International Energy Conservation Code
Envelope & Embodied Energy Subcommittee

Draft Notes

December 1, 2022
11:00 AM to 2:00 PM EST (3 hour)
Virtual meeting

Committee Chair: Tom Culp, Birch Point Consulting
Committee Vice Chair: Emily Lorenz, IIBEC

1. **Call to order**. Chair Culp called the meeting to order at 11:00 am eastern.
2. **Meeting Conduct** – Culp reminded attendees of the following items.
    a. Antitrust Reminder
    b. Identification of Representation/Conflict of Interest
    c. ICC Council Policy 7 Committees: Section 5.1.10 Representation of Interests
    d. ICC Code of Ethics: ICC advocates commitment to a standard of professional behavior that exemplifies the highest ideals and principles of ethical conduct which include integrity, honesty, and fairness. As part of this commitment it is expected that participants shall act with courtesy, competence and respect for others.

3. **Roll Call/Establish Quorum** – Vice Chair Lorenz called roll and established a quorum (19)

4. Name	Organization		Name	Organization	
*Culp, Tom (chair)	Glazing Industry Code Cmte; Aluminum Extruders Council	X	Guttman, Maureen	Energy Solutions	X
*Lorenz, Emily (vice chair)	Intl Inst of Building Enclosure Consultants	X	Humble, Jonathan	Amer Iron & Steel Institute	X
Altenhofen, David	RWDI	X	*Johnson, Greg	Natl Multifamily Housing Council	X

*Belcher, Matt	Enhanced Bldg Systems	X	*Kochkin, Vladimir	National Association of Homebuilders	X
Bradley, Jeff	American Wood Council	X	Melley, Michele	State of CT	X
*Brooks, Scott	Disney		*Ross, Bob	Austin Ind. School District	X
*Burton, Richard	City of Lincoln, NE	X	Sanders, Helen	Façade Tectonics Inst.	X
Cinnamon, Tony	Wiss, Janney, Elstner	X	Spiriev, Bistra	GA Finance & Investment	
*Churchill Norbert, Zepherinus	CARICOM	X	*Tillou, Mike	PNNL	X
*Clausing, Chris	Clausing Builders	X	VanGeem, Martha	Masonry Alliance for Codes and Standards	X
*Crandell, Jay	American Chemistry Council's Foam Sheathing Coalition	X	Weston, Teri	Air Barrier Assoc of Amer.	X
DeWein, Mike	North Branch Services	X	Zani, Andrea	Permasteelisa	

*Member of main IECC Commercial Committee

5. **Assign Note Taker—**Teri Weston volunteered to take notes.
6. **Approval of Agenda—**unanimous approval
7. **Approval of Minutes** – Nov 17, 2022 meeting – reminder to add reason statements and designate "as submitted" Use reason statements from proposals for two proposals that were approved at the Nov. 17 meeting.
8. **Administrative issues—**none at this time.
9. **New Business**
    a. Presentation on thermal bridging modeling (M. Tillou, PNNL)
    - *Link to prototype building models:* https://www.energycodes.gov/prototype-building-models#Commercial
    - *Tillou can share the characterizations with the subcommittee and will circulate PDF of PPT with notes.*
    - *Informal volunteer group on cladding thermal bridging: Theresa Weston, Jonathan Humble, Helen Sanders, Paula Zimm, Jay Crandell, Chip Clark, Greg Johnson, Martha VanGeem, Vladimir Kochkin, and Mike Tillou who is convening.*

10. **ACTION items**

Resume discussion / vote on editorial or clean-up proposals

a. CED1-092-22

Motion: As Modified (Crandell, Humble) 18-0-1 (cnv)

Modifications – (see meeting edits PDF)

- *as shown with "purple items" italicized.*
- *C402.1 #4 change "building thermal envelope assemblies" to "the building envelope"*

Reason: Consistent use of "building thermal envelope" terminology

b. CED1-094-22

Motion: As Modified (Guttman, Humble) 14-1-2 (cnv)

Modification: strike-out descriptions, leave section numbers only in C402.1 #1; Need to also change "component performance alternative" to "component performance method" in Table C402.1.4 title and exception 1 to C502.2 if this change is made (see meeting edits PDF)

Reason: Editorial clean-up of section references and titles for prescriptive U-factor, R-value, and component performance methods

c. CED1-098-22 (coordinate with CEDI-094)

Withdrawn by proponent

d. CED1-095-22

Motion: As Modified (Crandell, Johnson) 16-0-1 (cnv)

Modifications: (see meeting edits PDF)

4. Fenestration in building envelope assemblies shall comply with Section C402.5. ~~Alternatively, where~~ greater than buildings have a vertical fenestration area or skylight area ~~exceeding~~ that allowed in Section C402.5, the building and *building thermal envelope* shall comply with Item 2 of Section C401.2.1 ~~or Section C401.2.2.~~, or Section C402.1.4.

Reason: Clean-up and move requirements related to fenestration into one place (Item 4 of list) and add one missing section reference.

e. CED1-108-22

Motion: As Modified (Humble, Tillou) 16-0-1 (cnv)

Modification: need to change Table number in Table, in new section C402.1.2.1.6, and in section C402.1.4; update section numbers. (see meeting edits PDF)

Reason: move sections related to U-factor determination under section for U-factor determination and change title to remove reference to thermal resistance to be consistent focus on U-factors

f. CED1-119-22

Motion: As Modified (Crandell, Johnson) 15-0-2 (cnv)

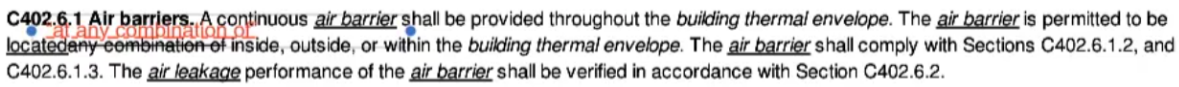
Modification: remove exception entirely. (see meeting edits PDF)

Reason: Clarify that the provisions are intended to apply to only to radiant heat system panels, not other type of radiant heating systems. The exception for heated slabs is deleted because they are not radiant heating system panels and the thermal requirements are addressed elsewhere.

g. CED1-128-22

Motion: As Modified (Lorenz, Weston) 15-0-1 (cnv)

Modification: (see meeting edits PDF)



C402.6.1 Air barriers. A continuous *air barrier* shall be provided throughout the *building thermal envelope*. The *air barrier* is permitted to be ~~located~~at any combination of ~~inside, outside, or within~~ the *building thermal envelope*. The *air barrier* shall comply with Sections C402.6.1.2, and C402.6.1.3. The *air leakage* performance of the *air barrier* shall be verified in accordance with Section C402.6.2.

Reason: clean-up of some terminology related to the use of "air leakage" and general grammar

h. CED1-104-22 – *withdrawn by proponent. Already taken care of in the updated PR draft.*

i. CED1-105-22 – *no action. Deal with later along with other mass wall items.*

If time remaining, review and provide feedback to Admin subcommittee:

j. ~~CED1-004-22~~ withdrawn as editorial, can be taken care of by staff.

k. CED1-005-22 *- reviewed, agree with proposal. Terminology change of 'thermal envelope" to "building thermal envelope" needs to be included for correlation with CED1-92.*

11. **Upcoming meetings**—first and third Thursdays of every month

a. Dec 15, 2022, 11:00 AM to 2:00 PM ET
(tentatively: thermal bridging votes, air leakage)

b. Jan 5, 2023, 11:00 AM to 2:00 PM ET
(tentatively: fenestration, air leakage)

c. Jan 19, 2023, 11:00 AM to 2:00 PM ET

d. Feb 2, 2023, 11:00 AM to 2:00 PM ET

e. Feb 16, 2023, 11:00 AM to 2:00 PM ET

f. Mar 2, 2023, 11:00 AM to 2:00 PM ET

g. Mar 16, 2023, 11:00 AM to 2:00 PM ET

12. **Adjourn**

FOR FURTHER INFORMATION BE SURE TO VISIT THE ICC WEBSITE:
ICC Energy webpage
The monograph of Code Changes and Public Comments to the IECC Commercial Public Comment Draft #1 is posted here.
An update to the IECC Commercial Public Comment Draft #1 that includes errata from staff and public comment is also posted.

