International Energy Conservation Code®

Code and Commentary

2006

ICC
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INTERNATIONAL ENERGY CONSERVATION CODE®

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2006 International Energy Conservation Code® Commentary

First Printing: September 2007

ISBN-13: 978-1-58001-488-5

PRINTED IN THE U.S.A.

PREFACE

The principal purpose of the Commentary is to provide a basic volume of knowledge and facts relating to building construction as it pertains to the regulations set forth in the 2006 *International Energy Conservation Code*. The person who is serious about effectively designing, constructing and regulating buildings and structures will find the Commentary to be a reliable data source and reference to almost all components of the built environment.

As a follow-up to the *International Energy Conservation Code*, we offer a companion document, the *International Energy Conservation Code Commentary.* The basic appeal of the Commentary is thus: it provides in a small package and at reasonable cost thorough coverage of many issues likely to be dealt with when using the *International Energy Conservation Code* — and then supplements that coverage with historical and technical background. Reference lists, information sources and bibliographies are also included.

Throughout all of this, strenuous effort has been made to keep the vast quantity of material accessible and its method of presentation useful. With a comprehensive yet concise summary of each section, the Commentary provides a convenient reference for regulations applicable to the construction of buildings and structures. In the chapters that follow, discussions focus on the full meaning and implications of the code text. Guidelines suggest the most effective method of application, and the consequences of not adhering to the code text. Illustrations are provided to aid understanding; they do not necessarily illustrate the only methods of achieving code compliance.

The format of the Commentary includes the full text of each section, table and figure in the code, followed immediately by the commentary applicable to that text. At the time of printing, the Commentary reflects the most up-to-date text of the 2006 *International Energy Conservation Code*. Each section's narrative includes a statement of its objective and intent, and usually includes a discussion about why the requirement commands the conditions set forth. Code text and commentary text are easily distinguished from each other. All code text is shown as it appears in the *International Energy Conservation Code*, and all commentary is indented below the code text and begins with the symbol ❖.

Readers should note that the Commentary is to be used in conjunction with the *International Energy Conservation Code* and not as a substitute for the code. **The Commentary is advisory only;** the code official alone possesses the authority and responsibility for interpreting the code.

Comments and recommendations are encouraged for through your input, we can improve future editions. Please direct your comments to the Codes and Standards Development Department at the Chicago District Office.

TABLE OF CONTENTS

Chapter 1: Administration

General Comments

The need for energy conservation is due to the increased demand for primary energy in this country coupled with the decline of domestic energy resource development. The vulnerability of our nation was illustrated by the Arab States' oil embargo of 1973. This event highlighted the United States' dependency on foreign energy supply, and awakened the nation to the crippling effects that might occur should offshore supply lines be interrupted. In 1975, the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) published Standard 90, *Energy Conservation in New Building Design*. This standard was a culmination of efforts that began in 1972, when the National Conference of States on Building Codes and Standards, Inc. (NCSBCS) voted to request continued National Bureau of Standards (NBS) emphasis on building-related standards for energy conservation.

In August 1973, NBS agreed to develop and design an evaluation criteria for energy conservation in new buildings, and in February 1974, ASHRAE accepted the responsibility to develop a national voluntary consensus standard based on the NBS criteria. After two public reviews, ASHRAE 90-75 was approved for publication in August 1975. This standard was subsequently revised in 1980, with the first nine sections published as ASHRAE 90A, and the remainder published as ASHRAE 90B and 90C.

Over the next several years, all 50 states eventually enacted regulations or developed their own energy-related codes based on the 1975 edition of ASHRAE 90 or on one of the several regional energy codes that also used the standard as a technical base.

The energy conservation code development efforts of the model code agencies and the various state energy conservation offices were first published as a separate code volume in 1977 as the *Code for Energy Conservation in New Building Construction*; subsequently renamed the *Model Code for Energy Conservation* (MCEC) in1981and then published as the *Model Energy Code* (MEC) by the Council of American Building Officials (CABO) in 1983. The CABO MEC was also based on the ASHRAE 90 series, specifically the 1980 edition of ASHRAE 90A. The CABO MEC was developed jointly by the International Code Council® (ICC®) legacy organizations: Building Officials and Code Administrators International (BOCA); International Conference of Building Officials (ICBO); National Conference of States on Building Codes and Standards (NCSBCS); and Southern Building Code Congress International (SBCCI), under a contract funded by the United States Department of Energy (DOE).

During that same year, the results of an extensive research program initiated by ASHRAE and DOE on energy conservation in building design demonstrated that significant cost-effective improvements could be made to the existing ASHRAE 90 series. The ASHRAE Standing Standards Project Review Committee (SSPC) 90R became responsible for maintaining the provisions of the ASHRAE 90 series applicable to other than low-rise residential buildings and buildings three stories or less in height. It took six years to finalize revisions to ASHRAE 90A and 90B as the 90.1 Standard. After three public reviews and two appeals, these revisions were published in 1989 as ASHRAE/IES 90.1, *Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings*. Since 1989, numerous addenda to this standard have been developed. Some have been published and others have undergone development and review.

With the 1990 Iraqi invasion of Kuwait, lawmakers in Washington again saw the need to lessen the nation's precarious dependence on sources of foreign oil. The federal government issued a mandate to regulate energy usage for the United States. This federal mandate began as two congressional bills: the National Energy Efficiency Act of 1991 for the House and the National Energy Security Act of 1991 for the Senate. After months of debate, the bills were combined into one document that was renamed the Energy Policy Act of 1992. On October 24, 1992, former President George H.W. Bush signed the Energy Policy Act of 1992 (EPAct) into law (Public Law 102-486).

EPAct established the 1992 CABO MEC (applicable to detached one- and two-family dwellings and low-rise residential buildings three stories or less in height) and AHRAE 90.1 (applicable to all other buildings) as the acceptable criteria for several building energy-related requirements. By October 24, 1994, each state had to certify to the secretary of the DOE that it had reviewed the provisions of its residential building code regarding energy efficiency and made a determination as to whether a revision of that code was needed to meet or exceed the 1992 CABO MEC. The states were not required to update their residential building energy codes, but only to review the code and determine if it was appropriate to update. If, for whatever reasons, a state determined that it was not feasible to revise its residential energy code, the state was required to submit to the Secretary of Energy, in writing, the reasons for such determination.

EPAct also mandates that whenever a new edition of the CABO MEC is published, the Secretary of Energy has one year to make a determination as to whether or not the new edition "would improve energy efficiency in residential buildings." The states then have two years from this determination to repeat the review process previously described. This analysis is also intended to assist the Department of Housing and Urban Development (HUD) in determining whether the latest edition of the CABO MEC meets EPAct's criteria for justifying its adoption of HUD loan programs.

Since the signing of EPAct in October 1992, two subsequent editions of the CABO MEC have been published and made available for adoption by the states: the 1993 and 1995 editions. While the CABO MEC is revised every three years, it was published again in 1993 because of a larger-than-average number of changes introduced during the 1992 code adoption cycle. The 1993 edition introduced more stringent ceiling and wall insulation requirements for single-family and low-rise multiple-family buildings in warmer (southern) locations, included new requirements for heating, ventilating and air-conditioning (HVAC) equipment efficiencies, which are consistent with the National Appliance Energy Conservation Act of 1987 (Public law 100-12); had less stringent requirements for duct insulation; and adopted by reference the 90.1 Standard for commercial buildings and high-rise residential buildings. The 1995 edition added a reference to a National Fenestration Rating Council (NFRC) standard for glazing *U*-factors and provides default *U*-factors; added criteria to specifically correct metal-stud framing in wall thermal calculations; strengthened the duct-sealing provisions and applied them to all supply and return ducts; adopted by reference the 1993 ASHRAE *Handbook of Fundamentals* in place of the 1989 ASHRAE *Handbook of Fundamentals*, thereby directing users to assume a higher fraction of wall area in framing; and adopted the *Energy Code for Commercial and High-Rise Residential Buildings—Based on ASHRAE Standard 90.1-1989* (90.1 Code) by reference in place of the current reference to ASHRAE/IESNA 90.1-1989.

On January 10, 2001, the DOE issued a Federal Register notice declaring that the 2000 *International Energy Conservation Code*® (IECC®) "will achieve substantial energy efficiency in low-rise residential buildings" compared to the 1995 CABO MEC and the 1998 IECC (FR 01742).

This determination implies that states must certify whether revision of their residential building energy codes meet or exceed the 2000 edition of the IECC by January 10, 2003. Furthermore, this determination justifies the adoption of the 2000 IECC for HUD-assisted housing.

Effective December 4, 1995, CABO assigned all rights and responsibilities of the MEC to the ICC. Through its efforts to develop a complete set of international construction codes without regional limitations and to provide proper interface with the *International Codes*®, the ICC subsequently introduced the first edition of the IECC in February 1998. The first edition of the IECC replaced the 1995 CABO MEC. To facilitate the transfer of responsibility, the secretariat, committee members, bylaws, appeals procedures and guidelines were simply redesignated ICC activities without change. In its first edition, the 1998 IECC incorporated the provisions of the 1995 edition of the MEC promulgated by CABO and included the technical content of the MEC as modified by approved changes from the 1995, 1996 and 1997 CABO code development cycles. Note that until the publishing of the 1998 IECC, code development activities during 1995, 1996 and 1997 were carried out under CABO code development procedures.

Significant changes incorporated into the 1998 IECC included:

- An organizational restructuring of the code's chapter to accommodate differences in format between a CABO code that has since evolved into an ICC *International Code*.
- The addition of maximum solar heat gain coefficient (SHGC) criteria for glazing in cooling-dominated climates.
- Revisions to the default *U*-factor tables for fenestration products.
- Heat traps for nonrecirculating service water heating systems.
- The addition of a simplified compliance approach for commercial buildings three stories or less in height, having a window and glazed door area not exceeding 40 percent, and having "simple" (a.k.a., single zone) mechanical systems.

In the 2000 edition, the IECC expanded in scope to include energy-related provisions for *all* commercial buildings into Chapter 8. Comprehensive language was also added to introduce useable provisions specific to "complex" (a.k.a., multiple zone) mechanical systems. A simplified and enforceable "total building performance" alternative to the estimated energy cost budget provisions of Chapter 7 was another improvement. Likewise, the interior lighting power requirements were revised, and are now fully autonomous from related requirements adopted by reference into Chapter 7.

The majority of the work involved in determining code compliance with this chapter is done during the plan review stage, thereby establishing a focal point for energy-related code enforcement.

A completely new, stand-alone chapter for one- and two-family dwellings, townhomes and low-rise, multiple-family residential buildings was added to the 2000 IECC. The new chapter, titled "Simplified Prescriptive Requirements for Residential Buildings," creates a platform for technical coordination of related energy conservation provisions in the *International Residential Code*® (IRC®).

The 2006 edition of the code represents another monumental edition in the development of the energy code. Between the 2003 and 2006 editions a major effort was made by the DOE and other interested parties to dramatically simplify the code. This effort was done to encourage and improve the enforcement of the provisions. The intention was that at a national level the overall energy requirements would be similar to those of the 2003 edition. The belief was that with an easier-to-understand code there would be additional adoptions and improved enforcement that would then result in a large savings of energy. Primarily, these changes affected the administrative provisions, the introduction of new climate zones and the complete replacement of the residential provisions. While this process was occurring, a similar effort of simplification was being led by others to address the commercial requirements. This overall effort resulted in an easier-to-understand document that was about one-third of the size of the previous edition.

Purpose

Though not stated specifically, this code is applicable to all buildings and structures and their components and systems that use energy primarily for human comfort. The code does not regulate the energy for industrial equipment for manufacturing or that needed for items like computers or coffee pots. The code, therefore, addresses the design of energy-efficient building envelopes and the selection and installation of energy-efficient mechanical, service water heating, electrical distribution and illumination systems and equipment in residential and commercial buildings alike [see Figures 1(1) and 1(2), respectively].

