



STATE OF WASHINGTON

STATE BUILDING CODE COUNCIL

026-2018
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2015 Washington State Energy Code Development Energy Code Proposal Short Form

For editorial **Coordination, Clarifications & Corrections** only,
without substantive energy or cost impacts

Code being amended: [Commercial](#) Provisions [Residential](#) Provisions
(A MS Word version of the code is linked to the name)

Code Section # C402.1.5 with small changes to C406.8, C503, and C505

Brief Description: This proposal:

- Corrects errors in Equation 4-2 terms C and D
- Provides definitions for Proposed Total Envelope UA and Allowed Total Envelope UA that can be referenced by C406.8, C503, and C505 which currently refer to C402.1.5 for some form of those terms which do not exist.
- Corrects error in Equation 4-3

In the other information at the end, two alternative formulations for equation 4-2 and on alternative for equation 4-3 are also presented. Two of the three alternatives represent more incremental changes and make it easier to separate the error correction from other changes. It may be that the safest approach would be to adopt the minimum change alternates. A calculation example of the error in Equation 4-2 terms C and D is also provided.

Proposed code change text: (Copy the existing text from the Integrated Draft, linked above, and then use underline for new text and ~~strikeout~~ for text to be deleted.)

C402.1.5 Component performance alternative. Building envelope values and fenestration areas are permitted to exceed determined in accordance with Equation 4-2 shall be permitted in lieu of compliance with the U-factors, ~~and~~ F-factors, and SHGC values in Table C402.1.4 and C402.4 and the maximum allowable fenestration areas in Section C402.4.1 where the proposed building satisfies Equations 4-2 and 4-3.

Replace Equation 4-2 and terms A, B, C, and D with:

Proposed Total Envelope UA ≤ Allowed Total Envelope UA (Equation 4-2)

Where:

Proposed Total Envelope UA = Sum of the (UA Proposed) and (FL Proposed) values for each distinct assembly type where,

UA Proposed = Proposed U-value x Proposed Area

FL Proposed = Proposed F-value x Proposed Perimeter length

Allowed Total Envelope UA = Sum of UA Allowed + Sum of FL Allowed, where for each distinct assembly type,

UA Allowed = (U-factor from Table C402.1.4 or C402.4) x Proposed Area x Allowed Area Factor for component type

FL Allowed = (F-factor specified in Table C402.1.4) x Proposed Perimeter length

Allowed Area Factors must be applied for each component type. The Allowed Area Factors shall be calculated as follows:

<u>Doors</u>	<u>= 1</u>
<u>Floors</u>	<u>= 1</u>
<u>Walls - Below grade</u>	<u>= 1</u>
<u>Walls - Above grade</u>	<u>= (TotNetWallA + ExcessVFA) / TotNetWallA</u>
<u>Windows</u>	<u>= (TotVFA – ExcessVFA) / TotVFA</u>
<u>Roofs</u>	<u>= (TotNetRoofA + ExcessSkyA) / TotNetRoofA</u>
<u>Skylights</u>	<u>= (TotSkyA – ExcessSkyA) / TotSkyA</u>

Where

ExcessVFA = the greater of 0 or the quantity TotVFA - MaxVFA

ExcessSkyA = the greater of 0 or the quantity TotSkyA - MaxSkyA

MaxVFA = the maximum window-to-wall ratio (WWR) x the gross above-grade wall area, where the maximum WWR is:

1. 30%
2. 40% if the building complies with Section C402.4.1.1; or
3. 40% if the U-values used in calculating UA Table for vertical fenestration are taken from Section C402.4.1.3 rather than Table C402.4

MaxSkyA = 0.05 x Gross Roof Area.

TotVFA = the sum of all proposed vertical fenestration areas

TotSkyA = the sum of all proposed skylight areas

TotNetWallA = the sum of all net proposed wall areas

TotNetRoofA = the sum of all net proposed roof areas

Replace current section C402.1.5.2, equation 4-3 and 4-4 with:

C402.1.5.2 SHGC rate calculations. Fenestration SHGC values for individual components are permitted to exceed the SHGC values in Table C402.4 and/or the proposed fenestration areas are allowed to exceed the maximum allowable fenestration areas in Section C402.4.1 where the proposed values satisfy Equation 4-3

Proposed Total Envelope SHGCA < Allowed Total Envelope SHGCA **(Equation 4-3)**

Where:

Proposed Total Envelope SHGCA = Sum of the (SHGCA Proposed) for each distinct fenestration type and SHGC category of the building thermal envelope where,

SHGCA Proposed = Proposed SHGC-value x Proposed Area

Allowed Total Envelope SHGCA = Sum of (SHGCA Table) – Cshgc– Dshgc where for each distinct fenestration type and SHGC category of the building thermal envelope,

SHGCA Allowed = (SHGC-factor from Table C402.4 or Section C402.4.1.3) x Proposed Area x Allowed Area Factor

Allowed Area Factors must be applied for each component and shall be calculated per C402.1.5.

C406.8 Enhanced envelope performance. The ~~total~~ Proposed Total Envelope UA of the building thermal envelope shall be 15 percent lower than the ~~maximum allowable~~ Allowed Total Envelope UA for a building of identical configuration and fenestration area in accordance with Section C402.1.5 and Equation 4-2, ~~where UA equals the sum of the U-values of each distinct envelope assembly multiplied by the area in square feet of that assembly.~~

C503.2 Change in space conditioning. Any nonconditioned space that is altered to become *conditioned space* or *semi-heated space* shall be required to be brought into full compliance with this code. Any semi-heated space that is altered to become conditioned space shall be required to be brought into full compliance with this code.

A simplified example follows. The proposed building has a single wall, window, and roof type and a 50% WWR. The allowed building window and wall areas are adjusted to reflect a maximum WWR of 30%. Based upon overall building heat loss rate, the proposed building UA is more than the allowed UA and should not pass. This I believe is the intent of the code, that only buildings with a UA better than the allowed amount may pass C402.1.5.

	Proposed			Allowed			
	Area	U	UA	Max WWR	Area	Code u	UA
Wall	1000	0.04	40		1400	0.05	70
window	1000	0.27	270	0.3	600	0.35	210
roof	1000	0.02	20		1000	0.03	30
Total			330				310

Note: The code values are randomly selected but the code selected will not impact this demonstration of the C402.1.5 calculation equation.

Now using the C402.1.5 equation 4-2

A building passes if:

$$A + B + C + D \leq 0$$

where

A = Sum of the (UA Dif) values for each distinct assembly type of the building thermal envelope, other than slabs on grade and below-grade walls:

$$UA \text{ Dif} = UA \text{ Proposed} - UA \text{ Table}$$

$$UA \text{ Proposed} = \text{Proposed U-value} \times \text{Area}$$

$$UA \text{ Table} = (\text{U-factor from Table C402.1.4 or C402.4 or Section C402.1.3}) \times \text{Area}$$

For the example above the calculation of the A term follows and equals -100. Note that Table UA is different than the allowed UA. This results from the proposed area rather than the allowed area being used with the code u-factor to get Table UA.

	Proposed		
	UA	Table UA	UA Diff
Wall	40	50	-10
window	270	350	-80
roof	20	30	-10
			-100

$C = (CA \times UV) - (CA \times U_{wall})$, but not less than zero

$$CA = (\text{Proposed Vertical Fenestration Area}) - (\text{Vertical Fenestration Area allowed})$$

UA Wall = Sum of the (UA Proposed) values for each opaque assembly of the exterior wall

UAW = Sum of the (UA Proposed) values for each above-grade wall assembly

$U_{wall} = UAW / \text{sum of wall area (excludes vertical fenestration area)}$

UAV = Sum of the (UA Proposed) values for each vertical fenestration assembly

$UV = UAV / \text{total vertical fenestration area}$

For the example,

$$CA = 1000 - 600 = 400$$

$$UA \text{ Wall} = 40 \text{ (note this quantity is not referenced anywhere and is not needed)}$$

$$UAW = 40$$

$$\begin{aligned}
 U_{\text{wall}} &= 40 / 1000 = 0.04 \\
 U_{\text{AV}} &= 270 \\
 UV &= 270 / 1000 = 0.27 \\
 C &= CA * UV - CA * U_{\text{wall}} = 400 * 0.27 - 400 * 0.04 = 92
 \end{aligned}$$

The example has no slabs or skylights so

$$\begin{aligned}
 B &= 0 \text{ since there are no slabs} \\
 D &= 0 \text{ since there are no skylights.} \\
 A + B + C + D &= -100 + 0 + 92 + 0 = -8
 \end{aligned}$$

A + B + C + D is less than zero therefore the building passes even though the proposed UA is more than the allowed UA.

