Automated Sealing of Home Enclosures with Aerosol Particles

Welcome to the Webinar! We will start at 11:00 AM Eastern Time

Be sure that you are also dialed into the telephone conference call:

Dial-in number: 888-989-7679; Pass code: 3599368

Download the presentation at: www.buildingamerica.gov/meetings.html

Date: October 14, 2011

Building AMERICA® U.S. Department of Energy

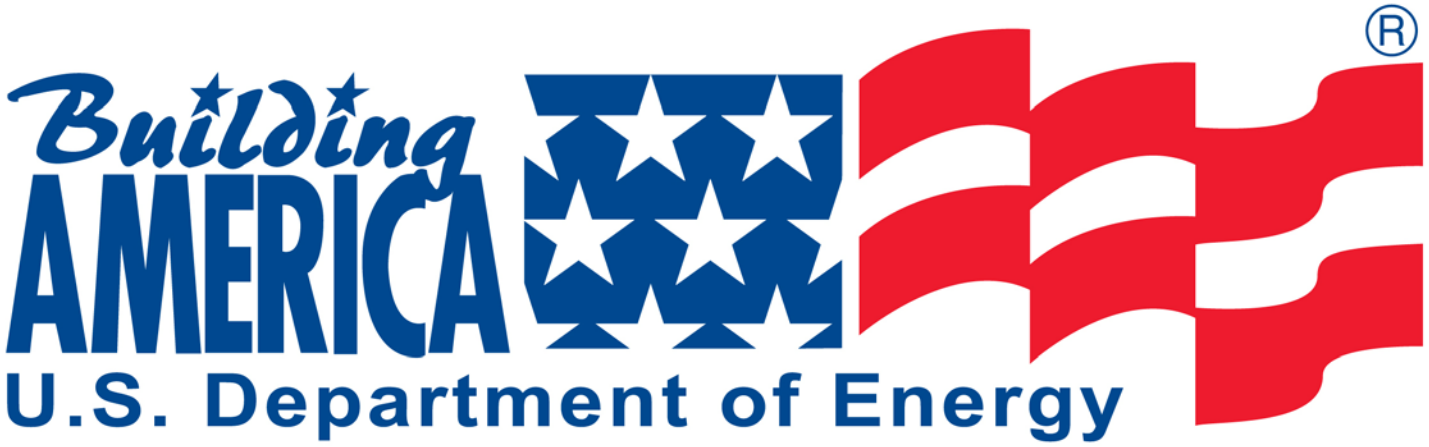
Building Technologies Program

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Building America: Introduction
October 14, 2011

Chuck Booten
Chuck.booten@nrel.gov

Introduction to Building America



- Reduce energy use in new and existing residential buildings
- Promote building science and systems engineering / integration approach
- “Do no harm”: Ensure safety, health and durability are maintained or improved
- Accelerate adoption of high performance technologies

www.buildingamerica.gov

15 Industry Research Teams

CARB
Consortium for Advanced Residential Buildings

Alliance for Residential Building Innovation (ARBI)

BA-PIRC

IBACOS
Home Quality + Performance

NAHB RESEARCH CENTER

NorthernSTAR Building America Partnership

Building America Retrofit Alliance (BARA)

bsc Building Science Corporation

BIRA
BUILDING INDUSTRY RESEARCH ALLIANCE
...a catalyst for change

Fraunhofer USA

ARIES Collaborative

DOW Building Solutions
Habitat Cost Effective Energy Retrofit Program

PARR
The Partnership for Advanced Residential Retrofit

N.E.L.C.
The National Energy Leadership Corps

Building Energy Efficient Homes for America (BeeHa)

Today's Speaker

Mark P. Modera is a Professor in Civil and Environmental Engineering, as well as Mechanical and Aerospace Engineering, and holds the Sempra Energy Chair in Energy Efficiency, all at UC Davis. He is also the Director of the Western Cooling Efficiency Center (WCEC) at UC Davis, a partner in Building Industry Research Alliance (BIRA), a Building America research team.

Dr. Modera joined the WCEC from Carrier Corp., where he was a Vice-President, and from Lawrence Berkeley National Laboratory (LBNL). At LBNL, Dr. Modera was a Principal Investigator on many research projects, including an aerosol-based duct sealing process that he will discuss today.

Mark's broad experience in research, business, entrepreneurship, education, and regulatory environments provides an excellent background for leading the WCEC in its mission of partnering to advance energy-efficient cooling systems.

Building America Webinar:

Sealing of Home Enclosures with Aerosol Particles

October 14, 2011

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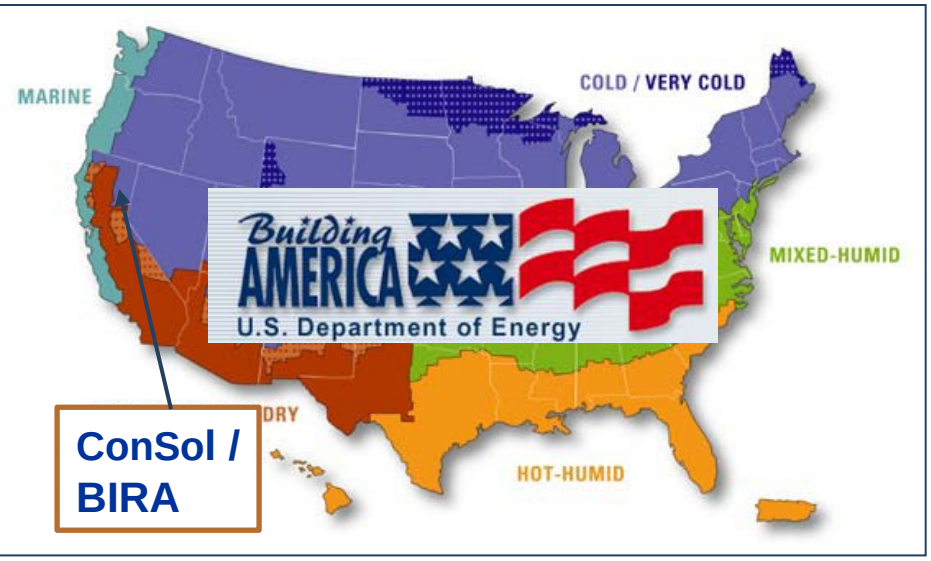
(800) 526-6765 · WWW.BIRA.WS

