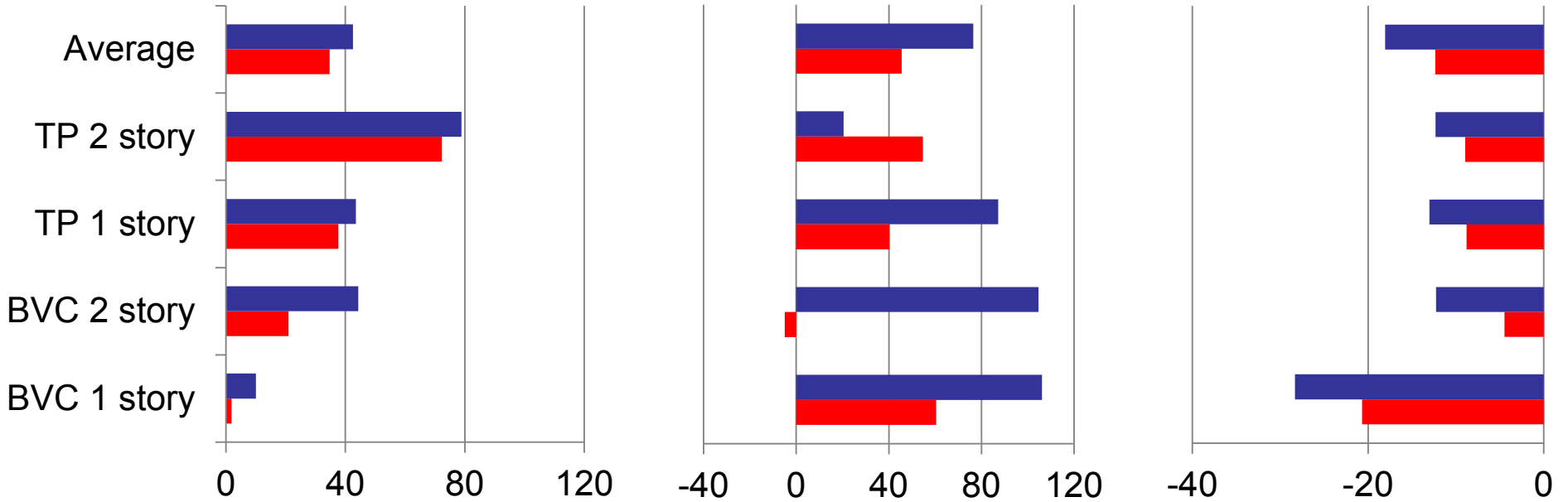


# Test Results

Average change in return flow (CFM)

Average change in sum of supply register flows (CFM)

Average change in duct leakage to outside (CFM25 per 100 ft<sup>2</sup>)



■ Aeroseal      ■ Hand



# Test Results

Method	Number floors	Average pre-retrofit leakage to outside (cfm/100 ft <sup>2</sup> )	Average post-retrofit leakage to outside (cfm/100 ft <sup>2</sup> )	Leakage to outside reduction (%)
Hand sealing	1 story	16.0	5.1	68%
	2 story	15.6	8.0	49%
Aeroseal®	1 story	17.5	1.6	91%
	2 story	13.6	1.3	91%

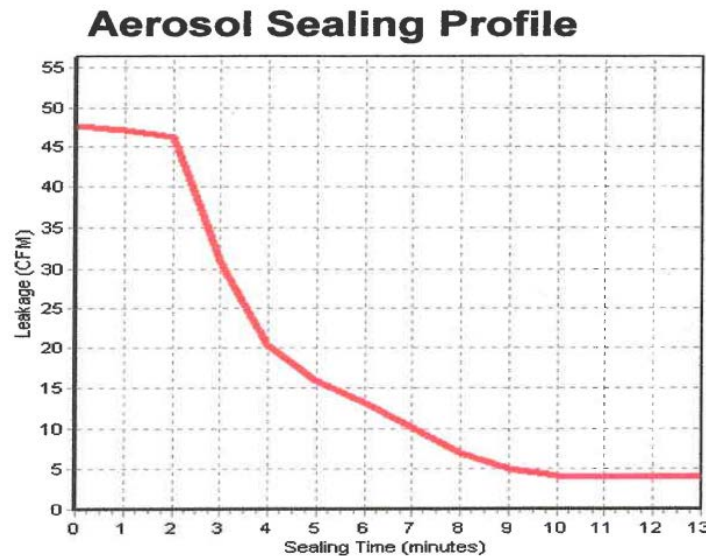
# Air Flow



- Return flow increased by average 40 CFM, slightly over 7%
- Flow increased more for the AeroSeal<sup>®</sup> units than the hand sealed units
- Supply register flows increased in most homes

# Aeroseal®

- Aeroseal® system records total duct leakage during sealing
- Approximately **70%** of the total leakage reduction was due to hand sealing at the air handler, return and registers.



