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AIR BARRIER EDUCATION TRACKS FOR
THE CONSTRUCTION INDUSTRY

Building Envelope Retro-Commissioning for Safe Havens

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Learning Objectives

1. Participants will be able to compare air leakage test results of various Safe Havens to known standards.
2. Participants will be able to evaluate potential areas as viable or nonviable Safe Havens.
3. Participants will be able to test and predict the air leakage rate of Safe Havens.
4. Participants will be able to identify common recommendations for reducing air leakage in Safe Havens.

What is a Safe Haven

Shelter-In-Place: A strategy to seek shelter and “stay put” in the event of danger.

Safe Haven: A shelter designed to protect occupants from one or more types of danger.

Can be stand alone or modified from existing buildings.



Industrial Applications Needs for Safe Havens



In this project, the danger is accidental release of anhydrous ammonia at industrial sites.

Safe Haven or 15-Minute Escape Pack



Safe Haven or 15-Minute Escape Pack

Ammonia Release

- The IDLH for ammonia is 300 ppm. Coughing and bronchial spasms will occur at 1700 ppm.
- 30 minute exposure at 2000 to 3000 ppm may be fatal.
- Fatal at 10,000 ppm or 1% by volume.



Retro-Commissioning Existing Building as a Safe Haven from Chemical Release

- Air Seal Envelope
- Close off HVAC
- Isolate HVAC from outdoor air & other spaces
- Air seal all penetrations & fenestrations



FEMA 453 Design Guidance for Shelters and Safe Rooms

- Selecting Location:
 - 5 SF per Person
 - Few to no windows
 - No suspended ceiling
 - Minimum number of doors
 - Interior rooms preferable
 - Away from toxic material storage
 - HVAC System Issues simple is best
 - Water, bathrooms