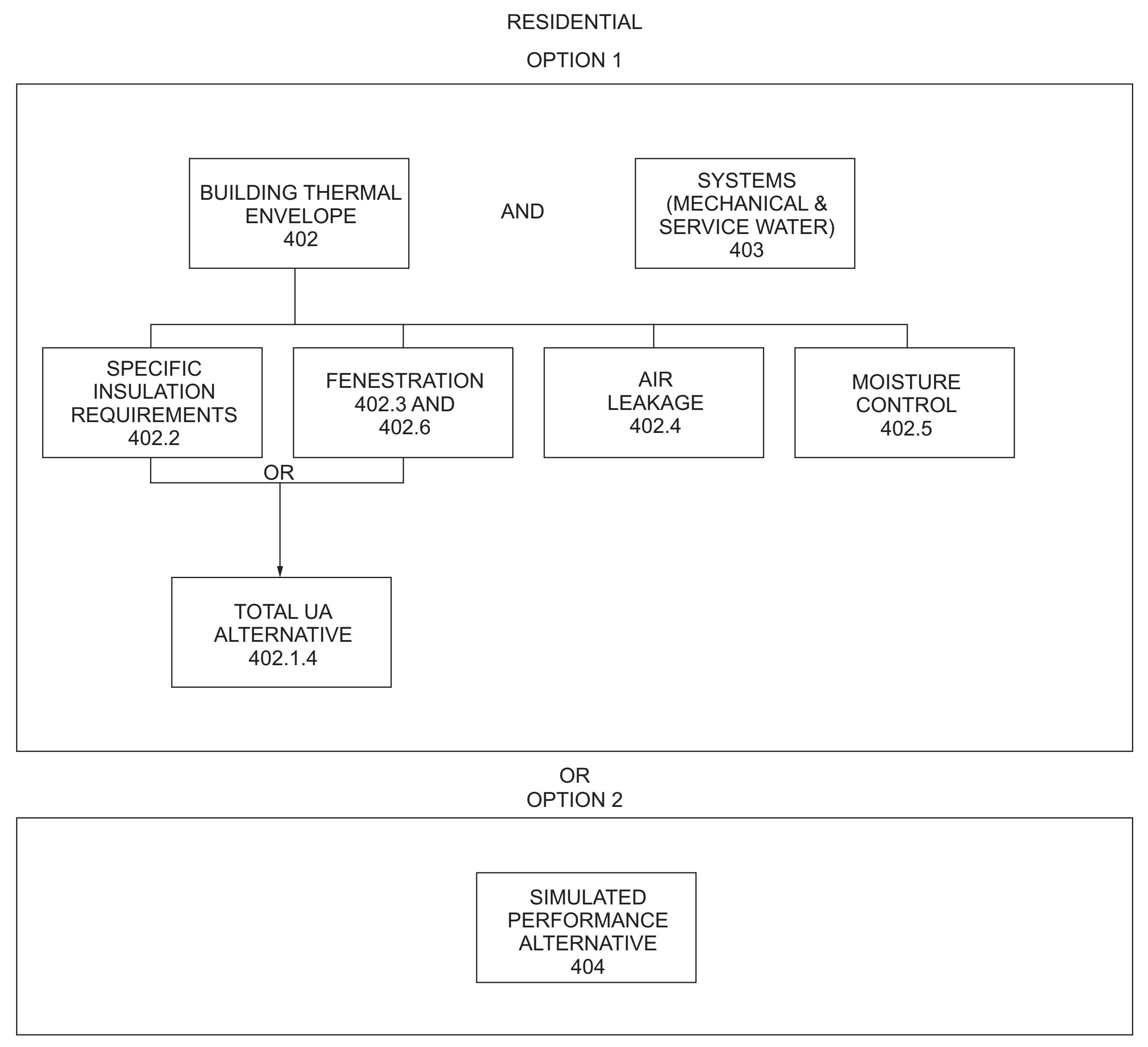


Figure 1(1)
IECC SCOPE AND APPLICATION ABSTRACT—RESIDENTIAL

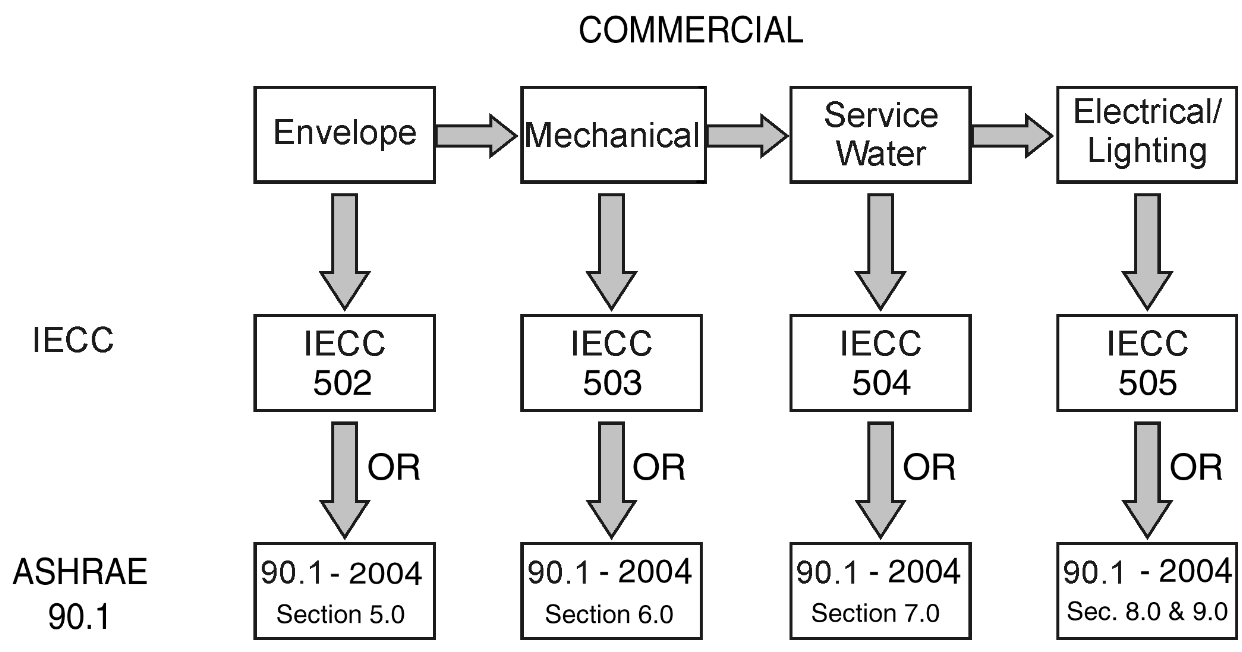


Figure 1(2)
IECC SCOPE AND APPLICATION ABSTRACT—COMMERCIAL

SECTION 101
SCOPE AND GENERAL REQUIREMENTS

101.1 Title. This code shall be known as the *International Energy Conservation Code* of [NAME OF JURISDICTION], and shall be cited as such. It is referred to herein as "this code."

❖ This section directs the adopting jurisdiction to insert the name of the jurisdiction into the code. Because the IECC is a "model" code, it is not an enforceable document until it is adopted by a jurisdiction or agency that has enforcement powers.

101.2 Scope. This code applies to residential and commercial buildings.

❖ The definitions for "Residential" and "Commercial" buildings will be important in correctly applying the provisions of the code. See the commentary related to the definitions in Chapter 2. Additional discussion will also be found in Chapters 4 and 5 of the commentary.

101.3 Intent. This code shall regulate the design and construction of buildings for the effective use of energy. This code is intended to provide flexibility to permit the use of innovative approaches and techniques to achieve the effective use of energy. This code is not intended to abridge safety, health or environmental requirements contained in other applicable codes or ordinances.

❖ This code is broad in its application, yet specific to regulating the use of energy in buildings where that energy is used primarily for human comfort or heating and cooling of a building to protect the contents. Thus, energy used for commercial or industrial processing is to be considered exempt from the code because that energy is not used for human comfort or conditioning the space. In general, the requirements of the code address the design of all building systems that affect the visual and thermal comfort of the occupants, including:

- Lighting systems and controls.
- Wall, roof and floor insulation.
- Windows and skylights.
- Cooling equipment (air conditioners, chillers and cooling towers).
- Heating equipment (boilers, furnaces and heat pumps).
- Pumps, piping and liquid circulation systems.
- Supply and return fans.
- Service hot water systems (kitchens and lavatories).
- Permanent electric motors (e.g., elevators and escalators).

It does not address the energy used by office equipment such as personal computers, copy machines, printers, fax machines and coffee makers. Nor does it address kitchen equipment in restaurants, commercial kitchens and cafeterias, although water heating, lighting and HVAC energy uses in these types of spaces are covered.

The intent of the code is to define requirements for the portions of a building and building systems that affect energy use in new construction and to promote the effective use of energy. Where code application for a specific situation is in question, the authority having jurisdiction in buildings should favor the action that will promote the effective use of energy. The code official may also consider the cost of the required action compared to the energy that will be saved over the life of that action.

This statement supports flexibility in application of the code requirements. Although many of the requirements are given in a prescriptive format for ease of use, it is not the intent of the code to stifle innovation—especially innovative techniques that conserve energy. Innovative approaches that lead to energy efficiency should be encouraged, even if the approach is not specifically listed in the code or does not meet the strict letter of the code. This principle should be applied to methods for determining compliance with the code and the building construction techniques used to meet the code.

Any design should first be evaluated to see whether it meets the code requirements directly. If an innovative approach is preferred, the applicant is responsible for demonstrating that the innovative concept promotes energy efficiency. Where the literal code requirements have not been satisfied but the applicant claims to meet the intent, the code official will likely have to exercise professional judgment to determine whether the proposed design meets the intent of the code in the interest of energy efficiency (see commentary, Section 103).

101.4 Applicability.

101.4.1 Existing buildings. Except as specified in this chapter, this code shall not be used to require the removal, alteration or abandonment of, nor prevent the continued use and maintenance of, an existing building or building system lawfully in existence at the time of adoption of this code.

❖ The code is designed to regulate new construction and new work and is not intended to be applied retroactively to existing buildings except where existing envelope, lighting, mechanical or service water heating systems are specifically affected by Section 101.4.3.

This section addresses the fact that, in general, the code does not affect existing buildings. It will permit an addition to be made to an existing building without requiring the existing building to conform to the IECC. In such a case, the addition is expected to comply with the current code, but it will not require changes for the existing portion. Therefore, this code does not apply retroactively to existing buildings. When an existing building is modified by an addition, alteration, renovation or repair, Section 101.4.3 will provide the guidance and requirements for such changes.

101.4.2 Historic buildings. Any building or structure that is listed in the State or National Register of Historic Places; designated as a historic property under local or state designation law or survey; certified as a contributing resource with a National Register listed or locally designated historic district; or with an opinion or certification that the property is eligible to be listed on the National or State Registers of Historic Places either individually or as a contributing building to a historic district by the State Historic Preservation Officer or the Keeper of the National Register of Historic Places, are exempt from this code.

❖ In some aspects this is a bit of a continuation of the "existing building" provisions but it goes even farther—historic buildings are exempt. In earlier editions of the code, this exemption applied only to the exterior envelope of such buildings, and to the interior only in those cases where the ordinance explicitly designated elements of the interior. With the current text, historic buildings are exempt from all aspects of the code. This exemption, however, is not without conditions. The most important criterion for application of this section is that the building must be specifically classified as being of historic significance by a qualified party or agency. Usually this is done by a state or local authority after considerable scrutiny of the historical value of the building. Most, if not all, states have authorities, such as a landmark commission, as do many local jurisdictions.

Due to the unique issues involved, historic buildings are exempt from the requirements of the code. This exemption could be extended to include all parts that are "historic," additions, alterations and repairs that would normally be addressed by Section 101.4.3. If the addition, alteration or renovation is not "historic," then the provisions of Section 101.4.3 should be applied. Consideration of energy conservation and compliance with the code is still of value in historic buildings. In exempting historic buildings, the code is simply recognizing that energy efficiency may be difficult to accomplish while maintaining the "historic" nature of the building.

101.4.3 Additions, alterations, renovations or repairs. Additions, alterations, renovations or repairs to an existing building, building system or portion thereof shall conform to the provisions of this code as they relate to new construction without requiring the unaltered portion(s) of the existing building or building system to comply with this code. Additions, alterations, renovations, or repairs shall not create an unsafe or hazardous condition or overload existing building systems.

Exception: The following need not comply provided the energy use of the building is not increased:

1. Storm windows installed over existing fenestration.
2. Glass only replacements in an existing sash and frame.

3. Existing ceiling, wall or floor cavities exposed during construction provided that these cavities are filled with insulation.

4. Construction where the existing roof, wall or floor cavity is not exposed.

❖ Simply stated, new work must comply with the current requirements for new work. Any alteration or addition to an existing system involving new work is subject to the requirements of the code. Additions or alterations can place additional loads or different demands on an existing system and those loads or demands could necessitate changing all or part of the existing system. Additions and alterations must not cause an existing system to be any less in compliance with the code than it was before the changes.

Additions to existing buildings must comply with the code when the addition is within the scope of the code and would not otherwise be exempted (see code text and commentary, Sections 101.4 and 101.5.2). Additions include new construction, such as a conditioned bedroom, sun space or enclosed porch added to an existing building. Additions also include existing spaces converted from unconditioned or exempt spaces to conditioned spaces. For example, a finished basement, an attic converted to a bedroom or a carport converted to a den are additions. The addition of an unconditioned garage would not be considered within the scope of the code because the code applies to heated or cooled (conditioned) spaces.

Although not specifically defined in the code, building codes typically define an "Addition" as any increase in a building's habitable floor area (which can be interpreted as any increase in the conditioned floor area). For example, an unconditioned garage converted to a bedroom is an addition. If a conditioned floor area is expanded, such as a room made larger by moving out a wall, only the newly conditioned space must meet the code. A flat window added to a room does not increase the conditioned space and thus is not an addition by this definition. If several changes are made to a building at the same time, only the changes that expand the conditioned floor area are required to meet the code. The addition (the newly conditioned floor space) complies with the code if it complies with all of the applicable requirements in either Chapter 4 or 5. For example, requirements applicable to the addition of a new room would most likely include insulating the exterior walls, ceiling and floor to the levels specified in the code; sealing all joints and penetrations; installing a vapor retarder in unventilated frame walls, floors and ceilings; identifying installed insulation *R*-values and window *U*-factors; and insulating and sealing any ducts passing through unconditioned portions or within exterior envelope components (walls, ceilings or floors) of the new space. Compliance approaches for additions include:

1. The entire building (the existing building plus the addition) complies with the code. If the building inclusive of the addition complies with the code, the addition will also comply, regardless of whether the addition complies alone. For example, a sunroom that does not comply with the code is added to a house. If the entire house (with the sunroom) complies, the addition also complies.

2. Where approved by the code official the addition, including possible concurrent renovation, does not result in any increase in the building's overall area-weighted thermal transmittance (*UA*), or otherwise any increase in annual demand for either fossil fuel or electrical energy supply. The change in *UA* or energy use can be quantified using any of the commonly used hourly, full-year simulation tools. For example, additions that add rooms while simultaneously upgrading existing HVAC systems, windows and insulation often reduce the annual energy use or *UA* of the existing part of the home, more than offsetting the energy use attributed to the added space in the home.

3. The addition itself can comply with the prescriptive methods found within either Chapter 4 or 5. This would be permitted due to the provisions of Sections 101.4.1 and 101.4.3. These provisions provide a simple, prescriptive specification menu for each climate zone that, if followed, will yield a building envelope meeting the requirements of either Table 402.1.1 or 502.2(1). The components of the building addition must meet the insulation *R*-values, fenestration *U*-factors and SHGC requirements shown in Table 402.1.1 or 502.2(1).

An existing energy-using system (envelope, mechanical, service water heating, electrical distribution or lighting) is generally considered to be "grandfathered" with code adoption if the criteria for this level are the regulations (or code) under which the existing building was originally constructed. It should be noted that a specific level of safety is dictated by provisions dealing with hazard abatement in existing buildings and maintenance provisions, as contained in the code, the *International Property Maintenance Code*® (IPMC®) and the *International Fire Code*® (IFC®).

The exceptions address situations where the alteration or repair of a structure or element are not required to comply with the provisions of the code. Some of these situations are typically either a normal part of on-going maintenance of the building, would improve the performance or would not present an opportunity for improved energy savings. All of these exceptions are tied to the fact that they are permitted, provided "the energy use of the building is not increased."

Exception 1 is a fairly self-evident provision. First of all, due to the limited nature of the work, there is little opportunity to make additional changes. This helps to reinforce the statement from the main paragraph that the intent is not to make "the unaltered portions(s) of the existing building or building system" comply with the code. In this case the addition of a storm window over an existing window will only improve performance of the existing fenestration.

Exception 2 addresses situations where the neighbor kid hits a baseball through your window. When the glass is being replaced, it would not make sense to force an existing window to be changed out so that it could meet the current code requirements. While the existing window may not meet the correct *U*-factor for the climate zone, a replacement in kind should be permitted. Although this provision does not place any requirement on the replacement glass, it would be best if the new glazing at least matched what had been existing. If the replacement is done with a less-efficient glazing product there could be future problems with excessive heating or cooling through the glass or even an increase with condensation and moisture problems. Therefore, if the removed glass was a double-pane, low-E glass, it would be unwise (though possibly not prohibited) to replace it with a single-pane of regular glass. In this situation, the code official would be able to invoke the fact that the exception is acceptable, provided the energy use of the building is not increased and request either an equivalent product or documentation to show that the proposed product will not create an increased demand.

Exception 3 is important for a couple of the limitations that it contains. First of all, the provision only applies when the ceiling, wall or floor cavity is "exposed during construction." Therefore, if the cavity is not opened up, then there is no requirement to do anything. If the cavity is exposed, the requirement will only be to "fill" it with insulation. Therefore, the level of insulation is not required to comply with the building thermal envelope requirements, but is instead only required to be "filled" with any type of insulation and not to any specific *R*-value.

Exception 4 will exempt the need to make changes to the building thermal envelope because the building cavities are not exposed.

101.4.4 Change in occupancy. Buildings undergoing a change in occupancy that would result in an increase in demand for either fossil fuel or electrical energy shall comply with this code.

❖ When a building undergoes a change of occupancy, energy-using systems (envelope, mechanical, service water heating, electrical distribution or illumination) must be evaluated to determine the effect the change of occupancy has on system performance and energy use. For example, if a mercantile building were converted to a restaurant, additional ventilation would be required for the public based on the increased occupant load. If an existing system serves an occupancy that is different from the occupancy it served when the code went into effect, the mechanical system must comply with the applicable code requirements for a mechanical system serving the newer occupancy. Depending on the nature of the previous occupancy, changing a building's occupancy classification could result in a change to the mechanical, service water heating, electrical distribution or illumination systems or any combination of these.

Buildings undergoing a change of occupancy must meet the applicable requirements of the code when peak demand is increased. For example, if a hotel is converted to multiple-family residential use and the conversion results in an increase in the building's peak connected load (space conditioning, lighting or service water heating), the entire building must be brought into compliance.

When the occupancy changes in a portion of an existing building (residential or commercial) and the new occupancy results in an increase in the peak demand for either fossil fuel or electrical energy supply, the portion of the building associated with the new occupancy must meet the code.

When a permittee claims that a change in occupancy will not increase the peak design rate of energy use for the building, it is the applicant's responsibility to demonstrate that the peak load of the converted building will not exceed the peak load of the original building. Without supporting documentation, the peak load generally must be assumed to increase with a change in occupancy.

