INTERNATIONAL CODE COUNCIL®

INTERNATIONAL ENERGY CONSERVATION CODE®

COMMENTARY

2003

2003 International Energy Conservation Code® Commentary

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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 2003 *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 2003 *International Energy Conservation Code*. As stated in the preface to the *International Energy Conservation Code,* the content of sections in the code which begin with a letter designation (i.e., Section 503.3.1) are maintained by another code development committee. 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.

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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 (Standard 90) was approved for publication in August 1975. This standard was subsequently revised in 1980, with the first nine sections published as ASHRAE 90A (Standard 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) in 1981and 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 Standard 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 the ASHRAE/IES 90.1 Standard (90.1 Standard), *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 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 the AHRAE 90.1 Standard (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 Housing and Urban Development (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 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, by-laws, 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 the 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 include:

- An organizational restructuring of the code's chapters 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 in 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 in Chapter 7.

The majority of the work involved in determining code compliance with this chapter will be 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®).

Purpose

This code is applicable to all buildings and structures and their components and systems that use energy primarily for human comfort. 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].

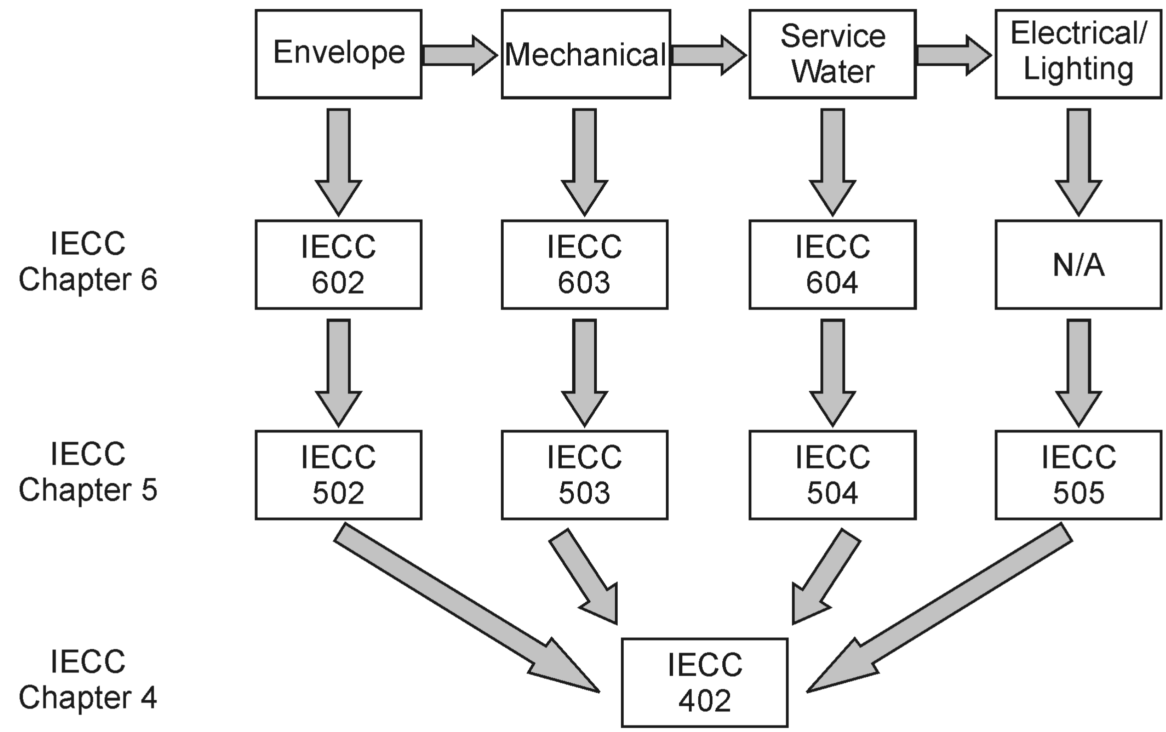


Figure 1(1)
IECC SCOPE AND APPLICATION ABSTRACT—RESIDENTIAL

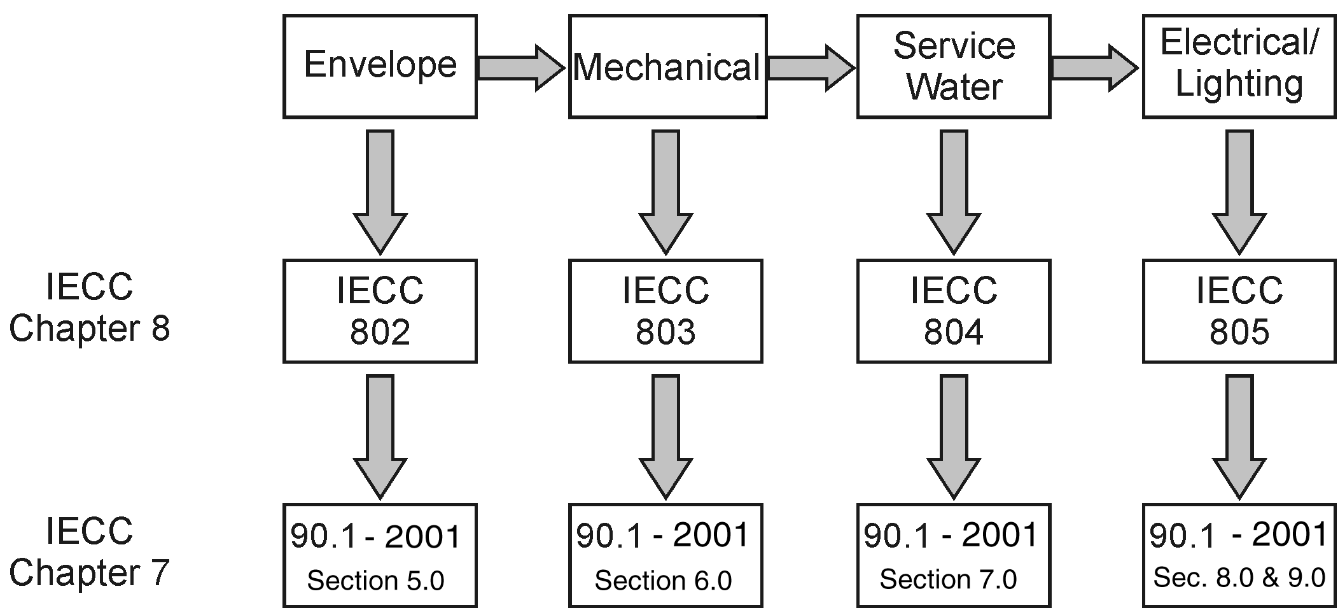


Figure 1(2)
IECC SCOPE AND APPLICATION ABSTRACT—COMMERCIAL

SECTION 101 GENERAL

101.1 Title. These regulations shall be known as the *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.

101.2 Scope. This code establishes minimum prescriptive and performance-related regulations for the design of energy-efficient buildings and structures or portions thereof that provide facilities or shelter for public assembly, educational, business, mercantile, institutional, storage and residential occupancies, as well as those portions of factory and industrial occupancies designed primarily for human occupancy. This code thereby 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 for the effective use of energy in these buildings and structures.

