ENERGY CODE REQUIREMENTS FOR COMMERCIAL LOW-SLOPE ROOF ASSEMBLIES

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A roofer installs a polymer-modified bitumen roof membrane.

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LEARNING OBJECTIVES

After reading this article, you should be able to:

- **UNDERSTAND model energy codes and code adoption processes and procedures.**
- **DISCUSS key roofing-related provisions of the International Energy Conservation Code (IECC).**
- **LIST several energy code considerations for reroofing projects.**
- **DESCRIBE the advantages of developing relationships with local building code officials on energy code requirements.**

Forty-three states and most U.S. jurisdictions have adopted regulations for energy-efficient construction of commercial buildings. These regulations usually include provisions related to low-slope roof assemblies—buildings whose roofs slope less than two units vertical in 12 units horizontal (2:12).

This course highlights commonly adopted energy-code provisions for commercial low-slope roof assembles and examines the process of how such provisions are adopted.

MODEL ENERGY CODES AND THE CODE ADOPTION PROCESS

As their name implies, model codes can be thought of as generic in nature. They are developed by a broad range of stakeholders, presumably in an open, transparent process, with the idea that they will be adopted, in whole or in part, by numerous jurisdictions.

Energy codes are usually established at the state level and apply to all jurisdictions within the state. Forty-three states have adopted a statewide energy code (see box, page 51).

The most commonly adopted model codes in the U.S., of course, are those

IT'S IMPORTANT TO CONSIDER HOW ENERGY CODE REQUIREMENTS MAY AFFECT THE DESIGN AND INSTALLATION OF ROOF ASSEMBLIES.

developed by the International Code Council—the so-called I-Codes, which include the International Energy Conservation Code. The IECC is updated on a three-year cycle. The current version, the 2015 edition (IECC 2015), which can be obtained at www.iccsafe.org, is the reference point for this course. To determine energy code requirements for specific roof system projects, designers should contact their local code officials.

IECC contains separate sets of provisions for commercial and residential buildings, both of which allow for either a prescriptive- or performance-based approach for code compliance. The **performance approach** involves analyzing the whole building and determining projected annual energy costs, which, for most roofing-related projects, makes it somewhat impractical for determining the minimum required roof system R-value and related roof system requirements within the IECC.

FIGURE 1. IECC 2015: COMMERCIAL BUILDINGS (INSULATION COMPONENT R-VALUE-BASED METHOD)

Climate Zone	Assembly description		
	Insulation entirely above deck	Metal buildings	Attic and other
1	R-20ci (all other) R-25ci (Group R)	R-19+ R-11 LS	R-38
2	R-25ci		
3			
4	R-30ci		R-38 (except Climate Zone Marine 4)
5			R-38 (all other) R-49 (Group R, Climate Zone Marine 4)
6		R-25+ R-11 LS	R-49
7	R-35ci	R-30+ R-11 LS	
8			

ci= Continuous insulation; LS= Liner system;
Group R= Residential occupancies as defined in IECC's Commercial Chapter

Architects, roof designers, and contractors need to consider the climate zone in determining the correct insulation R-value for the various forms of roof assembly.

The **prescriptive approach** does not require the time and expense to evaluate the rest of the building or extensive consulting with mechanical engineers or energy-management professionals. It is usually the preferred method to determine the roofing requirements under IECC. This is especially true for reroofing projects.

For typical commercial roofing projects, the following information should be obtained to determine the applicable roofing-related IECC requirements:

- The **climate zone** in which the building is located
- The **roof insulation** requirements
- The roof **solar reflectance** and **thermal emittance** requirements
- The **air-barrier** requirements
- The **skylight** requirements, if applicable.

Let's take these items one by one.

Determine the correct climate zone. Many IECC requirements vary according to the climate zone where project buildings are located. Climate zone determination is done per IECC Chapter 3, which provides a map and listing of U.S. counties. The map or county listing should be consulted to determine which climate zone pertains to a particular project building. If in doubt as to the correct climate zone, consult your local building code official.

Evaluate the roof insulation requirements. IECC Section C402—Building Envelope Requirements provides the prescriptive requirements applicable to the commercial building thermal envelope, of which the roof assembly is a key component.

