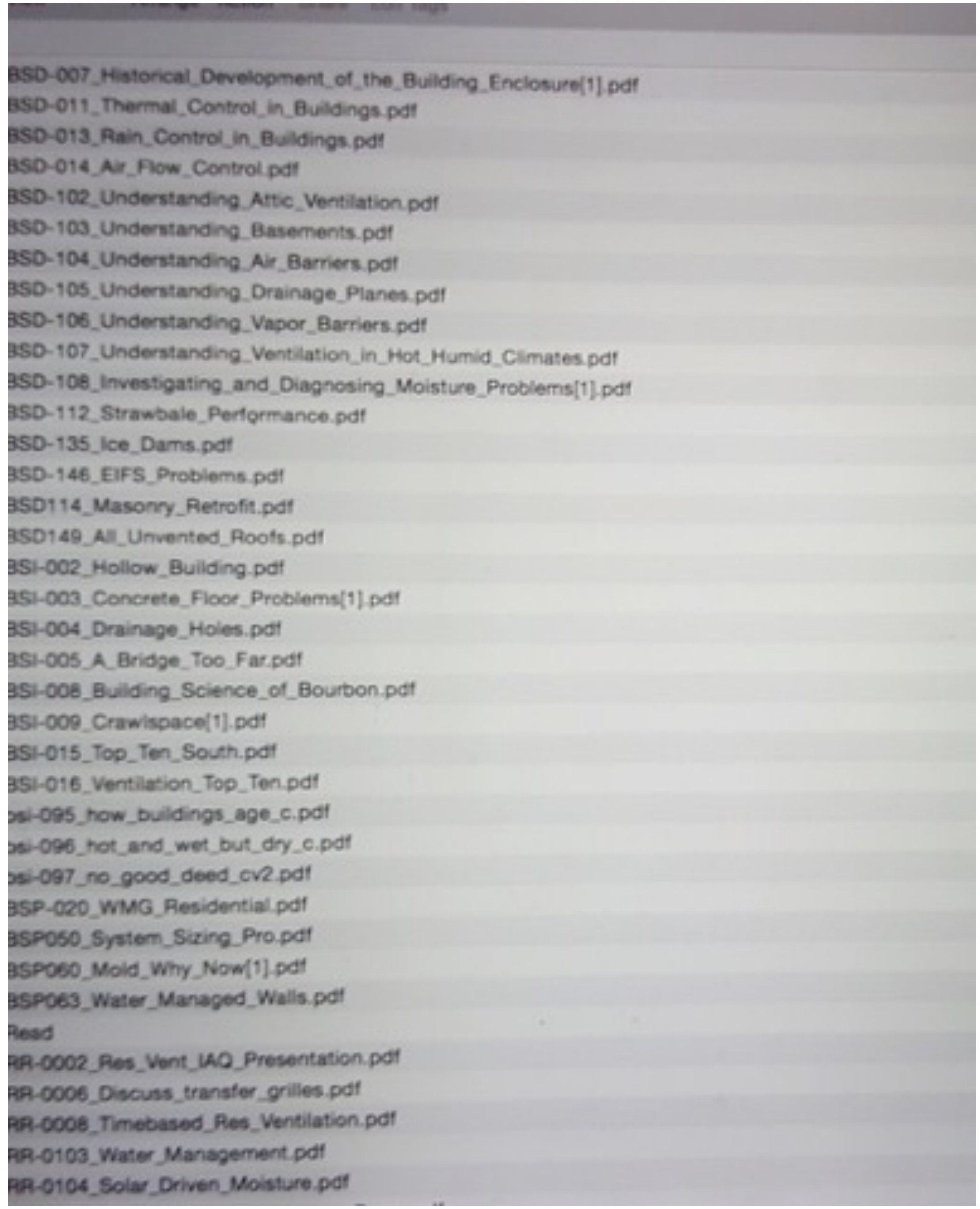
Diagnosing and Air Sealing Large Commercial and Residential Apartment Buildings

Hosted by:
Larry Harmon
Air Barrier Solutions, Inc.

"No Good Deed Goes Unpunished"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BSD-011_Thermal_Control_in_Buildings.pdf
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BSD-102_Understanding_Attic_Ventilation.pdf
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BSP-020_WMG_Residential.pdf
BSP050_System_Sizing_Pro.pdf
BSP060_Mold_Why_Now[1].pdf
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Read
RR-0002_Res_Vent_IAQ_Presentation.pdf
RR-0006_Discuss_transfer_grilles.pdf
RR-0008_Timebased_Res_Ventilation.pdf
RR-0103_Water_Management.pdf
RR-0104_Solar_Driven_Moisture.pdf

What is Air Barrier Solutions?

- Building envelope retrofit firm
- Existing building air barrier evaluations +/- 50 million SF annually
- Focus is on solving problems and getting buildings fixed
- We view our role as being a trusted advisor
- Generally several projects running in various states
- Private and public sector work
- We test what we fix wherever possible
- Quality assurance drives our firm

Why Air Barrier Solutions?

- Proprietary systems to lower costs and improve QA
- CHIEF$_{\text{Plus™}}$ analytical tool for savings calculations
- Team of building evaluators with multiple decades of experience each
- Building reports are comprehensive and designed for implementation
- ASTM E783, ASTM E779, ASTM E1105 and ASTM E1186 testing methodologies are employed
- Building measures are supported by scopes for QA
- Boutique retrofits with state-of-the-art M&V

Markets

- Airports to dog pounds
- Secure federal facilities
- Hospitals
- Schools
- Manufacturing
- Commercial
- Municipalities
- Multifamily
- Hospitality

Benefits of Building Envelope Retrofit

- Controls movement of air into and out of the building
- Reduces heat loss/gain
- Reduces dust, mold and pollutants in the building
- Reduces noise and odors
- Reduces condensation, mold and mildew
- Improves comfort and occupant experiences
- Helps control biologicals

You Should Not Be Trying To Airseal Big Buildings Without A…

Quality Assurance System

Key Concepts

- **Muda – wastefulness**
- **Muri – unreasonable**
- **Mura – non-uniformity**
- **Poka-Yoke – mistake proofing**
    - **Don’t accept a defect**
    - **Don’t make a defect**
    - **Don’t pass on a defect**

Importance of Quality Assurance

- Getting the task correct is the difference between a tight and leaky fix
- Continual QA keeps the team focused on the goal
- QA timing should be as close to the task as possible
- Air leakage testing as the final arbiter of a good seal-up really keeps the team focused

- **Specifications**

Standard Work Specification (SWS)

Topic: Window Work

SWS # 3

Subtopic: Cast-in-Place Weatherstripping

1) Detail Name: Metal frame, no weatherstrip by design, cast-in-place silicone gasket

Desired Outcome: Create a continuous air tight gasket

Row	Title	Specification(s)	Objective(s)
1	Safety	Worker follows relevant safety practices	Safe work practices and uninjured workers
2	Site	Site will be protected by moving objects and shielding areas	Prevent damage to objects near the work
3	Prepare frame and window	Window frame ready for gasket material	Have the frame free of corrosion dirt and oils
4	Sealant	100% pure silicone	Well adhered, gap filling, durable gasket

Quality Assurance System

- **Specifications**
- **Training for consistency**

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Job Instruction Breakdown Sheet (JIB)

Description of Task: *Initial Inspection and Repair of Door*					Rev. Date 2014-10-28
Materials:		**Tools & Equipment:**			
❑ Self-tapping screws ❑ Machine screws ❑ Tapcon with flush head that will countersink ***All materials must meet the job's specifications***		❑ Screw drivers ❑ Allen wrenches ❑ Hammer drill ❑ Driver ❑ Channel locks ❑ Hammer		❑ Chisel – wood ❑ Chisel - cold ❑ Punch	
Desired Outcome(s): Properly operating door prepped for weatherstrip removal or installation					
# Important Steps		**Key Points**		**Reasons**	
What?	**Logical steps that advance the work**	**How?**	**Tips in the "Important Steps" that will:** • **Make or break job** • **Prevent injury** • **Make easier**	**Why?**	**Reasons for Key Points**
Safety-related					
1				•	
Process					
2	Open and close door		• Inspect door's operation for minor repair items that can be fixed within 5 minutes • If repairs needed are beyond that timeline, make note of problems on Quality Checklist and turn into Supervisor		• Find out what needs to be adjusted before weatherstripping and fix if possible	
3	Inspect hinges and adjust if needed		• If door is striking the jamb, check for loose hinges and tighten • If hinge-bound, loosen the hinge where it is inset to		• Loose hinges allow sagging of door and hitting jamb • Hinge-bound doors tend to pop open and not close all the way	

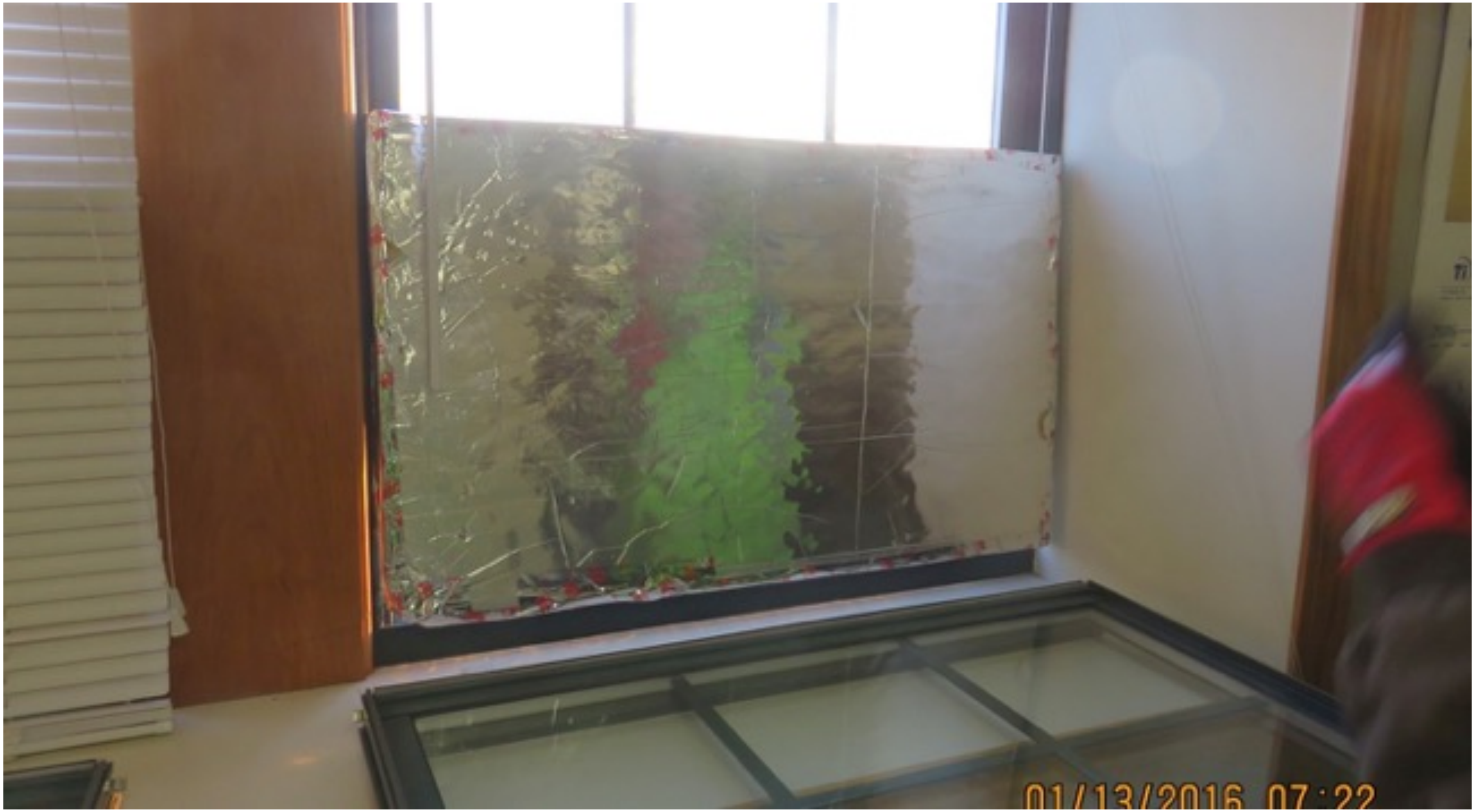
Quality Assurance – Doors

Training JIBs for door retrofits

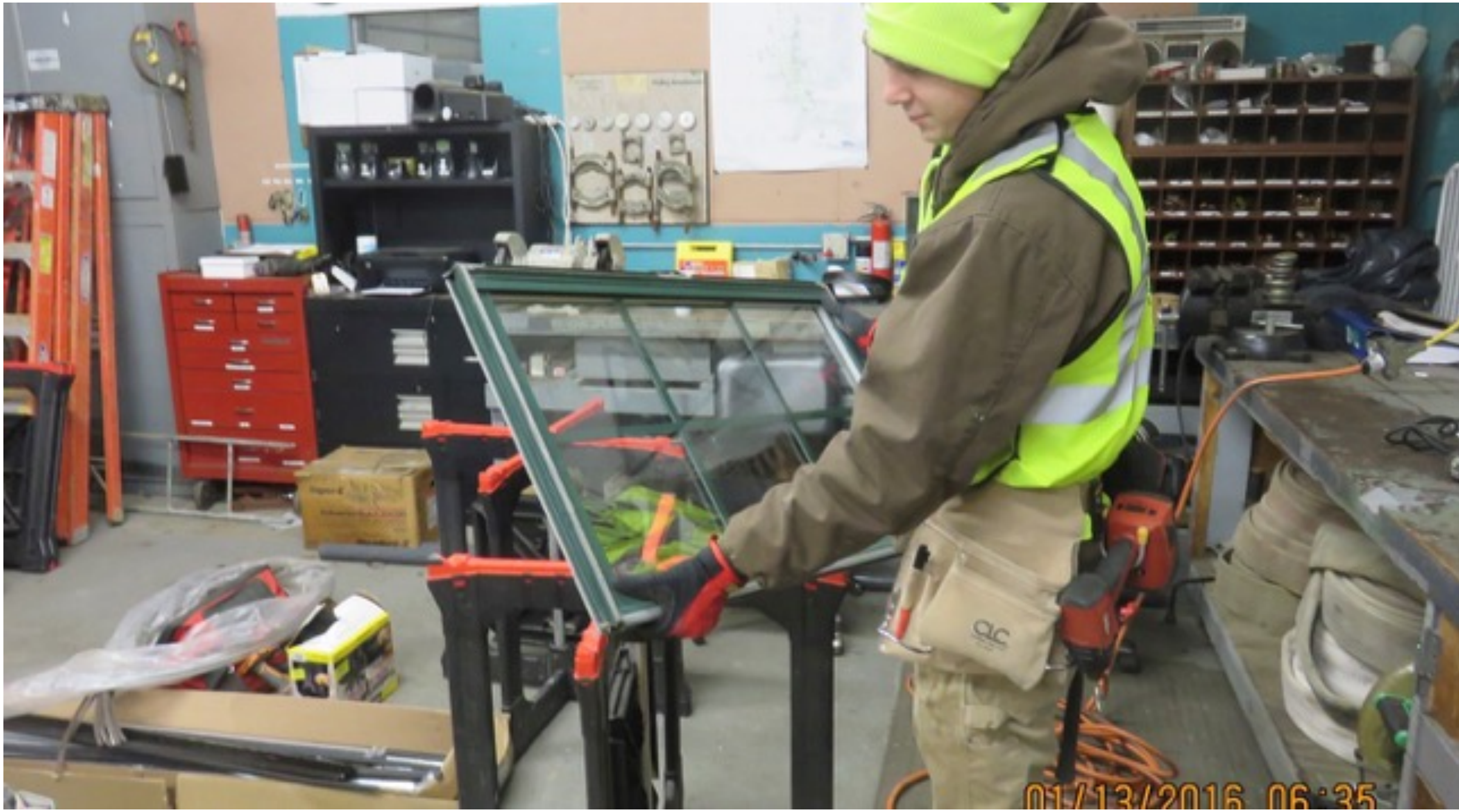
- Door inspection and repair
- Door weatherstrip removal
- Door weatherstrip installation: +/- 17 versions
- Door closer adjustments
- Door final inspection and checklist

Select Proper Window Plug

Remove Sash Install Plug



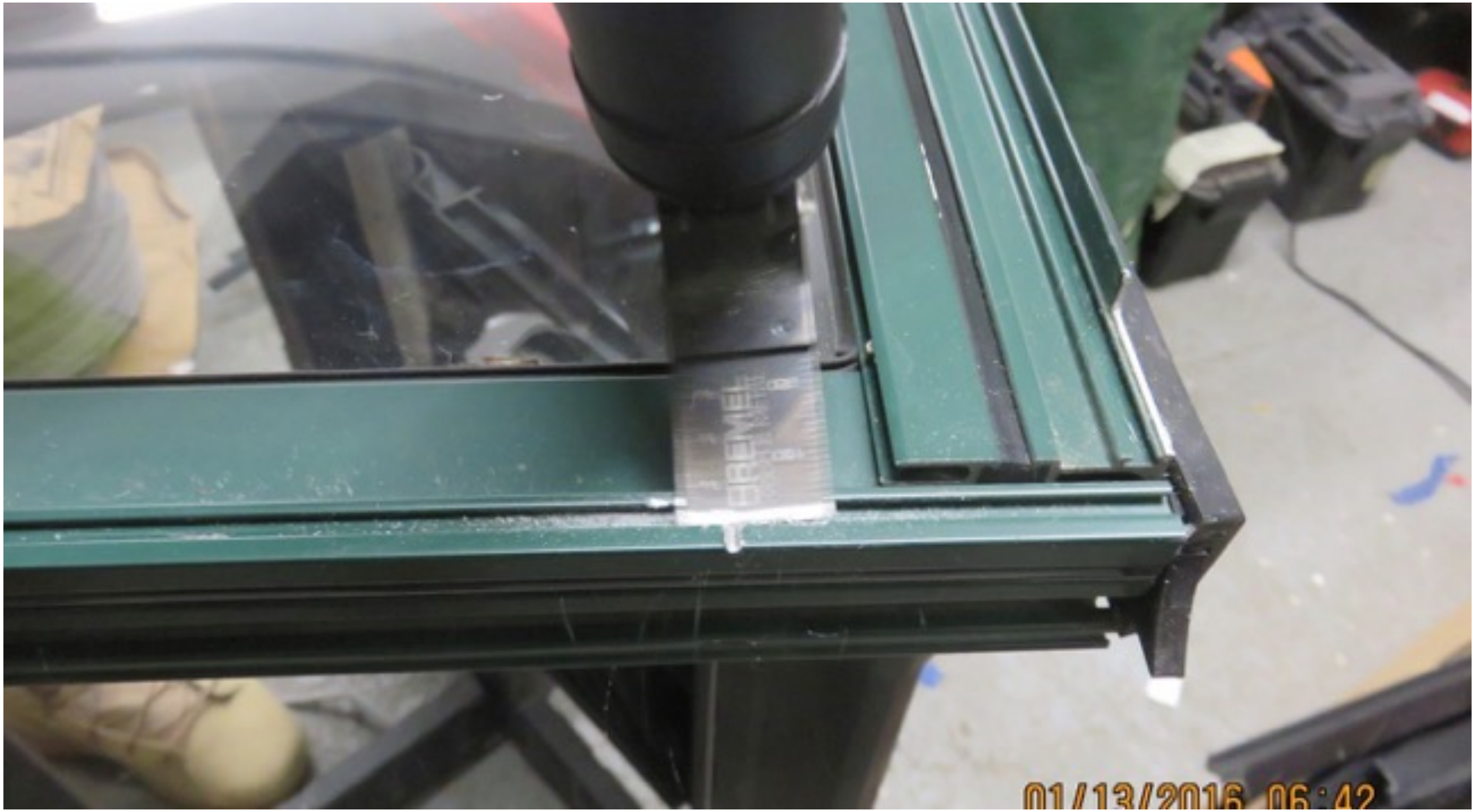
Place On Non-Skid Work Surface



Use Pick to Remove Weatherstrip

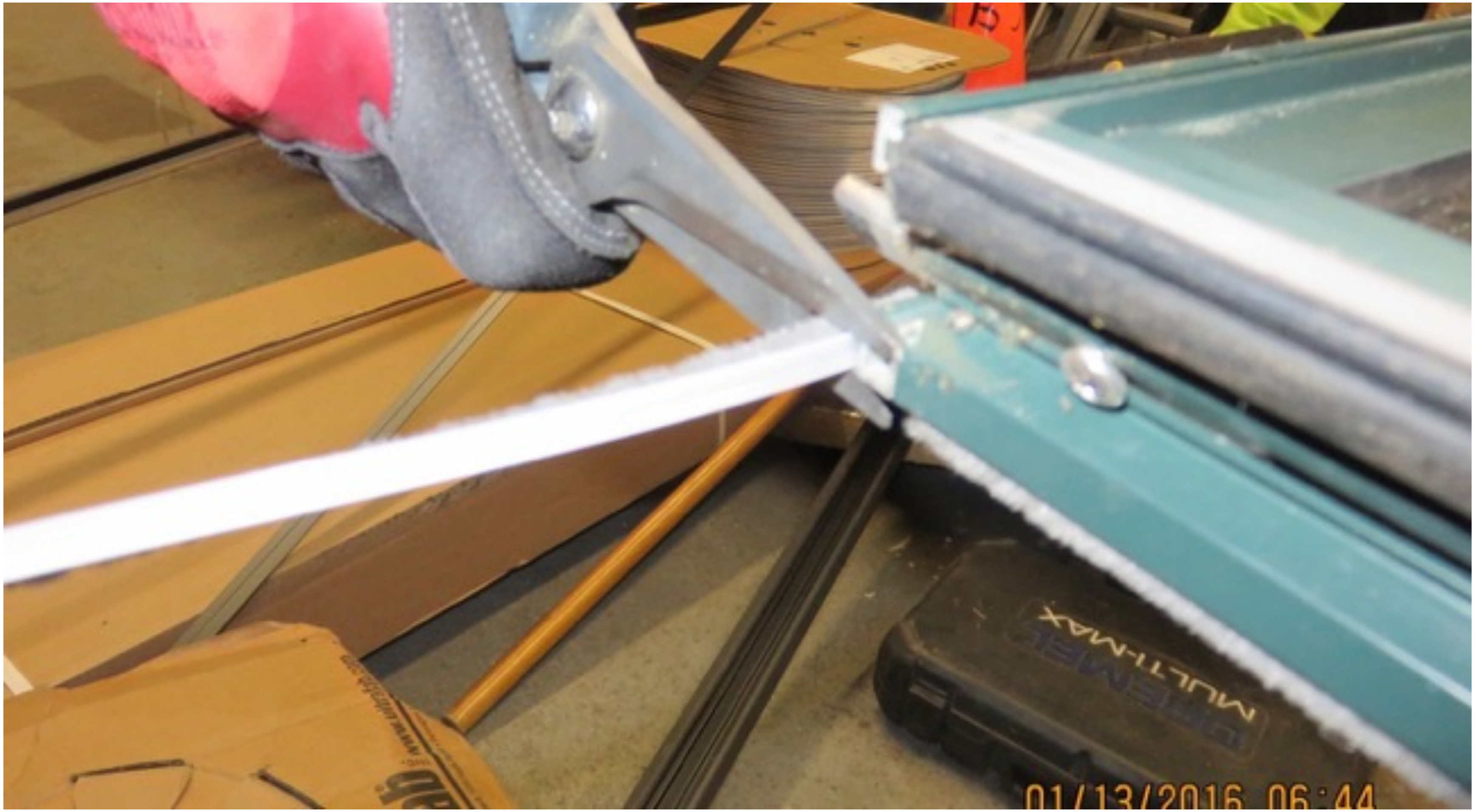
Locate Manufacturer's Crimps

De-burr with Multi Tool



Use GFCI For All Power Tools

Insert New Weatherstrip and Trim



Reassemble Sash if Necessary

Clean, Lubricate Latches, Reinstall

Quality Assurance System

- **Specifications**
- **Training for consistency**
- **Real-time worker support**

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Blocking open soffit critical details space.

Step 1.

Assess opening size and select material consistent with the QAS Manual. Complete any roof-wall joint opening into the sides of the space.

Step 2.

Fit and install rigid sheet goods tying the wall or header system to the roof. Note some fire rated applications may use rockwool and Hilti mastic for this application.

Step 3.

Fasten all edges and air seal in place. In this instance adhesive 2-component foam has done both tasks – Smart!

Step 4.

Fire protect as necessary. Use of a Hilti fire rated mastic or in this case DC-315 paint over foam achieves the proper protection.

