SIPs and the IECC-'15

INTRODUCTION

The 2015 International Energy Conservation Code (IECC) requires higher levels of insulation than previous energy codes and has a much greater emphasis on air tightness. As with most ICC codes, there are separate commercial and residential sections and there are several paths to compliance. The paths to compliance are the same for commercial and residential, though the required values are different.

1) Prescriptive Path (either R-Value or U-Value): This is the most common method and it requires that you meet or exceed the given code value for individual parts of the thermal envelope. In the IECC-'15, the prescriptive path includes some notations for continuous insulation (ci). SIPs qualify as continuous insulation in most cases, having no regular structural members that penetrate the insulation layer. The new U-Value charts also allow for “whole surface” comparisons.

2) Performance Path: This is based on sections C101.5.1 and R101.5.1, which state that the code official can “approve specific computer software, worksheets, compliance manuals, and other similar materials that meet the intent of the code.” SIPs are not conventional (stick-frame-and-infill) construction, therefore SIPs have needed to use the performance method in the past. As continuous insulation and whole surface codes have become more common SIPs do not need to use the performance path. This document is intended to provide the necessary proofs, and act as a compliance manual for approval by local code officials should they require additional proofs of the SIP whole surface numbers.

3) New in the IECC ‘15 is section C402.1.5 Component performance alternative for commercial or section R402.1.5 Total UA alternative for residential. Both of these sections are the same despite their different names. Simplified they state, if the total UA calculation for the building envelope and is less than or equal to the same UA calculation using the correct code minimums, then the building will pass. This document will also provide the information necessary to use SIPs in the Total UA method.

Regardless of the path to compliance the first steps to finding the correct code is knowing your building site’s climate zone and building occupancy category[1]. The climate zone can be found on the climate Zone Map Figure R301.1 from IECC 2015.

PRESCRIPTIVE PATH R-VALUES:

When using the prescriptive method for compliance, use Table C402.1.3 of IECC-'15 or the U-value Table C402.1.4 for commercial projects and Table R402.1.2 or the U-value table R402.1.4 for residential projects.

The only part of the R-value tables that can be applied directly to SIPs is the continuous insulation codes. SIPs typically either have no structural members within the insulation or a very few, therefore the continuous insulation codes are representative of the actual performance. In the commercial roof systems and the category “Insulation entirely above roof deck”, which gives continuous insulation (ci) codes. The wall and floor categories all assume

1 Building occupancy categories are defined in the IBC chapter 3, “Group R” includes all commercial buildings providing sleeping units except those included under the institutional category. “All Other” is all other commercial building types. Residential is single family homes under 3 stories tall.

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regular structural members penetrating the assembly, and do not offer a full ci R-value code except in conjunction with a high mass system.

The U-Value Code tables include the contribution of the framing members as well as sheathing and interior finish. They are therefore considered whole surface U-values and can be converted into whole surface R-values. Therefore, the U-value codes are better suited to compare to the SIP R-values. SIPs have no regular framing members, thus their use as continuous insulation, however when they are the primary structural wall system, they may require additional embedded members to support around Rough Openings for windows and doors. Given that it is more accurate to use the whole wall U-value codes, the next step is to find a formula the can be used to turn the R-value Codes into the equivalent whole wall U-values and use the same formula to compare SIPs. Below is a table that shows a method that allows the R-value codes to be equivalent to the whole surface U-values. R-values for these charts were taken from the Manuel J R-value of common building materials appendix 4.

	Wood Framed Wall Code R-Values to Whole Wall U-Values										
R- Value Codes	***R-13***	***R-20***	***R-13+5***	***R-20+5***	***R-13+10***	***R-13+3.8***	***R-20***	***R-13+7.5***	***R-20+3.8***	***R-13+15.6***	***R-20+10***
Wall Component	2x4	2x6	2x4	2x6	2x4	2x4 com	2x6 com	2x4 com	2x6 com	2x4 com	2x6 com
Continuous Insulation	0.00	0.00	5.00	5.00	10.00	3.80	0.00	7.50	3.80	15.60	10.00
OSB -7/16 (wafer board)	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55
stud (Southern Pine-Fir)	3.50	5.50	3.50	5.50	3.50	3.50	5.50	3.50	5.50	3.50	5.50
header (Southern Pine-Fir)	3.50	5.50	3.50	5.50	3.50	3.50	5.50	3.50	5.50	3.50	5.50
Cavity insulation	13.00	20.00	13.00	20.00	13.00	13.00	20.00	13.00	20.00	13.00	20.00
1/2" drywall	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Framing factor -studs	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Framing factor -headers	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Framing factor -cavity	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Calculated Whole Surface U-Value	0.083	0.055	0.058	0.043	0.045	0.063	0.055	0.051	0.046	0.036	0.036
Equivalent U-Value Code	***0.084***	***0.060***	***0.060***	***0.045***	***0.045***	***0.064***	***0.064***	***0.051***	***0.051***	***0.036***	***0.036***
Whole Surface R-value (1/ws U-value)	12	18	17	23	22	16	18	20	22	28	28

