BUILDING AIR LEAKAGE AND EFFECTS ON THE BUILDING ENVELOPE

TRC 002

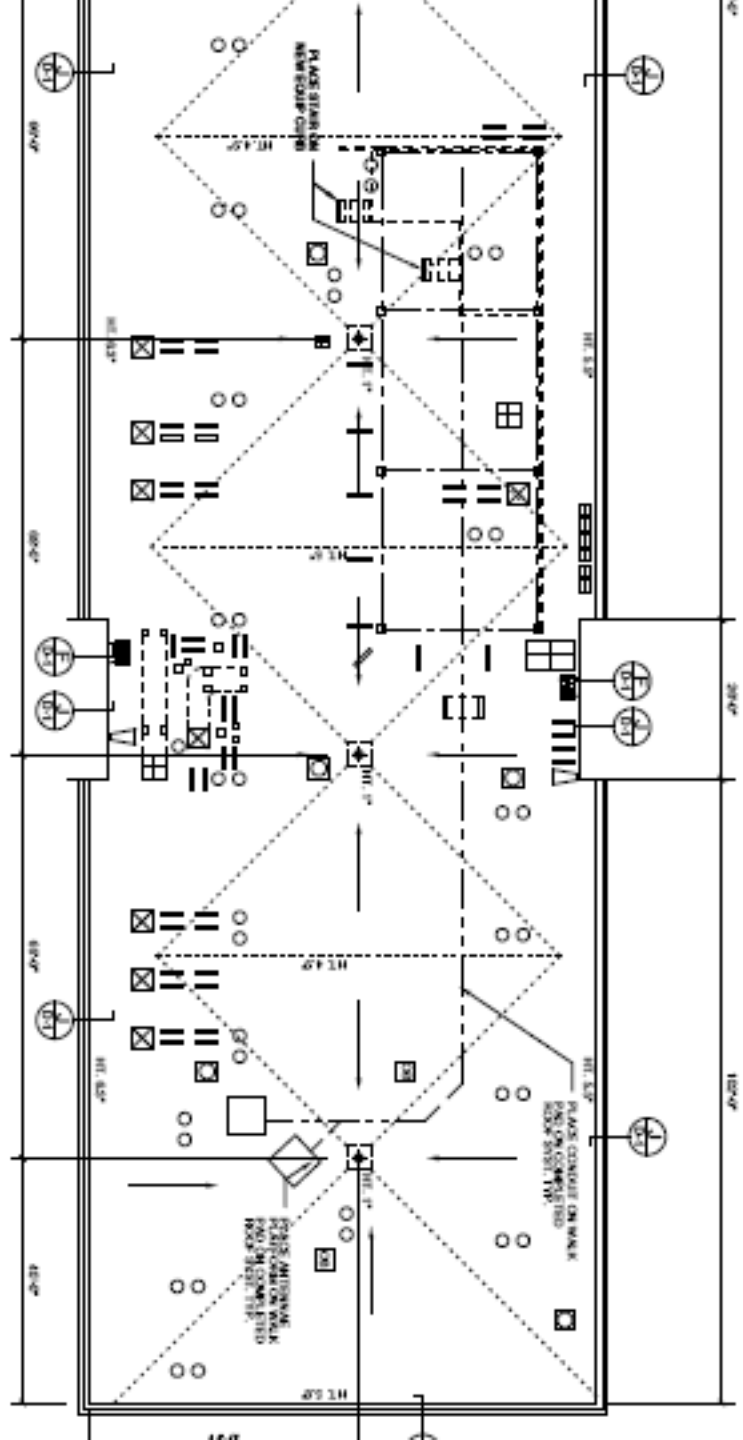
Tremco Roofing and Building Maintenance

J157

Presenter Name Steven Tratt

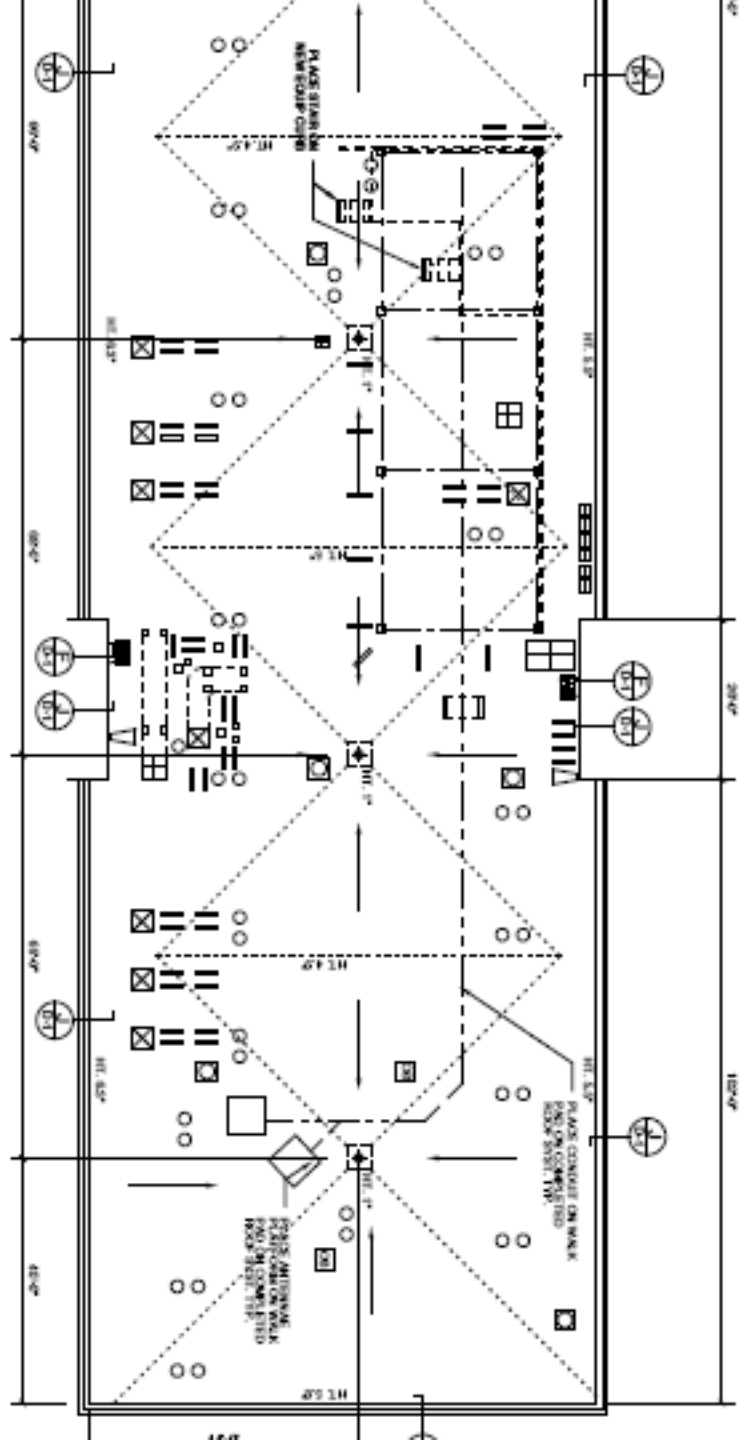
Date June 14th 2018

CONTINUING EDUCATION AIA



DESCRIPTION

This presentation is for architects and other design professionals interested in increasing their knowledge of the application and use of air barriers in the building envelope of commercial and multi-family residential buildings. Reseachers, architects, and code writers have shown that attention to specific details in both new and retrofitted envelopes result in better performing buildings with better comfort and long durability as well as lower energy consumption.



BUILDING AIR LEAKAGE AND EFFECTS ON THE BUILDING ENVELOPE

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This course is registered with **AIA CES** for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Learning Objectives:

At the end of the program, participants will be able to:

- Understand the definition of a High Performance Building and the importance of Air and Moisture Management to Occupants
- Understand the connection of the Building Envelope and the impact it has for the facilities Durability, Sustainability, Energy Efficiency, Occupancy Comfort/ Health and IAQ
- Understand the application differences of Air Barrier product types for new construction / major façade retrofit --- vs.---- remediation of existing buildings,(*when the building owner is not considering re-skinning the façade).*
- To understand what causes Building Air Leakage in the existing asset and how to remediate.

After the conclusion of this presentation there will be Examples / Results and time for Open discussion.

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Definition of the High Performance Building

The term "high performance building" means a building that integrates and optimizes all major high-performance building attributes, including *energy efficiency, durability, life-cycle performance, and occupant productivity.**

4 Elements of a High Performance Building

- *Heat Flow*
- *Air Flow and Pressure*
- *Moisture*
- *Air Quality*

National Institute of BUILDING SCIENCES
An Authoritative Source of Innovative Solutions for the Built Environment

*High Performance Building Council
a council of the National Institute of Building Sciences

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Air Barrier Continuity- Identifying breaches :

The Basics of Air leakage

- Continuity is the most important characteristic of the air barrier system prevents…..

  Infiltration / Exfiltration which is

  - Diffusion Flow
  - Orifice Flow
  - Channel Flow

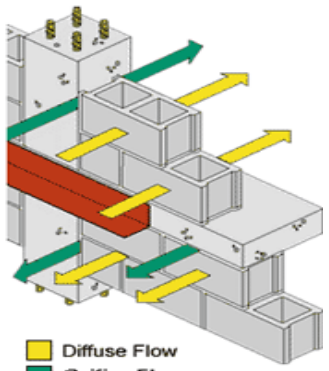


Fig. 1

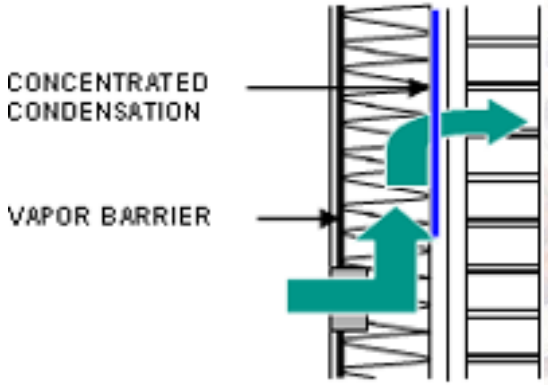
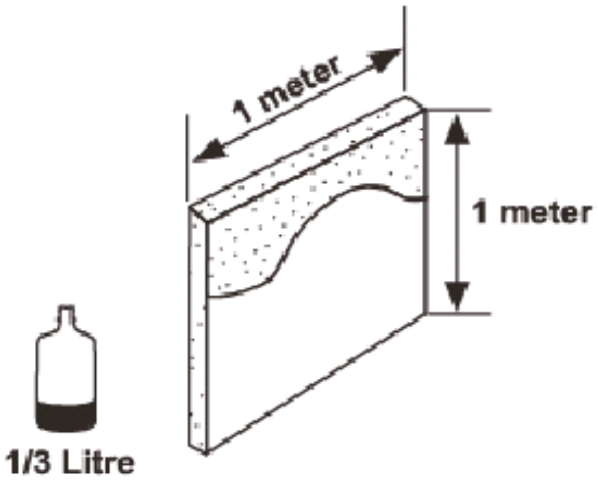


Fig. 2: Channel Flow

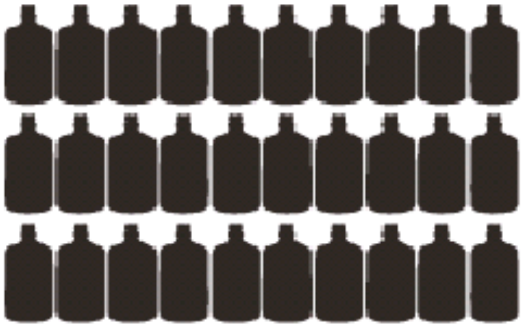
- Allows the proper control of air movement into and out of building enclosures
- All six sides of a building enclosure must be continuous within themselves and in conjunction with each other

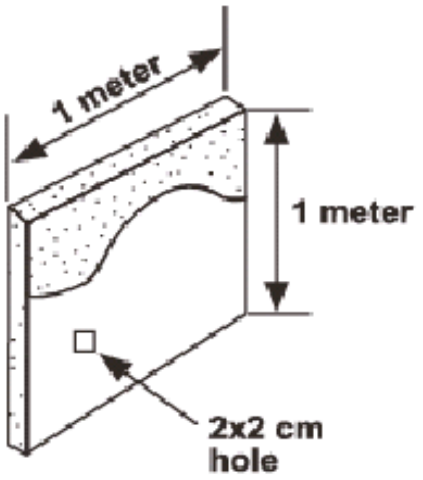
Air Leakage & Moisture

Transport via DIFFUSION over 1m²



Transport via AIR LEAKAGE Through 4 cm²





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TREMCO ROOFING & BUILDING MAINTENANCE

Air Barrier Materials and Installation

- Self-adhered sheet (e.g. rubberized asphalt sheet)
  - Generally acts as air and water barrier, traditionally a vapor retarder
  - Fully adhered membrane sheets applied to exterior sheathing
  - Seams are lapped, mastic or liquid membrane can be applied

Air Barrier Materials and Installation

- Fluid-Applied Membranes (e.g. asphalt emulsion, acrylic)
  - Generally acts as air and water barrier, available as vapor permeable and vapor retarder
  - Liquid membrane is applied to the exterior sheathing typically using a sprayer
  - No seams
  - Performance of membrane highly dependent on proper installation of material
  - Some have minimal track record

