Advanced Wall Assemblies

CEC Pre-Rulemaking Workshop

California Statewide Utility Codes and Standards Program

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Advanced Wall Assemblies

Potential Code Change Scope

- Increased Residential Wall Insulation
  - Increase prescriptive standard for wood-framed residential walls
- Advanced Envelope
  - New Compliance Options - Revisions to JA4 look-up tables
    - Advanced Wall Framing (AWF)
    - Insulating Concrete Forms (ICFs)
    - Structurally Insulated Panels (SIPs)

Residential Buildings

PRESCRIPTIVE WALL INSULATION REQUIREMENTS

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Prescriptive Insulation Standards Analysis

- Find lowest wall U-factor meeting cost effectiveness and feasibility requirement by CZ
  - Highest energy savings with negative lifecycle cost
    - Not necessarily most cost effective improvement (highest cost savings)
  - Variables
    - Framing size
    - Stud spacing
    - Cavity insulation type and R-value
    - ~~Continuous insulation type and R-value~~

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Cavity Insulation Values for Cost Analysis

	Nominal Framing Size	R-value Cavity Insulation
None	Any	0
R-11 batt	2x4	11
R-13 batt	2x4	13
R-15 batt [1]	2x4	15
3" medium density foam	2x4	17
R-19 batt	2x6	19
R-21 batt [1]	2x6	21
2" med. density foam, plus R-13 batt	2x6	24
2" med. density foam, plus R-15 batt	2x6	26
5" med. density foam	2x6	29

1 - high density batt insulation

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RS Means Cost Data – Cavity Insulation

- Lowest cost insulation type to reach cavity R-value
  - Note: Cost per square foot per inch for high-density batt insulation used is $0.07, while value of $0.13 per inch used in CEC Package A analysis
- Averaged across location and similar products

Stud Spacing	Nominal Framing Size	Cavity Insulation Value	Cavity Insulation	Sill Flashing (no external insulation)	Wall Framing	1/2-inch Gyp board	Total Interior Cost
16 in. o.c.	2x4	R-13	$1,712	$358	$2,966	$1,629	$6,666
	2x4	R-15	$2,087	$358	$2,966	$1,629	$7,042
	2x4	R-17	$4,764	$358	$2,966	$1,629	$9,718
	2x6	R-19	$2,127	$515	$3,537	$1,629	$7,809
	2x6	R-21	$2,923	$515	$3,537	$1,629	$8,605
	2x6	R-24	$4,868	$515	$3,537	$1,629	$10,551
	2x6	R-26	$5,244	$515	$3,537	$1,629	$10,927
	2x6	R-29	$7,937	$515	$3,537	$1,629	$13,620
24 in. o.c.	2x6	R-19	$2,212	$515	$3,113	$1,629	$7,470
	2x6	R-21	$3,039	$515	$3,113	$1,629	$8,298
	2x6	R-24	$5,063	$515	$3,113	$1,629	$10,321
	2x6	R-26	$5,454	$515	$3,113	$1,629	$10,712
	2x6	R-29	$8,255	$515	$3,113	$1,629	$13,513

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RS Means Cost Data – Exterior Insulation

- Data for 3-coat concrete stucco vs. synthetic stucco inconsistent with feedback from the industry
  - Cost of synthetic stucco likely less expensive than 3-coat stucco cost, but not reflected in RS Means (basis for analysis)

	Rated R-value of Continuous Insulation		
	R-0	R-4	R-8
OSB	$2,600	$2,6001	$2,600
Weather barrier	$560	$5603	$560
Additional Sill Flashing	$0	$78	$157
3-coat cement stucco	$14,0900	$0	$0
Synthetic stucco (EIFS)	$	$15,766	$16,453
Total Exterior Cost	$17,2514	$19,005	$19,771