Quality Assurance System

- Specifications
- Training for consistency
- Real-time worker support
- Checklists tracking progress and results

New Bedford Department of Public Infrastructure
Overhead Door W/S Install Guide and Quality Checklist for
RU/OH Door ID: RU-1
Repair Required:

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Material List

	Width	Height
Door Size (WxH)	9.5 feet	9.5 feet
	Channel Type	**Brush/Seal Type**
Sides	RU Clip-on	1.5in SSB
Top	5.5in STR-LS	3in LSB
Bottom	None	RU BTM Seal
Notes:		

Installed by: ____________________

Start Date/Time: ____________________

End Date/Time: ____________________

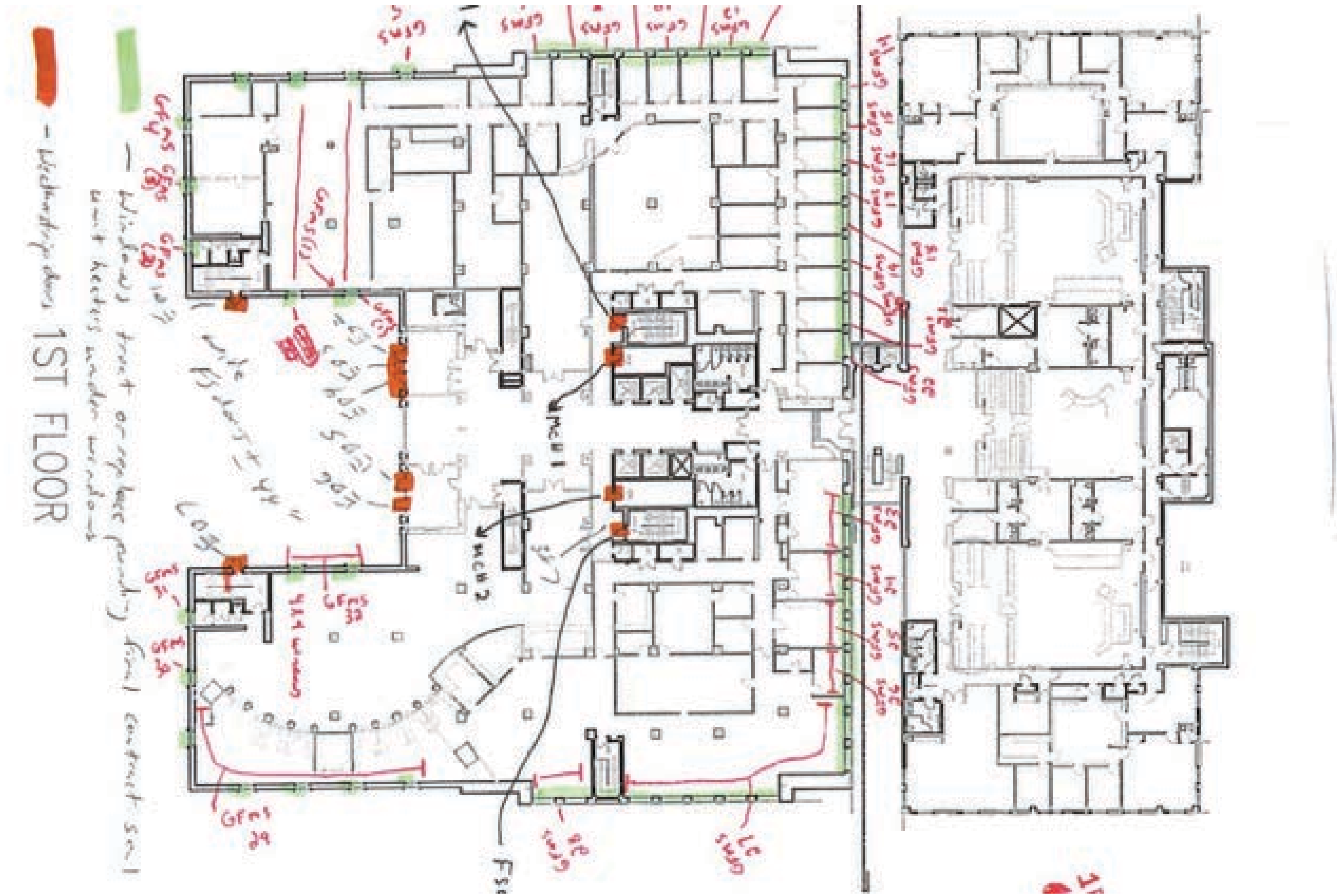
I (we) certify that all of the answers below are correct and this is a zero-defect installation:

Signature(s): ____________________

____

Quality Management Checklist

1. Write down known problems that may impact operation e.g. broken gear box
   ____
   ____
2. Cleaned metal/wood before installing
   ❑ Yes ❑ No If no, fixed ❑ Yes ❑ No
3. Continuous bead of caulk behind all carriers
   ❑ Yes ❑ No If no, fixed ❑ Yes ❑ No
4. Pieces are all correct length and match on each side, if piecing needed (can piece, must mirror cuts on each side)
   ❑ Yes ❑ No If no, fixed ❑ Yes ❑ No
5. Continuous installation with no gaps all around door – 100% contact
   a. Top and sides have slight contact, but do not interfere with door operation
      ❑ Yes ❑ No ❑ NA If no, fixed ❑ Yes ❑ No
   b. Bottom touches ground – no sunlight visible if floor is not uneven
      ❑ Yes ❑ No ❑ NA If no, fixed ❑ Yes ❑ No
   c. Tested fit/proper close after each piece installed
      ❑ Yes ❑ No If no, fixed ❑ Yes ❑ No
   d. If bottom is catching on side weatherstrip, trimmed metal back away from finseal
      ❑ Yes ❑ No ❑ NA If no, fixed ❑ Yes ❑ No
6. Carriers are screwed within 1-2" of each end then evenly spaced approximately every 10"
   ❑ Yes ❑ No If no, fixed ❑ Yes ❑ No
7. Tested door 10 times to make sure it is closing properly
   ❑ Yes ❑ No If no, fixed ❑ Yes ❑ No
8. **Work site is clean before proceeding**
   ❑ Yes ❑ No If no, fixed ❑ Yes ❑ No


1ST FLOOR
MCH 1
MCH 2

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Quality Assurance System

- **Specifications**
- **Training for consistency**
- **Real-time worker support**
- **Checklists tracking progress and results**
- **Daily reporting**
- **JIB review essential for each building**
- **Mock up everything and test it**

Value of a CFM Saved…

…it's not just the money!

Calculating Savings

CHIEF$_{\text{Plus™}}$ calculation tool:

- Developed by Air Barrier Solutions, Inc.
- Thermal savings follow U*A*ΔT
- Air leakage savings are based on formulae derived from ASHRAE Fundamentals
- Detailed data inputs
- Bin data for temperature and wind speeds
- Transparent
- “Hot” formulae
- Fit testing
- Detail tabs per building and summary tab per project

Calculating Savings

Fit Testing – Evaluate reasonableness of the model

- **Vetting the savings estimates and building operational assumptions**
- **Looks at percentage of baseline savings – reasonable?**
- **Btu/SF/HDD for benchmarking**
  - Does it make sense, given what we've found at the site?
  - Possible supplemental heat?
  - Possible errors in baseline data?
  - Building operations tweaks – seasonal usage/setback

Calculating Savings

- **Payback depends on:**
  - Fuel Rate
  - Electricity Rate
  - Efficiency of the HVAC equipment
  - Building operations/setbacks
  - Cost/complexity of measure
  - Labor Costs
  - Current baseline consumption
  - Average wind speed of the area
  - Height of building

CFM Savings Projections

- **Height of building**
- **Shielding class**
- **BIN hours/average temperatures**
    - Heating Occupied
    - Heating Unoccupied
    - Cooling Occupied
    - Cooling Unoccupied
- **Average wind velocity**
- **Setpoints/occupied hours**

Dollar Savings Projections

- Heating fuel costs
- Electricity/cooling energy costs

CHIEF$_{Plus}$™ Project Data

Inputs - Oxford, CT				
HDD (calcs use BINs)	6,375			
CDD (calcs use BINs)	334			
Avg. Wind	7.0			
# Stories	4			
Shielding	3			
Cost/MMBtu	$10.00			
Cost/kWh	$0.10			
Occupied hours	84			
Setbacks - heating	72/65			
Setbacks - cooling	74/78			
Heating System Efficiency	75%			
Outputs				
	H_O	H_U	C_O	C_U
CFM Decreases - 1 door	13	12	7	7
Savings/CFM Decrease	$1.10	$0.89	$0.07	$0.04
Total Savings	$25.68			

CHIEF$_{Plus}$™ Higher Wind Speed

Inputs - Oxford, CT (Impacts If Higher Avg Wind Speed)				
HDD (calcs use BINs)	6,375			
CDD (calcs use BINs)	334			
Avg. Wind	9.5			
# Stories	4			
Shielding	3			
Cost/MMBtu	$10.00			
Cost/kWh	$0.10			
Occupied hours	84			
Setbacks - heating	72/65			
Setbacks - cooling	74/78			
Heating System Efficiency	75%			
Outputs				
	H_O	H_U	C_O	C_U
CFM Decreases - 1 door	14	13	9	9
Savings/CFM Decrease	$1.10	$0.89	$0.07	$0.04
Total Savings	$28.01			

CHIEF$_{Plus}$™ Higher Utility Rates

Inputs - Oxford, CT (Impacts If Higher Utility Rates)				
HDD (calcs use BINs)	6,375			
CDD (calcs use BINs)	334			
Avg. Wind	7.0			
# Stories	4			
Shielding	3			
Cost/MMBtu	$13.50			
Cost/kWh	$0.15			
Occupied hours	84			
Setbacks - heating	72/65			
Setbacks - cooling	74/78			
Heating System Efficiency	75%			
Outputs				
	H_O	H_U	C_O	C_U
CFM Decreases - 1 door	13	12	7	7
Savings/CFM Decrease	$1.49	$1.21	$0.10	$0.17
Total Savings	$34.79			

CHIEF$_{Plus™}$ Project Data

Inputs - Miami, FL				
HDD (calcs use BINs)	140			
CDD (calcs use BINs)	2,886			
Avg. Wind	8.9			
# Stories	7			
Shielding	2			
Cost/MMBtu	$25.90	(Electric)		
Cost/kWh	$0.09			
Occupied hours	168			
Setbacks - heating	72/72			
Setbacks - cooling	73/73			
Heating System Efficiency	95%			
Outputs				
	H_O	H_U	C_O	C_U
CFM Decreases - 1 door	13	13	13	13
Savings/CFM Decrease	$7.04	$0.00	$25.60	$0.00
Total Savings	$32.64			

CHIEF$_{Plus}$™ Lower Wind Speed

Inputs - Miami, FL (Impacts If Lower Avg Wind Speed)				
HDD (calcs use BINs)	140			
CDD (calcs use BINs)	2,886			
Avg. Wind	5.5			
# Stories	7			
Shielding	2			
Cost/MMBtu	$25.90	(Electric)		
Cost/kWh	$0.09			
Occupied hours	168			
Setbacks - heating	72/72			
Setbacks - cooling	73/73			
Heating System Efficiency	95%			
Outputs				
	H_O	H_U	C_O	C_U
CFM Decreases - 1 door	10	10	10	10
Savings/CFM Decrease	$5.33	$0.00	$19.62	$0.00
Total Savings	$24.95			

CHIEF$_{Plus™}$ Lower Utility Rates

Inputs - Miami, FL (Impacts If Lower Utility Rates)				
HDD (calcs use BINs)	140			
CDD (calcs use BINs)	2,886			
Avg. Wind	8.9			
# Stories	7			
Shielding	2			
Cost/MMBtu	$10.44	(Natural Gas)		
Cost/kWh	$0.07			
Occupied hours	168			
Setbacks - heating	72/72			
Setbacks - cooling	73/73			
Heating System Efficiency	95%			
Outputs				
	H_O	H_U	C_O	C_U
CFM Decreases - 1 door	13	13	13	13
Savings/CFM Decrease	$2.84	$0.00	$20.28	$0.00
Total Savings	$23.11			

Payback? Not Always…

- **If the FL project were not all-electric, may still be very viable project**
- **Utility savings isn't everything – in many cases it isn't even "something"**
  - E.g. solving humidity problems can stop mold/ decaying building parts
  - Energy savings are a nice bonus, not the prime motivator

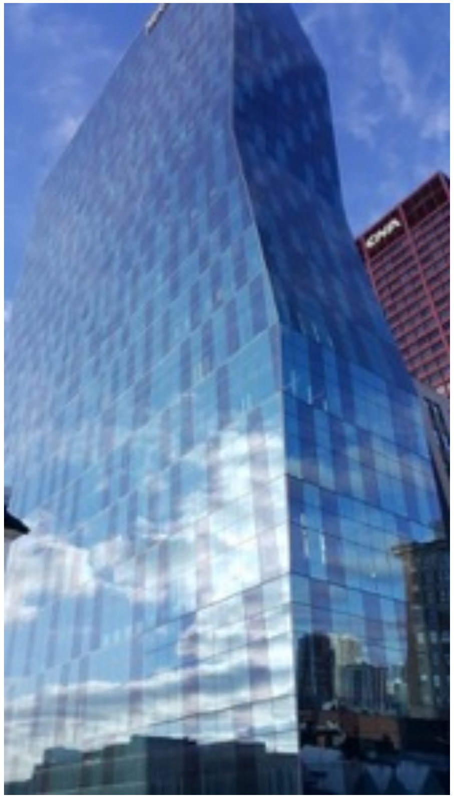
Payback? Not Always…

- **Talk solutions, not savings**
- **Turns the dialog upside down**
- **Broaden "savings" to include more than utilities**
  - Tomb plaster
  - Chapel deterioration
  - Lab rats not isolated
  - Apartments by fish market
  - Bedbugs/roaches at…

Payback? Not Always…

- Sometimes we're successful, sometimes not
- Deeply engrained that payback = litmus test for "go/no go"

Retrofits for Stack Effect



Common Stack Effect Issues

- Ice damming – yes even in commercial
- Comfort issues – complaints and open windows
- Building control issues – temp and pressure
- Pollutants from parking or even vent stacks
- Door closure – entry or elevator
- Mold/mildew
- Condensation

Common Stack Effect Measures

- Generally taller buildings
- Seal top of building

Seal the Top

- **Rooftop accesses**

Seal the Top

- **Rooftop accesses**
- **Rooftop mechanical rooms**


1340


02/01/2016 10:30

Seal the Top

- Rooftop accesses
- Rooftop mechanical rooms
- Top of elevator shafts and rooftop stair towers


576
ft/min
AREA
SETUP
407119A
02/01/2016 09:20


332
02/01/2016 09:21


48
CFM Hot Wire Anemometer
EXTECH
02/01/2016 10:10


ELEVATOR ROOM
AUTHORIZED PERSONNEL ONLY
FIRE
INSIDE
CAUTION
Stand to side of main line before operating switch.
LEAVE NO JUMPERS!
FOR EMERGENCY SERVICE CALL


Acorn Air
Acorn Air

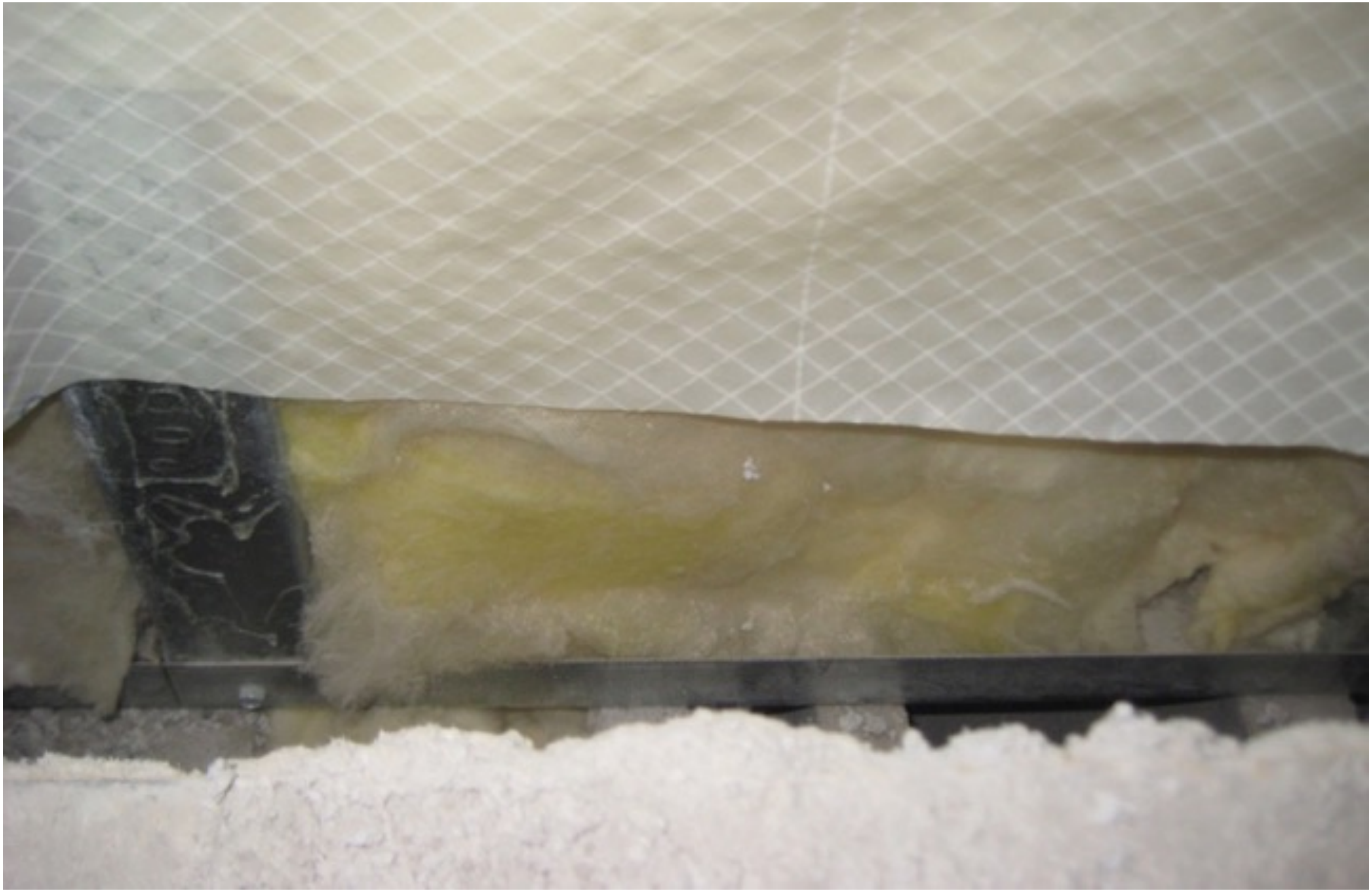
Seal the Top

- Rooftop accesses
- Rooftop mechanical rooms
- Top of elevator shafts and rooftop stair towers
- Curtain wall to parapet


02/01/2016 11:35

Seal the Top

- Rooftop accesses
- Rooftop mechanical rooms
- Top of elevator shafts and rooftop stair towers
- Curtain wall to parapet
- Soffits



Seal the Top

- Rooftop accesses
- Rooftop mechanical rooms
- Top of elevator shafts and rooftop stair towers
- Curtain wall to parapet
- Soffits
- Rooftop exhaust fans


03/04/2016 13:38

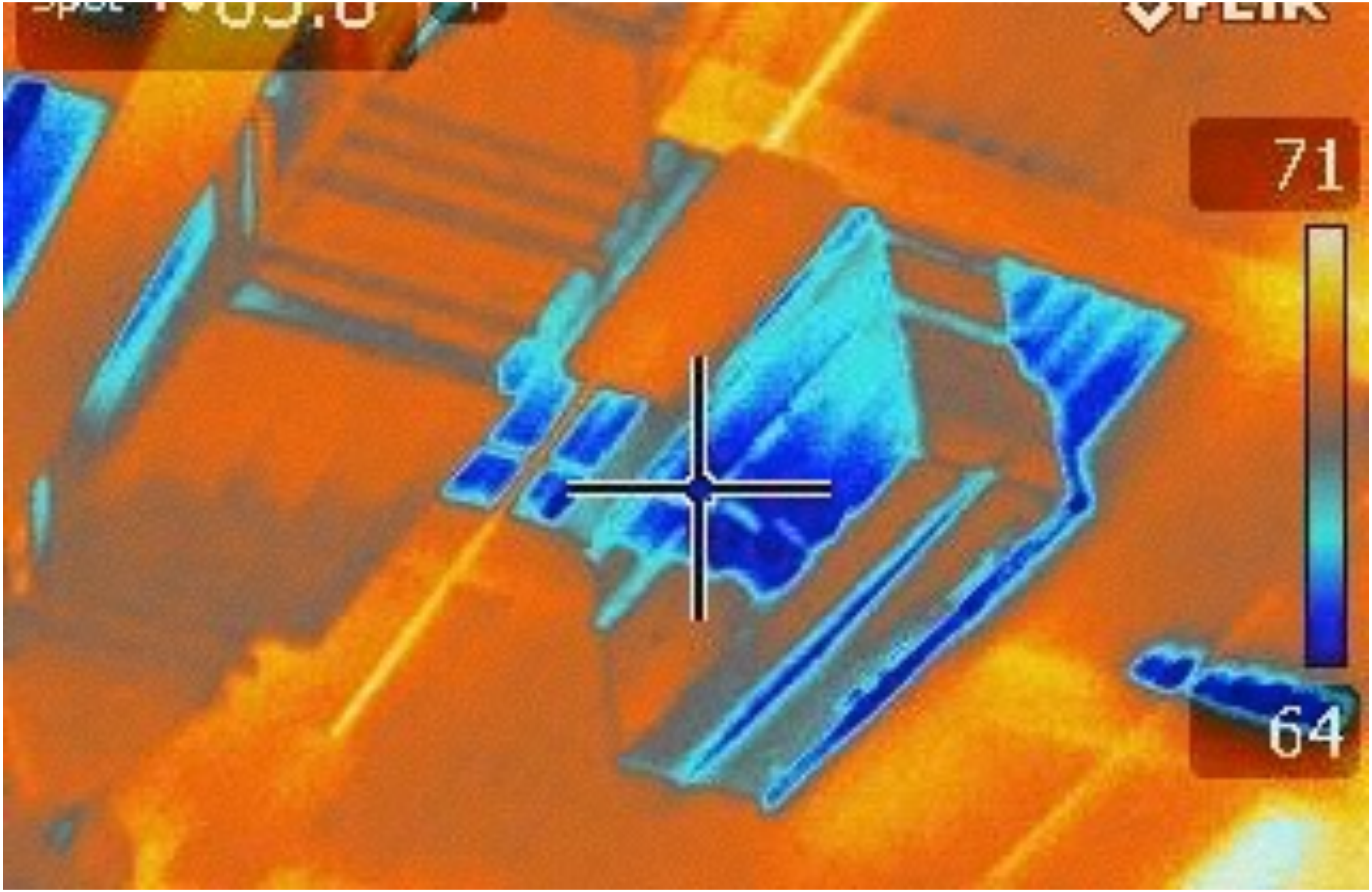
Ventilation Duct RO's Can Be Big Leaks!