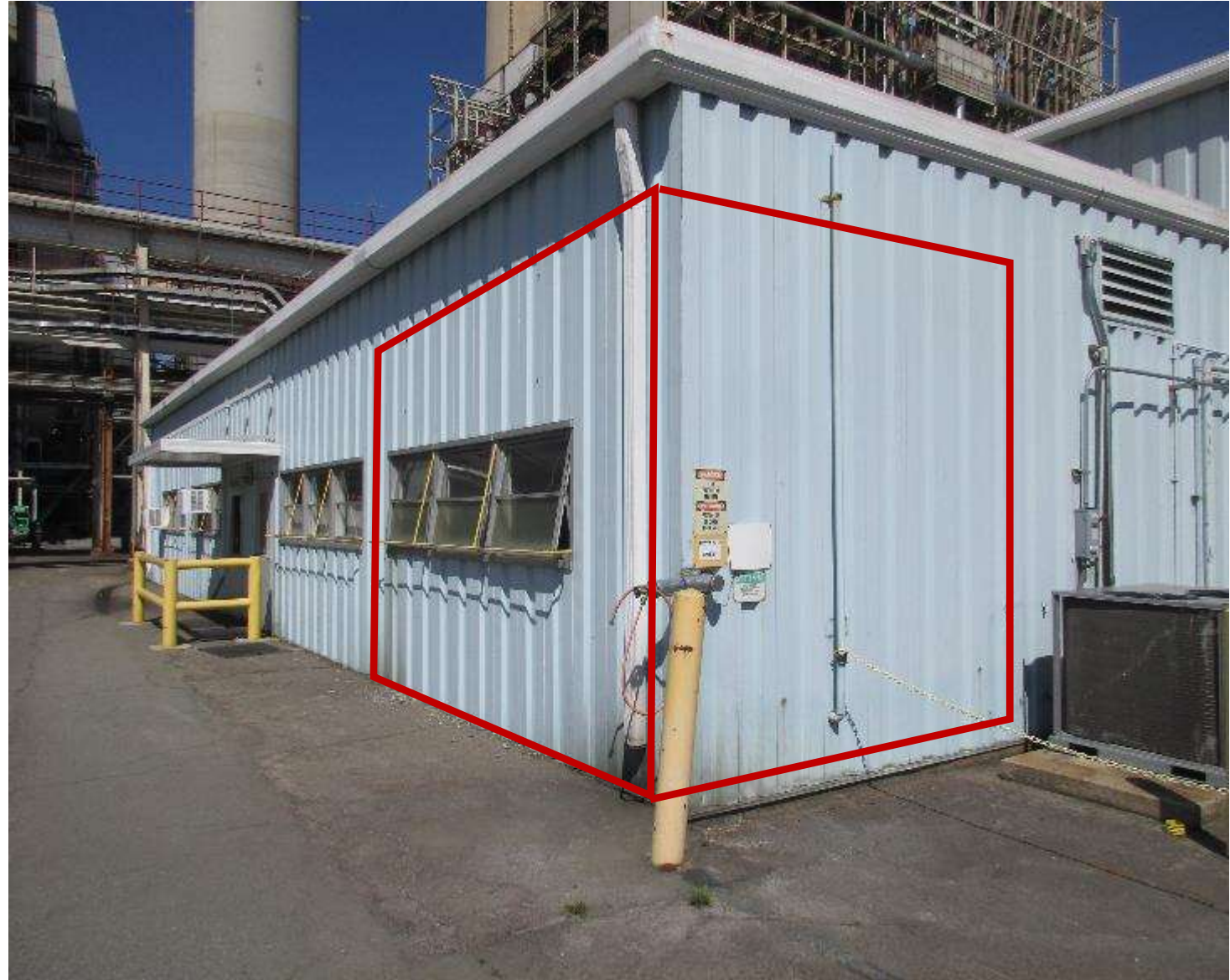


FEMA 453 Design Guidance for Shelters and Safe Rooms

Table 3-1: Comparison of the Three General Classes of Toxic-agent Safe Rooms

Class	Protection	Cost	Advantages and Limitations
1. Ventilated and pressurized with filtered air	high	high	Protection has no time limits, but it provides no protection against some toxic chemicals of high vapor pressure.
2. Filtration with little or no pressurization	medium	medium	Unventilated Class 2 is protective against all gases, but protection diminishes with duration of exposure (and against non-filterable gases).
3. Unventilated, no filtration	low	low	Protective against all agents, but protection diminishes with time of exposure. Carbon dioxide buildup may limit time in the shelter.

Right Sizing



Selecting a Safe Haven



Selecting a Safe Haven



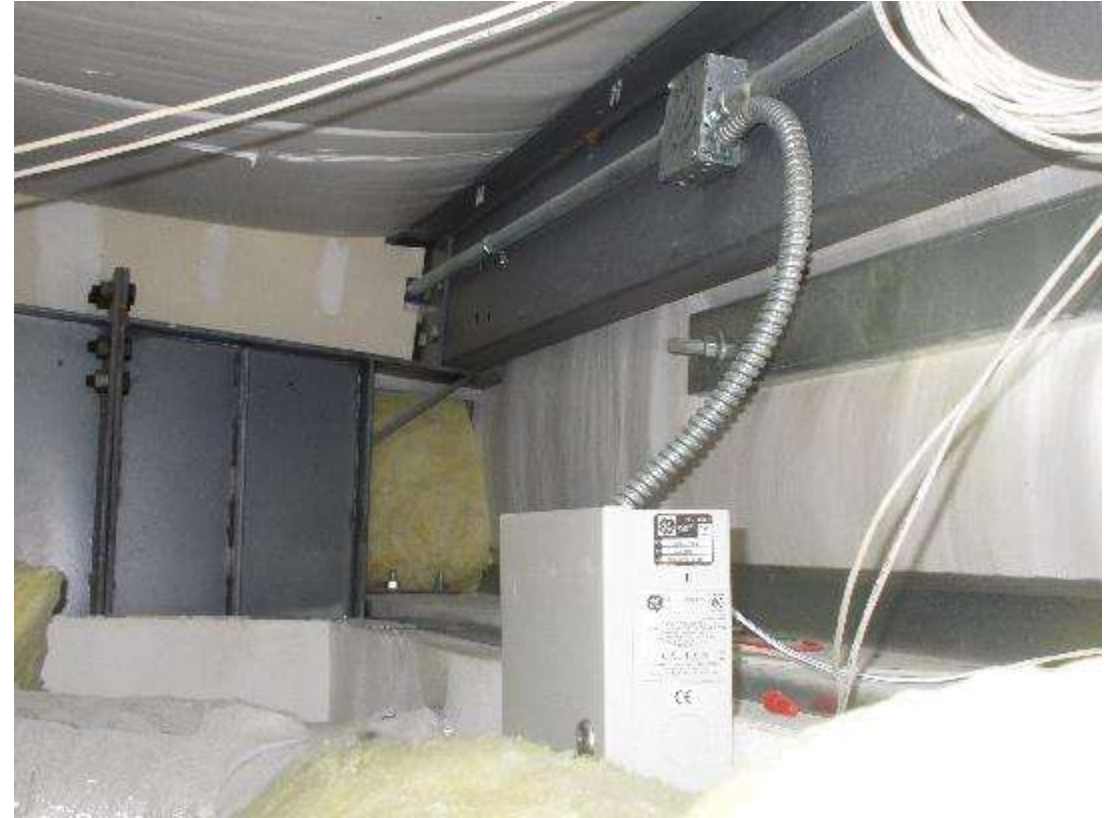
Selecting a Safe Haven



Viabile or Nonviable?