FOR ADDITIONAL INFORMATION, PLEASE CONTACT:

Committee Chair: Tom Culp, Birch Point Consulting, culp@birchpointconsulting.com
Committee Vice Chair: Emily Lorenz, IIBEC, emilyblorenz@gmail.com

We have started an interested-party email list for various subcommittee communications. Please contact Tom Culp to be placed on that email list.

BUILDING ENVELOPE
THERMAL ENVELOPE
ENVELOPE
ITALICIZE
MISSING

CED1-92-22

IECC: C105.2.2, SECTION 202, C401.3, SECTION C402, C402.1, C402.1.1.2, TABLE C402.1.1.2, TABLE C402.1.2, C402.1.2.2, TABLE C402.1.3, C402.1.4, TABLE C402.5, C402.6, C402.6.1.1, C402.6.2.3, C402.6.5, C403.4.1, C403.13.1, C403.14, C406.1.3, C406.2.1, C406.2.1.1, C406.3.8, TABLE C407.2(1), C409.6.1.4, C503.1, C503.2, C503.6, C504.2, C505.2, C505.2.1

Proponents: Aaron Phillips, representing Asphalt Roofing Manufacturers Association (aphillips@asphaltroofing.org)

2024 International Energy Conservation Code [CE Project]

Revise as follows:

C105.2.2 Building ~~Thermal~~ thermal envelope. Inspections shall verify the correct type of insulation, *R*-values, location of insulation, fenestration, *U*-factor, SHGC and VT, and that air leakage controls are properly installed, as required by the code, *approved* plans and specifications.

CONTINUOUS INSULATION (ci). Insulating material that is continuous across all structural members without thermal bridges other than fasteners and service openings. It is installed on the interior or exterior or is integral to any opaque surface of the *building thermal envelope*~~building envelope~~.

C401.3 Building ~~Thermal~~ thermal envelope certificate. A permanent *building thermal envelope*~~thermal envelope~~ certificate shall be completed by an *approved* party. Such certificate shall be posted on a wall in the space where the space conditioning equipment is located, a utility room or other *approved* location. If located on an electrical panel, the certificate shall not cover or obstruct the visibility of the circuit directory label, service disconnect label or other required labels. A copy of the certificate shall also be included in the construction files for the project. The certificate shall include the following:

1. *R*-values of insulation installed in or on ceilings, roofs, walls, foundations and slabs, *basement walls*, crawl space walls and floors and ducts outside *conditioned spaces*.
2. *U*-factors and *solar heat gain coefficients* (SHGC) of fenestrations.
3. Results from any *building thermal envelope* ~~envelope~~ air leakage testing performed on the *building*.

Where there is more than one value for any component of the *building thermal envelope*~~building envelope~~, the certificate shall indicate the area-weighted average value where available. If the area-weighted average is not available, the certificate shall list each value that applies to 10 percent or more of the total component area.

SECTION C402
BUILDING THERMAL ENVELOPE REQUIREMENTS

C402.1 General. *Building thermal envelope* assemblies for buildings that are intended to comply with the code on a prescriptive basis in accordance with the compliance path described in Item 1 of Section C401.2.1 shall comply with the following:

1. The opaque portions of the *building thermal envelope* shall comply with the specific insulation requirements of Section C402.2 and the thermal requirements of either the U-, C- and F-factor based method of Section C402.1.2; the R-value based method of C402.1.3; or the component performance alternative of Section C402.1.4. Where the total area of the through-wall penetrations of mechanical equipment is greater than 1 percent of the opaque above-grade wall area, the building thermal envelope shall comply with Section C402.1.2.4.
2. Wall solar reflectance and thermal emittance shall comply with Section C402.3.
3. Roof solar reflectance and thermal emittance shall comply with Section C402.4.
4. Fenestration in the *building thermal envelope*~~building envelope~~ ~~assemblies~~ shall comply with Section C402.5.
5. Air leakage of the building thermal envelope shall comply with Section C402.6.
6. Walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers shall comply with Section C403.12.
7. *Thermal bridges* in *above-grade walls* shall comply with Section C402.7.

Alternatively, where buildings have a vertical fenestration area or skylight area exceeding that allowed in Section C402.5, the building and *building thermal envelope* shall comply with Item 2 of Section C401.2.1 or Section C401.2.2.

C402.1.1.2 Greenhouses. Greenhouse structures or areas that are mechanically heated or cooled and that comply with all of the following shall be exempt from the *building thermal envelope*~~building envelope~~ requirements of this code:

1. Exterior opaque envelope assemblies comply with Sections C402.2 and C402.5.5.

Exception: Low energy greenhouses that comply with Section C402.1.1.

2. Interior partition *building thermal envelope* assemblies that separate the greenhouse from *conditioned space* comply with Sections C402.2, C402.5.3 and C402.5.5.
3. Fenestration assemblies that comply with the *building thermal envelope*~~thermal envelope~~ requirements in Table C402.1.1.2. The *U*-factor for a roof shall be for the roof assembly or a roof that includes the assembly and an *internal curtain system*.

Exception: Unconditioned greenhouses.

TABLE C402.1.1.2 FENESTRATION BUILDING THERMAL ENVELOPE MAXIMUM REQUIREMENTS

TABLE C402.1.2 OPAQUE BUILDING THERMAL ENVELOPE ASSEMBLY MAXIMUM REQUIREMENTS, U-FACTOR METHOD[a, b]

CLIMATE ZONE	0 AND 1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R
Roofs																
Insulation entirely above roof deck	U-0.048	U-0.039	U-0.039	U-0.039	U-0.039	U-0.039	U-0.032	U-0.032	U-0.032	U-0.032	U-0.032	U-0.032	U-0.028	U-0.028	U-0.028	U-0.028
Metal buildings	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.031	U-0.029	U-0.029	U-0.029	U-0.026	U-0.026
Attic and other	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.021	U-0.021	U-0.021	U-0.021	U-0.021	U-0.021	U-0.017	U-0.017	U-0.017	U-0.017
Walls, above grade																
Mass[f]	U-0.151	U-0.151	U-0.151	U-0.123	U-0.123	U-0.104	U-0.104	U-0.090	U-0.090	U-0.080	U-0.080	U-0.071	U-0.071	U-0.071	U-0.037	U-0.037
Metal building	U-0.079	U-0.079	U-0.079	U-0.079	U-0.079	U-0.052	U-0.052	U-0.050	U-0.050	U-0.050	U-0.050	U-0.050	U-0.044	U-0.039	U-0.039	U-0.039
Metal framed	U-0.077	U-0.077	U-0.077	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.055	U-0.055	U-0.049	U-0.049	U-0.049	U-0.042	U-0.037	U-0.037
Wood framed and other[c]	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.051	U-0.051	U-0.051	U-0.051	U-0.051	U-0.051	U-0.032	U-0.032
Walls, below grade																
Below-grade wall[c]	C-1.140[e]	C-1.140[e]	C-1.140[e]	C-1.140[e]	C-1.140[e]	C-1.140[e]	C-0.119	C-0.092	C-0.119	C-0.092	C-0.092	C-0.063	C-0.063	C-0.063	C-0.063	C-0.063
Floors																
Mass[d]	U-0.322[e]	U-0.322[e]	U-0.107	U-0.087	U-0.074	U-0.074	U-0.057	U-0.051	U-0.057	U-0.051	U-0.051	U-0.051	U-0.042	U-0.042	U-0.038	U-0.038
Joist/framing	U-0.066[e]	U-0.066[e]	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027
Slab-on-grade floors																
Unheated slabs	F-0.73[e]	F-0.73[e]	F-0.73[e]	F-0.73[e]	F-0.73[e]	F-0.54	F-0.52	F-0.52	F-0.52	F-0.51	F-0.51	F-0.434	F-0.51	F-0.434	F-0.434	F-0.424
Heated slabs	F-0.69	F-0.69	F-0.69	F-0.69	F-0.66	F-0.66	F-0.62	F-0.62	F-0.62	F-0.62	F-0.62	F-0.602	F-0.602	F-0.602	F-0.602	F-0.602
Opaque doors																
Nonswinging door	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31
Swinging door[g]	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37
Garage door < 14% glazing[h]	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31	U-0.31

For SI: 1 pound per square foot = 4.88 kg/m^2, 1 pound per cubic foot = 16 kg/m^3.