Stuck Dampers are Even Worse

Infill and Foam

Seal the Top

- Rooftop accesses
- Rooftop mechanical rooms
- Top of elevator shafts and rooftop stair towers
- Curtain wall to parapet
- Soffits
- Rooftop exhaust fans
- Rooftop AHU's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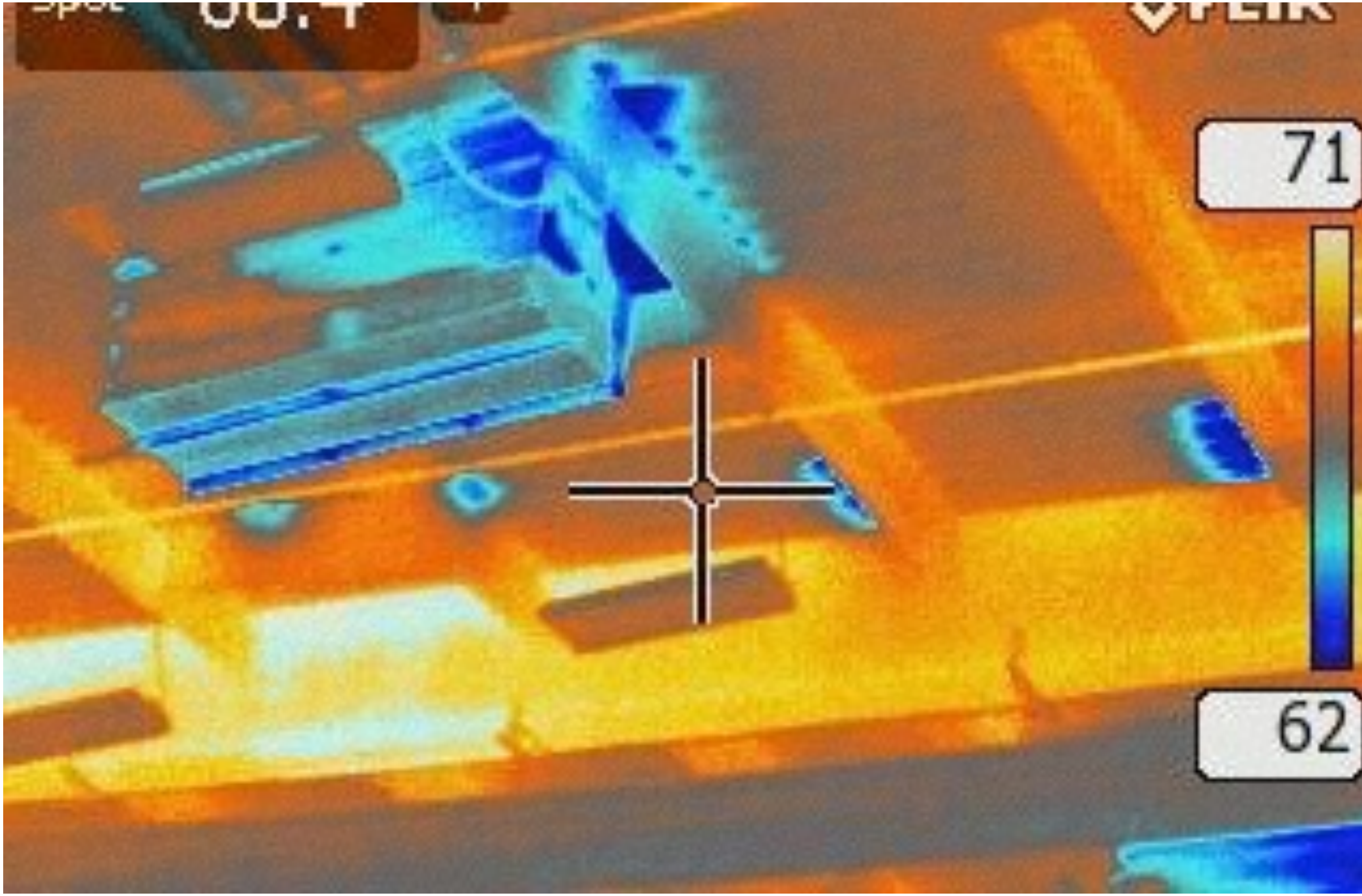
64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Seal the Top

- Rooftop accesses
- Rooftop mechanical rooms
- Top of elevator shafts and rooftop stair towers
- Curtain wall to parapet
- Soffits
- Rooftop exhaust fans
- Rooftop AHU’s
- Flue/intake penetrations


12/09/2015 11:48


12/09/2015 12:30

Seal the Top

- Rooftop accesses
- Rooftop mechanical rooms
- Top of elevator shafts and rooftop stair towers
- Curtain wall to parapet
- Soffits
- Rooftop exhaust fans
- Rooftop AHU's
- Flue/intake penetrations
- Mechanical dampers


12/09/2015 11:52

Common Stack Effect Measures

- **Generally taller buildings**
- **Seal top of building**
- **Seal lower connections**

Lower Connections

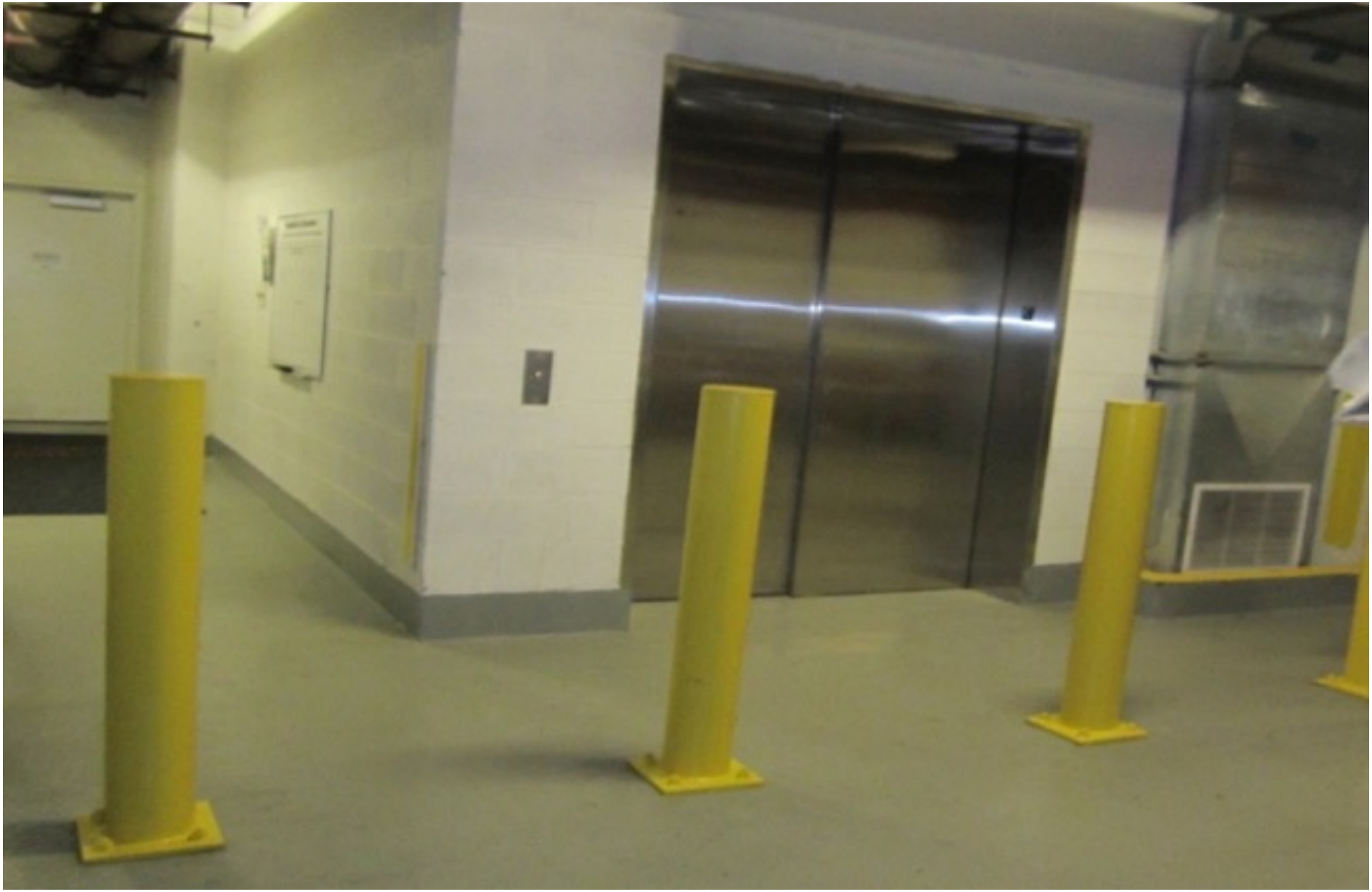
- **Entry doors**


07/01/2015 09:11

Lower Connections

- **Entry doors**
- **Parking garages – entry and core slab**


DO NOT ENTER
EXIT KEEP




02/01/2016 12:50


& Stairs
02/01/2016 12:52


02/01/2016 12:50

Lower Connections

- **Entry doors**
- **Parking garages – entry and core slab**
- **Loading docks – RU’s, entry doors, dock levelers and core slab**


MONARCH PLACE
02/01/2016 12:36


02/01/2016 12:40

Lower Connections

- Entry doors
- Parking garages – entry and core slab
- Loading docks – RU's, entry doors, dock levelers and core slab
- Pedestrian bridges


Monarch Place
Sheraton Hotel
02/01/2016 13:18


02/01/2016 13:21

Lower Connections

- **Entry doors**
- **Parking garages – entry and core slab**
- **Loading docks – RU's, entry doors, dock levelers and core slab**
- **Pedestrian bridges**
- **Soffits and overhangs**


DO
NOT
ENTER
02/17/2016 10:21


02/17/2016 10:30

Common Stack Effect Measures

- **Generally taller buildings**
- **Seal top of building**
- **Seal lower connections**
- **Seal floor to floor**

Floor to Floor

- **Core slab to curtain wall**


02/01/2016 12:01

Floor to Floor

- **Core slab to curtain wall**
- **Electrical rooms**


02/01/2016 11:13

Floor to Floor

- Core slab to curtain wall
- Electrical rooms
- Telecom rooms


02/01/2016 11:13

Floor to Floor

- **Core slab to curtain wall**
- **Electrical rooms**
- **Telecom rooms**
- **Custodial closets**


02/01/2016 11:07

Floor to Floor

- Core slab to curtain wall
- Electrical rooms
- Telecom rooms
- Custodial closets
- Fire stairs

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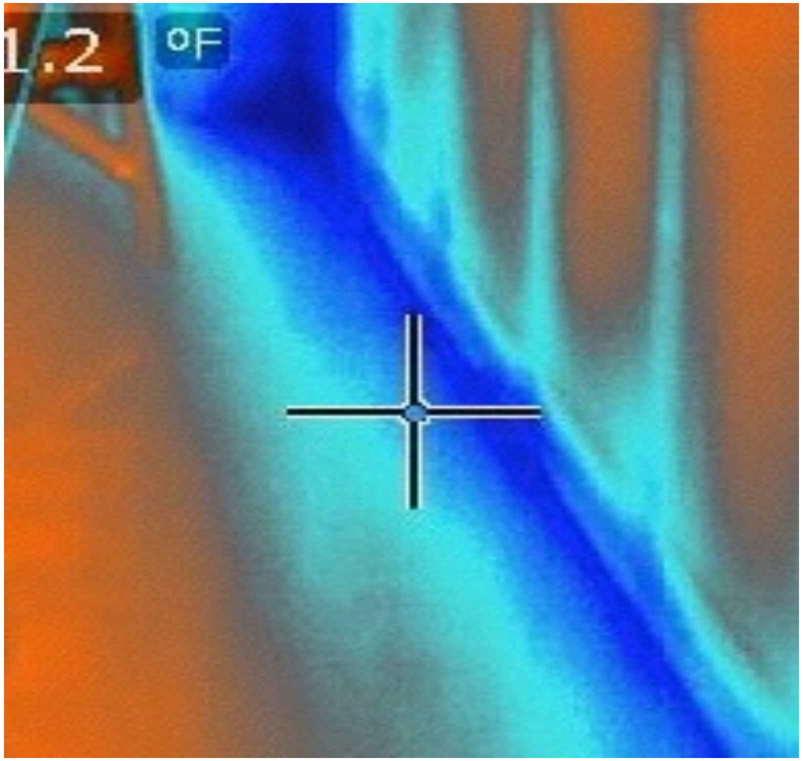
Floor to Floor

- Core slab to curtain wall
- Electrical rooms
- Telecom rooms
- Custodial closets
- Fire stairs
- Ventilation shafts

Floor to Floor

- Core slab to curtain wall
- Electrical rooms
- Telecom rooms
- Custodial closets
- Fire stairs
- Ventilation shafts
- Access panels to shafts

Wind Effect in Action



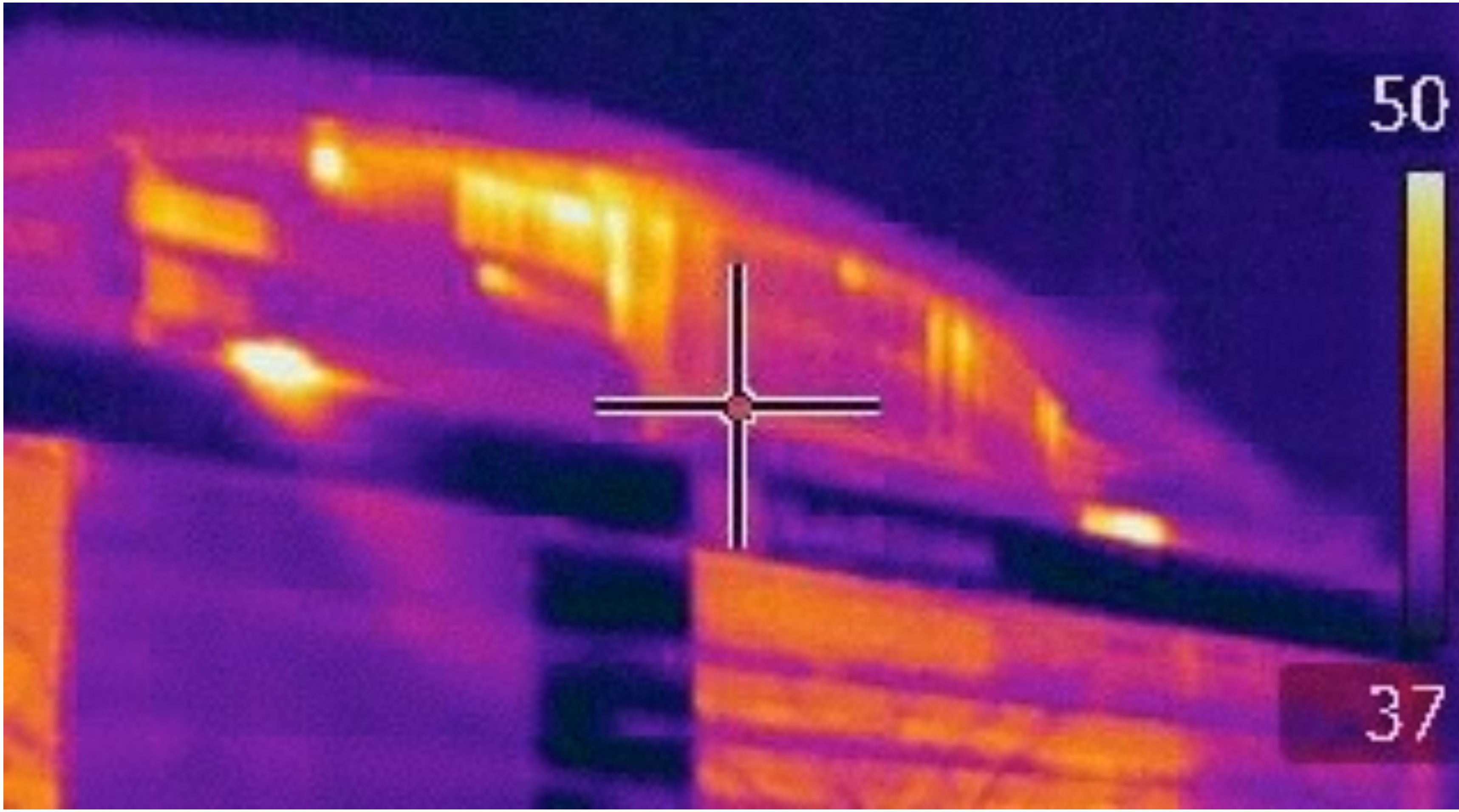
Common Wind Effect Issues

- Comfort issues: hot leeward, cold windward
- Lack of building control during windy weather
- Missing insulation – generally loose fill
- Drifting snow – in openings onto ???
- Water ingress – kinetic
- Panels dropping
- Door closure