Exception: Energy conservation systems and components in existing buildings undergoing repair, alteration or additions, and change of occupancy, shall be permitted to comply with the *International Existing Building Code*.

❖ 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. 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. 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 heating, ventilating and air-conditioning (HVAC) energy uses in these types of spaces are covered.

The exception serves as a connection to the *International Existing Building Code*® (IEBC®) and addresses the fact that in general, the code does not affect existing buildings (see Section 101.2.2.1). The IEBC will help in the regulation of existing buildings that undergo repair, alteration or additions or a change of occupancies. Depending on the level of work being undertaken, the code will establish different levels of compliance. As an example, see Section 906 of the IEBC. 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.

101.2.1 Exempt buildings. Buildings and structures indicated in Sections 101.2.1.1 and 101.2.1.2 shall be exempt from the building envelope provisions of this code, but shall comply with the provisions for building, mechanical, service water heating and lighting systems.

❖ 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 commercial buildings, the exemptions that follow in Sections 101.2.1.1 and 101.2.1.2 are intended to apply only to building thermal envelope requirements.

101.2.1.1 Separated buildings. Buildings and structures, or portions thereof separated by building envelope assemblies from the remainder of the building, that have a peak design rate of energy usage less than 3.4 Btu/h per square foot (10.7 W/m^2) or 1.0 watt per square foot (10.7 W/m^2) of floor area for space conditioning purposes.

❖ Buildings and portions of buildings whose summer and winter peak rates of energy use are both very low [below 3.4 Btu/h · ft^2 or 1.0 W/ft^2 (10.7 W/m^2)] are exempt from the code. The phraseology, "a peak 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 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.) 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, Section 101.2.1.2). 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. 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 101.2.1 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.

101.2.1.2 Unconditioned buildings. Buildings and structures or portions thereof which are neither heated nor cooled.

❖ The requirements of the code do not apply to buildings or portions of buildings that are neither heated nor cooled (unconditioned). 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.

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.

101.2.2 Applicability. The provisions of this code shall apply to all matters affecting or relating to structures and premises, as set forth in Section 101. Where, in a specific case, different sections of this code specify different materials, methods of construction or other requirements, the most restrictive shall govern.

❖ The scope of the code as described in Section 101.2 is referenced in this section. The most restrictive code requirement is to apply where different requirements may be specified in the code for a specific installation. 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 addressed in this section and Section 101.2.

[EB] 101.2.2.1 Existing installations. Except as otherwise provided for in this chapter, a provision in this code shall not require the removal, alteration or abandonment of, nor prevent the continued utilization and maintenance of, an existing building envelope, mechanical, service water-heating, electrical distribution or illumination system lawfully in existence at the time of the adoption of this code.

❖ 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. If there are no previous code criteria to apply, the code official is to apply those provisions of the code that are reasonably applicable to existing buildings. 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®).

[EB] 101.2.2.2 Additions, alterations or repairs. Additions, alterations, renovations or repairs to a building envelope, mechanical, service water-heating, electrical distribution or illumination 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 system to comply with all of the requirements of this code. Additions, alterations or repairs shall not cause any one of the aforementioned and existing systems to become unsafe, hazardous or overloaded.

❖ 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 exception and commentary, Section 101.2). 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, 5 or 6 (depending on which compliance approach is used). 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. 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 (see commentary, Section 202, "Simulation tool"). 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. Many builders and code officials have requested a more simplified method of compliance. Section 502.2.5 is one approach that provides a simple, prescriptive specification menu for representative heating degree day (HDD) ranges that, if followed, will yield a building envelope meeting the requirements of Table 502.2. However, this alternative method is limited to additions of less than 500 square feet (46 m^2) and having a total glazed area of 40 percent or less in both the wall and the roof of the addition. The components of the building must meet the insulation *R*-values, window *U*-factors and door *U*-factors shown in Section 502.2.5 (see commentary, Section 502.2.5).

[EB] 101.2.2.3 Historic buildings. The provisions of this code relating to the construction, alteration, repair, enlargement, restoration, relocation or movement of buildings or structures shall not be mandatory for existing buildings or structures specifically identified and classified as historically significant by the state or local jurisdiction, listed in *The National Register of Historic Places* or which have been determined to be eligible for such listing.

❖ This historic buildings exemption applies only to the exterior envelope of such buildings, and to the interior only in those cases where the ordinance explicitly designates elements of the interior. The section also gives the code official the widest possible flexibility in enforcing these building envelope requirements when the building in question has historic value. This flexibility, 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.

Because historic buildings are typically not new construction, this section would be relevant only to additions to historic buildings. However, under certain circumstances, additions to historic buildings can qualify for exempt status under the code as well.

[EB] 101.2.2.4 Change in occupancy. It shall be unlawful to make a change in the occupancy of any building or structure which would result in an increase in demand for either fossil fuel or electrical energy supply unless such building or structure is made to comply with the requirements of this code or otherwise approved by the authority having jurisdiction. The code official shall certify that such building or structure meets the intent of the provisions of law governing building construction for the proposed new occupancy and that such change of occupancy does not result in any increase in demand for either fossil fuel or electrical energy supply or any hazard to the public health, safety or welfare.

❖ 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 under the current utility rate tariff structure. Without supporting documentation, the peak load must be assumed to increase with a change in occupancy.

101.2.3 Mixed occupancy. When a building houses more than one occupancy, each portion of the building shall conform to the requirements for the occupancy housed therein. Where minor accessory uses do not occupy more than 10 percent of the area of any floor of a building, the major use shall be considered the building occupancy. Buildings, other than detached one- and two-family dwellings and townhouses, with a height of four or more stories above grade shall be considered commercial buildings for purposes of this code, regardless of the number of floors that are classified as residential occupancy.

❖ A mixed-occupancy building is one that contains both residential and commercial uses. When residential and commercial uses coexist in a building, each story must be evaluated separately. Thus, for every story, 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, is considered commercial.

For example, consider the three-story apartment building in Figure 101.2.3, 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. The first story is 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 8. The remainder of the first story is considered residential and must meet the residential requirements.

