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# Extreme Heat and Urban Heat Island Code Overlay

## An overlay of model building code language for limiting the impact of extreme heat and urban heat islands

Version 1.0 | March 2024

Codes for Climate™

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## Acknowledgments

We gratefully acknowledge the following individuals and organizations for their contributions and insight in developing the "Extreme Heat and Urban Heat Island Mitigation Code Overlay: An overlay of model building code language for limiting the impact of extreme heat and urban heat islands."

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## Introduction and Background

At the time of writing, 2023 has been the hottest year to date globally, and 2024 is poised to be even hotter. Global temperature rise is expected to increase by over 8 degrees Fahrenheit (°F) by 2100 due to global warming caused by the continuous burning and expansion of fossil fuels, paired with deforestation, and propelled by positive feedback loops [1].

As carbon dioxide (CO2) in the atmosphere has trended upward over the past decades, heat waves have increased in frequency, severity, and duration. Even locations in colder, northern climates are no longer immune to extreme heat. In the U.S., extreme heat costs $100 billion annually in lost worker productivity and this cost is projected to increase to $500 billion by 2050 [2]. Since that cost estimate only includes the impact on worker productivity, the full cost of extreme heat is much higher.

In the U.S., extreme heat costs **$100 Billion** annually in lost worker productivity

Heat is often higher in urban areas where dense buildings, concrete surfaces, and asphalt-covered roads absorb the sun's rays during the day and release their heat in the evening. This scenario leads to the urban heat island (UHI) effect. Since over 60% of a typical city's land area is covered in roofs and pavements, which absorb the sun's heat at a greater rate than trees and vegetation, building codes and policies that increase the solar reflectance of building surfaces and pavements are a vital part of any UHI mitigation policy plan [3].

In the U.S., heat is the most fatal climate event, over four times more fatal than cold temperatures [4]. Extreme heat exacerbates existing health vulnerabilities and is especially dangerous to those with chronic health conditions, outdoor workers, and low-income residents. Heat increases the prevalence of low-level ozone, or smog, which means that heat is correlated with increased respiratory problems. Extreme heat can lead to heat stress and heat stroke, where the body is severely dehydrated and cannot cool itself down to a safe level. High heat can also impact mental health, as extreme heat has been linked to reduced concentration, increased anxiety, and depression [5]. Extreme heat can even increase violence [5]. Furthermore, high temperatures can make some common medications less effective [6]. Some medicines reduce the body’s ability to cool down, putting a large percentage of the population at increased risk for heat illness [6].

Rising temperatures and extreme heat exacerbate the severity and prevalence of the UHI effect, a phenomenon where temperatures are higher in dense urban areas compared to surrounding suburban and rural areas. However, heat islands can also be experienced in any environment on a micro-level, such as a rural area with a large, dark asphalt parking lot. In the U.S., cities are, on average, 8°F warmer than surrounding rural areas, but differences as high as 13°F have been recorded in a metro area [7]. Heat islands are caused by the prevalence of dark, impervious surfaces like dark roofs and asphalt pavement, which absorb most of the sun’s energy and re-radiate it as heat to the surrounding area, increasing the temperatures of buildings, roads, air, and people throughout the day and into the night. Lack of vegetation, shade, and proper airflow further reduce the ability of a city to cool itself. At the same time, fossil-fuel-based transportation and industrial processes expel heat onto dark pavements and the air.

Addressing extreme heat and the UHI effect is pivotal in environmental justice efforts. Low- to moderate-income neighborhoods, which often have a higher percentage of people of color, suffer more from the UHI effect due to years of inequitable policy, such as redlining [7], [8]. Redlining is a practice by banks and the federal government that increases housing segregation and wealth disparity [7], [8]. Today, historically redlined neighborhoods are much more likely to have less tree cover, be located near polluting industries and highways, and thus, experience higher temperatures than the city average. These neighborhoods are also less likely to have cooling in their homes and less likely to have adequate access to healthcare. On top of this, they experience a higher likelihood of chronic conditions that put them at a higher risk for heat illness and stresses the local health system. While this cycle is more common in lower-income neighborhoods, no one population is immune from the impacts of climate change.

In the U.S., heat is the most fatal climate event, over four times more fatal than cold temperatures [4].

# The Role of Building Codes in UHI and Extreme Heat Mitigation

With extreme heat impacting most communities, all buildings should do their part to minimize the impact. Building codes set minimum requirements for all new and majorly renovated buildings. These codes should also incorporate measures to reduce urban heat islands and extreme heat to "preserve public health and safety and provide safeguards from hazards associated with the built environment," as the International Building Code and other codes are intended to do **[9]**.

Building construction codes can address many UHI mitigation strategies. This code overlay addresses topics in three main categories: Building surfaces, Building site, Cooling equipment.

While improved insulation, air sealing, electrification, and building decarbonization overall are all necessary steps toward increasing safety and resiliency during extreme heat, those strategies are outside the scope of this report. For more information on those strategies, please see NBI's *Building Decarbonization Code Overlay* **[10]**.

## BUILDING SURFACES

Installing cool roofs and walls (together, "cool surfaces") is a relatively inexpensive energy conservation measure to reduce cooling loads in warmer regions passively. Cool surfaces strongly reflect sunlight and efficiently radiate heat away from the roof or wall surface. Cool roofs and walls are generally light colors like white or grey, but they are also available in various traditional colors using cool-colored pigments. Installing a cool roof and walls reduces the conduction of heat into the building, thus reducing the need for air conditioning in conditioned spaces. Minimizing the need for air conditioning or other cooling types saves energy and money. Furthermore, the decreased energy load helps moderate peak grid demand during heat waves and hot summer afternoons, thereby reducing the risk of community-wide power outages. Decreasing the convection of heat into the building also offers increased occupant comfort and safety in buildings that don't have cooling.

## BUILDING SITE

Strategies within the building site category include cool and/or permeable pavements, trees/vegetation, and shading. Permeable pavements allow rainwater to percolate into the ground, reducing water runoff, which helps maintain cooler temperatures in groundwater and streams while cooling the air via increased evaporation. Similar to cool roofs and walls, cool pavements reflect a higher percentage of the sun's radiation back into the atmosphere and maintain lower surface temperatures throughout the day and night compared to conventional dark pavements. Reflective pavements can vary in shade or color but are generally no brighter than a light grey sidewalk and are much less reflective than the reflective strips in the middle of roads.

## COOLING EQUIPMENT

Mitigating extreme heat and UHIs has many wide-reaching benefits. In addition to alleviating the health risks, UHI mitigation can reduce energy consumption in buildings. For example, mechanical cooling equipment run time such as for heat pumps and air conditioners, can be reduced when UHI mitigation strategies are implemented. This, in turn, reduces greenhouse gas emissions from electricity use and reduces the amount of hot air that air conditioners expel. In fact, studies estimate that 20% of warming in dense urban areas is attributable to heat expelled from air conditioners [11, p. 25], [12]. Implementing passive cooling strategies like improved building insulation, window shading and awnings, increasing tree canopy, and installing cool roofs, walls, and pavements can reduce the need for active mechanical cooling in the form of heat pumps and air conditioners.

## UHI Mitigation Co-Benefits

Mitigating UHIs and extreme heat reduces the likelihood of electric grid brownouts and blackouts. It helps maintain buildings and roads longer, as they are likely to stay at a lower temperature and are less susceptible to buckling and damage from extreme heat. Cooler temperatures also result in less smog formation since heat is a catalyst for ground-level ozone production. Furthermore, cooler pavement surface temperatures reduce tire wear and tear, a major source of particulate matter pollution.