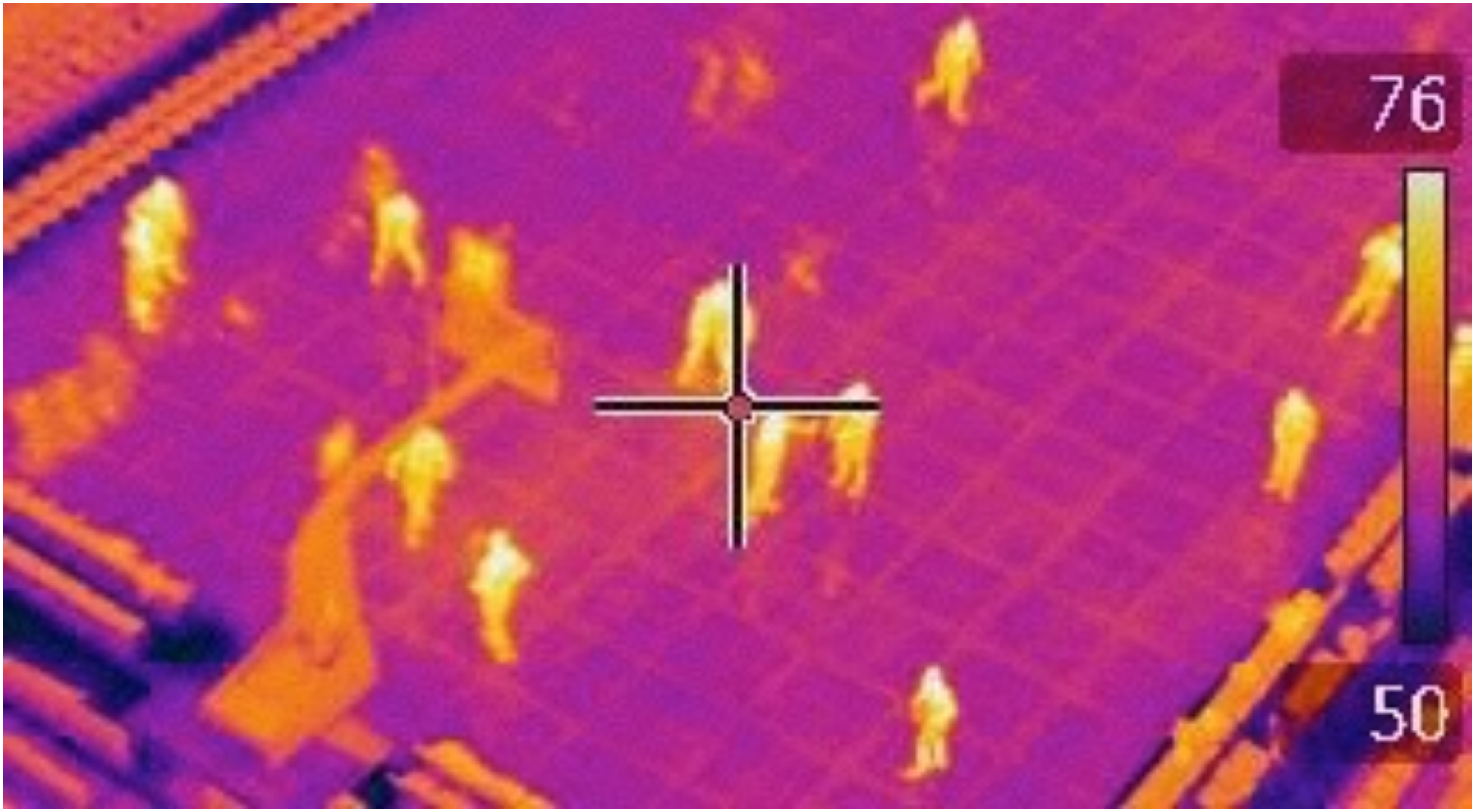
Common Wind Effect Measures

- **Soffit sealing**

Cowabunga Jumbo Soffit



Chicago Bulls at Practice



Fitting the Puzzle Together

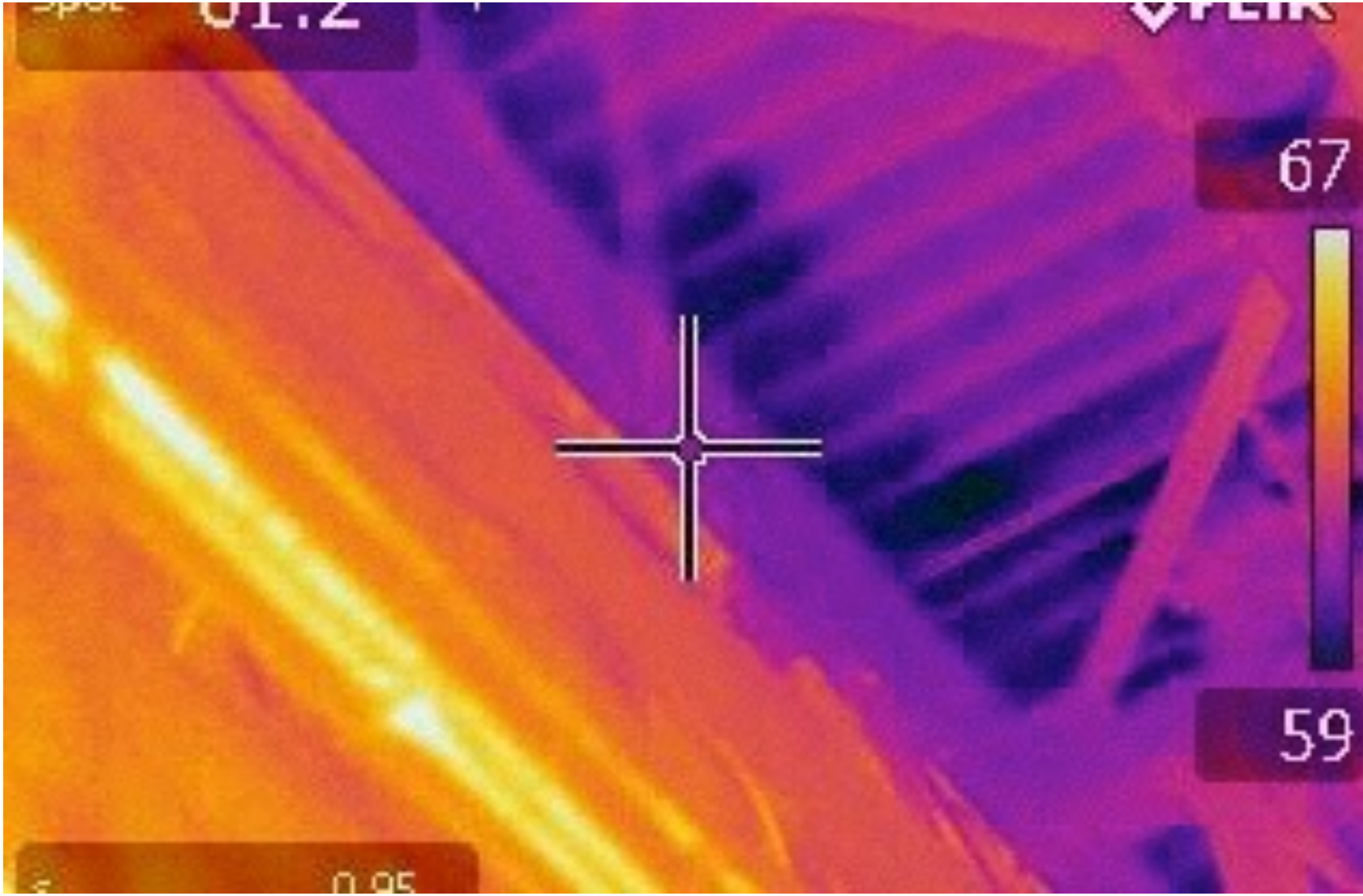
Thermax Fitted/Spray Seal Started

Sealed and Painted With DC-315


12/02/2014 13:58

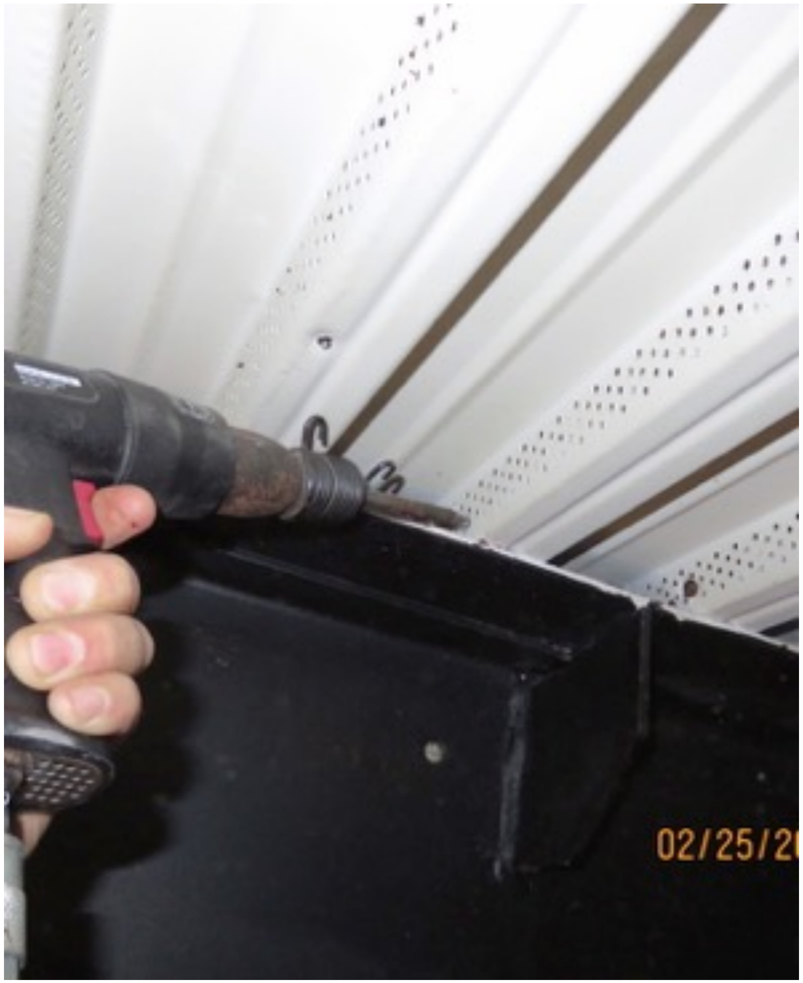
Common Wind Effect Measures

- **Soffit sealing**
- **Roof-wall joint sealing**


67
59


DOW
05/02/2016 15:08

Flutes are Critical



Common Wind Effect Measures

- **Soffit sealing**
- **Roof-wall joint sealing**
- **Window weatherstrip**

Common Wind Effect Measures

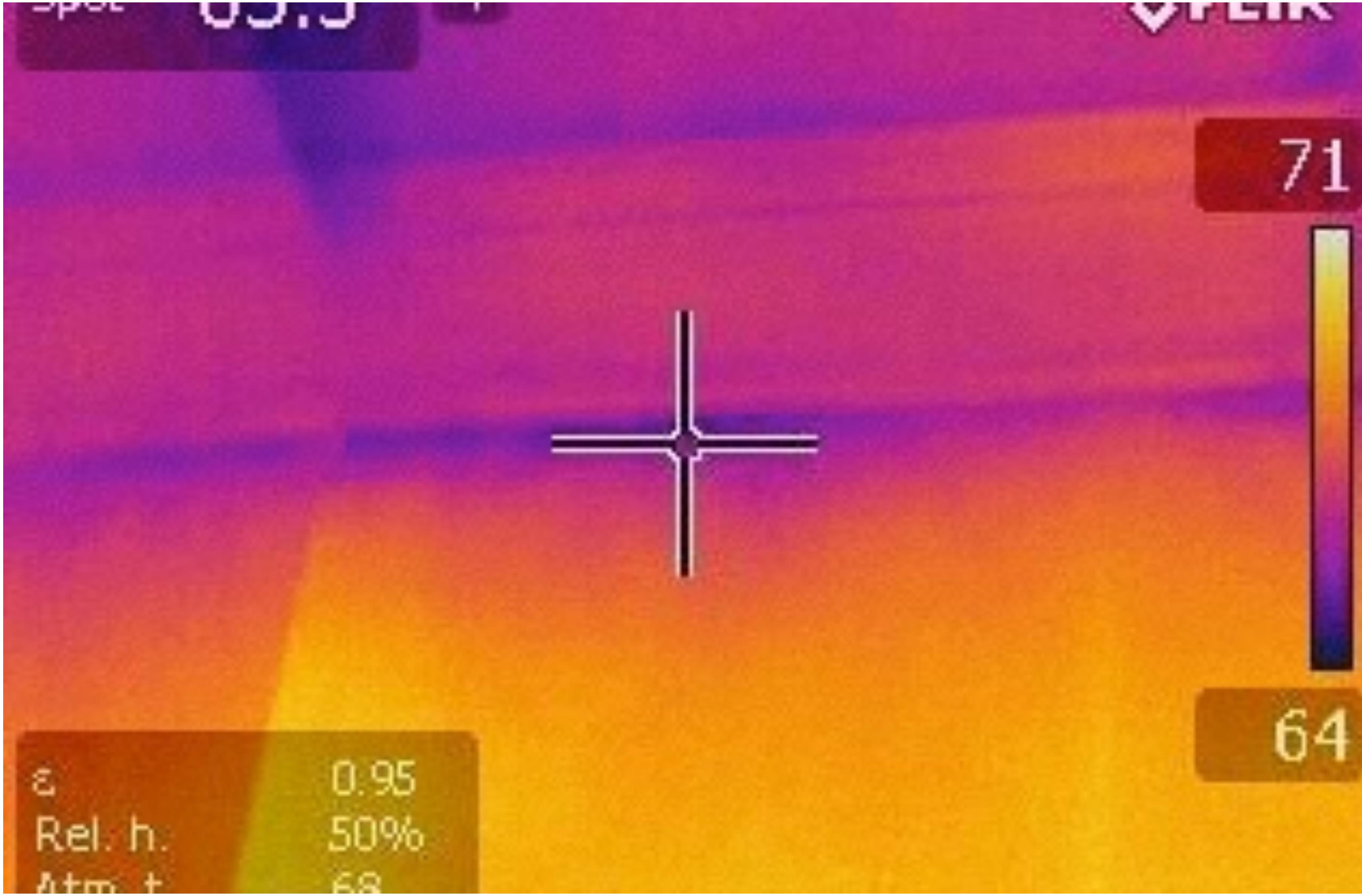
- **Soffit sealing**
- **Roof-wall joint sealing**
- **Window weatherstrip**
- **Window trim sealing**


06/09/2015 14:19


452
CFM Hot Wire Anemometer
EXTECH

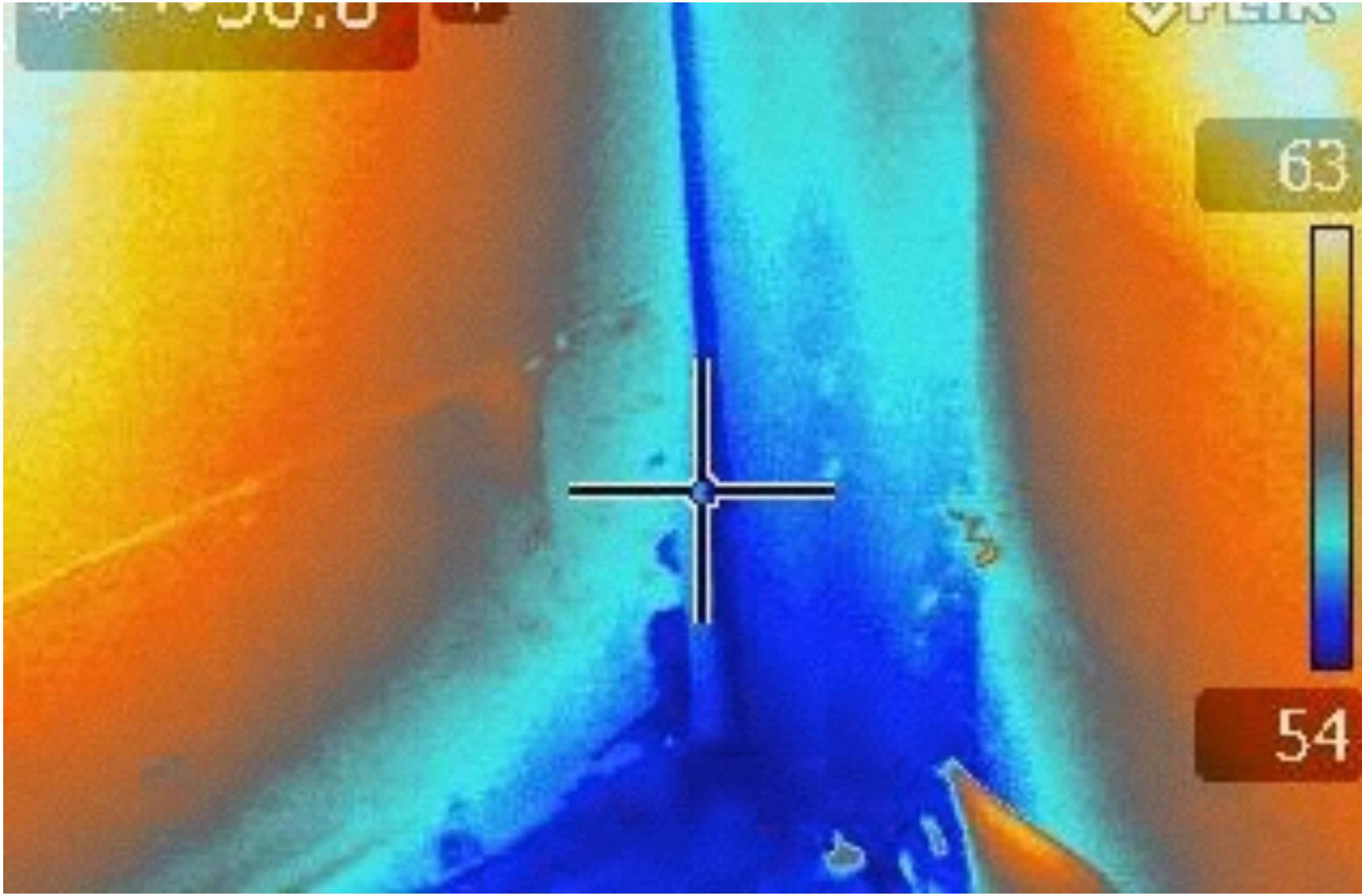
Common Wind Effect Measures

- Soffit sealing
- Roof-wall joint sealing
- Window weatherstrip
- Window-trim sealing
- Floor-to-wall sealing


71
64
ε 0.95
Rel. h. 50%

Common Wind Effect Measures

- Soffit sealing
- Roof-wall joint sealing
- Window weatherstrip
- Window trim sealing
- Floor-to-wall sealing
- Door weatherstripping


63
54

Mechanical Effect

Mechanical Effect Issues

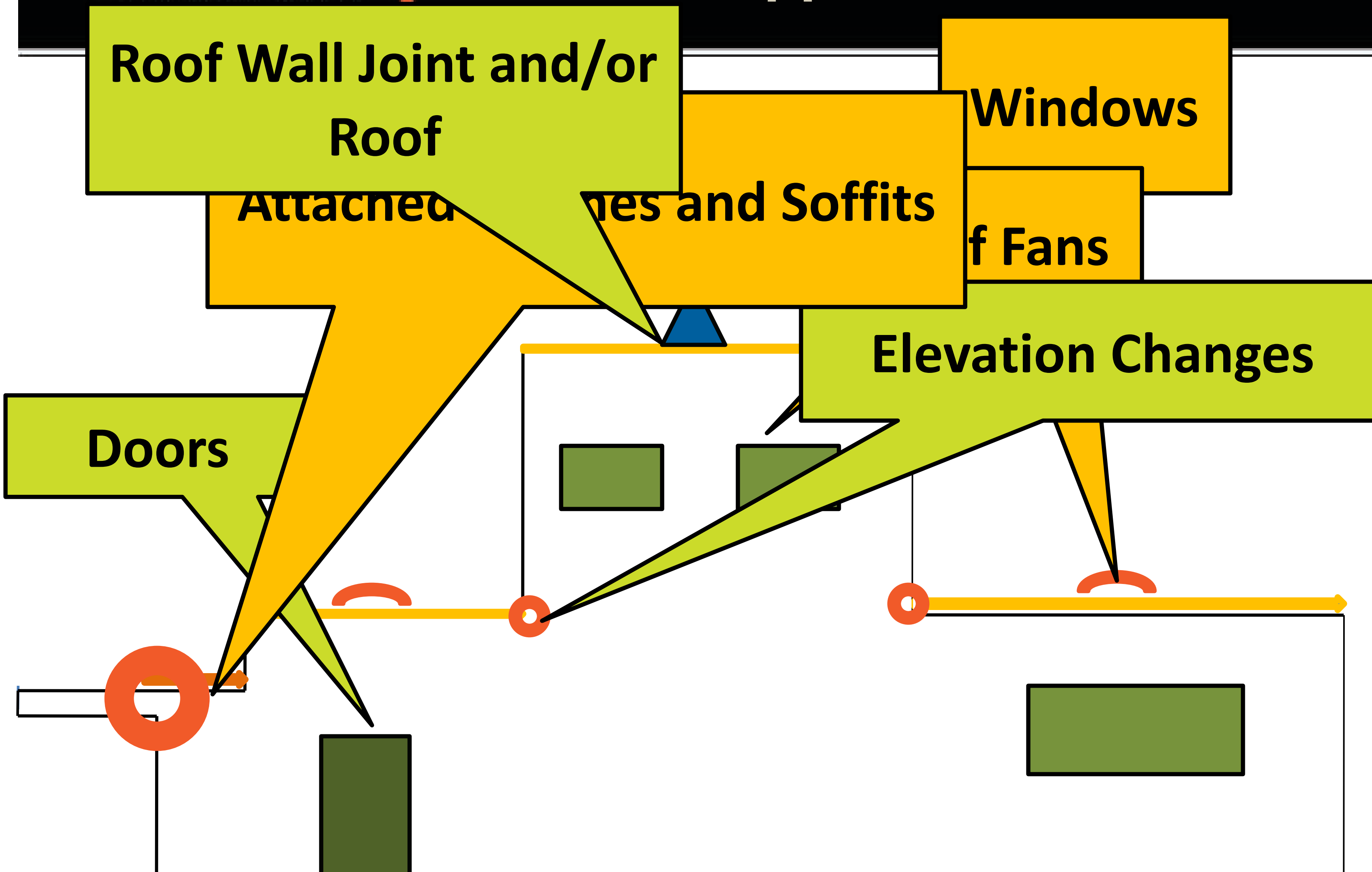
- **Building will not maintain pressure**
- **Humidity control not possible**
- **Comfort issues**
- **Building Automation System (BAS) loses building under certain conditions**
- **Severe stack effect issues in towers**
- **Building degradation issues**

Seal Everything

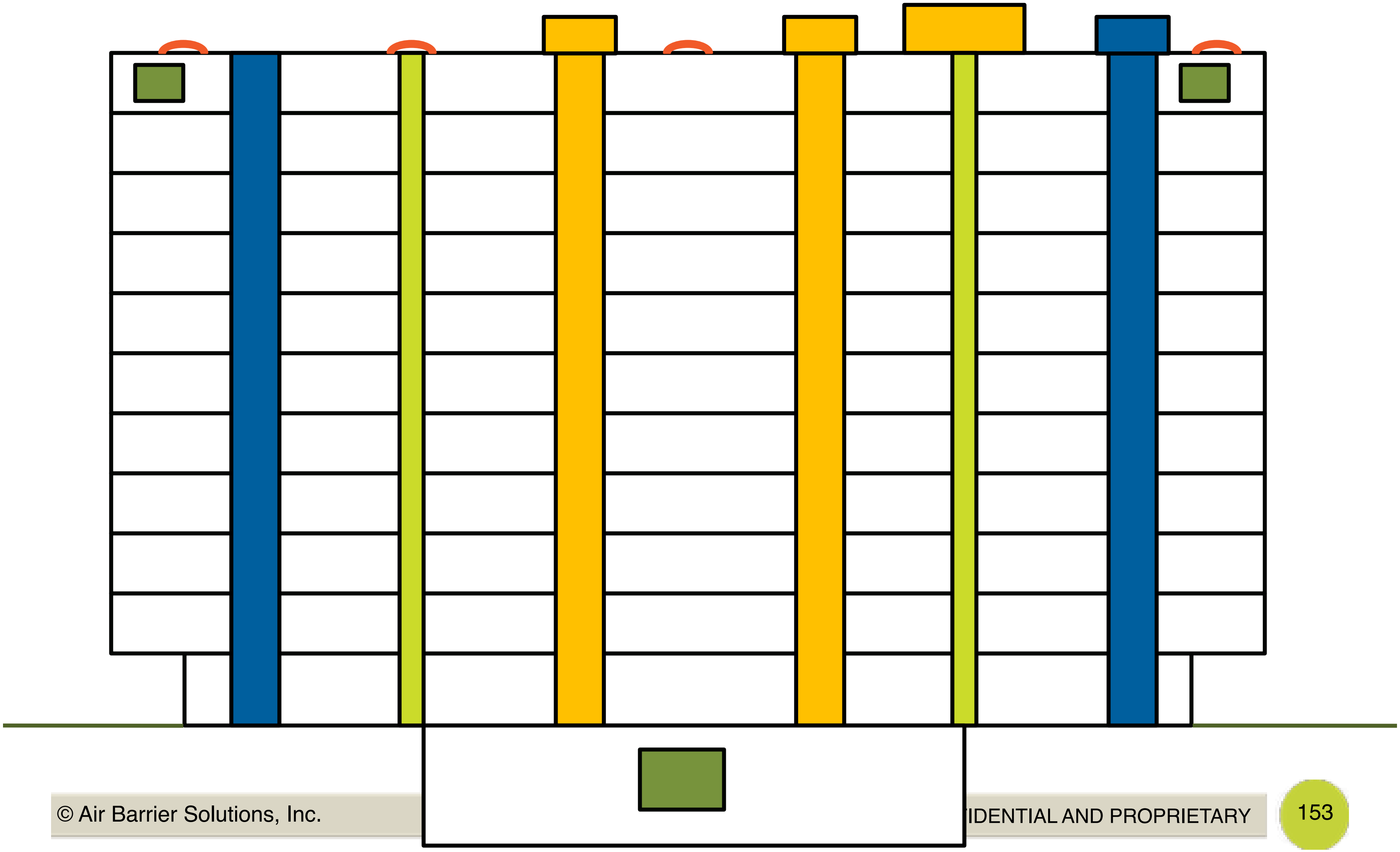
Issues Lead to Opportunities

So many possibilities!

Low Rise Opportunities



High Rise Issues



Technology Aids Innovation

Testing Anyone?

$$Q = C \times \Delta P^{N}$$

Paths for Envelope Testing

- **ASTM E783** Field Measurement of Air Leakage Through Installed Exterior Windows and Doors
- **ASTM E779** Standard Test Method for Determining Air Leakage Rate by Fan Pressurization
- **ASTM E1105** Field Determination of Water Penetration of Installed Exterior Windows, Skylights…
- **ASTM E1186** Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems

Air Leakage Testing – How Much?

ASTM E779 – 10

Standard Test Method for Determining Air Leakage Rate by Fan Pressurization

- Quantitative test not a qualitative test

Issues Testing Existing Buildings

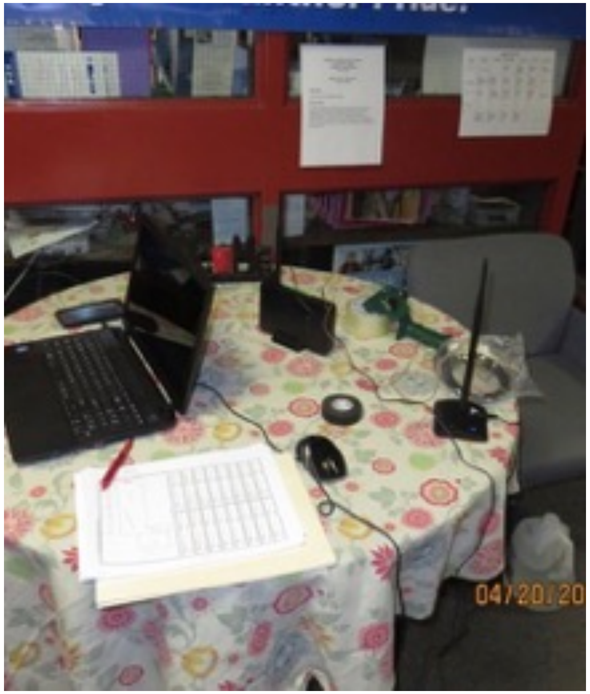
- How many fans becomes a real quandary
- Hole size limit of fan(s)
- Occupants
- Permissions
- Off-hours maintenance
- Expensive
- Time consuming
- All or part of the building
- Security concerns

Current Policy - Test if Possible

- We ask permission to test every building we are retrofitting
- We do not charge – need data and QA
- Some will, some won’t: get over it
- Some buildings we cannot test – size, use, etc.

Process – Set Up Equipment

Have a plan prepared



Or regret being unprepared

Seal Intentional Openings/ Disable Mechanicals

Locate Outdoor Pressure Taps

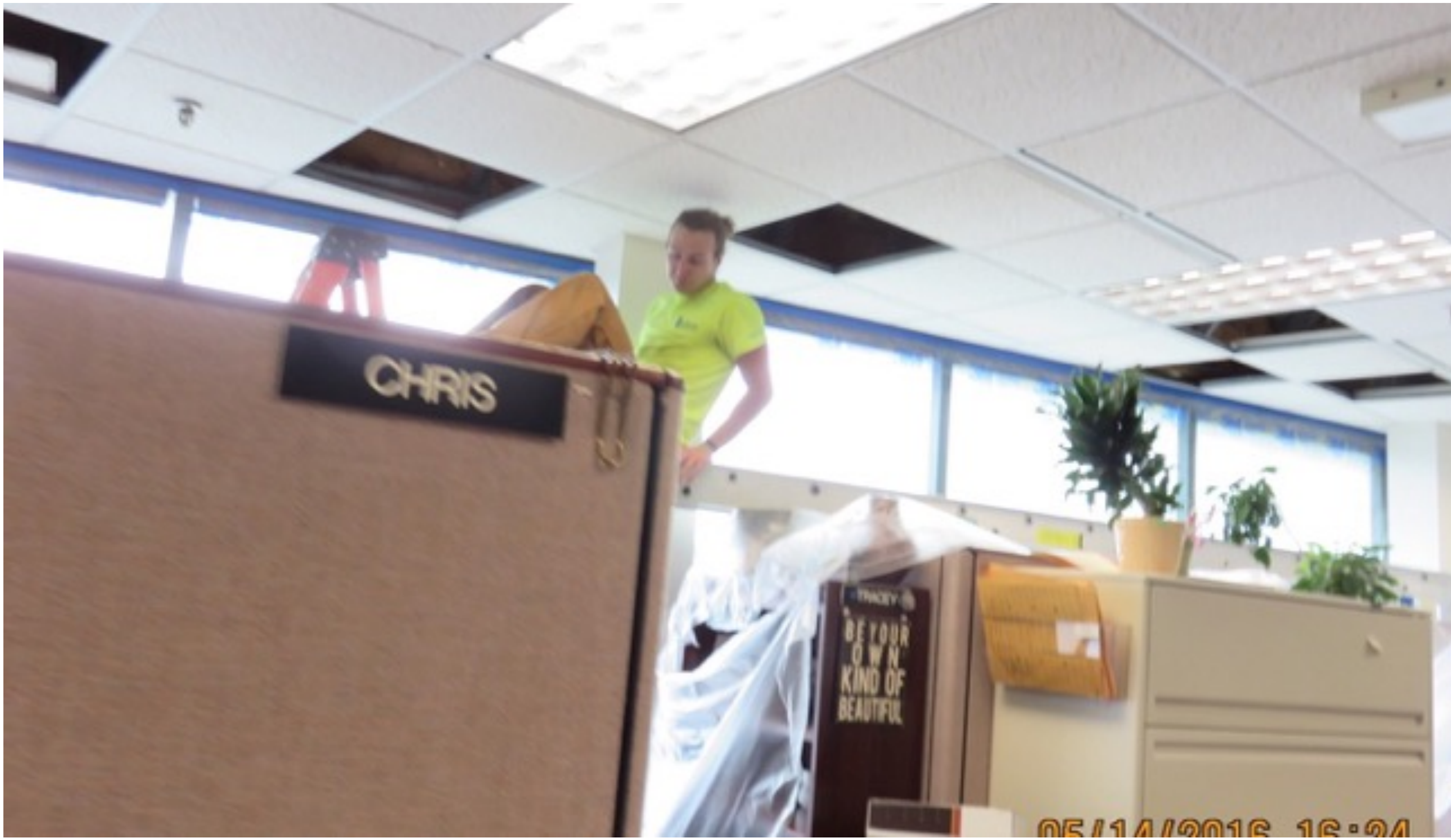
Finish Testing and Pack Up

Corporate HQ LeakFest

Lots of Soffit

Missing Sheathing into Soffit

Cover Up and Work Above



Really Cover UP

Sealing in Progress

Poor Connection Between Components

Center Connector Not Connected

Subway's Numbers: Phase 1

- **Pre-test:**
  - 134,500 CFM_{75}
  - 1.32 CFM_{75} per SF of surface area
- **Post-test:**
  - 72,000 CFM_{75}
  - 0.71 CFM_{75} per SF of surface area
- **A little over 62,000 CFM_{75} reduction**
- **ELA @ 10 PA dropped from 10,684 to 7,620**
- **ELA @ 4 PA dropped from 5,689 to 4,629**
- **Still a very leaky building**

Ground Floor – View Toward Exterior Wall

View Up Behind Beam

Ramifications of Phase 1

- Current HVAC system quit “overheating” and handled the load
- Building could be balanced and even pressurized
- If they do so, it will surly effloresce in a line around the ground and first-floor leakage
- If not finished, the building will need to be kept slightly negative

Commercial HQ Latham, NY

It is a Really Simple Building

Corporate Office Attached to Manufacturing

- Energy was not the driver
- Facility management wanted to correct several problems
- Rain and snow intrusion
- Ice dams
- Comfort complaints
- Building was tight
- Low-cost job