It is also important that users realize that under this code there can be a difference between the "change of occupancy" (the way a building is used) and what the *International Building Code*® (IBC®) deals with when a change of occupancy "classification" occurs. Therefore, if a storage building that has no heating or cooling is modified so that the building is heated to prevent the stock items from freezing, the IBC would not consider this as a "change of occupancy" because the occupancy classification would still be a Group S-1. The code would consider this a change in occupancy because the way the building is used would change and it would result in an increase in the demand for energy.

101.4.5 Mixed occupancy. Where a building includes both residential and commercial occupancies, each occupancy shall be separately considered and meet the applicable provisions of Chapter 4 for residential and Chapter 5 for commercial.

❖ A mixed-occupancy building is one that contains both residential and commercial uses (see definitions within Chapter 2). When residential and commercial uses coexist in a building, each occupancy must be evaluated separately. One tool that is sometimes used in situations where the majority of the space is one occupancy and only a small portion of the floor is different, is the accessory area requirements that are found within the IBC. For example, the residential portions of that story must meet the residential requirements of the code, unless 90 percent or more of the floor level is commercial, in which case, the story in question, inclusive of the 10-percent residential, may, with the code official's approval, be considered commercial.

For example, consider the three-story apartment building in Figure 101.4.5, with a portion of the first story leased out to a convenience store (a commercial use). The top two stories are clearly residential because they are devoted solely to residential use and the building is not over three stories high. Though not found within the code, the first story could generally be considered all residential if 10 percent or less of the total floor area is occupied by the store. In this case, the entire first floor is subject to the residential portions of the code. When more than 10 percent of the first story is occupied by the store, the first story is considered a mixed occupancy; the portion of the first story occupied by the store is considered commercial and is subject to the applicable commercial requirements in Chapter 5. The remainder of the first story is considered residential and must meet the residential requirements found in Chapter 4.

Consider another conceivable situation in which the first story of a four-story building may be one or more retail establishments (or other commercial use). Consider that the remaining stories of this four-story building consist entirely of dwelling units and are classified as residential. This and similar situations can cause confusion over how to apply the code. Is this a commercial building because it is over three stories high, or is it a residential building because it has three stories of dwelling units?

For our current example, the definition of “Residential” makes it clear that the entire building would be considered commercial and be subject to the requirements of Chapter 5. The approach is based on the fact that the patterns of energy use generally change in buildings four stories or greater in height, and that the code, as well as its predecessor MEC versions, limit residential buildings to a maximum height of three stories above grade. Any structure over three stories is considered a commercial building for purposes of applying the code, regardless of the occupancy classification of the structure. The only exception to this distinction would be single-family or duplex detached residences four stories or greater in height, which is considered rare. See also the definitions and commentary for “Commercial building” and “Residential building” to help clarify the application of the code to mixed-occupancy buildings.

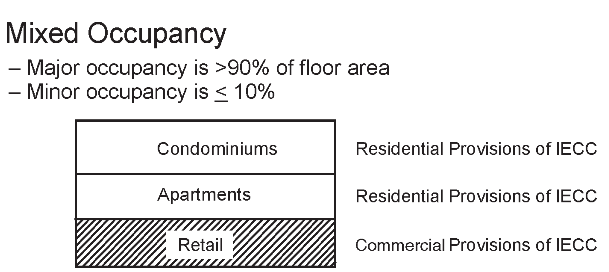


Figure 101.4.5
MIXED OCCUPANCY

101.5 Compliance. Residential buildings shall meet the provisions of Chapter 4. Commercial buildings shall meet the provisions of Chapter 5.

❖ As shown in Figure 1(1), the code contains three alternative design procedures for detached one- and two-family dwellings and low-rise residential buildings three stories or less in height. For commercial and high-rise residential buildings, the technical requirements of either Chapter 5 of the code or ASHRAE 90.1 (by way of being a reference standard in Section 501.1) are to be used to establish compliance with the energy conservation requirements of the code. This section provides the scoping to the various sections and methods of compliance within the code.

Residential

Residential buildings include all one- and two-family dwellings and all multiple-family residential buildings three stories or less in height above grade. The following is an overview of the residential design methods available in this code:

Chapter 4 provides three different methods that can be used to determine building thermal envelope requirements and it also contains a performance method where the overall compliance with the code can be demonstrated. These various methods provide options that will allow the designer or builder to demonstrate compliance with the code. The methods vary in their level of sophistication from the prescriptive (“just tell me what is required”) up to the performance (“trade-off” or “systems analysis”) approach. Therefore, the designer may use whichever option works the best for him or her or is simply easiest for him or her to use.

Most of Chapter 4 focuses on building envelope requirements such as insulation and windows. The building envelope is defined by those elements of a building that enclose conditioned space through which heat is transferred. Unconditioned garages, attics and crawl spaces are considered outside the building envelope. The insulation requirement for each building envelope component is based on the jurisdiction’s climate zone and the type of component (walls, roof/ceiling assemblies, floors over unconditioned spaces, basement walls, etc.). Under the prescriptive method, building envelope compliance for one- and two-family and low-rise multiple-family residential buildings can be demonstrated using any one of the three compliance methods:

The easiest way to comply with the insulation requirements found in Table 402.1.1 is by making each of the walls, floors and ceilings meet the specified *R*-value (see Sections 402.1.1 and 402.1.2). For those code users familiar with the 2003 and older editions, this was called the “Compliance by Performance on an Individual Component Basis.” This envelope compliance method states specific insulation requirements for each building envelope component based on building type and the climate zone for the jurisdiction.

If the designer wishes, he or she may use the "*U*-factor alternative" from Section 402.1.3. This method will require additional effort and calculations, but it will also allow the assemblies effectiveness to include not only the value of the insulation, but also the added value from other building materials or air films. See the commentary for Section 402.1.3 for additional discussion.

The last of the general "prescriptive" options for demonstrating building thermal envelope compliance is found in Section 402.1.4. This is the most complex of the three envelope compliance options, but it also provides the greatest flexibility for the designer. Under this method, it would be possible to have portions of the envelope that do not comply with the required insulation levels as long as other portions are increased to offset the difference. Prior to the 2006 code, this was called the "Compliance by Total Building Envelope Performance" method:

Using this option, a proposed design's component *U*-factors or *R*-values may vary from the required values when demonstrating compliance by total building envelope performance. This is often referred to as the "trade-off approach" Using the trade-off approach, the insulating value of an envelope component where the thermal performance level may fall short of meeting the individual component requirement may be "traded off" for another envelope component in the same building having a thermal performance level better than the code's individual component requirement. Trade-off calculations are based on the total area-weighted thermal transmittance, or *UA*, for the whole building. The *UA* is the sum of the component's *U*-factor times the area (*A*) for each building envelope component. Accordingly, the building design can be shown to comply with the code if the resultant total *UA* of the proposed design is no greater than the total *UA* of that same building insulated to just meet the individual component criteria of Chapter 4.

Section 404 provides an alternative way to meet the code's goal of effective use of energy based on showing the predicted annual energy use of a proposed design is less than or equal to that of the same home if it had been built to meet the "standard reference design," which uses prescriptive criteria specified within Table 404.5.2(1). Section 404 does not prescribe a single set of requirements. Rather, it provides a process to reach the energy-efficiency goal based on establishing equivalence with the intent of the code. Because of the level of detail required in the analysis, this method of design is not often used for residential buildings.

There are two fundamental requirements for using Section 404. First, compliance is based on total estimated annual energy usage across all energy-using systems in a building: envelope, lighting, mechanical and service water heating. Second, Section 404 compares the energy use of the proposed design to that of a hypothetical "standard reference design." The standard design is the same building design as that proposed, except that the energy features required by the code (insulation, windows, HVAC, infiltration) are established and are deemed to be the minimum requirements in this option. The standard design is used only for comparison, and is never actually built.

The "simulated performance alternative" of Section 404 sets both general principles and specific guidelines for use in computing the estimated annual energy use of the proposed and standard designs. These guidelines are necessary to maintain fairness and consistency between the proposed and standard designs. Although this alternative analysis method is the most complex method, it gives the design professional the flexibility to introduce exterior walls, roof/ceiling components, etc., that do not meet the prescriptive requirements of Sections 402 and 403, but are considered acceptable where the annual energy use of the proposed building is equal to or less than that of the standard design building. Envelope features that lower energy consumption (window orientation, passive-solar features or the use of "cool" reflective roofing products in cooling-dominated climates) and mechanical, electrical and service water heating systems that are more efficient than those required by the "standard reference design" are used to offset the potentially high thermal transmittance of an innovative exterior envelope design in this instance.

The performance method also allows energy supplied by renewable energy sources to be discounted from the total energy consumption of the proposed design building. Because renewable energy comes from nondepletable sources such as solar radiation, wind, plant byproducts and geothermal sources, its use is not counted as part of the proposed building's energy use.

Commercial

The following is an overview of the commercial design methods available in the code: commercial buildings include all buildings except one- and two-family dwellings and low-rise, multiple-family residential buildings.

Chapter 5 of this code describes a simplified and enforceable alternative to ASHRAE 90.1 for all commercial buildings (for more on ASHRAE 90.1, see commentary, Section 501). Envelope compliance for commercial buildings having a glazing area no greater than 40 percent of the above-grade exterior wall area is demonstrated by using the prescriptive tables in Chapter 5. The tables set the minimum level of thermal performance required for building envelope (roof, floor and wall insulation as well as fenestration requirements) based on the building's climate zone location. For buildings having a glazing area greater than 40 percent of the above-grade exterior wall area, envelope compliance must be demonstrated in accordance with Section 506 or by using ASHRAE 90.1

(see Sections 501.1 and 501.2). Energy code compliance for mechanical systems and HVAC equipment is addressed in Section 503. Buildings served by mechanical systems and equipment not otherwise covered by Section 503 must be evaluated for energy code compliance using Section 506 or ASHRAE 90.1. Buildings with relatively simple lighting systems, manual switches, occupancy sensors and dimmers are to be evaluated using the lighting criteria for the entire building or each specific building area type as stated in Chapter 5.

When the prescriptive requirements of Chapter 5 are used, each major energy-using subsystem (envelope, mechanical, lighting, service water heating) must comply. Simply put, when a candidate commercial building (or building system) does not meet the prescriptive commercial building criteria in Sections 501, 502, 503, 504 and 505 individually, the candidate building (or building system) must demonstrate compliance under Section 506 or ASHRAE 90.1. For innovative commercial and high-rise residential building designs or where more technically sophisticated building envelope, mechanical and lighting systems serve standard building types, consult the applicable requirements of ASHRAE 90.1 as adopted by reference in Section 501 of the code.

Buildings evaluated for compliance under ASHRAE 90.1 must be designed for the code's basic requirements and either the system/component or the energy-cost budget (ECB) method to show compliance. These design methods are comprehensive and somewhat complex. In fact, the requisite calculations are usually done by design professionals who have extensive experience with detailed energy conservation trade-offs and design methods.

Using the ECB method, proposed designs may use varying amounts and different forms of energy, with total annual energy cost (rather than annual energy usage) as the limiting design parameter. Using the system/component method, either prescriptive or system performance criteria may be used for lighting or exterior envelope compliance or both, whereas mechanical system compliance is evaluated using only prescriptive criteria.

Note that Section 506 includes a simplified alternative to meeting the ECB methods prescribed by the 90.1 Standard as based on total building performance. In addition to being an alternative building performance approach to that contained in Section 11 of the 90.1 Standard, Section 506 now provides a performance-based approach that, if followed, will result in a building design that complies with both this code and the 90.1 Standard.

Using the provisions of Section 506, it is possible to establish the annual energy use and cost for a proposed design assuming that it just satisfies the minimum requirements in Chapter 5. This information can form the basis for evaluating proposed designs based on total building performance. This concept is consistent with the provisions in Chapter 1 of other *International Codes* as well as Section 13 of ASHRAE 90.1.

101.5.1 Compliance materials. The code official shall be permitted to approve specific computer software, worksheets, compliance manuals and other similar materials that meet the intent of this code.

❖ As mentioned in Section 101.3, the code intends to permit the use of innovative approaches and techniques, provided that they result in the effective use of energy. This section simply recognizes that there are many federal, state and local programs as well as computer software that deal with energy efficiency. Therefore, the code simply states that the code official does have the authority to accept those methods of compliance, provided that they meet the intent of the code. Some of the easiest examples to illustrate this provision are the REScheck and COMcheck software that are put out by the U.S. DOE. An example of the other programs that may be deemed acceptable by the code official is the Energy Star® program. Energy Star homes for example are required to be 15 percent more efficient than homes built to the residential energy provisions of Chapter 11 of the IRC, which is very nearly identical to the prescriptive provisions of Chapter 4 of the code. Since the Energy Star homes are more efficient than the *International Codes* require, it would be reasonable for a code official to accept those homes as meeting the intent of the code.

101.5.2 Low energy buildings. The following buildings, or portions thereof, separated from the remainder of the building by building thermal envelope assemblies complying with this code shall be exempt from the building thermal envelope provisions of this code:

1. Those with a peak design rate of energy usage less than 3.4 Btu/h·ft² (10.7 W/m²) or 1.0 watt/ft² (10.7 W/m²) of floor area for space conditioning purposes.
2. Those that do not contain conditioned space.

❖ This section stipulates the conditions that permit a building or structure or portion of a building or structure to be exempt from the code based on the marginal energy savings potential of such low-energy-use structures. This section also shows that there is no justification for exempting building, mechanical, service water heating or lighting systems from the applicable criteria of the code simply because the building is not heated or cooled or is partially conditioned. Building, mechanical, service water heating and lighting systems and their subsystems are no less an energy conservation opportunity just because the building or space is unconditioned. Thus, for the buildings that follow in Items 1 and 2, the exemption is intended to apply only to the building thermal envelope requirements.

Item 1 exempts buildings and portions of buildings with low summer and winter peak rates of energy use [below 3.4 Btu/h·ft² or 1.0 W/ft² (10.7 W/m²)]. The phraseology, "a peak design rate of energy usage for space conditioning purposes," refers to the total peak primary energy used for space conditioning, service water heating and lighting for all fuels (electrical, gas, oil, propane, hydrogen, etc.). For example, consider a 100-square-foot (9.3 m^2) building with no space conditioning system and having a 100 watt lightbulb installed for interior lighting. This building is right at the threshold of 1.0 W/ft^2 (100 watts/100 ft^2 = 1.0 W/ft^2).

Thus, the addition of any space-conditioning equipment that uses more energy than the 100 watt light bulb would require code compliance. The peak rating of an appliance or piece of equipment can be determined by its nameplate rating or the manufacturer's literature.

Energy from on-site solar, on-site hydroelectric, on-site wind or other nondepletable, renewable source producing energy at the end-user's facility (or site) is excluded from the peak rate of energy use. (Renewable energy is considered energy that is not purchased. Nonrenewable, or conventional energy, is energy that is purchased, often from a utility service provider, co-op or municipal power authority. See the definition of "Energy cost" in Chapter 2) Conventional energy associated with the collection of renewable energy, such as energy used by the pumps and fans serving a solar collector, is included in the peak rate of energy use. When a home has both renewable and conventional systems, the peak rate includes the conventional systems even if the occupants primarily intend to use the renewable systems.

Few buildings designed for human occupancy will qualify for this exemption. The exemption generally applies only to buildings without heating or cooling systems or portions of buildings that are not heated or cooled, such as unconditioned garages and storage facilities (see commentary, Item 2 below). If an exemption is claimed for a building, the permittee should provide enough supporting documentation to validate the claim. A list detailing all mechanical equipment, appliances and lighting must be submitted to justify exemption under this section. The list should specifically note the energy sources for heating, cooling, lighting and water heating, including the nameplate input capacities for HVAC and water heating equipment.

