# Continuous Insulation Systems for Exterior Walls

High performance through
sprayed-in-place foam insulation

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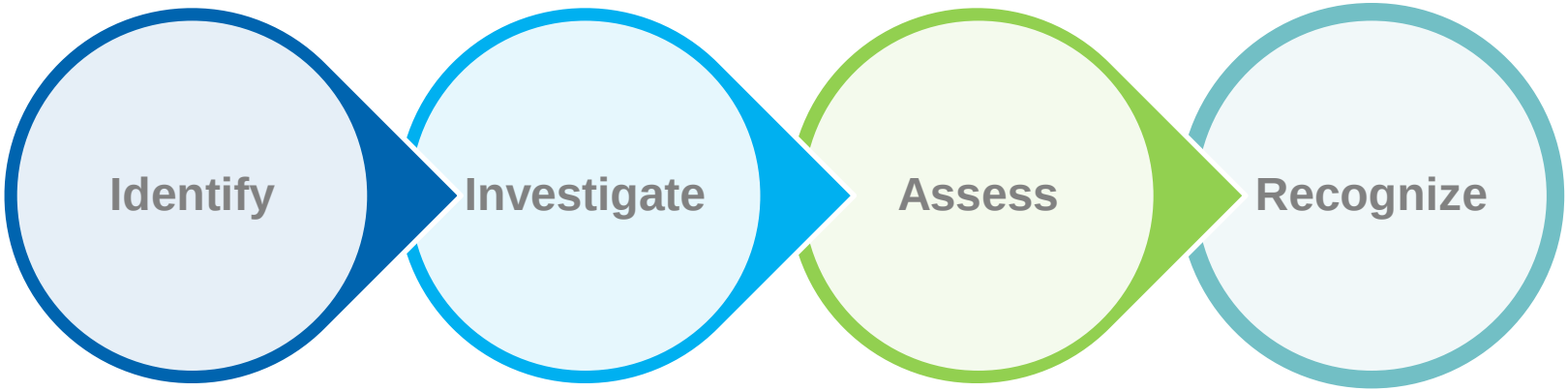
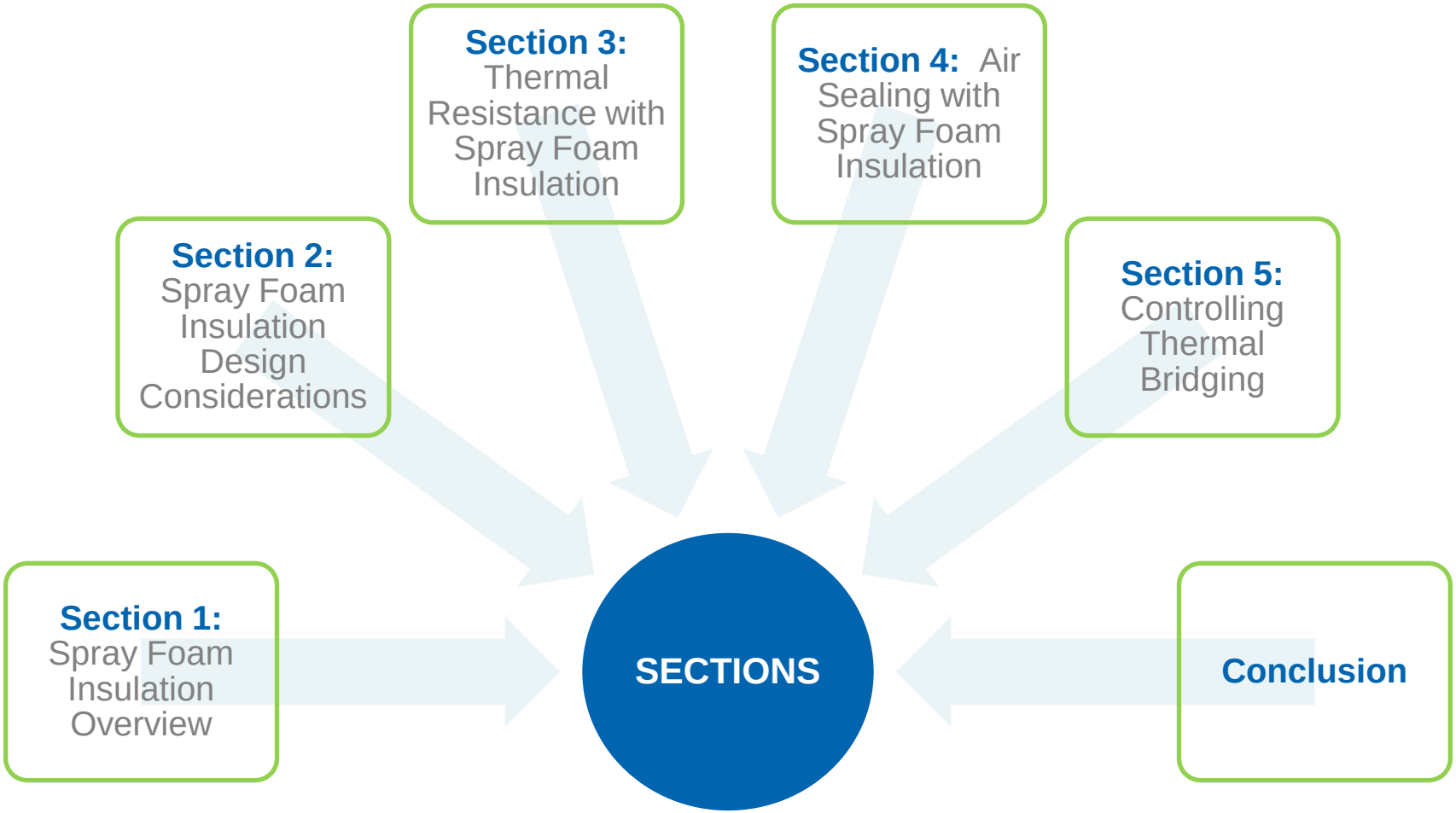
# Learning Objectives




- **Identify the characteristics** of high-performance spray foam continuously insulated exterior wall assemblies.
- **Investigate** the numerous opportunities to use spray foam insulation to achieve **thermal performance** goals.
- **Assess** the ability of spray foam insulation to act as an effective **air sealing barrier** that prevents unwanted air infiltration.
- **Recognize** the ways that **thermal bridging** can be thwarted in wall assemblies using continuous spray foam insulation.