3 items in the conditioned building impacted by air leakage:

Air – Moisture – Heat

- Building Science translates:

  - Air = Comfort / Productivity / IAQ Health
  - Moisture = Building Durability / IEQ Heath
  - Heat = Energy Efficiency / Equipment Sustainability

Building Air Leakage Consequences

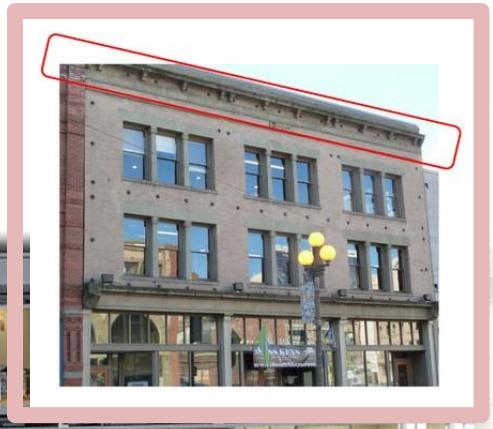
The Air and Moisture Connection

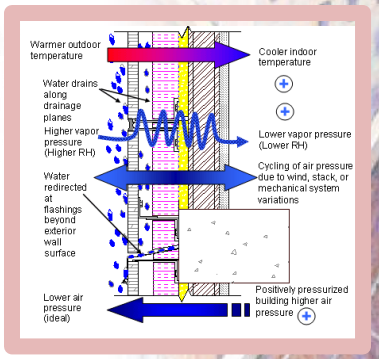
HVAC Sizing

Wind Effect/ Weather

Occupant Comfort

Indoor Air Quality





IAQ / IEQ

= Productivity

Durability

= Sustainability

Energy Efficiency

= Savings

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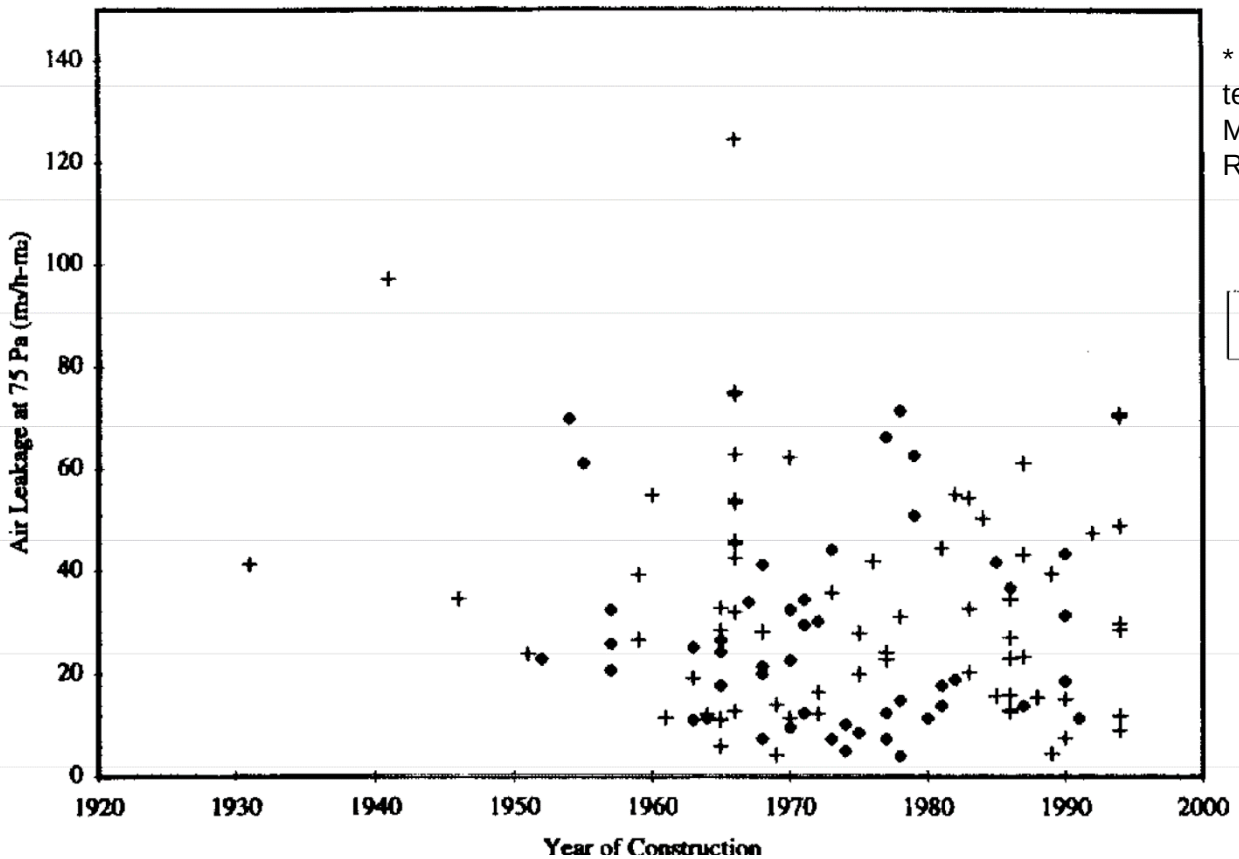
NIST / Emmerich 30 year Study..

Construction Technology Evolves but some things remain the same:

Air Leakage on Commercial Buildings by year



* Newer construction technology doesn't't Mean enhanced RESULTS!

We access 100 commercial buildings per year similar results

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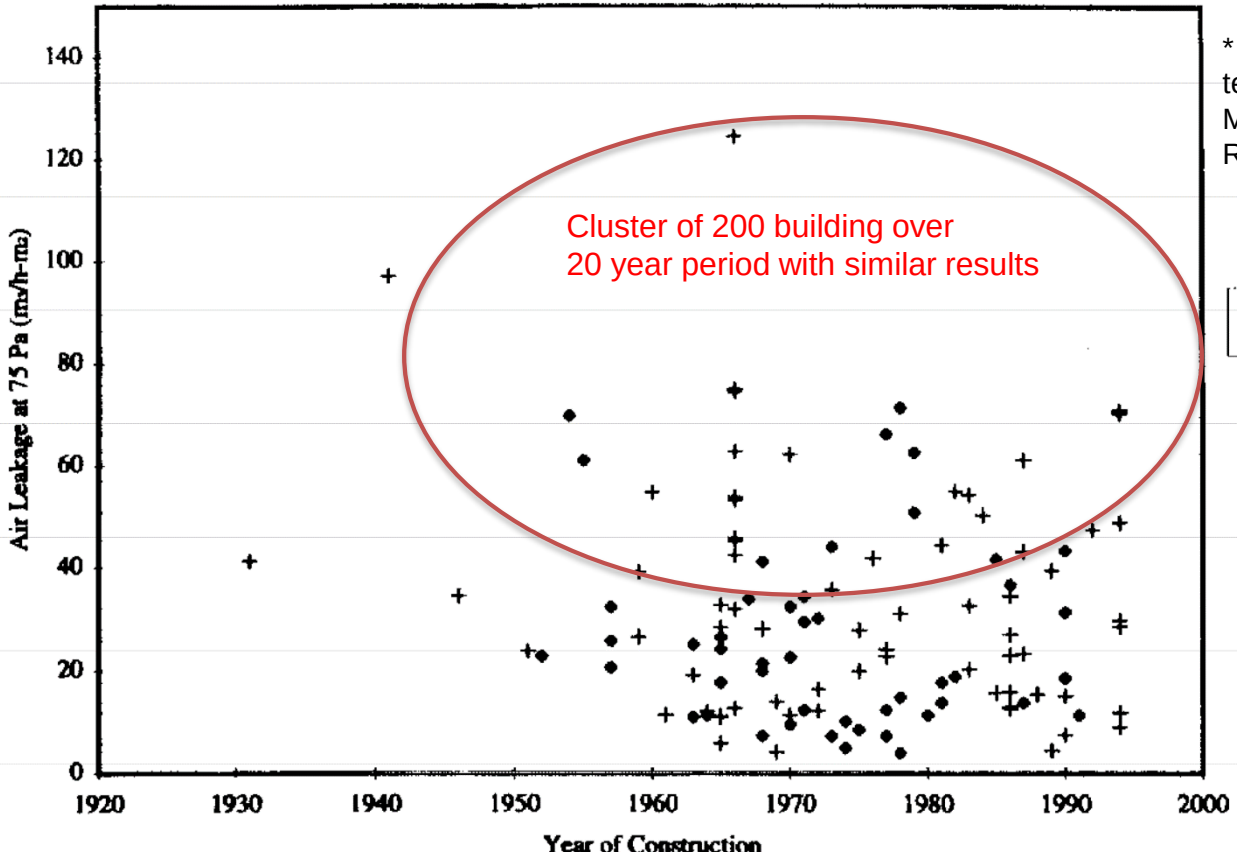

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We access 100 commercial buildings per year similar results

Influences- the Building Science has been there; Now becoming relevant!

Codes Standards and Recommendations

Factors that continue to push the construction industry to higher performance and more energy efficient buildings

- ASHRAE 90.1- 2010, 2013
- IECC 2012
- IBC
- USACE
- ABAA
- National Institute of Building Sciences
- Specialty Niche Organizations, (e.g. Joint Commission)

Base Diagnostic Tools:

For the forensic field assessor- identifying the source

Trained Assessor
with camera &
intake form

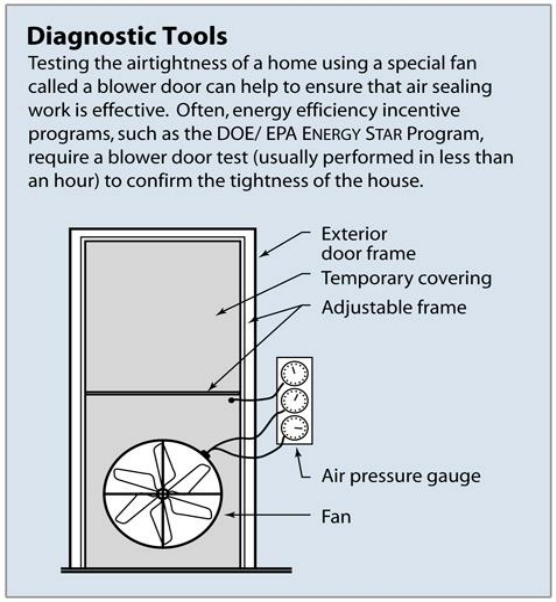
Smoke Pencil
or similar tool to
Provide show
of air flow

Flir E50 BX
IR camera

Velocicalc 9565
IAQ Probe 980 for:
Temp- RH
CO2 – Pressure
Mold and BIO snaps

Advanced Diagnostic Tools:

Optional cost, additional set-up- measured leakage



Blower Door

Standard Pressurization Kit and gauges used by Building Science Engineer Partner

Multi-fan or larger

Air Barrier Continuity:

Failure of air barrier systems

- Breaches in the air barrier and it's connections / continuity will make buildings:
    - Less healthy
    - Unsafe
    - Less durable
    - Uncomfortable
    - Energy inefficient

Air Barrier Continuity:

Failure of air barrier systems

- Leads to:
  - Uncontrolled and uncontrollable air leakage..
  - Infiltration / Exfiltration
- Caused by:
  - Stack effect
  - Wind effect
  - Mechanical effect

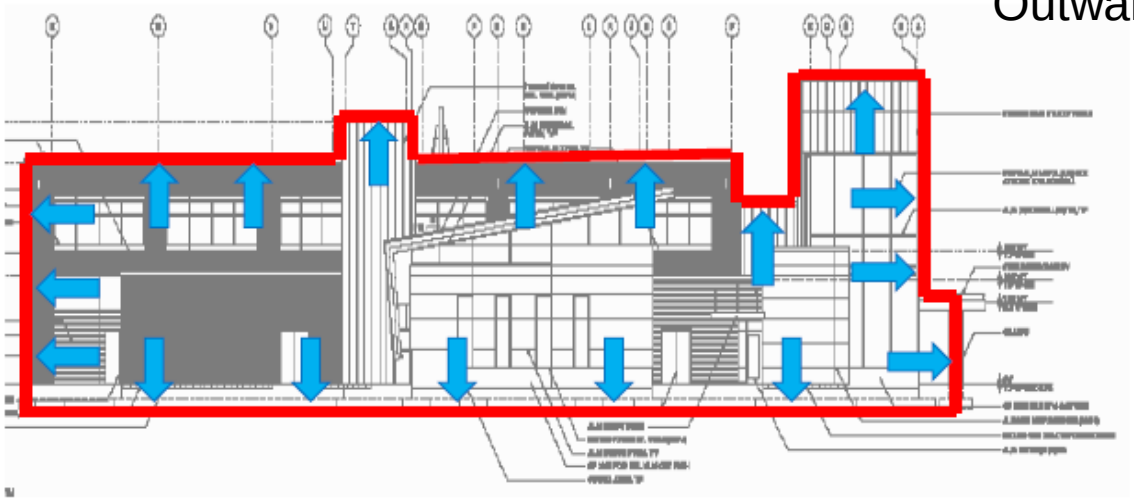
Air Barrier Continuity :

Building Connections and Conditioned Spaces

- Change in Plane
  - Wall to Roof connection
  - Transitions on Elevation (bump outs)
  - Overhangs / Soffits
- Interior Conditioned Spaces
  - Lab Spaces
  - Operating Rooms / Specialty spaces
  - Natatoriums
- Locations where two or more materials intersect
  - #1 concern: CONTINUITY OF AIR BARRIER

Unintended Air Leaks

Inward = Infiltration
Outward= Exfiltration



Importance of Continuity Intro to IAQ/ IEQ:

According to the Environmental Protection Agency

- Americans spend 80-90% of their time indoors, so IAQ is very important, for health and productivity reasons
- Sick Building Syndrome (SBS) involves health and comfort effects linked to time spent in a building
- Building Related Illness (BRI) involves symptoms of diagnosable illness attributed directly to airborne building contaminants (Asthma, aggravated allergies, etc.)