If the C term is calculated using UA Table rather than UA proposed then:

$$\begin{aligned}
 U_{\text{AW}} &= 50 \\
 U_{\text{wall}} &= 50 / 1000 = 0.05 \\
 U_{\text{AV}} &= 350 \\
 UV &= 350 / 1000 = 0.35 \\
 C &= CA * UV - CA * U_{\text{wall}} = 400 * 0.35 - 400 * 0.05 = 120
 \end{aligned}$$

With C = 120, A + B + C + D = 20 indicating the building does not pass which is the correct answer. Also, the term happens to equal UA proposed minus UA Allowed which is the correct behavior.

Alternate Formulations

Equation 4-2 Alt 1:

C402.1.5 Component performance alternative. Building envelope values and fenestration areas are permitted to exceed determined in accordance with Equation 4-2 shall be permitted in lieu of compliance with the U-factors, and F-factors, and SHGC values in Table C402.1.4 and C402.4 and or the maximum allowable fenestration areas in Section C402.4.1 where the proposed values satisfy Equations 4-2 and 4-3.

$$A + B + C + D \leq \text{Zero} \quad (\text{Equation 4-2})$$

Where:

A = Sum of the (UA Dif) values for each distinct assembly type of the building thermal envelope, other than slabs on grade:

$$\text{UA Dif} = \text{UA Proposed} - \text{UA Table}$$

$$\text{UA Proposed} = \text{Proposed U-value} \times \text{Area}$$

$$\text{UA Table} = (\text{U-factor from Table C402.1.4 or C402.4}) \times \text{Area}$$

B = Sum of the (FL Dif) values for each distinct slab on grade perimeter condition of the building thermal envelope:

$$\text{FL Dif} = \text{FL Proposed} - \text{FL Table}$$

$$\text{FL Proposed} = \text{Proposed F-value} \times \text{Perimeter length}$$

$$\text{FL Table} = (\text{F factor specified in Table C402.1.4}) \times \text{Perimeter length}$$

$$\text{Proposed Total Envelope UA} \leq \text{Allowed Total Envelope UA} \quad (\text{Equation 4-2})$$

Where:

$$\text{Proposed Total Envelope UA} = A_{\text{proposed}} + B_{\text{proposed}}$$

A_{proposed} = Sum of the (UA Proposed) values for each distinct assembly type of the building thermal envelope, other than slabs on grade where,

$$\text{UA Proposed} = \text{Proposed U-value} \times \text{Proposed Area}$$

B_{proposed} = Sum of the (FL Proposed) values for each distinct slab on grade perimeter of the building thermal envelope, where

$$\text{FL Proposed} = \text{Proposed F-value} \times \text{Proposed Perimeter length}$$

$$\text{Allowed Total Envelope UA} = A_{\text{allowed}} + B_{\text{allowed}} - C - D$$

A_{allowed} = Sum of the (UA Table) values for each distinct assembly type of the building thermal envelope, other than slabs on grade, where

$$\text{UA Table} = (\text{U-factor from Table C402.1.4 or C402.4}) \times \text{Proposed Area}$$

B_{allowed} = Sum of the (FL Table) values for each distinct slab on grade perimeter of the building thermal envelope, where

$$\text{FL Table} = \text{Allowed F-value} \times \text{Proposed Perimeter length}$$

The maximum allowed prescriptive vertical fenestration area, identified as “Vertical Fenestration Area allowed” in factor CA below, is the product of the maximum window-to-wall ratio (WWR) and as a percent of the gross above-grade wall area, ratio is either: The maxium WWR is:

1. 30%
2. 40% if the building complies with Section C402.4.1.1; or
3. 40% if the U-values used in calculating UA Table for vertical fenestration are taken from Section C402.4.1.3 rather than Table C402.4

Where the proposed vertical fenestration area is less than or equal to the maximum allowed prescriptive vertical fenestration area, the value of C (Excess Vertical Glazing Value) shall be zero. Otherwise, the calculation should include target area adjustment:

C = (CA x UV) – (CA x U_{Wall}), but not less than zero

$$\text{CA} = (\text{Proposed Vertical Fenestration Area}) - (\text{Vertical Fenestration Area allowed})$$