# Course Outline



# SECTION 1

- Section 1: **Spray Foam Insulation Overview**
- Section 2: Spray Foam Insulation Design Considerations
- Section 3: Thermal Resistance with Spray Foam Insulation
- Section 4: Air Sealing with Spray Foam Insulation
- Section 5: Controlling Thermal Bridging
- Conclusion

# Traditional Insulation Options

When selecting building insulation, architects have a broad range of products to choose from.

**EXTRUDED POLYSTYRENE FOAM BOARD**

**CELLULOSE FIBER**

**FIBERGLASS**

# The Spray Foam Insulation Option

- Performs as whole building insulation
- Simultaneously provides insulation and air barrier in one product
- Controls air leakage and interstitial condensation
- Can bond to adjacent framing components to form an integral part of a total wall system

# What is Spray Foam?

- Site applied material
- Liquid components are poured or sprayed in place
- Combined ingredients **expand**

into a foam plastic material

**that insulates and air seals**

# Typical Custom On-site Application

- High Pressure Foam
- Truck Based Spray Rigs
- Product sold in “sets” of two 55 gallon drums
  - **A Side**: “ISO” standard formulation
  - **B Side**: Manufacturer’s own formulation that determines a multitude of performance characteristics

# More than just R-values

Because of this full custom on-site application, spray foam insulation is generally found to be effective at **boosting the energy performance of wall assemblies in multiple ways.**

# Spray Foam Insulation General Characteristics

What is driving the increasing popularity of spray foam wall assemblies?

- Spray foam fills spaces completely
- Spray foam holds its shape over time - sagging, settling, gaps or voids are eliminated
- Air infiltration / leakage is reduced or controlled

# All Spray Foam is not created Equal

**A-Side (ISO)**

Isocyanate

Polymeric MDI (pMDI)

**B-Side (Resin)**

Polyols, Catalysts

Surfactants

Flame Retardants

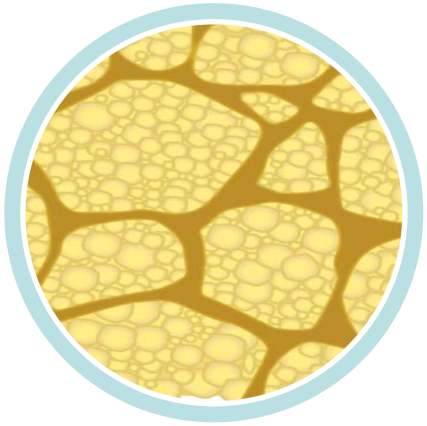
Water, Blowing Agent

- All foams are **not** the same
- Manufacturers material selections make foam systems very different
- Materials are **not** compatible from system to system or from one manufacturer to the next.
- Resin dictates physical properties (rise, yield, operating temps, water absorption etc.)