However, implementing passive cooling in new construction is likely not enough to keep indoor temperatures at a safe level in certain climate zones. Mechanical space conditioning can also improve indoor air quality in urban environments and during smoke seasons. For these reasons, we have included active cooling strategies, i.e., language for a maximum indoor temperature setpoint for the 2024 International Building Code (IBC), 2021 International Residential Code (IRC), and 2021 International Mechanical Code (IMC). While all three of these model codes have a minimum indoor temperature setpoint, which requires heating, they do not yet have a maximum requirement to protect communities against extreme heat.

In addition to the aforementioned codes we include code overlay language for the following standards and model codes: ASHRAE 90.1-2022, 2021 International Energy Conservation Code (IECC), and 2021 International Green Construction Code (IgCC)/2020 ASHRAE 189.1. While some of these codes and standards already have some language related to UHI mitigation, we have moved the requirements from prescriptive to mandatory and strengthened the language based on the best available research.

We have provided similar cool roof and cool wall language for use in the energy codes (90.1 and IECC) and the building codes (IRC, IBC, and IMC). Some jurisdictions update the building code more frequently than the energy code (while some jurisdictions don't have an energy code), so having the option of incorporating the cool roof and cool wall language in the IBC or IRC may allow more jurisdictions to incorporate UHI mitigation strategies.

The Cool Roof Rating Council (CRRC) has a **cool roof directory** and a **cool wall directory** that can help jurisdictions see the U.S. market availability of products of different SRI and SR values. In addition, they have tracked the **cool roof and cool wall requirements** that exist in jurisdictions throughout the U.S [15].

## Using the Code in Policy

While jurisdictions can directly use the language in this report to update their local building codes, they can also amend and implement the code language as policies other than code. Jurisdictions can choose to implement these strategies in ways that best apply to their jurisdiction's current code utilization and practices. For example, a housing policy can incorporate the maximum indoor temperature requirement [13], or a local zoning code may require a specific community to incorporate cool surfaces [14]. If a jurisdiction is not yet ready to mandate a UHI mitigation strategy, it can decide to introduce cool surfaces by providing density and permitting incentives for builders to install cool surfaces on their buildings and building sites.

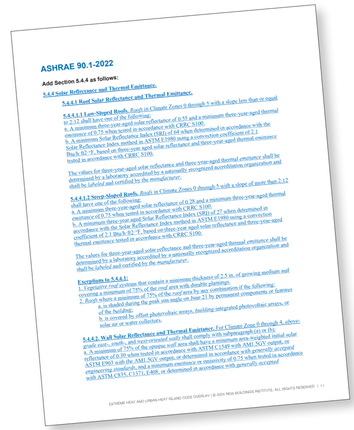
These strategies can also be combined to develop an ordinance that applies multiple UHI mitigation strategies, including building codes, zoning codes, required cooling for rental units, and free transit and cooling shelters on high-heat days.

# How to Use this Document

The Extreme Heat and Urban Heat Island Mitigation Code overlay was created for policymakers and provides template amendment language for the following codes and standards: 2021 IECC, 90.1-2022, 2021 IgCC/189.1-2020, 2024 IBC, 2021 IRC, and 2021 IMC. The amendments apply to residential and commercial new construction or major renovation.

Below are a few important considerations to increase the usability of this document.

1. The code language in this document is presented in Times New Roman. The code language can be used as-is or adapted (as noted in this document) and used in ordinances, legislation, zoning codes, procurement policies, or even incentive programs. Users can copy and paste language directly into formal proposals or documents. As written, the authority having jurisdiction (AHJ) may use any section of the overlay in its entirety or use portions of these sections to amend a code. The amendment language can be customized to a different version of a code to meet the needs of their communities and support their energy consumption and heat mitigation goals.
2. The underlined blue markup indicates new text. The ~~crossed-out red~~ markup indicates deleted text.
3. Code amendment language is followed by narrative text (depicted in *italicized grey text)* to explain the context, modifications, and relationship to code language. The narrative text should be removed for any formal proposal or repurposed as background information or a reason statement.


ASHRAE 90.1-2022

Add Section 5.4.4 as follows:

5.4.4 Solar Reflectance and Thermal Emittance.

5.4.4.1 Roof Solar Reflectance and Thermal Emittance.

5.4.4.1.1 Low-Sloped Roofs. *Roofs* in Climate Zones 0 through 5 with a slope less than or equal to 2:12 shall have one of the following:
a. A minimum three-year-aged solar reflectance of 0.55 and a minimum three-year-aged thermal *emittance* of 0.75 when tested in accordance with CRRC S100.
b. A minimum Solar Reflectance Index (SRI) of 64 when determined in accordance with the Solar Reflectance Index method in ASTM E1980 using a convection coefficient of 2.1 Btu/h·ft2·°F, based on three-year aged solar reflectance and three-year-aged thermal *emittance* tested in accordance with CRRC S100.

The values for three-year-aged solar reflectance and three-year-aged thermal *emittance* shall be determined by a laboratory accredited by a nationally recognized accreditation organization and shall be *labeled* and certified by the *manufacturer*.

5.4.4.1.2 Steep-Sloped Roofs. *Roofs* in Climate Zones 0 through 5 with a slope of more than 2:12 shall have one of the following:
a. A minimum three-year-aged solar reflectance of 0.28 and a minimum three-year-aged thermal *emittance* of 0.75 when tested in accordance with CRRC S100.
b. A minimum three-year aged Solar Reflectance Index (SRI) of 27 when determined in accordance with the Solar Reflectance Index method in ASTM E1980 using a convection coefficient of 2.1 Btu/h·ft2·°F, based on three-year aged solar reflectance and three-year-aged thermal *emittance* tested in accordance with CRRC S100.

The values for three-year-aged solar reflectance and three-year-aged thermal *emittance* shall be determined by a laboratory accredited by a nationally recognized accreditation organization and shall be *labeled* and certified by the *manufacturer*.

Exceptions to 5.4.4.1:
1. *Vegetative roof* systems that contain a minimum thickness of 2.5 in. of growing medium and covering a minimum of 75% of the *roof* area with durable plantings.
2. *Roofs* where a minimum of 75% of the *roof* area by any combination if the following:
a. is shaded during the peak sun angle on June 21 by permanent components or features of the *building*;
b. is covered by offset photovoltaic arrays, *building*-integrated photovoltaic arrays, or solar air or water collectors.

5.4.4.2. Wall Solar Reflectance and Thermal Emittance. For Climate Zone 0 through 4, *above-grade east-, south-,* and *west-oriented walls* shall comply with subparagraph (a) or (b):
a. A minimum of 75% of the *opaque wall* area shall have a minimum area-weighted initial solar reflectance of 0.30 when tested in accordance with ASTM C1549 with AM1.5GV output, or ASTM E903 with the AM1.5GV output, or determined in accordance with *generally accepted engineering standards*, and a minimum *emittance* or emissivity of 0.75 when tested in accordance with ASTM C835, C1371, E408, or determined in accordance with *generally accepted*

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## Access the Word Document

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## What is Albedo, Solar Reflectance, Solar Reflectance Index, and Thermal Emittance?

**Albedo, Solar Reflectance (SR):** Albedo, more commonly referred to as solar reflectance, is a measure of a material's ability to reflect sunlight (including the visible, infrared, and ultraviolet wavelengths) on a scale of 0 to 1. An albedo value of 0.0 indicates that the surface absorbs all solar radiation, and a 1.0 albedo value represents total reflectivity [16].

**Thermal Emittance:** The thermal emittance of a material refers to its ability to release absorbed heat. Scientists use a number between 0 and 1, or 0% and 100%, to express emittance. With the exception of metals, most construction materials have emittances above 0.85 (85%).