Building Industry Research Alliance



- Led by ConSol
- Concentrated Focus on Western United States
- 30+ industry partners:
  - Builders, Architects, Manufacturers, State Energy Offices and Utilities.
- BIRA works directly with partners to:
  - Provide cost-effective strategies to reach project goals and energy targets
  - Offer Technical Assistance during Building Construction
  - Evaluate and Integrate New/Emerging Technologies
  - Community-Scale Projects in New Construction and Retrofit Energy Efficiency

Western Cooling Efficiency Center

- Part of the Energy Efficiency Center at University of California, Davis
- Launched April 2007
- Current staff:
  - Over 20 people
  - Engineers and Physicists
  - Social Scientists
  - Graduate Students and Undergraduate Students

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Western Cooling Efficiency Center

"**MISSION:** Partner with stakeholders to identify technologies, conduct research and demonstrations, disseminate information, and implement programs that reduce cooling-system electrical demand and energy consumption in the Western United States."

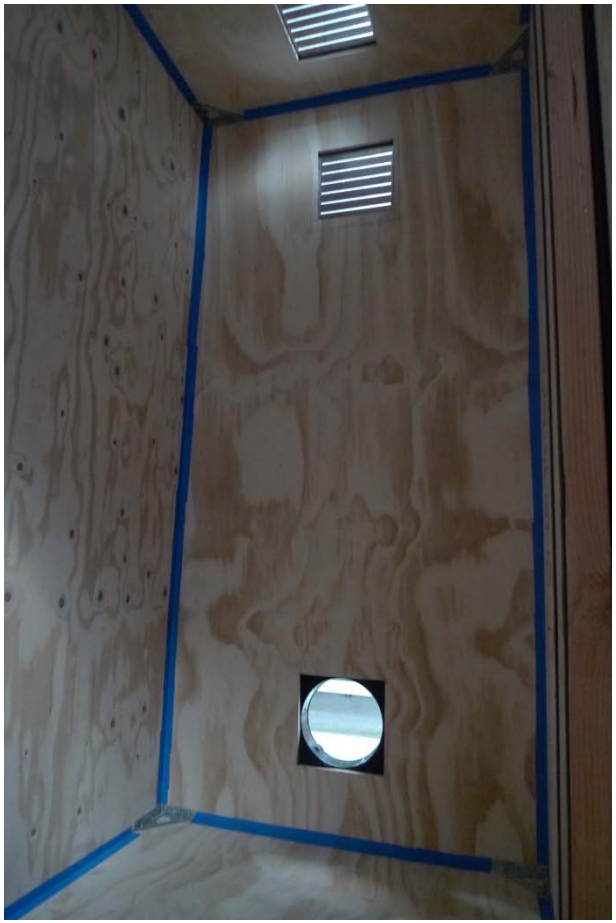
Presentation Overview

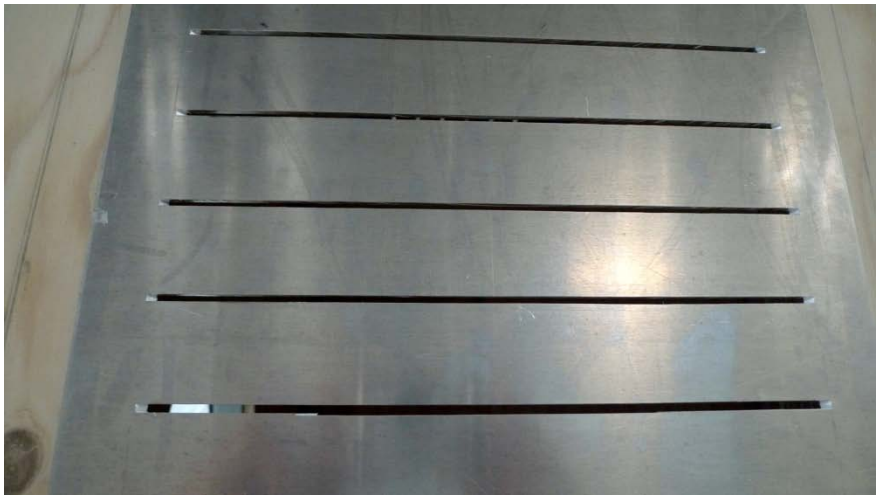
- Basic Concept
  - Seal New-Construction Building Shells at Rough-In
  - Potentially Seal Existing Construction from attic and/or crawlspace
  - Reduce cost, get better tightness and automated certification
- Current Effort
  - Build upon existing duct sealing technology
    - Address lack of carrier flow and turbulent mixing
  - Obtain Proof of Concept
    - Use 8’ high box to mimic house

Building America Gaps Addressed by Research

- **Airtightness:** Airtightness Strategies - strategies related to "good, better, best" airtightness goals (Deemed Important by 43.4%)
- **Airtightness:** Air Leakage Paths - identify relative contributions of specific air leakage paths (Deemed Important by 36.6%)
- **Walls:** Insulating and Air Sealing Inaccessible Places - develop solutions to insulate and air seal inaccessible places within wall construction (example, double brick wall) (Deemed Important by 17.2%)

Test “House” Sealing Process





Test “House”

- 8’ by 4’ by 8’ Tall
- Six removable leakage plates
  - 1/10” slots in 1/8” aluminum
  - Top, high on wall, far on wall
- 14” round inlet near top of box

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Test "House" Sealing Process