ACTUAL SIP PERFORMANCE, SUPPORTING DOCUMENTATION

The first listed R-value for the prescriptive method is a "center-of-cavity number". It's named this way because that is what it is. Conventional construction assumes that there will be studs, rafters, jacks, headers, etc. penetrating all the way through the cavity insulation. A batt of insulation labeled R-19 is just that, the batt itself is R-19. The 2x6 next to it is closer to R-6, and an equivalent metal stud is close to R-1. Clearly, the performance of the whole wall somewhat less than the cavity alone. According to research done by the DOE at Oak Ridge National Labs, the "whole wall" R-value of this prescriptive "R-19" wall was actually measured to be R-14[2]. SIPs have very few wood elements penetrating all the way through the insulation. In the same DOE research program, using the same test, a nominal R-23 SIP returned results of R-22[3] and an R-15 SIP was measured to be R-14[4]. This is the fundamental reason that SIPs with R-values below IECC table requirements are still compliant.

PERFORMANCE PATH R-VALUES

2 http://www.ornl.gov/sci/roofs+walls/AWT/HotboxTest/WoodFrame/2x6R_19/results.htm
3 http://www.ornl.gov/sci/roofs+walls/AWT/HotboxTest/SIPs/SIPA/test3.htm
4 http://www.ornl.gov/sci/roofs+walls/AWT/HotboxTest/SIPs/SIPA/test2.htm

The below method is based on the data from the DOE/ORNL hot box testing and allows us to find SIP framing factors. Using the DOE/ORNL Hot Box data we can establish the relative reduction in performance over a whole surface.

$$\frac{R_{ws.Conv}}{R_{nom.Conv}} = \frac{14}{19} = 0.73 \quad \text{and} \quad \frac{R_{ws.SIP}}{R_{nom.SIP}} = \frac{22}{23} = 0.96$$

Equations 1 & 2

Therefore, for a SIP wall, roof, or floor surface to equal it's conventional equivalent this relationship must be held:

$$R_{nom.Conv} \cdot \left(\frac{0.73}{0.96}\right) = R_{nom.Conv}(0.76)_{nom.SIP}$$

Equation 3

This relationship can be used directly, as in the following example. If a code requires R-20 conventional insulation, the required nominal SIP R-value would be:

$$R_{nom.Conv} \cdot (0.76) = R_{nom.SIP} \quad \rightarrow \quad R20 \cdot (0.76) = R15$$

Equation 4

The comparison can also be used in conjunction with the previous chart to create a SIP wall to conventional wall comparison. In order to adapt the data from the DOE/ORNL testing to the same format as is used for the code several assumptions are made. The DOE/ORNL testing did not include headers for the SIP testing though it did for the conventional testing this is because there are several cases when SIPs do not require headers. However there are also cases when the headers in a SIP wall would be substantially the same as the conventional wall, thus our choice to add the same percentage of headers to the SIP framing factor as is used in the Code comparison. The rest of the SIP framing factor is derived from the ORNL Testing data above to be about 4%. The DOE/ORNL data suggested that the conventional framing factor to be about 27% rather than the 20% that makes the Code R-value and U-value charts equivalent. Which means that the code is giving more credit to the conventional framing then testing shows and we are choosing to give SIPs less credit than they are capable of in some situations. These choices are intended to be very conservative so building officials can rely on SIPs being better performing than the conventional choice even at the code minimums.

	SIP Wall Nominal R-Values to Whole Wall U-Value Codes								
Wall Component	4.5" EPS SIP	6.5" EPS SIP	8.25" EPS SIP	4.5" NEO SIP	6.5" NEO SIP	8.25" NEO SIP	4.5" PIR SIP	6.5" PIR SIP	8.25" PIR SIP
stud (Southern Pine-Fir)	3.50	5.50	7.25	3.50	5.50	7.25	3.50	5.50	7.25
header (Southern Pine-Fir)	3.50	5.50	7.25	3.50	5.50	7.25	3.50	5.50	7.25
Cavity insulation	15.00	23.00	29.00	18.00	27.00	36.00	23.00	34.00	44.00
1/2" drywall	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Framing factor -studs	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Framing factor -headers	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Framing factor -cavity	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Calculated Whole Surface U-Value	0.068	0.045	0.036	0.057	0.038	0.029	0.045	0.031	0.024
Min U-Value Codes SIP Wall Meets	***0.084***	***0.045***	***0.036***	***0.060***	***0.045***	***0.036***	***0.045***	***0.036***	***0.036***
Max R-Value Codes SIP Wall Meets	***R-13***	***R-20+5, R-13+10***	***R-20+10, R-13+15.6***	***R-13+5, R-20***	***R-20+5, R-13+10***	***R-20+10, R-13+15.6***	***R-20+5, R-13+10***	***R-20+10, R-13+15.6***	***R-20+10, R-13+15.6***
Whole Surface R-value (1/ws U-value)	15	22	28	18	26	35	22	33	42