ci = Continuous Insulation, NR = No Requirement, LS = Liner System.

a. Where assembly *U*-factors, *C*-factors and *F*-factors are established in ANSI/ASHRAE/IESNA 90.1 Appendix A, such opaque assemblies shall be a compliance alternative where those values meet the criteria of this table, and provided that the construction, excluding the cladding system on walls, complies with the appropriate construction details from ANSI/ASHRAE/ISNEA 90.1 Appendix A.

b. Where *U*-factors have been established by testing in accordance with ASTM C1363, such opaque assemblies shall be a compliance alternative where those values meet the criteria of this table. The *R*-value of continuous insulation shall be permitted to be added to or subtracted from the original tested design.

c. Where heated slabs are below grade, below-grade walls shall comply with the *U*-factor requirements for above-grade mass walls.

d. “Mass floors” shall be in accordance with Section C402.2.3.

e. These *C*-, *F*- and *U*-factors are based on assemblies that are not required to contain insulation.

f. “Mass walls” shall be in accordance with Section C402.2.2.

g. Swinging door *U*-factors shall be determined in accordance with NFRC-100.

h. Garage doors having a single row of fenestration shall have an assembly *U*-factor less than or equal to 0.44 in Climate Zones 0 through 6 and less than or equal to 0.36 in Climate Zones 7 and 8, provided that the fenestration area is not less than 14 percent and not more than 25 percent of the total door area.

C402.1.2.2 U-factor thermal resistance of cold-formed steel assemblies. *U*-factors for *building thermal envelopes* ~~building envelopes~~ containing cold-formed steel framed ceilings and walls shall be permitted to be determined in accordance with~~with~~ AISI S250 as modified herein.

1. Where the steel-framed wall contains no cavity insulation, and uses continuous insulation to satisfy the U-factor maximum, the steel-framed wall member spacing is permitted to be installed at any on-center spacing.
2. Where the steel-framed wall contains framing at 24 inches (610 mm) on center with a 23 percent framing factor or framing at 16 inches (400 mm) on-center with a 25 percent framing factor, the next lower framing member spacing input values shall be used when calculating using AISI S250.
3. Where the steel-framed wall contains less than 23 percent framing factors the AISI S250 shall be used without any modifications.
4. Where the steel-framed wall contains other than standard C-shape framing members the AISI S250 calculation option for other than standard C-shape framing is permitted to be used.

TABLE C402.1.3 OPAQUE BUILDING THERMAL ENVELOPE INSULATION COMPONENT MINIMUM REQUIREMENTS, R-VALUE ALTERNATIVES [a]

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 4.88 kg/m^2, 1 pound per cubic foot = 16 kg/m^3.

ci = Continuous Insulation, NR = No Requirement, LS = Liner System.

a. Assembly descriptions can be found in ANSI/ASHRAE/IESNA 90.1 Appendix A.

b. Where using *R*-value compliance method, a thermal spacer block shall be provided, otherwise use the *U*-factor compliance method in Table C402.1.2.

c. R-5.7ci is allowed to be substituted with concrete block walls complying with ASTM C90, ungrouted or partially grouted not less than 32 inches or less on center vertically and not less than 48 inches on center horizontally, with ungrouted cores filled with materials having a maximum thermal conductivity of 0.44 Btu-in/h-f^2 ° F.

d. Where heated slabs are below grade, below-grade walls shall comply with the R-value requirements for above-grade mass walls .

e. "Mass floors" shall be in accordance with Section C402.2.3.

f. "Mass walls" shall be in accordance with Section C402.2.2.

g. The first value is for perimeter insulation and the second value is for full, under-slab insulation. Perimeter insulation and full-slab insulation components shall be installed in accordance with Section C402.2.4.1 .

h. The first value is *cavity insulation*; the second value is *continuous insulation*. Therefore, "R-0+R-12ci" means R-12 *continuous insulation* and no *cavity insulation*; "R-13+R-3.8ci" means R-13 *cavity insulation* and R-3.8 *continuous insulation*; "R-20" means R-20 *cavity insulation* and no *continuous insulation*. R-13, R-20, and R-27 *cavity insulation* as used in this table apply to a nominal 4-inch (101 mm), 6-inch (152 mm), and 8-inch (203 mm) deep wood or cold-formed steel stud cavities, respectively.

C402.1.4 Component performance alternative. *Building thermal envelope*~~Building envelope~~ values and fenestration areas determined in accordance with Equation 4-1 shall be an alternative to compliance with the *U*-, *F*-, psi-, chi-, and *C*-factors in Tables C402.1.2, C402.1.5, and C402.5 and the maximum allowable fenestration areas in Section C402.5.1. *Fenestration* shall meet the applicable SHGC requirements of Section C402.5.3.

$$A_P + B_P + C_P + T_P \leq A_T + B_T + C_T + T_T - V_F - V_S \quad \textbf{(Equation 4-1)}$$

A_P = Sum of the (area x U-factor) for each proposed building thermal envelope assembly, other than slab-on-grade or below-grade wall assemblies
B_P = Sum of the (length x F-factor) for each proposed slab-on-grade edge condition
C_P = Sum of the (area x C-factor) for each proposed below-grade wall assembly
T_P = Sum of the (ψL_P) and (χN_p) values for each type of thermal bridge condition of the building thermal envelope as identified in Section C402.6 in the proposed building. For the purposes of this section, the (ψL_P) and (χN_P) values for thermal bridges caused by materials with a thermal conductivity less than or equal to 3.0 Btu-in/h-ft^2-F shall be assigned as zero. For buildings or structures located in Climate Zones 0 through 3, the value of T_P shall be assigned as zero.
ψL_P= psi-factor × length of the thermal bridge elements in the proposed building thermal envelope.
χN_P = chi-factor x number of the thermal bridge point elements other than fasteners, ties, or brackets in the proposed building thermal envelope.
A_T = Sum of the (area x U-factor permitted by Tables C402.1.2 and C402.5) for each proposed building thermal envelope assembly, other than slab-on-grade or below-grade wall assemblies
B_T = Sum of the (length x F-factor permitted by Table C402.1.2 for each proposed slab-on-grade edge condition
C_T = Sum of the (area x C-factor permitted by Table C402.1.2) for each proposed below-grade wall assembly
T_T = Sum of the (ψL_T) and (χN_T) values for each type of thermal bridge condition in the proposed building thermal envelope as identified in Section C402.6 with values specified as "compliant" in Table C402.1.4. For the purposes of this section, the (ψL_T) and (χNT) values for thermal bridges caused by materials with a thermal conductivity less than or equal to 3.0 Btu-in/h-ft^2-F shall be assigned as zero. For buildings or structures located in Climate Zones 0 through 3, the value of T_T shall be assigned as zero.
ψL_T= (psi-factor specified as "compliant" in Table C402.1.5) × length of the thermal bridge elements in the proposed building thermal envelope.
χN_T = (chi-factor specified as "compliant" in Table C402.1.5) x number of the thermal bridge point elements other than fasteners, ties, or brackets in the proposed building thermal envelope.
P_F = Maximum vertical fenestration area allowable by Section C402.5.1, C402.5.1.1, or C402.5.1.2
Q_F = Proposed vertical fenestration area
$R_F = Q_F - P_F$, but not less than zero (excess vertical fenestration area)
S_F = Area-weighted average U-factor permitted by Table C402.5 of all vertical fenestration assemblies
T_F = Area-weighted average U-factor permitted by Table C402.1.2 of all exterior opaque wall assemblies
$U_F = S_F - T_F$ (excess U-factor for excess vertical fenestration area)
$V_F = R_F \times U_F$ (excess UxA due to excess vertical fenestration area)
P_S = Maximum skylight area allowable by Section C402.1.2
Q_S = Actual skylight area

$R_S = Q_S – P_S$, but not less than zero (excess skylight area)
S_S = Area-weighted average U-factor permitted by Table C402.5 of all skylights
T_S = Area-weighted average U-factor permitted by Table C402.1.2 of all opaque roof assemblies
$U_S = S_S – T_S$ (excess U-factor for excess skylight area)
$V_S = R_S \times U_S$ (excess UxA due to excess skylight area)
A proposed psi- or chi-factor for each thermal bridge shall comply with one of the following as applicable:

1. Where the proposed mitigation of a thermal bridge is compliant with the requirements of Section C402.6, the “compliant” values in Table C402.1.4 shall be used for the proposed psi- or chi-factors.
2. Where a thermal bridge is not mitigated in a manner at least equivalent to Section C402.6, the “non-compliant” values in Table C402.1.4 shall be used for the proposed psi- or chi-factors.
3. Where the proposed mitigation of a thermal bridge provides a psi- or chi-factor less than the “compliant” values in Table C402.1.4, the proposed psi- or chi-factor shall be determined by thermal analysis, testing, or other approved sources.