# Two Common Types of Spray Foam Insulation

**1. Medium Density**

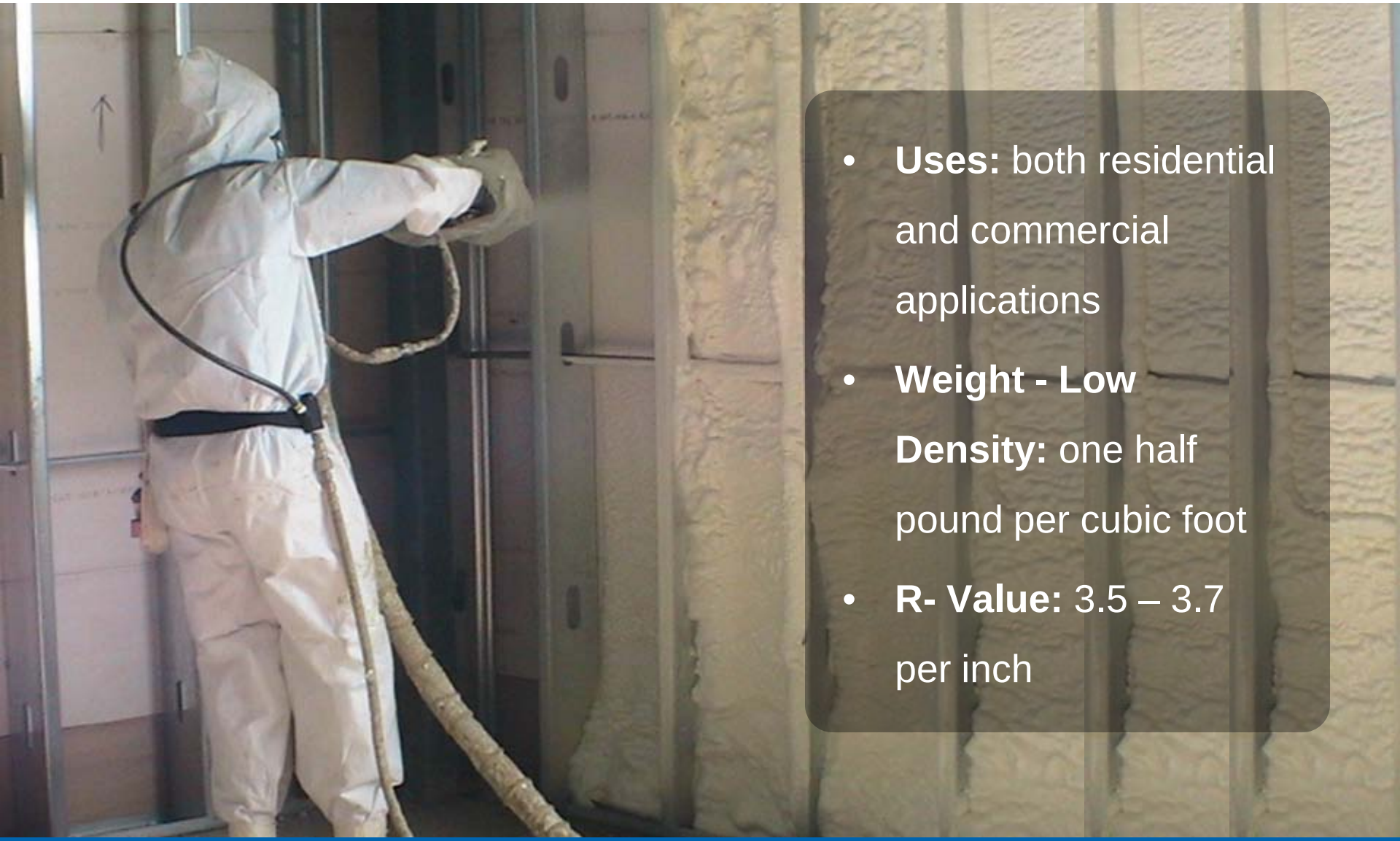
Closed Cell make-up
Hard, rigid foam



**2. Low Density**

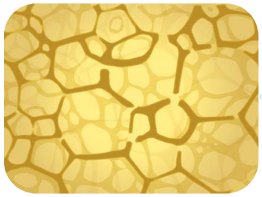
Open Cell make-up
Soft, flexible foam

# Low Density Open Cell Insulation



- **Uses:** both residential and commercial applications
- **Weight - Low Density:** one half pound per cubic foot
- **R- Value:** 3.5 – 3.7 per inch

# Low Density Open Cell Characteristics



- Typical blowing agent: Water
- Suitable for Interior Installations: cavity wall covered by sheathing on both sides
- Air sealing: softer makeup allows effective air sealing
- Movement: will flex and adjust as the building may settle expand or contract
- Acoustic control is enhanced
- Very favorable cost benefits, particularly when compared to labor and material for other types of insulation
- Life Cycle Analysis is also favorable with relatively short payback times

# Low Density Open Cell Characteristics (cont'd)

| | |
|---|---|
| Vapor permeability: | Does NOT seal against water vapor, rather allowing it to pass through |
| | Vapor barrier needed in wall assemblies in cold climates (e.g. vapor retardant paint) |
| | Verify vapor permeability with manufacturers |
| | Vapor permeability means any water in assembly can dry out |
| Mold: | Material is not a food source for mold |

# Medium Density Closed Cell Insulation

- **Uses:** both residential and commercial applications
- **Weight - Medium Density:** 2 lbs. per cubic foot
- **R-Value:** 4.9 – 6.9 per inch

High Density is also available at 3 lbs. per cu. ft. – mostly used in commercial roofing applications (both retrofit and new construction)

# Medium Density Closed Cell Characteristics

Blowing Agent: Dedicated, captive agent or Water Blowing Agent

Suitable for both Interior and Exterior Installations: cavity walls, exterior continuous insulation

Air Barrier: Serves as a full air barrier eliminating the need for a separate product to perform that function.

According to the Air Barrier Association of America (ABAA), many medium-density spray foam insulations are classified as air barrier materials

Vapor Barrier: Tests as a class II vapor retarder meaning it has very low permeability

# Medium Density Closed Cell Characteristics (cont'd)

Rigidity: Stronger, more resistant to construction impacts

Water Resistant

- Approved by FEMA as a flood-resistant material
- Does not provide food source for mold growth

Continuity: Can be applied as continuous insulation outside of studs and sheathing and covered over with facade material

# Medium Density Closed Cell Cost Benefit

- Achieves higher R-values in thinner wall assemblies
- Superior alternative to rigid foam board panels. One product provides multiple functions: insulation, air barrier, vapor barrier - no additional paint, membrane, or other material (joint tape, etc) is needed beyond this insulation
- Rigid and durable enough to be between masonry wythes or behind a masonry veneer

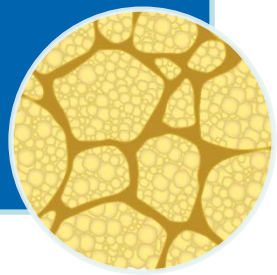
# Spray Foam Insulation Re-cap

- Soft, flexible foam
- Half pound (½ lb.) / cu. ft.
- Water blowing agent
- Open Cell
- R 3.5 - 3.7 per inch
- Permits drying
- Allows water to drain
- Rejects water at the surface

**Low Density**

- Hard, rigid foam
- Two pound (2 lb.) / cu. ft.
- Captive blowing agent or Water blowing agent
- Closed Cell
- R 4.9 – 6.9 per inch
- Barrier to vapor
- Barrier to bulk water
- Recognized by FEMA for use in flood zones

**Medium Density**



# General Cost Comparison

- Typically low density open cell insulation will cost less than medium density closed cell insulation for the same overall  R-value since fewer drums are required
- Medium Density closed cell will require thinner wall assemblies for that R-value however and may be a more economical wall system overall

## Typical Usage for the Same Interior Space of the Building Project:

Drums of Open Cell Insulation Required

Drums of Closed Cell Insulation Required

# SECTION 2

- Section 1: Spray Foam Insulation Overview
- Section 2: **Spray Foam Insulation Design Considerations**
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# Fire Resistance and NFPA testing

- IBC requires exterior wall systems with foam plastic insulation of any type must pass NFPA 285
- NFPA 285 is a test of the entire assembly, and not just of the component materials
- Details of the test assembly and materials identified in Chapter 26 of the IBC, Section 2603.5.5
- Common assemblies use a 15 minute thermal barrier (gypsum board) separating foam from interior
- In exterior wall assembly, ASTM E119 may also be required for the assembly
- Containment within assembly is needed
- Review manufacturer data closely

# Environmental Considerations

- Spray foam insulations require blowing agents - some agents are better for the environment than others.
- Blowing agents can be rated based on their Global Warming Potential (GWP).
- Carbon dioxide has a GWP rating of 1.
- Spray foam insulation using only water and carbon dioxide blowing agents also have a GWP rating of 1.
- Several low-density and  one medium-density spray foam product meets this level.