A potential problem can exist when claiming this exemption. It is easy to modify the use of a structure after occupancy without obtaining an additional permit, thereby producing a noncomplying structure. Although Section 101.4.4 will help regulate this problem, some building departments require a signed statement indicating that the permittee has claimed the exemption and that the structure will be brought into compliance with the code if its peak rate of energy use is raised above the maximum at any time thereafter. Each building department must consider what happens or is likely to happen within or to a structure after occupancy when granting this exemption.

Portions of buildings can also qualify for this exemption. Where a portion of a building meets the criteria for this exemption, that portion of the building is not required to comply with the requirements of the code to the extent that Section 101.5.2 permits. Other portions of the building, including the construction assemblies separating conditioned and unconditioned portions, define the limits of the building that must meet the code requirements.

Item 2 indicates that the thermal envelope requirements of the code do not apply to buildings or portions of buildings that are neither heated nor cooled to create a "conditioned space." Though not stated directly in the code, buildings with space-conditioning systems that use energy entirely from nondepletable, renewable sources are also exempt.

For a room or portion of a building to be considered neither heated nor cooled, the space must not contain:

1. A space-conditioning system designed to serve that space;
2. A space-conditioning register/diffuser or hydronic terminal unit serving the space; or
3. An uninsulated duct or pipe where one would normally be required to be insulated.

In the past, the code only considered a space as being "conditioned" when it was being heated or cooled to keep the temperature within the human comfort range. However, based on the definition for "Conditioned space," even a space that is heated only to a level to prevent the freezing of the contents would still be considered as a conditioned space and therefore unable to use the exemption this section provides. The space must also be physically separated from conditioned spaces by the building's thermal envelope. For example, a sunroom separated from the main house by an insulated door and wall is physically separated from the conditioned space. In this case, the door and wall separating the conditioned space from the sunroom are part of the building thermal envelope and must meet the code. In the case of a sunroom, Florida room, three-season room, etc., even a statement by the permittee that the space-conditioning system will not be used is not sufficient to demonstrate that a space qualifies for the "unconditioned" exception. Any type of added space conditioning system, such as a small portable heater, would affect compliance. See Chapter 2 and the definition for "Conditioned space."

SECTION 102
MATERIALS, SYSTEMS AND EQUIPMENT

102.1 Identification. Materials, systems and equipment shall be identified in a manner that will allow a determination of compliance with the applicable provisions of this code.

❖ The intent of this section is to make certain sufficient information exists to determine compliance with the code during the plan review and field inspection phases. The permittee can submit the required equipment and materials information on the building plans, specification sheets, schedules or in any other way that allows the code official to clearly identify which specifications apply to which portions of the building;

that is, which parts of the building are insulated to the levels listed. Materials information includes envelope insulation levels, glazing assembly *U*-factors and duct and piping insulation levels. Equipment information includes heating and cooling equipment and appliance efficiencies where high-efficiency equipment is claimed to meet code requirements.

This section contains specific material, equipment and system identification requirements for the approval and installation of the items required by the code. Although the means for permanent marking (tag, stencil, label, stamp, sticker, bar code, etc.) is often determined and applied by the manufacturer, if there is any uncertainty about the product, the mark is subject to the approval of the code official.

102.1.1 Building thermal envelope insulation. An *R*-value identification mark shall be applied by the manufacturer to each piece of building thermal envelope insulation 12 inches (305 mm) or greater in width. Alternately, the insulation installers shall provide a certification listing the type, manufacturer and *R*-value of insulation installed in each element of the building thermal envelope. For blown or sprayed insulation (fiberglass and cellulose), the initial installed thickness, settled thickness, settled *R*-value, installed density, coverage area and number of bags installed shall be listed on the certification. For sprayed polyurethane foam (SPF) insulation, the installed thickness of the areas covered and *R*-value of installed thickness shall be listed on the certification. The insulation installer shall sign, date and post the certification in a conspicuous location on the job site.

❖ The thermal performance of insulation is rated in terms of *R*-value. For products lacking an *R*-value identification, the installer (or builder) must provide the insulation performance data. For example, some insulation materials, such as foamed-in-place urethane, can be installed in wall, floor and cathedral ceiling cavities. These products are neither labeled, as is batt insulation, nor is it appropriate for them to be evaluated as required in the code for blown or sprayed insulation. However, the installer must certify the type, thickness and *R*-value of these materials.

The *R*-value of loose-fill insulation (blown or sprayed) is dependent on both the installed thickness and the installed density (number of bags used). Therefore, loose-fill insulation cannot be directly labeled by the manufacturer. Many blown insulation products carry a manufacturer's *R*-value guarantee when installed to a designated thickness, "inches = *R*-value." Blown insulation products lacking this manufacturer's guarantee can be subjected to special inspection and testing, what is referred to as "cookie cutting." Cookie cutting involves extracting a column of insulation with a cylinder to determine its density. The insulation depth and density must yield the specified *R*-value according to the manufacturer's bag label specification.

The code and Federal Trade Commission Rule 460 require that installers of insulation in homes, apartments and manufactured housing units report this information to the authority having jurisdiction in the form of a certification posted in a conspicuous location (see Figure 102.1.1).

102.1.1.1 Blown or sprayed roof/ceiling insulation. The thickness of blown in or sprayed roof/ceiling insulation (fiberglass or cellulose) shall be written in inches (mm) on markers that are installed at least one for every 300 square feet (28 m^2) throughout the attic space. The markers shall be affixed to the trusses or joists and marked with the minimum initial installed thickness with numbers a minimum of 1 inch (25 mm) in height. Each marker shall face the attic access opening. Spray polyurethane foam thickness and installed *R*-value shall be listed on certification provided by the insulation installer.

❖ To help verify the installed *R*-value of blown-in or spray-applied insulation, the installer must certify the following information in a signed statement posted in a conspicuous place (see Section 102.1.1):

- The type of insulation used and manufacturer.
- The insulation's coverage per bag (the number of bags required to result in a given *R*-value for a given area) as well as the settled *R*-value.
- The initial and settled thickness.
- The number of bags installed.

Under circumstances where the insulation *R*-value is guaranteed, only the initial thickness is required on the certification.

The provisions of this section help in demonstrating compliance and in enforcing the provisions found in Section 102.1.1. To assist with application and enforcement, loose-fill ceiling insulation also requires thickness markers that are attached to the framing and face the attic access. In a large space, markers placed evenly about every 17 feet (5182 mm) (with some markers at the edge of the space) will meet this requirement. For sprayed poly-urethane, such markers are not effective. When using this product, the code requires that the measured thickness and *R*-value be recorded on the certificate.

102.1.2 Insulation mark installation. Insulating materials shall be installed such that the manufacturer's *R*-value mark is readily observable upon inspection.

❖ For batt insulation, manufacturers' *R*-value designations and stripe codes are often printed directly on the insulation. Where possible, the insulation must be installed so these designations are readable. Backed floor batts can be installed with the designation against the underfloor, which means it would not be visible. In those cases, the *R*-value must be certified by the installer or be validated by some other means (see commentary, Section 102.1.1).

102.1.3 Fenestration product rating. *U*-factors of fenestration products (windows, doors and skylights) shall be determined in accordance with NFRC 100 by an accredited, independent laboratory, and labeled and certified by the manufacturer. Products lacking such a labeled *U*-factor shall be assigned a default *U*-factor from Table 102.1.3(1) or 102.1.3(2). The solar heat gain coefficient (SHGC) of glazed fenestration products (windows, glazed doors and skylights) shall be determined in accordance with NFRC 200 by an accredited, independent laboratory, and labeled and certified by the manufacturer. Products lacking such a labeled SHGC shall be assigned a default SHGC from Table 102.1.3(3).

❖ Until recently, the buyers of fenestration products received energy performance information in a variety of ways. Some manufacturers described performance by showing *R*-values of the glass. While the glass might have been a good performer, the rating did not include the effects of the frame. Other manufacturers touted the insulating value of different window components, but these, too, did not reflect total window system performance. When manufacturers rated the entire product, some used test laboratory measurements and others used computer calculations. Even among those using test laboratory reports, the test laboratories often tested the products under different procedures, making an “apples-to-apples” comparison difficult. The different rating methods confused builders and consumers. They also created headaches for manufacturers trying to differentiate the performance of their products from the performance of their competitors’ products.

The NFRC has developed a fenestration energy rat-

This Attic Has Been Insulated To

R- ☐

By A Professional Insulation Contractor

The insulation in this attic was installed by a qualified professional Contractor to the R-value stated above

Certificate of Insulation

BUILDING ADDRESS: ______________________________ ______________________________ ______________________________

Installation Date ______________

CONTRACTOR: ______________________________ ______________________________ ______________________________

License# ____________________

Area Insulated	R-Value	Installed Thickness	Settled Thickness	Installed Density	No. Bags	Sq. Ft.
Attic						
Walls						
Floors						

I, ____, (print name) certify that this residence/building has been insulated to the stated R-value and that the installation is in conformance with all applicable codes, standards, regulations and specifications.

Authorized Signature ____ Date ____________

Figure 102.1.1
SAMPLE CERTIFICATE OF INSULATION

(Logos courtesy of Cellulose Insulation Manufacturer’s Association, http:/cellulose.org, Insulation Contractors Association of North America, www.insulate.org, and North American Insulation Manufacturers Association, www.NAIMA.org) ing system based on whole-product performance. This accurately accounts for the energy-related effects of all the product's component parts, and prevents information about a single component from being compared in a misleading way to other whole-product properties. With energy ratings based on whole-product performance, NFRC helps builders, designers and consumers directly compare products with different construction details and attributes.

Products that have been rated by NFRC-approved testing laboratories and certified by NFRC accredited independent certification and inspection agencies carry a temporary and permanent label featuring the "NFRC-certified" mark. With this mark, the manufacturer stipulates that the energy performance of the product was determined according to NFRC rules and procedures.

By certifying and labeling their products, manufacturers are demonstrating their commitment to providing accurate energy and energy-related performance information. The code purposely sets the default values fairly high. This helps to encourage the use of products that have been tested and also ensures that products that have little energy savings value are not used inappropriately in the various climate zones. By setting the default value so high, it will also prevent someone from considering removing the label from a tested window and then using the default values. Therefore, the default values are most representative of the lower end of the energy-efficient products.

Products that are not NFRC certified and do not exactly match the specifications in Tables 102.1.3(1) and 102.1.3(2) must use the tabular specification for the product most closely resembling it. In the absence of tested *U*-factors, the default *U*-factor for doors containing glazing can be a combination of the glazing and door *U*-factor as described in the definition for "*U*-factor" (see commentary, Section 202, "*U*-factor"). The NFRC procedures determine *U*-factor and SHGC ratings based on the whole fenestration assembly [untested fenestration products have default *U*-factors and SHGC assigned as described in the commentary to [Tables 102.1.3(1) through 102.1.3(3)]. During construction inspection, the label on each glazing assembly should be checked for conformance to the *U*-factor specified on the approved plans. These labels must be left on the glazing until after the building has been inspected for compliance. A sample NFRC label is shown in Figure 102.1.3(1).

Products certified according to NFRC procedures are listed in the *Certified Products Directory*. The directory is published annually and contains energy performance information for over 1.4 million fenestration product options listed by over 450 manufacturers. When using the directory or shopping for NFRC-certified products, it is important to note that:

1. A product is considered to be NFRC certified only if it carries the NFRC label. Simply being listed in this directory is not enough.

2. The NFRC-certified mark does not signify that the product meets any energy-efficiency standards or criteria.

3. NFRC sets no minimum performance standards, nor does it mandate specific performance levels. Rather, NFRC ratings can be used to determine whether a product meets a state or local code or other performance requirement, and to compare the energy performance of different products during plan review. If you have questions about NFRC and its rating and labeling system, more information is available on the organization's website at www.nfrc.org. NFRC adopted a new energy performance label in 2005. It lists the manufacturer, describes the product, provides a source for additional information and includes ratings for one or more energy performance characteristics.

TABLE 102.1.3(1)
DEFAULT GLAZED FENESTRATION *U*-FACTOR

FRAME TYPE	SINGLE PANE	DOUBLE PANE	SKYLIGHT	
			Single	Double
Metal	1.20	0.80	2.00	1.30
Metal with Thermal Break	1.10	0.65	1.90	1.10
Nonmetal or Metal Clad	0.95	0.55	1.75	1.05
Glazed Block	0.60			

❖ The code offers an alternative to NFRC-certified glazed fenestration product *U*-factor ratings. In the absence of *U*-factors based on NFRC test procedures, the default *U*-factors in Table 102.1.3(1) must be used. When a composite of materials from two different product types is used, the code official should be consulted regarding how the product will be rated. Generally, the product must be assigned the higher *U*-factor, although an average based on the *U*-factors and areas may be acceptable in some cases.

The product cannot receive credit for a feature that cannot be seen. Because performance features such as argon-fill and low-emmissivity coatings for glass are not visually verifiable, they do not receive credit in the default tables. Tested *U*-factors for these windows are often lower, so using tested *U*-factors is to the applicant's advantage. Figure 102.1.3(2) illustrates visually verifiable window characteristics among other various window performance, function and cost considerations.

A single-glazed window with an installed storm window may be considered a double-glazed assembly and use the corresponding *U*-factor from the default table. For example, the *U*-factor 0.80 in Table 102.1.3(1) applies to a single-glazed, metal window without a thermal break (but with an installed storm window). If the storm window was not installed, the *U*-factor would be 1.20.

TABLE 102.1.3(2)
DEFAULT DOOR *U*-FACTORS

DOOR TYPE	*U*-FACTOR
Uninsulated Metal	1.20
Insulated Metal	0.60
Wood	0.50
Insulated, nonmetal edge, max 45% glazing, any glazing double pane	0.35

❖Door *U*-factors in Table 102.1.3(2) should be used wherever NFRC-certified ratings are not available. There are a few other aspects to note about doors. Opaque door *U*-factors must include the effects of the door edge and the frame. Calculating *U*-factors based on a cross section through the insulated portion is not acceptable. To take credit for a thermal break, the door must have a thermal break in both the door slab and in the frame. The values in the table are founded on principles established in the 1997 ASHRAE *Handbook of Fundamentals*.

TABLE 102.1.3(3)
DEFAULT GLAZED FENESTRATION SHGC

SINGLE GLAZED		DOUBLE GLAZED		GLAZED BLOCK
Clear	Tinted	Clear	Tinted	
0.8	0.7	0.7	0.6	0.6

❖This table offers an alternative to NFRC-certified SHGC values based on visually verifiable characteristics of the fenestration product. The SHGC is the fraction of incident solar radiation absorbed and directly transmitted by the window area, then subsequently reradiated, conducted or convected inward. SHGC is a ratio, expressed as a number between 0 and 1. The lower a window's SHGC, the less solar heat it transmits.

A SHGC of 0.40 or less is recommended in cooling-dominated climates (Climate Zones 1-3). In heating-dominated climates, a high SHGC increases passive solar gain for the heating, but reduces cooling season performance. A low SHGC improves cooling season performance, but reduces passive solar gains for heating.