Staff note existing items removed

TABLE C402.5 BUILDING THERMAL ENVELOPE FENESTRATION MAXIMUM U-FACTOR AND SHGC REQUIREMENTS

NR = No Requirement, PF = Projection Factor.

C402.6 Air leakage—building thermal envelope. The *building thermal envelope* shall comply with Sections C402.6.1 through C402.6.8.1.

C402.6.1.1 Air barrier design and documentation requirements . Design of the continuous air barrier shall be documented in the following manner:

1. Components comprising the continuous air barrier and their position within each *building thermal envelope* ~~building thermal envelope~~ assembly shall be identified.
2. Joints, interconnections, and penetrations of the continuous air barrier components shall be detailed.
3. The continuity of the air barrier building element assemblies that enclose conditioned space or provide a boundary between conditioned space and unconditioned space shall be identified.
4. Documentation of the continuous air barrier shall detail methods of sealing the air barrier such as wrapping, caulking, gasketing, taping or other approved methods at the following locations:

    4.1 Joints around fenestration and door frames.

    4.2 Joints between walls and floors, between walls at building corners, between walls and roofs including parapets and copings, where above-grade walls meet foundations, and similar intersections.

    4.3 Penetrations or attachments through the continuous air barrier in *building thermal envelope*~~building envelope~~ roofs, walls, and floors.

    4.4 Building assemblies used as ducts or plenums.

    4.5 Changes in continuous air barrier materials and assemblies.

5. Identify where testing will or will not be performed in accordance with Section C402.5.2 Where testing will not be performed, a plan for field inspections required by C402.5.2.3 shall be provided that includes the following:

    5.1 Schedule for periodic inspection,

    5.2 Continuous air barrier scope of work,

    5.3 List of critical inspection items,

    5.4 Inspection documentation requirements, and

    5.5 Provisions for corrective actions where needed.

C402.6.2.3 Building thermal envelope design and construction verification criteria. Where Section C402.6.2.1 and C402.6.2.2 are not appliable the installation of the continuous air barrier shall be verified by the *code official*, a *registered design professional* or *approved* agency in accordance with the following:

1. A review of the construction documents and other supporting data shall be conducted to assess compliance with the requirements in Section C402.6.1.
2. Inspection of continuous air barrier components and assemblies shall be conducted during construction to verify compliance with the requirements ofC402.6.2.3.1 or C502.6.2.3.2. The air barrier shall remain accessible for inspection and repair.
3. A final inspection report shall be provided for inspections completed by the *registered design professional* or *approved* agency. The inspection report shall be provided to the building owner or owner's authorized agent and the *code official*. The report shall identify deficiencies found during inspection and details of corrective measures taken.

C402.6.5 Air intakes, exhaust openings, stairways and shafts. Stairway enclosures, elevator shaft vents and other outdoor air intakes and exhaust openings integral to the *building thermal envelope*~~building envelope~~ shall be provided with dampers in accordance with Section C403.7.7.

C403.4.1 Thermostatic controls. The supply of heating and cooling energy to each *zone* shall be controlled by individual thermostatic controls capable of responding to temperature within the *zone*. Where humidification or dehumidification or both is provided, not fewer than one humidity control device shall be provided for each humidity control system.

Exception: Independent perimeter systems that are designed to offset only *building thermal envelope*~~building envelope~~ heat losses, gains or both serving one or more perimeter *zones* also served by an interior system provided that both of the following conditions are met:

1. The perimeter system includes not fewer than one thermostatic control *zone* for each building exposure having exterior walls facing only one orientation (within ±45 degrees) (0.8 rad) for more than 50 contiguous feet (15 240 mm).
2. The perimeter system heating and cooling supply is controlled by thermostats located within the *zones* served by the system.

C403.13.1 Duct and plenum insulation and sealing. Supply and return air ducts and plenums shall be insulated with not less than R-6 insulation where located in unconditioned spaces and where located outside the building with not less than R-8 insulation in *Climate Zones* 0 through 4 and not less than R-12 insulation in *Climate Zones* 5 through 8. Ducts located underground beneath buildings shall be insulated as required in this section or have an equivalent thermal distribution efficiency. Underground ducts utilizing the thermal distribution efficiency method shall be *listed* and *labeled* to indicate the *R*-value equivalency. Where located within a *building thermal envelope*~~building envelope~~ assembly, the duct or plenum shall be separated from the building exterior or unconditioned or exempt spaces by not less than R-8 insulation in *Climate Zones* 0 through 4 and not less than R-12 insulation in *Climate Zones* 5 through 8.

Exceptions:

1. Where located within equipment.
2. Where the design temperature difference between the interior and exterior of the duct or plenum is not greater than 15°F (8°C).

Ducts, air handlers and filter boxes shall be sealed. Joints and seams shall comply with Section 603.9 of the International Mechanical Code.

C403.14 Mechanical systems located outside of the building thermal envelope. Mechanical systems providing heat outside of the *building thermal envelope*~~thermal envelope of a building~~ shall comply with Sections C403.14.1 through C403.14.4.

C406.1.3 Substantial Alterations to Existing Buildings. The *building thermal envelope*, *equipment*, and *systems* in *alterations* to *buildings* exceeding 5000 square feet (46.5 m^2) of *gross conditioned floor area* shall comply with the requirements of Section C406.1.1 and C406.1.2 where the alteration includes replacementof two or more of the following:

1. HVAC unitary systems or HVAC central heating or cooling equipment serving the alteration area, not including ductwork or *piping*.
2. 80% or more of the lighting fixtures in the *alteration* area.
3. *Building thermal envelope*~~Building envelope~~ components in the *alteration* area including new exterior cladding, fenestration, or insulation.

C406.2.1 More Efficient Building Thermal Envelope. A project shall achieve credits for improved envelope performance by complying with one of the following measures:

1. Section C406.2.1.1: E01
2. Section C406.2.1.2: E02
3. Section C406.2.1.3: E03
4. Both E02 and E03
5. Any combination of:

    5.1. Section C406.2.1.3: E03

    5.2. Section C406.2.1.4: E04

    5.3. Section C406.2.1.5: E05

    5.4. Section C406.2.1.6: E06

C406.2.1.1 EO1 Improved envelope performance 901 Appendix C. *Building thermal envelope*~~envelope~~ measures shall be installed to improve the energy performance ofthe project. The achieved energy credits shall be determined using Equation 4-15.

(Equation 4-15)

$$EC_{ENV} = 1000 \times (EPF_B - EPF_P)/EPF_B$$

EC_{ENV}= E01 measure energy credits
EPFB= base envelope performance factor calculated in accordance with ASHRAE 90.1-2019-Appendix C.
EPF_P= proposed envelope performance factor calculated in accordance with ASHRAE 90.1-2019-Appendix C.

C406.3.8 G07 Building Thermal Mass. The project shall have additional passive interior mass and a night flush control of the HVAC system. The credit is available to projects that have at least 80 percent of gross floor area unoccupied between midnight and 6:00 a.m. The project shall meet the following requirements:

1. Interior to the *building thermal envelope* insulation, provide 10 lb/ft(50 kg/m) of project conditioned floor area of passive thermal mass in the *building interior wall*, the inside of the *exterior wall*, or interior floor construction. Mass *construction* shall have mass surfaces directly contacting the air in *conditioned spaces* with directly attached gypsum panels allowed. Mass with carpet or furred gypsum panels or *exterior wall* mass that is on the exterior of the insulation layer (e.g., the portion of CMU block on the exterior of insulation filled cell cavities) shall not be included toward the *building* mass required.
2. HVAC units for 80 percent or more of the supply airflow in the project shall be equipped with outdoor air economizers and fans that have variable or low speed capable of operating at 66 percent or lower airflow and be included in the night flush *control* sequence.