Introduction IAQ / IEQ continued:

IAQ / IEQ Factors

- Temperature
- Humidity, moisture
- Air Quality
- Thermal Controls

Strategies

- Improve (IAQ/ IEQ)
- Air leakage assessment /testing
- Air quality testing

IAQ / IEQ Benefits

- Reduced liability
- Reduced employee absenteeism
- Reduced occupant complaints
- Reduced vacancies and turnover
- Increase tenant satisfaction and retention
- Increase and extend the life and value of your facility

Occupant Control:

Temperature is the #1 complaint of office building occupants:

Thermal Comfort Involves:

- Humidity
- Air Speed
- Temperature
- Clothing
- Activity

Thermal Comfort Issues:

- Too hot, Too cold
- Too wet, Too dry

ANSI/**ASHRAE** Standard **55-2010**.
Thermal Environmental Conditions for Human Occupancy

Minimum Ventilation Standards:

ASHRAE baseline

Meet ASHRAE 62.1 – 2010 Standard (2013 Mod.)

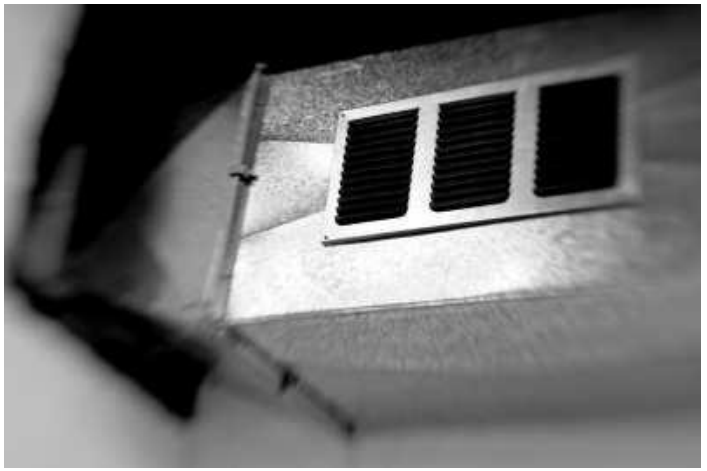
- Sets minimum ventilation provisions and IAQ levels
- Mechanical ventilation: ventilation rates

Moisture control (ideally 20% - 60%)

- Minimize Mold & Mold Spores

Monitor air exhausted from building

- Good way to monitor IAQ



Why should the owner care about building air leakage:

Its about having Control- *Air Leakage in a building effects:*

4 measurable items to monitor:

- Ventilation / Temperature / Humidity / CO_2
- Occupancy comfort
  - Pests
  - Airborne Infection
  - Odors / Fumes
- Inhabitant Productivity
- Building Durability
  - Moisture control
  - Exterior Building Envelope Appearance
  - Life Cycle Longevity

The byproduct / financial benefit of air sealing:

Is a cost justifiable process, not sole driver

– Energy Efficiency that will save you MONEY!

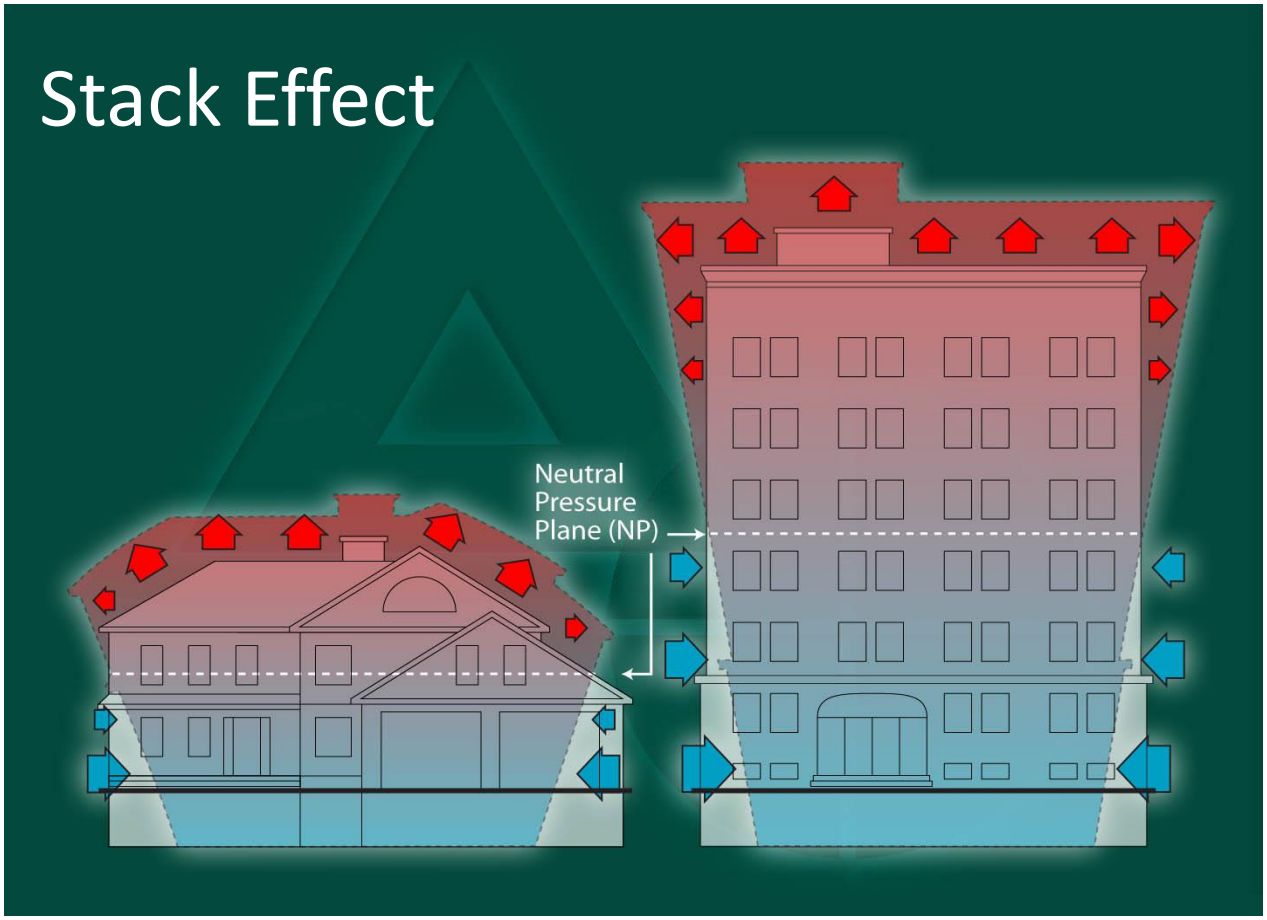
- More efficient ventilation in the HVAC system
- More efficient use of pumps and fans within the system
- Better performance of the system could mean longer operation life of the equipment

– 3 recommendations for all buildings (in order)

- Air Sealing – *inexpensive, is a building maintenance issue that is often ignored, should be looked at as long-term investment*
- Insulate- *ALWAYS done after air sealing to enhance the conditioned space*
- HVAC- *upgrade / redesign- done in this order will maximizes system efficiency*

The Building Science of Air Barrier Continuity

Failure of air barrier systems



Stack effect is a temperature-driven phenomenon, which is especially noticeable in cold weather, when warmer indoor air, which is more buoyant than the colder outdoor air, tends to rise in the building.

The Building Science of Air Barrier Continuity

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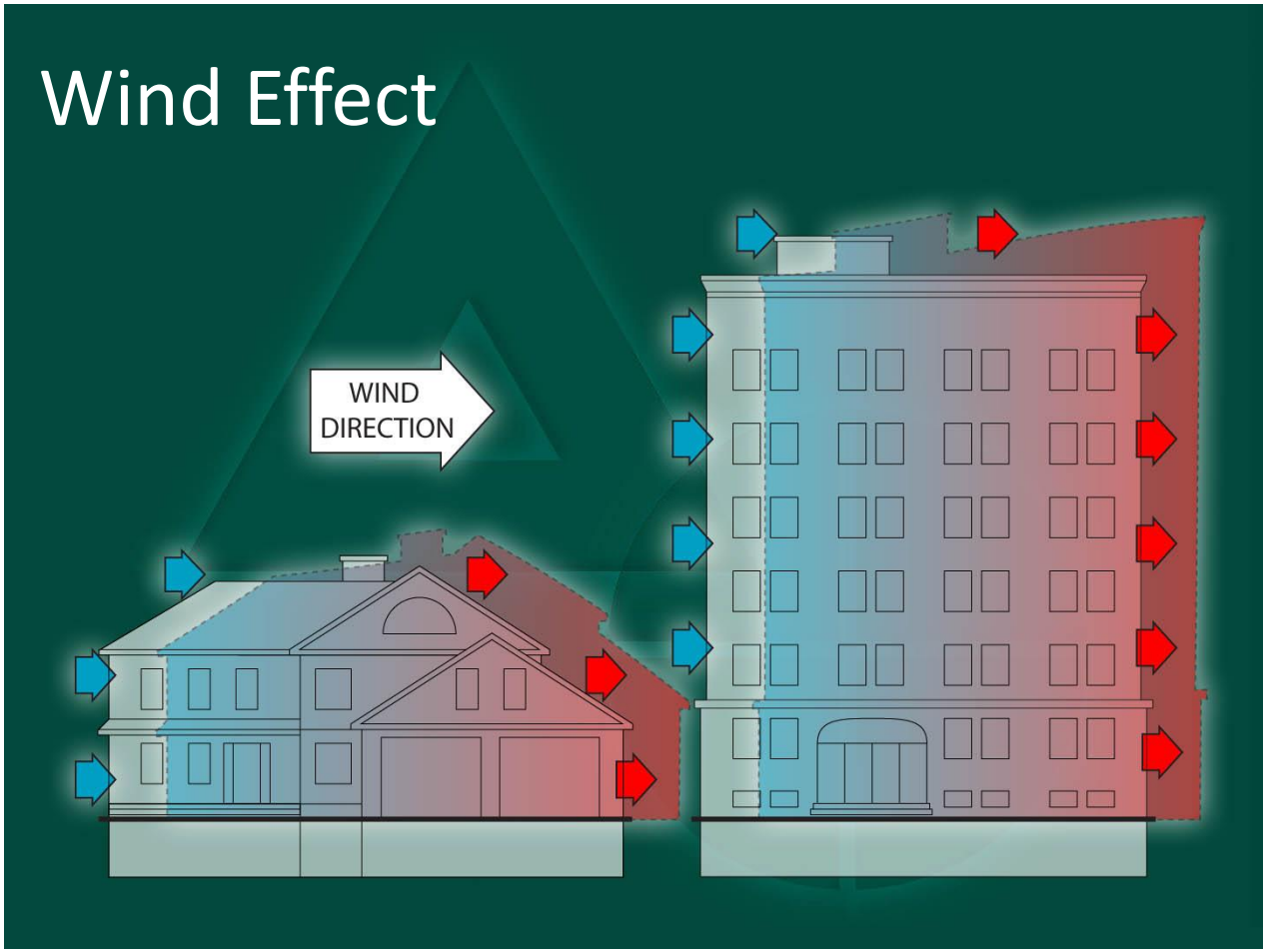