# Environmental Considerations (cont'd)

- All rigid foam insulation and most medium-density closed cell spray foam insulation rely on blowing agents other than water and carbon dioxide.
- GWP rating can be very high up to around 1,430 due to its hydro-fluorocarbon (HFC) make-up.
- Hence, some insulation contains greenhouse gas that is 1,430 times more potent than carbon dioxide.
- Environmental impact occurs only if it actually gets released into the air.
- When using closed cell spray foam insulation, seek out and specify a product with the lowest possible HFC content and the lowest possible GWP.

# Construction Considerations

- Any field-applied building product is directly dependent on the experience and qualifications of the installer
- Use trained and certified installers
- Variable field conditions need to be addressed:
  - air temperature
  - condition of the substrates
  - installer needs to understand and adjust to field conditions
- There will likely be some overspray or airborne spray that needs to be contained
- Protect the surrounding surfaces

# SECTION 3

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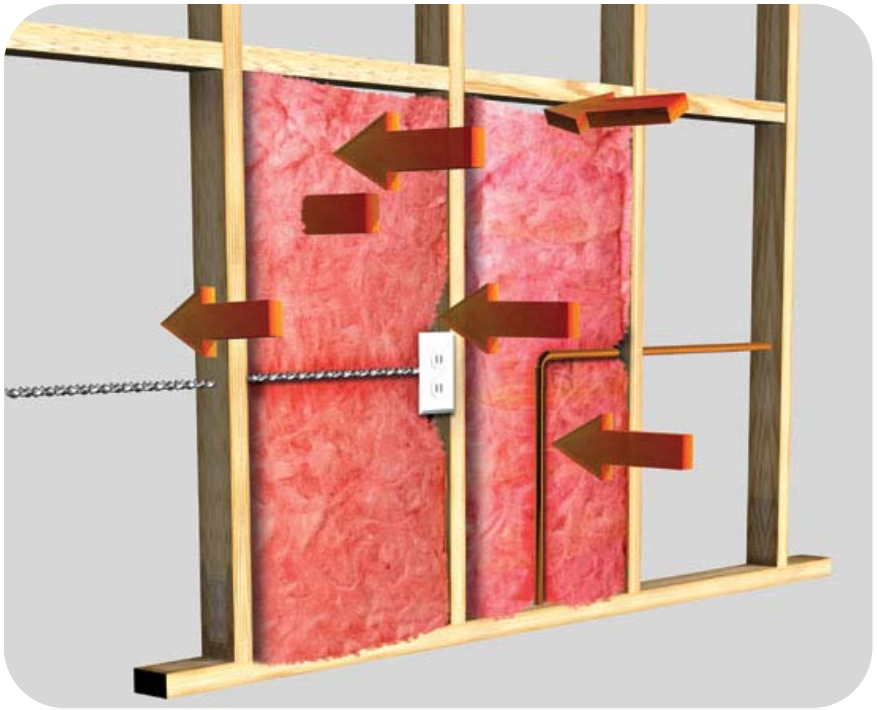
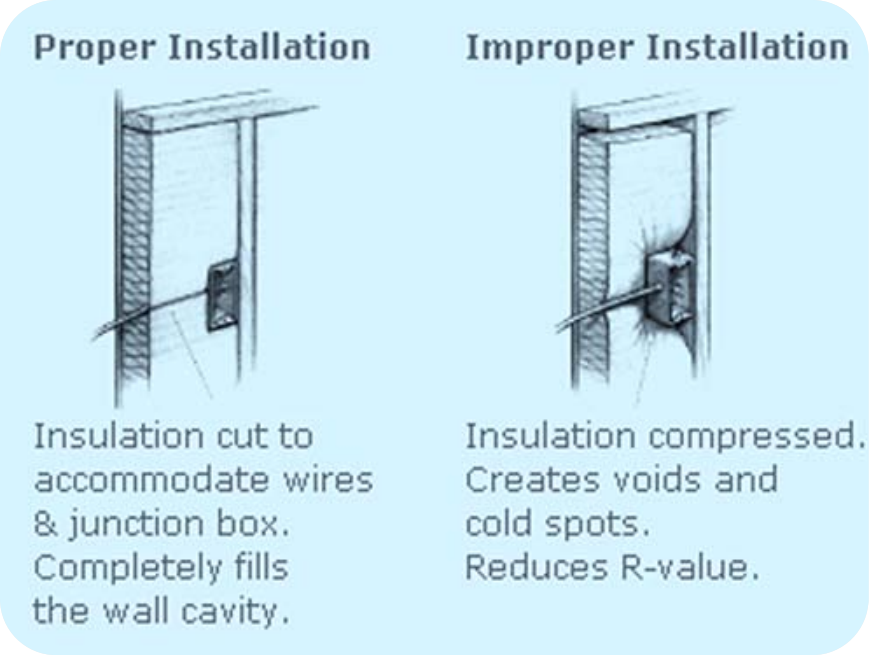
# Stud Cavity Batt Insulation



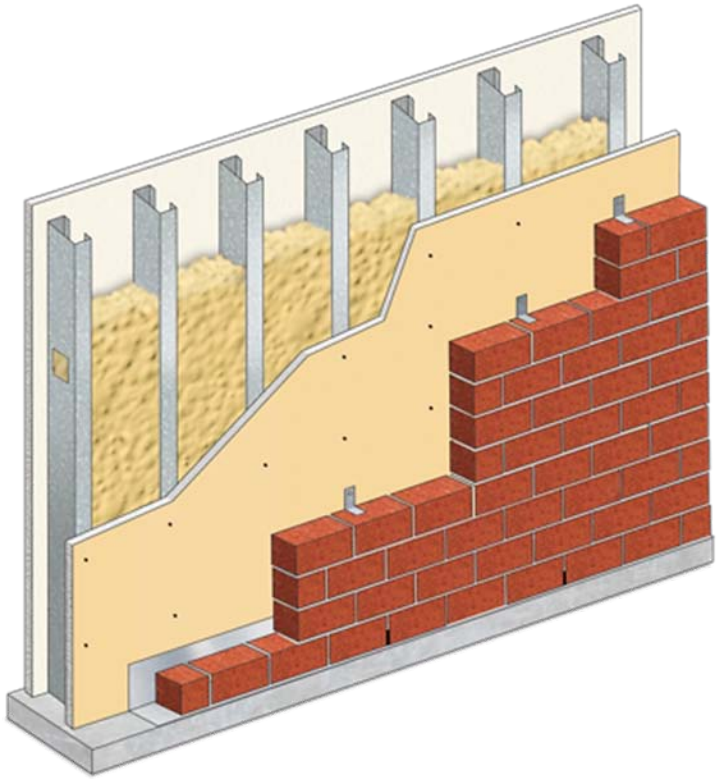
- Traditional approach is for batt type insulation to be placed between the framing members
- Insulation settles and sags over time or is loose to begin with
- Performance is lower as a result

# Stud Cavity Batt Insulation




- The batt insulation is also often compromised due to compression by mechanical, plumbing, or electrical components embedded within the same stud cavity.