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

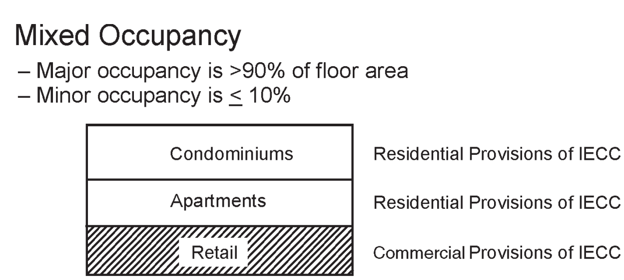


Figure 101.2.3
MIXED OCCUPANCY

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 requirements of this section make clear that the entire building would be considered commercial, subject to the requirements of Chapter 8. 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," "Multiple single-family dwelling (townhouse)," "Residential building, Group R-2" and "Residential building, Group R-4" to help clarify the application of the code to mixed-occupancy buildings.

101.3 Intent. The provisions of this code shall regulate the design of building envelopes for: adequate thermal resistance and low air leakage and the design and selection of mechanical, electrical, service water-heating and illumination systems and equipment which will enable effective use of energy in new building construction. It is intended that these provisions provide flexibility to permit the use of innovative approaches and techniques to achieve effective utilization of energy. This code is not intended to abridge safety, health or environmental requirements under other applicable codes or ordinances.

❖ 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 judgement to determine whether the proposed design meets the intent of the code in the interest of energy efficiency (see commentary, Section 103).

101.4 Compliance. Compliance with this code shall be determined in accordance with Sections 101.4.1 and 101.4.2.

❖ As shown in Figure 101.4(1), the code contains six 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 the code or the 90.1 ASHRAE Standard {by way of a secondary reference through the code are to be used to establish compliance with the energy conservation requirements of the code [see Figure 101.4(2)]. This section establishes the various methods of compliance with the code.

101.4.1 Residential buildings. For residential buildings the following shall be used as the basis for compliance assessment: a systems approach for the entire building (Chapter 4), an approach based on performance of individual components of the building envelope (Chapter 5), an approach based on performance of the total building envelope (Chapter 5), an approach based on acceptable practice for each envelope component (Chapter 5), an approach by prescriptive specification for individual components of the building envelope (Chapter 5), or an approach based on simplified, prescriptive specification (Chapter 6) where the conditions set forth in Section 101.4.1.1 or 101.4.1.2 are satisfied.

❖ 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, Building Design by Systems Analysis and Design of Buildings Utilizing Renewable Energy Sources: Chapter 4 describes 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 prescriptive criteria in Chapter 5. Chapter 4 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

Chapter 4. First, Chapter 4 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, Chapter 4 compares the energy use of the proposed design to that of a standard 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 modified to meet the minimum prescriptive requirements in Chapter 5. The standard design is used only for comparison, and is never actually built.

Chapter 4 sets both general principles and specific guidelines for use in computing the estimated annual energy use of the proposed and standard designs. These guidelines constitute a large portion of Chapter 4, but are necessary to maintain fairness and consistency between the proposed and standard designs.

Although the systems 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 requirements of the Chapter 5 component performance approach, 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 minimum prescriptive requirements in Chapter 5 are used to offset the potentially high thermal transmittance of an innovative exterior envelope design in this instance.

The systems analysis 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.

Chapter 5, Building Design by Component Performance Approach: Most of Chapter 5 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 annual Fahrenheit HDD and the type of component (walls, roof/ceiling assemblies, floors over unconditioned spaces, basement walls, etc.).

Building envelope compliance for one- and two-family and low-rise multiple-family residential buildings can be demonstrated using any one of the six compliance methods:

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 annual Fahrenheit HDD for the jurisdiction.

Compliance by Total Building Envelope Performance: Alternatively, a proposed design's component U_o, *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 U_o 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 the standard design for that same building insulated to just meet the individual component criteria of Chapter 5.

Compliance by Acceptable Practice on an Individual Component Basis: The methods used to establish compliance by acceptable practice on an individual component basis are founded on the principles described in *Compliance by Performance on an Individual Component Basis*. This compliance approach, however, is further limited by the select number of construction details offered in the appendix to meet building thermal envelope requirements.

Compliance by Prescriptive Specification on an Individual Component Basis: This envelope compliance method is by far the simplest of all residential envelope compliance options. It requires the applicant to determine the amount of window area as a percentage of the gross area of exterior walls. Based on that information and the annual Fahrenheit HDD for the jurisdiction, the building's thermal envelope criteria are determined.

Prescriptive Path for Additions and Window Replacements:This method was created as an alternative for additions with a conditioned floor area less than 500 square feet (46 m^2) and total fenestration product area not exceeding 40 percent of the wall and roof area of the addition.

Chapter 6, Simplified Prescriptive Requirements for Residential Buildings: This option was created to facilitate technical coordination of related provisions in Chapter 11 of the IRC. Thus the provisions of Chapter 6 are built upon elements of Chapter 5 while removing the perceived complexity (from the point of view of builders, designers, plan reviewers, and field contractors) when using and enforcing the energy code. It is worth noting that Chapter 6 consists of four pages in its entirety.