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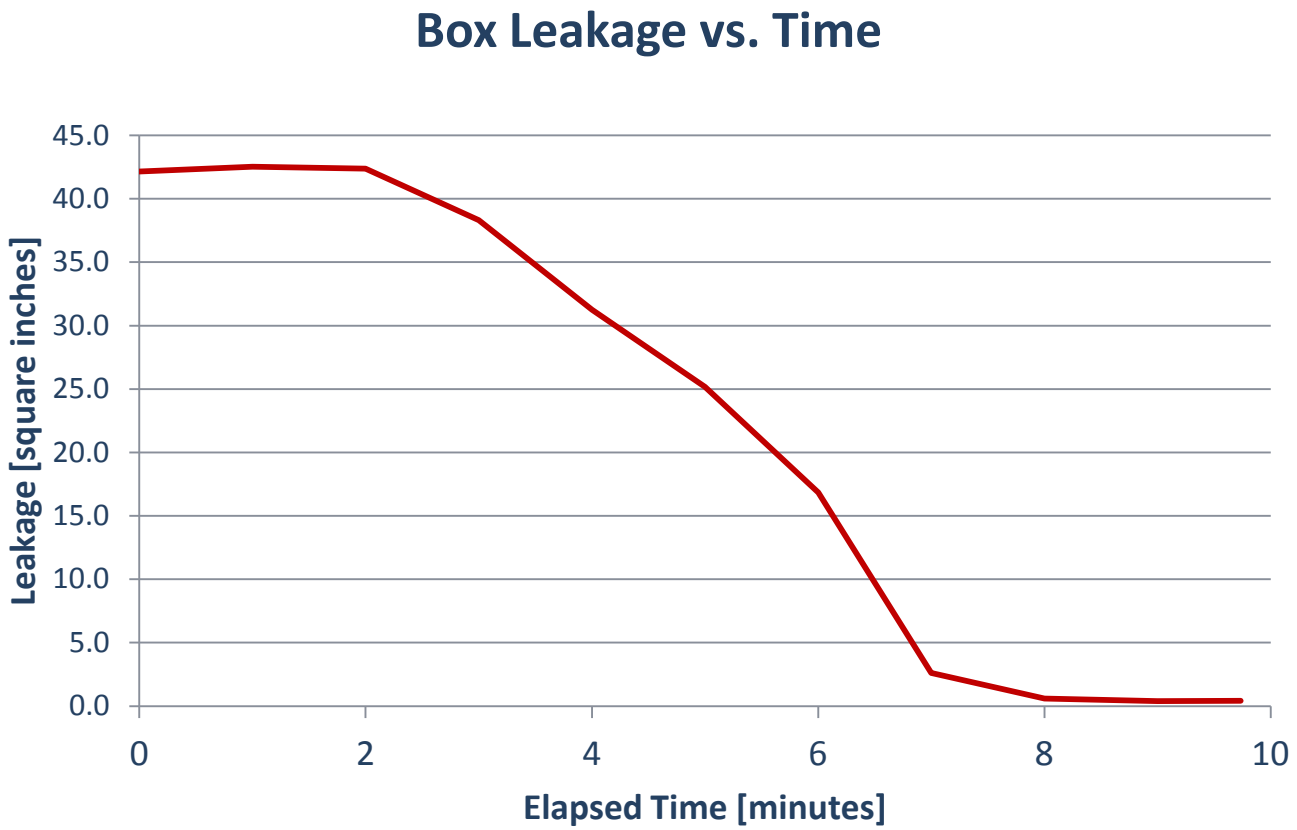
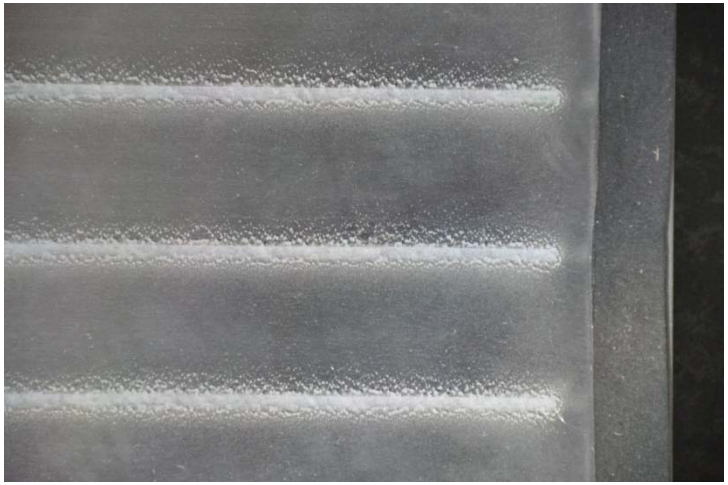