# Stud Cavity Spray Foam Insulation



- Spray foam insulation overcomes these thermal issues
- Field applied against sheathing, it fills the cavity space completely, assuring the full thermal value
- Result is a more effective full R-value from the spray foam than compromised R-value for batt insulation

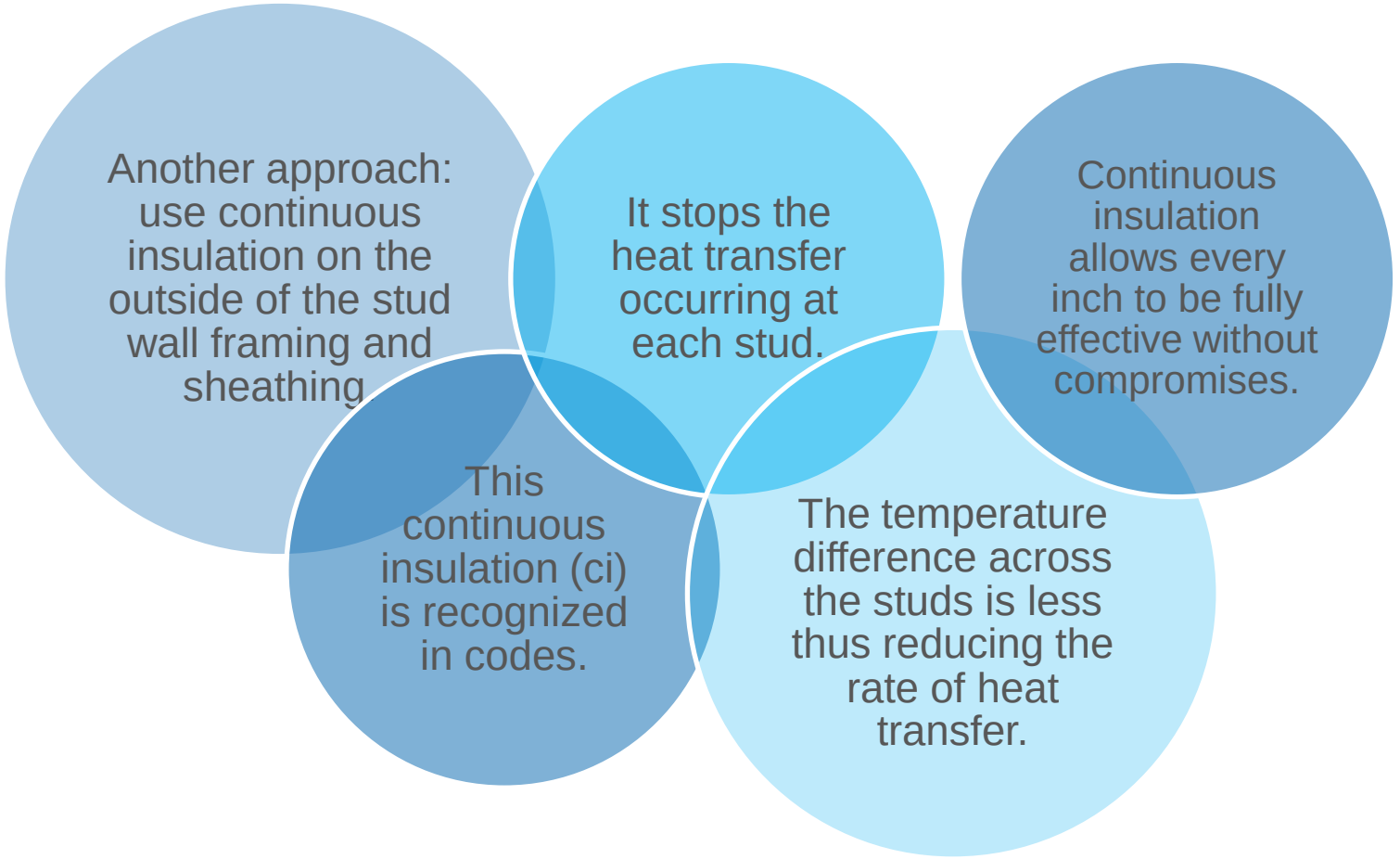
# Stud Wall Insulation Limitations

- Stud cavity insulation systems do not provide continuous insulation across a wall assembly
  - Recurring thermal bridges at each of the studs
- Energy codes and green building standards recognize that steel studs in particular have real performance limitations due to these thermal bridges
- They look at overall calculated U-factor of the total assembly and either:
  - Set the required insulation R-values higher
  - Or require a maximum U-factor of the total assembly be achieved

# Stud Wall Insulation Limitations

- ASHRAE 90.1 includes some very clear correction factors for thermal performance calculations
- EXAMPLE: A metal stud wall with 6-inch studs at 16-inch o.c. with insulation rated at R-3.5 per inch or a total of approximately R-21
- Stud wall is approx. 20 percent stud and track faces and only 80 percent solid insulation
- This ratio compromises the overall effective wall R-value by as much as 65 percent
- AHSRAE 90.1 assigns a total working value for this assembly of only R-7.4 (U-factor of 0.135) or about a third of the insulation R-value

# Exterior Continuous Insulation



# Combination Wall Assembly

A combination of low-density open cell spray foam insulation between steel studs and a continuous layer of medium-density closed cell spray foam insulation outside of the sheathing creates an exterior wall with superior thermal performance.