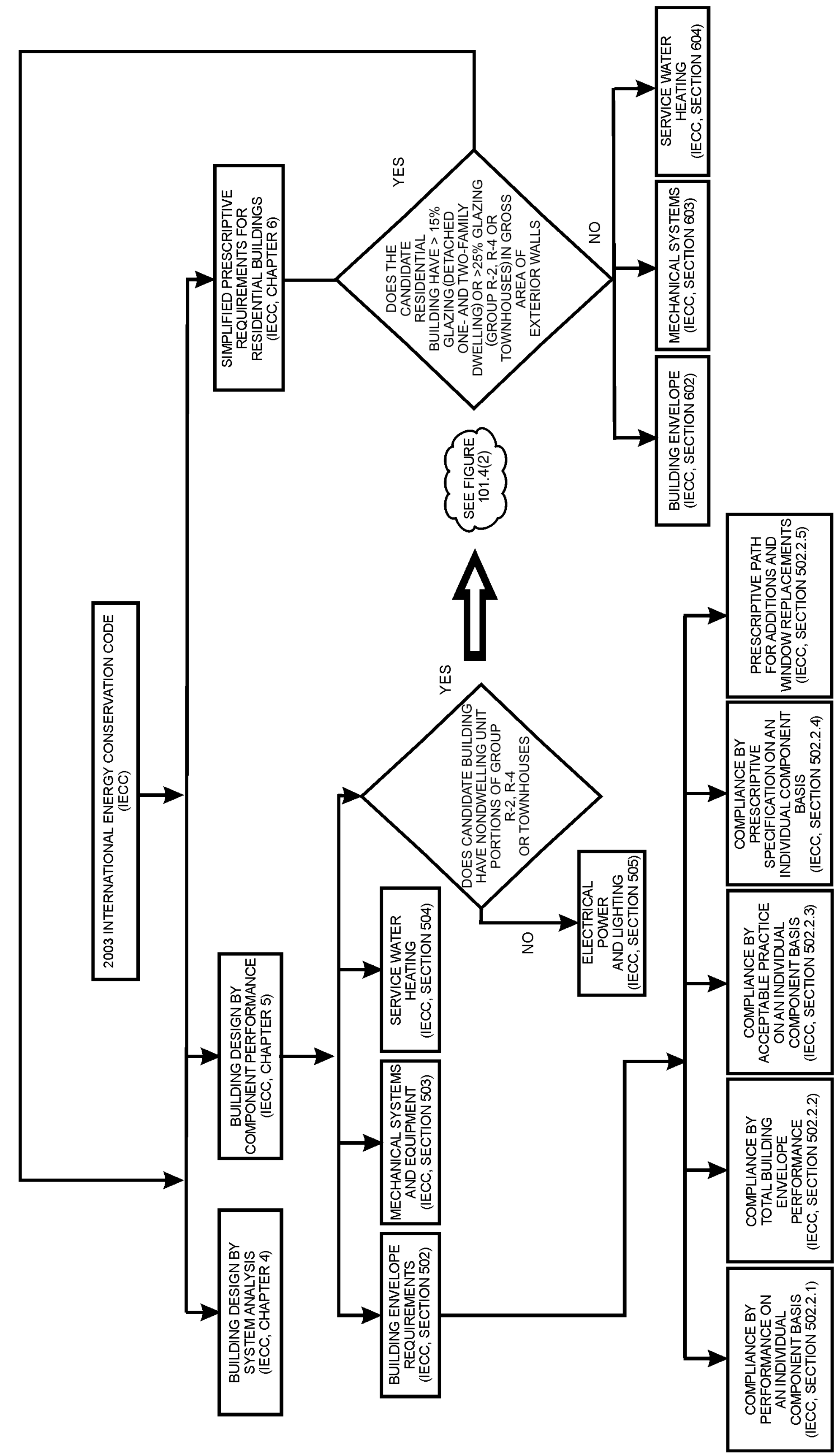


Figure 101.4(1)
DESIGN APPROACH—RESIDENTIAL BUILDINGS

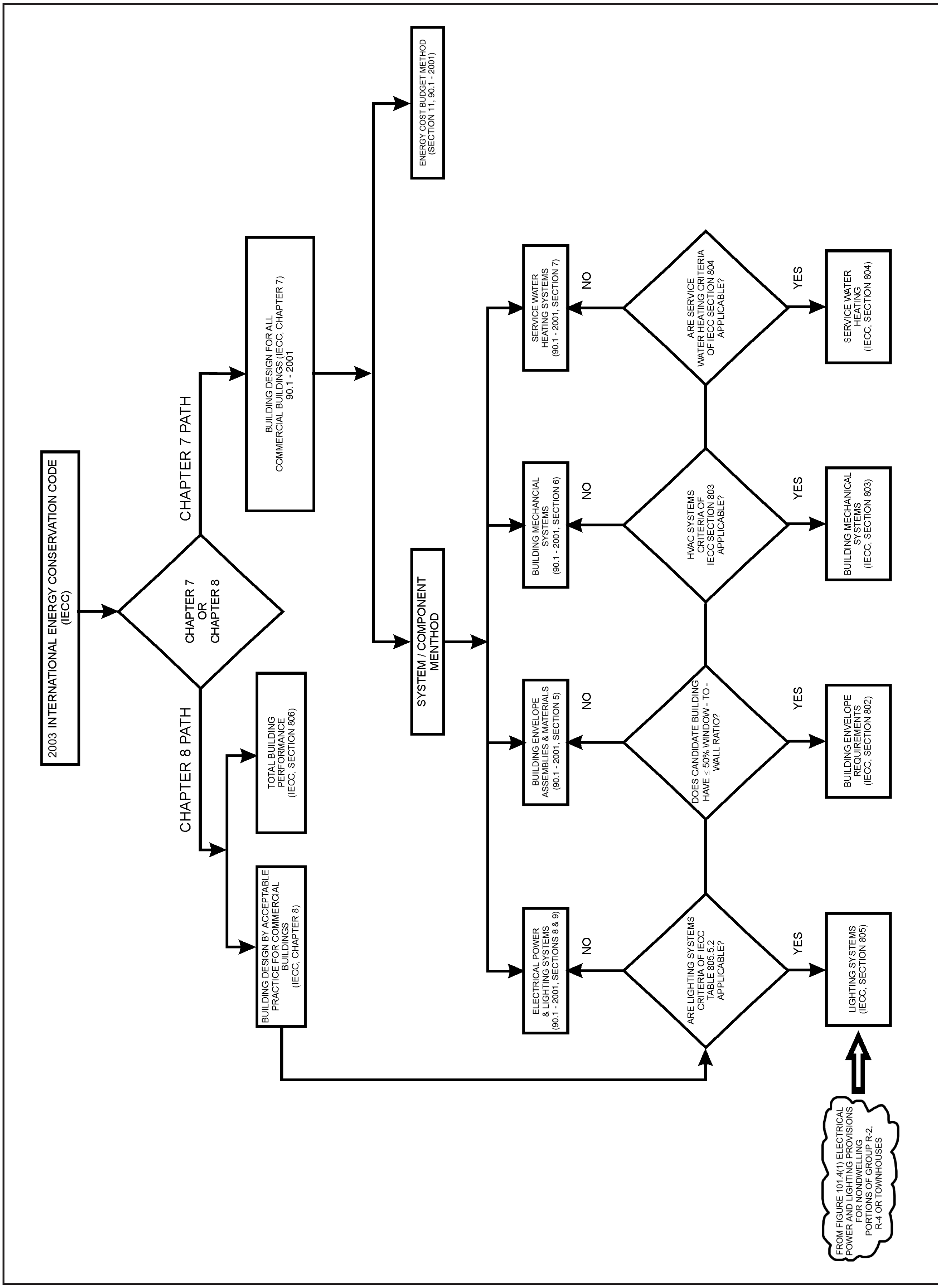


Figure 101.4(2)
DESIGN APPROACH—COMMERCIAL BUILDINGS

101.4.1.1 Detached one- and two-family dwellings. When the glazing area does not exceed 15 percent of the gross area of exterior walls.

❖ This section establishes the glazing area threshold for detached one- and two-family dwelling residential buildings for approaches using Chapter 6. Although equivalent compliance may still be demonstrated in accordance with either Chapter 4 or 5, one- and two-family dwellings exceeding the 15-percent threshold must use only Chapter 4 or 5 for compliance assessment.