**Solar Reflectance Index (SRI):** SRI is a value that incorporates both solar reflectance (SR) and thermal emittance (TE) in a single value to represent a material's temperature in the sun. SRI quantifies how hot a surface would get relative to standard black and standard white surfaces. It is calculated using equations based on previously measured values of solar reflectance and emittance as per ASTM Standard E1980 [17]. It is expressed as a fraction (0.0 to 1.0) or percentage (0% to 100%). SRI is specifically meant for horizontal surfaces such as pavements and roofs, while solar reflectance (SR) and thermal emittance (TE) calculations/requirements are best suited for walls.

# Code Language

# ASHRAE 90.1-2022

**Add Section 5.4.4 as follows:**

**5.4.4 Solar Reflectance and Thermal Emittance.**

**5.4.4.1 Roof Solar Reflectance and Thermal Emittance.**

**5.4.4.1.1 Low-Sloped Roofs.** *Roofs* in Climate Zones 0 through 5 with a slope less than or equal to 2:12 shall have one of the following:
a. A minimum three-year-aged solar reflectance of 0.55 and a minimum three-year-aged thermal *emittance* of 0.75 when tested in accordance with CRRC S100.
b. A minimum Solar Reflectance Index (SRI) of 64 when determined in accordance with the Solar Reflectance Index method in ASTM E1980 using a convection coefficient of 2.1 Btu/h·ft2·°F, based on three-year aged solar reflectance and three-year-aged thermal *emittance* tested in accordance with CRRC S100.

The values for three-year-aged solar reflectance and three-year-aged thermal *emittance* shall be determined by a laboratory accredited by a nationally recognized accreditation organization and shall be *labeled* and certified by the *manufacturer*.

**5.4.4.1.2 Steep-Sloped Roofs.** *Roofs* in Climate Zones 0 through 5 with a slope of more than 2:12 shall have one of the following:
a. A minimum three-year-aged solar reflectance of 0.28 and a minimum three-year-aged thermal *emittance* of 0.75 when tested in accordance with CRRC S100.
b. A minimum three-year aged Solar Reflectance Index (SRI) of 27 when determined in accordance with the Solar Reflectance Index method in ASTM E1980 using a convection coefficient of 2.1 Btu/h·ft2·°F, based on three-year aged solar reflectance and three-year-aged thermal *emittance* tested in accordance with CRRC S100.

The values for three-year-aged solar reflectance and three-year-aged thermal *emittance* shall be determined by a laboratory accredited by a nationally recognized accreditation organization and shall be *labeled* and certified by the *manufacturer*.

**Exceptions to 5.4.4.1:**
1. *Vegetative roof* systems that contain a minimum thickness of 2.5 in. of growing medium and covering a minimum of 75% of the *roof* area with durable plantings.
2. *Roofs* where a minimum of 75% of the *roof* area by any combination if the following:
   a. is shaded during the peak sun angle on June 21 by permanent components or features of the *building*;
   b. is covered by offset photovoltaic arrays, *building*-integrated photovoltaic arrays, or solar air or water collectors.

**5.4.4.2. Wall Solar Reflectance and Thermal Emittance.** For Climate Zone 0 through 4, *above-grade east*-, *south*-, and *west-oriented walls* shall comply with subparagraph (a) or (b):
a. A minimum of 75% of the *opaque wall* area shall have a minimum area-weighted initial solar reflectance of 0.30 when tested in accordance with ASTM C1549 with AM1.5GV output, or ASTM E903 with the AM1.5GV output, or determined in accordance with *generally accepted engineering standards*, and a minimum *emittance* or emissivity of 0.75 when tested in accordance with ASTM C835, C1371, E408, or determined in accordance with *generally accepted*

*engineering standards.* For the portion of the *opaque wall* that is glass spandrel area, a minimum solar reflectance of 0.29, determined in accordance with NFRC 300 or ISO 9050, shall be permitted. Area-weighting is permitted only between the *south*-, *east*-, and *west-oriented walls* and only between *walls* of the same *space conditioning category*.
b. A minimum of 30% of the *above-grade wall* area shall be shaded through the use of human-made *structures*, *existing buildings*, hillsides, permanent *building* projections, *on-site renewable energy systems*, or a combination of these. Shade coverage shall be calculated by projecting the shading surface downward on the *wall* at an angle of 45 degrees.

*This addition moves the cool roof and cool wall requirements from the prescriptive compliance path into the mandatory requirements. The language adds a cool roof requirement for steep-sloped roofs; currently, 90.1-2022 does not include steep-sloped roofs in their cool roof requirements. In addition, an existing exception for the cool roof requirement for higher insulation levels is removed because studies show that well-insulated buildings still stand to benefit from cool surfaces [18]. Cool roofs are currently required in the prescriptive path of ASHRAE 90.1 in Climate Zones 0 to 3. The overlay language extends the cool roof requirements to include climate zones 4 and 5 [19] and extends cool wall requirements to include climate zones 1, 2, 3, and 4 [20], [21], [22]. Cool walls are currently only required in the prescriptive path of ASHRAE 90.1 in Climate Zone 0, which is located outside of the U.S. According to Lawrence Berkeley National Laboratory, "glare [from cool walls] is unlikely unless the cool wall has a shiny metal surface or is extremely bright white" [23].*

*The climate zones can be expanded to suit a jurisdiction's UHI goals.*

# 2021 International Energy Conservation Code

**Add Section C401.4 as follows:**

**C401.4 Solar Reflectance and Thermal Emittance.**

**C401.4.1 Low-Sloped Roof solar reflectance and thermal emittance.** Low-sloped roofs in *Climate Zones* 0 through 5 shall comply with one or more of the options in Table C401.4.1.

**Exceptions:** The following roofs and portions of roofs are exempt from the requirements of Table C401.4.1:

1. Portions of the roof that include or are covered by the following:

    1.1. Photovoltaic systems or components.

    1.2. Solar air or water-heating systems or components.

    1.3. Vegetative roofs or landscaped roofs.

    1.4. Above-roof decks or walkways.

    1.5. Skylights.

    1.6. HVAC systems and components, and other opaque objects mounted above the roof.

2. Portions of the roof shaded during the peak sun angle on the summer solstice by permanent features of the building or by permanent features of adjacent buildings.

3. Roofs where not less than 75 percent of the roof area complies with one or more of the exceptions to this section.

**TABLE C401.4.1 MINIMUM ROOF REFLECTANCE AND EMITTANCE OPTIONS FOR LOW-SLOPED ROOFS[a]**

| |
|---|
| Three-year-aged solar reflectance of 0.55[b] and 3-year aged thermal emittance[c] of 0.75 |
| Three-year-aged solar reflectance index of 64[d] |

a. The use of area-weighted averages to comply with these requirements shall be permitted. Materials lacking 3-year-aged tested values for either solar reflectance or thermal emittance shall be assigned both a 3-year-aged solar reflectance in accordance with Section C401.4.1 and a 3-year-aged thermal emittance of 0.90.
b. Aged solar reflectance tested in accordance with ASTM C1549, ASTM E903 or ASTM E1918 or CRRC-S100.
c. Aged thermal emittance tested in accordance with ASTM C1371 or ASTM E408 or CRRCS100.
d. Solar reflectance index (SRI) shall be determined in accordance with ASTM E1980 using a convection coefficient of 2.1 Btu/h × ft2 × °F (12 W/m2 × K). Calculation of aged SRI shall be based on aged tested values of solar reflectance and thermal emittance. Where an aged solar reflectance required by Section C401.4.1 is not available, it shall be determined in accordance with Equation 4-x.

$$R_{aged} = [0.2 + 0.7(R_{initial} – 0.2)] \qquad \text{(Equation 4-x)}$$

where

$R_{aged}$ = The aged solar reflectance.