Viabile or Nonviable



Break Areas to Become Safe Havens

- Easy to work around
- Slab Floor with no penetrations
- No sensitive equipment
- Noise is not an issue



Control Rooms to Become Safe Havens

- Difficult to work around, tether all equipment including hard hats
- Many cable penetrations through the floor
- Sensitive (old) equipment can't bump
- Low noise requirement



Safe Haven Project

Evaluated 40 Safe Havens

7 Different Power Plants

3 Different States

FEMA 453 Guide

FEMA does not specify air
tightness criteria



Safe Haven Retro-Commissioning

- Evaluation Phase – Pre Weatherization & MEP Measurement
- Implementation Phase – Weatherization Work & MEP
- Post Evaluation Phase – Measurement & Verification
- Continual Monitoring Phase

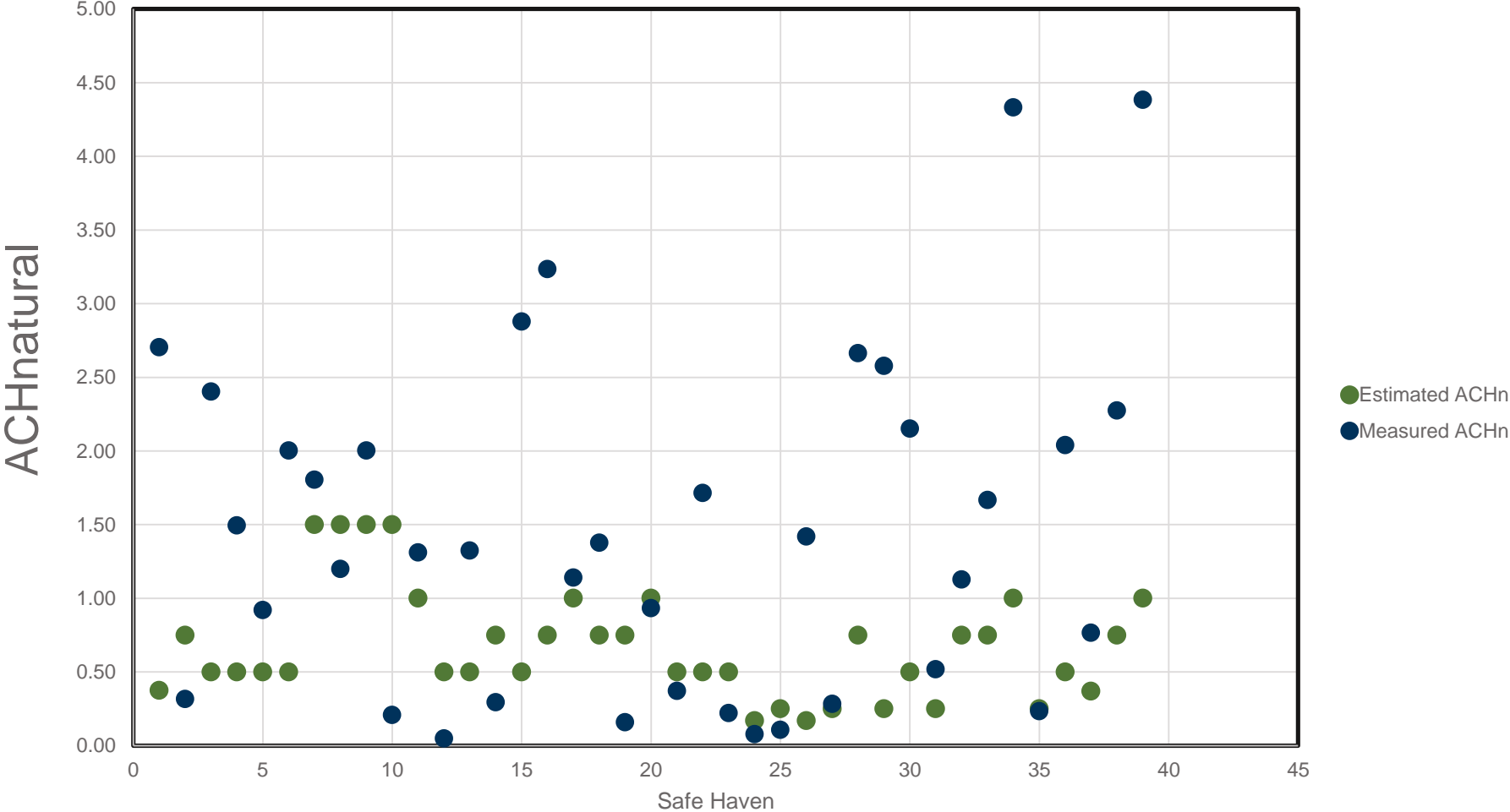


Air Leakage Testing Safe Havens

- ASTM E 779
- No taping HVAC
- Pressurization Only
- Results:
 - ACHn
 - CFM75/SF
 - CFM @ 4 Pascals



Safe Haven Leakage Rate (ACHnatural)