101.4.1.2 Residential buildings, Group R-2, R-4 or townhouses. When the glazing area does not exceed 25 percent of the gross area of exterior walls.

❖ This section establishes the glazing area threshold for residential buildings, Group R-2, R-4 or townhouses for approaches using Chapter 6 [see commentary, Section 202, "Residential building, Group R-2;" "Residential building, Group R-4" and "Multiple single-family dwelling (townhouse)"]. Low-rise multiple-family residential buildings having more than 25-percent glazing area must demonstrate compliance using the methods in Chapter 4 or 5.

101.4.2 Commercial buildings. For commercial buildings, a prescriptive or performance-based approach (Chapter 7) or as specified by acceptable practice (Chapter 8) shall be used as the basis for compliance assessment.

❖ 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 8 of this code describes a simplified and enforceable alternative to the 90.1 Standard for all commercial buildings (for more on the 90.1 Standard, see commentary, Chapter 7). Envelope compliance for commercial buildings having a glazing area no greater than 50 percent of the above-grade exterior wall area is demonstrated by acceptable practice using the prescriptive tables in Chapter 8. The tables set the minimum level of thermal performance required for a variety of roof, floor and wall configurations typical of commercial construction practices based on building location and glass-to-wall area ratio.

For buildings having a glazing area greater than 50 percent of the above-grade exterior wall area, envelope compliance must be demonstrated in accordance with Section 806 or Chapter 7 (i.e., 90.1 Standard).

Energy code compliance for mechanical systems and HVAC equipment is addressed in Section 803. Buildings served by mechanical systems and equipment not otherwise covered by Section 803 must be evaluated for energy code compliance using Section 806 or Chapter 7.

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 8.

When Chapter 8 is 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 801, 802, 803, 804 and 805 individually, the candidate building (or building system) must demonstrate compliance under Section 806 or Chapter 7 (see 90.1 Standard).

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 the 90.1 Standard as adopted by reference in Chapter 7 of the IECC.

Buildings evaluated for compliance under the 90.1 Standard 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 806 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 13 of the 90.1 Standard, Section 806 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 806, it is possible to establish the annual energy use and cost for a candidate proposed design assuming that it just satisfies the minimum requirements in Chapter 8. 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 the 90.1 Standard.

SECTION 102
MATERIALS, SYSTEMS AND EQUIPMENT

102.1 General. Materials, equipment and systems shall be identified in a manner that will allow a determination of their 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.

102.2 Materials, equipment and systems installation. All insulation materials, caulking and weatherstripping, fenestration assemblies, mechanical equipment and systems components, and water-heating equipment and system components shall be installed in accordance with the manufacturer's installation instructions.

❖ 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 approved 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.

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

❖ 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*.

102.4 Insulation installation. Roof/ceiling, floor, wall cavity and duct distribution systems insulation shall be installed in a manner that permits inspection of the manufacturer's *R*-value identification mark.

❖ 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 102.5.1).

102.4.1 Protection of exposed foundation insulation. Insulation applied to the exterior of foundation walls and around 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 area of the exterior insulation and extend a minimum of 6 inches (153 mm) below grade.

❖ The ultimate performance of insulation materials 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.

102.5 Identification. Materials, equipment and systems shall be identified in accordance with Sections 102.5.1, 102.5.2 and 102.5.3.

❖ 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, the mark is subject to the approval of the code official.

102.5.1 Building envelope insulation. A thermal resistance (*R*) identification mark shall be applied by the manufacturer to each piece of building envelope insulation 12 inches (305 mm) or greater in width.

Alternatively, the insulation installer shall provide a signed and dated certification for the insulation installed in each element of the building envelope, listing the type of insulation installations in roof/ceilings, the manufacturer and the *R*-value. For blown-in or sprayed insulation, the installer shall also provide the initial installed thickness, the settled thickness, the coverage area and the number of bags installed. Where blown-in or sprayed insulation is installed in walls, floors and cathedral ceilings, the installer shall provide a certification of the installed density and *R*-value. The installer shall post the certification in a conspicuous place 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 not 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 102.5.1).

102.5.1.1 Roof/ceiling insulation. The thickness of roof/ceiling insulation that is either blown in or sprayed shall be identified by thickness markers that are labeled in inches or millimeters 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 and minimum settled thickness with numbers a minimum of 1 inch (25 mm) in height. Each marker shall face the attic access. The thickness of installed insulation shall meet or exceed the minimum initial installed thickness shown by the marker.

❖ 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:

- The type of insulation used.
- The insulation's coverage per bag (the number of bags required to result in a given *R*-value for a given area).
- 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. 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.

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 102.5.1
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)

102.5.2 Fenestration product rating, certification and labeling. *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. 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. Where a shading coefficient for a fenestration product is used, it shall be determined by converting the product's SHGC, as determined in accordance with NFRC 200, to a shading coefficient, by dividing the SHGC by 0.87. Such certified and labeled *U*-factors and SHGCs shall be accepted for purposes of determining compliance with the building envelope requirements of this code.

When a manufacturer has not determined product *U*-factor in accordance with NFRC 100 for a particular product line, compliance with the building envelope requirements of this code shall be determined by assigning such products a default *U*-factor in accordance with Tables 102.5.2(1) and 102.5.2(2). When a SHGC or shading coefficient is used for code compliance and a manufacturer has not determined product SHGC in accordance with NFRC 200 for a particular product line, compliance with the building envelope requirements of this code shall be determined by assigning such products a default SHGC in accordance with Table 102.5.2(3). Product features must be verifiable for the product to qualify for the default value associated with those features. Where the existence of a particular feature cannot be determined with reasonable certainty, the product shall not receive credit for that feature. Where a composite of materials from two different product types is used, the product shall be assigned the higher *U*-factor.

❖ 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 National Fenestration Rating Council (NFRC) has developed a fenestration energy rating 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. Products that are not NFRC certified and do not exactly match the specifications in Table 102.5.2(1) must use the tabular specification for the product most closely resembling it. For example, a wood door with 1-inch (25 mm) panels would use the *U*-factor for wood doors with 1 $^{1}/_{8}$-inch (29 mm) panels.

