THE EVOLUTION OF TRANSITIONS IN THE BUILDING ENVELOPE: What to Consider for 2015

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As the building industry improves its construction practices with energy savings, water conservation, fire protection, natural resource preservation, and human wellbeing at the forefront, stricter building codes will be put in place to drive change. With the 2015 International Energy Conservation Code (IECC) taking effect on January 1, 2015, architects, specifiers, consultants, and other building professionals must begin embracing the future of high-performance commercial building.

Updates to the IECC come at a time when commercial buildings account for about 40% of the energy consumed in the U.S., and contribute to 38% of carbon dioxide emissions, according to the U.S. Green Building Council (USGBC). With these statistics in mind, it's not surprising that international code bodies and green building councils are taking measures to curb commercial energy use—in old and new facilities, alike—in order to reduce CO_2 and nonrenewable energy use.

In order to construct smarter facilities, the industry has had to evolve the way it looks at individual buildings. Instead of evaluating specific components—such as a building's roof, wall, or windows—commercial construction professionals must take the entire building envelope into consideration. A green building is no longer measured on the R-value of a roof or wall, but rather by the compatibility of all of the systems in its building envelope.

What those in the built community have learned over time is that transitions in the building envelope are critical to the effective control of heat, air, and moisture within a structure. The importance of a high-performance commercial facility is evident by the codes and standards mandated and updated by governing bodies such as the International Code Council (ICC), USGBC, and the Department of Energy (DOE). The entire building community will need to adjust to reduce energy use and protect our country's natural resources for a clean energy future.

Building codes are regularly amended to reflect changes in methods, materials, and standards for constructing smarter, more

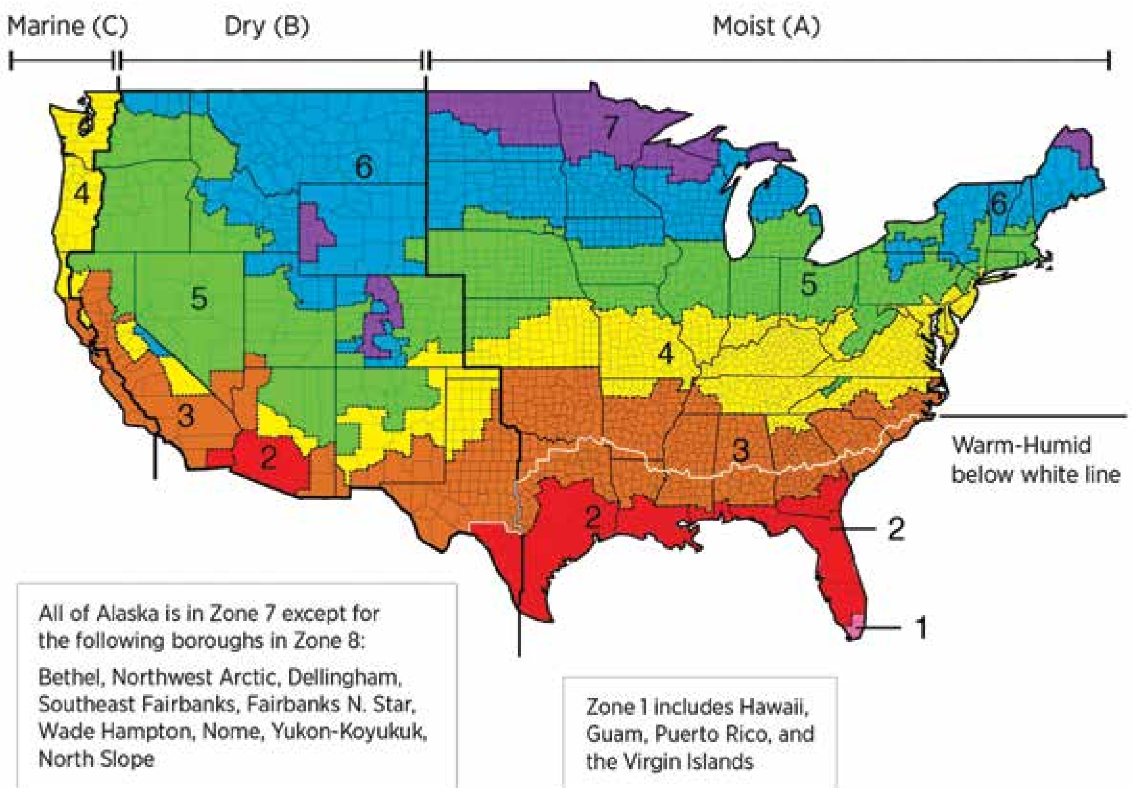

Figure 1 – The 2012 IECC identifies eight climate zones in the U.S. for building envelope thermal performance requirements.

durable structures. In fact, the building industry will see big changes next year with the introduction of the 2015 IECC. The code is updated every three years and serves as the model energy standard for states and local jurisdictions across the country. The Air Barrier Association of America (ABAA) updates its regulations every three years to align with IECC changes.