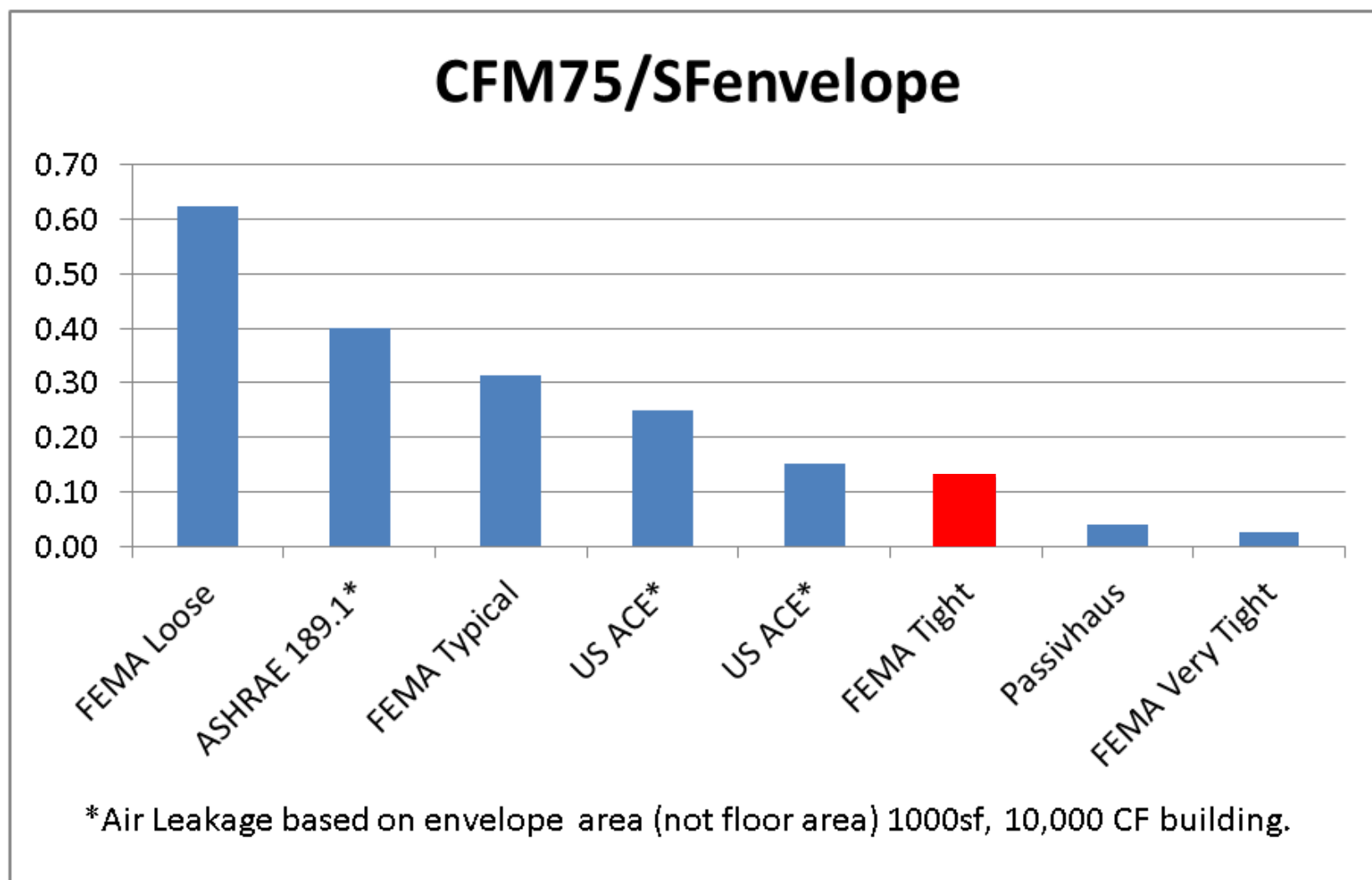


Air Leakage from FEMA 453

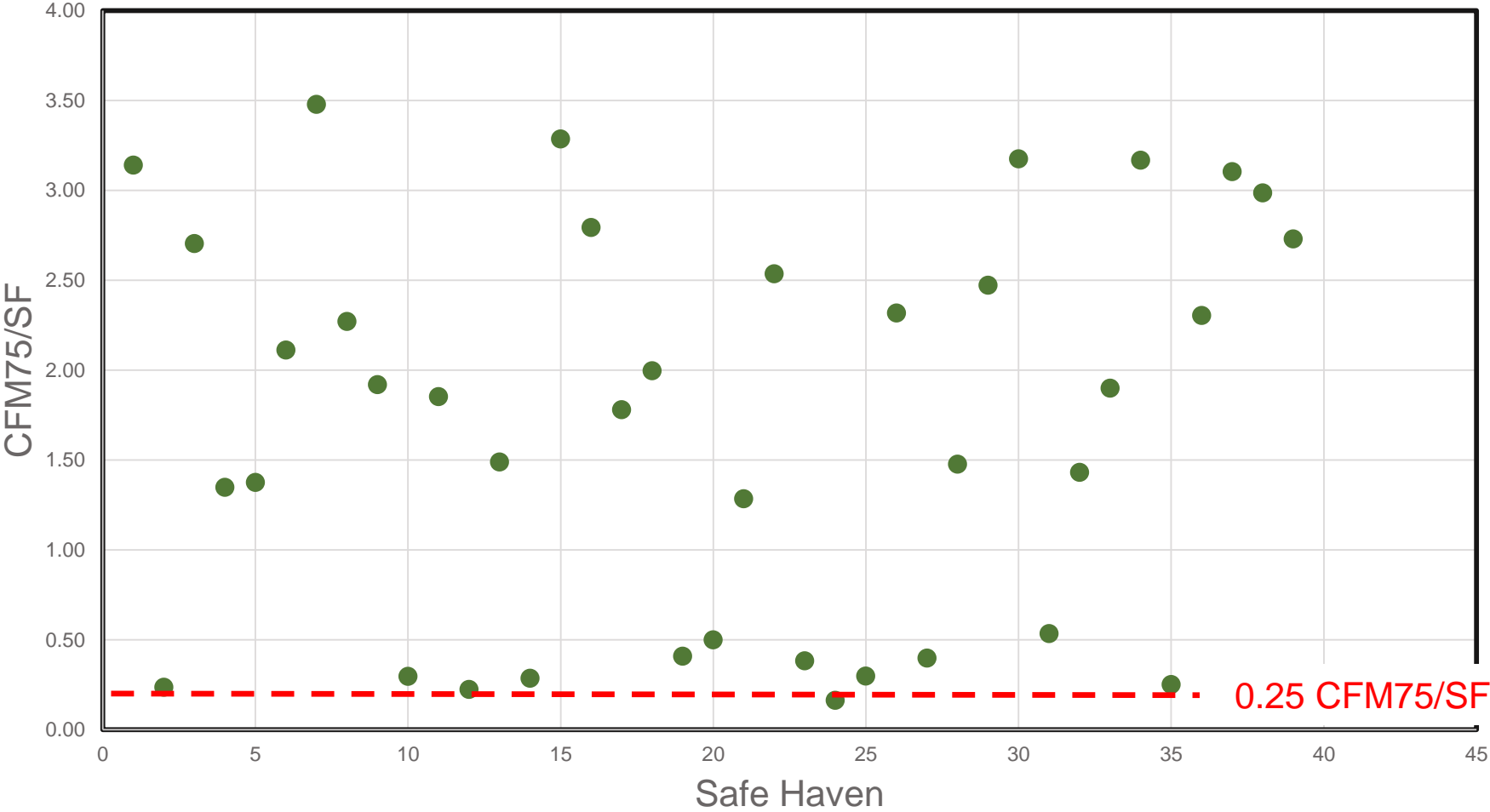
Table 3-2: Leakage per Square Foot for 0.1 lwg (estimated makeup airflow rate per square foot (floor area) to achieve an overpressure of 0.1 inch water gauge)

Construction Type	cfm per square foot of floor area
Very tight: 26-inch thick concrete walls and roof with no windows	0.04