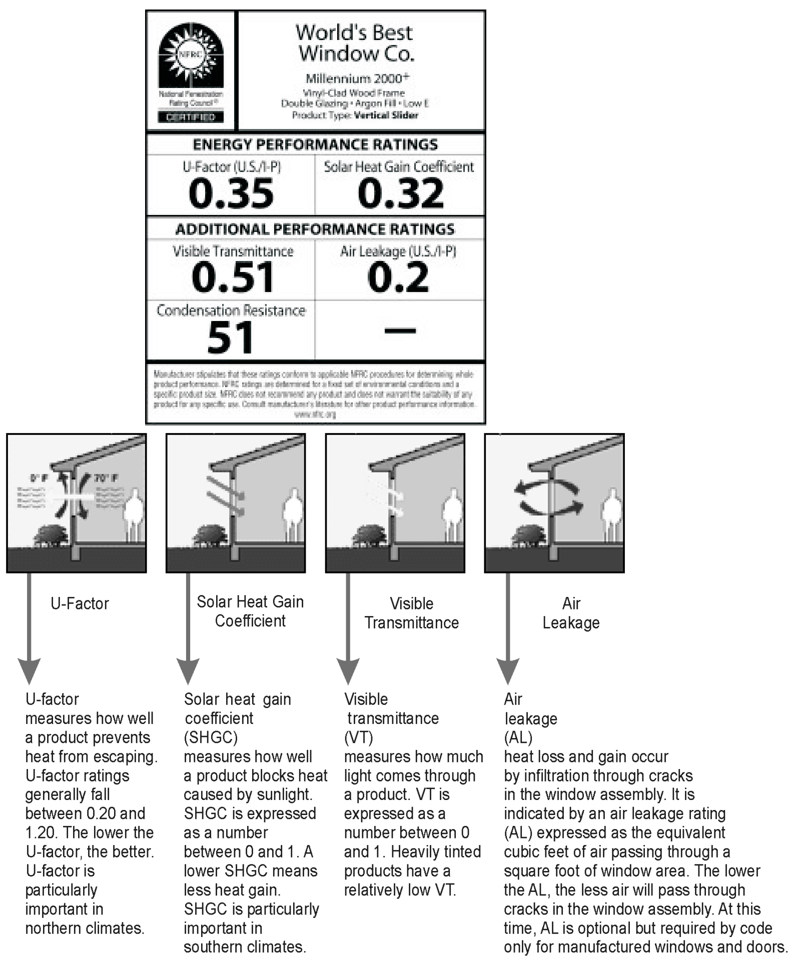
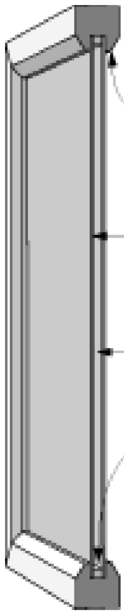


Figure 102.1.3(1)
SAMPLE NATIONAL FENESTRATION RATING COUNCIL (NFRC) LABEL

(Courtesy of National Fenestration Rating Council, www.NFRC.org)



Visually Verifiable Characteristics
- Size and shape
- Style
- Frame materials
- Glass color and clarity
- Single, double or triple-pane

Figure 102.1.3(2)
VISUALLY VERIFIABLE WINDOW CHARACTERISTICS

(Courtesy of Efficient Windows Collaborative, www.efficientwindows.org)

102.2 Installation. All materials, systems and equipment shall be installed in accordance with the manufacturer's installation instructions and the *International Building Code*.

❖ Manufacturer's installation instructions are thoroughly evaluated by the listing agency verifying that a safe installation is prescribed. When an appliance is tested to obtain a listing and label, the approval agency installs the appliance in accordance with the manufacturer's instructions. The appliance is tested under these conditions; thus, the installation instructions become an integral part of the labeling process. The listing agency can require that the manufacturer alter, delete or add information to the instructions as necessary to achieve compliance with applicable standards and code requirements.

Manufacturers' installation instructions are an enforceable extension of the code and must be in the hands of the code official when an inspection takes place. Inspectors must carefully and completely read and comprehend the manufacturer's instructions in order to properly perform an installation inspection. In some cases, the code will specifically address an installation requirement that is also addressed in the manufacturer's installation instructions. The code requirement may be the same or may exceed the requirement in the manufacturer's installation instructions. The manufacturer's installation instructions could contain requirements that exceed those in the code. In such cases, the more restrictive requirements would apply (see commentary, Section 107).

Even if an installation appears to be in compliance with the manufacturer's instructions, the installation cannot be completed or approved until all associated components, connections and systems that serve the appliance or equipment are also in compliance with the requirements of the applicable *International Code*(s) of reference. For example, a gas-fired boiler installation must not be approved if the boiler is connected to a deteriorated, undersized or otherwise unsafe chimney or vent. Likewise, the same installation must not be approved if the existing gas piping has insufficient capacity to supply the boiler load or if the electrical supply circuit is inadequate or unsafe.

Manufacturers' installation instructions are often updated and changed for various reasons, such as changes in the appliance, equipment or material design, revisions to the product standards and as a result of field experiences related to existing installations. The code official should stay abreast of any changes by reviewing the manufacturer's instructions for every installation.

102.2.1 Protection of exposed foundation insulation. Insulation applied to the exterior of basement walls, crawlspace walls and the perimeter of slab-on-grade floors shall have a rigid, opaque and weather-resistant protective covering to prevent the degradation of the insulation's thermal performance. The protective covering shall cover the exposed exterior insulation and extend a minimum of 6 inches (153 mm) below grade.

❖ The ultimate performance of insulation material is directly proportional to the workmanship involved in the materials' initial installation as well as the materials' integrity over the life of the structure. Accordingly, foundation wall and slab-edge insulation materials installed in the vicinity of the exterior grade line require protection from damage that could occur from contact by lawn mowing and maintenance equipment, garden hoses, garden tools, perimeter landscape materials, etc. In addition, the long-term thermal performance of foam-plastic insulation materials is adversely affected by direct exposure to the sun. To protect the insulation from sunlight and physical damage, it must have a protective covering that is inflexible, puncture resistant, opaque and weather resistant.

102.3 Maintenance information. Maintenance instructions shall be furnished for equipment and systems that require preventive maintenance. Required regular maintenance actions shall be clearly stated and incorporated on a readily accessible label. The label shall include the title or publication number for the operation and maintenance manual for that particular model and type of product.

❖ This section establishes an owner's responsibility for maintaining the building in accordance with the requirements of the code and other referenced standards. This section requires, among others, that mechanical and service water heating equipment and appliance maintenance information be made available to the owner/operator. This section does not require that labels be added to existing equipment; having the manufacturer's maintenance literature is usually sufficient to meet this requirement. During final occupancy inspection, the mechanical equipment and water heater should be inspected to verify that the information is taped to each unit or referenced on a label mounted in a conspicuous location on the units.

The code official has the authority to rule on the performance of maintenance work when equipment functions would be affected by such work. He or she also has the authority to require a building and its energy-using systems to be maintained in compliance with the public health and safety provisions required by other *International Codes*.

SECTION 103
ALTERNATE MATERIALS—METHOD OF CONSTRUCTION, DESIGN OR INSULATING SYSTEMS

103.1 General. This code is not intended to prevent the use of any material, method of construction, design or insulating system not specifically prescribed herein, provided that such construction, design or insulating system has been approved by the code official as meeting the intent of this code.

❖ This section reinforces Section 101.3, which states that the code is meant to be flexible, as long as the intent of the proposed alternative is to promote the effective use of energy. The code is not intended to inhibit innovative ideas or technological advances. A comprehensive regulatory document such as an energy code cannot envision and then address all future innovations in the industry. As a result, a performance code must be applicable to and provide a basis for the approval of an increasing number of newly developed, innovative materials, systems and methods for which no code text or referenced standards yet exist. The fact that a material, product or method of construction is not addressed in the code is not an indication that the material, product or method is prohibited.

The code official is expected to apply sound technical judgment in accepting materials, systems or methods that, while not anticipated by the drafters of the current code text, can be demonstrated to offer equivalent or better performance. By virtue of its text, the code regulates new and innovative construction practices while addressing the relative safety of building occupants. The code official is responsible for determining whether a requested alternative provides the equivalent level of protection of the public health, safety and welfare as required by the code.

103.1.1 Above code programs. The code official or other authority having jurisdiction shall be permitted to deem a national, state or local energy efficiency program to exceed the energy efficiency required by this code. Buildings approved in writing by such an energy efficiency program shall be considered in compliance with this code.

❖ The purpose of this section is to specifically state that the code official does have the authority to review and accept compliance with another energy program that may exceed that required by the code This provision really is a continuation of the provisions stated in Sections 101.3 and 103.1 and the fact that the code does intend to accept alternatives as long as the end result is an energy efficient building that is comparable or better to that required by the code.

This is also a good section to help reinforce the fact that the IECC as a model code is a "minimum" code. Therefore, it establishes the minimum requirement that must be met and that anything that exceeds that level is permitted. For example, the Energy Star program that is established by the U.S Environmental Protection Agency (EPA) and U.S. DOE requires that buildings be 15 percent more energy efficient than the IRC energy provisions, which are essentially equivalent to Chapter 4 of the code. Therefore, it would be permissible for the code official to approve a home that complies with the Energy Star program as being acceptable and meeting the requirements of this code.

While "above code programs" are acceptable because they do exceed the "minimum" requirements of the code, it would not be proper to require compliance with such "above code" programs. Besides the code being the minimum level of acceptable energy efficiency, it is also the maximum efficiency that the code official can require. A building built to the absolute minimum requirement is also the maximum that the code official can demand. It is perfectly acceptable for a designer or builder to exceed the code requirements, but it is not proper for the code official to demand such higher performance.

SECTION 104
CONSTRUCTION DOCUMENTS

104.1 General. Construction documents and other supporting data shall be submitted in one or more sets with each application for a permit. The code official is authorized to require necessary construction documents to be prepared by a registered design professional.

> **Exception:** The code official is authorized to waive the requirements for construction documents or other supporting data if the code official determines they are not necessary to confirm compliance with this code.

❖ In most jurisdictions, the permit application must be accompanied by not less than two sets of construction documents. The code official can waive the requirements for filing construction documents when the scope of the work is minor and compliance can be verified through other means. When the quality of the materials is essential for conformity to the code, specific information must be given to establish that quality.

This code must not be cited, or the term "legal" or its equivalent used as a substitute for specific information. For example, it would be improper for the plans to simply state "windows per IECC requirements."

A detailed description of the work covered by the application must be submitted. When the work is "minor," either in scope or needed description, the code official may use judgment in determining the need for a detailed description. An example of "minor" work that may not involve a detailed description is the replacement of an existing 60-amp electrical service in a single-family residence with a 100-amp service.

The exception permits the code official to determine that construction documents are not necessary when the code official determines that compliance can be obtained and verified without the documents.

104.2 Information on construction documents. Construction documents shall be drawn to scale upon suitable material. Electronic media documents are permitted to be submitted when approved by the code official. Construction documents shall be of sufficient clarity to indicate the location, nature and extent of the work proposed, and show in sufficient detail pertinent data and features of the building, systems and equipment as herein governed. Details shall include, but are not limited to, insulation materials and their *R*-values; fenestration *U*-factors and SHGCs; system and equipment efficiencies, types, sizes and controls; duct sealing, insulation and location; and air sealing details.

❖ For a comprehensive plan review, all code requirements should be incorporated in the design and construction documents. Adequate details must be included to allow the code official to verify code compliance. A statement on the construction documents, such as, "All insulation levels shall comply with the 2006 edition of the IECC," is not an acceptable substitute for showing the required information. Note also that the code official is authorized to require additional code-related information as necessary.

For example, insulation *R*-values and glazing and door *U*-factors must be clearly marked on the building plans, specifications or forms used to show compliance. Where two or more different insulation levels exist for the same component (two insulation levels are used in ceilings), record each level separately on the plans or specifications and clarify where in the building each level of insulation will be installed.

The following discussion is presented for the benefit of both the applicant and the plans examiner. This is not an all-inclusive list, but rather is intended to reflect the minimum scope of information needed to determine energy code compliance:

Permit Applicant's Responsibilities, Envelope. At permit application, the goal of the applicant is to provide all necessary information to show compliance with the code. If the plans examiner is able to verify compliance in a single review, the permit can be issued and construction may be started without delay. To assist in submitting the permit application, the applicant should review not only the following information specific to the applicant, but also the subsequent sections that review responsibilities of the plans examiner and the inspector (see commentary, Section 105.1). The discussion presented below addresses the two common problems with permit applications: missing information and incorrect information.

Information may be missing because the applicant is not aware of all of the code requirements or because the required information is located on the specifications but not on the plans. Note that building departments generally approve plans, but not specifications.

Depending on whether the prescriptive or performance methods of compliance are used, the amount and detail of the required information may vary. For example, if using the prescriptive method of compliance, the *U*-factor and SHGC may be the only information that is needed to verify fenestration compliance. If the "total *UA* alternative" (Section 402.1.4) or the performance option (Section 404 or 506) is used, then additional information such as the fenestration sizes and orientation may be needed to demonstrate compliance. The envelope information that needs to be on the plans can be presented in a number of ways:

- *On the drawings*. Include elevations that indicate window, door and skylight areas and sections that show insulation position and thickness.
- *On sections and in schedules*. For instance, list *R*-values of insulation on sections and include *U*-factors, shading coefficient, visible light transmittance and air infiltration on fenestration and opaque door schedules.
- *Through notes and callouts*. Note that all exterior joints are to be caulked, gasketed, weatherstripped or otherwise sealed.

- *Through supplementary worksheets or calculations*. Provide area-weighted calculations where required, such as for projection factors and heat capacity. The permit applicant may include these calculations on the drawings, incorporate as additional columns in the schedule or submit completed code compliance worksheets provided by the jurisdiction.

Incorrect information may be caused by a lack of understanding of the code. More likely, it indicates that the code has changed since the last project. The applicant can use a correction list as a reminder to update the office specifications to avoid receiving this same correction again in the future. Some features to note are:

- Roofs of commercial buildings with skylights cannot generally comply with the intended roof *R*-value requirements unless the skylights meet the prescriptive criteria requirements. This generally requires skylights to be at least double-glazed (triple in colder climates), and limits the skylight area to no more than 3 percent of the roof area in all cases. If intending to have more than 3 percent, then the provisions of Section 506 or of ASHRAE 90.1 would need to be used.
- Walls adjacent to unconditioned space require batt insulation in metal or wood frame walls, or at least insulation-filled cores for masonry walls in nearly all climates.
- Floors adjacent to unconditioned space cover floors over basements, and also include floors over parking garages and building overhangs.
- Below-grade wall insulation is more effective on the outside because the thermal mass is within the insulated shell; however, it needs to be protected from sunlight and future landscaping work when it extends above grade (see commentary, Section 102.2.1).
- For heated basements, the below-grade walls must be insulated, or if the basement is unconditioned, the floor above the basement must be insulated.
- For slab-on-grade floors, “unheated/heated” refers to whether there are pipes, ducts or other heating elements in the slab, not whether the space is heated or unheated. Vertical insulation must extend all the way to the top of the slab (see Figure 502.2.6).
- Building thermal envelopes include exterior walls and doors, both fire exit doors and roll-up loading doors. Uninsulated roll-up doors are comparable to single glazing; thus, unless using the prescriptive requirements, wall insulation must be increased to compensate if these doors are uninsulated. The insulation in door cavities is often made less effective by the metal at the edge of the door slab and the metal frame. Choose a door with a thermal break in the door slab and the door frame to get the best insulating value.
- Exterior walls with wood framing can usually meet the prescriptive *R*-value requirements with batt insulation filling the cavity except in the most severe climates (heating). It may however require that larger framing sizes be used to accommodate the insulation. For example 2- by 6-inch (51 mm by 152 mm) studs may be needed where 2 x 4 framing had been used previously.
- Exterior walls with metal framing in Climate Zones 5 and higher (also includes Marine 4) will generally require continuous insulating sheathing on either the inside or outside of the metal stud, in addition to filling the cavity with batt insulation. Exterior mass walls in all but the mildest climates require some additional insulation on either the exterior or the interior of the wall. Insulation-filled cores are usually not enough and do not work in climates subject to earthquakes where cores must be filled with concrete for seismic safety.
- Fenestration in the exterior wall includes windows, glass-sliding doors, glass-swinging doors and clerestory windows if they are in the plane of the wall [sloped at an angle of 60 degrees (1 rad) from the horizontal or greater]. Fenestration with a shallower slope is considered a skylight and must be included in the roof construction.
- Fenestration in Climate Zones 2 and higher must generally be at least double glazed to meet the prescriptive criteria. If using other than the prescriptive requirements, large window-to-wall ratios will often necessitate qualifying overhangs and low SHGCs.
- If more flexibility is desired for the fenestration, consider using the total building performance (see Section 506) or the simulated performance alternative trade-off procedures (see Section 404), but be aware that more calculations will be necessary to justify the inputs.