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Lifecycle Cost Calculation

Exterior Insulation	R-0				R-4				R-8			
Cavity Insulation	R-19	R-21	R-24	R-26	R-19	R-21	R-24	R-26	R-19	R-21	R-24	R-26
U-factor	0.071	0.066	0.062	0.060	0.053	0.049	0.046	0.045	0.043	0.040	0.038	0.037
CZ 01		(499)	1,052	1,176		(508)	1,235	1,444		(705)	1,113	1,377
CZ 02	(1,950)	(1,473)	130	282	(1,861)	(1,248)	504	732	(1,983)	(1,310)	522	801
CZ 03	(921)	(299)	1,486	1,745	(135)	566	2,450	2,756	163	916	2,870	3,200
CZ 04	(1,656)	(1,127)	536	717	(1,304)	(663)	1,122	1,377	(1,263)	(566)	1,294	1,582
CZ 05	(1,137)	(552)	1,172	1,390	(579)	89	1,921	2,195	(477)	243	2,131	2,437
CZ 06	(519)	159	2,014	2,311	594	1,343	3,259	3,589	1,075	1,851	3,805	4,153
CZ 07	145	907	2,865	3,218	1,633	2,427	4,418	4,790	2,319	3,123	5,128	5,510
CZ 08	(702)	(52)	1,771	2,045	286	1,011	2,908	3,229	701	1,463	3,398	3,737
CZ 09	(1,417)	(875)	817	1,021	(902)	(243)	1,538	1,812	(791)	(89)	1,766	2,073
CZ 10	(1,899)	(1,417)	195	352	(1,636)	(1,024)	420	661	(1,969)	(1,286)	536	819
CZ 11	(522)	(283)	1,039	1,046	(1,452)	(993)	549	682	(2,154)	(1,583)	99	298
CZ 12	(452)	(78)	1,422	1,514	(717)	(170)	1,503	1,697	(1,050)	(414)	1,361	1,602
CZ 13	(517)	(251)	1,109	1,121	(2,401)	(1,929)	(387)	(225)	(3,033)	(2,453)	(776)	(567)
CZ 14		(481)	865	868		(1,111)	459	592		(1,654)	42	250
CZ 15		(584)	640	578		(1,761)	(355)	(259)		(2,608)	(1,038)	(867)
CZ 16		(495)	935	984		(985)	660	826		(1,407)	355	582

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Energy Analysis

- Compare prototype standard (Package D) energy budget to same building with lower wall U-factor (each CZ)
  - Cavity insulation
    - 2x4 R-13, 15, and 17
    - 2x6 R-19, 21, 24*, 26*, 29*
  - Continuous insulation
    - R-0, 2, 4, 6, 8, 10
  - Framing Factors
    - 16 in. o.c. standard (25%)
    - 24 in. o.c. standard (22%)

* Assumes medium-density insulation

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Package A Recommendation

	2008 Prescriptive Std. (Base Case)				Proposed Prescriptive Standard			
Climate Zone	Cavity Insulation	External Insulation	Framing	U-factor	Cavity Insulation	External Insulation	Stud Spacing	U-factor
1	R-21	R-0	2x6 16" oc	0.069	R-21	R-4	2x6 24" oc	0.049
2	R-13	R-0	2x4 16" oc	0.102	R-19	R-4	2x6 24" oc	0.053
3	R-13	R-0	2x4 16" oc	0.102	R-19	R-4	2x6 24" oc	0.053
4	R-13	R-0	2x4 16" oc	0.102	R-19	R-4	2x6 24" oc	0.053
5	R-13	R-0	2x4 16" oc	0.102	R-19	R-4	2x6 24" oc	0.053
6	R-13	R-0	2x4 16" oc	0.102	R-19	R-0	2x6 24" oc	0.071
7	R-13	R-0	2x4 16" oc	0.102	R-19	R-0	2x6 24" oc	0.071
8	R-13	R-0	2x4 16" oc	0.102	R-19	R-0	2x6 24" oc	0.071
9	R-13	R-0	2x4 16" oc	0.102	R-19	R-4	2x6 24" oc	0.053
10	R-13	R-0	2x4 16" oc	0.102	R-19	R-4	2x6 24" oc	0.053
11	R-19	R-0	2x6 16" oc	0.074	R-21	R-4	2x6 24" oc	0.049
12	R-19	R-0	2x6 16" oc	0.074	R-21	R-4	2x6 24" oc	0.049
13	R-19	R-0	2x6 16" oc	0.074	R-26	R-4	2x6 24" oc	0.045
14	R-21	R-0	2x6 16" oc	0.069	R-21	R-4	2x6 24" oc	0.049
15	R-21	R-0	2x6 16" oc	0.069	R-26	R-4	2x6 24" oc	0.045
16	R-21	R-0	2x6 16" oc	0.069	R-21	R-4	2x6 24" oc	0.049