$R_{initial}$ = The initial solar reflectance determined in accordance with CRRC-S100.

**C401.4.2 Steep-Sloped Roof solar reflectance and thermal emittance.** Steep-sloped roofs in *Climate Zones* 0 through 5 shall comply with one or more of the options in Table C401.4.2.

**Exceptions:** The following roofs and portions of roofs are exempt from the requirements of Table C401.4.2:

1. Portions of the roof that include or are covered by the following:

    1.1. Photovoltaic systems or components.

    1.2. Solar air or water-heating systems or components.

    1.3. Vegetative roofs or landscaped roofs.

    1.4. Above-roof decks or walkways.

    1.5. Skylights.

    1.6. HVAC systems and components, and other opaque objects mounted above the roof.

2. Portions of the roof shaded during the peak sun angle on the summer solstice by permanent features of the building or by permanent features of adjacent buildings.

3. Roofs where not less than 75 percent of the roof area complies with one or more of the exceptions to this section.

**TABLE C401.4.2 MINIMUM ROOF REFLECTANCE AND EMITTANCE OPTIONS FOR STEEP-SLOPED ROOFS[a]**

| |
|---|
| Three-year-aged solar reflectance[b] of 0.28 and 3-year aged thermal emittance[c] of 0.75 |
| Three-year-aged solar reflectance index[d] of 27 |

a. The use of area-weighted averages to comply with these requirements shall be permitted. Materials lacking 3-year-aged tested values for either solar reflectance or thermal emittance shall be assigned both a 3-year-aged solar reflectance in accordance with Section C401.4.2 and a 3-year-aged thermal emittance of 0.90.
b. Aged solar reflectance tested in accordance with ASTM C1549, ASTM E903 or ASTM E1918 or CRRC-S100.
c. Aged thermal emittance tested in accordance with ASTM C1371 or ASTM E408 or CRRCS100.
d. Solar reflectance index (SRI) shall be determined in accordance with ASTM E1980 using a convection coefficient of 2.1 Btu/h × ft2 × °F (12 W/m2 × K). Calculation of aged SRI shall be based on aged tested values of solar reflectance and thermal emittance. Where an aged solar reflectance required by Section C401.4.2 is not available, it shall be determined in accordance with Equation 4-x.

$$R_{aged} = [0.2 + 0.7(R_{initial} - 0.2)] \qquad \text{(Equation 4-x)}$$

where

$R_{aged}$ = The aged solar reflectance.

$R_{initial}$ = The initial solar reflectance determined in accordance with CRRC-S100.

**C401.4.1.3 Wall Solar Reflectance and Thermal Emittance.** For Climate Zone 0 through 4, *above-grade east-*, *south-*, and *west-oriented walls* shall comply with subparagraph (a) or (b):

a. A minimum of 75% of the *opaque wall* area shall have a minimum area-weighted initial solar reflectance of 0.30 when tested in accordance with ASTM C1549 with AM1.5GV output, or ASTM E903 with the AM1.5GV output, or determined in accordance with *generally accepted engineering standards*, and a minimum *emittance* or emissivity of 0.75 when tested in accordance with ASTM C835, C1371, E408, or determined in accordance with *generally accepted engineering standards.* For the portion of the *opaque wall* that is glass spandrel area, a minimum solar reflectance of 0.29, determined in accordance with NFRC 300 or ISO 9050, shall be permitted. Area-weighting is permitted only between the *south*-, *east*-, and *west-oriented walls* and only between *walls* of the same *space conditioning category*.
b. A minimum of 30% of the *above-grade wall* area shall be shaded through the use of human-made *structures*, *existing buildings*, hillsides, permanent *building* projections, *on-site renewable energy systems*, or a combination of these. Shade coverage shall be calculated by projecting the shading surface downward on the *wall* at an angle of 45 degrees.

*This new section moves the commercial cool wall and cool roof requirements from the prescriptive path section into the mandatory section. In addition, it extends the cool roof requirements to include buildings in climate zones 4 and 5 and added cool wall/wall shading requirements for climate zones 0 through 4, based on ASHRAE 90.1. Further, reflectivity requirements have been added to steep-sloped roofs.*

*The climate zones can be expanded to suit a jurisdiction's UHI goals.*

**Add Section R401.2.6 as follows:**

**R401.2.6 Solar Reflectance and Thermal Emittance.**

This section establishes additional requirements applicable to all compliance approaches to achieve additional energy efficiency.

**R401.2.6.1 Low-Sloped Roof Solar Reflectance and Thermal Emittance.** Low-sloped roofs directly above conditioned spaces in *Climate Zones* 0 through 5 shall comply with one or more of the options in Table R401.2.6.1.

**Exceptions:** The following roofs and portions of roofs are exempt from the requirements of Table R401.2.6.1:

1. Portions of the roof that include or are covered by the following:

    1.1. Photovoltaic systems or components.

    1.2. Solar air or water-heating systems or components.

    1.3. Vegetative roofs or landscaped roofs.

    1.4. Above-roof decks or walkways.

    1.5. Skylights.

    1.6. HVAC systems and components, and other opaque objects mounted above the roof.

2. Portions of the roof shaded during the peak sun angle on the summer solstice by permanent features of the building or by permanent features of adjacent buildings.

3. Roofs where not less than 75 percent of the roof area complies with one or more of the exceptions to this section.

**TABLE R401.2.6.1 MINIMUM ROOF REFLECTANCE AND EMITTANCE OPTIONS FOR LOW-SLOPED ROOFS[a]**

| |
|---|
| Three-year-aged solar reflectance[b] of 0.55 and 3-year-aged thermal emittance[c] of 0.75 |
| Three-year-aged solar reflectance index[d] of 64 |

a. The use of area-weighted averages to comply with these requirements shall be permitted. Materials lacking 3-year-aged tested values for either solar reflectance or thermal emittance shall be assigned both a 3-year-aged solar reflectance in accordance with Section R401.2.6.1 and a 3-year-aged thermal emittance of 0.90.
b. Aged solar reflectance tested in accordance with ASTM C1549, ASTM E903 or ASTM E1918 or CRRC-S100.
c. Aged thermal emittance tested in accordance with ASTM C1371 or ASTM E408 or CRRCS100.
d. Solar reflectance index (SRI) shall be determined in accordance with ASTM E1980 using a convection coefficient of 2.1 Btu/h × ft2 × °F (12 W/m2 × K). Calculation of aged SRI shall be based on aged tested values of solar reflectance and thermal emittance. Where an aged solar reflectance required by Section R401.2.6.1 is not available, it shall be determined in accordance with Equation 4-2.

$R_{aged} = [0.2 + 0.7(R_{initial} – 0.2)]$ (Equation 4-x)

where

$R_{aged}$ = The aged solar reflectance.

$R_{initial}$ = The initial solar reflectance determined in accordance with CRRC-S100.

**R401.2.6.2 Steep-Sloped Roof Solar Reflectance and Thermal Emittance.** Steep-sloped roofs directly above conditioned spaces in *Climate Zones* 0 through 5 shall comply with one or more of the options in Table R401.2.6.2.

**Exceptions:** The following roofs and portions of roofs are exempt from the requirements of Table R401.2.6.2:

1. Portions of the roof that include or are covered by the following:
   1.1. Photovoltaic systems or components.
   1.2. Solar air or water-heating systems or components.
   1.3. Vegetative roofs or landscaped roofs.
   1.4. Above-roof decks or walkways.
   1.5. Skylights.
   1.6. HVAC systems and components, and other opaque objects mounted above the roof.
2. Portions of the roof shaded during the peak sun angle on the summer solstice by permanent features of the building or by permanent features of adjacent buildings.
3. Roofs where not less than 75 percent of the roof area complies with one or more of the exceptions to this section.