Tight: 12-inch thick concrete or block walls and roof with tight windows and multiple, sealed penetrations	0.20
Typical: 12-inch thick concrete or block walls with gypsum wall board ceilings or composition roof and multiple, sealed penetrations	0.50
Loose: Wood-frame construction without special sealing measures	1.00

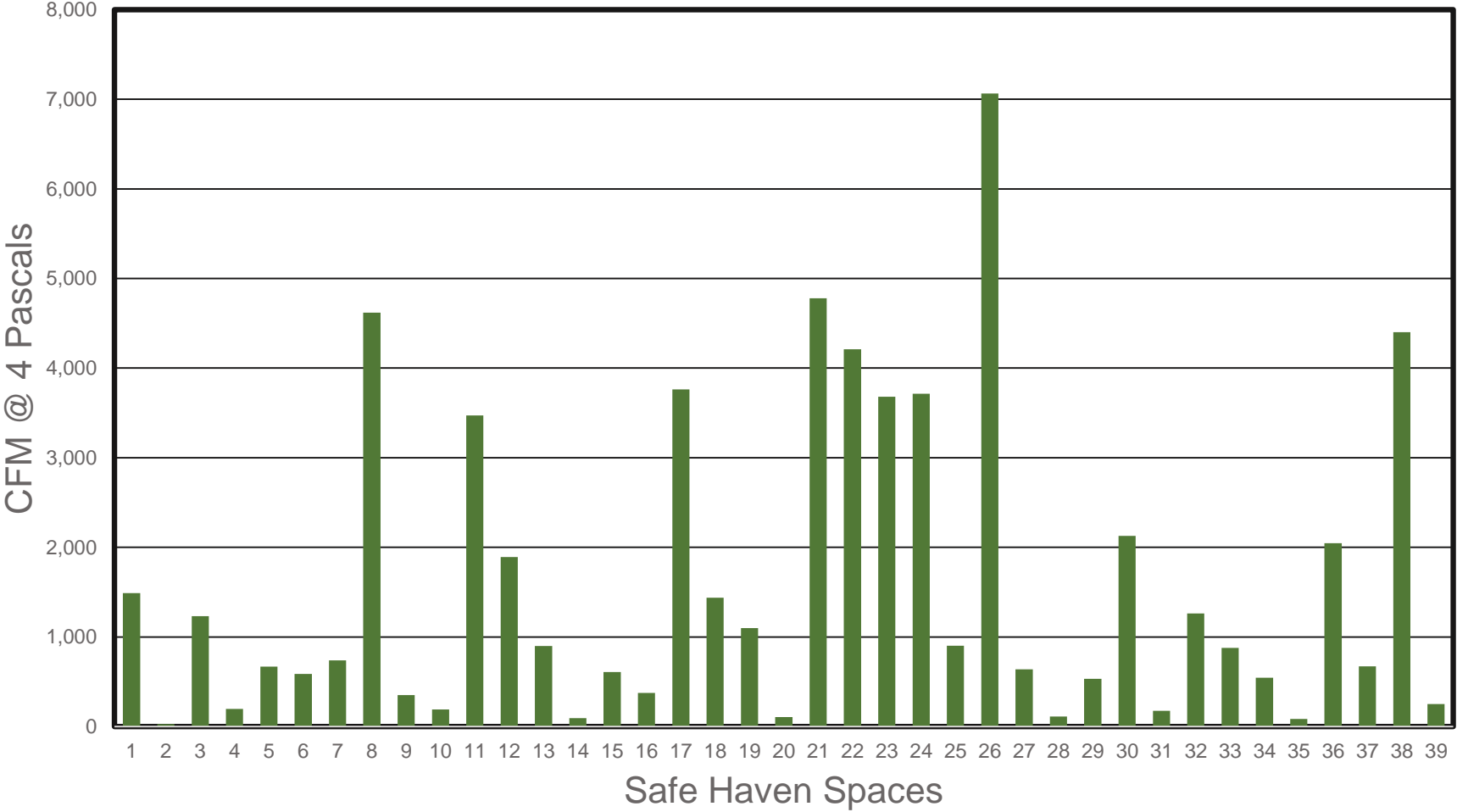
FEMA Table 3.2 Guide Compared to Air Tightness Standards