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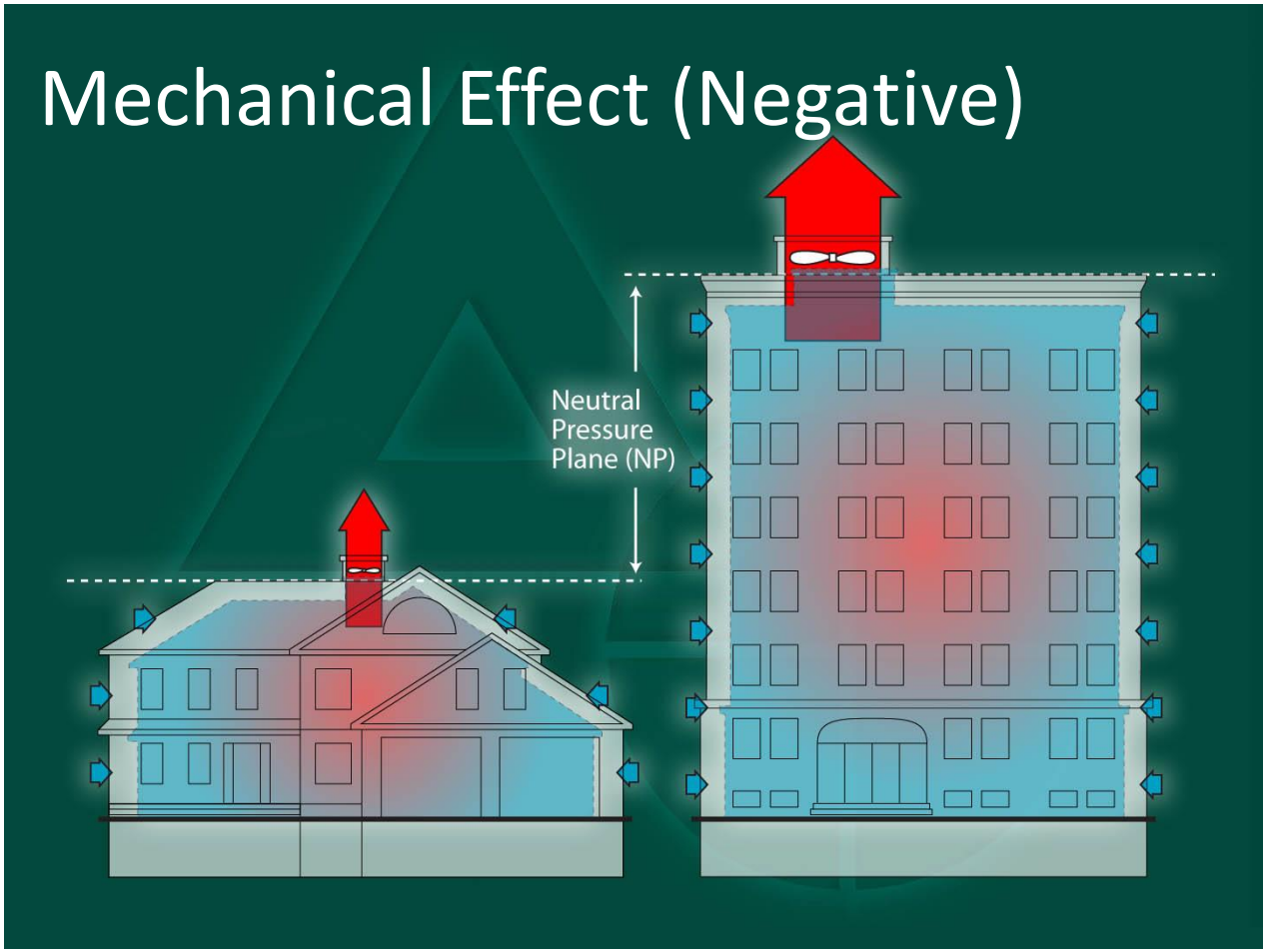

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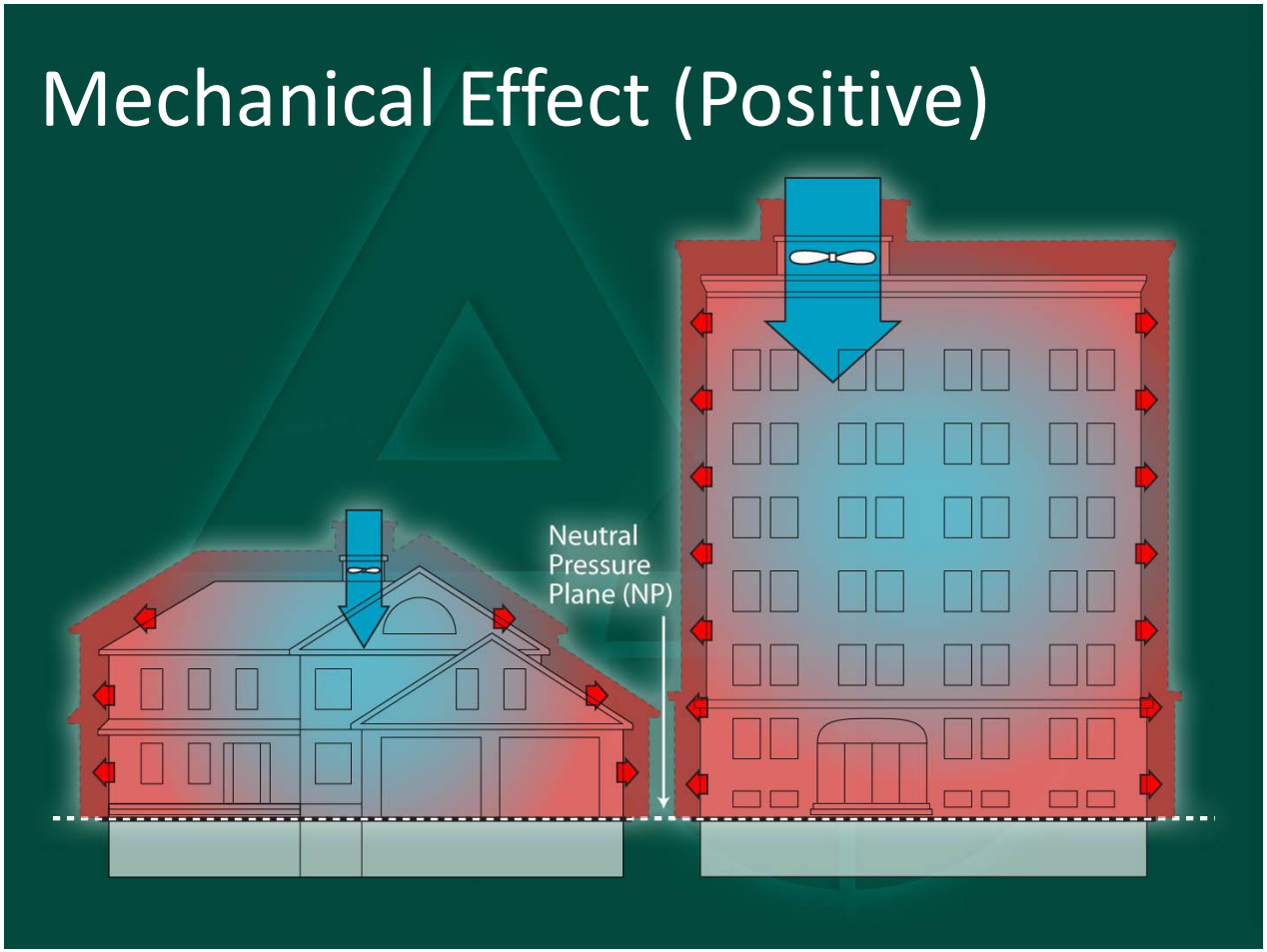


How Do We Implement??

There is a process for Assessment

Air Barrier Continuity

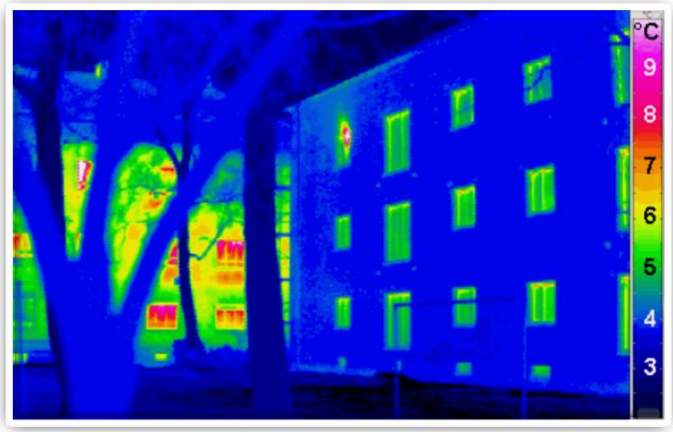
Diagnosing the problems

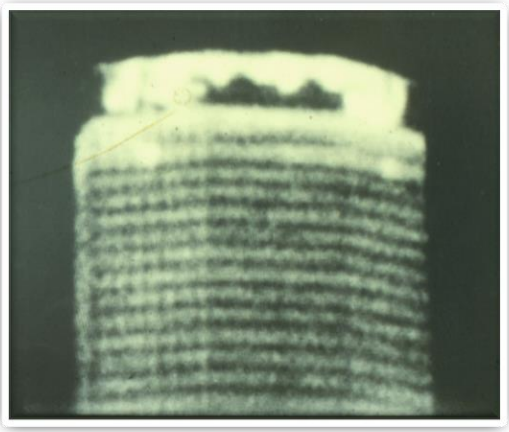
- Building envelope assessment
- Depressurization testing
- **Locating air leakage paths**

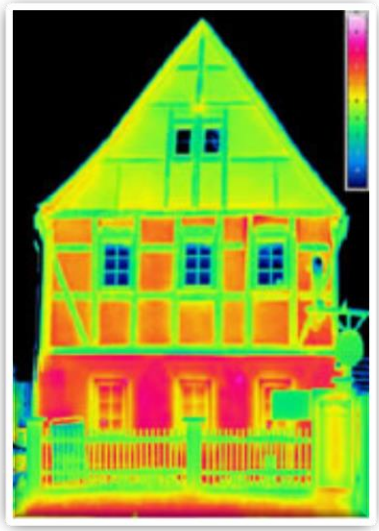
Air Barrier Continuity

Diagnosing the problems

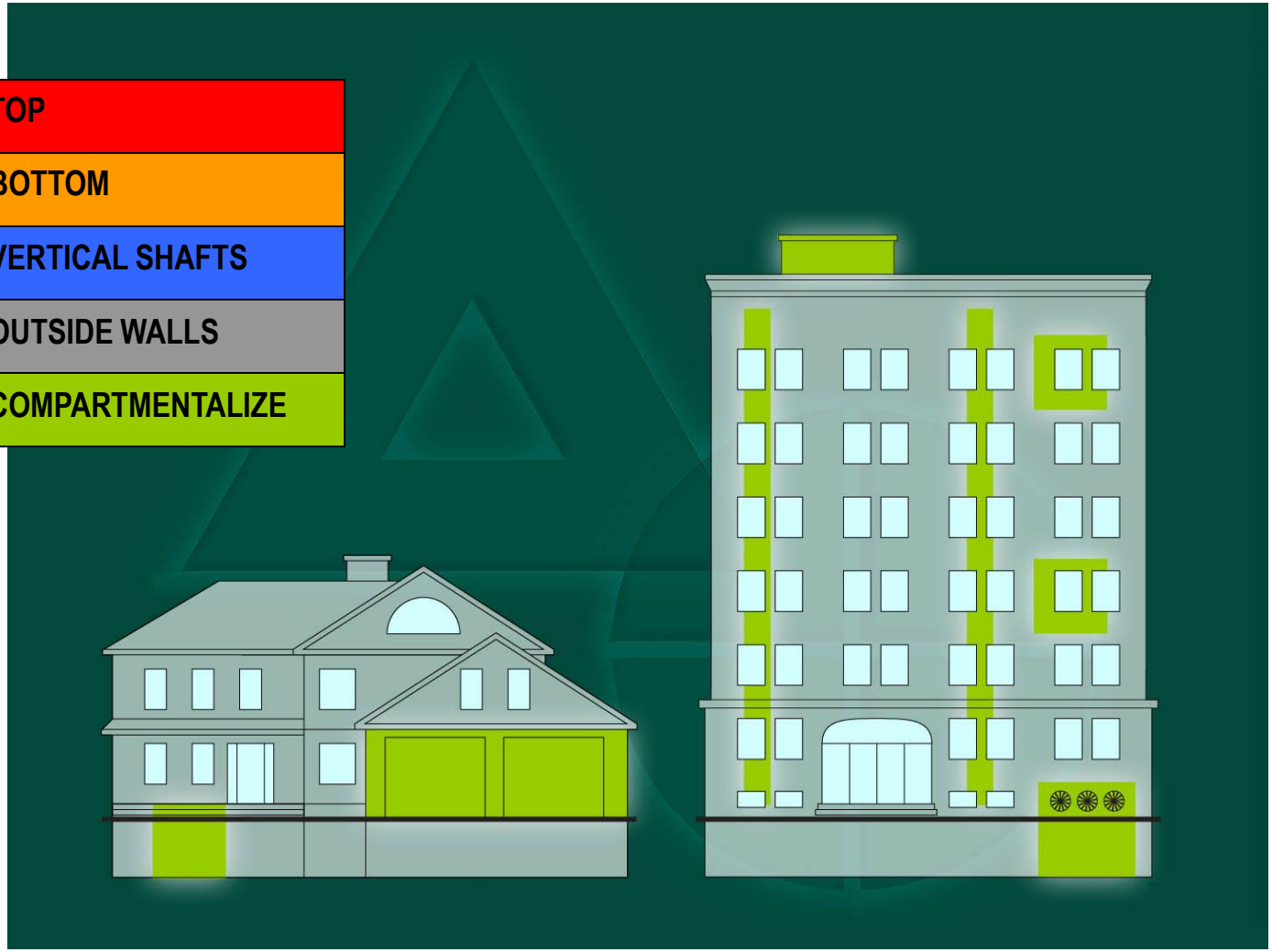
- Building envelope assessment
- Depressurization testing
- Locating air leakage paths
- **Infrared thermography**