Plans Examiner’s Responsibilities, Envelope. The plans examiner must review each permit application for code compliance before a permit is issued. By letting the designer and contractor know what’s expected of them early in the process, the building department can increase the likelihood that the approved drawings will comply with the code. This helps the inspector avoid the headache of correcting a contractor who is following drawings that do not meet the code requirements.

The biggest challenge for the plans examiner is often determining where the necessary information is and whether the drawings are complete. The plans examiner should make sure the applicant includes an envelope summary or checklist as part of the submittal package. When building envelope information is provided on the construction documents it makes the job of the plans examiner easier, generally making for a more thorough review and reducing turnaround time.

A complete building envelope plan review covers all the requirements specific to the architectural building shell, but the electrical drawings may also need to be included and reviewed if the applicant seeks credit for automatic daylighting control for skylights or fenestration. For the building envelope, first review the general comments with the applicant for a sense of key requirements, then:

- Check that fenestration (both window and door) air leakage are included on the fenestration and door schedules and that they do not exceed the maximum leakage allowed. A note referencing the applicable industry standard could also accompany the reference.
- Look for notes indicating that exterior joints, cracks and holes in the building envelope are to be caulked, gasketed, weatherstripped or otherwise sealed.
- Check that moisture migration is addressed, either through vapor retarders being shown on roof, wall and floor sections or by other acceptable means. The proper vapor retarder location will vary by climate. It is generally on the warm-in-winter side, but may be located on the warm-in-summer side, or not required at all for air-conditioned buildings in hot, humid climates such as in the southeastern United States.
- Check that the proposed roof *R*-value complies with the code and matches the drawings. Verify the percentage of skylight area.
- Verify that insulation *R*-values on the opaque roof sections are correct and that the *U*-factors have been calculated correctly to include framing effects and thermal short-circuiting caused by metal framing members, as applicable.
- Verify that the proposed *U*-factor for the skylights is on the skylight schedule, that the numbers and areas are correct, and that the *U*-factors are NFRC certified.
- Check that the proposed skylights: (1) do not exceed the area allowed; (2) do not exceed the *U*-factor allowed; and (3) are not greater than the SHGC required based upon the selected compliance method.
- Check that the proposed skylight *U*-factors and SHGCs match those on the drawings.
- Check that the *R*-value of the proposed interior wall adjacent to unconditioned space complies with the code and matches what is on the drawings.
- Verify that insulation *R*-values are on the drawings, that the areas are correct and that the *U*-factors have been calculated correctly to include framing effects and thermal short-circuiting caused by metal framing members, as applicable.
- Check that the *R*-value of the proposed floor over outdoor air or unconditioned space complies with the code and matches what is on the drawings.
- Check that all below-grade walls have an insulation *R*-value no less than that required.
- Verify that the insulation *R*-value is on the wall or foundation sections, and that the insulation is protected if it is installed on the outside of the foundation wall and extends above grade.
- Check that all slab-on-grade floors have a perimeter insulation *R*-value no less than that required.
- Verify that: (1) the insulation *R*-value is on the wall or foundation sections; (2) the value is correct based on horizontal or vertical installation; (3) the insulation extends no less than 24 or 48 inches (610 or 1219 mm) as required; and (4) it is protected if it is installed on the outside of the foundation and extends above grade.
- In commercial buildings or where the trade-off methods are used, check that the fenestration and wall area calculations are correct. Window area should include the entire rough opening area of all windows, sliding and swinging doors and clerestories, etc.
- Check that the proposed opaque exterior wall *R*-values comply with the code and match what is on the drawings.
- Verify that the insulation value of all wall types, including lightweight walls and heavyweight walls (mass walls), have been included.
- For lightweight walls, verify that: (1) insulation *R*-value is on the wall sections; (2) the wall areas are correct; and (3) the *U*-factors have been calculated correctly to include framing effects and thermal short-circuiting caused by metal framing members.
- For doors, verify that the door *U*-factor is listed in the door schedule, and that the *U*-factors are NFRC certified or calculated correctly and include the effects of thermal short-circuits in the door slab and door frame; that is, they are not just based on a cut through the center of the insulated section.

- For heavyweight (mass) walls, verify that: (1) insulation *R*-value is on the wall sections; (2) the areas are correct; (3) the *U*-factors have been calculated correctly to include framing effects and thermal short-circuiting caused by metal framing members; (4) the heat capacities have been calculated correctly; and (5) the mass and insulation are at the proper location.

- Check that the proposed fenestration *U*-factors, SHGCs and projection factors (if applicable) comply with the code and match the drawings.

- Verify that: (1) the proposed *U*-factors and SHGCs are on the fenestration schedule; (2) the numbers and areas (if applicable) of each are correct; (3) the *U*-factors are NFRC certified, are taken from the reference material in the code or are calculated correctly and include the effects of framing; and (4) the SHGCs are NFRC certified (includes the effects of the frame) or are taken from the manufacturer's specifications.

- Verify that the overhang projection and height used in the projection factor calculations are correct.

Permit Applicant's Responsibilities, Mechanical. The discussion presented below addresses the two common problems with mechanical permit applications: missing information and incorrect information.

Information may be missing because the applicant is not aware of all the code requirements or because the required information is located on the specifications but not on the plans. Note that building departments generally approve plans, but not specifications. The mechanical information that needs to be on the plans can be presented in a number of ways:

- *On the drawings.* Provide an HVAC layout with equipment location, air distribution ductwork and sizes, air intake and exhaust locations, piping layout, fan and pump type and location, control diagrams indicating type of HVAC control and the units that it controls.

- *In schedules.* For instance, list heating and cooling equipment capacity and efficiency, fan horsepower and airflow capacity, outside air volume, duct insulation *R*-values, pipe-insulation thicknesses and *k*-values (thermal conductivity per inch).

- *Through notes and callouts.* Note that the building owner is to be given operation and maintenance literature, and that control systems are to be tested to ensure elements are calibrated and in good working order.

- *Through supplementary worksheets or calculations.* Provide calculations such as those for heating and cooling design loads.

The applicant may include these calculations on the drawings or submit completed worksheets developed as code compliance tools specifically for the application. Incorrect information may be caused by a lack of understanding of the code. More likely, it indicates that the code has changed since the last project. The applicant can use a correction list as a reminder to update the office specifications to avoid receiving this same correction again in the future. Some features to note are:

- Separate systems are generally required for uses with different operating hours (office versus retail), and for zones having special process temperature and/or humidity requirements.

- Constant volume reheat systems are not allowed except in some areas of hospitals and laboratories.

- Equipment efficiency is specified at both peak conditions and at part load for many units.

- Economizers are typically required for HVAC equipment larger than 54,000 British thermal units per hour (Btu/h) cooling capacity and larger. Individual variable air volume (VAV) fan motors 10 horsepower (hp) (7.5 kW) and larger will need to have variable frequency drive or equivalent.

- Hydronic systems greater than 300,000 Btu/h in design capacity must have controls that reduce system pump flow by at least 50 percent of the design flow rates by way of variable speed drives or equipment.

- Automatic setback controls are generally required.

- Ductwork is designed to operate at static pressures in excess of 3 inch water gauge (746 Pa) to have leak testing for at least 25 percent of the system ductwork. Air and water system balancing is required.

Plans Examiner's Responsibilities, Mechanical. The biggest challenge for the mechanical plans examiner is often determining where the necessary information is and whether the drawings are complete. The mechanical plans examiner should make sure the applicant includes a mechanical summary or checklist as part of the submittal package. When mechanical systems information is included on the construction documents, it makes the job of the mechanical plans examiner easier, generally making for a more thorough review and reducing turnaround time.

A complete building mechanical system and equipment plan review covers all the requirements specific to the building HVAC system (service water heating is reviewed independently). For mechanical systems, first review the general comments with the applicant for a general sense of key requirements, then:

- Check that there is a heating and cooling equipment schedule with the correct efficiencies for both peak load and part load (as applicable). Directories from nationally recognized certification programs such as the Air-Conditioning and Refrigeration Institute (ARI) are a good resource for verification. Remember that compliance must be demonstrated at the standard rating conditions, not the proposed operating conditions.
- Check that heating and cooling load calculations have been submitted to support the equipment sizes selected.
- Check that calculations have been done correctly and are based on the design conditions specified in Chapter 3 of the code. Review the calculated loads and compare them to the peak output of the equipment specified. If the exception for smallest size is claimed, ask for a copy of the manufacturer's catalog to verify. If the exceptions for standby or multiple equipment are claimed, check that required controls are installed.
- Check that separate systems are installed for zones with special process temperature and/or humidity requirements.
- Check that fan systems over 10 hp (7.5 kW) are capable of operating at minimum outside air supply levels.
- Check that VAV fans with motors 10 hp (7.5 kW) and larger have variable frequency drive or equivalent. Ask to see fan curves from manufacturer's specifications, if necessary.
- Check that pumps connected to hydronic systems greater than or equal to 300,000 Btu/h (87 930 W) output capacity have variable speed drive or equivalent. Ask to see pump curves from the manufacturer's specifications, if necessary.
- Check that each heating and cooling system has a thermostat and that each zone is controlled by a thermostat in the zone. If an exception is claimed for complex mechanical systems, verify that the controls are interlocked to prevent simultaneous heating and cooling.
- Check that thermostats used for both heating and cooling are provided with at least a 5°F (2.8° C) dead-band. Setback controls should be capable of being set from 55°F (13°C) to 85°F (29°C)
- Check that heat pumps have automatic controls to prevent supplementary electric resistance heater operation when the load can be met entirely by the heat pump.
- Check that humidistats (humidity control device) are provided where humidification or dehumidification is provided.
- Check that there is no simultaneous heating and cooling, reheating or recooling by any HVAC system. If a VAV-related exception is claimed, check that the air supply to zone boxes can be reduced to the greater of 10 percent of the total fan system supply air flow rate, the minimum required to meet the ventilation requirements of the *International Mechanical Code*® (IMC®), or 300 cubic feet per minute (cfm) (0.14 m^3/s). If other exceptions are claimed, ask for supporting documentation and a note on the drawings.
- Check that air systems have controls for automatic supply temperature reset.
- Check that hydronic systems of at least 300,000 Btu/h (87 930 W) design capacity have controls for automatic supply temperature reset.
- Check that each system is equipped with automatic setback controls.
- Check that outdoor air supply and exhaust systems have automatic volume shutoff or reduction.
- Check that zones with different operating hours (office versus retail) are either served by separate systems or have isolation devices to shut off or set back each zone independently.
- Check that each cooling system of 54,000 Btu/h (15 822 W) or greater is equipped with an economizer (if applicable). If any exception is claimed, ask for supporting documentation.
- Check that economizers can provide partial cooling even when additional mechanical cooling is required to meet the remainder of the cooling load.
- Check that piping insulation thickness and conductivity (*k*-value) are on the drawings and comply with code.
- Check that the duct insulation *R*-value is on the drawings and complies with the code.
- Check that there is a note indicating that ducts are to be constructed and sealed in accordance with the applicable standard.
- Check that there is a note indicating that operating and equipment maintenance manuals will be supplied to the owner, that air and hydronic systems will be balanced and that the control system will be tested and calibrated.

Permit Applicant's Responsibilities, Service Water Heating. The discussion presented below addresses the two common problems with service water heating (plumbing) permit applications: missing information and incorrect information.

Information may be missing because the applicant is not aware of all of the code requirements or because the required information is located in the specifications but not on the plans. Note that building departments generally approve plans, but not specifications. The type of service water heating-related information that needs to be on the plans can be presented in a number of ways:

- *On the drawings.* Show a service water heating layout with equipment location, pump type and location, control diagrams indicating type of control and the units it controls.
- *In schedules.* For instance, list service water heating equipment capacity and efficiency, pipe insulation *R*-values and, where reviewed as a part of this code, that the flow rates in the *International Plumbing Code*® (IPC®) for shower heads and other items are in compliance.
- *Through notes and callouts.* For instance, indicate that showerheads and lavatories meet the requirements of the National Energy Policy Act.
- *Through supplementary worksheets or calculations.* Provide calculations where required, such as to use the exception for combined service water heating and space heating equipment. Information may be incorrect if the code has changed since the applicant's last project. Some features to note are:
  - Combination service water heating/space heating systems are generally not permitted to be dependent on year-round operation of a space heating boiler.
  - The first 8 feet (2438 mm) of piping for service water heating systems without a circulating pump must still be insulated as if it had a pump, unless there is a heat trap in the piping.

Plans Examiner's Responsibilities, Service Water Heating. The biggest challenge for the plans examiner when reviewing plumbing drawings often is determining where the necessary information is and whether the drawings are complete. The plans examiner should make sure that the applicant includes a service water heating systems summary or checklist as part of the submittal package. When service water heating systems information is included on the construction documents it makes the job of the plans examiner easier, generally making for a more thorough review and reducing turnaround time.

A complete building service systems and equipment plan review covers all of the requirements specific to service water heating systems (space heating, space cooling and ventilation issues are reviewed separately). For service water heating, first review the comments for the "Permit Applicant's Responsibilities" listed previously for a general sense of key requirements, then:

- Check that there is a service water heating equipment schedule with the correct efficiencies for both peak load and part load (as applicable).
- Check that piping-insulation thickness and conductivity (*R*-value) are on the drawings and comply with the code. A note should be on the drawings indicating a heat trap for all systems without a circulating pump or integral heat trap.
- Check that temperature controls allow storage temperature adjustment to one that is compatible with the intended use. A note should be on the drawings indicating the outlet temperature for equipment and lavatories servicing dwelling units, sleeping units and public facility restrooms is limited to 110° F (43°C).
- Check that there is a note indicating that shower heads and lavatories meet the requirements of the National Energy Policy Act and are labeled accordingly.
- Check that pool heaters have an on/off switch.
- Check that time switches are installed on electric water heaters and pumps.
- Check that heated pools have a cover. If the exception is claimed, ask for supporting documentation and a note on the drawings.
- Check whether separate equipment is used for space heating and service water heating.

Permit Applicant's Responsibilities, Electrical Power and Lighting. The discussion presented below addresses the two common problems with electrical lighting permit applications: missing information and incorrect information.

Information may be missing because the applicant was not aware of all the code requirements or because the required information was located in the specifications but not on the plans. Note that building departments generally approve plans, but not specifications. The type of electrical/lighting information that needs to be on the plans can be presented in a number of ways:

- *On the drawings.* Provide wiring diagrams with all electric feeders identified by use; lighting control diagrams indicating type of lighting control and the fixtures/circuits that it controls; and tandem ballast wiring of one- and three-lamp fixtures.
- *In schedules.* For instance, list total connected fixture wattage, number of luminaires and ballast power factor on a lighting-fixture schedule.

- *Through notes and callouts.* Indicate the types of lighting controls and operating sequences. Note that the building owner is to be given operation and maintenance literature and that exterior lighting is to be automatically controlled by a photocell, an astronomical time switch or a combination of the two, and must have a minimum 10-hour retention of programing.

- *Through supplementary worksheets or calculations.* Provide calculations where required, such as for interior connected lighting power and exterior lighting wattage and for lighting control points. These calculations can be included on the drawings or incorporated as addenda to project specifications.