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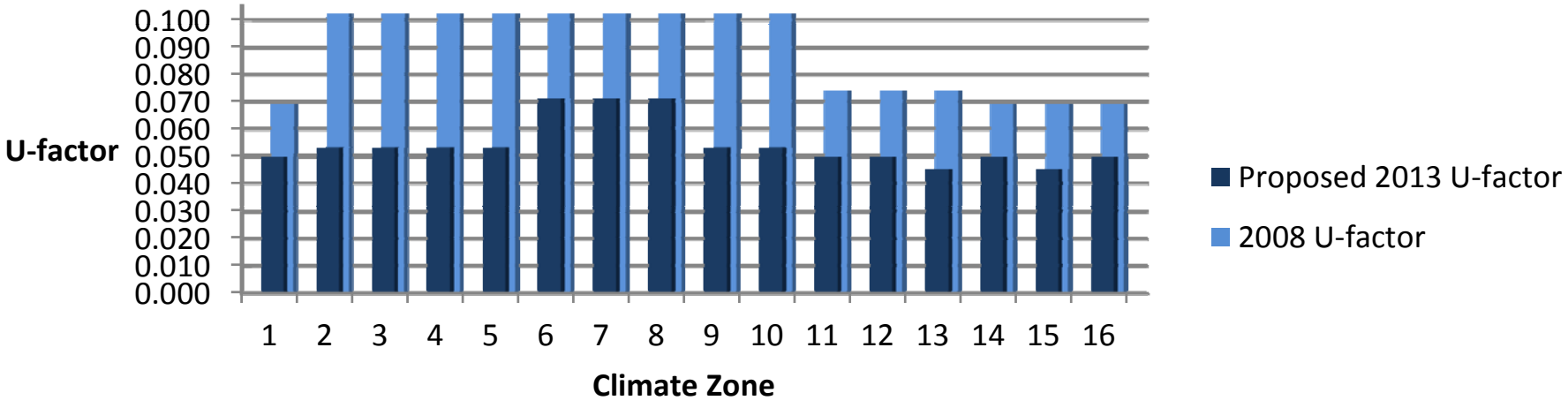
Proposed Wall U-Factors



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COMPLIANCE OPTIONS

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JA4 Look-up Table Revisions and Additions

- Revised table structure for wood framed walls
  - No bias towards insulation type(s)
  - Additional cavity insulation options with higher R-value per inch
- New look-up tables for:
  - Advanced wall framing (AWF)
  - Insulating concrete forms (ICF)
- Revised SIP table
  - Include additional products

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2008 JA4 Look-up Table

Table 4.3.1 - U-Factors of Wood Framed Walls

				Rated R-value of Continuous Insulation [2]							
				R-0	R-2	R-4	R-6	R-7	R-8	R-10	R-14
Spacing	Cavity Insulation	Nominal Framing Size		A	B	C	D	E	F	G	H
16 in. OC	None	Any	1	0.356	0.208	0.147	0.114	0.102	0.093	0.078	0.059
	R-11 batt	2x4	2	0.110	0.090	0.076	0.066	0.062	0.059	0.052	0.043
	R-13 batt	2x4	3	0.102	0.085	0.072	0.063	0.060	0.056	0.050	0.042
	R-15 batt [1]	2x4	4	0.095	0.080	0.069	0.061	0.057	0.054	0.049	0.041
	R-19 batt	2x6	5	0.074	0.064	0.057	0.051	0.049	0.046	0.043	0.036
	R-21 batt [1]	2x6	6	0.069	0.061	0.054	0.049	0.047	0.044	0.041	0.035
	R-19 batt	2x8	7	0.065	0.058	0.052	0.047	0.045	0.043	0.039	0.034
	R-22 batt	2x8	8	0.061	0.054	0.049	0.045	0.043	0.041	0.038	0.033
	R-25 batt	2x8	9	0.057	0.051	0.046	0.042	0.041	0.039	0.036	0.032
	R-30 batt [1]	2x8	10	0.055	0.050	0.045	0.041	0.040	0.038	0.035	0.031
	R-30 batt	2x10	11	0.047	0.043	0.040	0.037	0.035	0.034	0.032	0.028
	R-38 batt	2x10	12	0.046	0.042	0.039	0.036	0.035	0.034	0.032	0.028
	R-38 batt	2x12	13	0.039	0.036	0.034	0.032	0.031	0.030	0.028	0.025
	Foamed Plastic or Cellulose Insulation [3]	2x4	14	0.103	0.085	0.073	0.064	0.060	0.056	0.051	0.042
		2x6	15	0.071	0.062	0.055	0.050	0.047	0.045	0.042	0.036
		2x8	16	0.056	0.050	0.046	0.042	0.040	0.039	0.036	0.031
		2x10	17	0.045	0.041	0.038	0.035	0.034	0.033	0.031	0.028
		2x12	18	0.038	0.035	0.033	0.031	0.030	0.029	0.028	0.025

Notes

1. Higher density fiberglass batt is required in these cases.
2. Continuous insulation may be installed on either the inside or the exterior of the wall, or both.
3. Foamed plastic and cellulose shall fill the entire cavity. Cellulose shall have a binder to prevent sagging.