IECC Table C402.1.3 lists minimum thermal resistance (R-value) requirements and contains values that pertain to roofing assembly types, notably:

- **Insulation entirely above roof deck.** This assembly category is used for roofs with insulation entirely above deck (continuous insulation). It is acceptable for above deck continuous insulation to have interruptions for framing and pads for mechanical equipment as long as the combined total area of such interruptions does not exceed 1% of the roof area. This assembly is the most common commercial low-slope roofing type.
- **Metal buildings.** This assembly category is used for metal building roofs. A metal building is defined as a "complete integrated set of mutually dependent components and assemblies that form a building, which consists of a steel-framed superstructure and metal skin."
- **Attic and other.** This assembly category is used for buildings that don't fall into either of the other two categories. Buildings that rely on insulation both above and below a structural deck to meet the thermal resistance requirements in IECC Table C402.1.3 would fall into

this category.

A summary of minimum R-values for roof insulation by climate zone is shown in Fig. 1.

Roof system designers should determine the applicable climate zone and assembly description that pertains to a particular building project and provide enough insulation so that the overall R-value is at least as much as is shown in Fig. 1. Note that, for metal buildings, two types of insulation are required.

IECC requires staggering of joints between layers of rigid roof board insulation and that insulation products are required to be installed according to insulation manufacturers' instructions. When tapered insulation is used, the thickness of insulation at roof drains or scuppers (the typical low point in tapered roof insulation layouts) can be reduced by one inch to ensure proper drainage.

Review the solar reflectance and thermal emittance requirements. Low-slope roofs in Climate Zones 1-3 are required to meet minimum roof reflectance and emittance provisions (sometimes referred to as "cool roofs"). **Solar reflectance** is a measure of the surface's ability to stay cool in the sun by reflecting solar radiation and emitting thermal radiation. **Thermal emittance** is the ability of a material to radiate the heat that it absorbs.

IECC Table C402.3 provides two options to demonstrate compliance:

- A roofing surface with a minimum three-year aged solar reflectance of 0.55 and a minimum three-year aged thermal emittance of 0.75.
- A roofing surface with a minimum three-year-aged solar reflectance index (SRI) of 64.

Several commonly available low-slope roofing materials that have been tested based on the requirements in IECC Section C402.3 meet or exceed the required values. These materials tend to be white or light tan in appearance.

IECC Section C402.3 also includes exceptions for portions of roof systems that include or are covered by:

- Photovoltaic and solar air- or water-heating systems
- Vegetative roofs
- Above-roof decking or walkways
- Skylights or HVAC systems
- Permanently shaded areas
- Ballast (at least 17 lb/sf) or pavers (at least 23 lb/sf)

Items in the above list are not required to comply with the roof reflectance and emittance provisions of IECC Section C402.3.

AN AIR BARRIER MUST BE CONTINUOUS THROUGHOUT THE BUILDING ENVELOPE—ROOFS, WALLS, AND FOUNDATION. PENETRATIONS THROUGH THE AIR BARRIER MUST BE SEALED.

Air-barrier requirements were first added in the 2012 edition of the IECC. Their purpose is to mitigate the movement or flow of air through the building envelope. IECC defines an "air barrier" as "material(s) assembled and joined together to provide a barrier to air leakage through the building envelope." It may be a single material or a combination of materials.

IECC defines a "continuous air barrier" as "a combination of materials and assemblies that restrict or prevent the passage of air through the building thermal envelope."

Both terms address creating a continuous air barrier somewhere within a building envelope so that air movement between the exterior and the conditioned space inside the building is kept to a minimum.

It is important to note that, in using the term "air barrier," the IECC assumes that an absolute barrier against air leakage can be achieved. In everyday commercial construction, it is virtually impossible to do this. For this reason, the NRCA has adopted the term "air retarder" for what IECC refers to as an "air barrier."

FIGURE 2: MAXIMUM U-FACTOR AND SHGC REQUIREMENTS FOR SKYLIGHTS

Climate Zone	1	2	3	4 Except Marine	5 And Marine 4	6	7
U-factor*	0.75	0.65	0.55	0.50	0.50	0.50	0.50
SHGC**	0.35	0.35	0.35	0.40	0.40	0.40	NR

NR = No requirement
SHGC = Solar Heat Gain Coefficient
*Section C402.4.3.2 permits increased values for specific situations.
**Section C402.4.3.1 permits increased values for specific situations.