First Test: Using 100 ccm sealant, and no pressure control

Test “House” Sealing Process

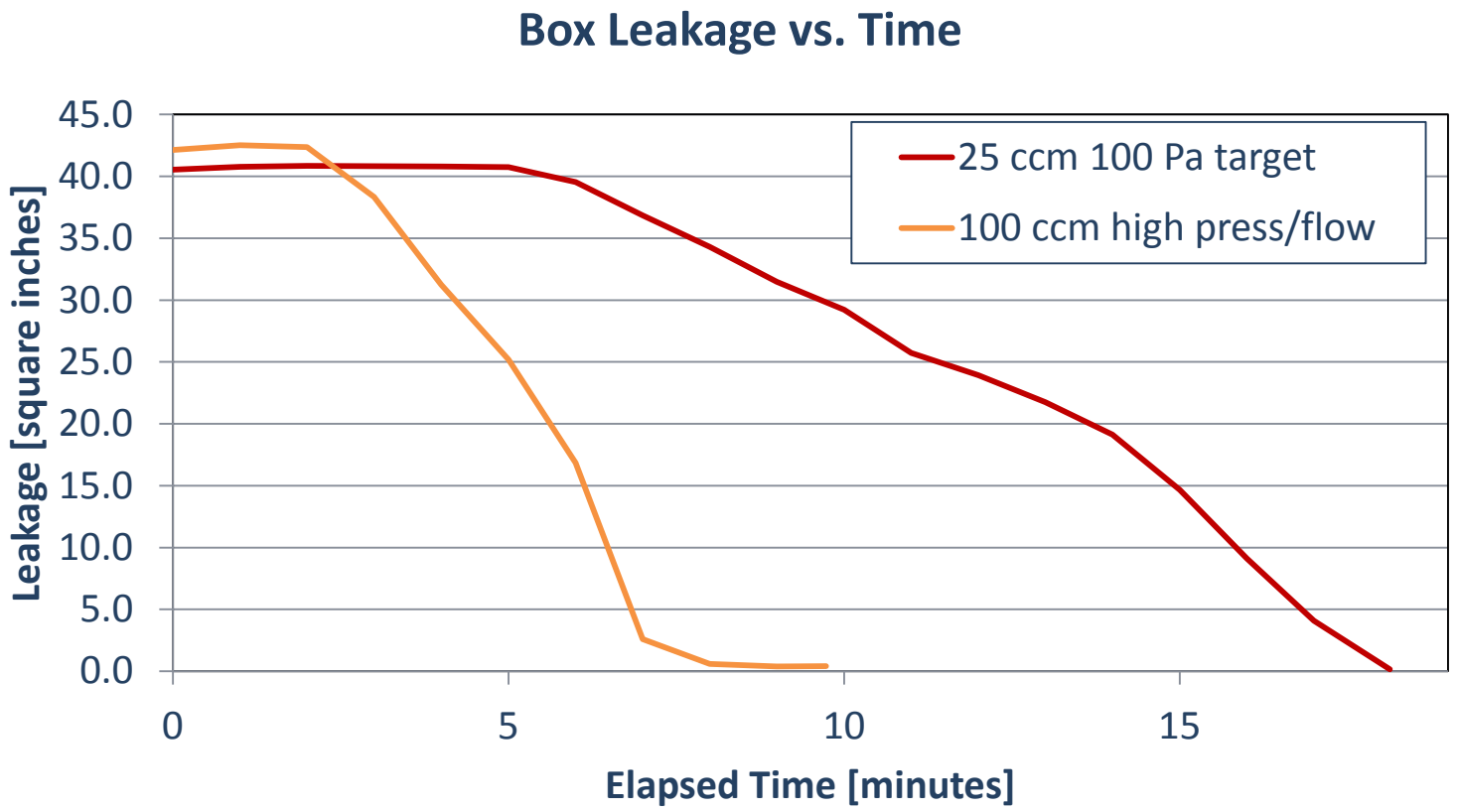


Low wall leak opposite injection

Ceiling leak near injection

First Test: Using 100 ccm sealant, and no pressure control

Lower Sealant Flow and Box Pressure

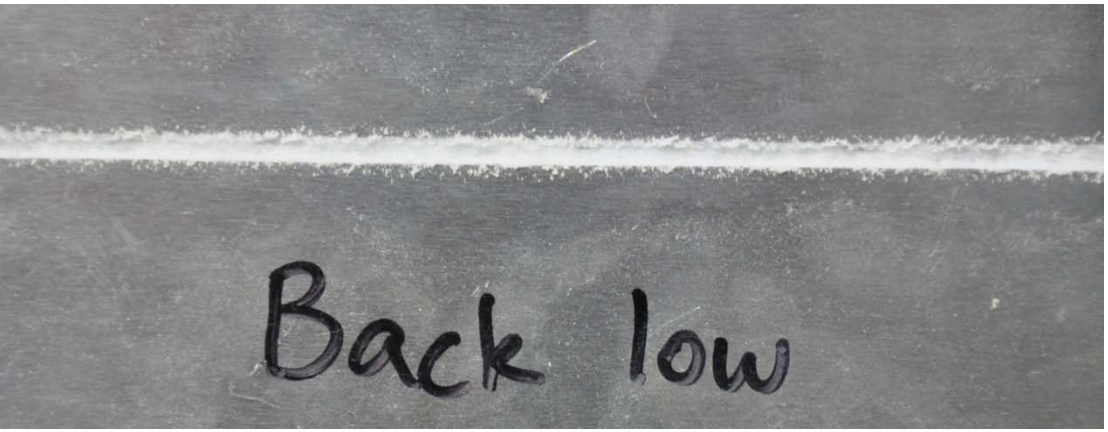


Performance Comparison

- Lowered sealant flow specifically to slow down process
- Test also included controlling the pressure in the box by modulating air flow (FOR SAFETY AND CONTROL PURPOSES)
  - Changed deposition process at leaks
    - Resulted in less sealant deposits around leaks
  - Decreased mixing velocities in box
    - Average jet velocity reduced from 7.2 ft/s to 4.0 ft/s