3. Night flush controls shall be configured with the following sequence or another night flush strategy shall be permitted where demonstrated to be effective, avoids added morning heating, and is approved by the *authority having jurisdiction*.

   3.1. Summer mode shall be activated when outdoor air temperature exceeds 70ºF (21ºC) and shall continue uninterrupted until deactivated when outdoor air temperature falls below 45ºF (7ºC). During summer mode, the occupied cooling *set point* shall be set 1ºF (0.6ºC) higher than normal and the occupied heating *set point* shall be reset 2ºF (1.1ºC) lower than normal.

   3.2. When all the following conditions exist, night flush shall be activated:

      3.2.1. Summer mode is active in accordance with item 3.1.

      3.2.2. Outdoor air temperature is 5ºF (2.8ºC) or more below indoor average zone temperature.

      3.2.3. Indoor average zone temperature is greater than morning occupied heating *set point*.

      3.2.4. In climate zones 0A through 3A, outdoor dewpoint is below 50ºF (10ºC) or outdoor air enthalpy is less than indoor air enthalpy.

      3.2.5. Local time is between 10:00 pm and 6:00 am.

   3.3. When night flush is active,*automatic* night flush controls shall operate outdoor air *economizers* at low fan speed not exceeding 66 percent during the unoccupied period with *mechanical cooling* and heating locked out.

TABLE C407.2(1) REQUIREMENTS FOR TOTAL SIMULATED BUILDING PERFORMANCE

SECTION [a]	TITLE
Envelope	
C401.3	*Building thermal envelope* Thermal envelope certificate Thermal envelope should be struck here.
C402.2.1.1	Joints staggered
C402.2.1.2	Skylight curbs
C402.2.6	Insulation of radiant heating system
C402.6	Air leakage—*building thermal envelope* ~~thermal envelope~~
Mechanical	
C403.1.1	Calculation of heating and cooling loads
C403.1.2	Data centers
C403.2	System design
C403.3	Heating and cooling equipment efficiencies
C403.4	Thermostatic controls
C403.4.2	Off-hour controls
C403.4.7	HVAC system controls for operable openings to the outdoors
C403.5.5	Economizer fault detection and diagnostics
C403.7, except C403.7.4.1	Ventilation and exhaust systems
C403.8, except C403.8.6	Fan and fan controls
C403.9	Large-diameter ceiling fans
C403.12, except C403.12.3	Refrigeration equipment performance
C403.13	Construction of HVAC system elements
C403.14	Mechanical systems located outside of the building thermal envelope
C404	Service water heating
C405, except C405.3	Electrical power and lighting systems
C406.1.2	Additional renewable and load management credit requirements
C408	Maintenance information and system commisioning

a. Reference to a code section includes all the relative subsections except as indicated in the table.

C409.6.1.4 Building Thermal Envelope Components. *Building thermal envelope* ~~Building envelope~~ components modeled in the standard reference design and the proposed design shall comply with the requirements of this Section.

C503.1 General. *Alterations* to any *building* or structure shall comply with the requirements of Section C503. *Alterations* shall be such that the existing *building* or structure is not less conforming to the provisions of this code than the existing *building* or structure was prior to the *alteration*. *Alterations* to an existing *building*, *building* system or portion thereof shall conform to the provisions of this code as those provisions relate to new construction without requiring the unaltered portions of the existing *building* or *building* system to comply with this code. *Alterations* shall not create an unsafe or hazardous condition or overload existing *building* systems.

Exception: The following *alterations* need not comply with the requirements for new construction, provided that the energy use of the building is not increased:

1. Storm windows installed over existing *fenestration*.
2. Surface-applied window film installed on existing single-pane *fenestration* assemblies reducing solar heat gain, provided that the code does not require the glazing or *fenestration* to be replaced.
3. *Roof recover*.
4. Roof replacement where roof assembly insulation is integral to or located below the structural roof deck.
5. *Air barriers* shall not be required for *roof recover* and roof replacement where the *alterations* or renovations to the building do not include *alterations*, renovations or *repairs* to the remainder of the *building thermal envelope* ~~building envelope~~.
6. An existing building undergoing alterations that complies with Section C407.

C503.2 Building thermal envelope. Alterations of existing *building thermal envelope* assemblies shall comply with this section. New *building thermal envelope*~~building envelope~~ assemblies that are part of the *alteration* shall comply with Section C402 . An area-weighted average *U*-factor for new and altered portions of the *building thermal envelope* shall be permitted to satisfy the *U*-factor requirements in Table C402.1.4. The existing *R*-value of insulation shall not be reduced or the *U*-factor of a *building thermal envelope* assembly be increased as part of a *building thermal envelope* alteration except where complying with Section C407.

Exception: Where the existing building exceeds the fenestration area limitations of Section C402.5.1 prior to alteration, the building is exempt from Section C402.5.1 provided that there is no increase in fenestration area.

C503.6 Additional energy efficiency credits. *Alterations* shall comply with measures from Sections C406.2 and C406.3 to achieve not less than 10 percent the number of required efficiency credits from Table C406.1.1 based on building occupancy group and *climate zone*. Where a project contains multiple occupancies, credits in Table C406.1.1 from each building occupancy shall be weighted by the gross floor area to determine the weighted average project energy credits required. Accessory occupancies shall be included with the primary occupancy group for purposes of this section.

Exceptions:

1. *Alterations* that include replacement of no more than one of the following:
   - 1.1 HVAC unitary systems or HVAC central heating or cooling equipment serving the *work area* of the *alteration*.
   - 1.2 Water heating equipment serving the *work area* of the alteration.
   - 1.3 50 percent or more of the lighting fixtures in the *work area* of the alteration.
   - 1.4 50 percent or more of the area of interior surfaces of the *building thermal envelope*~~thermal envelope~~ in the *work area* of the alteration.
   - 1.5 50 percent or more of the building's *exterior wall envelope*, including fenestration.
2. *Alterations* to *buildings* in Utility and Miscellaneous Group U, Storage Group S, Factory Group F, High-Hazard Group H.
3. *Alterations* that do not contain conditioned space.
4. Portions of *buildings* devoted to manufacturing or industrial use.
5. *Buildings* in Climate Zone 0A.
6. *Alterations* that are permitted with an *addition* complying with Section C502.3.7.
7. *Alterations* that comply with Section C407.

C504.2 Application. For the purposes of this code, the following shall be considered to be repairs:

1. Glass-only replacements in an existing sash and frame.
2. *Roof repairs*.
3. Air barriers shall not be required for *roof repair* where the repairs to the building do not include *alterations*, renovations or *repairs* to the remainder of the *building thermal envelope*~~building envelope~~.
4. Replacement of existing doors that separate conditioned space from the exterior shall not require the installation of a vestibule or revolving door, provided that an existing vestibule that separates a conditioned space from the exterior shall not be removed.
5. *Repairs* where only the bulb, the ballast or both within the existing luminaires in a space are replaced, provided that the replacement does not increase the installed interior lighting power.

C505.2 Energy use intensities. *Building thermal envelope*~~Building envelope~~, space heating, cooling, ventilation, lighting and service water heating shall comply with Sec-tions C505.2.1 through C505.2.4.

Exceptions:

1. Where it is demonstrated by analysis approved by the *code official* that the change will not increase energy use intensity.
2. Where the occupancy or use change is less than 5,000 square feet (464 m^2) in area.

C505.2.1 Building thermal envelope. Where a *change of occupancy* or use is made to a whole building that the results in fenestration area greater than the maximum fenestration area allowed by Section C402.4.1, the *building* shall comply with Section C402.1.5, with a proposed UA that shall not be greater than 110 percent of the target UA.

Exception: Where the *change of occupancy* or use is made to a portion of the *building*, the new occupancy is exempt from Section C402.4.1 provided that there is not an increase in fenestration area.

Reason: "Building thermal envelope" is a defined term in the IECC, but "building envelope" and "thermal envelope" are not defined. This proposal

attempts to standardize terminology throughout the commercial provisions by replacing all instances of "building envelope" and "thermal envelope" with the defined term "building thermal envelope." Within the commercial provisions of the First Public Comment Draft there are twenty-five uses of "building envelope" and twelve uses of "thermal envelope" that have been changed. If there are technically valid reasons to retain existing terminology in specific situations, please consider amending this proposal for those sections, as necessary.

