Thermal Bridging Requirements in Standard 90.1-2022

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ANSI/ASHRAE/IESNA Standard 90.1, *Energy Standard for Sites and Buildings Except Low-Rise Residential Buildings*, offers "the minimum energy efficiency requirements for design and construction of new sites and buildings and their systems, new portions of buildings and their systems, and new systems and equipment in existing buildings, as well as criteria for determining compliance with these requirements." The 2022 edition of Standard 90.1 incorporates many changes to the building envelope, lighting, mechanical, service hot water, and renewable energy systems that span the prescriptive and performance compliance paths. These changes will be described in a series of articles in *ASHRAE Journal*. This article, the second in the series, focuses on changes in Section 5, Building Envelope, related to thermal bridging in building envelopes.

For simplicity and in support of the energy modeling programs then available in Standard 90.1, the building envelope was broken into two main categories: (1) opaque (walls) and (2) fenestration (windows). The opaque envelope was represented by an overall assembly U-factor that was then translated into an R-value of insulation for ease of compliance.

This overall U-factor was then used for modeling and assumed a perfect connection to other building elements. As wall insulation levels were increased in subsequent Standard 90.1 editions, a disparity grew between how buildings are constructed and the ideal thermal models used for compliance. This disparity led to requests for a more rigorous approach to modeling and calculating the effects of real-world building assemblies on ideal (modeled) U-factors. Therefore, several research projects studied the effects of thermal bridging in building envelopes.[1,2,3]

The new provisions for thermal bridging mitigation address common assembly interfaces, such as floor-to-roof and floor-to-wall connections. Whether projects use the prescriptive, trade-off, or modeling compliance path, Standard 90.1 provides guidance and default values for steel-framed, mass, and wood-framed walls and roofs. However, not all thermal bridges in every building were addressed in the new provisions; the focus was regulating the most common intersections and scenarios.

Organization of New Thermal Bridges Content

The thermal bridging provisions introduced into Standard 90.1-2022 are in Section 5.5, which means

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they are prescriptive and "tradeable" as opposed to the mandatory criteria in Section 5.4. The newly introduced Section 5.5.5 begins with a scoping paragraph that outlines that two types of thermal bridges—point and linear—need to be addressed. The third type of thermal bridge—clear field thermal bridge—is addressed by Appendix A; Section 5.5.5 only addresses linear and point thermal bridges. In addition, Section 3 now includes definitions to describe the types of thermal bridges and associated calculation factors. Graphic examples of the types of thermal bridges are shown in *Table 1*.

Details of New Thermal Bridges Content

The thermal bridging requirements include various exceptions for warmer climates and semiheated spaces. One notable exception is for materials with a thermal conductivity (k) less than 3.0 Btu·in/h·ft^2·°F (0.433 W/[m·K]), which is characteristic of wood.

The provisions proceed through a series of prescriptive requirements, the envelope trade-off method (Section 5.6 and Appendix C), and modeling protocols (Section 12 and Appendix G). The prescriptive option (Section 5.5.5) requires mitigation of thermal bridges in opaque assembly constructions. By design, the prescriptive path provides a straightforward approach to compliance. It is intended to encourage user understanding by defining thermal bridge mitigation in terms of the required increase in insulation (R-value). This approach eliminates the need for more complex calculations that may be applicable under certain situations and that have been accomodated under the trade-off approaches described below.

The following paragraphs describe specific criteria in Section 5.5.5 for five common types of thermal bridges. The discussion then moves to trade-off and performance options and helpful figures in the Standard.

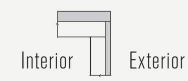
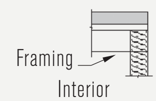
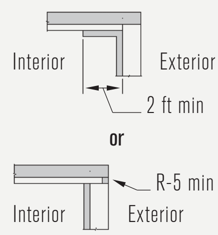
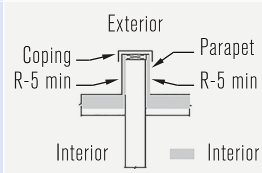
Roof and Wall Intersections

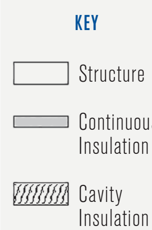
Section 5.5.5.1, Roof and Wall Intersections, applies to roofs with insulation entirely above deck. It explains when insulation can be interrupted by the structural elements or members of the building envelope. Subsections explain what to do for each category, such as roof edges that intersect with walls, parapets at the building perimeter, and parapets within the field of a roof (e.g., fire walls). Examples can be seen in the section on Informative Appendix K (*Table 1*).

Floor to Wall

Section 5.5.5.2, Intermediate Floor Intersections, explains how to address floors that intersect with the building envelope wall. It distinguishes between requirements for floor edges with and without projections (e.g., balconies or overhangs that penetrate the building envelope). Each subsection of Section 5.5.5.2 describes how the insulation is to be installed and adjusted to mitigate thermal bridging, depending on the type of insulation and how it is incorporated into the building envelope.

TABLE 1 Example of figures contained in Standard 90.1's Informative Appendix K.

CATEGORY	SUBCATEGORY	FIGURE
Roof edges with continuous insulation	With or without parapet	
Roof edges with integral or cavity insulation	With or without parapet	
Roof edges with interior insulation	With or without parapet	
Parapets within the field of a roof		



Cladding Support

Section 5.5.5.3, Exterior Cladding Support, covers the allowances for thermal bridges related to shelf angles that support masonry exterior cladding. The contents of Section 5.5.5.3 discuss the maximum allowances for point thermal bridging and the minimum offset for the support system to allow continuous insulation to bypass the support and mitigate the thermal bridge. In addition, the provisions discuss the option to choose approved designs contained in Standard 90.1's Normative Appendix A, "Rated R-Value of Insulation and Assembly U-Factor, C-Factor, and F-Factor Determinations." For example, metal building systems have provisions to account for thermal bridging.