Once Again, Lots of Cover Ups

Multiple Lines Sealing the Roof-Wall Joint

Window Trim Sealing

Numerous Corners Wet Glazed

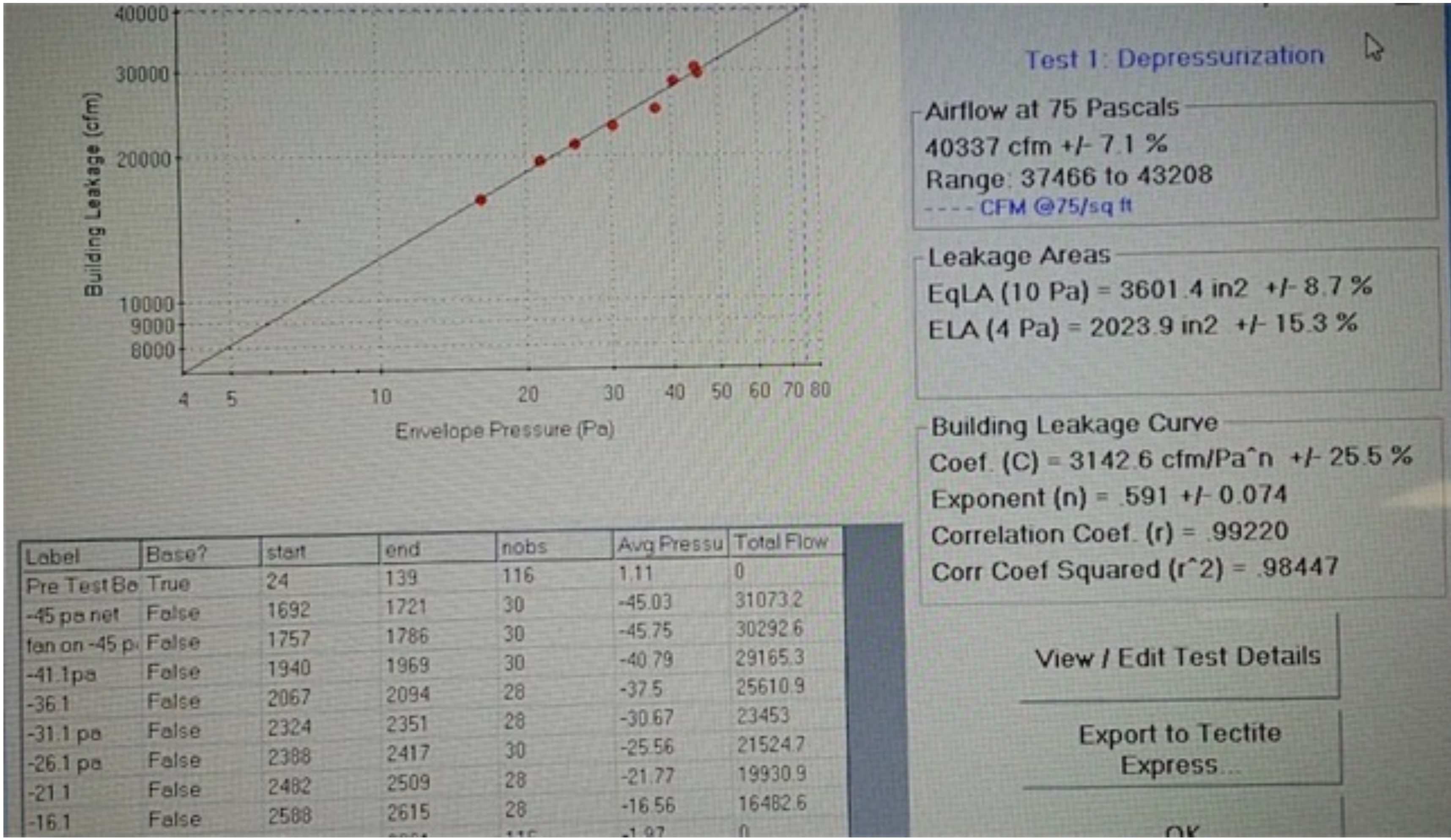
Phase 2 Will be the Exterior

New Seal Installed and Mock-up Completed

The Numbers

- **Pre-retrofit**
  - 13,949 CFM_{75}
  - ELA 1,239 sq in @ 4 Pa
  - 0.19 CFM_{75} per SF of surface area
- **Pre-retrofit**
  - 11,842 CFM_{75}
  - ELA 617 sq in @ 4 Pa
  - 0.16 CFM_{75} Pa per SF of surface area
- **Roughly 15% reduction**
- **Water intrusion in problem areas stopped**

Maine School – No Air Barrier



Label	Base?	start	end	nobs	Avg Pressu	Total Flow
Pre Test Ba	True	24	139	116	1.11	0
-45 pa net	False	1692	1721	30	-45.03	31073.2
fan on -45 p	False	1757	1786	30	-45.75	30292.6
-41.1pa	False	1940	1969	30	-40.79	29165.3
-36.1	False	2067	2094	28	-37.5	25610.9
-31.1 pa	False	2324	2351	28	-30.67	23453
-26.1 pa	False	2388	2417	30	-25.56	21524.7
-21.1	False	2482	2509	28	-21.77	19930.9
-16.1	False	2588	2615	28	-16.56	16482.6

The Problem


PERFORMANCE
OWENS-CORNING
Fiberglas
Building
04/20/2015 10:31

The Problem

The Problem

Now an OSHA Confined Space

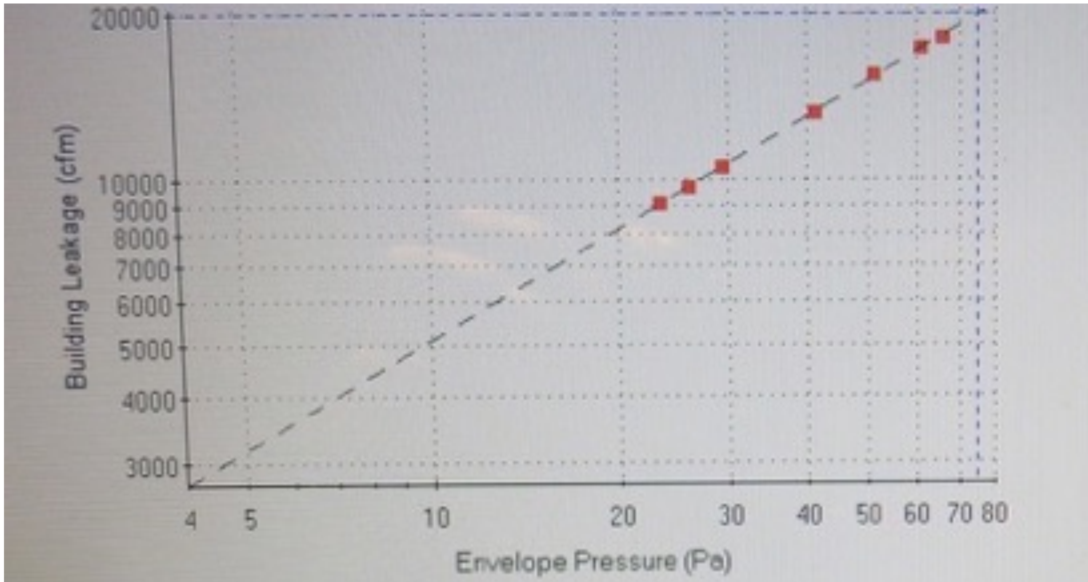

05/05/2015 20:47

Solution: Encapsulate

Gable End and View Down

Gap Down into Building

Post-Retrofit Results



Label	Base?	start	end	nobs	Avg Pressu	Total Flow
-66 Pascals	False	693	721	29	-65.99	18086.2
-61 pascals	False	761	790	30	-60.72	17385.4
-51 pascals	False	909	936	28	-50.97	15523.1
-41 pascals	False	1124	1153	30	-41.07	13191.5
-31 pascals	False	1257	1284	28	-29.39	10557.6
-26 pascals	False	1353	1382	30	-26	9709.9
-21 pascals	False	1419	1448	30	-23.28	9049.1

Test 2: Depressurization

Airflow at 75 Pascals

19936 cfm +/- 1.5 %

Range: 19637 to 20234

---- CFM @75/sq ft

Leakage Areas

EqLA (10 Pa) = 1497.2 in2 +/- 2.9 %

ELA (4 Pa) = 777.8 in2 +/- 4.6 %

Building Leakage Curve

Coef. (C) = 1072.1 cfm/Pa^n +/- 7.4 %

Exponent (n) = .677 +/- 0.020

Correlation Coef. (r) = .99967

Corr Coef Squared (r^2) = .99934

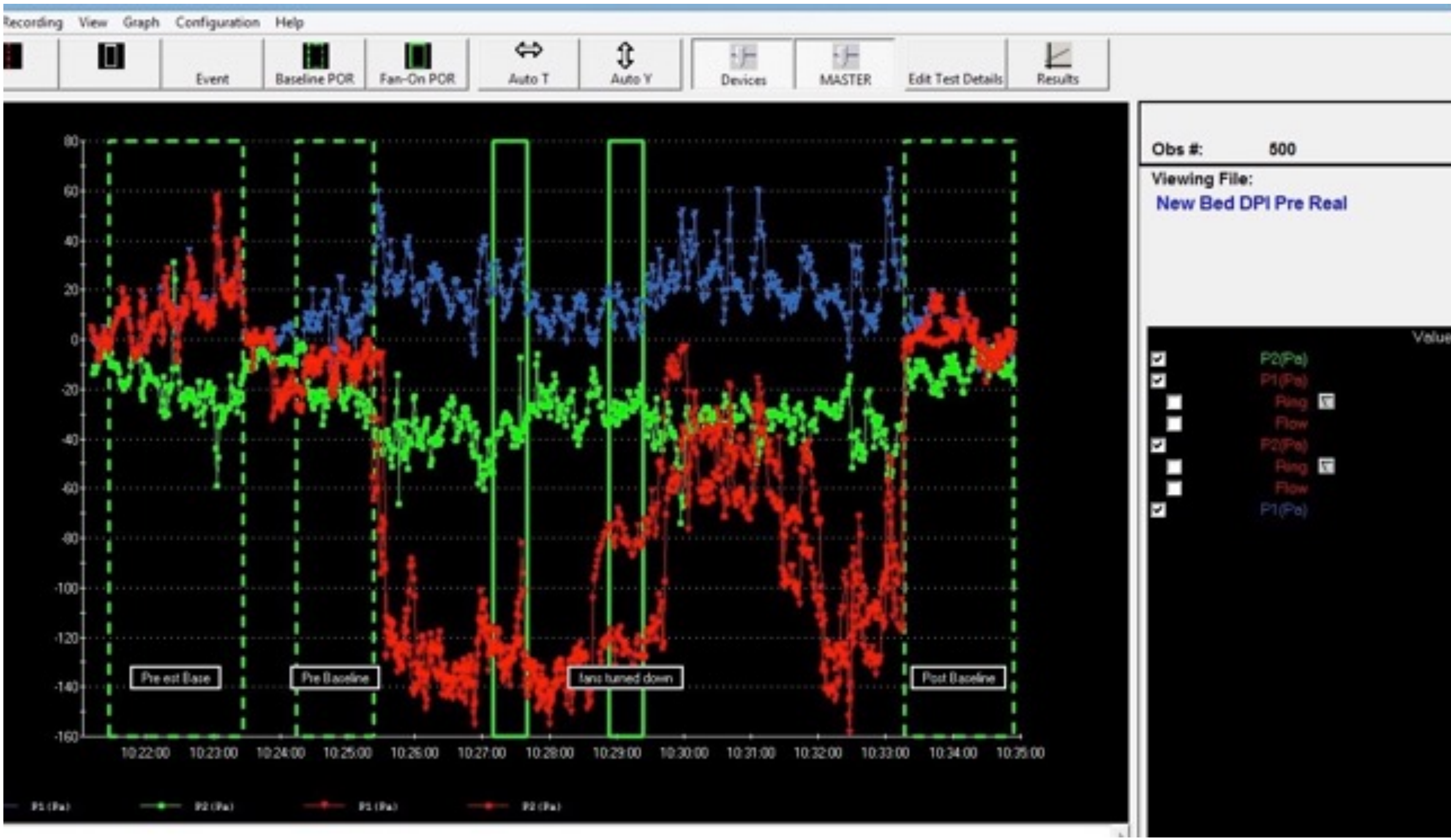
View / Edit Test Details

Export to Tectite Express...

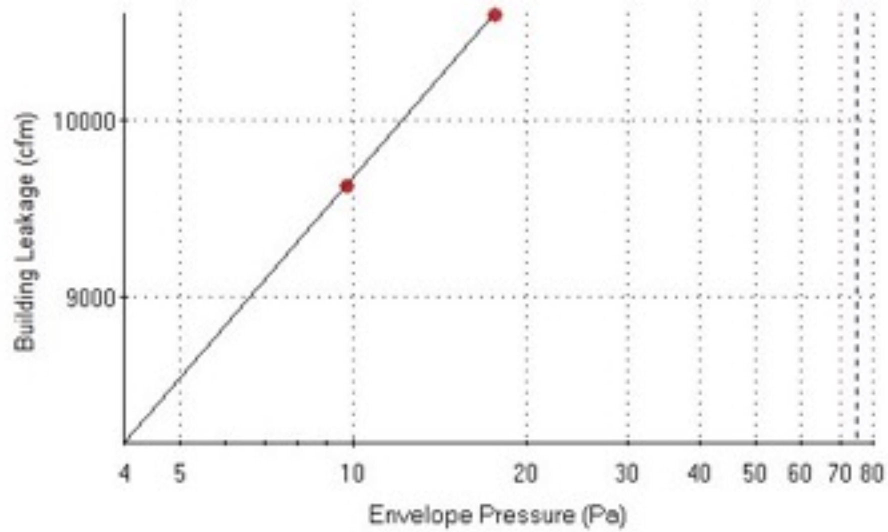
Palermo Results

- Roughly 15 person-hours for pre-test and post-test
- 58% reduction in hole size @ 10 PA
- 62% reduction in hole size @ 4 PA
- CFM_{75} went from 40,337 to 19,936
- Reduction of 4.67 CFM_{75} per SF of ceiling area treated – 0.32 CFM per $
- Reduction of 0.47 sq in per SF of ceiling area treated – $31.36 per sq in

New Bedford DPI Garage Pre-Test



New Bedford DPI Pre-Test Results



Label	Base?	start	end	nobs	Avg Pressu	Total Flow
Pre est Bas	True	17	132	116	-19.11	0
Pre Baselin	True	178	245	68	-20.92	0
	False	352	379	28	-35.03	10660.5
fans turned	False	451	478	28	-27.16	9622.6
Post Baseli	True	707	801	95	-12.23	0

Test to View test 1

Test 1: Depressurization

Airflow at 75 Pascals
13697 cfm
---- CFM @75/sq ft

Leakage Areas
EqLA (10 Pa) = 2840.0 in2
ELA (4 Pa) = 2341.3 in2

Building Leakage Curve
Coef. (C) = 6491.0 cfm/Pa^n
Exponent (n) = .173
Correlation Coef. (r) = .00000
Corr Coef Squared (r^2) = .00000

View / Edit Test Details

Export to Tectite Express...

City Infrastructure Building

- Sewer repair
- Pothole fixers
- Water main breaks
- Striping and painting
- Snow plowing
- Keep the town going
- (14) 16’W x 10’H overhead doors in a masonry building
- Seemed like an interesting thing to test


01/19/2016 08:26


01/19/2016 08:25


01/22/2016 14:11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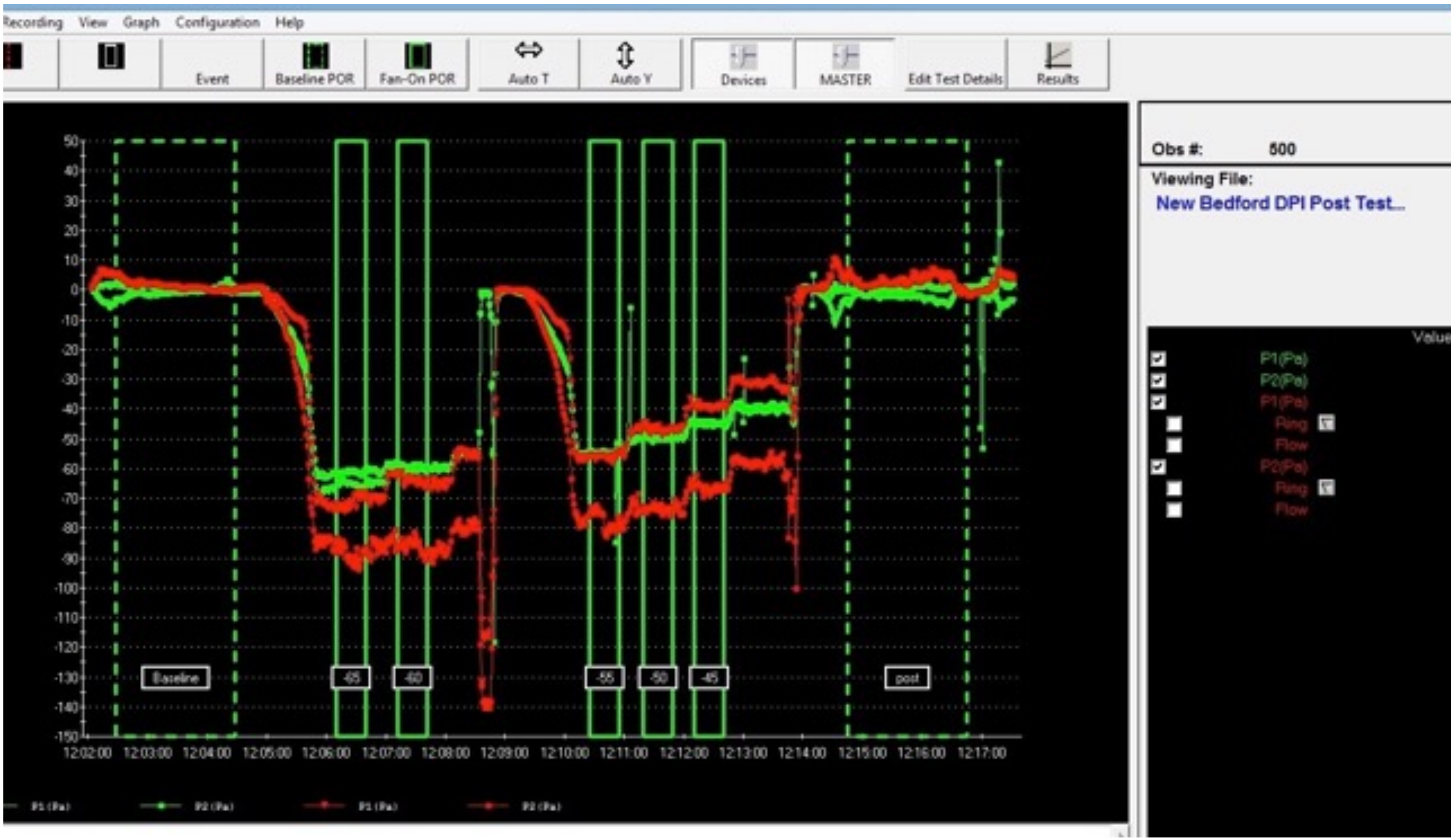
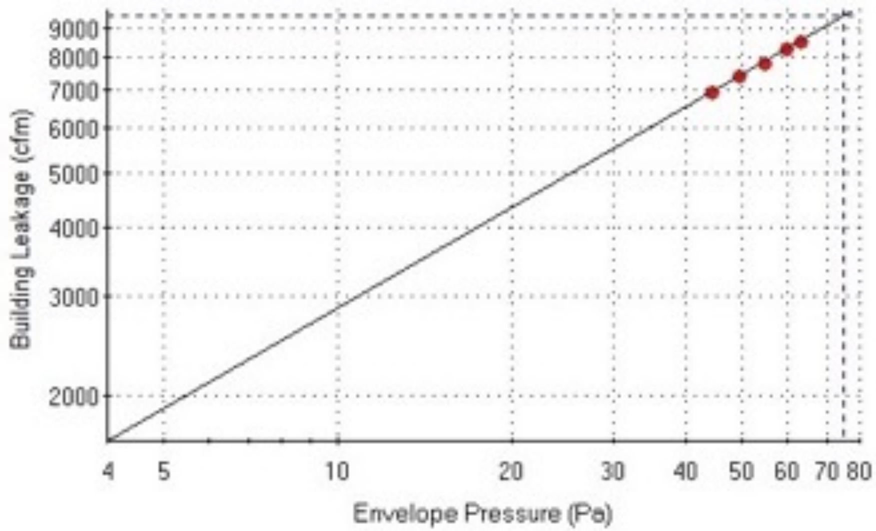
New Bedford DPI Garage Post-Test



New Bedford DPI Post-Test Results



Label	Base?	start	end	nobs	Avg Pressu	Total Flow
Baseline	True	26	141	116	-0.14	0
-65	False	241	270	30	-63.47	8589.3
-60	False	300	329	30	-60.01	8316.8
-55	False	488	517	30	-55.34	7853.2
-50	False	540	569	30	-49.92	7450.7
-45	False	590	619	30	-45.01	6971.5
post	True	741	856	116	-1.1	0

Test to View Test 1

Test 1: Depressurization

Airflow at 75 Pascals

9538 cfm +/- 1.7 %

Range: 9371 to 9705

---- CFM @75/sq ft

Leakage Areas

EqLA (10 Pa) = 841.6 in2 +/- 8.3 %

ELA (4 Pa) = 470.4 in2 +/- 12.8 %

Building Leakage Curve

Coef. (C) = 724.5 cfm/Pa^n +/- 19.5 %

Exponent (n) = .597 +/- 0.049

Correlation Coef. (r) = .99900

Corr Coef Squared (r^2) = .99800

View / Edit Test Details

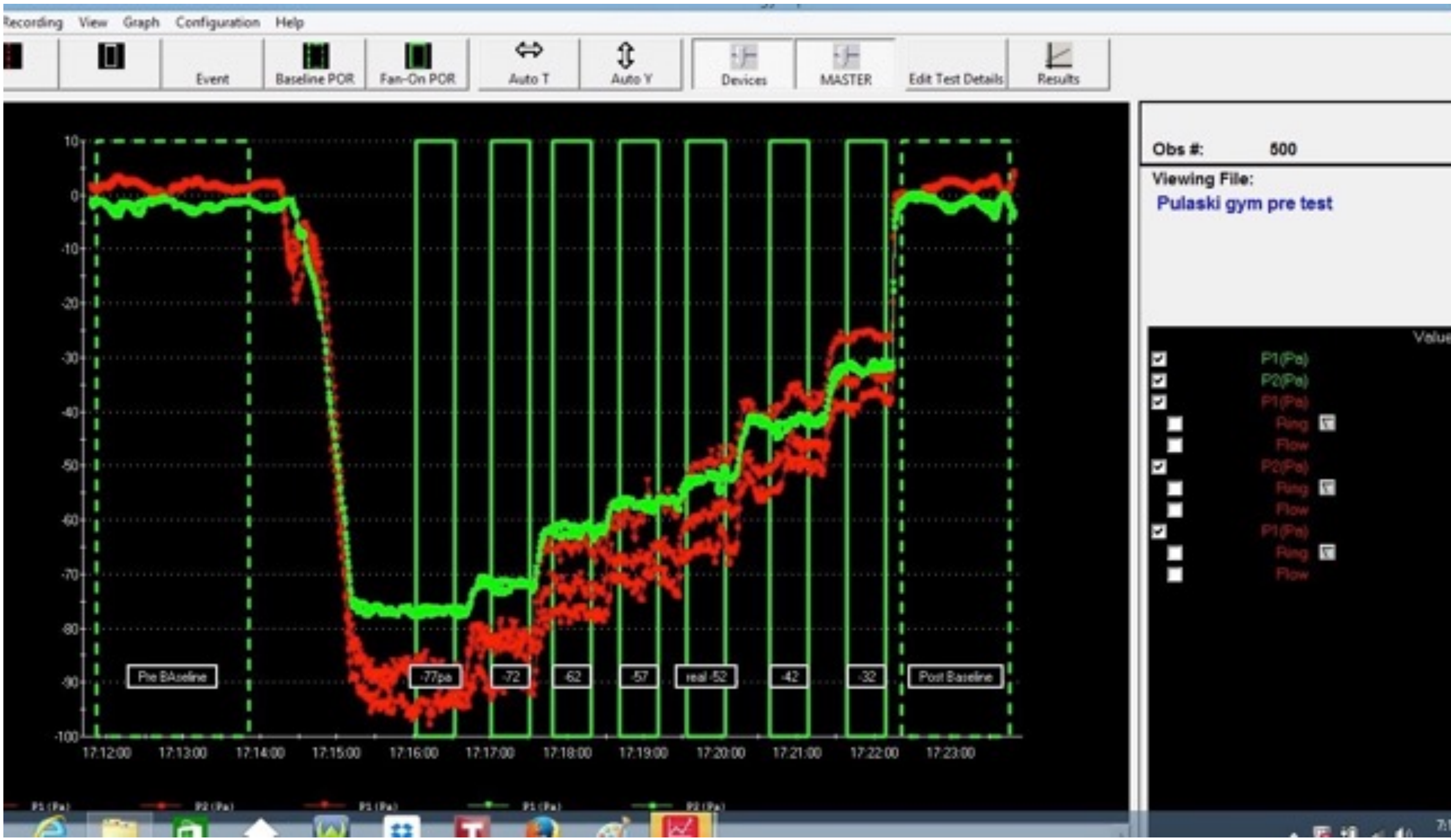
Export to Tectite Express...