Cost Impact: The code change proposal will neither increase nor decrease the cost of construction.
This proposal modifies terminology without intending to make technical changes. Therefore, there will be no impact on cost of construction.

CED1-94-22

Proponents: Jay Crandell, representing Foam Sheathing Committee of the American Chemistry Council (jcrandell@aresconsulting.biz)

2024 International Energy Conservation Code [CE Project]

Revise as follows:

C402.1 General. *Building thermal envelope* assemblies for buildings that are intended to comply with the code on a prescriptive basis in accordance with the compliance path described in Item 1 of Section C401.2.1 shall comply with the following:

1. The opaque portions of the *building thermal envelope* shall comply with the specific insulation requirements of Section C402.2 and the thermal requirements of either ~~the U-, C- and F-factor based~~ method ~~of~~ Section C402.1.2; ~~the R-value based method of~~ Section C402.1.3; or ~~the~~ component performance method ~~alternative of~~ Section C402.1.4. Where the total area of the through-wall penetrations of mechanical equipment is greater than 1 percent of the opaque above-grade wall area, the building thermal envelope shall comply with Section C402.1.2.4.
2. Wall solar reflectance and thermal emittance shall comply with Section C402.3.
3. Roof solar reflectance and thermal emittance shall comply with Section C402.4.
4. Fenestration in building envelope assemblies shall comply with Section C402.5.
5. Air leakage of the building thermal envelope shall comply with C402.6.
6. ~~6.~~ 7. Walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers shall comply with Section C403.12.
7. ~~7.~~ 6. *Thermal bridges* in *above-grade walls* shall comply with Section C402.7.

Alternatively, where buildings have a vertical fenestration area or skylight area exceeding that allowed in Section C402.5, the building and *building thermal envelope* shall comply with Item 2 of Section C401.2.1 or Section C401.2.2.

C402.1.2 Assembly U-factor, C-factor or F-factor ~~based~~ method. *Building thermal envelope* opaque assemblies shall have a *U*-, *C*- or *F*-factor not greater than that specified in Table C402.1.2. Commercial buildings or portions of commercial buildings enclosing *Group R* occupancies shall use the *U*-, *C*- or *F*-factor from the "*Group R*" column of Table C402.1.2. Commercial buildings or portions of commercial buildings enclosing occupancies other than *Group R* shall use the *U*-, *C*- or *F*-factor from the "All other" column of Table C402.1.2

C402.1.3 Insulation component R-value method ~~alternatives~~. For opaque portions of the *building thermal envelope* using this section as an alternative to Section C402.1.2, the *R*-values for cavity insulation and continuous insulation shall be not less than that specified in Table C402.1.3. Commercial buildings or portions of commercial buildings enclosing *Group R* occupancies shall use the *R*-values from the "*Group R*" column of Table C402.1.3. Commercial buildings or portions of commercial buildings enclosing occupancies other than *Group R* shall use the *R*-values from the "All other" column of Table C402.1.3.

TABLE C402.1.3 OPAQUE THERMAL ENVELOPE INSULATION COMPONENT MINIMUM REQUIREMENTS, R-VALUE METHOD ~~ALTERNATIVES~~ [a]

Portions of table not shown remain unchanged.

Note: also change “component performance alternative” to “component performance method” in Table C402.1.4 title and exception 1 to C502.2 if this change is made

C402.1.4 Component performance method ~~alternative~~. Building envelope values and fenestration areas determined in accordance with Equation 4-1 shall be an alternative to compliance with the *U*-, *F*-, psi-, chi-, and *C*-factors in Tables C402.1.2, C402.1.5, and C402.5 and the maximum allowable fenestration areas in Section C402.5.1. *Fenestration* shall meet the applicable SHGC requirements of Section C402.5.3.
(remainder of section unchanged)

Reason: This proposal is a clean-up so that the U-factor, R-value, and component performance methods are all titled the same and referenced the same in Section C402.1. These editorial changes also make the section titles consistent with the titles of Tables C402.1.2 and C402.1.3. Also, two items listed in Section C402.1 are re-ordered to align with the sequence of requirements and sections in C402.

Cost Impact: The code change proposal will neither increase nor decrease the cost of construction.
This proposal is editorial in making section and table titles consistent. There are no changes in requirements.

Workgroup Recommendation

Proposal # 720

CED1-95-22

Proponents: Jay Crandell, representing Foam Sheathing Committee of the American Chemistry Council (jcrandell@aresconsulting.biz)

2024 International Energy Conservation Code [CE Project]

Revise as follows:

C402.1 General. *Building thermal envelope* assemblies for buildings that are intended to comply with the code on a prescriptive basis in accordance with the compliance path described in Item 1 of Section C401.2.1 shall comply with the following:

1. The opaque portions of the *building thermal envelope* shall comply with the specific insulation requirements of Section C402.2 and the thermal requirements of either the U-, C- and F-factor based method of Section C402.1.2; the R-value based method of C402.1.3; or the component performance alternative of Section C402.1.4. Where the total area of the through-wall penetrations of mechanical equipment is greater than 1 percent of the opaque above-grade wall area, the building thermal envelope shall comply with Section C402.1.2.4.
2. Wall solar reflectance and thermal emittance shall comply with Section C402.3.
3. Roof solar reflectance and thermal emittance shall comply with Section C402.4.
4. Fenestration in building envelope assemblies shall comply with Section C402.5. ~~Alternatively,~~ where buildings have a vertical fenestration area or skylight area greater than ~~exceeding~~ that allowed in Section C402.5, the building and *building thermal envelope* shall comply with Item 2 of Section C401.2.1, ~~or~~ Section C401.2.2., or Section C402.1.4.
5. Air leakage of the building thermal envelope shall comply with C402.6.
6. Walk-in coolers, walk-in freezers, refrigerated warehouse coolers and refrigerated warehouse freezers shall comply with Section C403.12.
7. *Thermal bridges* in *above-grade walls* shall comply with Section C402.7.

~~Alternatively, where buildings have a vertical fenestration area or skylight area exceeding that allowed in Section C402.5, the building and *building thermal envelope* shall comply with Item 2 of Section C401.2.1 or Section C401.2.2.~~

Reason: This proposal is editorial clean-up and merely moves a "dangling" allowance for fenestration into item 5 of the list where fenestration is specifically addressed.

Cost Impact: The code change proposal will neither increase nor decrease the cost of construction.
This proposal makes no technical change and moves existing text to a more appropriate location.

Workgroup Recommendation

Proposal # 721

CED1-108-22

Proponents: Jay Crandell, representing Foam Sheathing Committee of the American Chemistry Council (jcrandell@aresconsulting.biz)

2024 International Energy Conservation Code [CE Project]

Revise as follows:

C402.1.2.1.5 ~~C402.1.2.2 U-factor thermal resistance of c~~ Cold-formed steel assemblies. *U*-factors for building envelopes containing cold-formed steel framed ceilings and walls shall be permitted to be determined in accordance withwith AISI S250 as modified herein.

1. Where the steel-framed wall contains no cavity insulation, and uses continuous insulation to satisfy the U-factor maximum, the steel-framed wall member spacing is permitted to be installed at any on-center spacing.
2. Where the steel-framed wall contains framing at 24 inches (610 mm) on center with a 23 percent framing factor or framing at 16 inches (400 mm) on-center with a 25 percent framing factor, the next lower framing member spacing input values shall be used when calculating using AISI S250.
3. Where the steel-framed wall contains less than 23 percent framing factors the AISI S250 shall be used without any modifications.
4. Where the steel-framed wall contains other than standard C-shape framing members the AISI S250 calculation option for other than standard C-shape framing is permitted to be used.

C402.1.2.1.6 ~~C402.1.2.3 Thermal Resistance of~~ Spandrel Panels. U-factors of opaque assemblies within fenestration framing systems shall be determined in accordance with the default values in Table C402.1.2.3, ASTM C1363, or ANSI/NFRC 100.

Note: change Table number in Table, in new section C402.1.2.1.6, and in section C402.1.4

C402.1.2.1.7 ~~C402.1.2.4 Thermal Resistance of m~~ Mechanical equipment penetrations. Where the total area of through-wall penetrations of mechanical equipment is greater than 1 percent of the opaque above grade wall area, such area shall be calculated as a separate wall assembly with a published and approved U-factor for that equipment or a default U-factor of 0.5.