Sealant Deposition Pattern

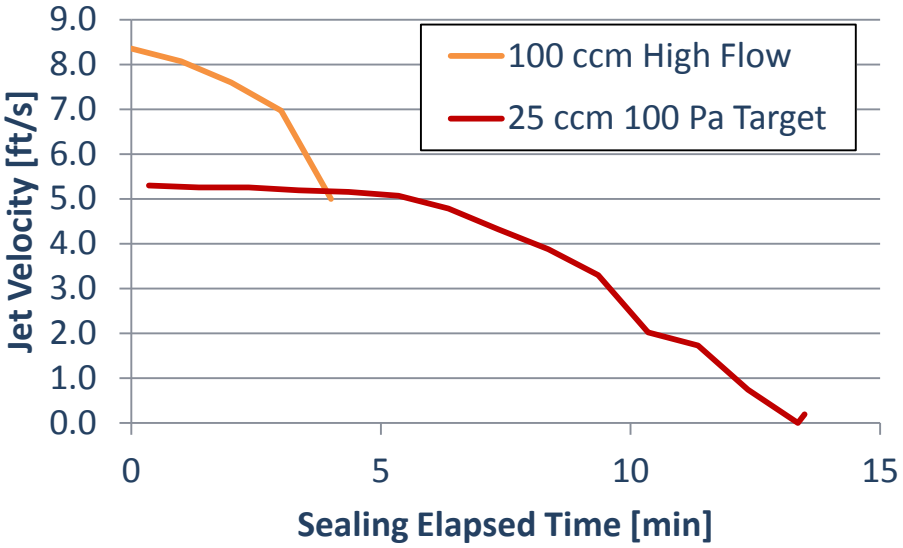
100 ccm sealant, High flow/pressure

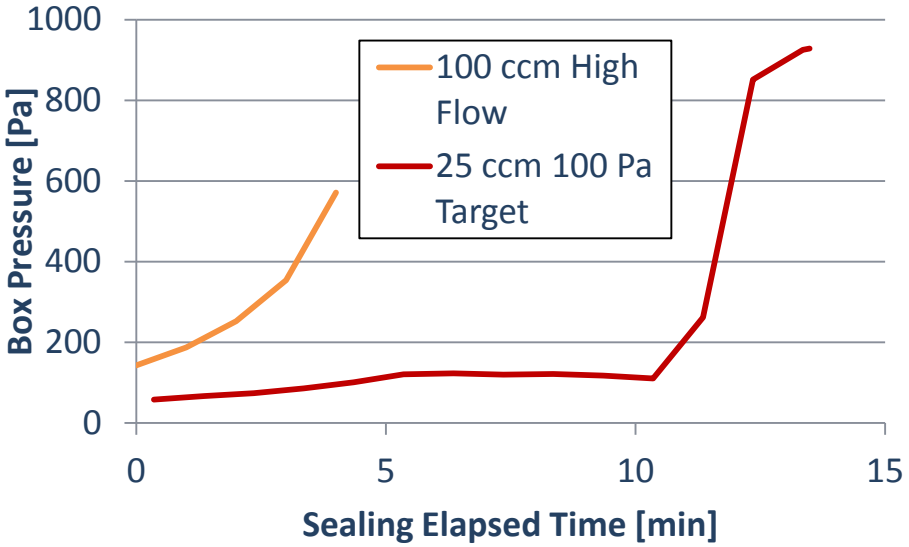


25 ccm sealant, 100 Pa target

Low wall leak opposite injection

Test Comparison:
Jet Velocity (Mixing) and Pressure (Deposition)





Systematic Sensitivity Experiments - Variables

- **Pressure Across Leaks:**
  - Higher pressure should increase particle removal in and around leaks
- **Mixing within Box:**
  - Mixing should help keep particles suspended, but could also increase deposition on walls
- **Particle Size:**
  - Smaller particles should be easier to keep suspended, but should not deposit as effectively in leaks

NOTE: With current experimental apparatus it is difficult to separately control pressure and mixing – pressure is increased by higher flow (i.e. mixing)

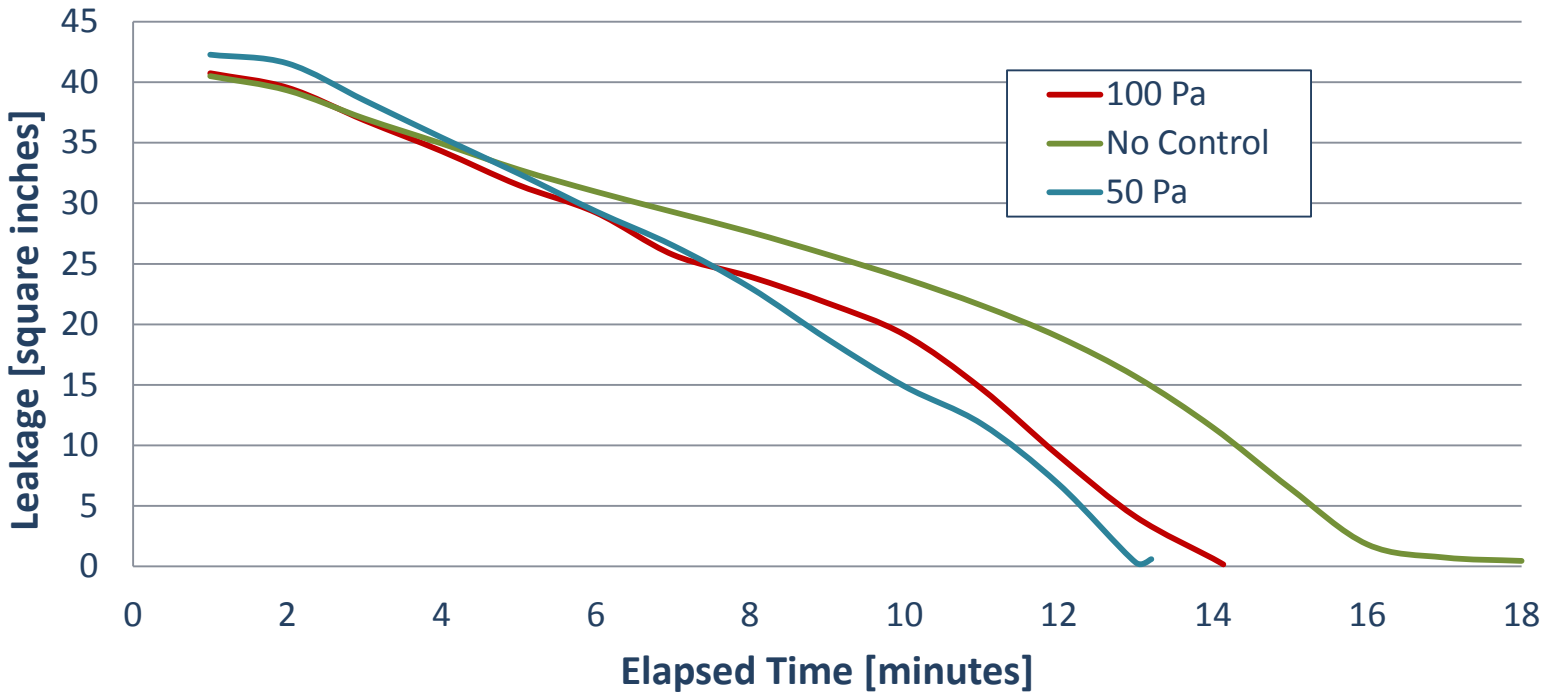
Sensitivity Experiments

Test	Sealant Solid Content	Liquid Sealant Flow Rate [ccm]	Solid Sealant Flow Rate [ccm]	Target Pressure [Pa]
A	35%	25	8.75	**none**
B	35%	25	8.75	**100**
C	35%	25	8.75	**50**
D	18%	25	4.375	100