**TABLE R401.2.6.2 MINIMUM ROOF REFLECTANCE AND EMITTANCE OPTIONS FOR STEEP-SLOPED ROOFS[a]**

| | |
|---|---|
| Three-year-aged solar reflectance[b] of 0.25 and 3-year-aged thermal emittance[c] of 0.75 | |
| Three-year-aged solar reflectance index[d] of 20 | |

a. The use of area-weighted averages to comply with these requirements shall be permitted. Materials lacking 3-year-aged tested values for either solar reflectance or thermal emittance shall be assigned both a 3-year-aged solar reflectance in accordance with Section R401.2.6.2 and a 3-year-aged thermal emittance of 0.90.
b. Aged solar reflectance tested in accordance with ASTM C1549, ASTM E903 or ASTM E1918 or CRRC-S100.
c. Aged thermal emittance tested in accordance with ASTM C1371 or ASTM E408 or CRRCS100.
d. Solar reflectance index (SRI) shall be determined in accordance with ASTM E1980 using a convection coefficient of 2.1 Btu/h × ft2 × °F (12 W/m2 × K). Calculation of aged SRI shall be based on aged tested values of solar reflectance and thermal emittance. Where an aged solar reflectance required by Section R401.2.6.2 is not available, it shall be determined in accordance with Equation 4-x.

$R_{aged} = [0.2 + 0.7(R_{initial} – 0.2)]$ (Equation 4-x)

where

$R_{aged}$ = The aged solar reflectance.

$R_{initial}$ = The initial solar reflectance determined in accordance with CRRC-S100.

**R401.2.6.3 Wall Solar Reflectance and Thermal Emittance.** For Climate Zone 0 through 4, *above-grade east*-, *south*-, and *west-oriented walls* shall comply with subparagraph (a) or (b):

a. A minimum of 75% of the *opaque wall* area shall have a minimum area-weighted initial solar reflectance of 0.30 when tested in accordance with ASTM C1549 with AM1.5GV output, or ASTM E903 with the AM1.5GV output, or determined in accordance with *generally accepted engineering standards*, and a minimum *emittance* or emissivity of 0.75 when tested in accordance with ASTM C835, C1371, E408, or determined in accordance with *generally accepted engineering standards*. For the portion of the *opaque wall* that is glass spandrel area, a minimum solar reflectance of 0.29, determined in accordance with NFRC 300 or ISO 9050, shall be permitted. Area-weighting is permitted only between the *south*-, *east*-, and *west-oriented walls* and only between *walls* of the same *space conditioning category*.
b. A minimum of 30% of the *above-grade wall* area shall be shaded through the use of human-made *structures*, *existing buildings*, hillsides, permanent *building* projections, *on-site renewable energy systems*, or a combination of these. Shade coverage shall be calculated by projecting the shading surface downward on the *wall* at an angle of 45 degrees.

*This section adds mandatory residential cool roof and cool wall requirements. There are no requirements in the 2021 IECC related to solar reflectance and albedo for residential buildings, neither in the prescriptive nor in the mandatory section.*

*The climate zones can be expanded to suit a jurisdiction's UHI goals.*

# 2021 International Green Construction Code / 189.1-2020

## Modify Section 501.3.5 (5.3.5) as follows:

**501.3.5 (5.3.5) Mitigation of Heat Island Effect**

**501.3.5.1 (5.3.5.1) Site Hardscape.** At least 60~~50~~% of the *site hardscape* that is not covered by *solar energy systems* shall be provided with one or any combination of the following:

a. Existing trees and vegetation or new *biodiverse plantings* of *native plants* and *adapted plants*, which shall be planted either prior to the final approval by the *AHJ* or in accordance with a contract established to require planting no later than 12 months after the final approval by the *AHJ* so as to provide the required shade no later than ten years after the final approval. The effective shade coverage on the *hardscape* shall be the arithmetic mean of the shade coverage calculated at 10 a.m., noon, and 3 p.m. on the summer solstice.
b. Having materials with a minimum initial *solar reflectance index (SRI)* of 29. A default *SRI* value of 35 for new concrete without added color pigment is allowed to be used instead of measurements.
c. *Open-graded (uniform-sized) aggregate, permeable pavement, permeable pavers,* and *porous pavers (open-grid pavers). Permeable pavement* and *permeable pavers* shall have a percolation rate of not less than 2 gal/min • $ft^2$ (100 L/min • $m^2$).
d. Shading through the use of structures, provided that the top surface of the shading structure complies with the provisions of Section 501.3.5.3 (5.3.5.3).
e. Parking under a building, provided that the *roof* of the building complies with the provisions of Section 501.3.5.3 (5.3.5.3).
f. Buildings or structures that provide shade to the *site hardscape*. The effective shade coverage on the *hardscape* shall be the arithmetic mean of the shade coverage calculated at 10 a.m., noon, and 3 p.m. on the summer solstice.

**Exception:** Section 501.3.5.1 (5.3.5.1) shall not apply to *building projects* in *Climate Zones* 6, 7, and 8.

*In this section, the percentage of site hardscape needing to comply with section requirements is increased to 60%. All cool surface requirements in the 202 IgCC are in the mandatory requirements section. If used in zoning code, the percentage can be increased for specific neighborhoods or communities.*

## Modify Section 501.3.5.2 (5.3.5.2) as follows:

**501.3.5.2 (5.3.5.2) [JO] Walls.** Above-grade building *walls* and retaining walls shall be shaded in accordance with this section. The building is allowed to be rotated up to 45 degrees to the nearest cardinal orientation for purposes of calculations and showing compliance. Compliance with this section shall be achieved through the use of shade-providing *plants*, man-made structures, existing buildings, hillsides, permanent *building projections*, *on-site renewable energy systems*, or a combination of these, using the following criteria:

a. Shade shall be provided on at least 30% of the east, south, and west above-grade *walls* and retaining walls from grade level to a height of 20 ft (6 m) above grade, or the top of the exterior *wall*, whichever is less. Shade coverage shall be calculated at 10 a.m. for the east *walls*, noon for the south *walls*, and 3 p.m. for the west *walls* on the summer solstice.
b. Where shading is provided by vegetation, such vegetation shall be existing trees and vegetation or new *biodiverse plantings* of *native plants* and *adapted plants.* Such planting shall occur prior to the final approval by the *AHJ* or in accordance with a contract established to require planting no later than 12 months after the final approval by the *AHJ* so as to provide the required shade no

later than ten years after the final approval. Vegetation shall be appropriately sized, selected, planted, and maintained so that it does not interfere with overhead or underground utilities. Trees shall be placed a minimum of 5 ft (1.5 m) from and within 50 ft (15 m) of the building or retaining wall.

**Exceptions:**

1. The requirements of this section are satisfied if 75% or more of the opaque *wall* surfaces on the east, south, and west have a minimum solar reflectance of 0.30 and minimum thermal emittance of 0.75 ~~*SRI* of 29~~. Each *wall* is allowed to be considered separately for this exception.
2. East *wall* shading is not required for buildings located in Climate Zones 5, 6, 7, and 8. West *wall* shading is not required for buildings located in Climate Zones 7 and 8. South *wall* shading is not required for buildings located in Climate Zones 5, 6, 7, and 8.