# Combination Wall Performance

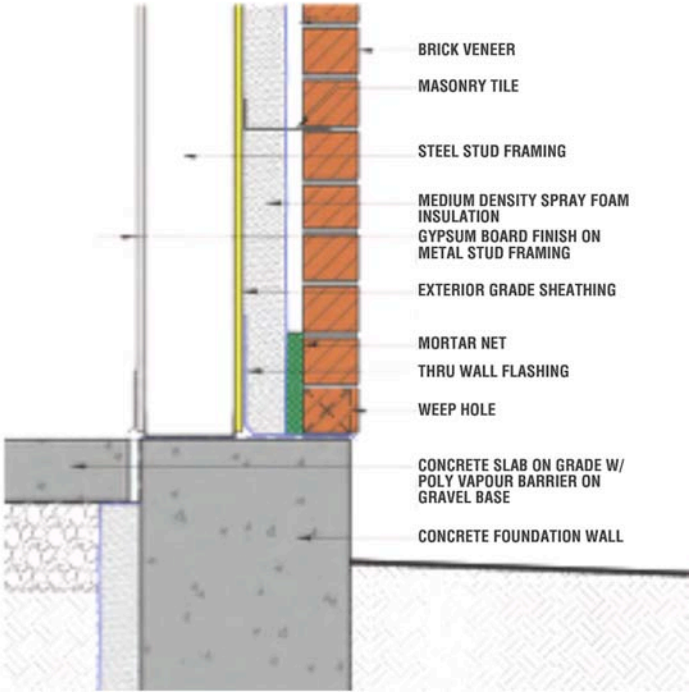
**Comparative Example**

- A nominal 4 inch stud wall filled with low-density spray foam insulation of R-3.5 per inch or approx. R-13
- Added 2” layer of medium-density spray foam insulation on the outside at R-6.9 per inch adds approx. R-14
- Combined wall assembly total R-value is approx. R-27 in the same total wall thickness as a 6 inch stud wall that only delivered the approximately R-21
- Result is superior performance without increasing assembly thickness

# Continuous Insulation Impact

- Thermal bridging at studs effect is dramatically reduced
- Energy codes recognize the higher overall U-factor of the wall assembly
- Directly improves the overall energy performance of wall and building
- Contributes energy cost savings of the building