AIR BARRIER SOLUTIONS INC

New Bedford DPI Results

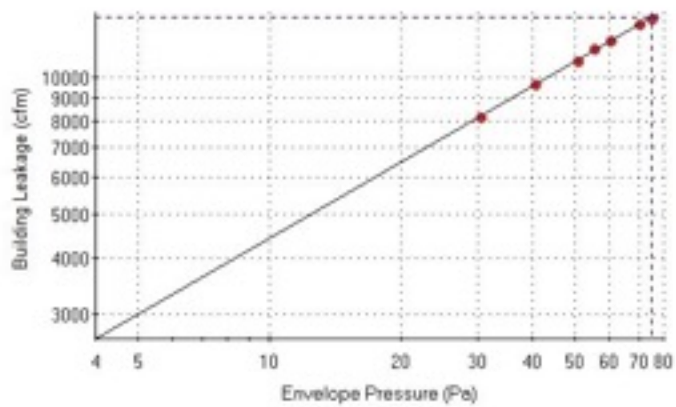
- Roughly 8 person-hours pre-test and post-test
- 2 fans used due to power constraints
- Wind gusting to over 50 mph on pre-test
- 70% reduction in hole size @ 10 PA
- 80% reduction in hole size @ 4 PA
- CFM_{75} went from 13,697 to 9,538
- Reduction of 4,159 CFM_{75} from 728 lineal feet of weatherstripping = 5.72 CFM_{75} per foot
- LA reduction: 2.75 sq in per foot at 10 PA

Pulaski Gym Pre-Test



Pulaski Gym Pre-Test Results

Airtightness Results (95% confidence, non-weighted fit)



Label	Base?	start	end	nobs	Avg Pressu	Total Flow
Pre BAselin	True	5	120	116	-1.93	0
-77pa	False	247	276	30	-76.84	13659
-72	False	305	334	30	-72.05	13279.6
-62	False	352	380	29	-61.91	12196.8
-57	False	403	430	28	-57.23	11708
real -52	False	454	481	28	-52.54	11011
-42	False	517	544	28	-42.29	9751.4
-32	False	575	602	28	-32	8291.6
Post Baseli	True	616	699	84	-1.41	0

Copy Data Table to Clipboard

Reporting Pressure (Pa) 75

Test to View test 1

Test 1: Depressurization

Airflow at 75 Pascals

13563 cfm +/- 0.8 %

Range: 13454 to 13673

0.585 CFM @75/sq ft (0.580 to 0.590)

Leakage Areas

EqLA (10 Pa) = 1299.1 in2 +/- 2.9 %

ELA (4 Pa) = 753.8 in2 +/- 4.5 %

Building Leakage Curve

Coef. (C) = 1228.4 cfm/Pa^n +/- 6.9 %

Exponent (n) = .556 +/- 0.017

Correlation Coef. (r) = .99963

Corr Coef Squared (r^2) = .99926

View / Edit Test Details

Export to Tectite Express...

OK


02/25/2016 15:33


02/25/2016 15:34


02/25/2016 15:34


02/25/2016 15:42


02/25/2016 15:44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mec 2633ES
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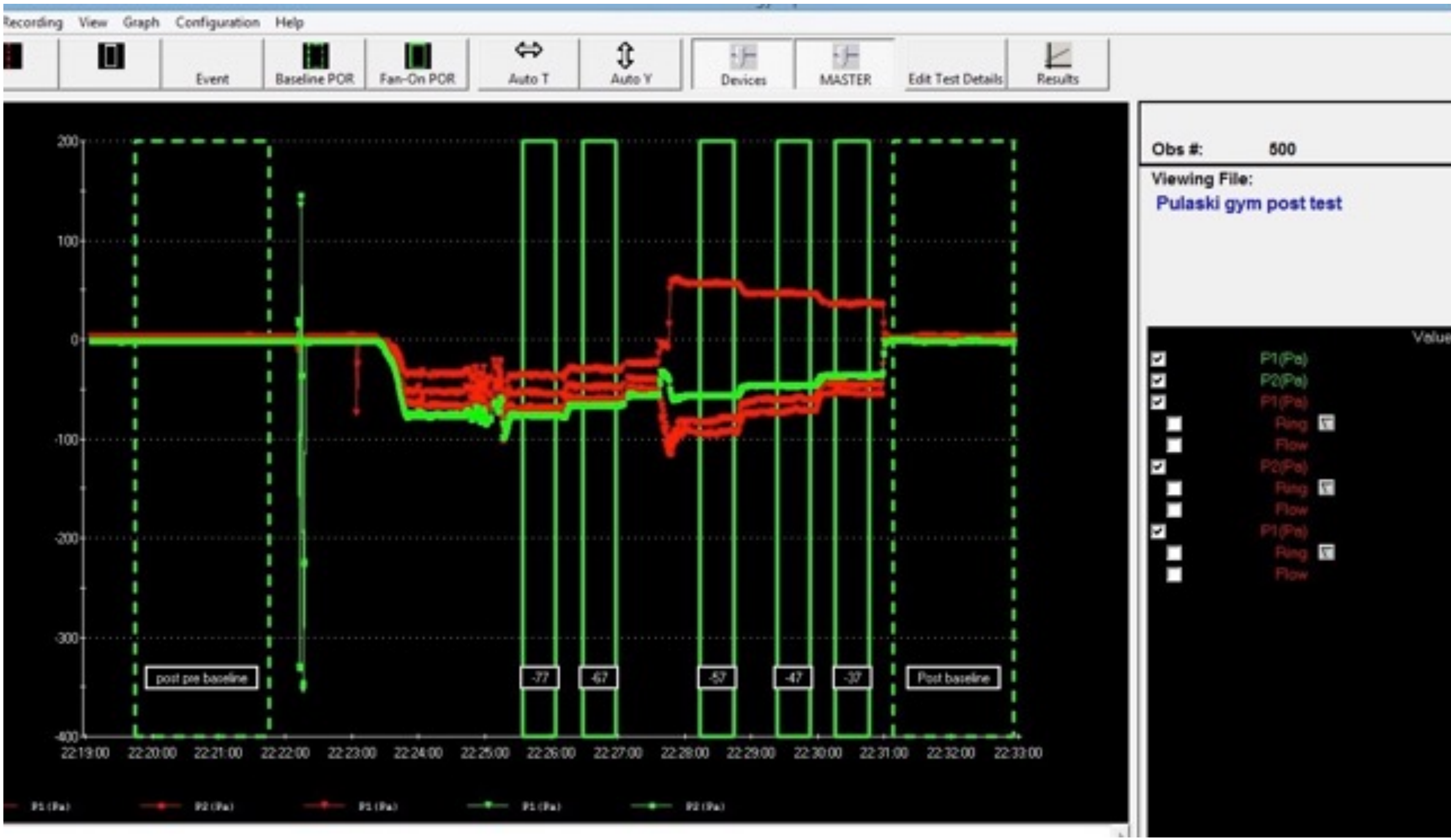
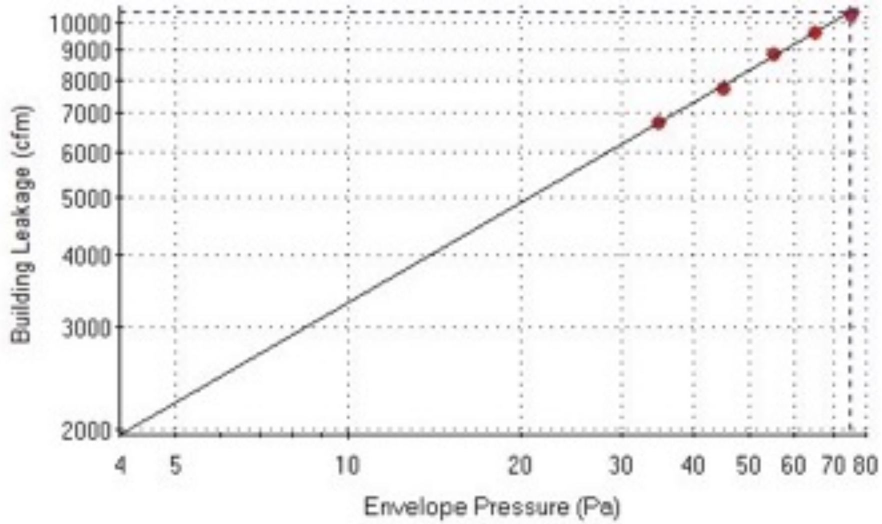
Pulaski Gym Post-Test



Pulaski Gym Post-Test Results



Label	Base?	start	end	nobs	Avg Pressu	Total Flow
post pre ba:	True	41	156	116	-2.27	0
-77	False	376	405	30	-76.93	10529.8
-67	False	428	457	30	-66.97	9793.1
-57	False	529	558	30	-57.17	8979.7
-47	False	596	625	30	-47.1	7837.6
-37	False	646	675	30	-36.9	6832.8
Post baselii	True	696	801	106	-2.13	0

Test 1: Depressurization

Airflow at 75 Pascals

10479 cfm +/- 2.1 %
Range: 10256 to 10701
0.452 CFM @75/sq ft (0.442 to 0.461)

Leakage Areas

EqLA (10 Pa) = 969.8 in2 +/- 8.1 %
ELA (4 Pa) = 554.0 in2 +/- 12.5 %

Building Leakage Curve

Coef. (C) = 881.8 cfm/Pa^n +/- 19.1 %
Exponent (n) = .573 +/- 0.048
Correlation Coef. (r) = .99896
Corr Coef Squared (r^2) = .99792

View / Edit Test Details

Export to Tectite Express...

Pulaski Gym Results

- Roughly 8 person hours pre-test and post-test
- 25.5% reduction in hole size @ 10 PA
- CFM_{75} went from 13,563 to 10,479
- Return grill blew open on post – out of time
- Porous brick masonry walls
- Roughly 50 lineal feet done as mock-up prior
- 330 sq in reduction @ 10PA: 0.95 sq in per lineal foot
- 8.86 CFM_{75} reduction per lineal foot sealed

Component Leakage Testing – ASTM E783

- Possible to test individual units or banks of units
- We use both duct blasters and an MLM calibrated-orifice device
- Depends on the amount of air and pressure required
- Failures are possible

Duct Blaster Pressurizing Door

MLM Device Testing Door Leakage

Component Results

- **We test to a prescribed building pressure meant to mimic seasonal conditions**
- **Pre and post testing is encouraged**
- **A real motivator for the installers: seeing immediate feedback**
- **30 – 45 minutes to set up and run**
- **Useful data for future assumptions**

Component Test Results

Door ID	Pre pa	Pre leakage	Post pa	Post leakage	W/S?
ED 16	15 pa	95 cfm	15 pa	20 cfm	Yes
ED 10	15 pa	83 cfm	15 pa	22 cfm	Yes
ED 9	15 pa	43 cfm	15 pa	7 cfm	Yes
ED 12	15 pa	24 cfm	15 pa	6 cfm	Yes
ED 22	15 pa	156 cfm	15 pa	20 cfm	Yes

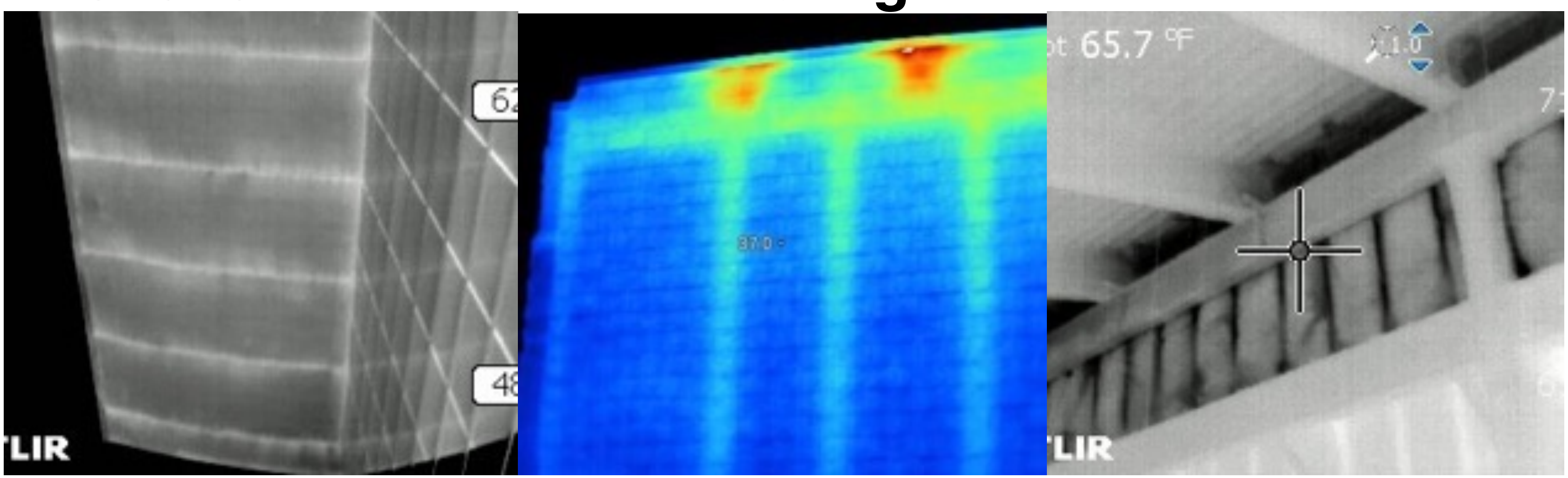
ASTM E1186 – 03

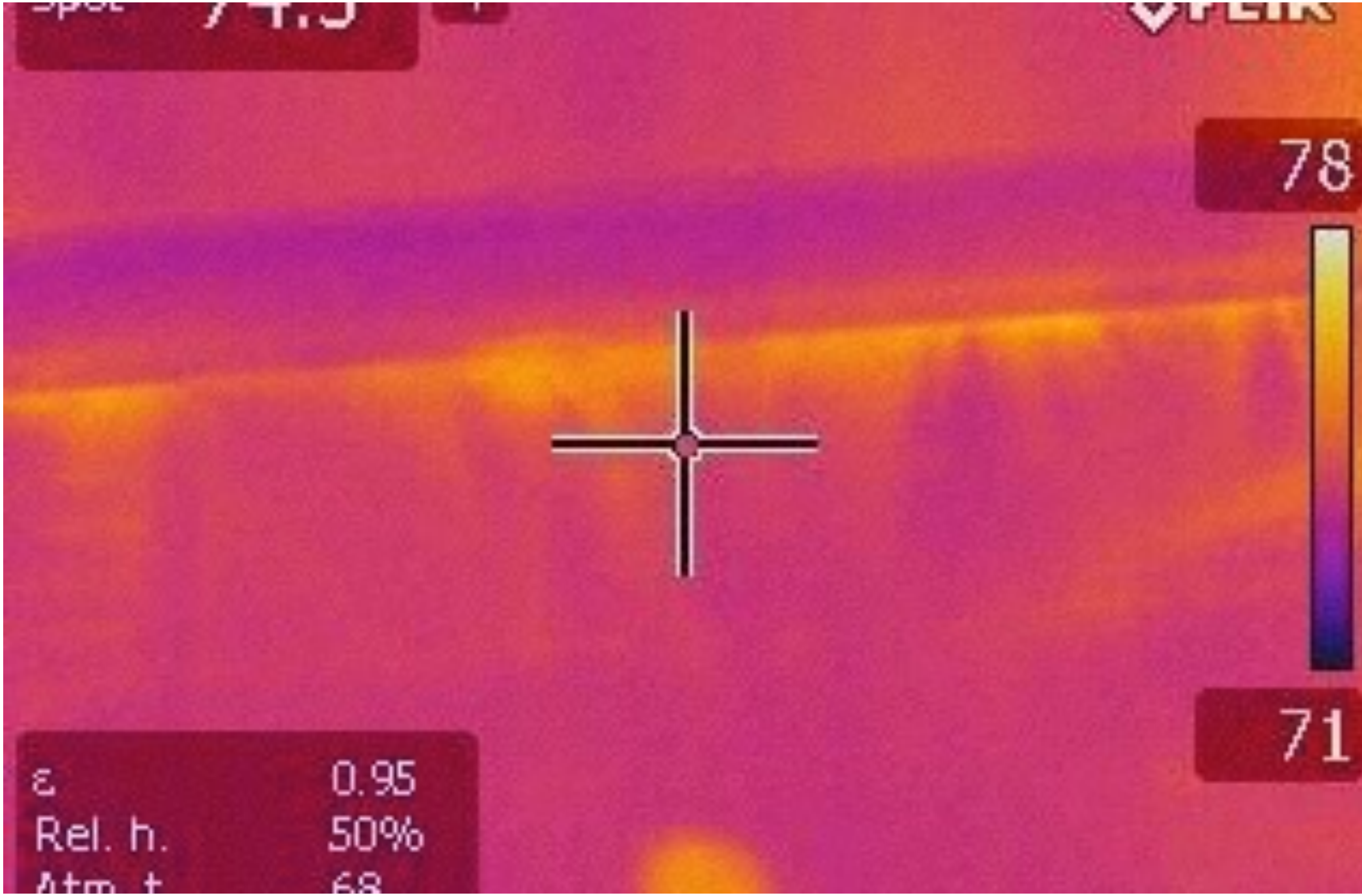
Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems

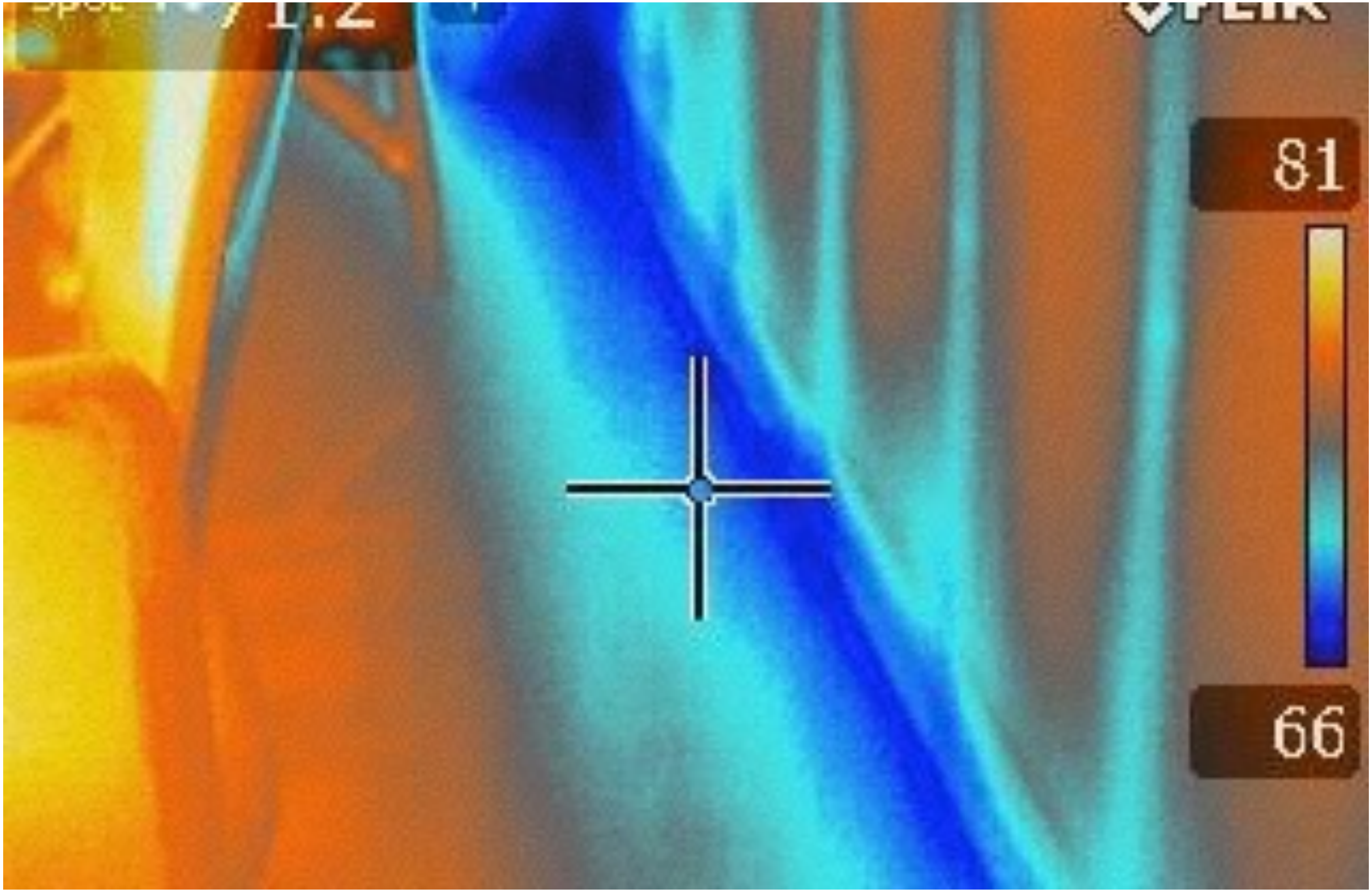
ASTM E1186 – 03

Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems

- **Section 4.2.1 Infrared Testing**




78
71
ε 0.95
Rel. h. 50%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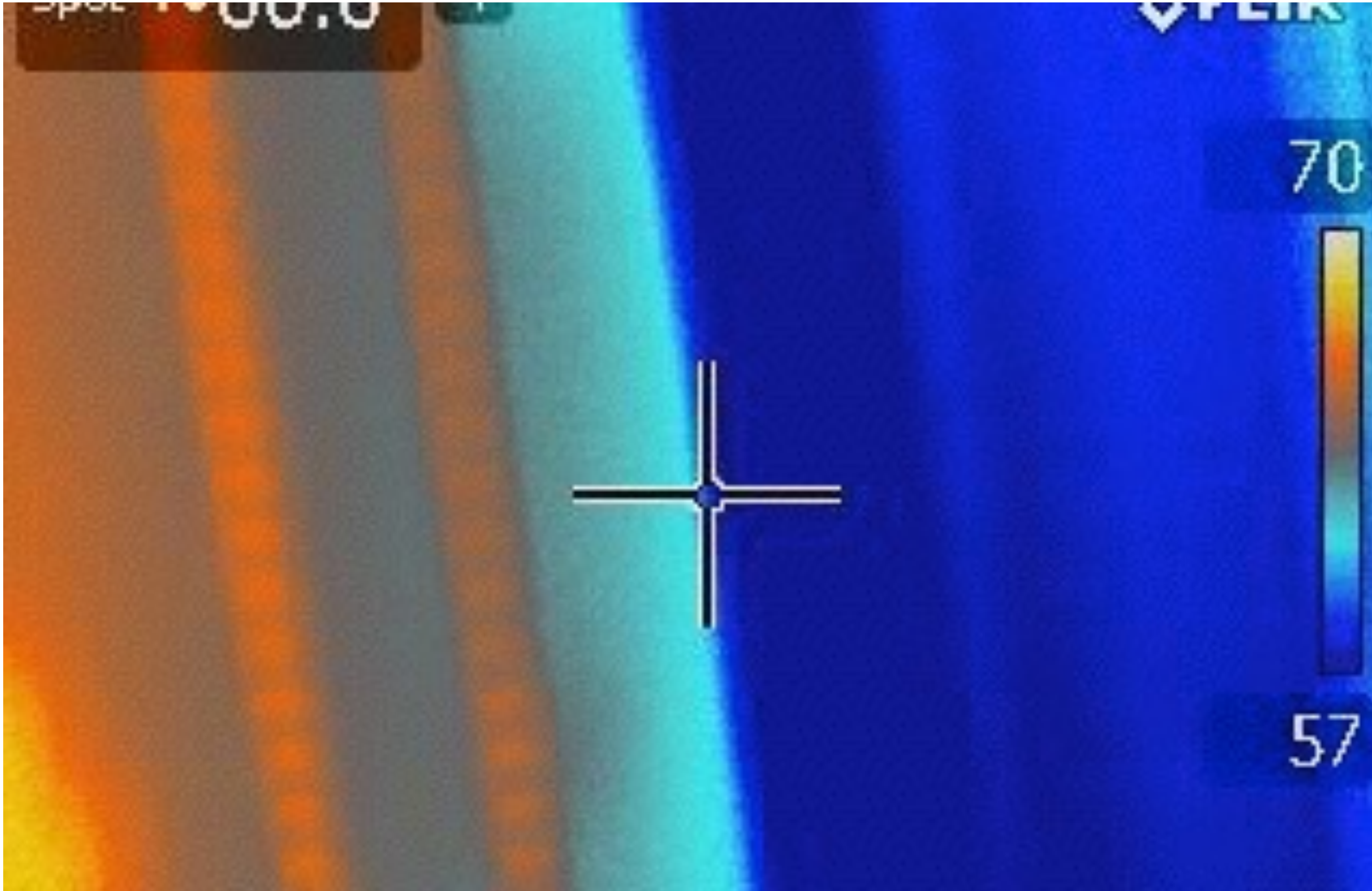
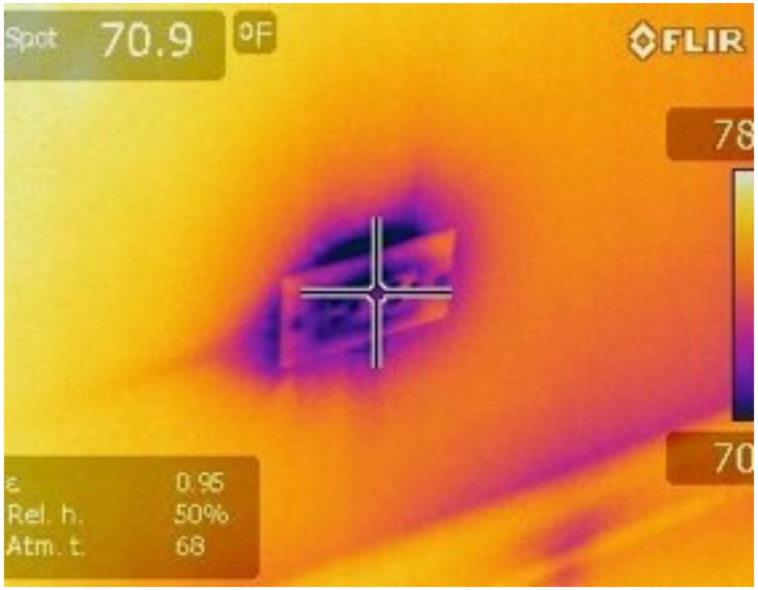
66