*This section extends the cool wall and wall shading requirements to include the south-facing wall in climate zones 1 – 4. In addition, the cool wall requirements are changed from an SRI metric to a solar reflectance and thermal emittance metric to better align with SRI use and calculation guidelines.*

*The climate zones can be expanded to suit a jurisdiction's UHI goals.*

## Modify Section 501.3.5.3 (5.3.5.3) as follows:

**501.3.5.3 (5.3.5.3) Roofs.** This section applies to the building and covered parking *roof* surfaces for

*building projects* in Climate Zones 0 through 5 ~~0, 1, 2, 3, 4A, and 4B~~. A minimum of 75% of the *roof* surface area shall be covered with products that:

a. Have a minimum three-year-aged *SRI* of 64 in accordance with Section 501.3.5.4 (5.3.5.4) for *roofs* with a slope of less than or equal to 2:12.
b. Have a minimum three-year-aged *SRI* of ~~25~~ 27 in accordance with Section 501.3.5.4 (5.3.5.4) for *roofs* with a slope of more than 2:12.

The area occupied by one or more of the following shall be excluded from the calculation to determine the *roof* surface area required to comply with this section:

a. *Roof* penetrations and associated equipment
b. *On-site renewable energy systems*, including photovoltaics, solar thermal energy collectors, and required access around the panels or collectors
c. Portions of the *roof* used to capture heat for building energy technologies
d. *Roof* decks and rooftop walkways
e. Vegetated terrace and roofing systems complying with Section 501.3.5.5 (5.3.5.5).

**Exception~~s~~ to 501.3.5.3 (5.3.5.3):**

~~1. *Building projects* where an annual energy analysis simulation demonstrates that the total annual building energy cost and total annual *CO2e*, as calculated in accordance with Section 701.5.2 (7.5.2), are both a minimum of 2% less for the proposed *roof* than for a *roof* material complying with the *SRI* requirements of Section 501.3.5.3 (5.3.5.3).~~
~~2. Existing buildings in Climate Zones 4A and 4B undergoing alteration, repair, relocation,~~
~~or a change in occupancy.~~
~~3.~~ *Roofs* used to shade or cover parking, ~~and *roofs* over *semiheated spaces*,~~ provided that they have a minimum initial *SRI* of 29. A default *SRI* value of 35 for new concrete without added color pigment is allowed to be used instead of measurements.

~~1. Ballasted *roofs* in Climate Zones 4A and 4B having a stone ballast of not less than 17 lb/ft2 (83 kg/m2) or a paver ballast of not less than 23 lb/ft2 (112 kg/m2).~~

*This section extends the cool roof requirements to include Climate Zone 4C and 5 and increases the steep-sloped roof SRI requirement to 27, to help align the market with existing steep-roof requirements in certain parts of the U.S.* [24], [25], [26]*. In addition, the code proposal removes the exceptions related to energy cost and CO2e emissions, existing buildings, roofs over semi-heated spaces, and ballasted roofs.*

# 2021 International Residential Code

### Modify Section R202 as follows:

**Section R202 DEFINITIONS**
**EAST-ORIENTED.** Facing within 45 degrees of true east to the south and within less than 22.5 degrees of true east to the north in the northern hemisphere; facing within 45 degrees of true east to the north and within less than 22.5 degrees of true east to the south in the southern hemisphere.

**GENERALLY ACCEPTED ENGINEERING STANDARD.** A specification, rule, guide, or procedure in the field of engineering, or related thereto, recognized and accepted as authoritative.

**NORTH-ORIENTED.** Facing within 67.5 degrees of true north in the northern hemisphere; facing within 67.5 degrees of true south in the southern hemisphere.

**SOUTH-ORIENTED.** Facing within 45 degrees of true south in the northern hemisphere; facing within 45 degrees of true north in the southern hemisphere.

**WEST-ORIENTED.** Facing within 45 degrees of true west to the south and within less than 22.5 degrees of true west to the north in the northern hemisphere; facing within 45 degrees of true west to the north and within less than 22.5 degrees of true west to the south in the southern hemisphere.

*This section adds definitions for concepts that are used in the cool wall and cool roof code overlay language. The definitions are mirrored from ASHRAE 90.1-2022.*

### Add Section R303.11 as follows:

**R303.11 Required cooling.**

Where the outdoor summer design dry-bulb temperature in Table R301.2 is above **[TEMPERATURE SETPOINT]**, every *dwelling unit* shall be provided with active and/or passive cooling facilities capable of maintaining a room temperature of not more than 77°F (25°C) at a point 3 feet (914 mm) above the floor and 2 feet (610 mm) from exterior walls in habitable rooms at the design temperature. The installation of one or more portable space coolers shall not be used to achieve compliance with this section.

*This section adds a maximum indoor temperature in the IRC for all buildings intended for human occupancy, aligning with the requirement for minimum indoor temperature. Currently, the IRC only has a minimum temperature setpoint that requires heating during cold weather but does not have a maximum temperature requirement that would require cooling.*

*Recognizing that a changing climate has increased the need for indoor cooling across the U.S., and that the climate burden is disproportionately placed on low-income households, it is critical that the IRC recognize cooling as a basic requirement for health and safety in all new housing. Similar to the restriction in heating that portable heaters not be used to meet the requirement, this language requires that cooling equipment be permanently installed, prohibiting the use of window units, room air conditioners, and other similar appliances to be used to meet this requirement. The language proposed here uses a 77-degree F set point, a common interior design condition for cooling that is considered acceptable under a variety of applications of ASHRAE Standard 55. The degree setpoint also aligns with the World Health Organization's findings on temperature setpoints' effect on health* [27], [28].

*The outdoor summer design dry-bulb temperature that is in Table R301.2 in IRC 2021 is decided on by the jurisdiction. ICC recommends jurisdictions use ACCA Manual J to calculate the temperature. Jurisdictions can also use the ENERGY STAR Certified Homes County-Level Design Temperature Reference Guide,* [29] *which includes summer design temperatures for all U.S. counties (e.g., 1% design temperatures).*

*Jurisdictions may choose to adopt this language for buildings with a specific number of units, for housing policies, or offer development incentives in the zoning code for projects that include a maximum indoor temperature.*

**Add Section R909 as follows:**

**R909 Roof Solar Reflectance**

**R909.1 General**

Low-sloped roofs in *Climate Zones* 0 through 5 shall comply with one or more of the options in Table R909.2.

Steep-sloped roofs in *Climate Zones* 0 through 5 shall comply with one or more of the options in Table R909.3.

**Exceptions:** The following roofs and portions of roofs are exempt from the requirements of Table R909.2 and Table R909.3:

1. Portions of the roof that include or are covered by the following:
    1.1. Photovoltaic systems or components.
    1.2. Solar air or water-heating systems or components.
    1.3. Vegetative roofs or landscaped roofs.
    1.4. Above-roof decks or walkways.
    1.5. Skylights.
    1.6. HVAC systems and components, and other opaque objects mounted above the roof.
2. Portions of the roof shaded during the peak sun angle on the summer solstice by permanent features of the building or by permanent features of adjacent buildings.
3. Roofs where not less than 75 percent of the roof area complies with one or more of the exceptions to this section.

**TABLE R909.2 MINIMUM ROOF REFLECTANCE AND EMITTANCE OPTIONS FOR LOW-SLOPED ROOFS[a]**

| |
|---|
| Three-year-aged solar reflectance[b] of 0.55 and 3-year aged thermal emittance[c] of 0.75 |
| Three-year-aged solar reflectance index[d] of 64 |

a. The use of area-weighted averages to comply with these requirements shall be permitted. Materials lacking 3-year-aged tested values for either solar reflectance or thermal emittance shall be assigned both a 3-year-aged solar reflectance in accordance with Section R909.2 and a 3-year-aged thermal emittance of 0.90.
b. Aged solar reflectance tested in accordance with ASTM C1549, ASTM E903 or ASTM E1918 or CRRC-S100.

c. Aged thermal emittance tested in accordance with ASTM C1371 or ASTM E408 or CRRCS100.
d. Solar reflectance index (SRI) shall be determined in accordance with ASTM E1980 using a convection coefficient of 2.1 Btu/h × ft2 × °F (12 W/m2 × K). Calculation of aged SRI shall be based on aged tested values of solar reflectance and thermal emittance. Where an aged solar reflectance required by Section R909.2 is not available, it shall be determined in accordance with Equation 4-2.