SIP Sizes to Meet Residential Roof and Floor U-Value Codes							
	EPS SIP	***EPS SIP***	***EPS SIP***	***NEO SIP***	***NEO SIP***	***PIR SIP***	***PIR SIP***
Wall Component	***12.25***	***10.5***	***8.25***	***10.25***	***8.25***	***8.25***	***6.5***
Blocking (SPF)	12.25	9.50	7.25	9.25	7.25	7.25	5.50
SIP	45	38	29	45	36	44	34
1/2" Drywall	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Blocking Framing Fa	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Cavity Framing Fact	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Whole Surface U-value of SIP	0.023	0.027	0.035	0.023	0.028	0.023	0.030
Max U-Value Code SIP Meets	**0.026**	**0.035**	**0.035**	**0.026**	**0.030**	**0.026**	**0.030**
Calculated Whole Surface R-value	44	37	29	44	35	43	33

The above charts apply to walls for both commercial and residential, however in the case of roofs and floors there are no headers and generally less framing in both SIPs and conventional framing. Also the codes for floors and roofs are not as consistent as walls. Depending which type of roof or floor and which chart you are looking at the required insulation is different. For example: the climate 6 insulation above the roof deck code is R-30ci which equals a U-value of 0.033, the U-value chart for the same code says 0.032 which equals R-31ci meaning that if you are looking at the U-value chart you must have a higher insulation than the same category in the R-value chart. Also within the U-Value chart the climate 6 roof lists the U-value for attic roofs at 0.021 equal to R-48 whole surface which means the whole surface insulation of an attic roof must be much higher than a roof with the insulation entirely above the roof deck. With all the conflicting codes and no clear category for SIPs deciding how SIPs should meet the roof code is very tricky. As mentioned before SIPs fall most naturally into the continuous insulation category so for commercial codes we would tend to compare SIPs to the Insulation above the roof deck category. As there is no equivalent category in the residential code the best choice is to just use the U-value chart as a whole surface number and the DOE/ORNL framing percentage for SIPs to come up with the appropriate SIP to meet the code. The chart below compares various SIP types to the residential roof and floor codes.

TOTAL UA VALUE METHOD:

New in the IECC-’15 is the option for doing a total UA calculation to instead of using the basic prescriptive method. This method is more flexible and allows for the building to make up performance gaps in one area by over preforming in another area. To use SIPs in the UA calculations you only need to know two things. The first thing to know is the R-value of the panel, which is found on our specification sheets. The second thing to know is the framing factor of the opaque wall system, that is of the whole opaque wall how much of it has structural members and how much is insulation. For SIPs the framing factor is dependent on the overall structural system, because SIPs get used in many types of applications. We are listing some suggested framing factors for various applications along with the reasoning for that suggestion. We are suggesting a range, because in any application the more complex the design and the more rough openings there are the greater the percentage of framing factors there will be. In order to find these numbers we looked at several different buildings and mapped out all the thermal bridges and figured out how much of the SIP wall was and how much the same wall would be with conventional framing, from that we got conventional walls ranging from 15% to 45% comparable to the 5%-25% with SIP wall.

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Structural System	Framing Factor range %	Reasoning (Full SIP numbers based on actual examples)
Timber Frame/Steel Frame Walls: Timbers or steel members carry all gravity loads, panels have small spans and carry lateral loads.	3%-5%	The only framing mememers that go through the panels are window bucking and possibly a shoe plate. This is continuous insulation, though panel edges may have 2x lumber so we use the DOE/ORNL testing to determine actual whole surface R-value.
Timber Frame/Steel Frame Roof: Timbers or steel members carry all gravity loads, panels have small spans and carry lateral loads.	0%-2%	The only framing mememers that go through the panels are skylight bucking. This is the truest form of continuous insulation.
SIP as Nailbase Walls, Roof or Floor: Panels can be used to wrap a conventional structure.	0%-2%	The only framing mememers that go through the panels are RO bucking. This is the truest form of continuous insulation.
Structural SIP Roof: Panels spanning ridge to eave.	3%-8%	Panels may have embedded lumber at connections (Ridges, Valleys and Dormer connections). Long spans may have I-joist splines every 4 feet to reinforce panels.
Structural SIP Walls: Panels carrying full gravity and lateral loads.	5%-25%	Panels may have embedded lumber at connections (Headers, Posts under large carrying beams, ect...). Panels will have shoe plates, and sometimes full width cap plates at floor dck connections.

CONTACT AND TECHNICAL SUPPORT

For any questions or consultations on particular applications, feel free to contact myself or any other project manager at Foard Panel. We'll be happy to help.

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