Incorrect information may be caused by a lack of understanding of the code. More likely, it indicates that the code has changed since the last project. The applicant can use a correction list as a reminder to update the office specifications to avoid receiving this same correction again in the future. Some features to note are:

- Although not required by the code, electrical power feeders should be subdivided as follows: lighting, HVAC, service water heating, elevators and other equipment or systems of more than 20 kilowatts (kW). This has the effect of promoting the efficient use of systems and equipment through the easy accommodation of separate metering. If users can track their energy use, it is easier for them to operate building systems and equipment efficiently and to determine cost-effective investments in energy efficiency.

- Although not required by the code, motors typically will need to be classified "energy-efficient" rather than standard, to comply with minimum federal efficiency guidelines.

- Assuming a reasonable spacing and product efficiencies, most one- or two-lamp fluorescent fixtures with energy-efficient lamps and ballasts will comply with the interior lighting power allowance for most occupancies. For three-lamp fixtures, the options are more limited unless electronic ballasts are used. The days of four-lamp fixtures are past. Incandescents can be used sparingly, but compact fluorescents facilitate compliance. Parking garage lighting will need to be more efficient than conventional fluorescent.

- Generally, a bi-level switching arrangement (two switches) or some type of automatic lighting control (occupancy sensors, programmable timers, photocell dimming) is necessary to provide the minimum number of controls.

Plans Examiner's Responsibilities, Electrical Power and Lighting. The biggest challenge for the electrical/lighting plans examiner is often determining where the necessary information is and whether the drawings are complete. The electrical/lighting plans examiner should make sure that the applicant includes an electrical and lighting summary checklist as part of the submittal package. When electrical power and lighting systems information is included on the construction documents it makes the job of the electrical/lighting plans examiner easier, generally making for a more thorough review and reducing turnaround time.

A complete electrical power and lighting plan review covers all the requirements specific to building lighting and power systems. For electrical power and lighting systems, first review the responsibilities of the applicant listed previously to get a general sense of key requirements, then:

- Look for notes indicating that electrical schematics and operations and maintenance literature will be given to the owner.

- Check that the proposed exterior lighting matches the drawings and schedules, and that it includes source efficacy, number of lamps, ballast type, total wattage, etc. Also note that exterior lighting that operates at greater than 100 watts must have a minimum efficacy of at least 60 lumens per watt. Check the total exterior allowance for each proposed application.

- Check that the interior lighting power allowance is determined correctly for each building area type and that the area calculations are correct.

- Check that the proposed interior lighting matches the drawings and schedules, and that it includes the number of lamps, ballast type, total connected fixture wattage, etc. (Tip: The effect of the ballast on total fixture wattage will vary by ballast type. For fluorescent lamps with magnetic ballasts, this may mean a total that is 1.1 times the lamp wattage. For electronic ballasts, the fixture wattage may be the same as or lower than that of the lamps alone.) Make sure all exceptions, if any, are justified.

- Check that the lighting controls are shown on the drawings, that they have the features required (readily accessible with temporary override as applicable and automatic return to the original schedule for programmable timing controls as applicable, etc.), that they control the number of fixtures claimed and that they match the drawings. Make sure all exceptions, if any, are justified.

- Check that interior lighting controls are accessible from within the space controlled, and that hotel and motel guestrooms have a master switch at the main entry door.
- Check that exterior lighting controls have a photocell, an automatic timer or both with the necessary features.
- Check that recessed one- and three-lamp fluorescent fixtures are tandem wired.

Remember that a good plan review is important. It's much easier to change a number on a drawing than to remove equipment after it has already been installed.

SECTION 105 INSPECTIONS

105.1 General. Construction or work for which a permit is required shall be subject to inspection by the code official.

❖ When a permit is required by state or local law, the building is subject to an inspection. The code official must determine whether appropriate energy-efficiency features and equipment are installed in accordance with the approved construction documents and applicable code requirements.

Generally, a department's administrative rules will list required periodic inspections. Because the majority of energy efficient construction occurs in steps or phases, periodic inspections are often necessary before portions of these systems are covered. The exact number of required inspections cannot always be specified. A reinspection may be necessary if violations are noted and corrections are required (see commentary, Section 105.4). If time permits, frequent inspections of some job sites, especially where the work is complex, can be beneficial to detect potential problems before they become too difficult to correct.

The discussion that follows is for the benefit of both the applicant and field inspection personnel. It is not an all-inclusive list, but rather is intended to reflect the tasks necessary to incorporate aspects of energy code enforcement into an already busy inspection schedule.

Field Inspector's Responsibilities, Envelope. The inspector's task is to make sure the project is constructed in accordance with the approved plans. Be aware that a number of requirements will vary from project to project. Consequently, while some requirements may be learned once, others will require on-site checking of the approved plans.

The primary challenge for the inspector may be educating the contractors about changes in the code requirements so that installations are performed correctly, not simply the way they may have been routinely done in the past.

Some of the important energy conservation items are listed below. Keep in mind that the performance of the fenestration is largely based on the quality control of the manufacturer, while the performance of the insulation is largely based on the quality of the installer. As a start, review the comments following Section 104.2 for the applicant and building envelope plans examiner for a general sense of key requirements:

For the foundation inspection:

- Verify that the perimeter slab insulation has the *R*-value shown on the drawings and that it covers the areas shown on the drawings. If the insulation is vertical, check to see that the insulation goes all the way to the top of the slab (see Figure 502.2.6) or is protected from sunlight and landscaping if installed on the exterior (see commentary, Section 102.2.1).
- Verify that the below-grade wall insulation has the *R*-value shown on the plans. If insulation is to be installed later on the exterior, verify that the correct *R*-value is installed before the wall is backfilled.
- Inform the contractor of any missing items or corrections that need to be made:

For the framing inspection:

- Verify that problems noted at the foundation inspection have been addressed.
- Verify fenestration requirements as soon as products begin arriving on the construction site, since it is difficult to make changes after the fenestration has been installed. If there is a problem, it can be fixed more easily early in the process. For large buildings, most of the windows may not have been fabricated yet.
- Verify that windows, skylights, sliding-glass, swinging-glass, opaque-swinging and roll-up doors do not exceed the infiltration rate specified.
- Verify that exterior joints, cracks and holes are caulked, gasketed, weatherstripped or otherwise sealed. Key areas to check for caulking and sealing are where the framing abuts the foundation wall or slab floor, around perimeter joists and between floors, around window and door frames, around wall panels, where the wall meets the roof and at utility penetrations. Site-built windows with fixed lights should be caulked and operating sashes should be weatherstripped. Doors in the building thermal envelope should be weatherstripped.
- Verify that skylight *U*-factors, or the frame type, the number of glazing layers, gap width, low-emissivity coatings, gas fillings and spacer types match the drawings. (Tip: To attempt to verify gas fills in sealed glass units, look for two little plugs in the spacer separating the panes—one for pumping the gas in and the other for letting the air out).

Note that these plugs suggest there is a gas fill other than air, but do not guarantee it; however, if there are no plugs, gas fill is unlikely. Also, to verify insulating/nonmetallic spacers, look for a dark colored material separating the panes of glass, rather than aluminum. Be aware that there are some insulating aluminum spacers that look similar to the eye but have a different profile beneath that improves their performance.

Although windows using low-emissivity coatings or gas fillings are extremely cost-effective technologies for code compliance, these technologies are typically not discernible to the human eye. For this reason, consumers, builders, utility representatives and others have asked for a simple hand-held detector to determine what type of coating (if any) is used on a double-glazed window. Such a detector has been developed and is commercially available. The detector measures reflectance in the near infrared portion of the solar spectrum where the different coating technologies have significantly different reflectances. Most detectors are low cost, incorporating a measuring technique that uses an infrared light-emitting diode and phototransistor. Oftentimes, a nearly instantaneous readout is displayed giving a simple indication of whether the window is clear, regular low-e or spectrally selective low-e.

- Verify opaque and glazed door *U*-factors.

For the insulation inspection:

- Verify that problems noted at the framing inspection have been addressed.
- Verify moisture migration features such as vapor retarders (if appropriate at this stage).
- Verify insulation *R*-value for roofs. Verify that insulation is in substantial contact with the surface being insulated to avoid air paths that bypass the insulation. If eave vents are installed, verify baffling of vent openings to deflect incoming air above the insulation.
- Verify that Type IC (insulation contact) light fixtures are installed, if shown on the plans or if insulation contacts the fixtures. Verify space between light fixtures and sheetrock is sealed with caulking or with manufacturer-supplied gasketing.
- Verify the insulation *R*-value for interior walls adjacent to unconditioned space. Verify that insulation is in substantial contact with the surface being insulated to avoid air paths that bypass the insulation.
- Verify the insulation *R*-value for floors over outdoor air or unconditioned space. Verify that insulation is in substantial contact with the surface being insulated to avoid air paths that bypass the insulation. For framed floors, this may mean installing supports to keep the insulation tight against the floor.
- Verify the insulation *R*-value of below-grade walls (if not done previously).
- Verify that below-grade wall insulation is protected as it extends above grade (see commentary, Section 102.2.1). If the below-grade wall is furred out and insulation installed on the interior, protection is usually not a problem. If the below-grade wall insulation is installed on the exterior (generally preferable from an energy point of view), it must extend above the ground to the top of the foundation wall and be protected.
- If below-grade walls are partially below grade and partially above grade, make sure that a continuous thermal barrier is installed.
- Verify the insulation *R*-value for exterior walls. Also verify that: (1) insulation is in substantial contact with the surface being insulated to avoid air paths that bypass the insulation; (2) that insulation is not compressed by inset stapling of batt insulation or other means; (3) that insulation fills all cavities completely by cutting insulation around electrical outlets and switches, and by slicing insulation to fit behind and in front of electrical wiring in the cavity; and, (4) that band joists and other interstitial floor elements of the wall are insulated.
- Inform the contractor of any missing items or corrections to be made.

For the final inspection:

- Verify that problems noted at the insulation inspection have been addressed.

An inspector's ongoing challenge is responding to change orders during construction. In any construction project there will be field changes. The call is easy if a more efficient piece of equipment is being substituted for a less efficient one. For the opaque elements, more insulation is generally better. For fenestration, a lower *U*-factor and SHGC is generally better. Unfortunately, changing the glass almost always changes more than one characteristic and it is not always clear whether energy efficiency is being improved. If there is any doubt concerning the impact, the inspector should confer with the plans examiner for the project.

A more difficult change order is one that reduces efficiency. For example, if the proposed substitute fenestration has a higher *U*-factor and SHGC, or if the window area is to be increased, the inspector must check with the plans examiner. The amount of information and the ease of confirming compliance will depend upon whether the prescriptive or performance approach was used initially. In these cases, compliance is based on a combination of the fenestration area, *U*-factor SHGC, the projection factor, and (if a performance-based analysis has been used) even the opaque wall characteristics. Although there may be enough latitude to decrease the efficiency somewhat, it is not possible to make such a determination without reviewing all the elements and how compliance was initially demonstrated. Whenever there are significant changes such as are described above, the inspector is expected to request that the applicant submit revised plans, so the plans examiner can verify compliance and ensure there is a correct record on file in the building department.

An even tougher case is when the contractor has already installed noncomplying equipment without checking with the inspector. For instance, ordinary double glazing may have been installed instead of double glazing with a low-emissivity coating. The inspector should be quite strict for several reasons. First, because most contracts are awarded on a cost-competitive basis, the low-bid company might win the job and then make its profit by installing noncomplying equipment. This would be unfair to the high-bid contractors.

Second, a lenient inspector's job will be more difficult in the future. If a noncomplying contractor skates by this time, that contractor will most likely have additional requests for future projects. In addition, other contractors will also begin to ask for special treatment. Self-policing, which works well if everyone is being treated fairly, will begin to decline.

Finally, there is the situation in which the approved plans do not contain all of the code requirements. If information or notes are missing from the plans, the inspector can, for instance, simply direct the contractor to make the necessary changes in the field (for example, caulk and seal joints).

The inspector's job is more difficult, however, if drawings contain information that is wrong. Perhaps the inspector in a cold climate notices the metal stud wall is not covered with insulating sheathing as is required in that climate and informs the contractor. The contractor responds saying that he or she is following the approved plans, and indeed he or she is. The inspector, as the representative of the code official, is clearly authorized to require the contractor to build the project to code. (If necessary, the inspector can show the contractor the building department note, which says, "Approved subject to errors and omissions." See also IBC Section 105.4) In this case, it would be appropriate for the inspector to inform the plans examiner of the problem and ask the plans examiner to help solve the problem. The plans examiner may be able to suggest improvements in other areas that would compensate for this shortfall. It is important that the plans examiner and inspector appreciate the challenges of each other's work and the benefits of a team effort.

Field Inspector's Responsibilities, Mechanical. The inspector's task is to make sure the project is constructed in accordance with the approved plans. Be aware that a number of requirements will vary from project to project. Consequently, while some requirements may be learned once, others will require on-site checking of the approved plans.

The primary challenge for the inspector may be educating the contractors about any changes in the code requirements so that installations are performed correctly, not simply the way they may have been routinely done in the past.

Some of the most important energy conservation items are listed below. As a start, review the responsibilities for the applicant and mechanical plans examiner in the commentary that follows Section 104.2 to get a general sense of key requirements:

For the rough-in "okay-to-cover" inspection:

- Verify heating and cooling equipment efficiency.
- Verify heating and cooling equipment size. If an exception is claimed, verify the required controls are installed.
- Verify whether separate air distribution systems are installed.
- Verify variable-frequency drive or other control type as indicated on drawings for VAV fan motors 10 hp and larger.
- Verify variable-speed drive or other control type as indicated on drawings for hydronic systems of 300,000 Btu/h (87 930 W) output capacity or more.
- Verify that each heating and cooling system has a temperature control device.
- Verify that the heating and cooling supply to each zone is controlled by a thermostat in that zone.
- Verify that heat pumps have controls to prevent electric resistance supplementary heater operation when the load can be met by the heat pump.
- Verify that simultaneous heating and cooling does not exceed that allowed by the drawings. Expect VAV systems in most cases, with constant volume reheat limited to certain sections of hospitals and laboratories.
- Verify that automatic setback controls are installed.
- Verify that outdoor air supply and exhaust systems have motorized or gravity dampers for automatic volume shutoff or reduction.
- Verify that zones with different operating hours (office versus retail) are either served by separate systems or have isolation devices to shut off or set back each zone independently as indicated by the plans.

- Verify that each cooling system of 54,000 Btu/h or greater is equipped with an economizer unless exempted on the plans.
- Verify that ducts are constructed and sealed appropriately. Note that unlisted pressure-sensitive tape (duct tape) cannot be used as a sealant on any ducts.
- Inform the contractor of any missing items or corrections to be made.

For the final inspection:

- Verify piping insulation thicknesses and conductivity.
- Verify duct insulation *R*-value.
- Verify that problems noted at the rough-in inspection have been addressed.

An inspector's ongoing challenge is responding to change orders during construction. The call is easy if a more efficient piece of equipment is being substituted for a less efficient one. For instance, it would be acceptable to substitute R-11 duct insulation if the drawings specify R-8 insulation. Also, a 90,000 Btu/h air-cooled heat pump with a 3.6 coefficient of performance (COP) for cooling would be an improvement over one with a 3.4 COP, if the equipment wasn't oversized and had the necessary controls to stage the use of electric resistance heat.

A more difficult change order is one that reduces efficiency. For example, if the proposed substitute heat pump has a COP of only 3.0 for cooling but meets the code minimum for this size heat pump, the inspector should check with the plans examiner to make sure that no trade-offs were made that resulted in a requirement for a higher efficiency heat pump. Whenever there are significant changes, the inspector is expected to request that the applicant submit revised plans so the plans examiner can verify compliance and ensure there is a correct record on file in the building department.