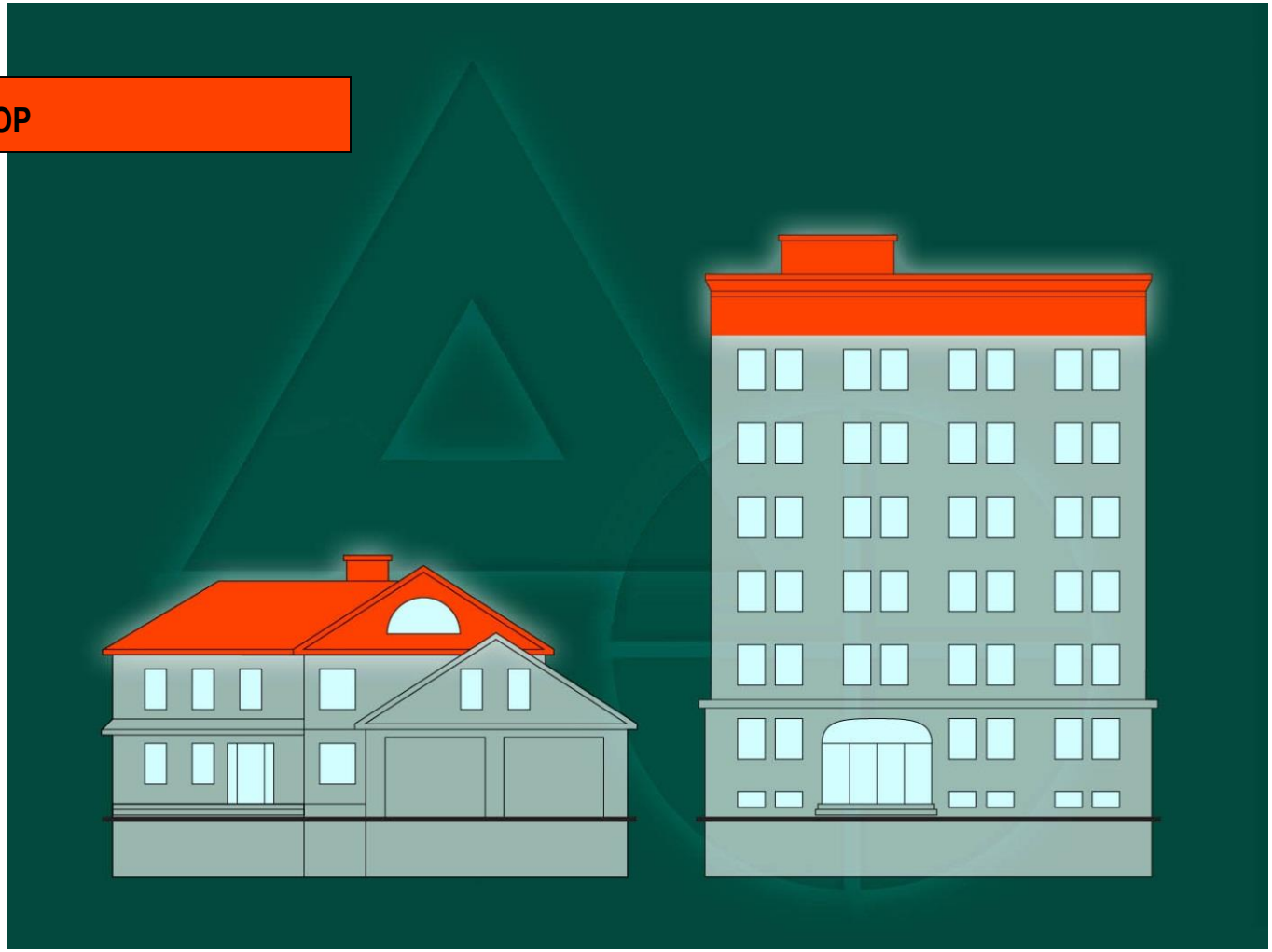


Air Barrier Continuity



Air Barrier Continuity

i. TOP



Air Barrier Continuity

Seal top of building

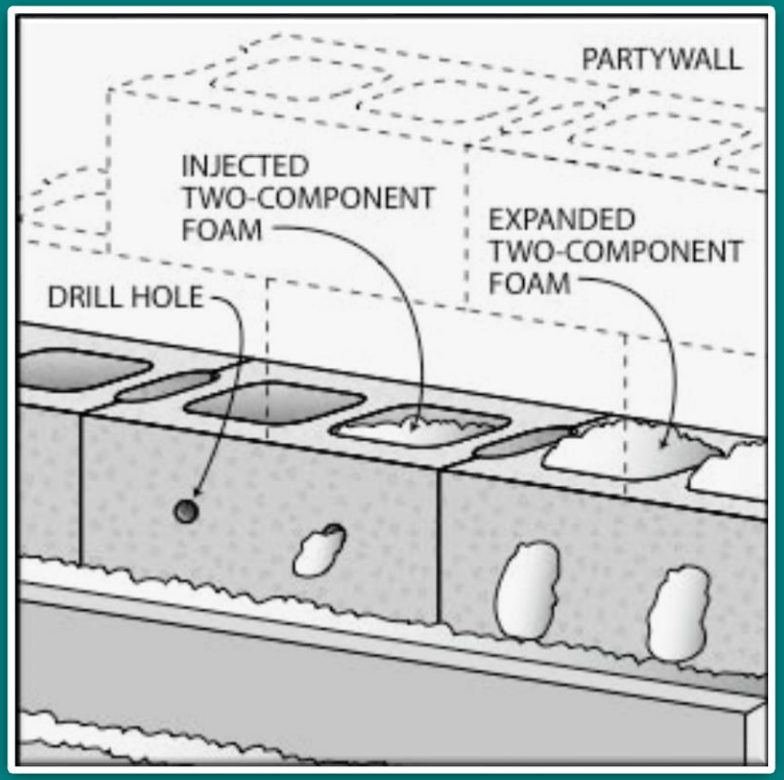
- Attics
- Roof/wall intersections and plenum spaces
- Mechanical penthouse doors and walls
- HVAC equipment
- Other roof penetrations

Air Barrier Continuity

Seal top of building

Air Barrier Continuity

Seal top of building

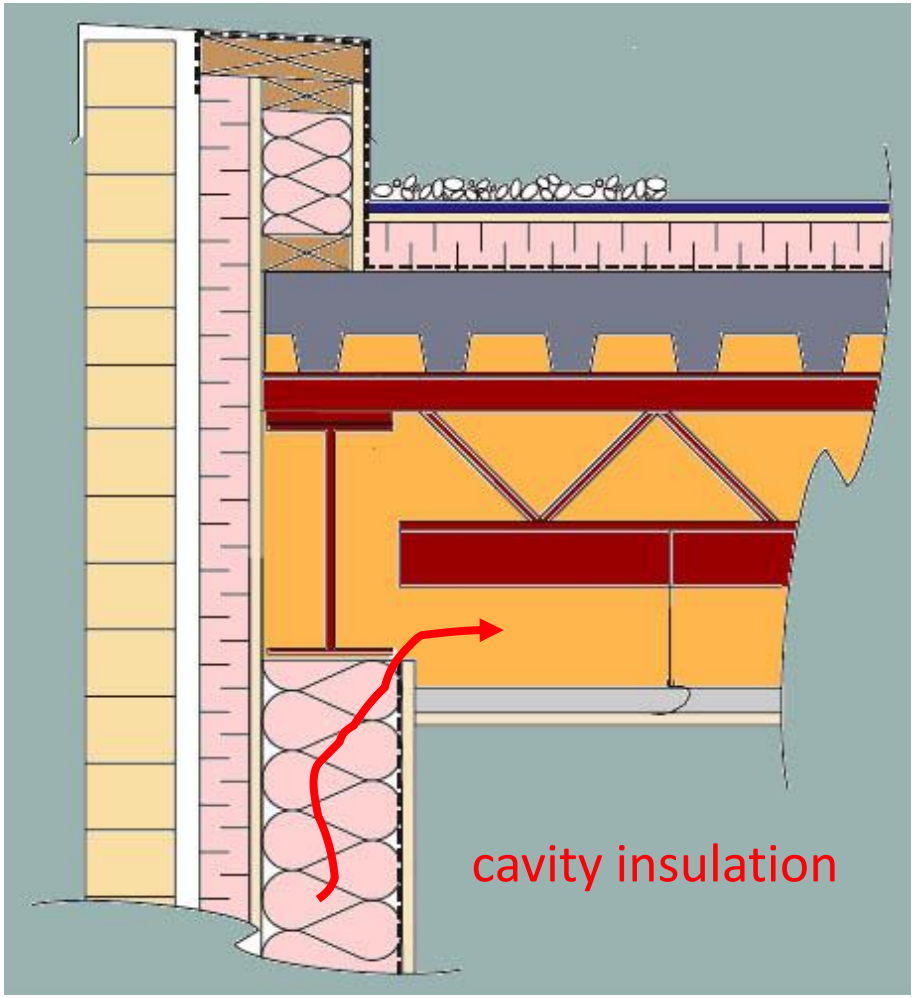


Air Barrier Continuity

Seal top of building

Air Barrier Continuity

- **The plenum**
  - Air can be extracted through many different assemblies if air barrier systems are not in place



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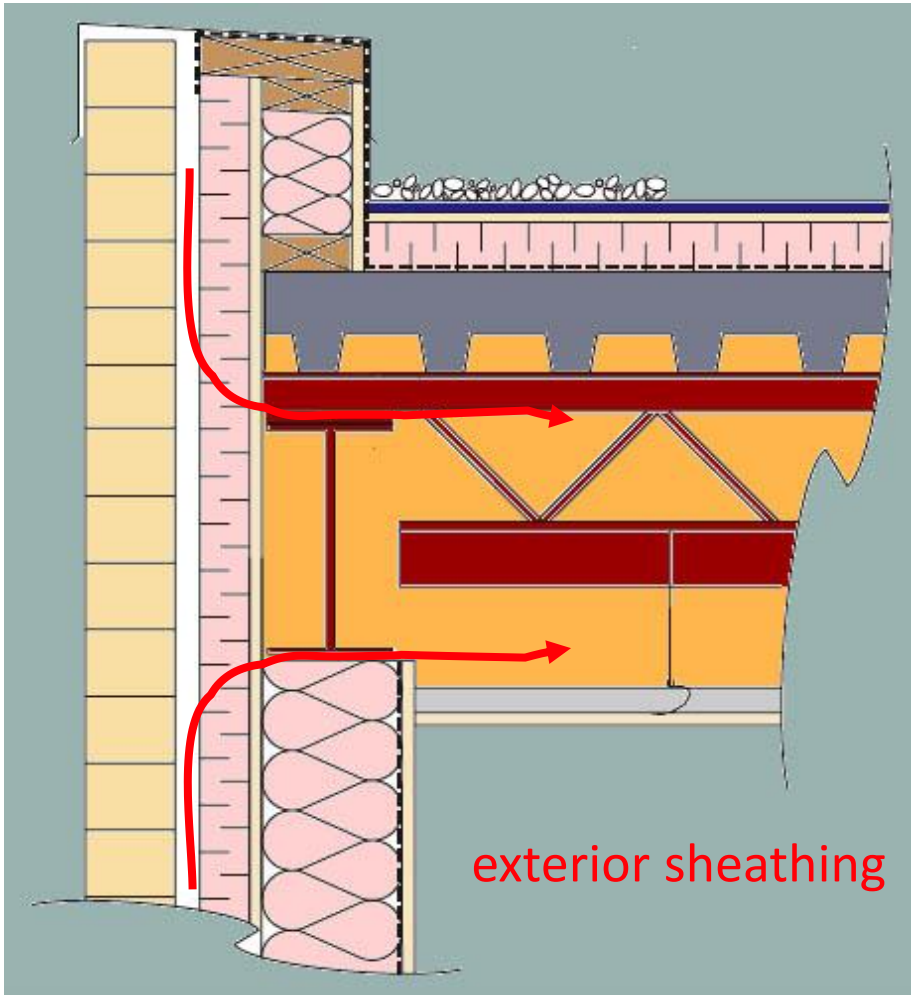

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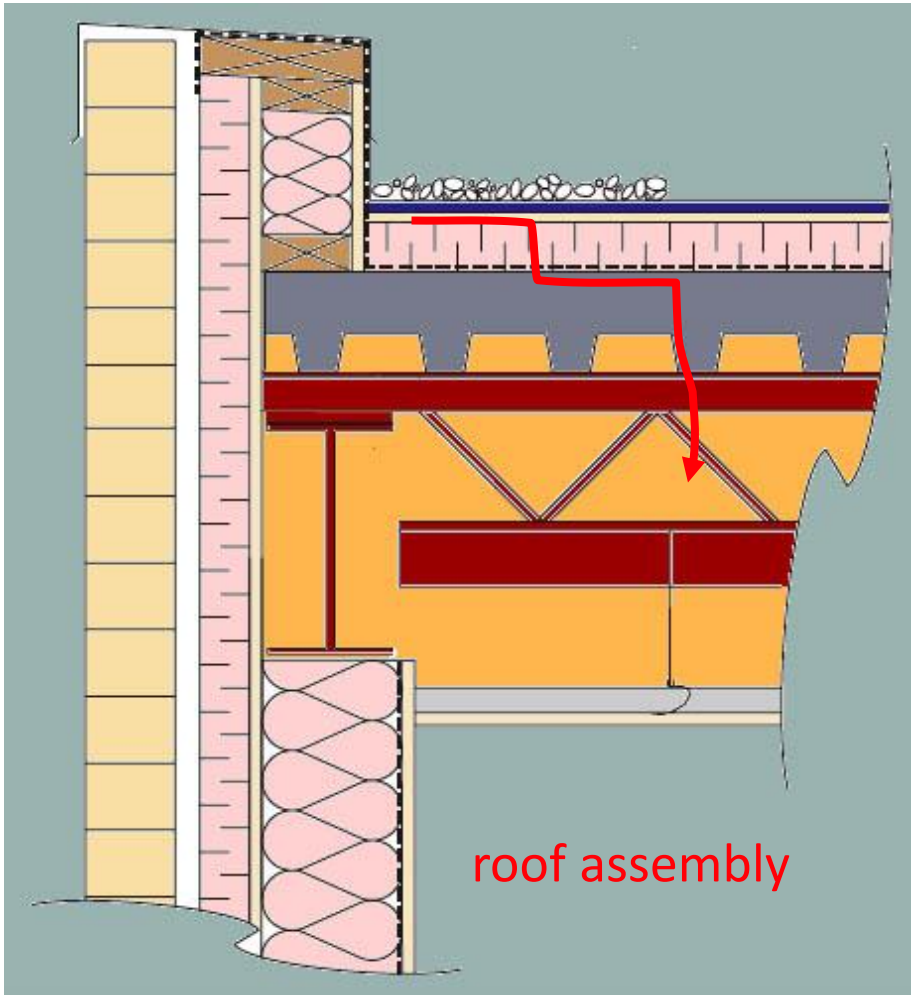