Safe Haven Leakage Rate (CFM75/SF)



CFM Required to Maintain Positive Pressure with 5 mph Wind



Weatherizing Safe Havens

Envelope

- Walls
- Floors
- Ceilings

MEP

- Lights
- HVAC
- Sprinklers



Envelope – Air Sealing

- Blower Door Directed Air Sealing
- Typical Penetrations
- Windows
- Recessed Lights
- Interior Walls



Blower Door Directed Air Sealing



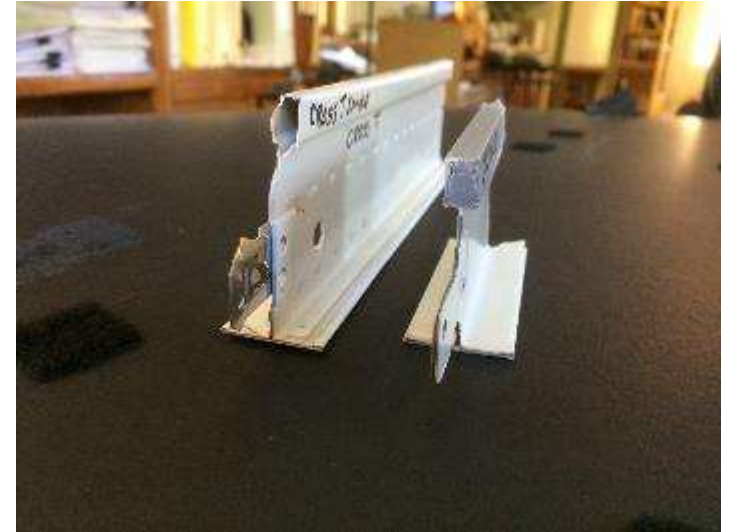
Tricky Walls





Envelope - Ceilings

- Suspended Ceiling System Can Work – Becomes the Air Barrier
- Cleanroom System Application:
 - Gasketed Grid System
 - Air Impermeable Tiles
- Issues with Acoustics



Lights

- Allows leakage through the suspended ceiling system
- Recommend:
 - Airtight Recessed
 - Cleanroom Style Fixtures