When we arrived,  
**YOUR DUCTS HAD:**

**45 CFM** of Leakage, equivalent to a  
**9 Square Inch Hole**

After we finished,  
**YOUR DUCTS HAVE:**

**7 CFM** of Leakage, equivalent to a  
**1 Square Inch Hole**

This corresponds to a **85% Reduction** in Duct Leakage

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FIELD STUDY

RESULTS

**MODELING**

BILLING ANALYSIS

LESSONS

CONCLUSION



# Annual whole house MBtu savings

- Four units modeled with BEopt to predict post-retrofit whole-house energy savings

Annual whole-house MBTU savings

Method	Number floors	Terrace Park	Berkshire
Hand sealing	1 story	3.9%	4.8%
	2 story	4.2%	3.2%
Aeroseal	1 story	4.8%	7.0%
	2 story	5.9%	6.9%

# Costs

Method	Floors	Cost per unit
Hand sealing	1	\$511
	2	\$275
Aeroseal	1	\$700
	2	

# Cost Effectiveness – Annualized Energy Expense

Method	Plan	Pre-retrofit annualized energy expense	Post-retrofit annualized energy expense	Annual savings	% Change
Hand sealing	TP1	\$1,550	\$1,514	\$36	2.3%
	TP2	\$1,667	\$1,615	\$52	3.1%
	BV1	\$1,567	\$1,517	\$50	3.2%
	BV2	\$1,673	\$1,594	\$79	4.7%
Aeroseal®	TP1	\$1,565	\$1,520	\$45	2.9%
	TP2	\$1,670	\$1,605	\$65	3.9%
	BV1	\$1,568	\$1,495	\$73	4.7%
	BV2	\$1,717	\$1,679	\$38	2.2%

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FIELD STUDY

RESULTS

MODELING

**BILLING ANALYSIS**

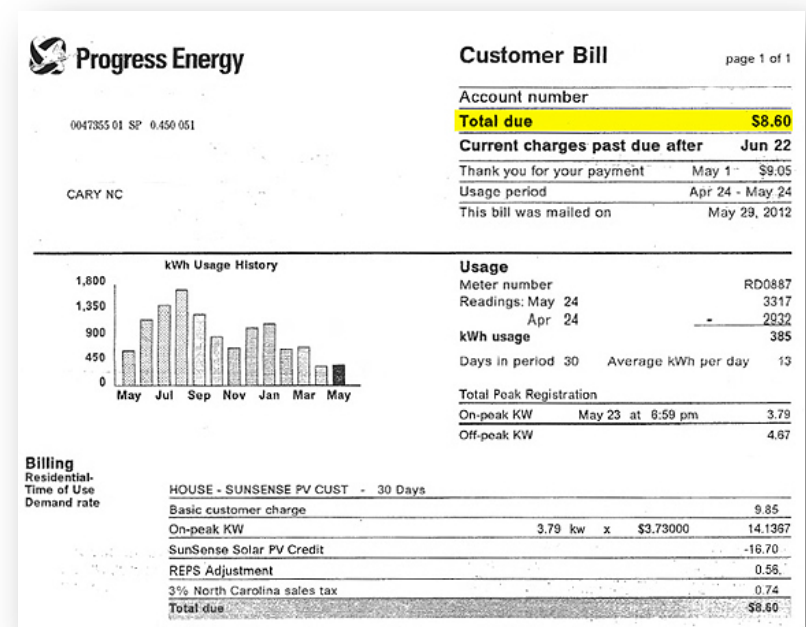
LESSONS

CONCLUSION

# Utility Bill Analysis

- One year pre-post utility bills
- Average savings:

Method	Heating energy	Cooling energy
Hand	16.2%	16.3%
Aeroseal	13.7%	15.5%



# Average Annual Utility Bill Savings

Method	Energy Savings (therms)	Energy Savings (kWh)	Utility Bill Savings/Unit	Simple Payback (years)	Sample Size
Hand sealing	30	809	\$179	2.2	7, 1-story 4, 2-story
Aeroseal®	19	731	\$150	4.7	5, 1-story 2, 2-story

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FIELD STUDY

RESULTS

MODELING

BILLING ANALYSIS

**LESSONS**

CONCLUSION

# Aeroseal<sup>®</sup> Benefits

- Allows sealing inaccessible ducts
- Avoids some hassles of manual sealing:
  - Removing duct insulation, cleaning ducts, applying mastic, waiting for mastic to dry, reapplying insulation
- Avoids some quality control issues of hand sealing





# Aeroseal® Challenges

- Small units required slow air flow
- High ambient relative humidity required low air flow
- Nozzle clogged due to low air flow and sequential jobs
- Arranging equipment challenging in small homes
- Lack of clearance between air handler and ceiling to connect to supply plenum