UA_{Wall} = Sum of the (UA Proposed) values for each opaque assembly of the exterior wall

UAW = Sum of the (UA ~~Proposed~~Table) values for each above-grade wall assembly

U_{Wall} = UAW/sum of wall area (excludes vertical fenestration area)

UAV = Sum of the (UA ~~Proposed~~Table) values for each vertical fenestration assembly

UV = UAV/total vertical fenestration area

Where the proposed skylight area is less than or equal to the skylight area allowed by Section C402.4.1, the value of D (Excess Skylight Value) shall be zero. Otherwise, the calculation should include target area adjustment:

D = (DA x US) – (DA x U_{Roof}), but not less than zero

$$\text{DA} = (\text{Proposed Skylight Area}) - (\text{Allowable Skylight Area from Section C402.4.1})$$

UAR = Sum of the (UA ~~Proposed~~Table) values for each roof assembly

U_{Roof} = UAR/sum of roof area (excludes skylight area)

UAS = Sum of the (UA ~~Proposed~~Table) values for each skylight assembly

US = UAS/total skylight area

Equation 4-2 Alternate 2 (minimal change):

C402.1.5 Component performance alternative. Building envelope values and fenestration areas determined in accordance with Equation 4-2 shall be permitted in lieu of compliance with the U -factors and F -factors in Table C402.1.4 and C402.4 and the maximum allowable fenestration areas in Section C402.4.1

$$A + B + C + D \leq \text{Zero} \quad (\text{Equation 4-2})$$

Where:

A = Sum of the (UA Dif) values for each distinct assembly type of the building thermal envelope, other than slabs on grade:

$$\text{UA Dif} = \text{UA Proposed} - \text{UA Table}$$

$$\text{UA Proposed} = \text{Proposed U-value} \times \text{Area}$$

$$\text{UA Table} = (\text{U-factor from Table C402.1.4 or C402.4}) \times \text{Area}$$

B = Sum of the (FL Dif) values for each distinct slab on grade perimeter condition of the building thermal envelope:

$$\text{FL Dif} = \text{FL Proposed} - \text{FL Table}$$

$$\text{FL Proposed} = \text{Proposed F-value} \times \text{Perimeter length}$$

$$\text{FL Table} = (\text{F-factor specified in Table C402.1.4}) \times \text{Perimeter length}$$

The maximum allowed prescriptive vertical fenestration area, identified as “Vertical Fenestration Area allowed” in factor CA below, as a percent of the gross above-grade wall area ratio is either:

- 30%
- 40% if the building complies with Section C402.4.1.1; or
- 40% if the U -values used in calculating A for vertical fenestration are taken from Section C402.4.1.3 rather than Table C402.4

Where the proposed vertical fenestration area is less than or equal to the maximum allowed prescriptive vertical fenestration area, the value of C (Excess Vertical Glazing Value) shall be zero. Otherwise:

$$C = (\text{CA} \times \text{UV}) - (\text{CA} \times \text{U}_{\text{Wall}}), \text{ but not less than zero}$$

$$\text{CA} = (\text{Proposed Vertical Fenestration Area}) - (\text{Vertical Fenestration Area allowed})$$

$$\text{U}_{\text{Wall}} = \text{Sum of the (UA Proposed) values for each opaque assembly of the exterior wall}$$

$$\text{UAW} = \text{Sum of the (UA Proposed/} \underline{\text{Table}} \text{) values for each above-grade wall assembly}$$

$$\text{U}_{\text{Wall}} = \text{UAW}/\text{sum of wall area (excludes vertical fenestration area)}$$

$$\text{UAV} = \text{Sum of the (UA Proposed/} \underline{\text{Table}} \text{) values for each vertical fenestration assembly}$$

$$\text{UV} = \text{UAV}/\text{total vertical fenestration area}$$

Where the proposed skylight area is less than or equal to the skylight area allowed by Section C402.4.1, the value of D (Excess Skylight Value) shall be zero. Otherwise:

$$D = (\text{DA} \times \text{US}) - (\text{DA} \times \text{U}_{\text{Roof}}), \text{ but not less than zero}$$

$$\text{DA} = (\text{Proposed Skylight Area}) - (\text{Allowable Skylight Area from Section C402.4.1})$$

$$\text{UAR} = \text{Sum of the (UA Proposed/} \underline{\text{Table}} \text{) values for each roof assembly}$$