THERMAL PERFORMANCE REQUIREMENTS

The movement of heat, air, liquid moisture, and vapor moisture into and out of a facility is controlled by specifically designed systems that enclose a facility across its foundation, roof, walls, doors, and windows.

While a building is made up of different parts, assemblies must complement each other in order to reach peak efficiency. The 2012 IECC and 2013 ASHRAE Standard 90.1 mandate that a building envelope provide continuous resistance to air leakage, water penetration, and heat transfer—as well as control the transmission of moisture in the form of water vapor—for new commercial construction in Climate Zones 1-8 (see *Figure 1*). The notable exception to this requirement is that air barriers are not required in Climate Zones 1-3. The rationale for omitting air control in these zones is not completely clear, since there is limited value in insulating a structure without controlling air leakage.

When these building requirements were updated in 2012, new construction projects became more complex from a design, specification, and implementation perspective. Among the most significant challenges for designers is the use of unlike materials in forming a continuous air barrier. As the 2015 IECC indicates, these codes will continue to become more complex rather than increasingly simplified.

An important area for professionals to understand—whether they are using a system or assembly of products—is the transition from the roof to the wall. The best results come when using compatible products to maintain the continuity of the air barrier.

Figure 2 reviews opaque thermal envelope requirements based on type of roof and wall assembly and the climate zone in which a building is located.

CONTROLLING AIR MOVEMENT

Uncontrolled air movement through a wall assembly can have damaging, long-lasting effects on a structure and its occupants. Energy use and interior air quality are two areas that can be impacted negatively.

Air leakage is caused by a differential pressure across the exterior building envelope. Influences can be wind, stack effect, or mechanical equipment. Wind generates high pressures on the exposed, windward side of a structure. This results in areas of low pressure on the leeward walls and roof, which forces air out of the building. The stack effect is based on the principle that hot air rises and cool air sinks, creating areas of high pressure at the top of a building and low pressure at the foundation, causing air to leak. Another cause of differential pressure in a building is mechanical equipment. Imbalances in the air intake and exhaust systems can create positive or negative pressure. The imbalance can be caused by improper commissioning and often results in air freely entering and exiting a facility.

TABLE C402.2 OPAQUE THERMAL ENVELOPE REQUIREMENTS[a]

CLIMATE ZONE	1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R
Roofs																
Insulation entirely above deck	R-20ci	R-20ci	R-20ci	R-20ci	R-20ci	R-20ci	R-25ci	R-25ci	R-25ci	R-25ci	R-30ci	R-30ci	R-35ci	R-35ci	R-35ci	R-35ci
Metal buildings (with R-5 thermal blocks)[a, b]	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-25 + R-11 LS	R-25 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS
Attic and other	R-38	R-38	R-38	R-38	R-38	R-38	R-38	R-38	R-38	R-49	R-49	R-49	R-49	R-49	R-49	R-49
Walls, Above Grade																
Mass	R-5.7ci	R-5.7ci	R-5.7ci	R-7.6ci	R-7.6ci	R-9.5ci	R-9.5ci	R-11.4ci	R-11.4ci	R-13.3ci	R-13.3ci	R-15.2ci	R-15.2ci	R-15.2ci	R-25ci	R-25ci
Metal building	R-13+ R-6.5ci	R-13 + R-6.5ci	R13 + R-6.5ci	R-13 + R-13ci	R-13 + R-6.5ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13+ R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13+ R-19.5ci	R-13 + R-13ci	R-13+ R-19.5ci
Metal framed	R-13 + R-5ci	R-13 + R-5ci	R-13 + R-5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-15.6ci	R-13 + R-7.5ci	R-13+ R17.5ci
Wood framed and other	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-15.6ci or R-20 + R-10ci	R-13 + R-15.6ci or R-20 + R-10ci

Figure 2 – Table C402.2 from IECC 2012 provides opaque thermal envelope requirements for commercial buildings.