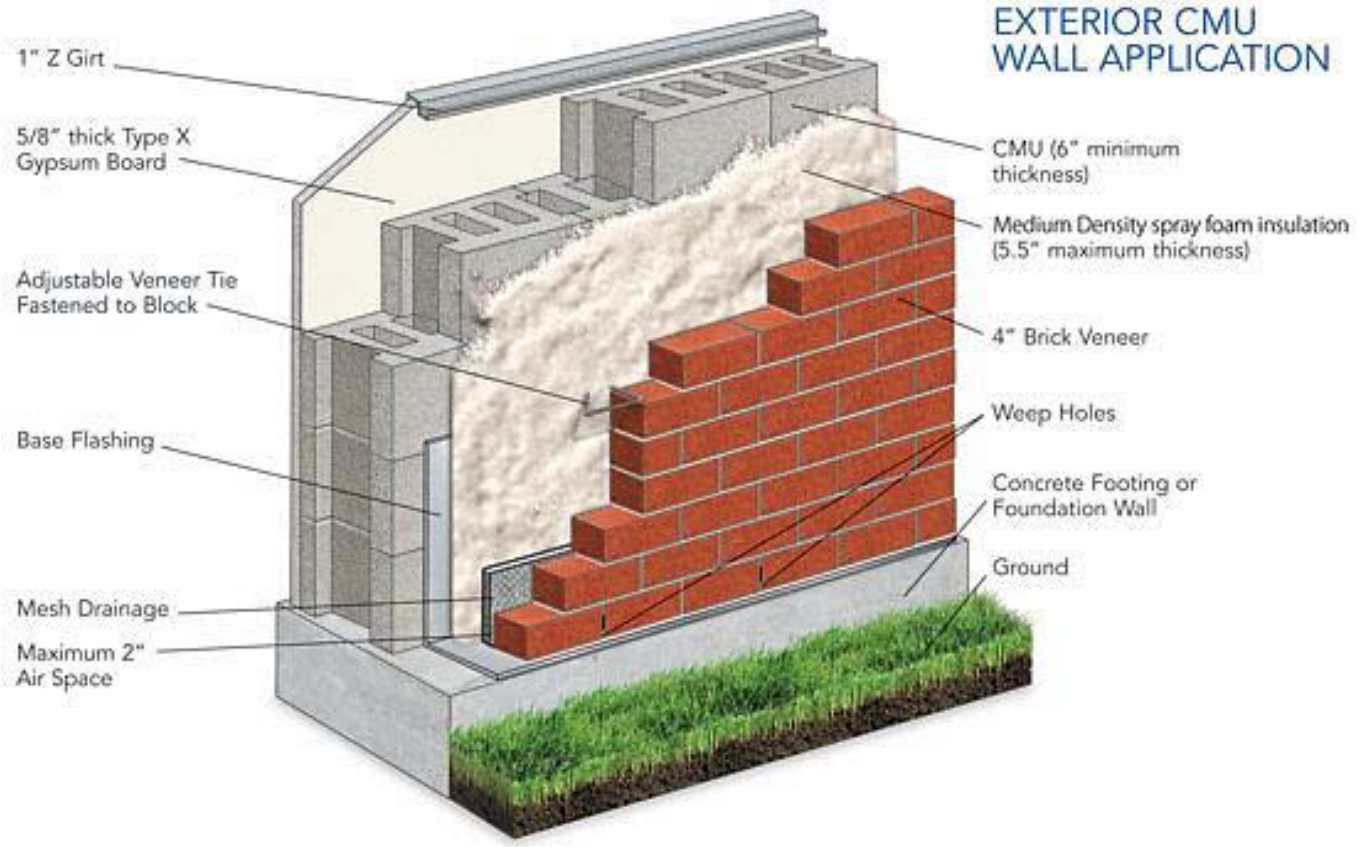
# Covering Continuous Insulation



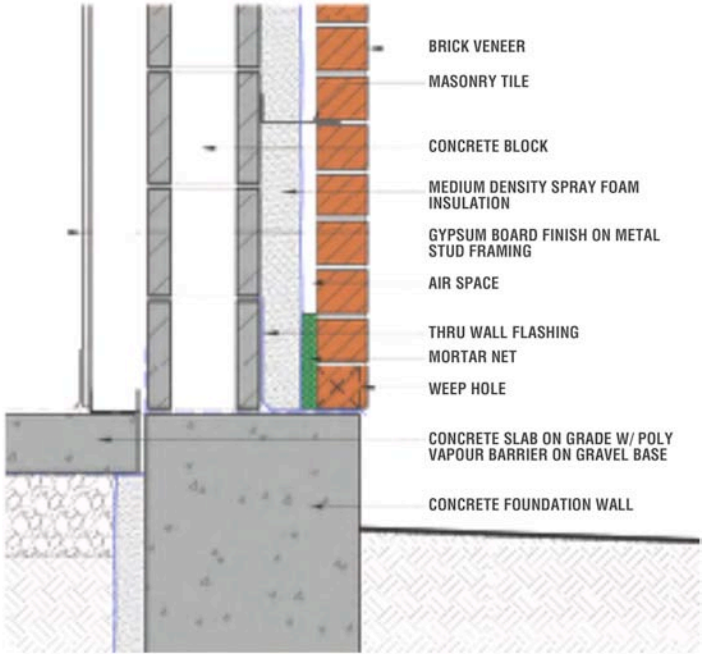

- Exterior layer of spray foam insulation is covered with wall façade treatment of choice
- Attachment anchors installed to the sheathing before the spray foam insulation is applied
- The final wall appearance and design is not limited by spray foam use

# Masonry Wall Applications

A continuous layer of medium-density closed cell spray foam insulation in a traditional masonry wall provides durability, thermal resistance and air sealing performance.



# Masonry Wall Construction




- Traditional method still applies: erect CMU wall, apply masonry ties, install insulation, install the masonry veneer
- The mason can focus on masonry and an insulation installer can focus on spray foam insulation

# Masonry Wall Veneer

Spray foam insulation can be used to completely fill and seal around brick ties and other irregularities in conventional construction.

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# Air Sealing Significance

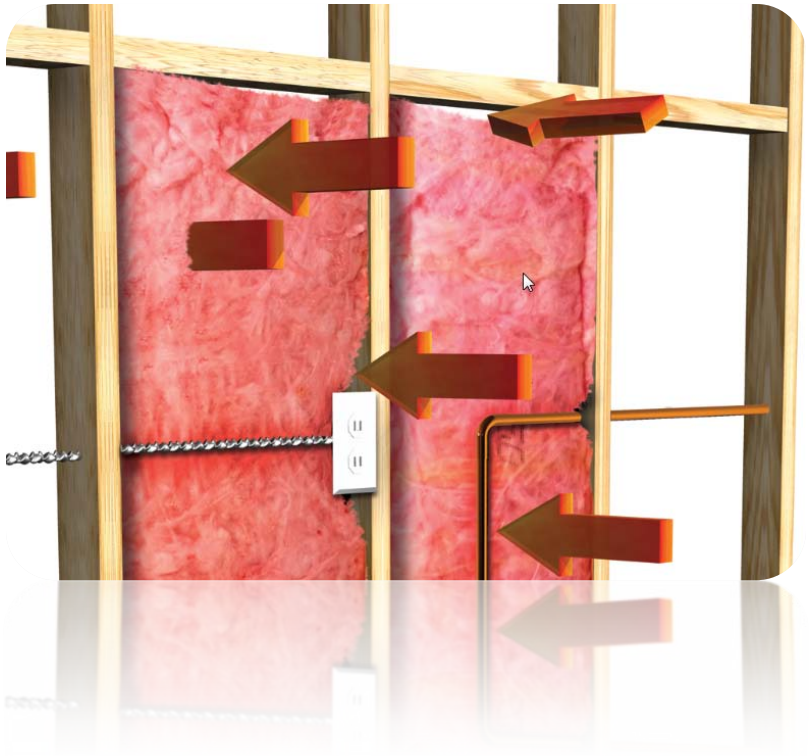
- U.S. Department of Energy and others have shown air infiltration is equally significant to the insulating R-values for overall energy performance in a building.

- The International Energy Conservation Construction Code and many standards now include air sealing requirements.

# Air Sealing Approach

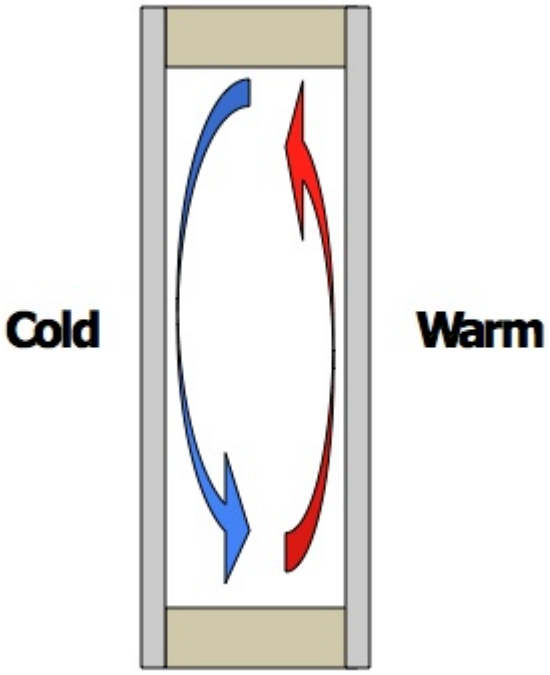
- Traditional approach adds an air barrier to the outside of the sheathing and taping seams
- This approach is less than perfect - subject to gaps, tears, and incomplete coverage around openings, penetrations, etc.
- Continuous layer of spray foam insulation on the outside of the wall sheathing overcomes these shortcomings
- Spray foam prevents air from moving through it
- Covers irregular places where sheet goods may not
- Continuous spray means no seams or junctions