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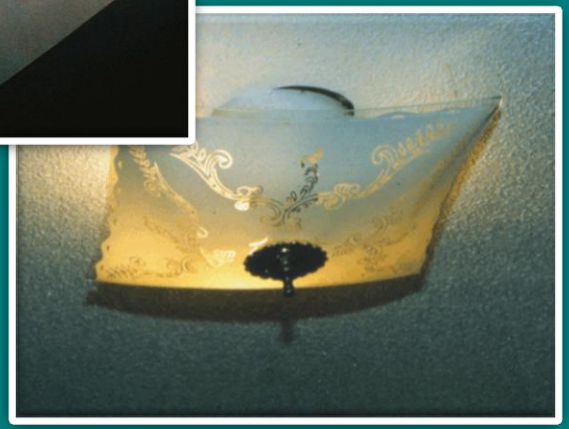

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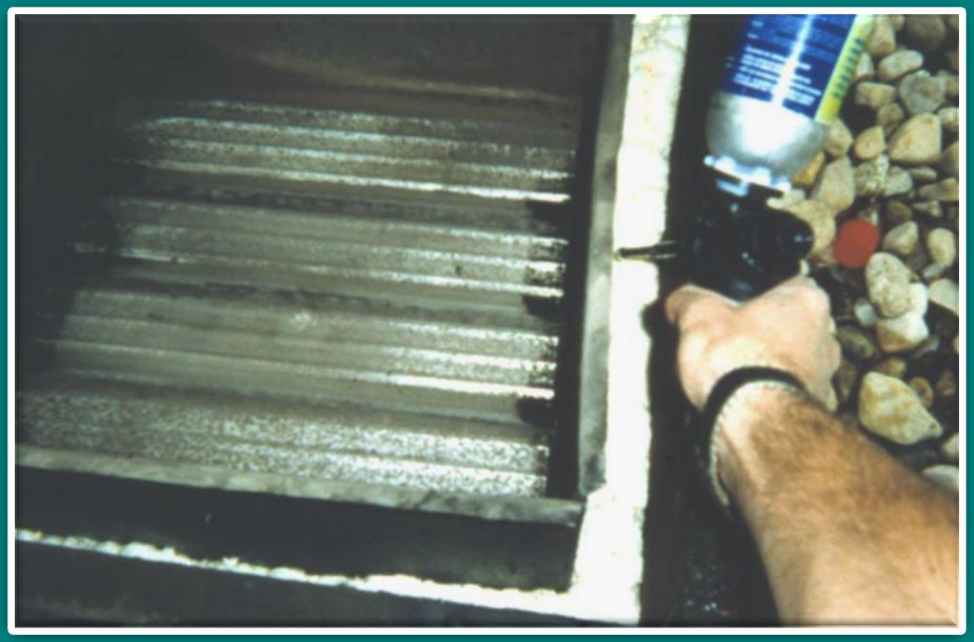
Seal top of building



Air Barrier Continuity

Seal top of building

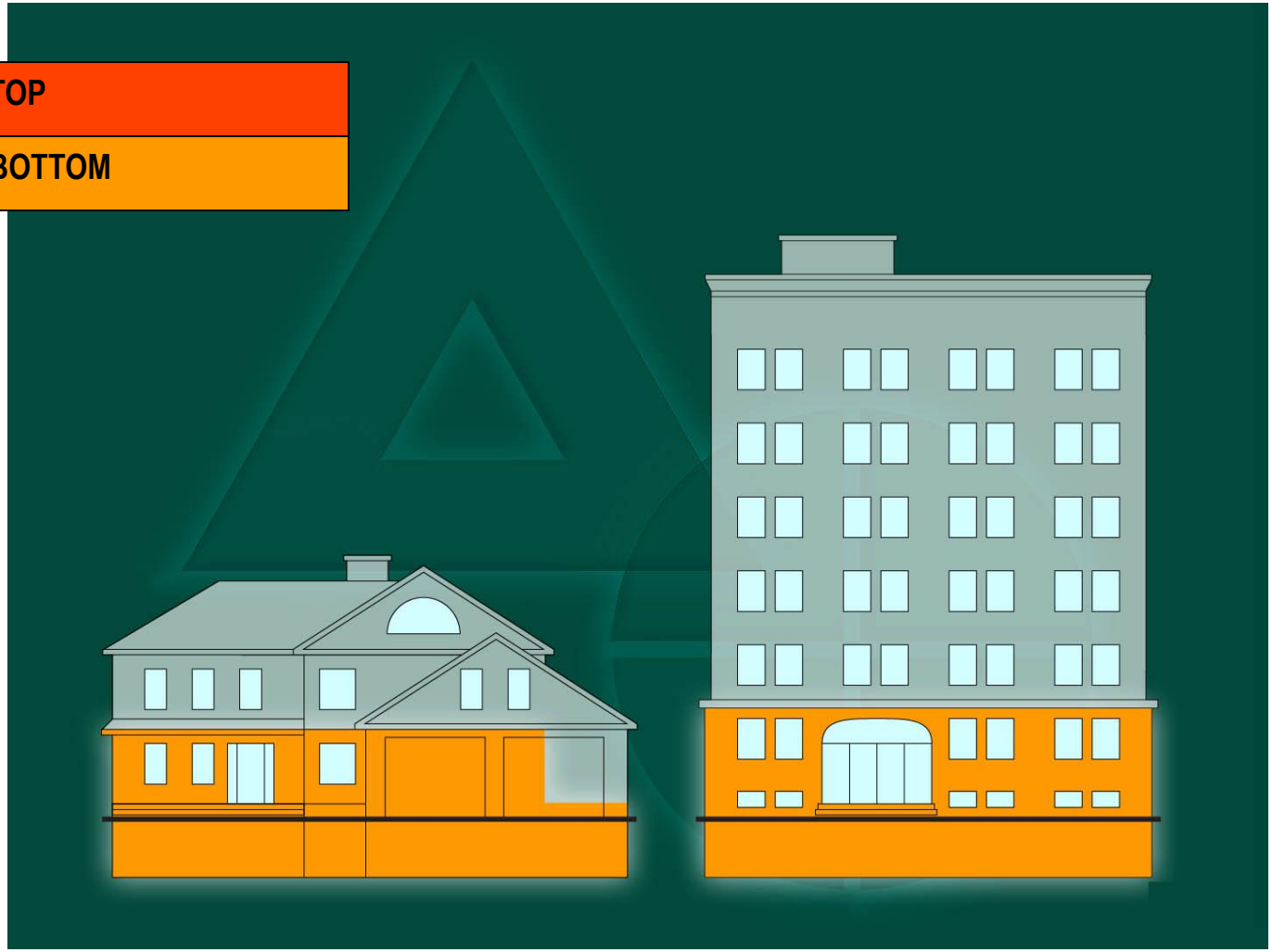
Air Barrier Continuity

Seal top of building

Air Barrier Continuity

i. TOP

ii. BOTTOM



Air Barrier Continuity

Seal bottom of building

- Defined as: “the ground floor and anything below grade
- Typically a unique area of the building
- Soffits and ground floor access doors
- Underground parking access doors
- Exhaust and air intake vents
- Pipe, duct, cable and other service penetrations into core of building
- Sprinkler hangar penetrations, inspection hatches and other holes
- Seal core wall to floor slab
- Residential crawl spaces

Air Barrier Continuity

Seal bottom of building

Air Barrier Continuity

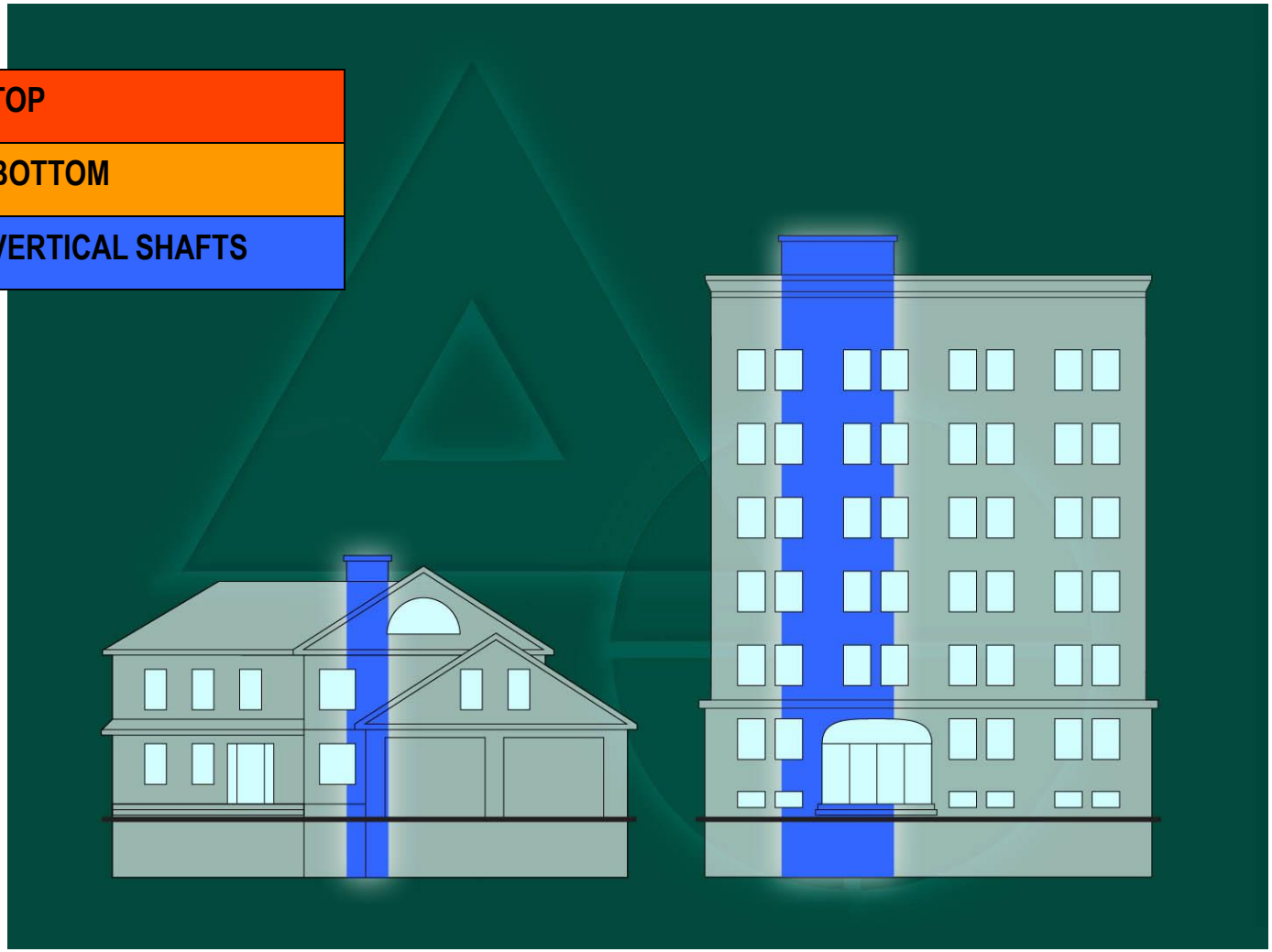
Seal bottom of building

Air Barrier Continuity

i. TOP

ii. BOTTOM

iii. VERTICAL SHAFTS



Air Barrier Continuity

Seal vertical shafts

- Stairwell fire doors
- Fire hose cabinets
- Plumbing, electrical, cable and other penetrations within service rooms
- Elevator rooms- cable holes, door controller cable holes, bus bar openings

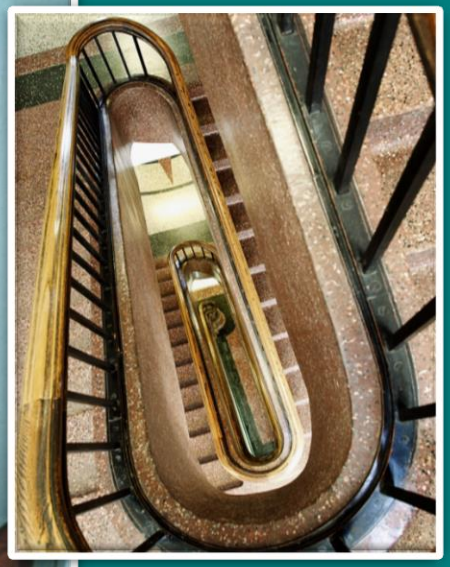
Air Barrier Continuity

Seal vertical shafts

- Garbage chute perimeter and access hatches
- Hallway pressurization grille perimeters
- Smoke shaft access doors
- Elevator shaft smoke control grilles
- Service shafts