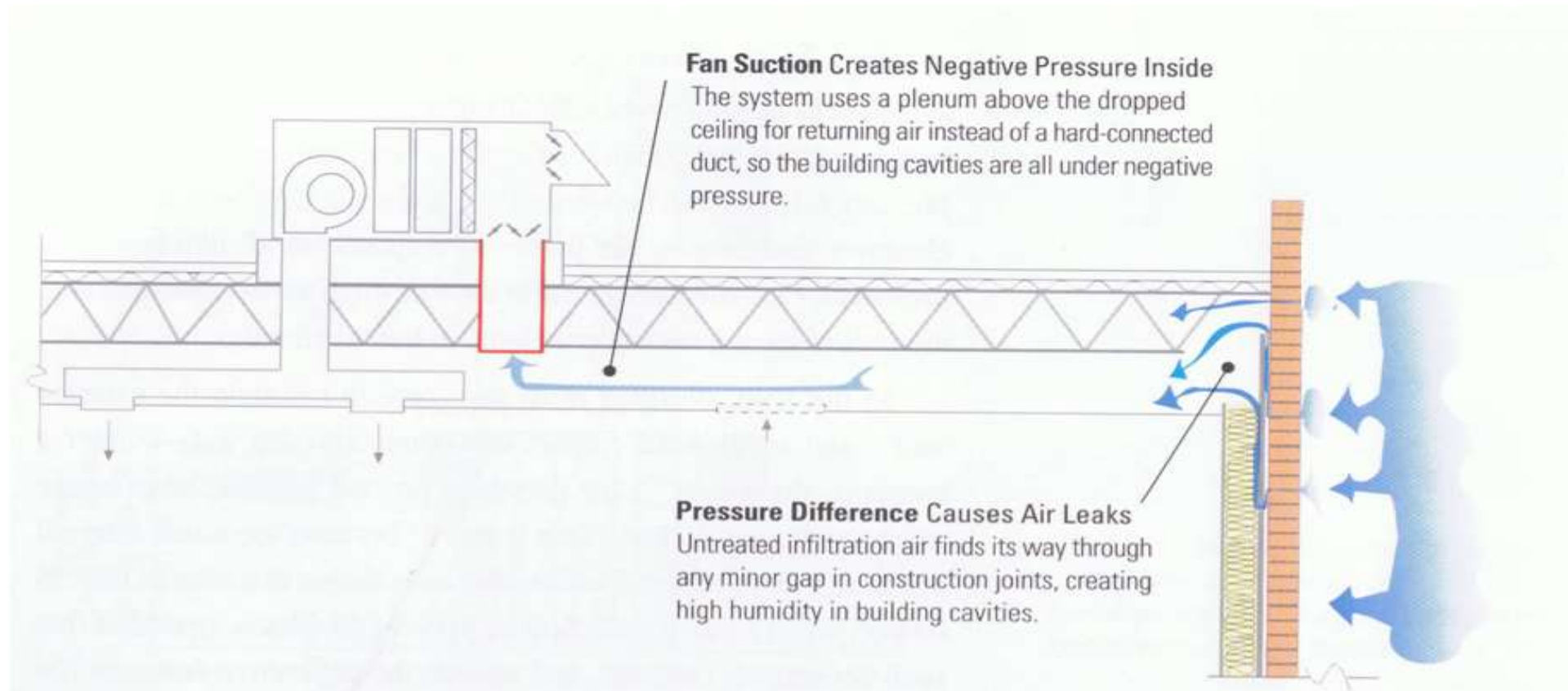


HVAC

- Isolate the Safe Haven
 - Supply Ducts
 - Return Ducts/Plenum
 - Exhaust Fans
 - Outdoor Air System
- Low Leakage Dampers
- Emergency Shut Off