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2013 JA4 Look-up Table – 16-in. o.c.

			Rated R-value of Continuous Insulation [1]							
			R-0	R-2	R-4	R-6	R-7	R-8	R-10	R-14
			A	B	C	D	E	F	G	H
Any	R-0	1	0.356	0.204	0.144	0.111	0.100	0.091	0.077	0.059
2x4	R-11	2	0.110	0.087	0.073	0.063	0.059	0.056	0.050	0.041
2x4	R-13	3	0.102	0.081	0.068	0.059	0.056	0.052	0.047	0.039
2x4	R-15[3]	4	0.095	0.076	0.064	0.056	0.053	0.050	0.045	0.038
2x4	R-17[5]	5	0.090	0.072	0.061	0.053	0.050	0.047	0.043	0.036
2x6	R-19	6	0.074	0.063	0.055	0.049	0.046	0.044	0.040	0.034
2x6	R-21[3]	7	0.069	0.058	0.051	0.046	0.043	0.041	0.038	0.032
2x6	R-24[5]	8	0.065	0.055	0.048	0.043	0.041	0.039	0.036	0.031
2x6	R-26[5]	9	0.063	0.053	0.047	0.042	0.040	0.038	0.035	0.030
2x6	R-29[5]	10	0.060	0.051	0.044	0.040	0.038	0.036	0.033	0.029
2x8	R-19	11	0.065	0.057	0.050	0.045	0.043	0.041	0.038	0.033
2x8	R-22	12	0.061	0.053	0.047	0.042	0.040	0.039	0.036	0.031
2x8	R-25	13	0.057	0.050	0.044	0.040	0.038	0.037	0.034	0.030
2x8	R-27[4]	14	0.055	0.048	0.043	0.039	0.037	0.035	0.033	0.029
2x8	R-30[3]	15	0.052	0.046	0.041	0.038	0.036	0.034	0.032	0.028
2x8	R-33[5]	16	0.050	0.044	0.039	0.035	0.034	0.033	0.030	0.026
2x8	R-35[5]	17	0.049	0.043	0.038	0.035	0.033	0.032	0.029	0.026
2x8	R-37[5]	18	0.048	0.042	0.037	0.034	0.032	0.031	0.029	0.025
2x10	R-30	19	0.047	0.042	0.038	0.035	0.034	0.032	0.030	0.027
2x10	R-33	20	0.045	0.040	0.036	0.033	0.032	0.031	0.029	0.026
2x10	R-36	21	0.043	0.039	0.035	0.032	0.031	0.030	0.028	0.025
2x10	R-38	22	0.046	0.041	0.037	0.034	0.033	0.031	0.029	0.026
2x10	R-41[5]	23	0.041	0.037	0.033	0.030	0.029	0.028	0.026	0.023
2x10	R-43[5]	24	0.040	0.036	0.032	0.030	0.029	0.028	0.026	0.023
2x10	R-45[5]	25	0.039	0.035	0.032	0.029	0.028	0.027	0.025	0.023
2x10	R-47[5]	26	0.039	0.035	0.031	0.029	0.028	0.027	0.025	0.022
2x10	R-49[5]	27	0.038	0.034	0.031	0.028	0.027	0.026	0.024	0.022
2x12	R-38	28	0.039	0.035	0.032	0.030	0.029	0.028	0.026	0.023
2x12	R-41[4]	29	0.037	0.034	0.031	0.029	0.028	0.027	0.025	0.023
2x12	R-44[5]	30	0.036	0.033	0.030	0.028	0.027	0.026	0.025	0.022
2x12	R-47[5]	31	0.035	0.032	0.029	0.027	0.026	0.025	0.024	0.021
2x12	R-49[5]	32	0.035	0.031	0.029	0.027	0.026	0.025	0.023	0.021
2x12	R-52[5]	33	0.034	0.031	0.028	0.026	0.025	0.024	0.023	0.020

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2013 JA4 Look-up Table – 24-in. o.c.