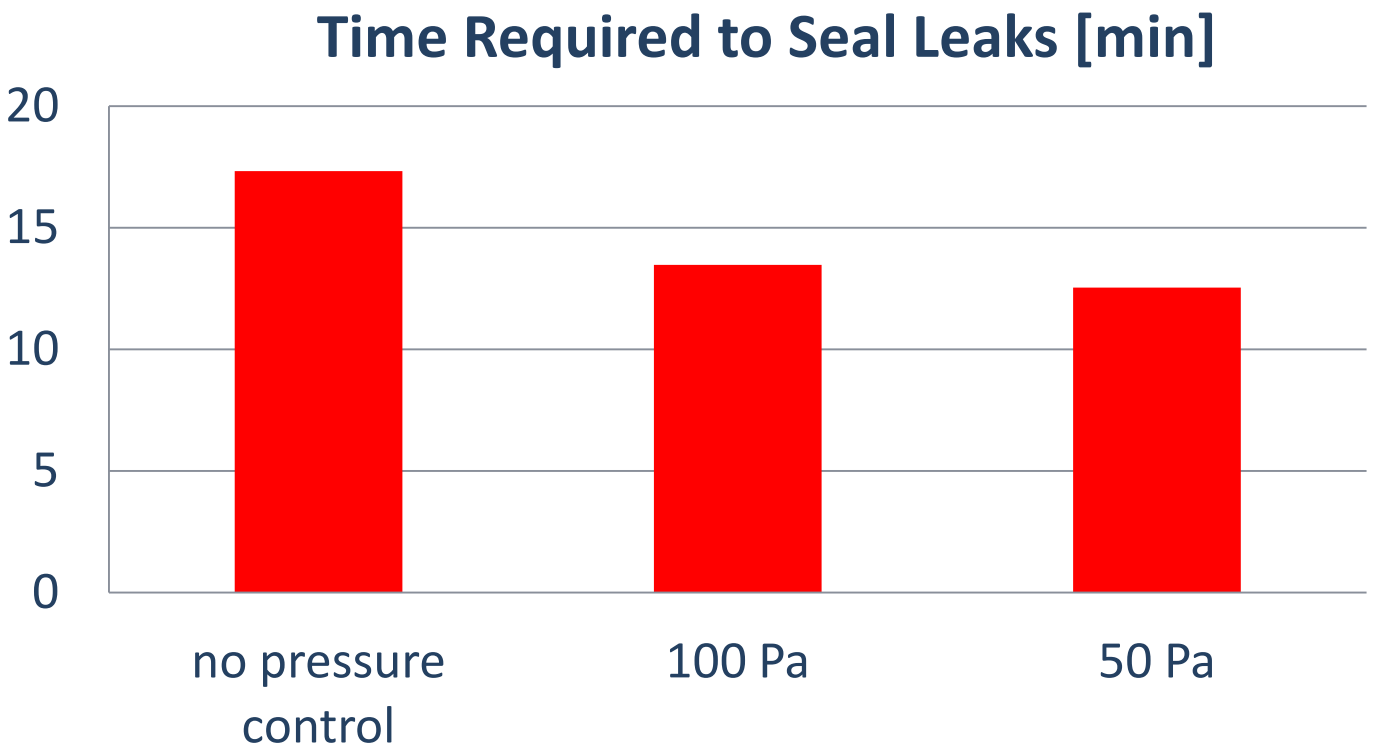
Sensitivity Experiments: Performance Metrics

- **Time Required to Seal Leaks**
- **Sealant Required to Seal Leaks**
  - only looking at sealant injected into box
- **Sealant Deposition Pattern**
  - where does sealant go?

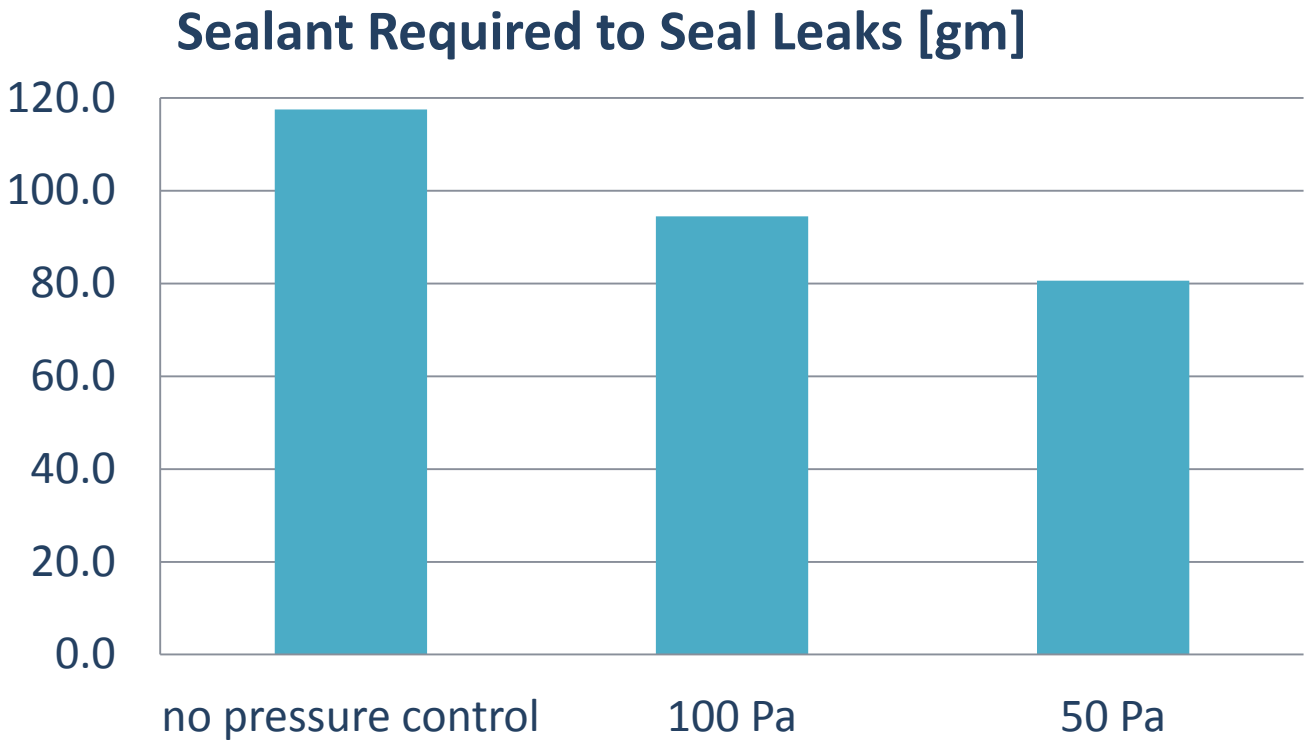
Impact of Pressure Control on Sealing Profile