# Production Scale Retrofits



- Most time spent on AeroSeal® is setup and cleanup
- Equipment idle, being moved or set-up 70% of the time
- Connect two duct systems simultaneously using a “Y” connector
- Smaller system suitable for lower flow would make work in small units simpler and quicker

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MODELING

BILLING ANALYSIS

LESSONS

**CONCLUSION**

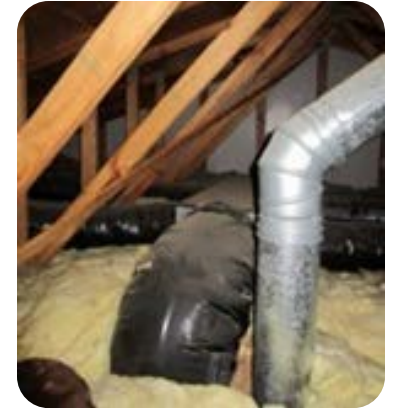
# Conclusion

- Both methods reduced duct leakage
- Reduction greater for AeroSeal<sup>®</sup>, especially for inaccessible ducts
- Manual sealing required for AeroSeal<sup>®</sup> units (70% of leakage reduction due to hand sealing)
- Annualized energy expenditure reduction same for both methods



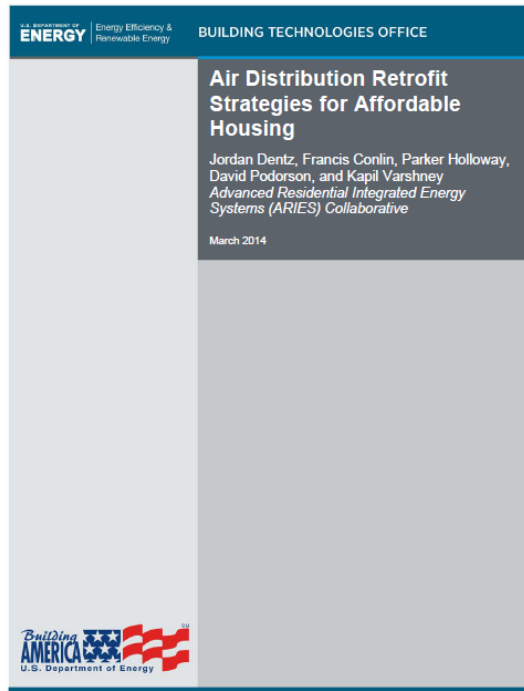
# Conclusions

- Simple payback 4.7 years for AeroSeal and 2.2 years for hand sealing
- Utility bill analysis showed ~15% space conditioning energy savings for both methods
- Opportunity to streamline AeroSeal® technology for production scale work and smaller homes



# Report

## Report and case study on the Building America website



#### PROJECT INFORMATION

Project Name: Raleigh Housing Authority Duct Sealing  
Location: Raleigh, NC  
Partners:  
Raleigh Housing Authority  
[www.raleighnc.com/](http://www.raleighnc.com/)  
Advanced Residential Integrated Solutions Collaborative (ARIES)  
<http://levypartnership.com/>  
Building Component: HVAC  
Application: Retrofit; single and multifamily  
Year Tested: 2012  
Applicable Climate Zone(s): All

#### PERFORMANCE DATA

Cost of energy efficiency measure (including labor): \$700 per unit  
Projected energy savings: 17% heating and cooling  
Projected energy cost savings: \$100/year-\$600/year

Duct leakage is a significant problem in many residential buildings that can contribute to energy waste, reduced comfort, poor indoor environmental quality, and moisture problems. Duct sealing alone can save up to 30% of home heating and cooling energy expenditure; therefore, it is important for enhancing building performance. Unfortunately, ducts can be difficult to access (for example, when located in floors, in cramped crawlspaces, or under low, sloped roofs), making the repairs expensive or impossible with traditional manual methods.

In this project, the Raleigh Housing Authority (RHA) worked with U.S. Department of Energy Building America team, the Advanced Residential Integrated Solutions Collaborative (ARIES), to determine the most cost-effective ways to reduce duct leakage in its low-rise housing units. The team evaluated the use of injected foam sealant and found it to be an effective way to eliminate duct leakage when combined with manual sealing of other easily accessible areas. This process involves injecting spray sealant into pressurized supply ducts. Sealant particles accumulate at leakage locations, gradually closing the leak. The injection system continuously

measures airflow and leakage throughout the sealing process, which stops when the leakage has been reduced to the desired level. After the duct sealing procedure in the RHA units, the ducts were extraordinarily airtight, resulting in more comfortable and energy-efficient housing.

*"The Building America program has shown us new ways of energy conservation that are effective, reproducible and more importantly, the measures can be implemented within the budget constraints of public housing agencies."*

- Gill Iris Keeter, Director of Development, Raleigh Housing Authority