			Rated R-value of Continuous Insulation [1]							
			R-0	R-2	R-4	R-6	R-7	R-8	R-10	R-14
			A	B	C	D	E	F	G	H
Any	R-0	34	0.362	0.207	0.145	0.112	0.101	0.092	0.077	0.059
2x4	R-11	35	0.106	0.085	0.072	0.062	0.058	0.055	0.049	0.041
2x4	R-13	36	0.098	0.079	0.067	0.058	0.055	0.052	0.046	0.039
2x4	R-15[3]	37	0.091	0.073	0.062	0.055	0.051	0.049	0.044	0.037
2x4	R-17[5]	38	0.086	0.069	0.059	0.052	0.049	0.046	0.042	0.036
2x6	R-19	39	0.071	0.061	0.053	0.047	0.045	0.043	0.039	0.034
2x6	R-21[3]	40	0.066	0.056	0.049	0.044	0.042	0.040	0.037	0.032
2x6	R-24[5]	41	0.062	0.053	0.046	0.042	0.040	0.038	0.035	0.030
2x6	R-26[5]	42	0.060	0.051	0.045	0.040	0.038	0.037	0.034	0.029
2x6	R-29[5]	43	0.057	0.048	0.043	0.038	0.037	0.035	0.032	0.028
2x8	R-19	44	0.063	0.055	0.049	0.044	0.042	0.040	0.037	0.032
2x8	R-22	45	0.058	0.051	0.046	0.041	0.040	0.038	0.035	0.030
2x8	R-25	46	0.056	0.048	0.043	0.039	0.037	0.036	0.033	0.029
2x8	R-27[4]	47	0.053	0.046	0.041	0.038	0.036	0.035	0.032	0.028
2x8	R-30[3]	48	0.050	0.047	0.042	0.038	0.037	0.035	33.000	0.028
2x8	R-33[5]	49	0.048	0.042	0.038	0.034	0.033	0.031	0.029	0.026
2x8	R-35[5]	50	0.047	0.041	0.037	0.033	0.032	0.031	0.029	0.025
2x8	R-37[5]	51	0.045	0.040	0.036	0.032	0.031	0.030	0.028	0.025
2x10	R-30	52	0.045	0.041	0.037	0.034	0.033	0.031	0.029	0.026
2x10	R-33	53	0.043	0.039	0.035	0.032	0.031	0.030	0.028	0.025
2x10	R-36	54	0.041	0.037	0.034	0.031	0.030	0.029	0.027	0.024
2x10	R-38	55	0.040	0.036	0.033	0.030	0.029	0.029	0.026	0.023
2x10	R-41[5]	56	0.039	0.035	0.032	0.029	0.028	0.027	0.025	0.023
2x10	R-43[5]	57	0.038	0.034	0.031	0.029	0.028	0.027	0.025	0.022
2x10	R-45[5]	58	0.037	0.033	0.030	0.028	0.027	0.026	0.024	0.022
2x10	R-47[5]	59	0.037	0.033	0.030	0.027	0.026	0.026	0.024	0.021
2x10	R-49[5]	60	0.036	0.032	0.029	0.027	0.026	0.025	0.024	0.021
2x12	R-38	61	0.037	0.034	0.031	0.029	0.028	0.027	0.025	0.023
2x12	R-41[4]	62	0.036	0.033	0.030	0.028	0.027	0.026	0.025	0.022
2x12	R-44[5]	63	0.034	0.031	0.029	0.027	0.026	0.025	0.024	0.021
2x12	R-47[5]	64	0.033	0.030	0.028	0.026	0.025	0.024	0.023	0.021
2x12	R-49[5]	65	0.033	0.030	0.027	0.026	0.025	0.024	0.023	0.020
2x12	R-52[5]	66	0.032	0.029	0.027	0.025	0.024	0.023	0.022	0.020

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2013 JA4 Table 4.3.1 Notes

1. Continuous insulation may be installed on either the interior or the exterior of the wall, or both.

2. R-values can be met using one or multiple insulation types within a cavity.

Low-density (open cell) spray-in insulation shall fill the entire cavity, when used independent of medium-density (closed cell) spray foam insulation.

When used alone or in combination with another insulation type, medium-density insulation must be applied as a first layer and need not fill the thickness of the cavity.

The R-value of low-density insulation shall be 3.6 per inch thickness. Cellulose shall have a binder to prevent sagging.

The R-value of medium-density insulation shall be 5.8 per inch thickness.