Impact of Pressure Control on Sealing Profile



Impact of Pressure Control on Sealant Requirements

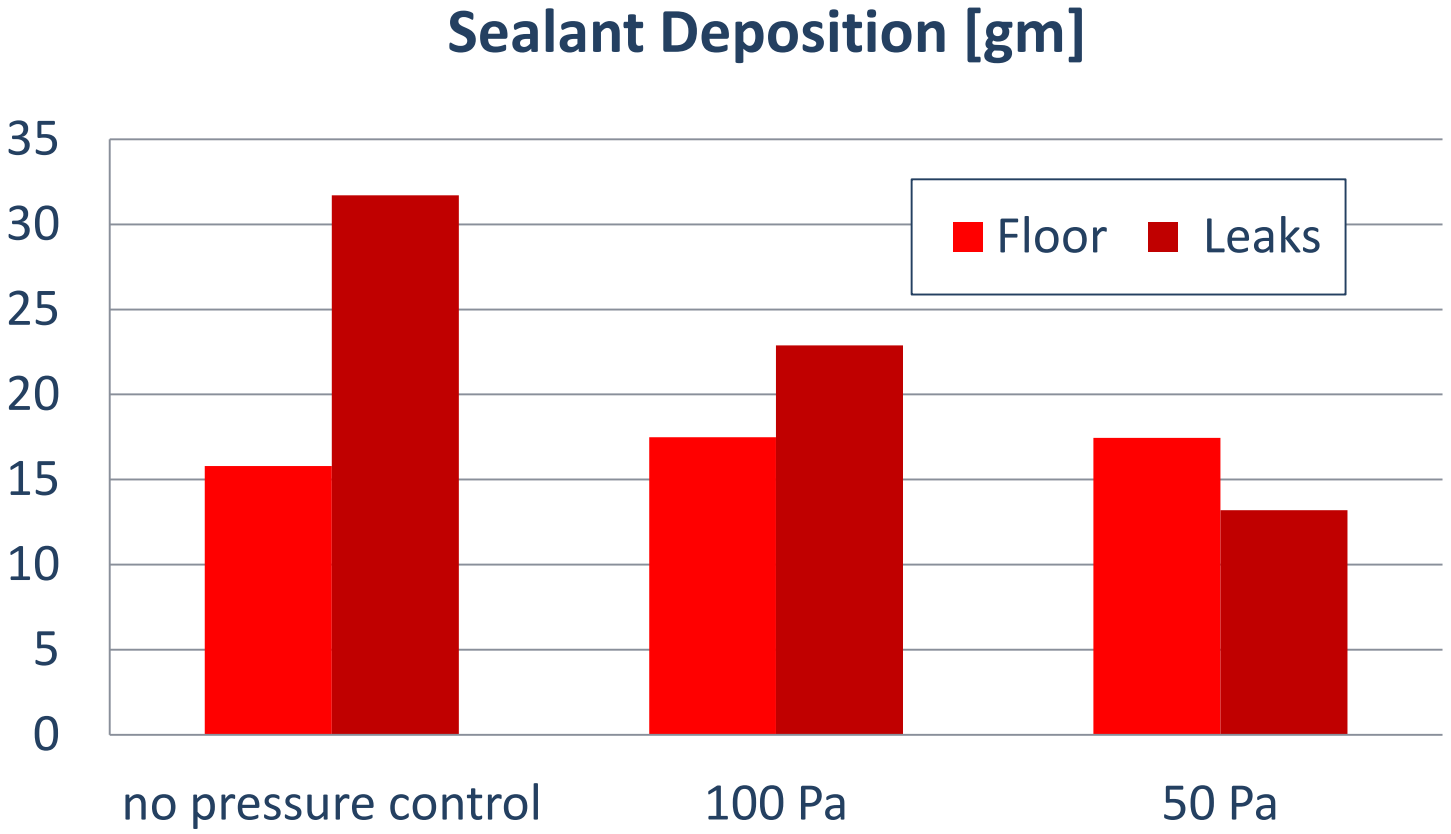


Sealant Distribution Pattern

How sealant deposition at different locations is determined

- **Leaks:** sealant removed from leaks and weighed after experiment
- **Layflat Inlet Tubing:** weighed before and after experiment
- **Floor of Box:** plastic sheet weighed before and after experiment
- **Ceiling of Box:** plastic sheet weighed before and after experiment
- **Walls of Box:** wall patches weighed before and after experiment
- **Lost Through Leaks:** calculated by subtraction

Impact of Pressure Control on Sealant Deposition



Particle Size Manipulation

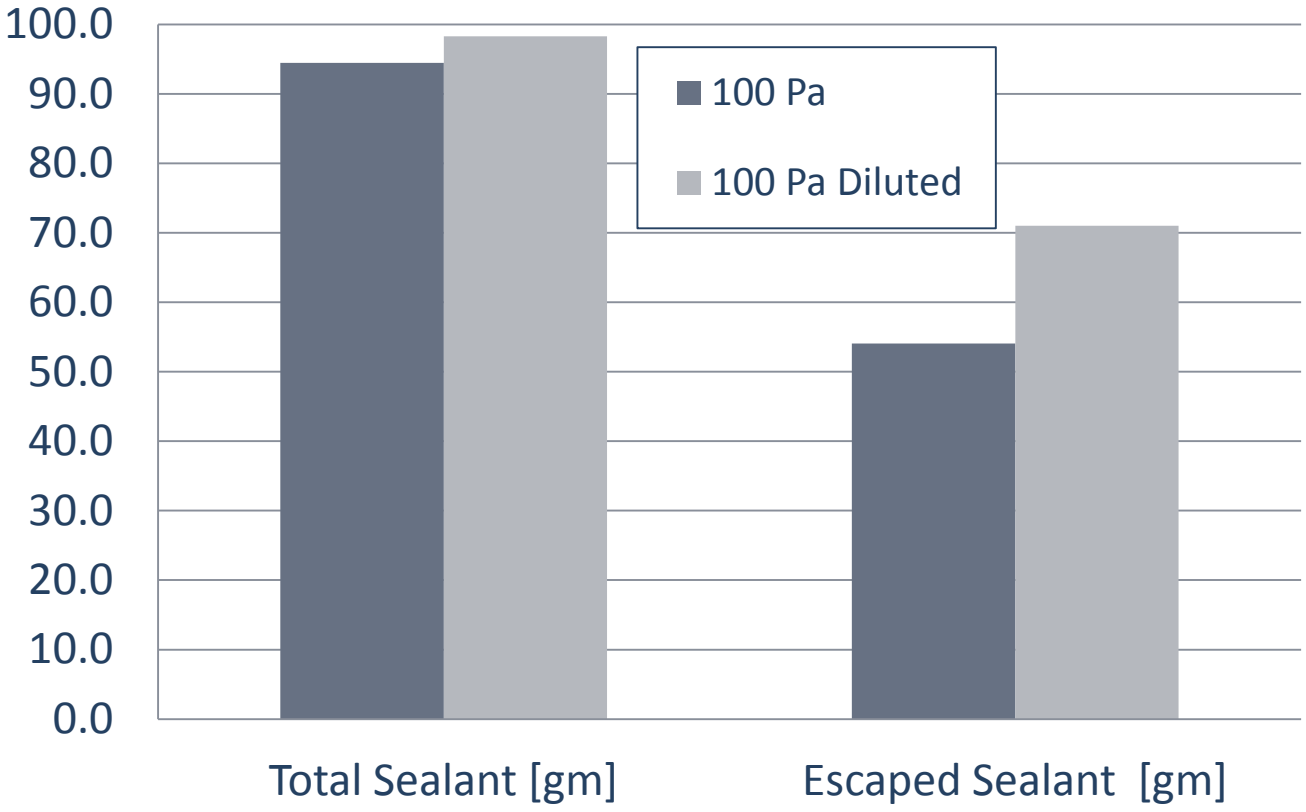
Sealant Dilution Used to Change Particle Size