# Batt Insulation and Air Sealing



- Conventional fibrous batt insulation allows for air to pass through it
- It is a misperception that it is a way to “seal up” a wall assembly
- It is not accurate that “stuffing” an opening, gap, or void with fibrous batt insulation will help seal off any air leaks

# Convection Air Currents




- Stud cavities are prone to convection currents inside
- Includes stud cavities with batt insulation
- Currents create an internal thermal air flow cycle
- Warm wall surface heats air adjacent to it inside stud cavity
- Warmed air rises to top, pulling cool air
- Warm air cools and descends
- This air current transfers heat directly through the cavity wall – reduces performance
- Process is same in all seasons, just on different wall faces

# Convection Air Currents and Insulation

- Convection currents reduce performance of  fibrous insulation
- Energy needed to operate the HVAC system increases due to the poor performance of the batt insulation in the wall
- Spray foam insulation in a stud cavity stops convection currents
- Filling the stud cavity fully with spray foam insulation prevents convection currents from occurring
- Delivers full performance of the wall insulation
- Even partially filling cavity with foam will be airtight and convection currents will not be able to form

# SECTION 5

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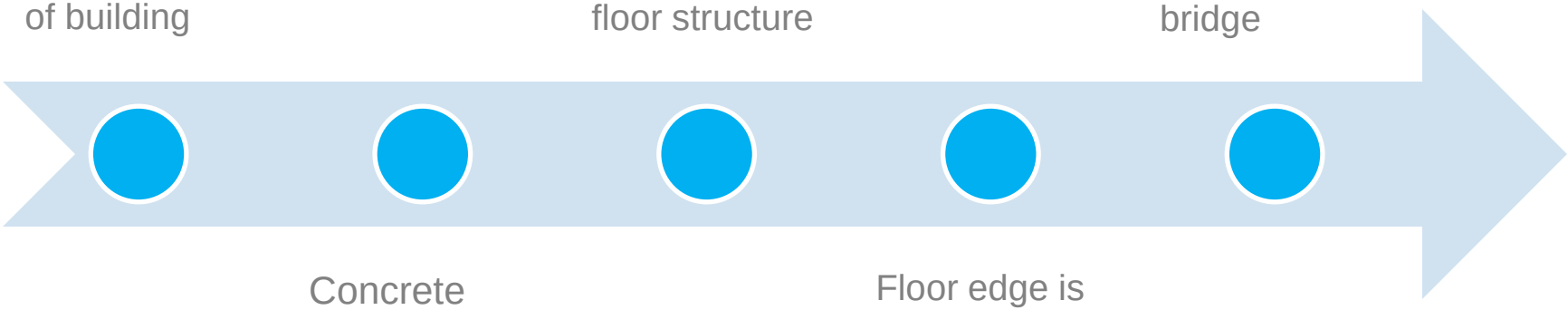
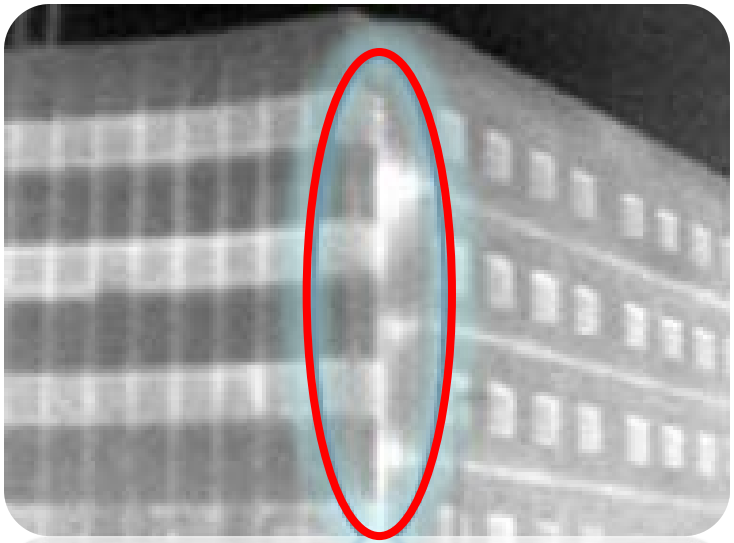
# Thermal Bridging at Floors



# Continuous Spray Foam at Floor Edges

- Use continuous insulation across floor edges as part of overall insulation scheme
- Spray foam insulation both boosts the performance of stud walls and combats floor edge thermal bridge.
- Affects the entire height of the building across multiple floors on all sides
- Dramatically increases the performance of the overall building

# Thermal Bridging at Structural Elements



Infrared photo showing warm air (bright) leaking out at column enclosure.

- Studs are not often the primary structure, rather a steel frame or concrete system is used
- Un-insulated structural elements are direct thermal short circuits just like floor slabs
- Applies to in line structure and corner conditions

# Continuous Spray Foam at Structure

Continuous spray foam insulation applied outside of the corners and the structure of a building stops thermal bridging there.

# Thermal Bridging at Irregular Places


Spray foam insulation can fill and seal in and around areas that are difficult or complicated for other insulation systems.

# Thermal Bridging Significance

Significance of thermal bridging cannot be overstated.

Thermal performance in a typical building construction without continuous insulation is compromised more than just 20 percent example in stud wall construction.

Floor edges, structural components, and parapets bring total un-insulated areas up to 30, 40, or even 50 percent of facades.

Continuous insulation integrated over all of these areas significantly impacts actual energy performance comfort of its occupants.

# CONCLUSION

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# Conclusion

1. Spray foam insulation offers a complete energy performance solution
2. Stud cavities can be completely filled with low-density open cell spray foam insulation providing thermal resistance, air sealing, and elimination of convection air currents
3. Continuous insulation (ci) provided with medium-density closed cell spray foam also provides complete air and vapor barrier
4. Continuous spray foam insulation covers over all energy draining thermal bridges
5. End result is a total high performance wall assembly consistent with any architectural design approach
6. Building owner reaps benefits of energy cost savings and longevity of building

# Continuous Insulation Systems for Exterior Walls

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## Questions?

### Thank You for Attending!

This concludes the American Institute of Architects Continuing Education System Program

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