Reason: This proposal is editorial and moves sections that address how to determine U-factors and places them as subsections under Section C402.1.2.1 which is where methods and requirements for determining U-factors are located. In addition the subsection titles are revised to remove reference to "thermal resistance" since the provision is addressing U-factors, not R-values.

Cost Impact: The code change proposal will neither increase nor decrease the cost of construction.
The proposal is editorial and does not change requirements. It just places them in the proper location within the intended framework of Section C402.1.2.

Workgroup Recommendation

Proposal # 724

CED1-119-22

Proponents: Jay Crandell, representing Foam Sheathing Committee of the American Chemistry Council (jcrandell@aresconsulting.biz)

2024 International Energy Conservation Code [CE Project]

Revise as follows:

C402.2.6 Insulation of radiant heating system~~s~~ panels. *Radiant heating system* panels, and their associated components that are installed in interior or exterior assemblies, shall be insulated to an *R*-value of not less than R-3.5 on all surfaces not facing the space being heated. *Radiant heating system* panels that are installed in the *building thermal envelope* shall be separated from the exterior of the building or unconditioned or exempt spaces by not less than the *R*-value of insulation installed in the opaque assembly in which they are installed or the assembly shall comply with Section C402.1.2.

~~**Exception:** Heated slabs on grade shall be insulated in accordance with Section C402.2.4 and Section C402.1.~~

Reason: This proposal clarifies that Section C402.2.6 is addressing radiant heating system panels. Also, heated slabs on grade are not an exception for heating system panels. It is an assembly that is addressed elsewhere in the code. Thus, the exception is moved to the last sentence and changed to a requirement that references appropriate sections for heated slab provisions.

Cost Impact: The code change proposal will neither increase nor decrease the cost of construction.
The proposal clarifies an existing provisions without any changes in requirements.

Workgroup Recommendation

Proposal # 727

CED1-128-22

Proponents: Emily Lorenz, representing self (emilyblorenz@gmail.com)

2024 International Energy Conservation Code [CE Project]

Revise as follows:

C402.6.1 Air barriers. A continuous *air barrier* shall be provided throughout the *building thermal envelope*. The *air barrier* is permitted to be located ~~at any combination of~~ inside, outside, or within the *building thermal envelope*. The *air barrier* shall comply with Sections C402.6.1.2, and C402.6.1.3. The *air leakage* performance of the *air barrier* shall be verified in accordance with Section C402.6.2.

Exception: *Air barriers* are not required in buildings located in *Climate Zone* 2B.

C402.6.1.1 Air barrier design and documentation requirements . Design of the continuous *air barrier* shall be documented as follows ~~in the following manner~~:

1. Components comprising the continuous *air barrier* and their position within each *building thermal envelope* assembly shall be identified.
2. Joints, interconnections, and penetrations of the continuous *air barrier* components shall be detailed.
3. The continuity of the *air barrier* building element assemblies that enclose conditioned space or provide a boundary between conditioned space and unconditioned space shall be identified.
4. Documentation of the continuous *air barrier* shall detail methods of sealing the *air barrier* such as wrapping, caulking, gasketing, taping or other *approved* methods at the following locations:

   4.1 Joints around fenestration and door frames.

   4.2 Joints between walls and floors, between walls at building corners, between walls and roofs including parapets and copings, where above-grade walls meet foundations, and similar intersections.

   4.3 Penetrations or attachments through the continuous *air barrier* ~~in building envelope roofs, walls, and floors~~.

   4.4 Building assemblies used as ducts or plenums.

   4.5 Changes in continuous *air barrier* materials and assemblies.

5. Identify where testing will or will not be performed in accordance with Section C402.6~~5~~.2 Where testing will not be performed, a plan for field inspections required by C402. 6~~5~~.2.3 shall be provided that includes the following:

   5.1 Schedule for periodic inspection,

   5.2 Continuous *air barrier* scope of work,

   5.3 List of critical inspection items,

   5.4 Inspection documentation requirements, and

   5.5 Provisions for corrective actions where needed.

C402.6.2.1 Whole building test method and reporting. The *building thermal envelope* shall be tested by an *approved* third ~~thrid~~ party for *air leakage* in accordance withASTM E3158 or an equivalent *approved* method. ~~method~~ A report that includes the tested surface area, floor area, air by volume, stories above grade, and *air leakage* rates shall be submitted to the code official and the building owner.

Exceptions: ~~Add optional paragraph text here~~

1. For buildings less than 10,000 ft^2 (1000 m^2) the entire *building thermal envelope* shall be permitted to be tested in accordance with ASTM E779, ASTM E3158, ~~or~~ ASTM E1827 , or an equivalent *approved* method.
2. For buildings greater than 50,000 ft^2 (4645 m^2), portions of the building shall be permitted to be tested and the measured *air leakage* shall be area-weighted by the surface areas of the *building thermal envelope* in each portion. The weighted average tested *air leakage* shall not be greater than the whole building *air leakage* limit. The following portions of the building shall be tested:

   2.1 The entire *building thermal envelope* area of stories that have any conditioned spaces directly under a roof.

   2.2 The entire *building thermal envelope* area of stories that have a building entrance, a floor over unconditioned space, a loading dock, or that are below grade.

   2.3 Representative above-grade portions of the building totaling not less than 25 percent of the wall area enclosing the remaining conditioned space.

Reason: This proposal is editorial and is not meant to change the meaning or stringency of the requirements. Any changes submitted as part of the errata proposal for CECPI-3 are also included in this proposal to assist with correlation. Only five changes are included in this proposal that are new:
1. Section C402.6.1, changed "any combination of" to "located"

2. Section C402.6.1.1, changed "in the following manner" to "as follows"

3. Section C402.6.2.1, added "air" to "...and air leakage rates shall be submitted..." in the second sentence.

4. Section C402.6.2.1, exception 1, deleted "or" in "...ASTM E3158, ~~or~~ ASTM E1827, or an equivalent..."

5. Section C402.6.2.1, exception 2, added "air" to "...building air leakage limit." in the second sentence.

Cost Impact: The code change proposal will neither increase nor decrease the cost of construction.
Proposal only includes editorial changes to language.

Workgroup Recommendation

Proposal # 715

Pacific Northwest
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Thermal Bridging Analysis in IECC 2024 Progress Indicator

December 7, 2022

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U.S. DEPARTMENT OF ENERGY BATTELLE

PNNL is operated by Battelle for the U.S. Department of Energy

Thermal Bridging Analysis Methodology

Characterize Thermal Bridges in each Prototype

- By prototype
- By floor (ground, middle, top)

Calculate Thermal Bridge Heat Flows Btu/(h-°F)

- By type and floor of each prototype
- Calculated for both mitigated and unmitigated cases
- Individual heat flows are summed to determine total for each floor
- Calculated using proposed IECC mitigated and unmitigated PSI factors.

Calculate Thermal Bridge adjustment factors

- By floor for each prototype
- Calculated for both mitigated and unmitigated cases
- U-factor adjustment with units BTU/(h-ft^2-°F

Calculate Adjusted Above-Grade-Wall U-factors

- Sum of prescriptive AGW U-factor and thermal bridging adjustment factor.
- Unique U-factors for each floor, prototype and climate zone.
- Based on wall type of each prototype.
- Values for both mitigated and unmitigated cases.

Final Modeling Analysis

- Adjusted AGW U-factors are input into analysis.
- **IECC 2021 baseline uses unmitigated AGW U-factors**
- **IECC 2024 proposed case uses mitigated AGW U-factors**
- No thermal bridging adjustments were made for CZ 0-3.

PI energy savings are based on these differences.

Characterization of Thermal Bridges in Prototypes

Identified thermal bridges* in prototypes:

- **Parapets** – prototypes with continuous above deck insulation are assumed to include a parapet.
- **Balconies** – Large Hotel, Midrise MF and Highrise MF are assumed to include balconies based on modeling assumptions used to account for sliding door HVAC switches that were added into ASHRAE 90.1.
- **Vertical window/wall intersections** – calculated for each prototype
- **Cladding supports** - calculated for each prototype

*Intermediate floor-wall intersections were not assumed to be a thermal bridge.

Characteristics of each thermal bridge type were described separately for the Ground, Middle and Top floors of each prototype.