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 glazing area (see commentary, Section 202, "Glazing area"). The NFRC procedure determines *U*-factor and SHGC ratings based on the whole fenes-

TABLE 102.5.2(1)
***U*-FACTOR DEFAULT TABLE FOR WINDOWS, GLAZED DOORS AND SKYLIGHTS**

FRAME MATERIAL AND PRODUCT TYPE[a]	SINGLE GLAZED	DOUBLE GLAZED
Metal without thermal break:		
Curtain wall	1.22	0.79
Fixed	1.13	0.69
Garden window	2.60	1.81
Operable (including sliding and swinging glass doors)	1.27	0.87
Site-assembled sloped/overhead Glazing	1.36	0.82
Skylight	1.98	1.31
Metal with thermal break:		
Curtain wall	1.11	0.68
Fixed	1.07	0.63
Operable (including sliding and swinging glass doors)	1.08	0.65
Site-assembled sloped/overhead Glazing	1.25	0.70
Skylight	1.89	1.11
Reinforced vinyl/metal clad wood:		
Fixed	0.98	0.56
Operable (including sliding and swinging glass doors)	0.90	0.57
Skylight	1.75	1.05
Wood/vinyl/fiberglass:		
Fixed	0.98	0.56
Garden window	2.31	1.61
Operable (including sliding and swinging glass doors)	0.89	0.55
Skylight	1.47	0.84

a. Glass-block assemblies with mortar but without reinforcing or framing shall have a *U*-factor of 0.60.

tration assembly [untested fenestration products have default *U*-factors assigned as described in the commentary to Table 102.5.2(1)]. 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 102.5.2(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 61,000 products. 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 organizations's website at www.nfrc.org.

NFRC rates all products in two standard sizes so that consumers and others can be sure they are comparing products of the same size. On the label, these two sizes are listed as "Res" and "Nonres" (commercial). Therefore the first row (Res) is always used for compliance with Chapters 4, 5 and 6 and the second row (NonRes) is used for compliance with Chapters 7 or 8.

TABLE 102.5.2(1). See page 1-16.

❖ The code offers an alternative to NFRC-certified fenestration product *U*-factor ratings. In the absence of *U*-factors based on NFRC test procedures, the default *U*-factors in Table 102.5.2(1) must be used. When a composite of materials from two different product types is used, the product must be assigned the higher *U*-factor. 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 102.5.2(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 0.87 in Table 102.5.2(1) applies to a single glazed, operable metal window without thermal break (but with an installed storm window).

TABLE 102.5.2(2)
***U*-FACTOR DEFAULT TABLE FOR NONGLAZED DOORS**

DOOR TYPE	WITH FOAM CORE	WITHOUT FOAM CORE
Steel doors (1.75 inches thick)	0.35	0.60
	WITH STORM DOOR	WITHOUT STORM DOOR
Wood doors (1.75 inches thick)		
Hollow core flush	0.32	0.46
Panel with 0.438-inch panels	0.36	0.54
Panel with 1.125-inch panels	0.28	0.39
Solid core flush	0.26	0.40

For SI: 1 inch = 25.4 mm.

TABLE 102.5.2(2).

❖ The *U*-factors for exterior doors in this table are for doors without glazing. Values are based on a nominal 32-inch by 80-inch (813 mm by 2032 mm) door size. Interpolation and extrapolation between values is prohibited. Opaque door *U*-factors in Table 102.5.2(2) should be based on NFRC-certified ratings wherever possible.

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*.

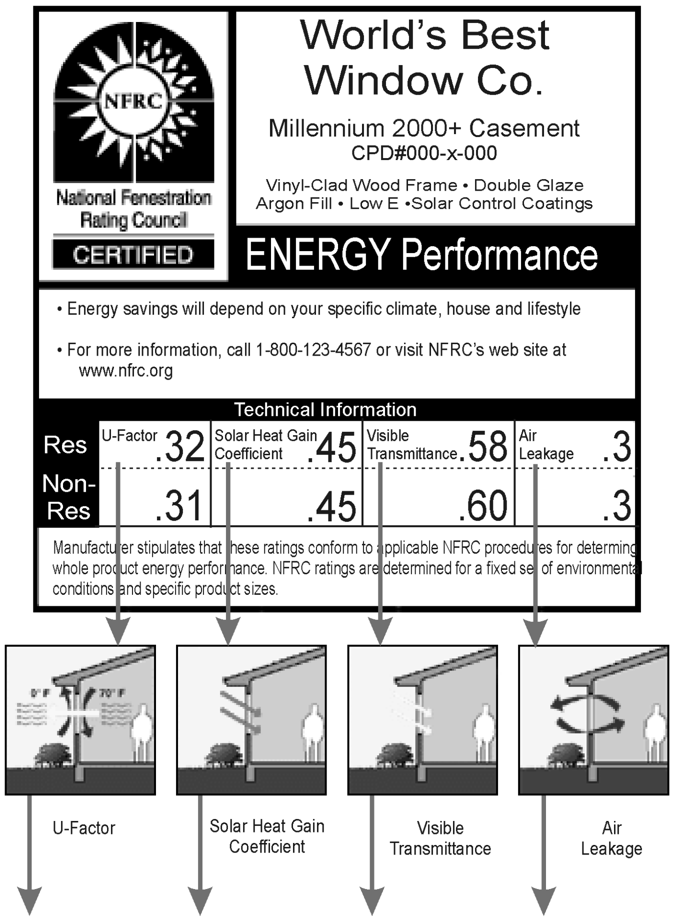
TABLE 102.5.2(3). See page 1-18.

❖ 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 covected 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 (HDD > 3,500). 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.

TABLE 102.5.2(3)
SHGC DEFAULT TABLE FOR FENESTRATION

PRODUCT DESCRIPTION	SINGLE GLAZED				DOUBLE GLAZED			
	Clear	Bronze	Green	Gray	Clear + Clear	Bronze + Clear	Green + Clear	Gray + Clear
Metal frames								
Fixed	0.78	0.67	0.65	0.64	0.68	0.57	0.55	0.54
Operable	0.75	0.64	0.62	0.61	0.66	0.55	0.53	0.52
Nonmetal frames								
Fixed	0.75	0.64	0.62	0.61	0.66	0.54	0.53	0.52
Operable	0.63	0.54	0.53	0.52	0.55	0.46	0.45	0.44



U-factor measures how well a product prevents heat from escaping. U-factor ratings generally fall between 0.20 and 1.20. The lower the U-factor, the better. U-factor is particularly important in northern climates.

Solar heat gain coefficient (SHGC) measures how well a product blocks heat caused by sunlight. SHGC is expressed as a number between 0 and 1. A lower SHGC means less heat gain. SHGC is particularly important in southern climates.

Visible transmittance (VT) measures how much light comes through a product. VT is expressed as a number between 0 and 1. Heavily tinted products have a relatively low VT.

Air leakage (AL) heat loss and gain occur by infiltration through cracks in the window assembly. It is indicated by an air leakage rating (AL) expressed as the equivalent cubic feet of air passing through a square foot of window area. The lower the AL, the less air will pass through cracks in the window assembly. At this time, AL is optional but required by code only for manufactured windows and doors.