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2013 JA4 Table 4.3.1 Notes

3. Requires high-density batt insulation or medium-density spray-in insulation. Medium density insulation may be used in combination with batt or spray-in cellulose insulation to reach cavity insulation R-value

4. Requires spray-in insulation (low or medium density). Medium-density insulation may be used in combination with batt or spray-in cellulose insulation to reach cavity insulation R-value.

5. Requires use of medium-density spray foam insulation. May be used in combination with batt or spray-in cellulose insulation to reach cavity insulation R-value.

Advanced Wall Assemblies

Proposed Compliance Options

- Advanced Wood Framing
  - Set of techniques and practices that minimize the amount of wood necessary in wall framing
    - 17% framing factor vs. 22% assumed in Title 24
    - Typical AWF wall u-values from 0.021 to 0.065
    - Construction cost savings up to $1,441 per 2700sf home (prototype D)
  - Proposed Code
    - Look-up table added to JA4
    - Quality Insulation Installation (QII) as a prerequisite
    - HERS inspection required

Advanced Wall Assemblies

AWF Look-up Table

				Rated R-value of Continuous Insulation [1] Cost Per SF							
				R-0	R-2	R-4	R-6	R-7	R-8	R-10	R-14
Spacing	Nominal Framing Size	Cavity Insulation R-value[2]		A	B	C	D	E	F	G	H
24 in. OC	Any	R-0	1	0.381	0.213	0.149	0.114	0.103	0.093	0.078	0.060
	2x4	R-11	2	0.100	0.081	0.069	0.060	0.057	0.053	0.048	0.040
	2x4	R-13	3	0.091	0.074	0.064	0.056	0.053	0.050	0.045	0.038
	2x4	R-15[3]	4	0.084	0.069	0.059	0.052	0.049	0.047	0.043	0.036
	2x4	R-17[5]	5	0.079	0.065	0.056	0.049	0.047	0.044	0.040	0.034
	2x6	R-19	6	0.065	0.056	0.049	0.044	0.042	0.040	0.037	0.032
	2x6	R-21[3]	7	0.061	0.053	0.047	0.042	0.040	0.039	0.036	0.031
	2x6	R-24[5]	8	0.057	0.049	0.044	0.039	0.038	0.036	0.033	0.029
	2x6	R-26[5]	9	0.054	0.047	0.042	0.038	0.036	0.035	0.032	0.028
	2x6	R-29[5]	10	0.052	0.044	0.040	0.036	0.034	0.033	0.030	0.027
	2x8	R-19	44	0.060	0.053	0.047	0.043	0.041	0.039	0.036	0.032
	2x8	R-22	45	0.055	0.048	0.044	0.040	0.038	0.036	0.034	0.030
	2x8	R-25	46	0.051	0.045	0.041	0.037	0.036	0.034	0.032	0.028
	2x8	R-27[4]	47	0.049	0.043	0.039	0.036	0.034	0.033	0.031	0.027
	2x8	R-30[3]	48	0.046	0.041	0.037	0.034	0.032	0.031	0.029	0.026
	2x8	R-33[5]	49	0.044	0.039	0.035	0.032	0.031	0.030	0.028	0.025
	2x8	R-35[5]	50	0.042	0.037	0.034	0.031	0.030	0.029	0.027	0.024
	2x8	R-37[5]	51	0.041	0.036	0.033	0.030	0.029	0.028	0.026	0.023

- Table continues with 2x10 and 2x12 assemblies

Advanced Wall Assemblies

Proposed Compliance Options

- Insulating Concrete Forms
  - Stay-in-place panels of insulating materials for constructing cast-in-place solid concrete walls
    - Typical ICF wall U-values from 0.022 to 0.058
    - Increased construction cost: $6,036 per 2700 sf prototype home (prototype D)
  - Proposed Code
    - Look-up table added to JA4