Window to Wall

Section 5.5.5.4, Opaque Wall and Vertical Fenestration Intersection, contains four options for demonstrating compliance that are predicated on the location of the window fenestration within the building thermal envelope. Each option attempts to address the most common installation of the fenestration product in relation to the location of the insulation within the opaque envelope.

Types of Thermal Bridges and Calculation Factors

Thermal bridge: an element that has higher thermal conductivity than the surrounding materials, which creates a path of least resistance for heat transfer.

Clear-field thermal bridge: elements of a building envelope assembly that are distributed over the area of the assembly; for example, studs, webs and face shells of masonry units, ties, tracks, plates, girts and purlins for metal building envelopes, and fasteners.

Linear thermal bridge: a length-based element (horizontal, vertical, or diagonal) that penetrates the insulation in the building envelope and with length measured along the exterior surface of the building envelope; for example, edges of floors, balconies, columns and beams in the plane of an assembly, parapets, roof-wall floor intersections, fenestration interfaces, shelf angles, and similar conditions not otherwise defined as a clear-field thermal bridge or point thermal bridge.

Point thermal bridge: a discrete element that penetrates the insulation in the building envelope; for example, a beam penetrating a wall, a column penetrating a roof or floor, and an anchor or connection used to attach an element to the building and not otherwise defined as a clear field thermal bridge or linear thermal bridge. The cross-sectional area of the point thermal bridge is measured at the outer surface of the outermost layer of insulation that is penetrated by the element.

Chi-factor (χ or Chi): thermal transmittance of a point thermal bridge in units of Btu/(h·°F) [W/K]

Psi-factor (ψ or Psi): thermal transmittance per unit length of a linear thermal bridge in units of Btu/(h·ft·°F) (W/[m·K)

Other Elements

Section 5.5.5.5, Other Elements and Building Assembly Intersections, focuses on individual point and linear thermal bridges not already covered by Sections 5.5.5.1 through 5.5.5.4. Examples include roofs outside a building entrance supported by framing members cantilevering from the building, dunnage supporting roof HVAC equipment, and the like. Rather than describing the permitted mitigation options, this section requires the user to complete a basic analysis by applying an area weighting method using a simple equation. An informative note provides resources for assisting the user in completing the analysis.

Building Envelope Trade-Off Compliance Path

If a project cannot comply with one or all of the thermal bridging provisions in Section 5.5, the project can use the envelope trade-off option (Section 5.6), or the full performance path options, i.e., Chapter 12 (Energy Cost Budget Method) or Appendix G (Performance Rating Method). The envelope-only trade-off option under Section 5.6 is intended to be incorporated in the next version of ComCheck. To show compliance via Section 5.6, the user enters the salient building information related to the envelope, wall area, fenestration area, etc., which is the same as before. Additionally, users must account for the type and quantity of linear and/or point thermal bridges and their associated opaque assemblies. Therefore, each of the project's Appendix C calculations for linear or point thermal bridges must be assigned to an associated floor, wall, or roof assembly.

Users start the process by working through the five types of thermal bridges from Section 5.5.5 to determine whether compliance will be achieved through the prescriptive or trade-off path. In many cases, the project design complies with the prescriptive requirements of Section 5.5, but the user has decided to apply Appendix C/ComCheck to take advantage of other envelope trade-off calculations. In such situations, it is unnecessary to enter information about the length and quantity of the thermal bridges that are present in the design.

For each thermal bridge that does not meet prescriptive requirements, the user would enter the Psi or Chi factor from the "Unmitigated" column in Table A10.1 (located in Appendix A) or a Psi or Chi factor from another recognized source (allowed per Section A10.1). Conversely, if a design uses a high-performance structural connection that is better than the prescriptive requirements, it can be entered into the Appendix C calculation or ComCheck and can be credited toward overall envelope performance. If a project consists of a mixture of non-compliant and compliant thermal bridges with respect to Section 5.5, the values in the "Default" column in Table A10.1 are to be entered as the values for those thermal bridges that comply.

Assembly U-Factor Adjustment for Simulation of Thermal Bridges (A10.2)

For projects that wish to use the whole building performance option, Section A10.2 permits using Section 12, "Energy Cost Budget Method," or Appendix G, "Performance Rating Method." The modeling approach allows the user to alter the conductance value assigned to one or more insulation layers within the modeled assembly without altering the properties of the modeled building material layers in the performance-modeling process.

Should the user select either modeling option, similar rules apply as in Section 5.6 and Appendix C. The designer would have to indicate in the energy cost budget or performance-rating model if the applicable wall intersections either comply or do not comply with the prescriptive tables, and then enter either the unmitigated or mitigated condition and quantity.

Informative Figures

Informative Appendix K, "Informative Figures—Thermal Bridges" includes figures for the convenience Standard 90.1 users. They are designed to provide a graphic representation to supplement the written description of the related thermal bridge category from Section 5.5.5. Table 1 is an example from Appendix K of some roof insulation above deck configurations.

References

1. ASHRAE. 2011. ASHRAE RP 1365, Thermal Performance of Building Envelope Details for Mid- and High-Rise Buildings.
2. BC Housing. 2018. Guide to Low Thermal Energy Demand for Large Buildings. https://tinyurl.com/33kjnnb6
3. BC Hydro Power Smart. 2021. Building Envelope Thermal Bridging Guide. https://tinyurl.com/39h5n3vd ■