Air Barrier Continuity

Seal vertical shafts



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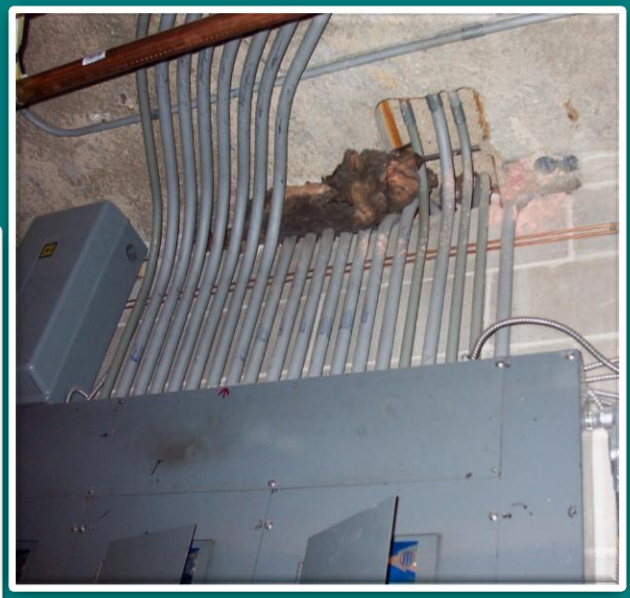

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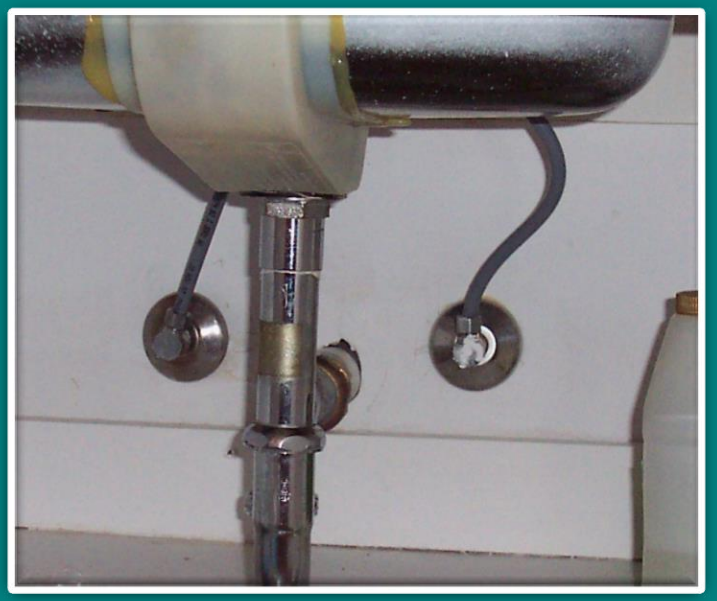


Air Barrier Continuity

Seal vertical shafts

Air Barrier Continuity

i. TOP

ii. BOTTOM

iii. VERTICAL SHAFTS

iv. OUTSIDE WALLS

Air Barrier Continuity

Seal outside walls and openings

- Weather-strip windows, doors, including balcony/patio doors and seal window trim
- Exhaust fans and ducting
- All service penetrations
- Baseboard heaters
- Electrical receptacles
- Baseboards

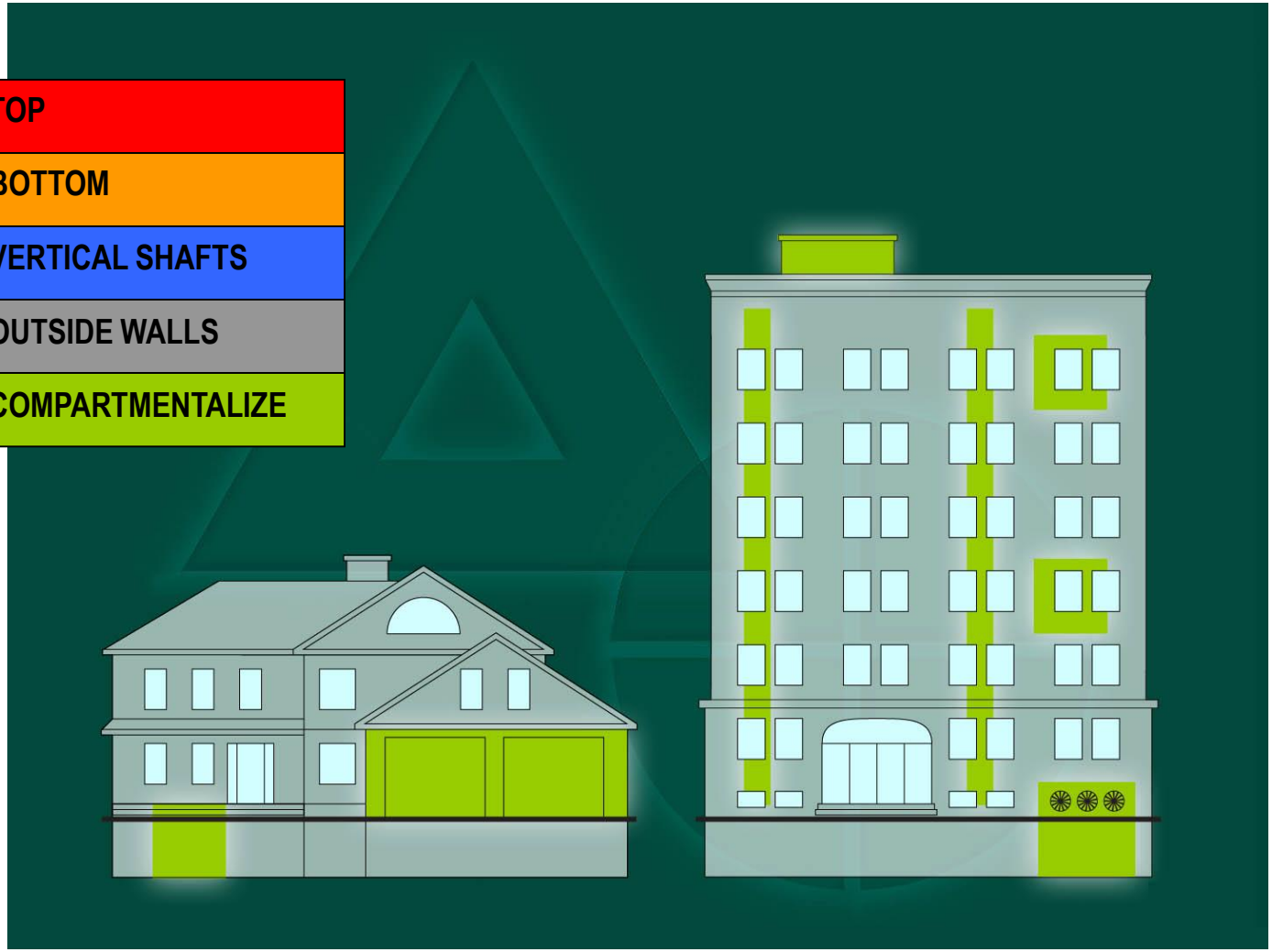
Air Barrier Continuity

Seal outside walls and openings

Air Barrier Continuity

Seal outside walls and openings

Air Barrier Continuity



Air Barrier Continuity

Compartmentalize

- Garages
- Vented mechanical rooms
- Garbage compactor room
- Emergency generator room
- High voltage rooms
- Shipping docks
- Elevator rooms
- Workshops

Air Barrier Continuity

Compartmentalize

Air Barrier Continuity

Compartmentalize

Air Barrier Continuity

Fixing and preventing air leakage paths

- Conduct building assessment
- Determine location and severity of air leakage pathways
- Identify internal pathways
- Develop scope of work to create air barrier continuity

Air Barrier Continuity

Materials used

2-component polyurethane foam insulating air seal kits

Must meet requirement of ULC Standard S711.1

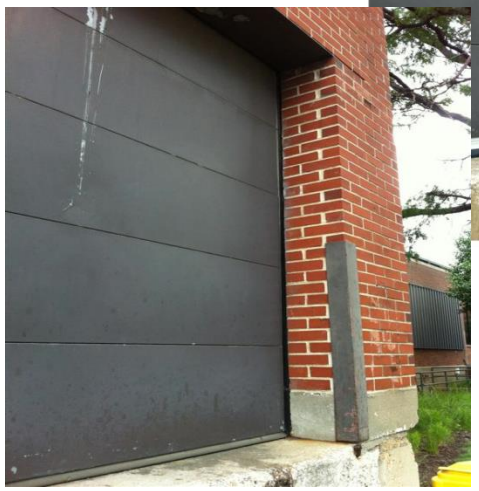
Air Barrier Continuity

Materials used

Air Barrier Continuity

Materials used

Before /After Photos



Now the building is tight… Now what?

- Evaluate if rebalancing is necessary
  - Where areas cold while others too hot?
  - Was there an attempt to correct through HVAC
  - Understand how to manage the building RH
- Evaluate if the ventilation system is clean
  - Check coils to see if packed with dust /dirt
  - Check duct work to verify clean
- Evaluate other issues to determine correction of:
  - Pests, fecal matter and parts
  - Moisture infiltration building durability issues
  - IAQ issue continues, odors, dust levels remain the same, WHY?

Air Barrier Continuity

Improving health, safety, durability, comfort and energy efficiency in healthcare, commercial, institutional and multi-family buildings is as easy as ABC

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Case Study

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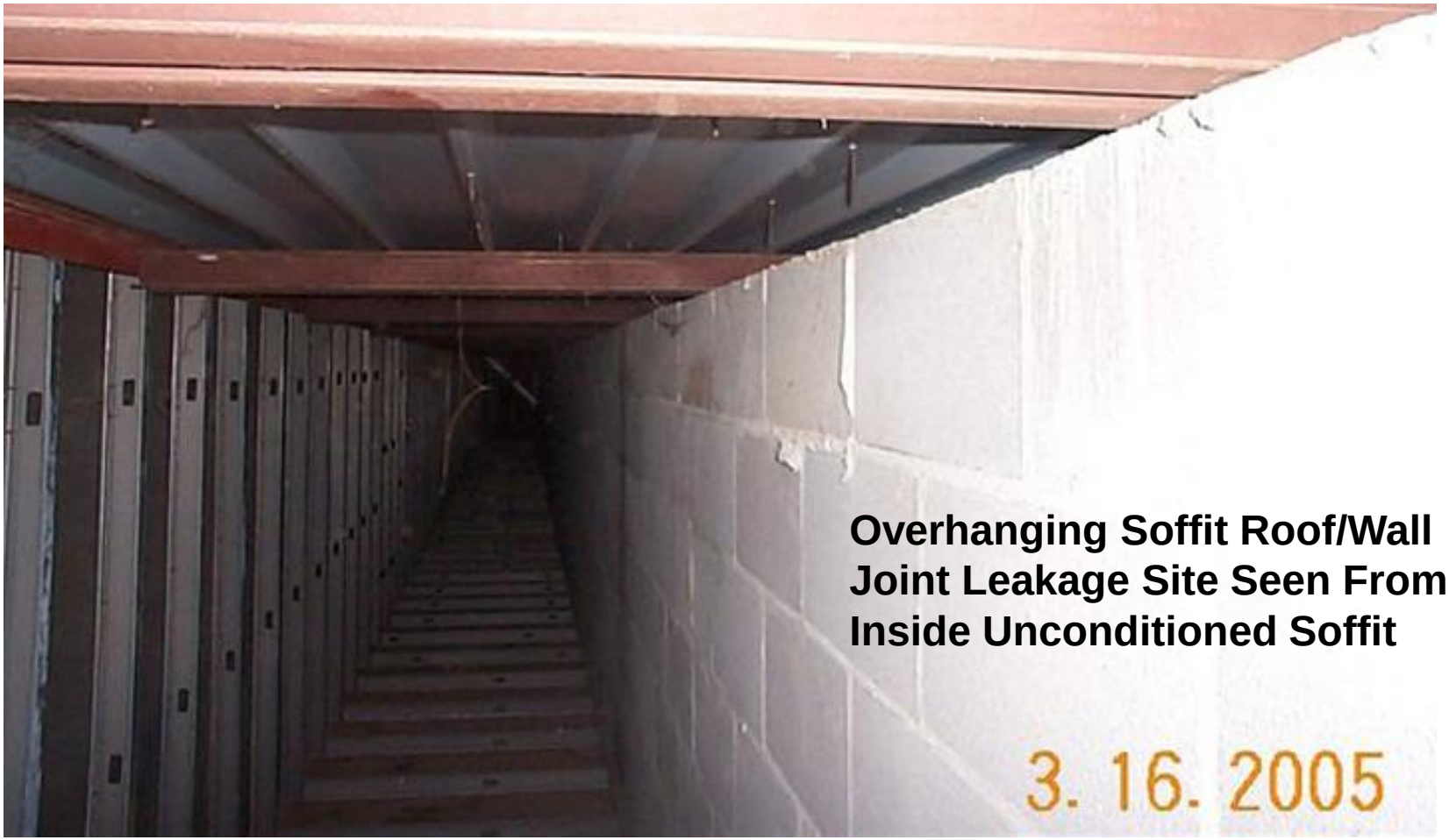