Advanced Wall Assemblies

Proposed ICF Look-up Table

Table 4.x.x - Properties of Insulating Concrete Forms

Insulation Type	Insulation Thickness Per Side (Total R-value)	Performance Factor		Flat[1]					Waffle Grid[2]		Screen Grid[2]
				Concrete Core Thickness (inches)							
				4"	6"	8"	10"	12"	6"	8"	6"
				A	B	C	D	E	F	G	H
EPS[3]	2.0 (15.4)	U-factor	1	0.058	0.057	0.056	0.055	0.055	0.045	0.036	0.039
		C-factor									
		HC		12.20	17.00	21.80	26.60	31.40	13.90	15.87	12.10
	2.25 (18.9)	U-factor	2	0.052	0.051	0.051	0.050	0.050	0.041	0.033	0.036
		C-factor									
		HC		12.22	17.02	21.82	26.62	31.42	13.92	15.89	12.11
	2.5 (19.25)	U-factor	3	0.047	0.047	0.046	0.046	0.045	0.038	0.031	0.034
		C-factor									
		HC		12.24	17.04	21.84	26.64	31.44	13.94	15.91	12.13
	2.625 (20.2)	U-factor	4	0.045	0.045	0.044	0.044	0.043	0.037	0.030	0.033
		C-factor									
		HC		12.25	17.05	21.85	26.65	31.45	13.95	15.92	12.14
	2.75 (21.2)	U-factor	5	0.043	0.043	0.042	0.042	0.042	0.036	0.030	0.032
		C-factor									
		HC		12.26	17.06	21.86	26.66	31.46	13.96	15.92	12.15
	3.0 (23.1)	U-factor	6	0.040	0.040	0.039	0.039	0.039	0.033	0.028	0.030
		C-factor									
		HC		12.27	17.07	21.87	26.67	31.47	13.98	15.94	12.17
	3.5 (27.0)	U-factor	7	0.035	0.034	0.034	0.034	0.034	0.030	0.025	0.027
		C-factor									
		HC		12.31	17.11	21.91	26.71	31.51	14.01	15.98	12.21
	4.0 (30.8)	U-factor	8	0.031	0.030	0.030	0.030	0.030	0.027	0.023	0.024
		C-factor									
		HC		12.35	17.16	21.95	26.75	31.55	14.05	16.02	12.24

Advanced Wall Assemblies

ICF Look-up Table (continued)

XPS	2.0 (20.0)	U-factor	9	0.045	0.045	0.045	0.044	0.044	NA	NA	NA
		C-factor									
		HC		12.29	17.09	21.89	26.69	31.49	NA	NA	NA
	2.5 (25.0)	U-factor	10	0.037	0.037	0.036	0.036	0.036	NA	NA	NA
		C-factor									
		HC		12.35	17.15	21.95	26.75	31.55	NA	NA	NA
	2.625 (26.3)	U-factor	11	0.035	0.035	0.035	0.035	0.034	NA	NA	NA
		C-factor									
		HC		12.36	17.16	21.96	26.76	31.56	NA	NA	NA
	2.75 (27.5)	U-factor	12	0.034	0.034	0.033	0.033	0.033	NA	NA	NA
		C-factor									
		HC		12.38	17.18	21.98	26.78	31.58	NA	NA	NA
	3.0 (30.0)	U-factor	13	0.031	0.031	0.031	0.031	0.030	NA	NA	NA
		C-factor									
		HC		12.41	17.21	22.01	26.81	31.61	NA	NA	NA
	3.5 (35.0)	U-factor	14	0.027	0.027	0.027	0.027	0.026	NA	NA	NA
		C-factor									
		HC		12.46	17.26	22.06	26.86	31.66	NA	NA	NA
	4.0 (40)	U-factor	15	0.024	0.024	0.024	0.023	0.023	NA	NA	NA
		C-factor									
		HC		12.52	17.32	22.12	26.92	31.72	NA	NA	NA
Polyurethane	1.5 (9.09)	U-factor	16	0.050	0.049	0.049	0.048	0.048	NA	NA	NA
		C-factor									
		HC		12.23	17.03	21.83	26.63	31.43	NA	NA	NA
	2.0 (10.9)	U-factor	17	0.042	0.042	0.041	0.041	0.041	NA	NA	NA
		C-factor									
		HC		12.41	17.21	22.01	26.81	31.61	NA	NA	NA
	4.5 (20.95)	U-factor	18	0.023	0.023	0.023	0.022	0.022	NA	NA	NA
		C-factor									
		HC		12.58	17.38	22.18	26.98	31.78	NA	NA	NA

Advanced Wall Assemblies

ICF Look-up Table (continued)

Cement/EPS Compound	2.0 (12.0)	U-factor		NA	NA	NA	NA	NA	0.055	0.044	0.048
		C-factor	**19**								
		HC		NA	NA	NA	NA	NA	16.49	18.46	14.69
	3.0 (18.0)	U-factor		NA	NA	NA	NA	NA	0.042	0.035	0.037
		C-factor	**20**								
		HC		NA	NA	NA	NA	NA	17.50	19.47	15.69
	4.0 (24.0)	U-factor		NA	NA	NA	NA	NA	0.033	0.029	0.030
		C-factor	**21**								
		HC		NA	NA	NA	NA	NA	18.51	20.47	16.70

Notes

[1] Flat Insulated Concrete Forms utilizes rigid insulation as the form and do not use a cement compound as the form.