Skylights add another dimension to roofing projects in terms of meeting energy code requirements for U-factor and SHGC (solar heat gain coefficient).

For many commercial buildings with membrane roof systems, the roof membrane itself acts as a component of the continuous building air barrier—at least as long as it is connected to the portion of the wall system that is acting as the wall air barrier and all penetrations through the roof membrane are air sealed. For most buildings with attic spaces, air-barrier materials likely will be placed at the ceiling level, where they would not be part of the roofing assembly.

IECC requires roof designers to determine continuous building air-barrier connections and show their locations on construction details included in the project construction documents. This is the best way to ensure compliance with the air-barrier provisions for the finished project. IECC Section C103.2 provides an explicit requirement for air-barrier–related details to be included in construction documents.

IECC's air-barrier provisions applicable to commercial buildings are in Section C402.5, Air Leakage (Mandatory). This section establishes several important points:

1] A building air barrier must be continuous throughout the building envelope—roof, walls, and foundation. Penetrations through air-barrier materials must be sealed.

2] A building air barrier can be located anywhere within the building envelope construction. It is not uncommon for a continuous building envelope air barrier to be comprised of a combination of exterior surface materials, interior surface materials, and materials located within a wall or roof system. The important point is that all air-barrier materials, wherever they are located, should be connected and continuous.

3] Because a building air barrier may be located anywhere within the building envelope, air exchange between communicating wall and roof assemblies is not restricted. As long as air encounters a code-compliant air barrier before it reaches the exterior environment, the building envelope is considered compliant with the air-barrier requirements of the code. In other words, as long as the building envelope is resistant to air leakage, it complies.

4] When tested in accordance with ASTM E2178, any material with air permeability no greater than 0.004 cfm/ft^2 (L/s · m^2) under a pressure differential of 0.3 inches water gauge (75 Pa) complies with IECC.

IECC has a list of "deemed-to-comply" air-barrier materials that, as their name implies, do not require an air permeance test report. Roofing-related deemed-to-comply materials include:

- Closed-cell spray foam with a minimum density of 1.5 pcf (2.4 kg/m^3) and a thickness of not less than 1½ inches (38 mm)
- Built-up roofing membrane
- Modified bituminous roof membrane
- Fully adhered single-ply roof membrane.

IECC also provides an alternative method to

demonstrate compliance with air-barrier-related provisions via a building test. If this compliance option is selected, a fan pressurization test (per ASTM E779, "Standard Test Method for Determining Air Leakage Rate by Fan Pressurization") is conducted to determine the air leakage rate of a completed building. Presumably, if a continuous air barrier is constructed using air-barrier materials and assemblies compliant with IECC, all joints and penetrations are sealed, and construction complies with all other applicable air-barrier provisions, such a test per ASTM E779 would demonstrate compliance with IECC Section C402.5.

Understanding skylight requirements. IECC contains a number of requirements related to rooftop skylights (see Fig. 2).

IECC Section C402.4.1 limits skylights on roofs to not greater than 3% of the gross roof area. If skylights with daylight-responsive controls are used, IECC Section C405.2.3.1 allows 5% of the roof area to be covered by skylights. "Daylight-responsive control" is defined in IECC as "a device or system that provides automatic control of electric light levels based on the amount of daylight in a space."

Note: Discussion of compliance with IECC's lighting controls provisions (IECC Section C405.2 and IECC Section C402.4) is beyond the scope of this course.

IECC's Table C402.3 lists the maximum U-factor (a measure of how well a product—in this case, a skylight—prevents heat from escaping a building) and solar heat gain coefficient (SHGC, the measure of the solar radiation admitted through a window) values that must be met when fenestration products are used.

IECC also addresses skylight curbs. IECC Section 402.2.2 requires that skylight curbs be insulated to the level of the roof with insulation entirely above deck or R-5, whichever is less. However, unit skylight curbs included as a component of a skylight listed and labeled in accordance with National Fenestration Rating Council 100, "Procedure for Determining Fenestration Product U-Factors," are not required to be insulated.