$R_{aged} = [0.2 + 0.7(R_{initial} - 0.2)]$ (Equation 9-x)

where

$R_{aged}$ = The aged solar reflectance.

$R_{initial}$ = The initial solar reflectance determined in accordance with CRRC-S100.

**TABLE R909.3 MINIMUM ROOF REFLECTANCE AND EMITTANCE OPTIONS FOR STEEP-SLOPED ROOFS[a]**

| |
|---|
| Three-year-aged solar reflectance[b] of 0.25 and 3-year aged thermal emittance[c] of 0.75 |
| Three-year-aged solar reflectance index[d] of 20 |

a. The use of area-weighted averages to comply with these requirements shall be permitted. Materials lacking 3-year-aged tested values for either solar reflectance or thermal emittance shall be assigned both a 3-year-aged solar reflectance in accordance with Section R909.3 and a 3-year-aged thermal emittance of 0.90.
b. Aged solar reflectance tested in accordance with ASTM C1549, ASTM E903 or ASTM E1918 or CRRC-S100.
c. Aged thermal emittance tested in accordance with ASTM C1371 or ASTM E408 or CRRCS100.
d. Solar reflectance index (SRI) shall be determined in accordance with ASTM E1980 using a convection coefficient of 2.1 Btu/h × ft2 × °F (12 W/m2 × K). Calculation of aged SRI shall be based on aged tested values of solar reflectance and thermal emittance. Where an aged solar reflectance required by Table R909.3 is not available, it shall be determined in accordance with Equation 9-x.

$R_{aged} = [0.2 + 0.7(R_{initial} - 0.2)]$ (Equation 9-x)

where

$R_{aged}$ = The aged solar reflectance.

$R_{initial}$ = The initial solar reflectance determined in accordance with CRRC-S100.

*The 2021 IRC does not have cool roof requirements. This new section adds solar reflectance requirements to 2021 IRC for low-sloped and steep-sloped residential roofs. Adding cool surface requirements to the IRC aligns with the residential code's role of protecting life and safety, since cool roofs reduce indoor temperatures and help protect residents against extreme heat. The climate zones in the requirements can be expanded to suit a jurisdiction's UHI goals.*

**Add Section R611 as follows:**

**R611 Wall Solar Reflectance and Thermal Emittance.**

**R611.1 General.**

Walls must comply with section R611.2.

**R611.2 Wall Solar Reflectance and Thermal Emittance Requirements.**

For Climate Zone 0 through 4, *above-grade east-*, *south-*, and *west-oriented walls* shall comply with subparagraph (a) or (b):

a. A minimum of 75% of the opaque wall area shall have a minimum area-weighted initial solar reflectance of 0.30 when tested in accordance with ASTM C1549 with AM1.5GV output, or ASTM E903 with the AM1.5GV output, or determined in accordance with *generally accepted engineering standards*, and a minimum *emittance* or emissivity of 0.75 when tested in accordance with ASTM C835, C1371, E408, or determined in accordance with *generally accepted engineering standards.* For the portion of the opaque wall that is glass spandrel area, a minimum solar reflectance of 0.29, determined in accordance with NFRC 300 or ISO 9050, shall be permitted. Area-weighting is permitted only between the *south-*, *east-*, and *west-oriented walls* and only between *walls* of the same space conditioning category.

b. A minimum of 30% of the *above-grade wall* area shall be shaded through the use of human-made *structures*, *existing buildings*, hillsides, permanent *building* projections, on-site renewable energy systems, or a combination of these. Shade coverage shall be calculated by projecting the shading surface downward on the *wall* at an angle of 45 degrees.

*The 2021 IRC does not have cool wall requirements. This new section adds solar reflectance requirements to 2021 IRC for residential building walls. Adding cool surface requirements to the IRC aligns with the residential code's role of protecting life and safety, since cool walls reduce indoor temperatures and help protect residents against extreme heat. The climate zones in the requirements can be expanded to suit a jurisdiction's UHI goals.*

# 2024 International Building Code

### Modify Section 202 as follows:

**Section 202 DEFINITIONS**
**EAST-ORIENTED.** Facing within 45 degrees of true east to the south and within less than 22.5 degrees of true east to the north in the northern hemisphere; facing within 45 degrees of true east to the north and within less than 22.5 degrees of true east to the south in the southern hemisphere.

**GENERALLY ACCEPTED ENGINEERING STANDARD.** A specification, rule, guide, or procedure in the field of engineering, or related thereto, recognized and accepted as authoritative.

**NORTH-ORIENTED.** Facing within 67.5 degrees of true north in the northern hemisphere; facing within 67.5 degrees of true south in the southern hemisphere.

**SOUTH-ORIENTED.** Facing within 45 degrees of true south in the northern hemisphere; facing within 45 degrees of true north in the southern hemisphere.

**WEST-ORIENTED.** Facing within 45 degrees of true west to the south and within less than 22.5 degrees of true west to the north in the northern hemisphere; facing within 45 degrees of true west to the north and within less than 22.5 degrees of true west to the south in the southern hemisphere.

*This section adds definitions for concepts that are used in the cool wall and cool roof code overlay language. The definitions are mirrored from ASHRAE 90.1-2022.*

### Modify Section 1203 as follows:

**1203.1 Heating equipment and systems.**

Interior spaces intended for human occupancy shall be provided with active or passive space heating systems capable of maintaining an indoor temperature of not less than 68°F (20°C) at a point 3 feet (914 mm) above the floor on the design heating day.

**Exceptions:** Space heating systems are not required for:

1. Interior spaces where the primary purpose of the space is not associated with human comfort.
2. Group F, H, S or U occupancies.

**1203.2 Cooling equipment and systems.**
Interior spaces intended for human occupancy shall be provided with active or passive space cooling systems capable of maintaining an indoor temperature of not more than 77°F (25°C) at a point 3 feet (914 mm) above the floor on the design cooling day.

**Exceptions:** Space heating systems are not required for:

1. Interior spaces where the primary purpose of the space is not associated with human comfort.
2. Group H, S or U occupancies.

*This section adds a maximum indoor temperature in the IBC for all buildings intended for human occupancy. The exceptions do not include factories in order to protect the health and safety of workers. Currently, the IBC only has a minimum temperature setpoint.*

*This cooling measure is modeled off the heating requirement under IBC 1203.1. Recognizing that a changing climate has increased the need for indoor cooling across the U.S., and that the climate burden* *is disproportionately placed on low-income households, it is critical that the IBC recognizes cooling as a basic requirement for health and safety in all new buildings. Similar to the restriction in heating that portable heaters not be used to meet the requirement, this language requires that cooling equipment be permanently installed, prohibiting the use of window units, room air conditioners, and other similar appliances to be used to meet this requirement. The language proposed here uses a 77-degree set point, a common interior design condition for cooling that is considered acceptable under a variety of applications of ASHRAE Standard 55. The degree setpoint also aligns with the World Health Organization's findings on temperature setpoints' effect on health* [27], [28].

**Add Section 1513 as follows:**

**1513 Roof Solar Reflectance**
**1513.1 General**
Low-sloped roofs in *Climate Zones* 0 through 5 shall comply with one or more of the options in Table 1513.2.