[2] Waffle and screen type Insulated Concrete Forms typically utilize either a cement/EPS compound or EPS insulation as the form. ICF's using the cement/EPS compound do not utilize rigid insulation added to the interior and exterior surfaces.

[3] 1.5 lb density EPS insulation at R-3.85 per inch except for the 2.25" insulation thickness which uses 2.0 lb density EPS at R-4.2 per inch

Advanced Wall Assemblies

Proposed Compliance Options

- More SIP assembly options
  - Foam plastic insulation core securely bonded between two structural facings
  - Proposed Code
    - Revise JA4 look-up tables to match available products
      - Core insulation values
      - Spline types
      - Walls, floors, ceilings

Advanced Wall Assemblies

SIP Look-up Tables

Table 4.x - U-factors of Structural Insulated Panels (SIPs) Walls

Insulation Core R-value[1]	Wood Framing Connection Type (spline)	Typical Panel Thickness		Rated R-value of Additional Layer of Continuous Insulation[5]							
				None	R-2	R-4	R-6	R-7	R-8	R-10	R-14
				A	B	C	D	E	F	G	H
R-14.0	OSB Spline	4.5"	1	0.061	0.055	0.049	0.045	0.043	0.041	0.038	0.033
R-14.0	Single 2x Spline	4.5"	2	0.071	0.061	0.054	0.048	0.046	0.044	0.040	0.035
R-14.0	Double 2x Spline	4.5"	3	0.077	0.065	0.057	0.050	0.048	0.046	0.042	0.035
R-14.0	I-Joist Spline	4.5"	4	0.070	0.060	0.053	0.048	0.046	0.044	0.040	0.034
R-18.1[2]	OSB Spline	4.5"	5	0.053	0.045	0.041	0.037	0.036	0.034	0.031	0.028
R-18.1[2]	Single 2x Spline	4.5"	6	0.061	0.052	0.047	0.042	0.040	0.039	0.036	0.031
R-18.1[2]	Double 2x Spline	4.5"	7	0.066	0.056	0.050	0.045	0.042	0.041	0.037	0.032
R-18.1[2]	I-Joist Spline	4.5"	8	0.059	0.051	0.046	0.042	0.040	0.038	0.035	0.031
R-21.7	OSB Spline	6.5"	9	0.041	0.038	0.036	0.033	0.032	0.031	0.029	0.026
R-21.7	Single 2x Spline	6.5"	10	0.050	0.044	0.040	0.037	0.036	0.034	0.032	0.028
R-21.7	Double 2x Spline	6.5"	11	0.054	0.048	0.043	0.039	0.037	0.036	0.033	0.029
R-21.7	I-Joist Spline	6.5"	12	0.048	0.043	0.039	0.036	0.035	0.033	0.031	0.028
R-28.4	OSB Spline	8.25"	13	0.032	0.030	0.029	0.027	0.026	0.026	0.024	0.022
R-28.4	Single 2x Spline	8.25"	14	0.039	0.036	0.033	0.031	0.030	0.029	0.027	0.024
R-28.4	Double 2x Spline	8.25"	15	0.043	0.039	0.035	0.033	0.031	0.030	0.028	0.025
R-28.4	I-Joist Spline	8.25"	16	0.037	0.034	0.032	0.030	0.029	0.028	0.026	0.024

- Table continues up to 12.25” panel thickness and R-55
- Similar tables for SIPS roofs and floors

Advanced Wall Assemblies

SIP Look-up Table Notes

[1] The insulation R-value must be at least R-14 in order to use this table. This table assumes molded expanded polystyrene (EPS) unless noted otherwise. Although other insulation types are used by some SIP manufacturers, such as polyurethane and extruded expanded insulation (XPS), EPS is the most common insulation used in SIP construction.

[2] R-18.1 is achievable using extruded expanded polystyrene (XPS) insulation in 4.5" thick panels

[3] R-33.2 is achievable using polyurethane insulation in 6.5" panels.

[4] R-55.3 is achievable using polyurethane insulation in 10.25" panels.

[5] For credit, continuous insulation shall be at least R-2 and may be installed on either the inside or the exterior of the roof/ceiling.

Advanced Wall Assemblies

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QUESTIONS & COMMENTS

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