5 KEY ISSUES IN IECC PROVISIONS RELATED TO REROOFING PROJECTS

IECC address five specific issues related to reroofing:

- Air barriers
- Roof recover
- Roof replacement, insulation entirely above deck
- Roof replacement, other insulation configurations
- Roof repair

Air barriers/roof recover. Under the IECC, reroofing is considered an alteration. IECC Section C503.1 lists exceptions for alterations that need not comply with the requirements for new construction, provided the energy use of a building is not increased. The two roofing-related exceptions not specifically addressed in editions of IECC prior to 2015 are:

1] Roof recover, which IECC defines as the process of installing an additional roof covering over an existing roof covering without removing the existing roof covering.

2] Air barriers shall not be required for roof recover and roof replacement where the alterations or renovations to the building do not include alterations, renovations, or repairs to the remainder of the building envelope.

The roof-recover exception in IECC Section C503.1 makes clear that such work shall not trigger having to comply with current IECC provisions. IECC Section C503.1 also makes clear that, for a typical reroofing project (including roof replacement and roof recover), air-barrier provisions do not apply unless the scope of work also includes alterations to the remainder of the building envelope. In other words, IECC does not require the installation of a roof air barrier where it will not be connected to wall air barriers.

Roof replacement with insulation entirely above the deck. As has been noted, IECC air-barrier requirements do not apply to roof replacement projects. IECC Section C503.3.1 establishes that, other than air-barrier provisions, IECC requirements for new construction also apply for roof replacement projects. IECC defines roof replacement as "the process of removing the existing roof covering, repairing any damaged substrate, and installing a new roof covering."

Roof replacement with other insulation configurations. IECC Section C503.1 addresses compliance for existing roof assemblies with insulation installed between roof framing members or inside

MOST STATES HAVE ADOPTED A STATEWIDE ENERGY CODE

Forty-three states have adopted a statewide energy code. Alaska, Arizona, Kansas, Missouri, North Dakota, South Dakota, and Wyoming have not. In states that have not adopted an energy code, energy code provisions are often adopted at the county or municipal level.

To assist roofing professionals, the National Roofing Contractors Association (NRCA) compiled a database of states' current energy code adoption. This information was obtained either from individual states' websites or the Department of Energy's Energy Code's Program website, www.energycodes.gov/states.

You can contact the government agency having jurisdiction to verify the specific energy codes applicable to your project.

NRCA's database of energy codes by state can be accessed at: www.nrca.net/Technical/EnergyCodes.

a cavity below the roof deck. These assemblies are typically exempt from IECC's new construction requirements, provided current insulation R-values are maintained. The roof-specific exemption from the air-barrier requirements also applies if the project does not also include alterations to the rest of the building envelope.

Roof repairs. IECC defines roof repair as a "reconstruction or renewal of any part of an existing roof for the purpose of its maintenance." Roof repairs to existing buildings do not trigger IECC compliance. Where roof system repairs affect components regulated by IECC, repairs shall maintain compliance with the energy code in effect at the time the roof system was installed. For instance, a roof repair may not result in a reduction of roof insulation R-value below the R-value required at the time the roof system was installed.

GET TO KNOW YOUR CODE OFFICIALS

As most U.S. jurisdictions are under the purview of an energy code, it is important to consider how such requirements may affect the design and installation of roof assemblies. While this course references the current edition of IECC, jurisdictions may be following older editions or may have amended the model code. Determining the energy code requirements that pertain to a specific project is important to ensure compliance.

It is advisable to coordinate with local code officials when, for example, existing building conditions make it difficult to add the full thickness of above-deck roof insulation required by the IECC. In the past, through-wall flashings and rooftop equipment curb heights were often installed at heights appropriate for insulation thicknesses that were much less demanding than those required to meet the minimum R-values under current energy code. Where you can demonstrate that raising the flashing and curb heights will substantially add to the cost of the project, local code officials may accept less insulation so that hard-to-modify building elements may be allowed to remain in the roof replacement. Such interactions with local code officials often can prevent or minimize misunderstandings and project delay.+

+EDITOR'S NOTE

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