$$\text{U}_{\text{Roof}} = \text{UAR}/\text{sum of roof area (excludes skylight area)}$$

$$\text{UAS} = \text{Sum of the (UA Proposed/} \underline{\text{Table}} \text{) values for each skylight assembly}$$

$$\text{US} = \text{UAS}/\text{total skylight area}$$

Where required by other sections of the code Proposed Total Envelope UA and Allowed Total Envelope UA shall be calculated as:

$$\text{Proposed Total Envelope UA} = \text{Sum of UA Proposed and FL Proposed for each distinct envelope assembly.}$$

$$\text{Allowed Total Envelope UA} = \text{Sum UA Table} - C - D, \text{ where Sum UA Table} = \text{Sum of UA Table and FL Table for each distinct envelope assembly}$$

Equation 4-3 Alternate (minimal change):

C402.1.5.2 SHGC rate calculations. ~~Solar heat gain coefficient shall comply with Table C402.4. The target SHGCA_t and the proposed SHGCA_p shall be calculated using Equations 4-3 and 4-4 and the corresponding areas and SHGCs from Table C402.4.~~

~~Fenestration SHGC values for individual components and/or fenestration areas are permitted to exceed the SHGC values in Table C402.4 and/or the maximum allowable fenestration areas in Section C402.4.1 where the proposed values result in SHGCA_p less than SHGCA_t as determined by Equations 4-3 and 4-4.~~

EQUATION 4-3 TARGET SHGCA_T

$$\text{SHGCA}_t = \text{SHGC}_{\text{Ogt}}(\text{A}_{\text{Ogt}}) + \text{SHGC}_{\text{Vgt}}(\text{A}_{\text{Vgt}} + \text{A}_{\text{Vgmt}} + \text{A}_{\text{Vgmot}} + \text{A}_{\text{Vgdt}})$$

Where:

SHGCA_t := The target combined specific heat gain of the target fenestration area.

SHGC_{Ogt} := The solar heat gain coefficient for skylight fenestration found in Table C402.4.

A_{Ogt} := The ~~proposed-target~~ skylight area.

SHGC_{Vgt} := The solar heat gain coefficient for fenestration found in Table C402.4 which corresponds to the proposed total fenestration area as a percent of gross exterior wall area.

A_{Vgt} := The ~~proposed-target~~ vertical fenestration area with nonmetal framing

A_{Vgmt} := The ~~proposed-target~~ vertical fenestration area with fixed metal framing

A_{Vgmot} := The ~~proposed-target~~ vertical fenestration area with operable metal framing

A_{Vgdt} := The proposed entrance door area

NOTE: The vertical fenestration area does not include opaque doors and opaque spandrel panels.

~~If the proposed vertical fenestration area does not exceed the Vertical Fenestration Area allowed the target area for each vertical fenestration type shall equal the proposed area. If the proposed vertical fenestration area exceeds the Vertical Fenestration Area allowed, the target area of each vertical fenestration element shall be reduced in the base envelope design by the same percentage and the net area of each above-grade wall type increased proportionately by the same percentage so that the total vertical fenestration area is exactly equal to the Vertical Fenestration allowed.~~

~~If the proposed skylight area does not exceed the Allowable Skylight Area from Section C402.4.1 the target area shall equal the proposed area. If the proposed skylight area exceeds the Allowable Skylight Area from Section C402.4.1, the area of each skylight element shall be reduced in the base envelope design by the same percentage and the net area of each roof type increased proportionately by the same percentage so that the total skylight area is exactly equal to the allowed percentage per Section C402.3.1 of the gross roof area.~~

EQUATION 4-4 PROPOSED SHGCA_P

$$\text{SHGCA}_p = \text{SHGC}_{\text{Og}}\text{A}_{\text{Og}} + \text{SHGC}_{\text{Vg}}\text{A}_{\text{Vg}}$$

Where:

SHGCA_t := The combined proposed specific heat gain of the proposed fenestration area.

SHGC_{Og} := The solar heat gain coefficient of the skylights.

A_{Og} := The skylight area.

SHGC_{Vg} := The solar heat gain coefficient of the vertical fenestration.

A_{Vg} := The vertical fenestration area.

NOTE: The vertical fenestration area does not include opaque doors and opaque spandrel panels.