Figure 102.5.2(1)
SAMPLE NATIONAL FENESTRATION RATING COUNCIL (NFRC) LABEL

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

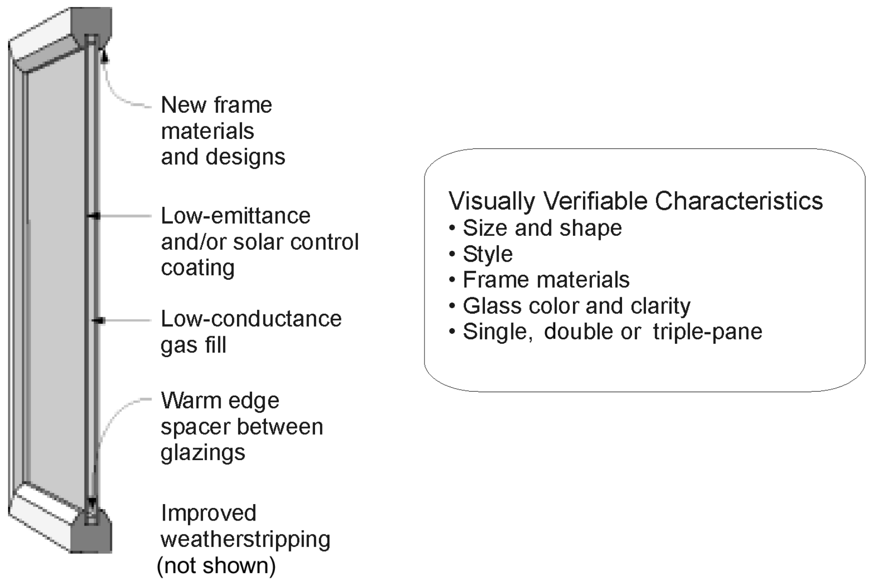


Figure 102.5.2(2)
VISUALLY VERIFIABLE WINDOW CHARACTERISTICS

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

102.5.3 Duct distribution systems insulation. A thermal resistance (*R*) identification mark shall be applied by the manufacturer in maximum intervals of no greater than 10 feet (3048 mm) to insulated flexible duct products showing the thermal performance *R*-value for the duct insulation itself (excluding air films, vapor retarders or other duct components).

❖ To aid the inspection process, duct insulation must have a label affixed to it by the manufacturer with the manufacturer's name, the thermal resistance (*R*) at the specified installation thickness, and the flame spread and smoke-developed indexes. A third-party agency must perform quality control inspections at the manufacturer's facility in accordance with the requirements for identification contained in Section 102.5. Testing performed by an independent agency must determine the insulating *R*-value, the flame spread index and the smoke-developed index. The 10-foot (3048 mm) label intervals are intended to increase the likelihood that every cut piece of insulation and flexible duct will have a label.

It is important for design professionals, duct manufacturers and mechanical system installers in particular to note that Section 604.7 of the *International Mechanical Code®* (IMC®) requires *R*-value markings and other label information at 36-inch (914 mm) intervals rather than at 10-foot (3048 mm) intervals. It is reasonable to assume that a code official would require the closer marking interval.

The thermal performance of duct insulation depends on its installed condition, including the compressed condition for duct wrap insulations. For example, insulation materials manufactured and tested specifically for duct applications are generally assumed to have a thickness of 75 percent of the nominal uninstalled thickness. The *R*-value on the product will account for the decreased thermal resistance caused by compression of the product.

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

103.1 General. The provisions of this code are 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 the code.

Compliance with specific provisions of this code shall be determined through the use of computer software, worksheets, compliance manuals and other similar materials when they have 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 code 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 judgement in accepting materials, systems or methods, which, while not anticipated by the drafters of the current code text, can be demonstrated to offer equivalent 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.

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 construction documents and designs submitted under the provisions of Chapter 4 shall be prepared by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed. Where special conditions exist, the code official is authorized to require additional construction documents to be prepared by a registered design professional.

Exceptions:

1. The code official is authorized to waive the submission of construction documents and other supporting data not required to be prepared by a registered design professional if it is found that the nature of the work applied for is such that reviewing of construction documents is not necessary to obtain compliance with this code.
2. For residential buildings having a conditioned floor area of 5,000 square feet (465 m^2) or less, designs submitted under the provisions of Chapter 4 shall be prepared by anyone having qualifications acceptable to the code official.

❖ 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. When the quality of the materials is essential for conformity to the code, specific information must be given to establish that quality. Also, this code must not be cited, or the term “legal” or its equivalent used as a substitute for specific information.

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 judgement 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.

Exception 1 requires the code official to determine that state professional registration laws are complied with as they apply to the preparation of construction documents for code compliance.

Exception 2 applies to most one- and two-family dwellings. The 5,000 square feet (465 m^2) refers to the total conditioned floor area of each one- or two-family dwelling or multiple-family building.

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 and the equipment and systems as herein governed, including, but not limited to, design criteria, exterior envelope component materials, *U*-factors of the envelope systems, *U*-factors of fenestration products, *R*-values of insulating materials, size and type of apparatus and equipment, equipment and systems controls and other pertinent data to indicate compliance with the requirements of this code and relevant laws, ordinances, rules and regulations, as determined by the code official.

❖ 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 determine compliance. A statement on the construction documents, such as, “All insulation levels shall comply with the 2003 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. 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, weather-stripped or otherwise sealed.
- *Through supplementary worksheets or calculations.* Provide area-weighted calculations where required, such as for projection factors and heat capacity. You 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 roof *R*-value requirements unless the skylights meet the exemption criteria. This exemption 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.
- 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 102.4.1).
- 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 802.2.7).
- Exterior walls include opaque doors, both fire exit doors and roll-up loading doors. Uninsulated roll-up doors are comparable to single glazing; thus, 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 frame walls usually fall within the 0 to 4.9 Btu/ft^2 · °F[kJ/(m^2 · k)] heat capacity range.
- 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).
- Exterior walls with metal framing in climates over 4,000 HDD 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 (6.0 or greater heat capacity) 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 climates over 3,000 HDD must be at least double glazed to meet the prescriptive criteria. 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 806) or the systems analyst's (see Chapter 4) trade-off procedures, 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 and opaque door air leakage are included on the fenestration and opaque 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 exempt 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 exempt 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 exempt 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.
- 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.
- Check that the window-to-wall ratio calculation (values in table are expressed as a percentage) is correct. Window area should include the entire rough opening area of all windows, sliding and swinging glass doors and clerestories.
- Check that the proposed opaque exterior wall *R*-values comply with the code and match what is on the drawings.
- Verify that lightweight walls, heavyweight walls and opaque doors 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 opaque 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; and (4) the heat capacities have been calculated correctly.
- 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 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 in-

clude the effects of framing; and (4) the SHGCs are NFRC-certified SHGCs (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.