Furthermore, air leakage may occur through unsealed voids in exterior sealant, ill-fitting window gaskets, plumbing penetrations, or unsealed mechanical vents.

As codes have become more stringent, professionals have turned to air and vapor barriers, continuous insulation (CI), and through-wall flashing to create a continuous barrier to meet thermal performance requirements.

AIR AND VAPOR BARRIERS

Air and vapor barriers regulate uncontrolled air movement in and out of a building to mitigate undesirable results. An air barrier can come in multiple forms, including self-adhered sheet or liquid-applied membranes, medium-density sprayed polyurethane foams, mechanically fastened commercial building wraps, and board stock, among others. These materials work with accessories like sealants, tapes, and transition membranes to create a continuous barrier.

Air barriers are intended to prevent air leakage through the building enclosure, including exterior walls, roofs, and foundation floors.

Air barriers are tested and measured based on the amount of air that passes through them in accordance with ASTM E2178, *Standard Test Method for Air Permeance of Building Materials*. The ABAA defines an air barrier as "one that has been tested and has an air permeance less than 0.02 L/(s•m^2) @ 75 Pa (0.004 cfm/ft^2 @ 1.57 lb/ft^2)." Air permeance is defined by the amount of air that migrates through an air barrier, while leakage is the air that passes through holes or gaps.

To be effective, air barrier systems must be:

- Continuous across the entire building envelope
- Structurally sound to be able to resist the positive or negative pressures created from wind, the stack effect, or mechanical systems
- Durable enough to last without requiring replacement
- Able to impede the flow of air through the exterior envelope in compliance with the code-specified rates

A facility's air barrier system works with all of the assemblies in the building envelope, including the roof, windows, walls, and doors.

In order to be considered or classified as an air barrier, material cannot allow the passage of more than 0.004 cfm of air per square foot at a static pressure differential of 0.3 inches of water across the material. Similarly, an air barrier for a window assembly cannot allow the passage of more than 0.04 cfm of air per square foot at the same differential pressure.

This amount of air leakage through an assembly allows an increased amount at joints between the air barrier and building envelope component (roof, windows, walls, or doors). The code permits a total of 0.4 cfm of air leakage per square foot at the same differential air pressure for the entire building envelope. This increased amount of permissible air leakage allows for additional joints by uniting numerous air barrier assemblies to create an entire building system.

The IECC and several states now require the use of air barriers. The ABAA believes the number of code adopters will continue to grow as municipalities and green building groups back their importance.

While air barriers restrict the migration of air, vapor barriers must simultaneously protect against water vapor and act as an air barrier. They also minimize drafts and reduce moisture migration to help mitigate mold. However, the opposite is not always true, as not all air barriers are vapor barriers.

The 2012 IECC defines three different classes of vapor barriers in terms of perms:

- Class 1: <0.1 perms; materials such as sheet polyethylene and non-perforated aluminum foil
- Class 2: 0.1 to 1.0 perms; materials such as kraft-faced fiberglass batts or paint with a perm rating greater than 0.1 and less than or equal to 1.0
- Class 3: 1.0 to 10 perms; materials such as latex or enamel paint

The proper location of a vapor retarder depends on the climate zone, the building occupancy, and the thermal properties of the building envelope. Locating a vapor retarder should be done using a thorough hygrothermal analysis of the building envelope.

CONTINUOUS INSULATION

Continuous insulation (CI) runs continuously over structural members and is free of significant thermal bridging. ASHRAE mandates that CI be used to minimize thermal bridging and to help improve the thermal performance of wall assemblies. Some of CI's benefits include:

- Certain foam plastics can provide a reduced environmental footprint.
- Energy code solutions for every climate zone (*Figure 1*)
- Increased energy efficiency

When selecting a CI product, architects, specifiers, and consultants should look for options that contain foam technologies using HCFC-free blowing agents that do not contribute to the depletion of the ozone (non-ODP). There are also products that offer low global warming potential (low-GWP) and that are also formaldehyde-free.

THROUGH-WALL FLASHING

The 2012 IECC requires an exterior wall envelope design to collect, control, and prevent the accumulation of water within the wall assembly by providing a water-resistive barrier behind the exterior veneer. Water barrier systems are generally composed of liquid-applied membranes, self-adhered sheets, or mechanically fastened membranes made of ethylene propylene diene monomer (EPDM), butyl rubber, or polyethylene. Because these materials are combustible, an exterior wall assembly containing them must be tested and found to be compliant with minimum standards set by the 2012 NFPA 285, *Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Non-Load-Bearing Wall Assemblies Containing Combustible Components*.