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Characterization of Thermal Bridges in Prototypes

Prototype characteristics identified by floor: Ground, Middle, & Top

Roof thermal bridges are included on Ground Floor in the SA Retail because it is a 1 story building.

Calculated length, by floor, of each linear thermal bridge type

Opaque wall area of each floor

PNNL Prototype Model Takeoffs	Medium Office	Standalone Retail	Large Office
Length of Balcony (ft)			
Ground Floor:			
floor area, sf	17,878	24,690	38400
roof area, sf	-	24,690	-
Floor perimieter, ft	546	634	800
Floor Slab height, ft	0.50	0.50	0.50
total Wall area (opaque + fenestration area+ doors), sf	7,097	12,669	10400
glass door area, sq.ft.		84	
opaque door area, sq.ft.	126	568	252
fenestration area, sf (does not include doors)	2,342	820	4158
fenestration height, ft.	4.3	3.74	5.2
Punched Windows (Y/N)	N	N	N
Number of Windows	4	2	16
# through the wall HVAC units	-	-	-
roof edge, lf	-	634	-
parapet length,lf	-	634	-
above grade floor-wall intersection length, ft.	-	-	-
balcony/deck at opaque wall intersection length, ft.	-	-	-
balcony/deck at vertical fenestration length ft.	-	-	-
Cladding girt length, ft	59	144	77
opaque wall - vertical fen. Intersection, ft	1,126	453	1,766
Other Element and Assembly Intersections	-	-	-
mechnical penetration/louver area, sf	-	-	-
clear field opaque wall area, sf	4,629	11,197	5,990

Characterization of Thermal Bridges in Prototypes - Balconies

Balcony thermal bridges are based on modeling assumptions developed for the characterization of sliding glass door HVAC interlock controls in ASHRAE 90.1.

PNNL Prototype Model Takeoffs	Large Hotel	Small Hotel	Midrise Multifamily	Highrise MF
building area, sf	122132	43200	33700	84360
Total Wall area (opaque + fenestration area + doors), sf	100820	18240	16600	41500
Building Width, ft	GF:75', MF&	60	55.5	55.5
Building Length, ft	284	180	152	152
Number of Floors	6	4	4	10
Above Grade Wall Type	mass	steel-frame	steel-frame	steel-frame
HVAC System Type				
Balconies				
Included (Yes/No)	Yes	No	Yes	Yes
Percentage of dwelling/sleeping units	9.6%		11.6%	36.5%
Dwelling/Sleeping Units per floor	42		8	8
Length of Balcony (ft)	9		9	9

Calculating Thermal Bridge Heat Flows

Thermal bridging heat flow calculated by type for each floor of each prototype.

Total thermal bridging heat flow impact, by floor.

Above-grade-wall U-factor adjustment calculated by floor.

Code Version	IECC		Medium Office				Standalone Retail			
Thermal Bridge Type	Thermal Bridging Factor (TBF) Type	Include?	Unmitigated TBF	Mitigated TBF	Unmitigated Heat Flow, Btu/(h-°F)	Mitigated Heat Flow, Btu/(h-°F)	Unmitigated TBF	Mitigated TBF	Unmitigated Heat Flow, Btu/(h-°F)	Mitigated Heat Flow, Btu/(h-°F)
					BTU/(h-F)					
Ground Floor										
Roof edge	PSI - BTU/(h-ft-F)	N	0	0	-	-	0	0	-	-
Parapet	PSI - BTU/(h-ft-F)	Y	0.4	0.2	-	-	0.4	0.2	253.6	126.8
Intermediate floor to wall intersection	PSI - BTU/(h-ft-F)	N	0.5	0.2	-	-	0.5	0.2	-	-
Intermediate floor balcony or overhang to	PSI - BTU/(h-ft-F)	N	0.5	0.2	-	-	0.5	0.2	-	-
Intermediate floor balcony in contact with Vertical Fenestration	PSI - BTU/(h-ft-F)	N	0.5	0.2	-	-	0.5	0.2	-	-
Cladding Support	PSI - BTU/(h-ft-F)	Y	0.3	0.2	17.8	11.9	0.3	0.2	43.1	28.7
Wall to Vertical Fenestration intersection	PSI - BTU/(h-ft-F)	Y	0.3	0.2	337.7	168.9	0.3	0.2	136.0	68.0
Other Element and Assembly Intersections	CHI - BTU/(h-ft-F)	N	0.0	0.0	-	-	0.0	0.0	-	-
Mechanical penetrations and louvers >1%	Other (BTU/(h-ft2-F)	N			-	-			-	-
Thermal Bridge - Total Heat Flow Impact					355.5	180.7			432.7	223.5
Thermal Bridge Adjustment for AGW U-factor					0.077	0.0			0.0	0.0
Mid Floor										
Roof edge	PSI - BTU/(h-ft-F)	N	0.0	0.0	-	-	0.0	0.0	-	-
Parapet	PSI - BTU/(h-ft-F)	Y	0.4	0.2	-	-	0.4	0.2	-	-
Intermediate floor to wall intersection	PSI - BTU/(h-ft-F)	N	0.5	0.2	-	-	0.5	0.2	-	-
Intermediate floor balcony or overhang to opaque wall intersection	PSI - BTU/(h-ft-F)	Y	0.5	0.2	-	-	0.5	0.2	-	-
Intermediate floor balcony in contact with Vertical Fenestration	PSI - BTU/(h-ft-F)	Y	0.5	0.2	-	-	0.5	0.2	-	-
Cladding Support	PSI - BTU/(h-ft-F)	Y	0.3	0.2	18.3	12.2	0.3	0.2	-	-
Wall to Vertical Fenestration intersection	PSI - BTU/(h-ft-F)	Y	0.3	0.2	337.7	168.9	0.3	0.2	-	-
Other Element and Assembly Intersections	CHI - BTU/(h-ft-F)	N	0.0	0.0	-	-	0.0	0.0	-	-
Mechanical penetrations and louvers >1%	Other (BTU/(h-ft2-F)	N			-	-			-	-
Thermal Bridge - Total Heat Flow Impact					356.0	181.0			-	-
Thermal Bridge Adjustment for AGW U-factor					0.075	0.0			0.0	0.0

Calculating Adjusted Above-Grade-Wall U-factors

Adjusted AGW U-factors that capture unmitigated and mitigated thermal bridging impacts.

Calculated by climate zone and floor

Prescriptive AGW U-Factor, from C402, based on wall type. For example, Medium Office has steel-frame walls and Standalone Retail has mass walls.

Calculated thermal bridging U-factor adjustment.

		Medium Office					Standalone Retail				
			Unmitigated		Mitigated			Unmitigated		Mitigated	
Climate Zon		AGW U-factor	Thermal Bridge Adjust	Adjust AG Wall U-factor	Thermal Bridge Adjust	Adjust AG Wall U-factor	AGW U-factor	Thermal Bridge Adjust	Adjust AG Wall U-factor	Thermal Bridge Adjust	Adjust AG Wall U-factor
4A	Ground Floor	0.055	0.077	0.132	0.039	0.094	0.09	0.039	0.129	0.020	0.110
	Mid Floor		0.075	0.130	0.038	0.093			NA		NA
	Top Floor		0.121	0.176	0.061	0.116			NA		NA
4B	Ground Floor	0.064	0.077	0.141	0.039	0.103	0.10	0.039	0.143	0.020	0.124
	Mid Floor		0.075	0.139	0.038	0.102			NA		NA
	Top Floor		0.121	0.185	0.061	0.125			NA		NA
4C	Ground Floor	0.064	0.077	0.141	0.039	0.103	0.10	0.039	0.143	0.020	0.124
	Mid Floor		0.075	0.139	0.038	0.102			NA		NA
	Top Floor		0.121	0.185	0.061	0.125			NA		NA
5A	Ground Floor	0.055	0.077	0.132	0.039	0.094	0.09	0.039	0.129	0.020	0.110
	Mid Floor		0.075	0.130	0.038	0.093			NA		NA
	Top Floor		0.121	0.176	0.061	0.116			NA		NA
5B	Ground Floor	0.055	0.077	0.132	0.039	0.094	0.09	0.039	0.129	0.020	0.110
	Mid Floor		0.075	0.130	0.038	0.093			NA		NA
	Top Floor		0.121	0.176	0.061	0.116			NA		NA

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Thank you