Steep-sloped roofs in *Climate Zones* 0 through 5 shall comply with one or more of the options in Table 1513.3.

**Exceptions:**

1. Portions of the roof that include or are covered by the following:
    1.1. Photovoltaic systems or components.
    1.2. Solar air or water-heating systems or components.
    1.3. Vegetative roofs or landscaped roofs.
    1.4. Above-roof decks or walkways.
    1.5. Skylights.
    1.6. HVAC systems and components, and other opaque objects mounted above the roof.
2. Portions of the roof shaded during the peak sun angle on the summer solstice by permanent features of the building or by permanent features of adjacent buildings.
3. Roofs where not less than 75 percent of the roof area complies with one or more of the exceptions to this section.

**1513.2 Solar Reflectance of Low-Sloped Roofs.**

**TABLE 1513.2 MINIMUM ROOF REFLECTANCE AND EMITTANCE OPTIONS FOR LOW-SLOPED ROOFS[a]**

| |
|---|
| Three-year-aged solar reflectance[b] of 0.55 and 3-year aged thermal emittance[c] of 0.75 |
| Three-year-aged solar reflectance index[d] of 64 |

a. The use of area-weighted averages to comply with these requirements shall be permitted. Materials lacking 3-year-aged tested values for either solar reflectance or thermal emittance shall be assigned both a 3-year-aged solar reflectance in accordance with Section 1531.2 and a 3-year-aged thermal emittance of 0.90.
b. Aged solar reflectance tested in accordance with ASTM C1549, ASTM E903 or ASTM E1918 or CRRC-S100.
c. Aged thermal emittance tested in accordance with ASTM C1371 or ASTM E408 or CRRCS100.
d. Solar reflectance index (SRI) shall be determined in accordance with ASTM E1980 using a convection coefficient of 2.1 Btu/h × ft2 × °F (12 W/m2 × K). Calculation of aged SRI shall be based on aged tested values of solar reflectance and thermal emittance. Where an aged solar

reflectance required by Section 1513.2 is not available, it shall be determined in accordance with Equation 15-x.

$R_{aged} = [0.2 + 0.7(R_{initial} - 0.2)]$ (Equation 15-x)

where

$R_{aged}$ = The aged solar reflectance.

$R_{initial}$ = The initial solar reflectance determined in accordance with CRRC-S100.

**1513.3 Solar Reflectance of Steep-Sloped Roofs.**

**TABLE 1513.3 MINIMUM ROOF REFLECTANCE AND EMITTANCE OPTIONS FOR STEEP-SLOPED ROOFS[a]**

| |
|---|
| Three-year-aged solar reflectance[b] of 0.28 and 3-year aged thermal emittance[c] of 0.75 |
| Three-year-aged solar reflectance index[d] of 27 |

a. The use of area-weighted averages to comply with these requirements shall be permitted. Materials lacking 3-year-aged tested values for either solar reflectance or thermal emittance shall be assigned both a 3-year-aged solar reflectance in accordance with Section 1513.3 and a 3-year-aged thermal emittance of 0.90.
b. Aged solar reflectance tested in accordance with ASTM C1549, ASTM E903 or ASTM E1918 or CRRC-S100.
c. Aged thermal emittance tested in accordance with ASTM C1371 or ASTM E408 or CRRCS100.
d. Solar reflectance index (SRI) shall be determined in accordance with ASTM E1980 using a convection coefficient of 2.1 Btu/h × ft2 × °F (12 W/m2 × K). Calculation of aged SRI shall be based on aged tested values of solar reflectance and thermal emittance. Where an aged solar reflectance required by Section 1513.3 is not available, it shall be determined in accordance with Equation 15-x.

$R_{aged} = [0.2 + 0.7(R_{initial} - 0.2)]$ (Equation 15-x)

where

$R_{aged}$ = The aged solar reflectance.

$R_{initial}$ = The initial solar reflectance determined in accordance with CRRC-S100.

*The 2024 IBC does not have cool roof requirements. This new section adds solar reflectance requirements to 2024 IBC for low-sloped and steep-sloped roofs of commercial and tall residential buildings. Adding cool surface requirements to the IBC aligns with the building code's role of protecting life and safety, since cool roofs reduce indoor temperatures and help protect residents against extreme heat. The climate zones in the requirements can be expanded to suit a jurisdiction's UHI goals.*

**Add new Section 1402.11 as follows:**

**1402.11 Wall Solar Reflectance**

For *Climate Zone* 0 through 4, *above-grade east*-, *south*-, and *west-oriented walls* shall comply with subparagraph (a) or (b):

a. A minimum of 75% of the opaque wall area shall have a minimum area-weighted initial solar reflectance of 0.30 when tested in accordance with ASTM C1549 with AM1.5GV output, or ASTM E903 with the AM1.5GV output, or determined in accordance with *generally accepted engineering standards*, and a minimum *emittance* or emissivity of 0.75 when tested in accordance with ASTM C835, C1371, E408, or determined in accordance with *generally accepted engineering standards.* For the portion of the opaque wall that is glass spandrel area, a minimum solar reflectance of 0.29, determined in accordance with NFRC 300 or ISO 9050, shall be permitted. Area-weighting is permitted only between the *south*-, *east*-, and *west-oriented walls* and only between *walls* of the same space conditioning category.
b. A minimum of 30% of the *above-grade wall* area shall be shaded through the use of human-made *structures*, *existing buildings*, hillsides, permanent *building* projections, on-site renewable energy systems, or a combination of these. Shade coverage shall be calculated by projecting the shading surface downward on the *wall* at an angle of 45 degrees.

*The 2024 IBC does not have cool wall requirements. This new section adds solar reflectance requirements to 2024 IBC for commercial and tall residential building walls. Adding cool surface requirements to the IRC aligns with the building code's role of protecting life and safety, since cool walls reduce indoor temperatures and help protect residents against extreme heat. The climate zones in the requirements can be expanded to suit a jurisdiction's UHI goals.*

## 2021 International Mechanical Code

**Add Section [BG] 309.2 as follows:**

**[BG] 309.2 Space-cooling systems.**

Interior spaces intended for human occupancy shall be provided with permanently installed active or passive space-cooling systems capable of maintaining an average indoor temperature of no more than 77°F (25°C) at a point 3 feet (914 mm) above floor on the cooling design day. The installation of portable space coolers shall not be used to achieve compliance with this section.

**Exceptions:**

1. Interior spaces where the primary purpose is not associated with human comfort.
2. Group H, S and U *occupancies*.

*This section adds a maximum indoor temperature in the IMC for all buildings intended for human occupancy. The exceptions do not include factories in order to protect the health and safety of workers. Currently, the IMC only has a minimum temperature setpoint.*

*This code measure is modeled off the heating requirement under IMC 309.2. Recognizing that a changing climate has increased the need for indoor cooling across the U.S., and that the climate burden is disproportionately placed on low-income households, it is critical that the IMC recognize cooling as a basic requirement for health and safety in all new buildings. Similar to the restriction in heating that portable heaters not be used to meet the requirement, this language requires that cooling equipment be permanently installed, prohibiting the use of window units, room air conditioners, and other similar appliances to be used to meet this requirement. The language proposed here uses a 77-degree set point, a common interior design condition for cooling that is considered acceptable under a variety of applications of ASHRAE Std 55. The degree setpoint also aligns with the World Health Organization's findings on temperature setpoints' effect on health* [27], [28].

*Jurisdictions may choose to adopt this language for buildings with a specific number of units, for housing policies, or offer development incentives in the zoning code for projects that include a maximum indoor temperature.*

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