Through-wall flashing can be used at the bases of walls, along windowsills, over doors, on parapets, and around support angles to defend against water damage.

When selecting a through-wall flashing material, durability and longevity are of utmost importance. Through-wall flashing products must be protected from damage. A tough yet flexible membrane will protect walls against moisture to help a facility function at its highest level. An ideal flashing also features thermal and dimensional stability and superior resistance to weathering, ozone, and ultraviolet (UV) radiation.

When using these three systems together, building professionals should select compatible air and vapor barriers, CI, and through-wall flashing materials in order to optimize energy efficiency.

> Air barriers are not required in Climate Zones 1-3. The rationale for omitting air control in these zones is not completely clear, since there is limited value in insulating a structure without controlling air leakage.

PROFESSIONAL CERTIFICATION TOOLS

Architects, specifiers, and consultants want to know that the products and systems they select for exterior wall systems meet code requirements. With so many options to choose from, the choices may be daunting. To make the specification and design process easier, there are certification programs to help architects and other building professionals know they are selecting high-quality, approved materials. For example, UL's certification for exterior wall systems and components is used to validate systems are in compliance with:

- Fire propagation resistance to NFPA 285, *Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Non-Load-Bearing Wall Assemblies Containing Combustible Components*
- Water penetration resistance to ASTM E331, *Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference*
- Air leakage resistance to ASTM E2357, *Standard Test Method for Determining Air Leakage of Air Barrier Assemblies*

By selecting systems that are certified by UL to meet NFPA 285, ASTM E331, and ASTM E2357 requirements, professionals can have peace of mind they are utilizing materials that can allow them to design safe structures.

WHAT TO LOOK FOR IN 2015

Many of the revisions coming in 2015 pertain to commercial building energy performance, while others relate to existing and historic buildings. "The updates related to existing and historic buildings clarify and further extend the code's impact on the current building stock and will mean large energy savings growing over time," says Jim Edelson, senior manager of codes and policy for the New Buildings Institute (NBI). "Taken together, the approved code changes represent the most significant code revisions for energy consumption of existing buildings since the 1970s."

Hundreds of amendments have been proposed. For this article's purpose, changes to the C402.2 Specific Insulation Requirements are of the most importance:

> Opaque assemblies shall comply with Table C402.2. Where two or more layers of continuous insulation board are used in a construction assembly, the continuous insulation boards shall be installed in accordance with Section C303.2. If the continuous insulation board manufacturer's installation instructions do not address installation of two or more layers, the edge joints between each layer of continuous insulation boards shall be staggered.

As noted earlier, there is some confusion over why air barrier requirements for building envelope thermal performance vary based on climate zones as defined by the 2012 IECC. In the 2012 iteration, air barriers are not required in Climate Zones 1-3.

Arguably, a lot of proposed changes are intended to eliminate some of the discrepancies and ambiguity that exists within the 2012 IECC as it pertains to continuous insulation (among other things).

For example, some commercial building professionals would recommend—based on research and past failures—that Climate Zones 1-3 should require air barriers because of their proven performance to help increase energy savings and prevent moisture problems. Zones 1-3 are temperate climates and often experience more rain and humidity. Air barriers can be used in wall systems in concert with exterior insulation and can also serve as a waterproofing mechanism for improved energy efficiency, indoor air quality, comfort, and durability.

According to the DOE, it is important to also note that any proposed amendments for 2015 that extract criteria from ASHRAE 90.1-2010 or any published addenda to that standard would be addressed by ASHRAE pursuant to procedures that guide ASHRAE involvement in development of model codes and standards.

While the 2015 IECC is still being finalized, potential changes to C402.2, Specific Insulation Requirements, are important to be aware of, as it is incumbent upon specifiers and consultants to understand the needs of a building's design of the roof systems, walls, and all of the details in between. It is that keen understanding that ensures continuous, effective, and installable transitions between a building's components. If designed and installed correctly, a cavity wall system or assembly will increase energy efficiency, meet the required energy and fire code standards, and provide cost savings during the lifespan of the building.

REFERENCES

Air Barrier Association of America – ABAA – www.airbarrier.org

International Building Code, 2012 Edition – www.iccsafe.org

International Energy Conservation Code, 2012 Edition – www.iccsafe.org

New Buildings Institute: http://newbuildings.org/

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