- Nozzle creates fixed-size droplets
- Dilution reduces solid content of each droplet
- Once water is evaporated, smaller particles remain
- 1:1 dilution reduces particle diameter by factor of $2^{1/3}$
- Particle diameter reduced by ~20% on average

Liquid injection rate was not modified

- Solid sealant flow rate **reduced by 50%**

Impact of Particle Size on Sealant Use and Loss



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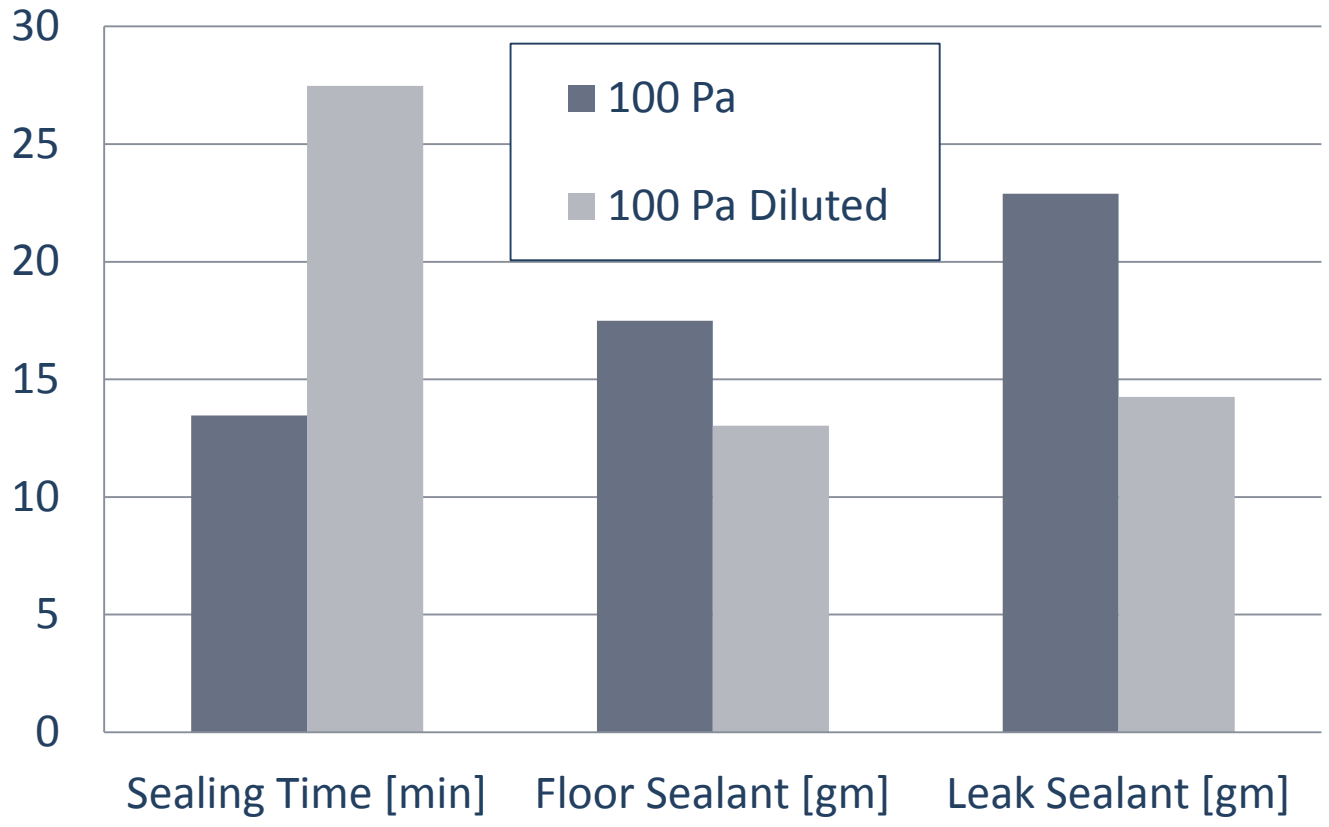
Impact of Particle Size on Sealant Deposition



Summary and Conclusions

- Initial tests of aerosol sealing of enclosures are encouraging
  - Sealing rates in small (nominally quiescent) enclosure are as good or **better than that experienced in ducts**
  - Deposition on floor is comparable to deposition in leaks
  - Minimal deposition on ceiling and walls
- Lower **Operating Pressure**
  - Reduces overall sealing time and sealant use
  - Reduces sealant deposition in/around leaks
  - Small impact on floor deposition

Summary and Conclusions

- Smaller **Particle Size**
  - Did not impact the sealant required for sealing
  - Decreased deposition on floor
  - Decreased deposition around leaks
  - Increased sealant blown through leaks

Next Steps

Additional Box Tests

- Repeatability Tests
- Characterize velocity field in box – try mixing fans?
- Performance modeling

Actual Structure Tests

- Decouple mixing and leak pressures
- Decouple pressurization and particle generation
- Test horizontal spread issues

Thank you for attending the webinar

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