An even tougher case is when the contractor has already installed noncomplying equipment without checking with the inspector. For instance, a heat pump with a cooling COP of 2.8 may have been installed.

The inspector should be quite strict for several reasons. First, because most contracts are awarded on a cost-competitive basis, the low-bid company might win the job and then make its profit by installing noncomplying equipment. This would be unfair to the high-bid contractors.

Second, a lenient inspector's job will be more difficult in the future. If a noncomplying contractor skates by this time, that contractor will most likely have additional requests for future projects. In addition, other contractors will also begin to ask for special treatment. Self-policing, which works well if everyone is being treated fairly, will begin to decline.

Finally, there is the situation in which the approved plans do not contain all of the code requirements. If information or notes are missing from the plans, the inspector can simply direct the contractor to make the necessary changes in the field. For instance, the inspector may direct the contractor to install an automatic setback thermostat, or to use some sealant for the ductwork other than pressure sensitive tape.

The inspector's job is more difficult, however, if the drawings contain information that is wrong. Perhaps the inspector notices that the efficiency of the installed heat pump is too low and informs the contractor, but the contractor responds that he or she is following the approved plans, and indeed he or she is. The inspector, as the representative of the code official, is clearly authorized to require that the contractor build the project to code. (If necessary the inspector can show the contractor the building department note that says, "Approved subject to errors and omissions." See also IBC Section 105.4.) In this case, it would be appropriate for the inspector to inform the plans examiner of the problem and ask the plans examiner to help solve it. The plans examiner may be able to suggest improvements in other areas that would compensate for this shortfall. It is important for the plans examiner and inspector to appreciate the challenges of each other's work and the benefits of a team effort.

Field Inspector's Responsibilities, Service Water Heating. The inspector's task is to make sure the project is constructed in accordance with the approved plans. Be aware that a number of requirements will vary from project to project. Consequently, although some requirements may be learned once, others will require on-site checking of the approved plans.

The primary challenge for the inspector may be educating the contractors about any changes in the code requirements so that installations are performed correctly, not simply the way they may have been routinely done in the past.

Some of the most important energy conservation items are listed below. As a start, review the responsibilities for the applicant and mechanical plans examiner in the previous two subsections to get a general sense of key requirements:

For the rough-in "okay-to-cover" inspection:

- Verify service water heating equipment efficiencies.
- Verify a heat trap for all noncirculating systems.
- Check that temperature controls are installed to allow storage temperature adjustment to a temperature compatible with the intended use.
- Verify that shower heads and lavatories are labeled as meeting the requirements of the National Energy Policy Act. (See also flow rates listed in the IPC.)
- Verify that pool heaters have an on/off switch.

- Verify that time switches are installed on electric water heaters and pumps.
- Verify that separate equipment is used for space heating and service water heating or that the drawings allow an exemption.
- Inform the contractor of any missing items or corrections to be made.

For the final inspection:

- Verify piping insulation thicknesses and conductivity (*k*-value).
- Verify that heated pools have a cover unless drawings allow an exemption.
- Verify that problems noted at the rough-in inspection have been addressed.

Field Inspector's Responsibilities, Electrical Power and Lighting. The inspector's task is to make sure that the project is constructed in accordance with the approved plans. Be aware that a number of requirements will vary from project to project. Consequently, while some requirements may be learned once, others will require on-site checking of the approved plans.

The primary challenge for the inspector may be educating the contractors about any changes in the code requirements so that installations are performed correctly, not simply the way they may have been routinely done in the past.

Some of the most important energy conservation items are listed below. As a start, review the responsibilities for the applicant and the electrical plans examiner in the previous two subsections to get a general sense of key requirements:

For the rough-in "okay-to-cover" inspection:

- Verify lamp and ballast types. It is important to confirm that the lamps and ballasts are the same as those listed on the drawings and schedules. (Tip: It may be advisable to look at lamps when they are coming out of the box so it won't be necessary to climb a ladder and disassemble a fixture after it's been installed in the ceiling.) Expect T-8 lamps (the skinny tubes, 1 inch $^{8}/_{8}$-inch diameter) or T-5 ($^{5}/_{8}$-inch diameter) rather than the old T-12 lamps (1$^{1}/_{2}$-inches $^{12}/_{8}$-inch diameter). Expect compact fluorescents in hallways rather than incandescents. Expect something more efficient than incandescents in most retail spaces. Expect metal halide or high-pressure sodium luminaires in parking garages and in most high-ceiling manufacturing and warehouse spaces.
- Verify the number of fixtures and the spacing.
- Verify the number and type of interior lighting controls. Assume that there is a local control with two switches required in each space instead of an occupancy sensor. Assume that some type of automatic lighting control is required unless there is a bilevel switching (two switches) arrangement proposed.
- Verify the type of automatic exterior lighting controls. Expect a photocell or look for an astronomical timer with scheduling capabilities and 10-hour retention of programming.
- Verify tandem wiring of one- and three-lamp ballasts.
- Inform the contractor of any missing items or corrections to be made.

For the final inspection:

- Verify that problems or unresolved issues noted at the rough-in inspection have been addressed.
- Verify that the contractor has given the building owner a schematic of the electrical systems.
- Verify automatic controls for exterior lighting. Expect a photocell or look for an astronomical timer with scheduling capabilities and 10-hour program retention.
- Verify exempt exterior and interior exempt lighting fixtures, if applicable.
- Verify lighting systems exempt from control requirements.
- Verify installation of all required lighting controls.
- Verify accessibility of all manual controls.
- Verify operation of automatic lighting controls, if used.

An inspector's ongoing challenge is responding to change orders during construction. The call is easy if a more efficient piece of equipment is being substituted for a less efficient one. For instance, a lamp and ballast combination rated at 64 watts is an improvement over a 67-watt combination, if the number of fixtures isn't increased and the substituted ballast doesn't affect any automatic controls.

A more difficult change order is one that reduces efficiency. For example, if a 69-watt lamp and ballast combination is substituted for one with 64 watts, the inspector must check with the plans examiner. In this case, compliance is based on a calculation of the total installed wattage, which will vary based on the fixture wattage and the number of fixtures. Whenever there are significant changes, the inspector is expected to request that the applicant submit revised plans so the plans examiner can verify compliance and ensure there is a correct record on file in the building department.

An even tougher case is when the contractor has already installed noncomplying equipment without checking with the inspector. The inspector should be quite strict for several reasons.

First, since most contracts are awarded on a cost-competitive basis, the low-bid company might win the job and then make its profit by installing noncomplying equipment. This would be unfair to the high-bid contractors.

Second, a lenient inspector's job will be more difficult in the future. A noncomplying contractor who skates by will most likely have additional requests for future projects. In addition, other contractors will also begin to ask for special treatment. Self-policing, which works well if everyone is being treated fairly, will begin to decline.

Finally, there is the situation in which the approved plans do not contain all the code requirements. If information or notes are missing from the plans, the inspector can, for instance, simply direct the contractor to make the necessary changes in the field (for example, tandem-wire ballasts or provide a minimum of lighting controls in each space).

The inspector's job is more difficult, however, if the drawings contain information that is wrong. Perhaps the inspector notices that the efficiency of the installed motor is too low and informs the contractor. The contractor responds that he or she is following the approved plans, and indeed he or she is. The inspector, as the representative of the code official, is clearly authorized to require that the contractor build the project to code. (If necessary, the inspector can show the contractor the building department note, which says, "Approved subject to errors and omissions." See also IBC Section 105.4) In this case, it seems appropriate for the inspector to inform the plans examiner of the problem and ask the plans examiner to help solve the problem. The plans examiner may be able to suggest improvements in other areas that would compensate for this shortfall. It is important for the plans examiner and the inspector to appreciate the challenges of each other's work and the benefits of a team effort.

105.2 Required approvals. No work shall be done on any part of the building beyond the point indicated in each successive inspection without first obtaining the written approval of the code official. No construction shall be concealed without being inspected and approved.

❖ The contractor, builder, owner or other authorized party is responsible for arranging and coordinating required inspections to prevent work from being concealed prior to inspection. For example:

- Insulation must be inspected prior to concealment. Where the insulation is concealed prior to inspection and approval, the code official has the authority to require removal of the concealing components.
- Basement wall insulation may be installed on the exterior of a below-grade basement wall. Where the insulation application is not confirmed prior to backfilling, reinspection is necessary.
- Glazing assembly *U*-factor labels are to be left on until after the building has been inspected for compliance. The applicant is responsible for giving the inspector adequate information on site to verify code-related features, such as window *U*-factor and equipment efficiencies.

After the field inspector has performed the required inspections and observed any required equipment and system tests (or has received written reports of the results of such tests), the code official must determine whether the installation or work is in compliance with all applicable sections of the code. The code official must issue a written notice of approval if the subject work or installation is in apparent compliance with the code. The notice of approval is given to the permit holder and a copy of the notice is retained on file by the code official.

105.3 Final inspection. The building shall have a final inspection and not be occupied until approved.

❖ To establish compliance with all previously issued correction orders and to determine whether subsequent violations exist, a final inspection is required. The final inspection is completed after all work is completed.Typically, the final inspection includes all items installed after the rough-in inspection and not concealed in the building construction. Subsequent reinspection is necessary if the final inspection generates a notice of violation (see commentary, Section 105.4). All violations observed during the final inspection must be noted and the permit holder must be advised of them.

Final approval is required prior to issuing the certificate of occupancy and therefore before the occupancy of the building may be occupied.

105.4 Reinspection. A building shall be reinspected when determined necessary by the code official.

❖ The provisions for reinspection could affect the entire structure or a portion of the structure. As an example, under the circumstance where no approval was given to apply interior finish that conceals ducts in an exterior wall, the code official must require removal of the interior finish to verify the ducts are insulated to code.

Reinspections generally occur when some type of violation or correction notice was issued during one of the previous inspections or where the work was not ready for the inspection. As an example, if the inspector went to the project to conduct an insulation inspection and not all of the insulation was installed at that point. The inspector would need to go back to the project and "reinspect" the insulation to verify that it had been completed. After the reinspection, the inspector would issue the approval (see Section 105.2) to permit the wall or ceiling cavities to be enclosed and therefore conceal the insulation.

SECTION 106
VALIDITY

106.1 General. If a portion of this code is held to be illegal or void, such a decision shall not affect the validity of the remainder of this code.

❖ This section is applicable when a court of law rules that a portion of the code (or the jurisdiction's energy code) is ruled invalid. Only invalid sections of the code (as established by the court of jurisdiction) can be set aside. This is essential to safeguard the application of the code text to situations in which a provision of the code is declared illegal or unconstitutional. This section preserves the original legislative action that put the legal requirements (energy code) in place.

All sections of the code not judged invalid must remain in effect. Although a dispute over a particular issue (such as an appliance efficiency requirement) may have precipitated the litigation causing the requirement to be found invalid, the remainder of the code must still be considered as being applicable. This is sometimes called the "severability clause" and simply means that the invalid section can be removed from the code without affecting the entire document.

SECTION 107
REFERENCED STANDARDS

107.1 General. The standards, and portions thereof, referred to in this code and listed in Chapter 6 shall be considered part of the requirements of this code to the extent of such reference.

❖ The code references many standards promulgated and published by other organizations. A complete list of these standards appears in Chapter 6. The wording of this section was carefully chosen to establish the edition of the standard that is enforceable under the code.

Although a standard is referenced, its full scope and content is not necessarily applicable. The standard is applicable only to the extent indicated in the text in which the standard is specifically referenced. A referenced standard or the portion cited in the text is an enforceable extension of the code as if the content of the standard were included in the body of the code. The use and applicability of referenced standards are limited to those portions of the standards that are specifically identified.

107.2 Conflicting requirements. Where the provisions of this code and the referenced standards conflict, the provisions of this code shall take precedence.

❖ In general, the code takes precedence when the requirements of the standard conflict with the requirements of the code or the requirements of the standard are less stringent than those of the code. Although the intention of the code is to be in harmony with referenced standards, the code text generally governs should a conflict occur. One specific situation where caution should be used is when the requirements of the standard are more restrictive.

In such a situation, the first action it to verify the scope of the standard (see commentary, Section 107.1). After considering the limitations of the scoping, it is also important to review what affect the difference would make. For example, the code would not intend to require a piece of equipment to be installed in a manner that violates its listing nor would the code intend to create any type of a hazard (see Section 101.3). Therefore, it is possible given the multitude of products and applications that there will be situations where the requirements of the standard or listing will take precedence over that found within the code. Such unique situations should be discussed with the code official for approval.

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Chapter 2: Definitions

General Comments

All terms defined in the code are listed alphabetically in Chapter 2. The words or terms defined in this chapter are considered to be of prime importance in either specifying the subject matter of code provisions or in giving meaning to certain terms used throughout the code for administrative or enforcement purposes. The code user should be familiar with what terms are found in this chapter because the definitions are essential to the correct interpretation of the code and because the user might not be aware of the fact that a particular term found in the text is defined.

Purpose

Codes, by their nature, are technical documents. Literally every word, term and punctuation mark can add to or change the meaning of the intended result. This is even more so with a performance code where the desired result often takes on more importance than the specific words. Furthermore, the code, with its broad scope of applicability, includes terms inherent in a variety of construction disciplines. These terms can often have multiple meanings, depending on the context or discipline being used at the time. For these reasons a consensus on the specific meaning of terms contained in the code must be maintained. Chapter 2 performs this function by stating clearly what specific terms mean for the purpose of the code.

SECTION 201 GENERAL

201.1 Scope. Unless stated otherwise, the following words and terms in this code shall have the meanings indicated in this chapter.

❖ For the purposes of this code, certain abbreviations, terms, phrases, words and their derivatives have the meanings given in Chapter 2. The code, with its broad scope of applicability, includes terms used in a variety of construction and energy-related disciplines. These terms can often have multiple meanings, depending on their context or discipline. Therefore, Chapter 2 establishes specific meanings for these terms.

201.2 Interchangeability. Words used in the present tense include the future; words in the masculine gender include the feminine and neuter; the singular number includes the plural and the plural includes the singular.

❖ Although the definitions contained in Chapter 2 are to be taken literally, gender, number and tense are considered to be interchangeable.

201.3 Terms defined in other codes. Terms that are not defined in this code but are defined in the *International Building Code*, ICC *Electrical Code*, *International Fire Code*, *International Fuel Gas Code*, *International Mechanical Code*, *International Plumbing Code*, or the *International Residential Code* shall have the meanings ascribed to them in those codes.

❖ When a word or term that is not defined in this chapter appears in the code, other references may be used to find its definition, such as other *International Codes*®. Definitions that are applicable in other *International Codes* are applicable everywhere the term is used in the code. As stated in both the "Purpose" section above and in the commentary to Section 201.1, a bit of caution is needed when looking at definitions from other codes. Because the context and discipline can vary, it is important to determine that the term does fit within the code context. As an example, the term "accessible" would have a different meaning in the *International Pluming Code*® (IPC®) and *International Mechanical Code*® (IMC®) versus that of the *International Building Code*® (IBC®).

201.4 Terms not defined. Terms not defined by this chapter shall have ordinarily accepted meanings such as the context implies.

❖ Another option for defining words or terms not defined here or in other codes is their "ordinarily accepted meanings." The intent of this statement is that a dictionary definition may suffice, if the definition is in context. Oftentimes, construction terms used throughout the code may not be defined in Chapter 2 or in a dictionary. In such a case, the definitions contained in the referenced standards (see Chapter 6) and in published textbooks on the subject in question are good resources.

Due to the substantial changes that occurred between the 2003 and 2006 editions of the code, many of the previously existing definitions were eliminated from the code. While the majority of those definitions are no longer needed, there may be some situations where it may be beneficial to consider the use of those older definitions. If an older definition is used, it is important to carefully consider whether the previous defi-