You 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 vs. 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 of 3,000 cubic feet per minute (cfm) (1.4 m^3/s) and larger and 65,000 British thermal units per hour (Btu/h) cooling capacity and larger. Individual variable air volume (VAV) fan motors 25 horsepower (hp) and larger will need to have variable frequency drive or equivalent.
- Hydronic systems greater than 600,000 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 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 systems 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 25 hp are capable of operating at minimum outside air supply levels.
- Check that VAV fans with motors 25 hp and larger have variable frequency drive or equivalent. Ask to

see fan curves from manufacturer's specifications if necessary.

- Check that pump systems over 10 hp 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 are capable of being set from 55°F (13°C) to 85°F (29°C) with at least a 5°F dead-band.
- 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 are capable of being set to maintain a humidity from 30 to 60 percent unless special process humidity requirements dictate otherwise.
- 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 IMC, or 300 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 600,000 Btu/h 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 fan system of 3,000 cfm (1.4 m^3/s) or greater and 65,000 Btu/h or greater is equipped with an air or water economizer. 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 duct insulation *k*-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 thickness and flow rates for shower heads in residential construction.
- *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 space heating boiler.
- 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. In addition, piping close to the tank must be insulated regardless.

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, guestrooms 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 that separate equipment is used for space heating and service water heating. If the exception is claimed, ask for supporting documentation and a note on the drawings.

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, a timeclock or a combination of the two, and must have a minimum 4-hour power backup.
- *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 kilowatt (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, most one- or two-lamp fluorescent fixtures with energy-efficient lamps and ballasts will comply with the interior lighting power allowance. 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 all exterior lighting must have a source efficacy of at least 45 lumens per watt.
- Check that the interior lighting power allowance is filled out correctly using either the entire-building, tenant-area or portion-of-building method.
- 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 guest rooms 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 above 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 802.2.7) or is protected from sunlight and landscaping if installed on the exterior (see commentary, Section 102.4.1).

- 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 should be weatherstripped.
- Verify that exempt 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 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 102.4.1). 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. 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 they are following the approved plans and indeed they are. The inspector, as the representative of the code official, is clearly authorized to require 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.") 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 onsite 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 heating and cooling equipment efficiency.
- Verify heating and cooling equipment size. If an exception is claimed, verify the required controls are installed.
- Verify that separate air distribution systems are installed.
- Verify variable-frequency drive or other control type as indicated on drawings for VAV fan motors 25 hp and larger.
- Verify variable-speed drive or other control type as indicated on drawings for pumping systems over 10 hp.
- 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 fan system of 3,000 cfm (1.4 m^3/s) or greater and 65,000 Btu/h or greater is equipped with an air or water 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".) 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.
- 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 $^{8}/_{8}$th-inch diameter) rather than the old T-12 lamps ($1^{1}/_{2}$-inches $^{12}/_{8}$th-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 4-hour battery backup.
- 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 4-hour battery backup.
- 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.") 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 Approvals required. No work shall be done on any part of the building or structure beyond the point indicated in each successive inspection without first obtaining the written approval of the code official. No construction shall be concealed without inspection approval.

❖ 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. There shall be a final inspection and approval for buildings when completed and ready for occupancy.

❖ 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.

105.4 Reinspection. A structure 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.

SECTION 106
VALIDITY

106.1 General. If a section, subsection, sentence, clause or phrase of this code is, for any reason, held to be unconstitutional, such decision shall not affect the validity of the remaining portions of this code.

❖ 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 legislative action that put the legal requirements 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 applicable.

SECTION 107
REFERENCED STANDARDS

107.1 General. The standards, and portions thereof, which are referred to in this code and listed in Chapter 10, 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 10. 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. When a section of this code and a section of a referenced standard from Chapter 10 specify different materials, methods of construction or other requirements, the provisions of this code shall apply.

❖ 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 governs should a conflict occur.

Bibliography

The following resource materials are referenced in this chapter or are relevant to the subject matter addressed in this chapter.

ASHRAE 90A-80, *Energy Conservation in New Building Design* with Addendum 90A-2-87. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1987.

ASHRAE 90B-75, *Energy Conservation in New Building Design*. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1975.

ASHRAE 90C-77, *Energy Conservation in New Building Design*. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1977.

ASHRAE 90.1-89, *Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings*. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1989.

ASHRAE/IESNA-93, *Energy Code for Commercial and High-Rise Residential Buildings - Based on ASHRAE/IES 90.1-89.* Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1993.

ASHRAE-97, *Handbook of Fundamentals*. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.,1997.

CABO-92, *Model Energy Code*. Falls Church, VA: Council of American Building Officials, 1992.

CABO-93, *Model Energy Code*. Falls Church, VA: Council of American Building Officials, 1993.

CABO-95, *Model Energy Code*. Falls Church, VA: Council of American Building Officials, 1995.

CABO-95, *Model Energy Code Commentary*. Falls Church, VA: Council of American Building Officials, 1998.

IECC-98, *International Energy Conservation Code*. Falls Church, VA: International Code Council, 1998.

IECC-2000, *International Energy Conservation Code*. Falls Church, VA: International Code Council, 2000.

IECC-2003, *International Energy Conservation Code*. Falls Church, VA: International Code Council, 2003

IRC-2000, *International Residential Code*. Falls Church, VA: International Code Council, 2000.

NFRC, *Certified Products Directory 2000*. Silver Spring, MD: National Fenestration Rating Council, Inc., 2000.

PNNL-97, *Assessment of the 1995 Model Energy Code for Adoption.* Richland, WA: Prepared for U.S. Department of Housing and Urban Development Office of Policy Development and Research by Pacific Northwest National Laboratory, 1997.

U.S. DOE-97, Technical Support Document for COM*Check*-EZ™, V1.0. Washington, DC: U.S. Department of Energy, 1997.

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 otherwise expressly stated, the following words and terms shall, for the purposes of this code, 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, 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. Where terms are not defined in this code and are defined in the *International Building Code*, ICC *Electrical Code*, *International Fire Code*, *International Fuel Gas Code*, *International Mechanical Code* or the *International Plumbing Code*, such terms shall have meanings ascribed to them as 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.

201.4 Terms not defined. Where terms are not defined through the methods authorized by this section, such terms shall have ordinarily accepted meanings such as the context implies.

❖ Another resource 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 10) and in published textbooks on the subject in question are good resources.

SECTION 202
GENERAL DEFINITIONS

ACCESSIBLE (AS APPLIED TO EQUIPMENT). Admitting close approach because not guarded by locked doors, elevation or other effective means (see "Readily accessible").

❖ Providing access to mechanical equipment and appliances is necessary to facilitate inspection, observation, maintenance, adjustment, repair or replacement. Access to equipment means the equipment can be physically reached without having to remove a permanent