Overhanging Soffit Roof/Wall Joint Leakage Site Seen From Inside Unconditioned Soffit

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Overhanging Soffit Roof/Wall Joint Leakage Site Seen From Inside Conditioned Space

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Opening exposed to outside overhang,
Repaired with Foamboard and sealant

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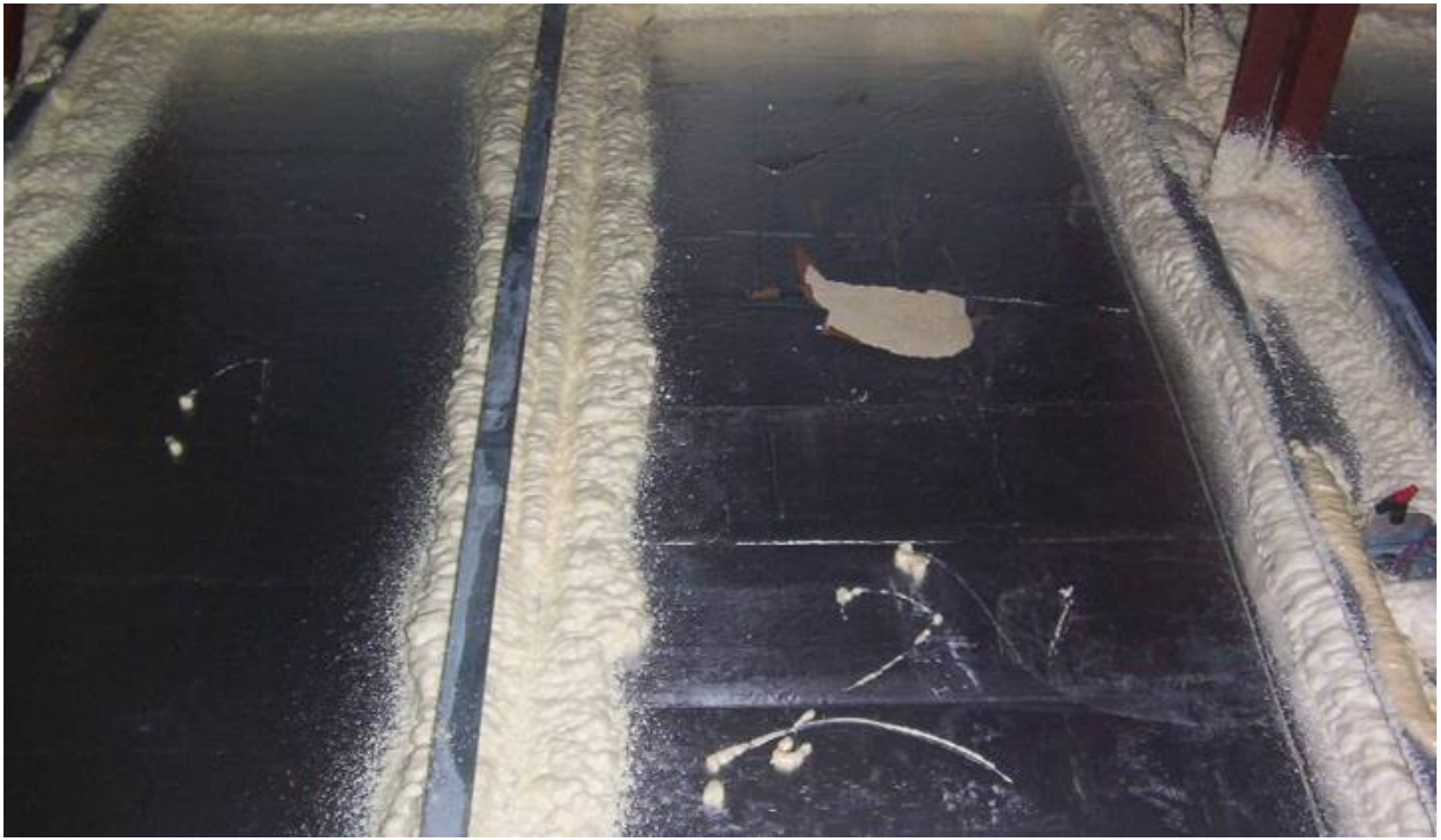

Metal soffit panel seams, sealed with foam sealant

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Other Project Profiles

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Improving indoor air quality and occupant comfort enhances the learning environment.

Air Sealing of School Delivers Measurable Improvements for Energy Savings

Testing confirms air sealing makes the grade with significant reduction in air leakag

Problem

Originally constructed in 1946, the 60,000 square foot elementary school located in Vancouver, British Columbia had a big building envelope problem. Students and staff complained of temperature swings and uncomfortable drafts throughout the original building, as well as the newer wing built in 1972.

The metal-framed windows and exterior doors were noticeably drafty and HVAC costs were higher than similar buildings in the district. Those higher HVAC bills were soon explained by an air barrier assessment, which determined the school was experiencing unwanted air infiltration and exfiltration equivalent to a 26.7-squarefoot hole in the building.

Solution

The cost to replace the doors, windows and other original building envelope components was not an economically viable option. Fortunately, Canam Building Envelope Specialists Inc., a subsidiary of Tremco Roofing and Building Maintenance, offered an economically attractive turnkey air sealing solution that included the identification and remediation of all sources of unwanted air infiltration. The remediation was projected to generate over $7,000 in annual energy savings and included:

- Weatherstripping of all doors and hatches
- Re-glazing of windows
- Sealing of roof-to-wall intersections, roof penetrations and attic ductwork and openings
- Compartmentalization of soffits

Results

Air sealing effectiveness was verified by an independent blower door evaluation conducted before and after the air sealing occurred. Energy auditors use blower door testing to pressurize buildings and locate sources of air leakage and energy loss. A blower door test consists of a calibrated fan installed in an exterior door opening. By pulling air out of the building, indoor air pressure is lowered, which allows higher outside air pressure to enter through cracks and openings.

Testing after the air sealing confirmed that air leakage was reduced by 14%, from a value of 21,880-CFM before air sealing to a post-sealing value of 18,230-CFM for even more energy savings than originally estimated. Indoor comfort and air quality are also significantly improved, at a fractior of the cost of replacing the school's origina construction components.

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Colquitt County Schools
Number of buildings: 63
Total square feet: 1.2 million
Problem Rectified: Occupant Comfort/ Energy Efficiency

Sealing Air Leaks Saves Energy and Improves Indoor Air Quality for Colquitt County Schools

Testing confirms air sealing makes the grade with significant reduction in air leakage

Problem

Located in Moultrie, Georgia, the Colquitt County School District's cooling costs were above average and indoor temperatures were uncontrollable when they contracted with leading facility management firm ABM Building Solutions to improve their energy efficiency. ABM inspected Norman Park, the first of 15 schools in the district, and immediately identified a gap above the ceiling tiles so large "that we could see outside", according to ABM's project development engineer Clint Knudson.

Recognizing that openings like this made air leakage a likely problem in the district's 60+ buildings, ABM contracted with Canam Building Envelope Specialists to conduct air barrier continuity inspections and testing across the district.

Solution

Canam inspected approximately one million square feet of buildings, documenting findings with digital images and infrared tests. Like the Norman Park School, many buildings had ridged roofs with vented soffits, and no air barrier between the vented attics and the air-conditioned classrooms. The results revealed the district's buildings air leakage paths are the equivalent of a 300 square foot hole responsible for unintended air leakage in and out of the building.

A scope of work was developed to provide a continuous air barrier solution for each building. In addition to sealing the space between the vented attics and the classroom ceilings, caulking windows and weather-stripping doors was recommended to control air leakages across the building envelope.

Results

Sealing Colquitt's air leaks means indoor air temperature can be better controlled for improved student and staff comfort, and the energy load for each building is reduced as conditioned air is no longer wasted. Annual savings of $117,954 has been projected by Canam, with a payback of 6.8 years for the district. According to ABM's Knudson, "The savings provided by Canam's air barrier solution will help fund the other energy conservation measures the district otherwise wouldn't be able to afford."

Exterior door has new quality weather-stripping.

Large openings at soffit caused considerable energy loss and comfort-related issues. This was typical in most of the buildings.

Soffit is blocked with insulated board and sealed with polyurethane foam.

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Other Project Profiles

BUILDING ENVELOPE SPECIALISTS

PROJECT SPECS:

LOCATION:	Naperville, Illinois
BUILDING SF:	366,000
# OF BUILDINGS:	1 - Main Building Connected to the Education Center
BUILDING AGE:	Built 1920, Many Additions and Renovations

Balancing the Mechanical System With Air Sealing Provides More Even Temperatures Throughout Edward Hospital Buildings

Stack effect pressure issues resolved through air sealing measures.

Problem

Edward Hospital had relied on Tremco's assistance for the asset management of their roofs for many years. When Edward Hospital mentioned they were interested in saving money by making the building more energy efficient and durable, while also creating a more healthy, safe and comfortable environment, they allowed Tremco's service companies of WTI/CANAM to show them what could be done to achieve their desired results.

Canam inspected the Main Building and the Education Building, which is connected to the Main Building. The original building was built in 1920, with a brick facade, but has had many additions and renovations over the years. In addition to typical issues that affect a building of this age, such as failing weather-seals around doors and windows, Canam discovered extreme pressure differences throughout the building. Stack effect was very prevalent, bringing in outside cold air along with dirt, moisture, pollutants, etc.

Testing window shows air infiltration before caulk.

Solution

Canam inspected the Main Building and connected Education Building, totaling 366,000 sq. ft., using the air leakage detector and digital and infrared photos, identifying temperature differences through air leakage. Most of the issues identified were a result of typical air leakage areas such as windows, doors and roof exhausts. Canam concluded that the main cause of the strong stack effect was attributed to the gaps, cracks and holes throughout the buildings.

Air sealing measures that Canam recommended to Edward Hospital, to rectify the air leakage issues, were typical, and included replacing worn and missing weather-stripping to doors and windows and sealing roof exhausts and leaky roof/wall intersections.

Window complete shows no air movement.

Results

As a typical healthcare facility, Edward Hospital required difficult access and special project coordination so the patients would not be disturbed.

Air sealing and insulation measures conducted on Edward Hospital have reduced the air leakage issues, but more importantly have helped to eliminate the extreme pressure differences that were caused by stack effect. Canam projected annual savings for the Main Building to be approximately $13,351, with a payback of 3.2 years, and the Education Center to expect approximate annual savings of $8,237, with a payback of 4.8 years. The majority of these repairs have a duration life of 15-20 years. The simple payback actually provides an accumulated investment value for an additional 10-15 years, or a total savings from utility costs of $123,000-$224,297, over this period.

In addition, less than 6 months later, the client requested that Canam return and assess 4 additional buildings on the Edward Hospital campus.

Sealing perimeter of ducting at RTE

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BUILDING ENVELOPE SPECIALISTS

PROJECT SPECS:

LOCATION:	Jonesboro, Arkansas
BUILDING SF:	20,000
# OF BUILDINGS:	1
BUILDING AGE:	Built 1936; Renovated 1986

Air Sealing Makes Noticable Difference in Occupant Comfort and IAQ for Arkansas State University

Customer confirms air sealing measures increase occupant comfort and IAQ

Problem

The project for ASU, Jonesboro, Arkansas, was sold primarily to resolve occupant comfort, Indoor Air Quality issues and for the customer to use as a pilot project for future air sealing work in other buildings.

Canam inspected one building, The College of Science and Mathematics, and identified several problem areas. The largest issue proved to be the window systems that were installed a couple of decades ago. These were replacement windows which were inserted into the opening of the original windows, however, the replacement windows appeared to be 3" to 4" too short to the underside of the top frame. In addition, there was a gap above the replacement windows that were stuffed with fiberglass batting to bridge the window frame. This was not providing a good air barrier and the batt was also collecting dirt from the outside which was migrating into the building.

Smoke pencil testing identified that the window systems to the sills had a gap allowing air migration into the building. This caused a great deal of negative pressure.

Solution

Canam inspected one building, totaling approximately 20,000 sq. ft., documenting findings with smoke pencil testing and digital images. Our recommendations to rectify the problem areas in this building were based on a very common scope of work. The scope included typical measures such as door weather-stripping, sealing roof exhausts, etc., however, the main problem area required air sealing and insulating above the tops of the window systems with 2-part polyurethane closed-cell spray foam.

Other issues that were brought to the attention of ASU management and addressed were soffits that were open to the building that required frame and black and sealing the perimeter, sealing multiple pipe penetrations and addressing the mildew that was forming on the South side of the building above the suspended ceiling during the hot summer months when the outside humid air entered the building, causing condensation with the inside air conditioning.

Blocked and sealed soffits are no longer open to the outside.

Results

Air sealing and insulation measures conducted on ASU, will reduce the likeliness of moisture migration into the building, thus insuring the building durability. In addition, Canam projected annual savings of approximately $1,588, or $0.08 sq. ft., with a payback of 12.1 years.

More importantly, one year later, the customer has reported back that the comfort has increased. According to ASU's David Hakenewerth, Energy Conservation Engineer Facilities Management, " I believe the improvements at CSM have made a noticeable difference in the comfort level and IAQ. I have not done an audit of the utilities because the weather conditions the last 12 months have been so unusual."

Air sealing above drop ceiling now provides a proper air barrier resulting in eliminating dirt entering the building at this detail, and increased occupant comfort.

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