70
57


Spot 72.0 °F
FLIR
86
71
ε 0.95
Rel. h. 50%
Atm. t. 68

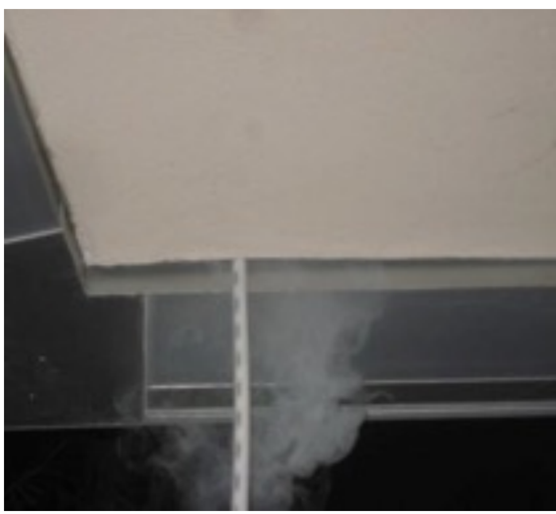

Spot 70.9 °F
FLIR
78
70
ε 0.95
Rel. h. 50%
Atm. t. 68

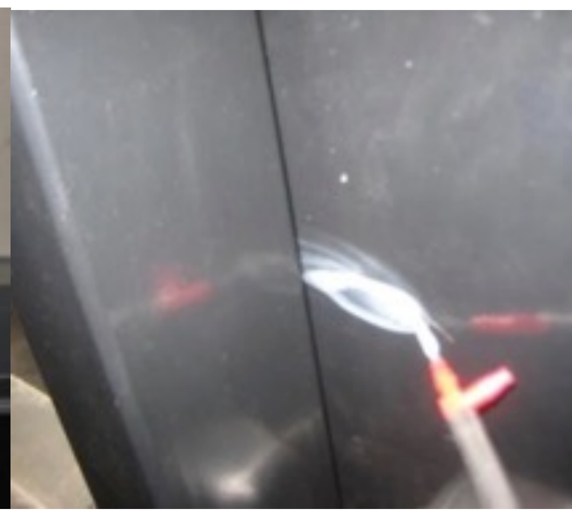

Spot 83.8 °F
FLIR
91
83
ε 0.95
Rel. h. 50%
Atm. t. 68

ASTM E1186 – 03

Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems

- Section 4.2.2 Smoke Tracer



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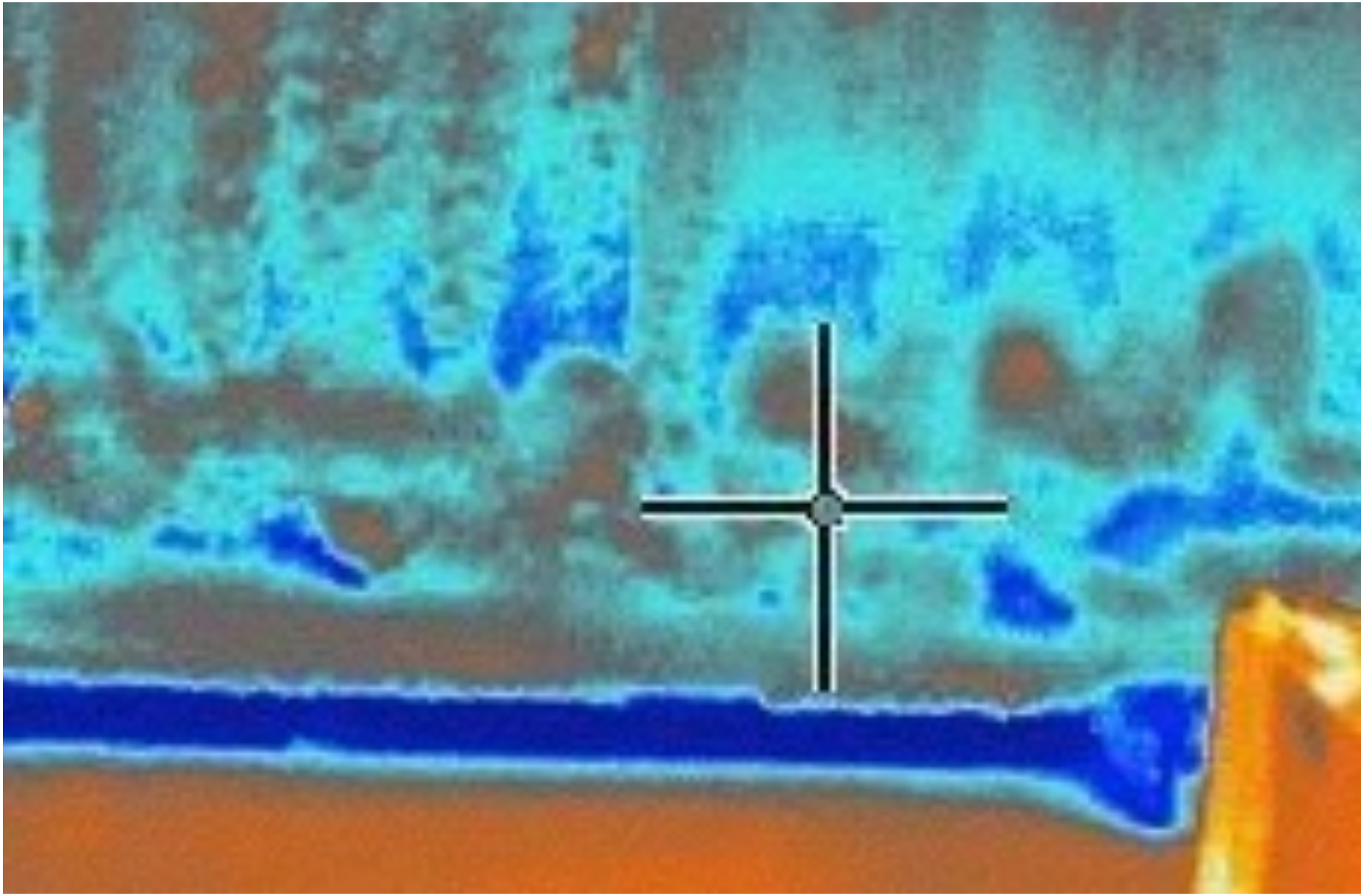
02/17/2016 11:03

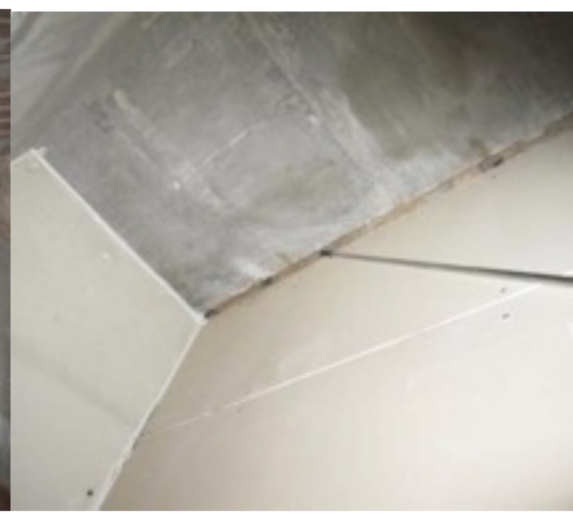

02/17/2016 10



ASTM E1186 – 03

Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems

- **Section 4.2.3 Air Flow Measurement Devices**




CFM
02/17/2016 10:38


124
CFM Hot Wire Anemometer
EXTECH
02/17/2016 10:38


DG-700 Pressure & Flow Gauge
DEVICE
CONFIG
10.1
0.0
MODE
TIME AVG
DEVICE
UNITS
CONFIG
MODE
CLEAR
TIME AVG
BASE LINE
START
ENTER
INPUT
A
ON/ OFF
LIGHT
HOLD
02/17/2016 10:46


248
808
Ft/min
POWER
HOLD
ESC
REC
Enter


598


CFM
POWER

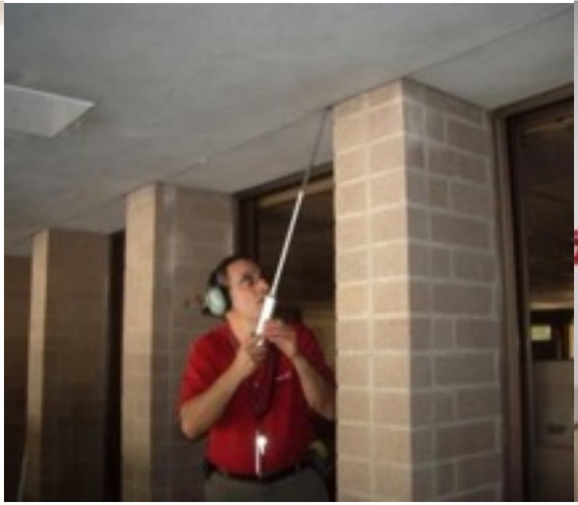

1188

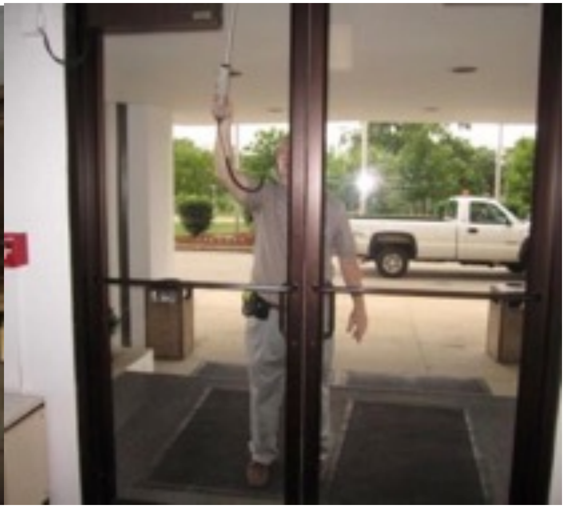

HOLD
REC

ASTM E1186 – 03

Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems

- **Section 4.2.4 Sound Generation Devices**






Air Barrier
Solutions, LLC

ASTM E1186 – 03

Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems

- Section 4.2.5 Tracer Gas Testing
- Section 4.2.6 Chamber Testing with Smoke Tracers
- Section 4.2.7 Chamber Testing with Water
- Section 4.2.8 Specialized Testing – smoke bombs etc.

ASTM Section 4.2.8 Flotation Devices

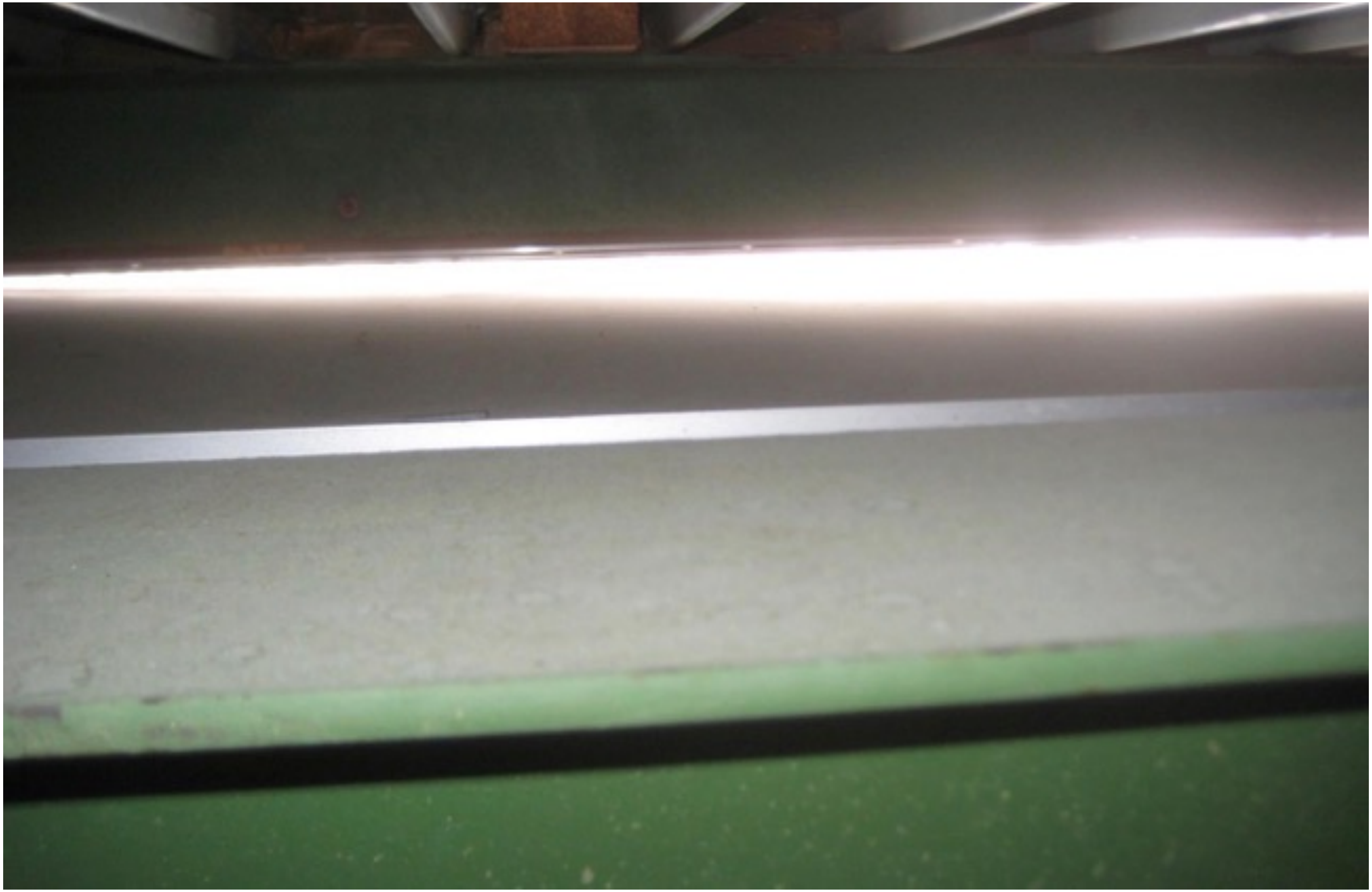
Common retrofits

Unintentional Daylighting

The roof-wall connection

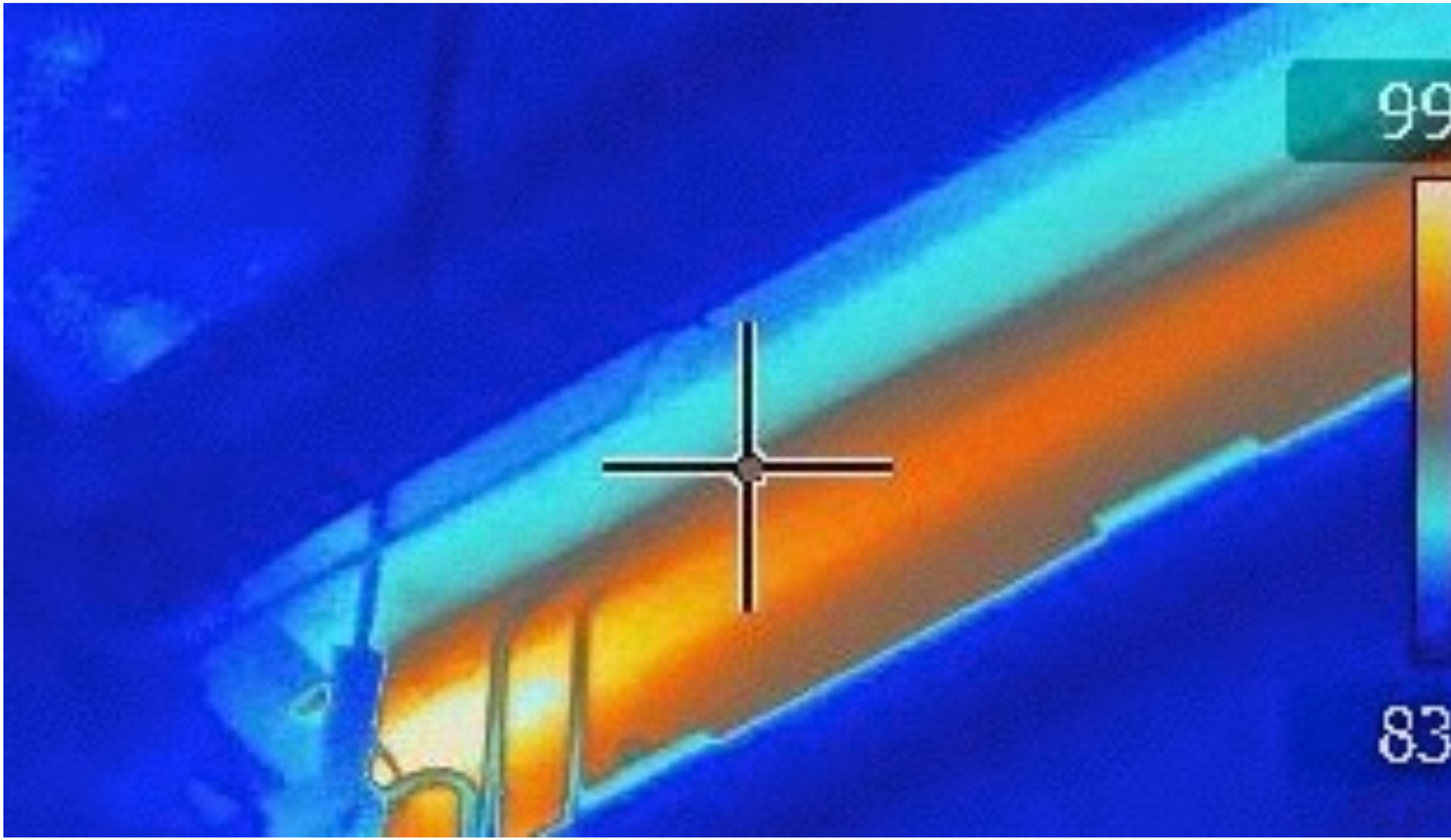
Roof-Wall Rules

- Generally ½ the leakage is above what you are staring at
- Single-component foam will not work – adhesion and cure
- Often there are fire-rated issues
- Fall protection is vital
- Safety officer as well
- Use of PPE mandatory



Roof-Wall Leak Hotwire

Roof-Wall Leak IR



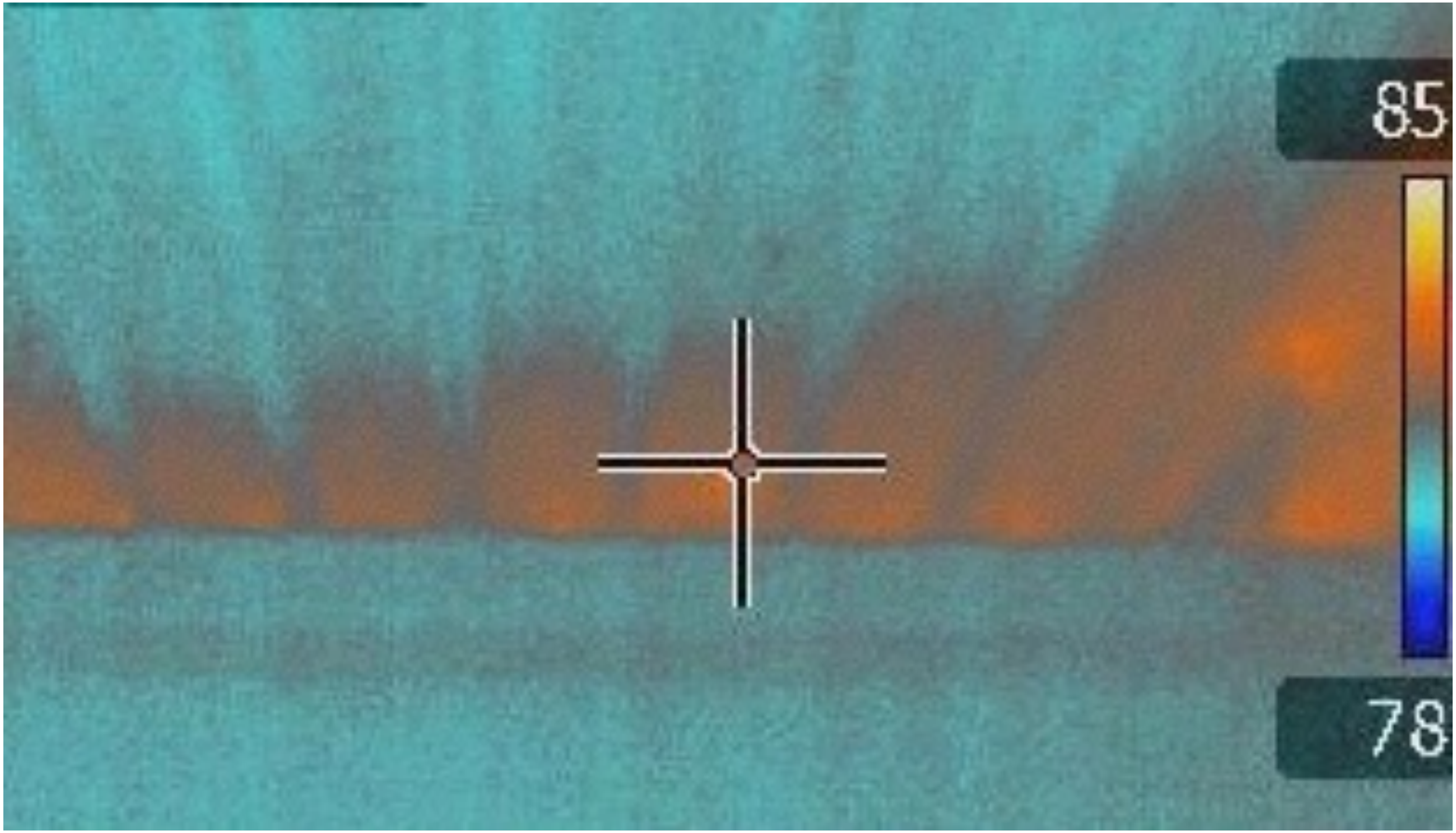
Smoke Tracer Roof-Wall Joint

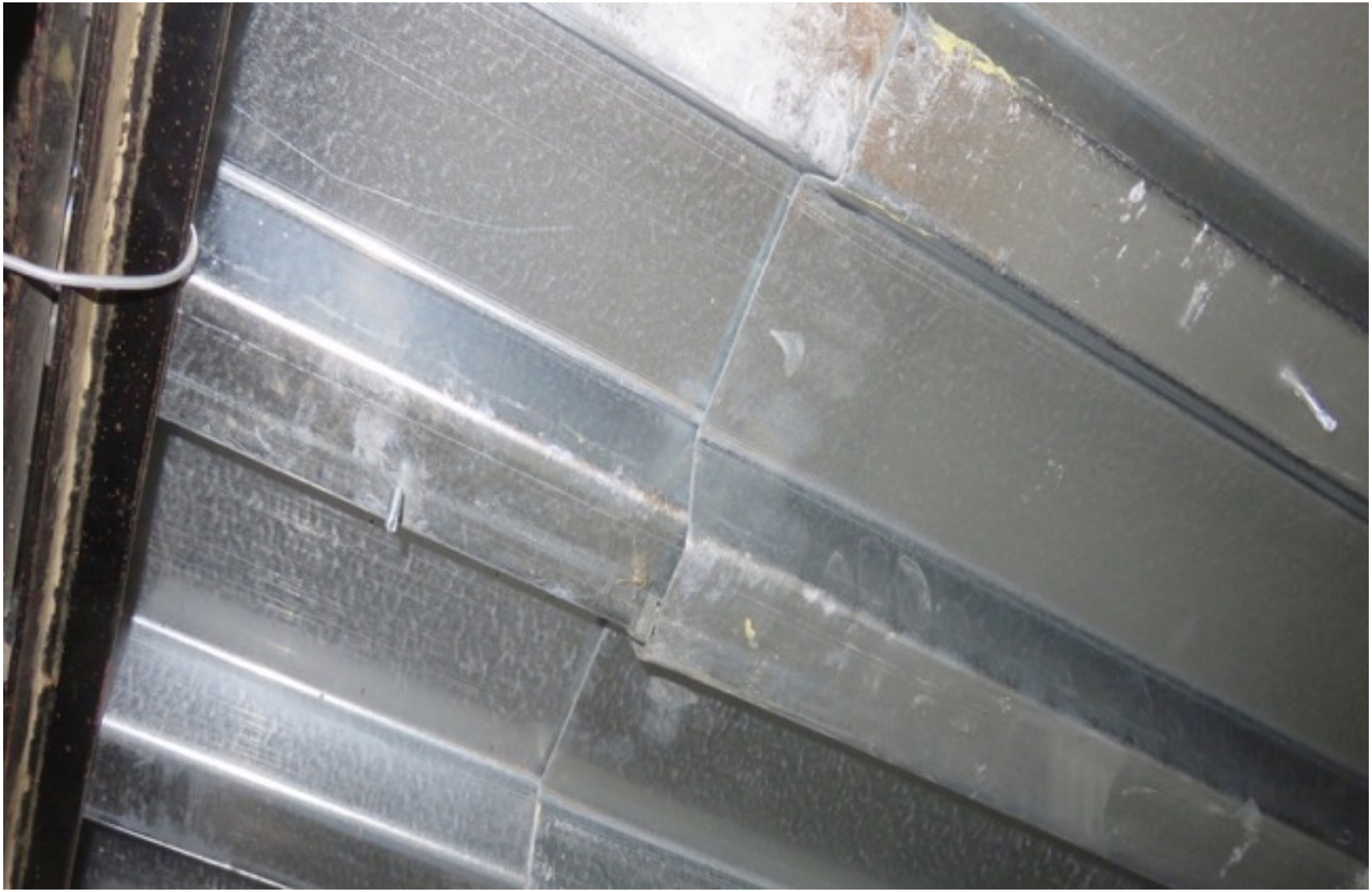
Industrial Roof-Wall and Beams!