HVAC

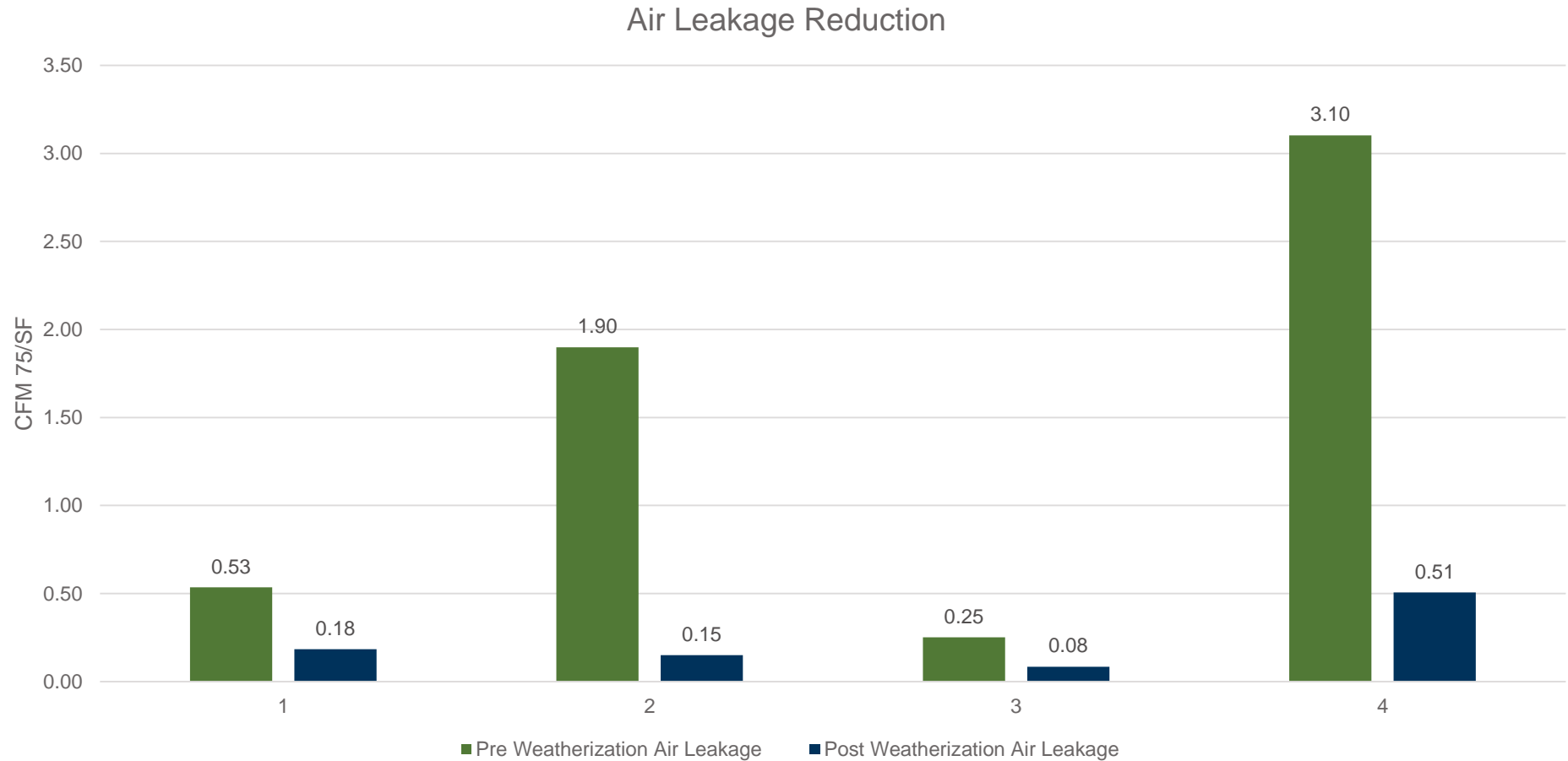


Sprinklers

- Cleanroom Style Sprinklers
 - Make air tight connection to suspended ceiling system



Pre and Post Results



Retro BECx Case Study – Manufacturing Facility Statesville

- Manufacturing Facility
- 100 Year Old Building
- Roll-Up Door
- ASTM E 779 Testing
- Measured Air Leakage Rate:
 - 0.0841 CFM75/SF of Envelope Area
 - Hole Size: 1.60 SF (EqLA)



Retro BECx Case Study – Manufacturing Facility Statesville



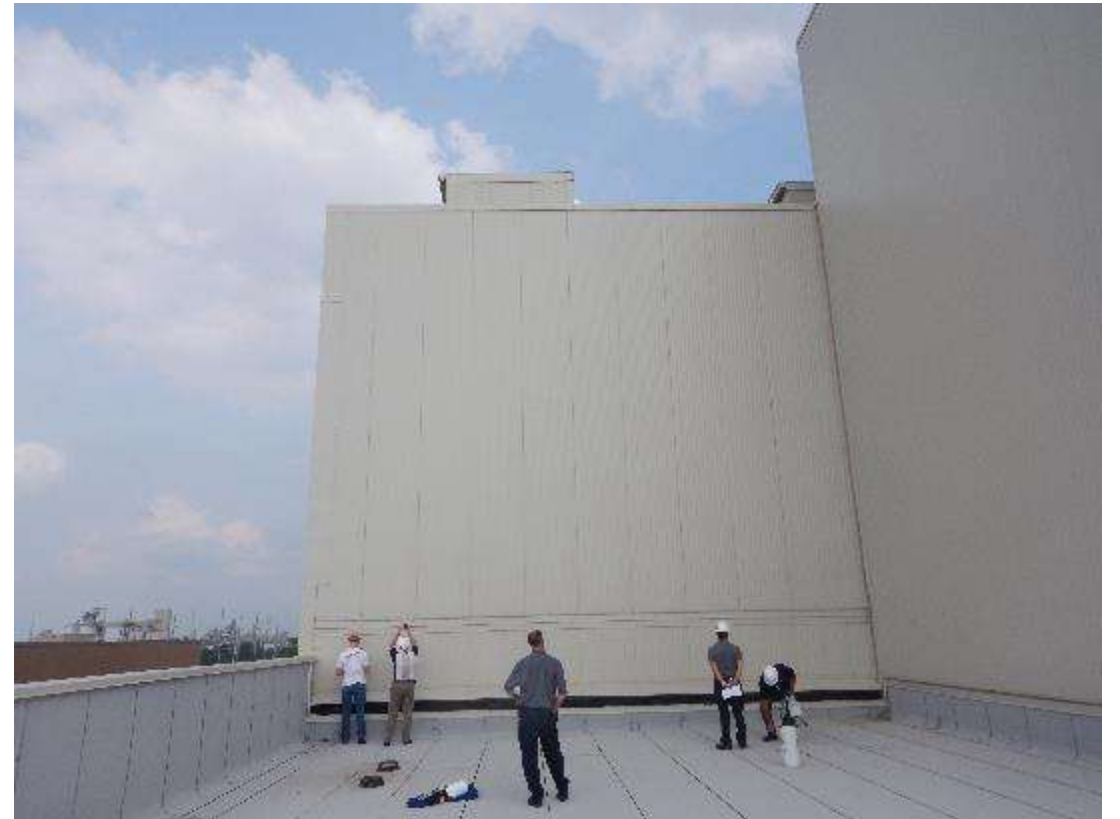
Inspection with Synthetic Smoke



Retro-BECx Case Study – Pharmaceutical Refrigerator

Leaky 500,000CF Cooler

- Condensation On Product
 1. Find Leaks
 2. Repair Leaks



Using Blower Door to Find Leaks



Find Leaks - Seal Leaks



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Thank You!