Hotwire Reading Air Leakage at Column

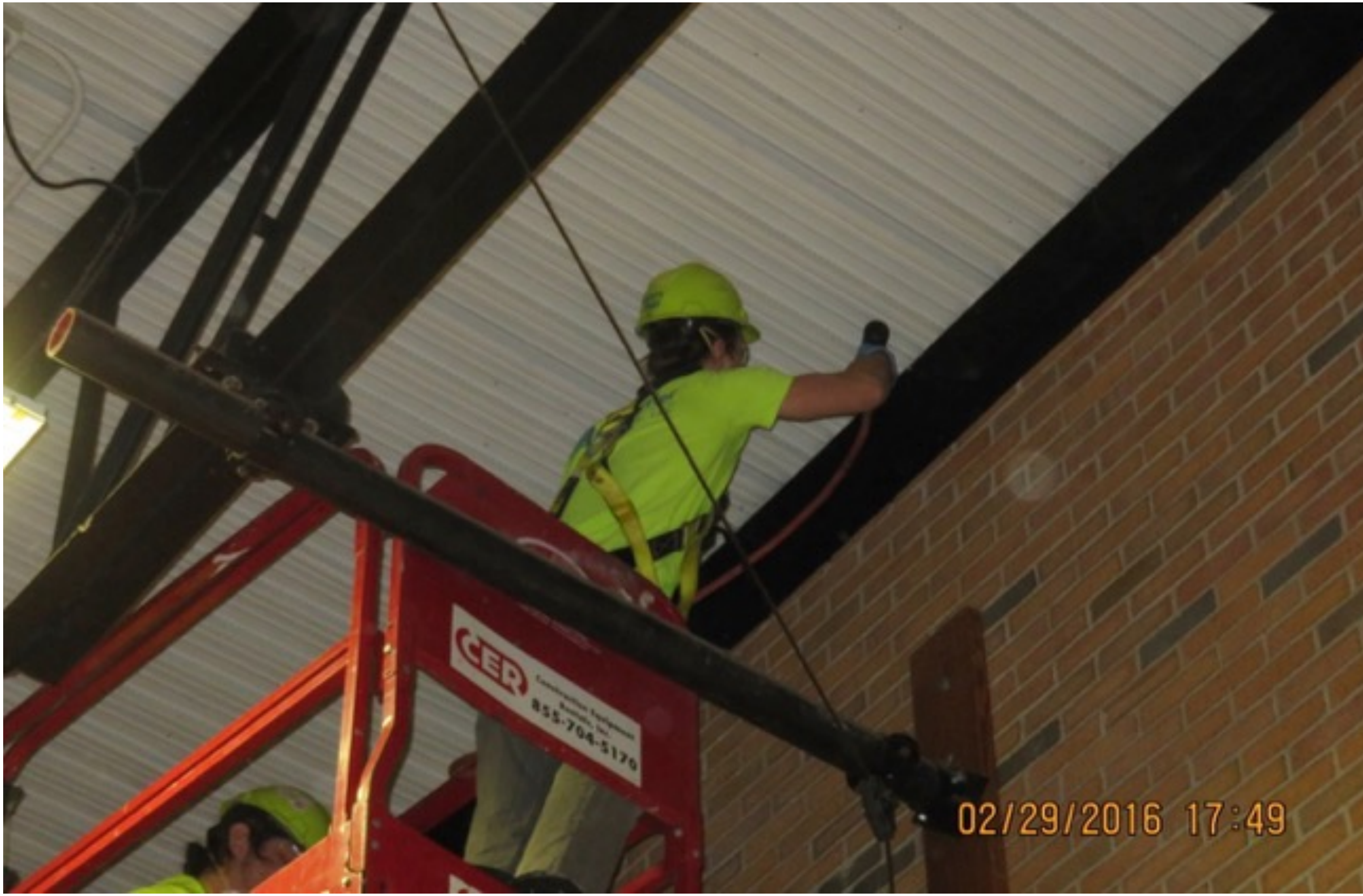
Why Worry about the Flutes?

Decking-Joint Gap IR





Roof-Wall Sealed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Rooftop Fans

Rooftop Fan Issues

- They are often neglected: clean and lubricate
- Stuck or missing dampers are common
- Broken belts are more common
- Broken pulleys…..
- Missing or damaged dampers
- Bad or unsafe electrical
- Sometimes all of the above


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Profit in Soffit

Soffit Rules

- Go for thermal if there is building above it
- Normally, we continue a plane of airtightness aligned with the interior surface
- Rigid material – no bending, moving or sagging.
- Choose materials carefully – fire-rated example.
- We often use Thermax, 2-component foam and intumescent paint


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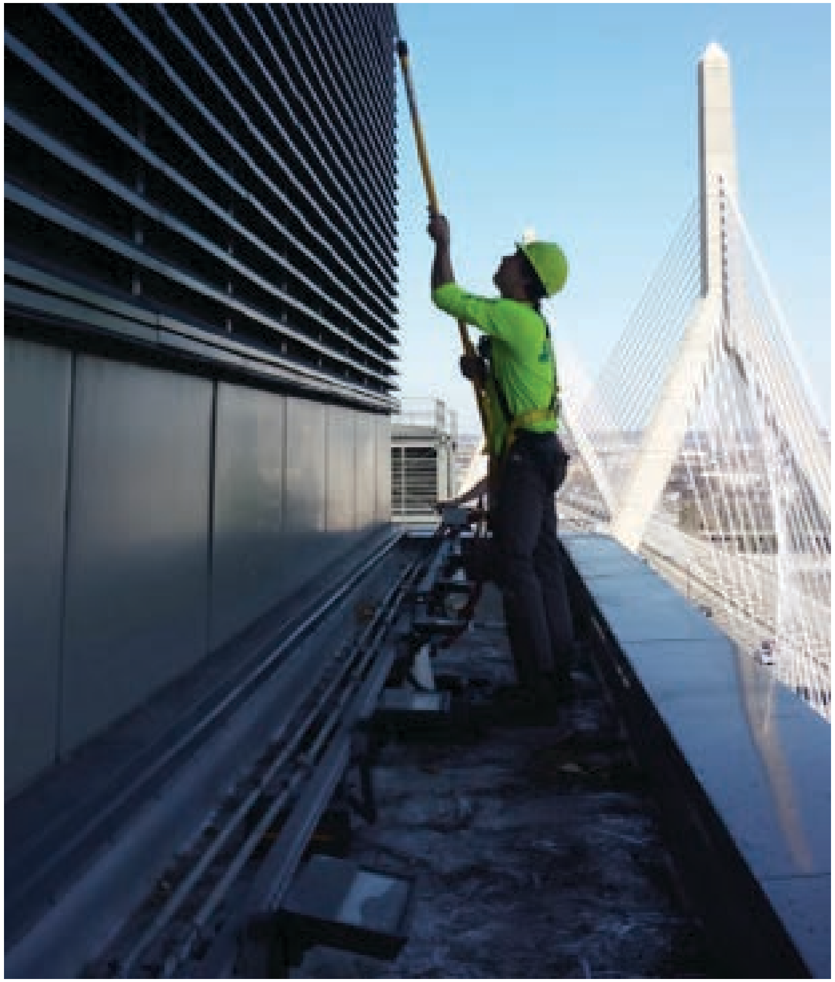
Remember... no matter how bad your day is going... at least You are [redacted] not stuck in a fence getting laughed at by a cow.

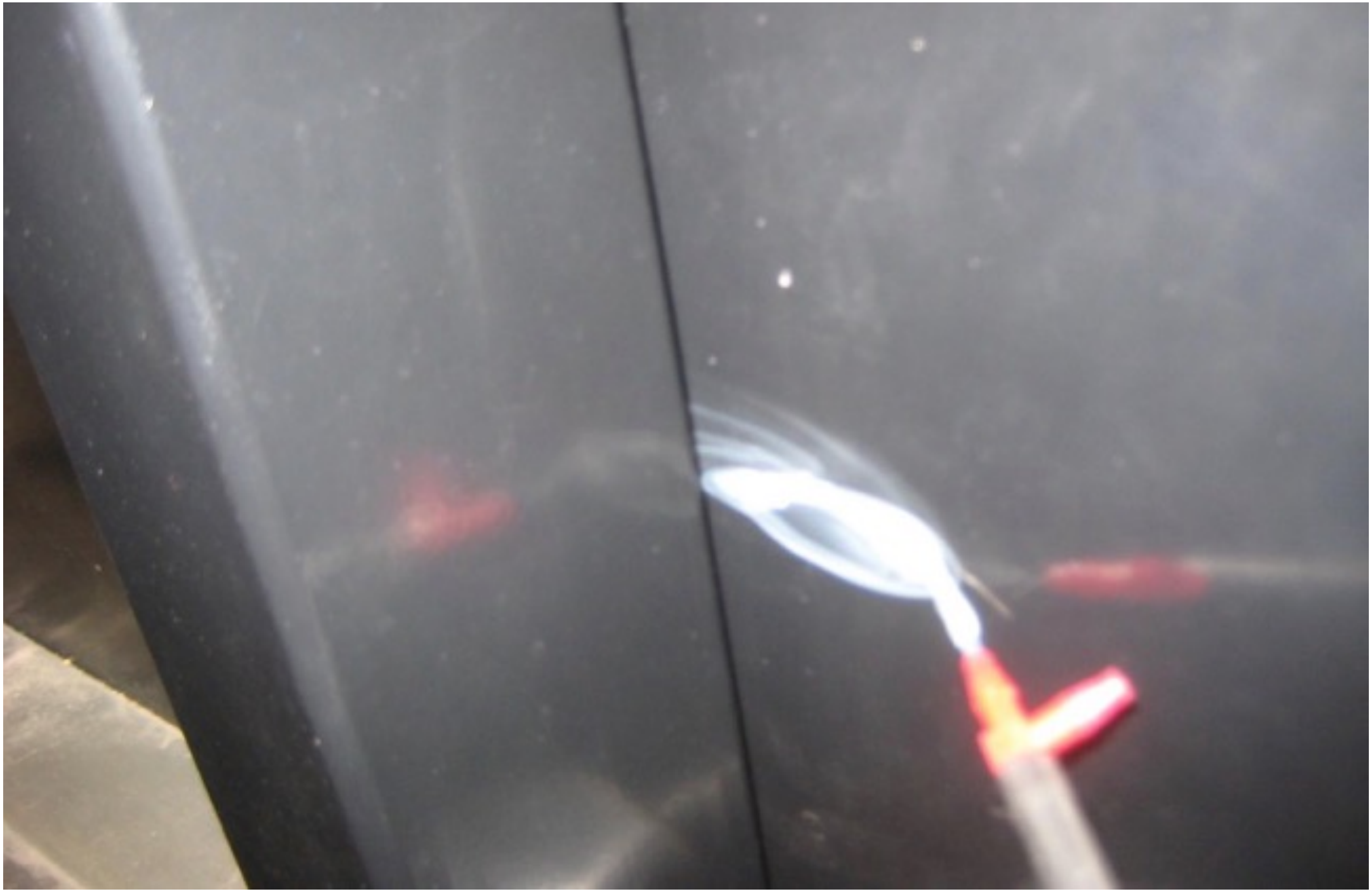
Spray Foam Very Carefully When Doing Soffits

- **Never spray daylight**
- **Spray from the building toward the soffit**
- **Mocking up the other end would have helped**



Sealing and Weatherstripping Windows, Doors and Skylights

Hotwire – Door Leaking



Window Seals

Got Weatherstrip?

AIR BARRIER SOLUTIONS INC

Fenestration Wisdom

- Doors are hard – I know they look easy
- Many windows leak at the frame-to-wall juncture
- Most replacement windows leak due to the install
- Many windows can be retrofitted with weatherstrip
- Door stops can often have their gaskets changed
- Skylights are generally water tight but seldom air tight

Old – Works Better Than New

- Old boiler room door
- Automatic door bottom FR SR
- Door gaskets on carrier FR SR
- What happens in the boiler room stays there

Stage Doors

- Masonry repair
- Wood trim replacement
- Q-Lon door gaskets
- Fin-seal astragals and sweeps
- Safety officer for pedestrians and workers
- Lotta time and money
- Leakage reduction is huge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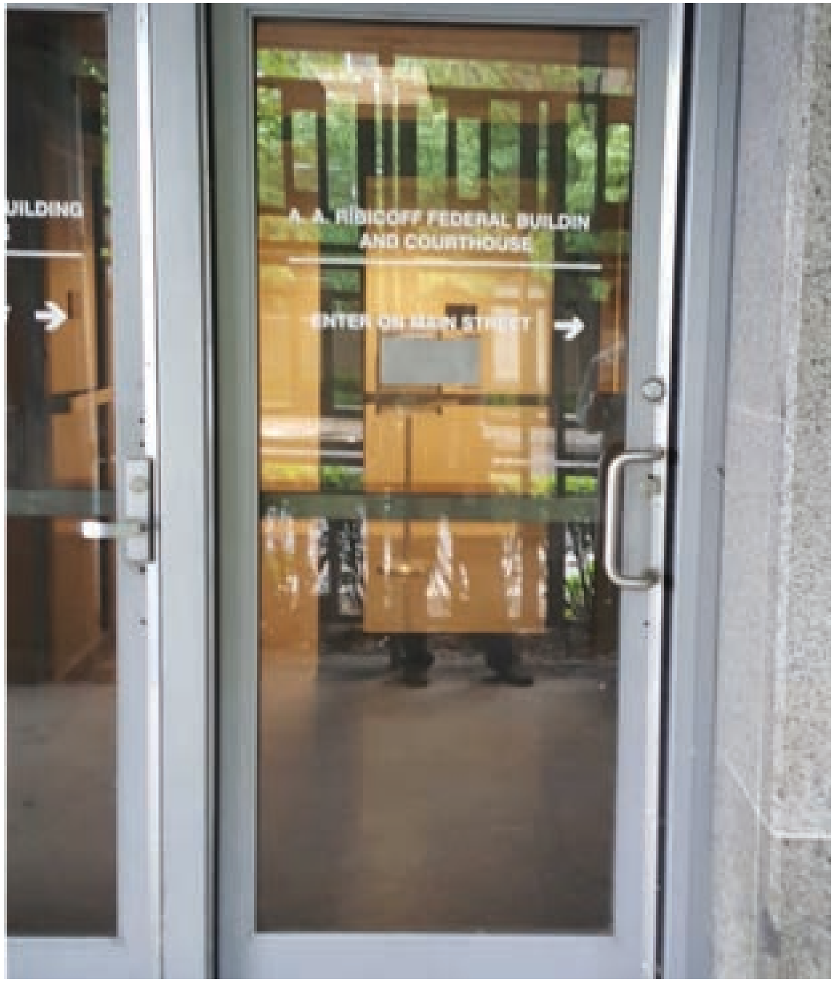
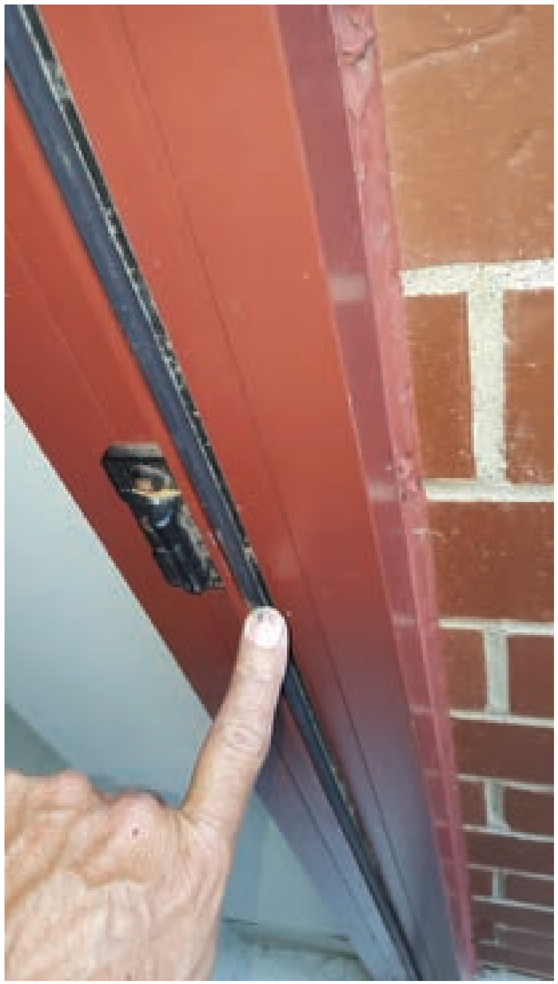
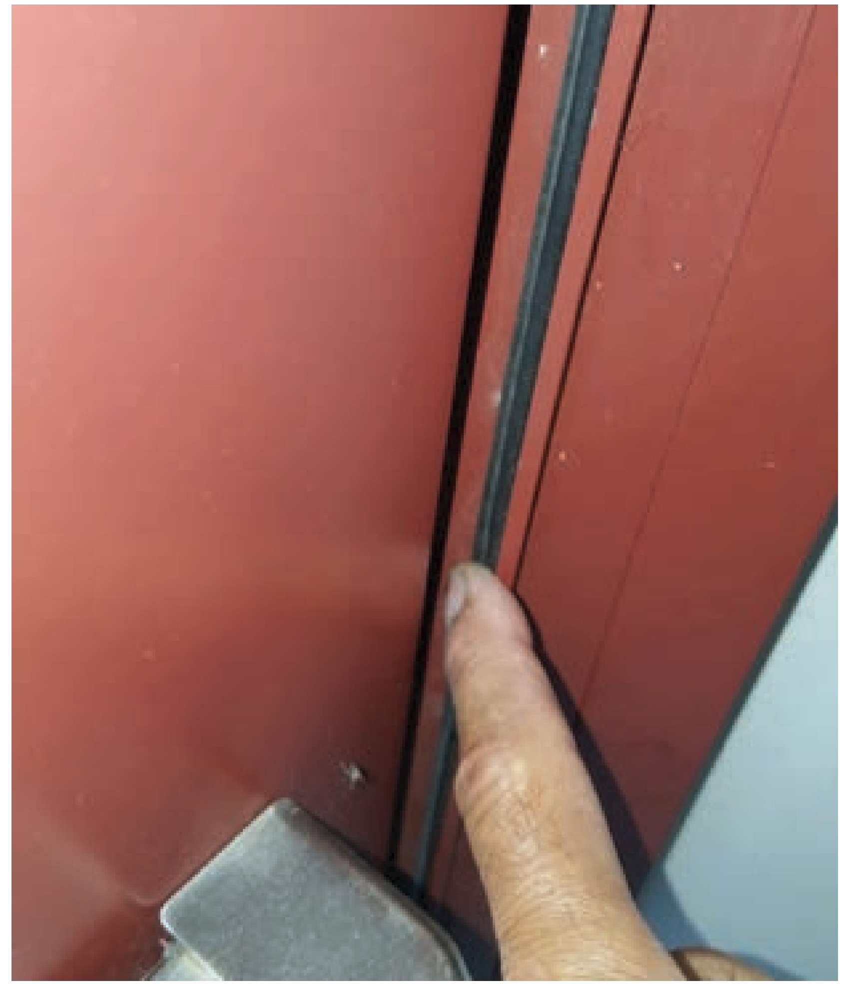
Pivot Doors

- Change "fuzz" wherever possible
- Sweeps top and bottom
- Astragals along sides of doors
- A careful install will really reduce the hole size



Deficient New Does not Mean Forever



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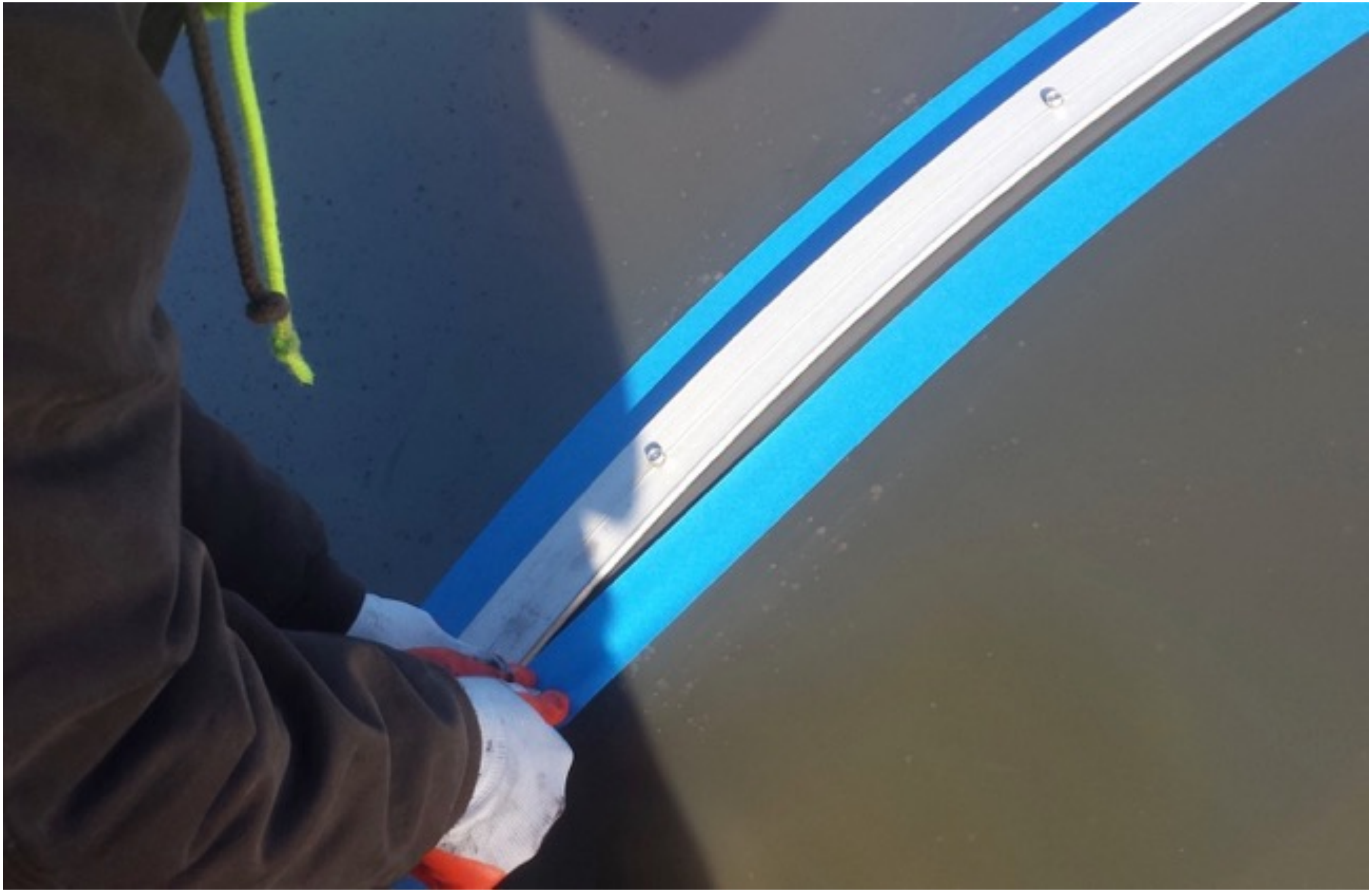

SOLVING YOUR BUILDING PROBLEMS
ON TIME • ON BUDGET • QUALITY ASSURED

You're Free!

Thanks for your attention and patience.

Larry Harmon
www.AirBarrierSolutions.com