

Approved modifications to Appendix JA4 are noted below by section:

## 2008 REFERENCE APPENDICES

### Appendix JA4 – U-factor, C-factor, and Thermal Mass Data

- **Change 1:**

#### 4.1.7 R-values and U-factors for Spray Polyurethane Foam (SPF) Insulation: Medium-Density Closed Cell and Low-Density Open Cell

These procedures apply to two types of SPF used as building insulation: medium-density closed cell SPF (ccSPF) and low-density open cell SPF (ocSPF).

- **ccSPF**

A spray applied polyurethane foam insulation having a closed cellular structure resulting in an installed nominal density of greater than 1.5 to less than 2.5 pounds per cubic foot (pcf).

R-value: The total R-value shall be calculated based on the nominal required thickness of the insulation multiplied by an R-value of 5.8 per inch. Based on this calculation, the overall assembly U-factor shall be determined by selecting the assembly that matches the assembly type, framing configuration, and cavity insulation from the appropriate Reference Joint Appendix JA4 table. The R-value of ccSPF insulation shall meet or exceed the thickness specified in Table 4.1.7.

Alternatively, the R-value of the installed insulation shall be based on the verified thickness at an R-value of 5.8 per inch. Approved compliance software shall make appropriate adjustments to account for the R-value and U-factor effects of the ccSPF assembly.

Nominal Thickness: ccSPF sprayed into framed cavities or on flat surfaces will expand with variable thicknesses, visibly appearing as undulations on the surface of the insulation. The average thickness of the foam insulation must meet or exceed the required R-value. Depressions in the foam insulation's surface shall not be greater than 1/2-inch less of the required thickness at any given point of the surface area being insulated.

NOTE: ccSPF insulation installed in high-rise residential, hotel/motel, and nonresidential buildings is required to have a HERS Rater verify the installation following the procedures of Reference Appendix JA7 of the Reference Appendices or those specified in *Alternative Quality Insulation Installation Procedures for Spray Polyurethane Foam (SPF) Insulation: Medium-Density Closed Cell and Low-Density Open Cell SPF*.

- **ocSPF**

A spray applied polyurethane foam insulation having an open cellular structure resulting in an installed nominal density of 0.4 to 1.5 pounds per cubic foot (pcf).

R-value: The total R-value shall be calculated based on the nominal required thickness of the insulation multiplied by an R-value of 3.6 per inch. Based on this calculation, the overall assembly U-factor shall be determined by selecting the assembly that matches the assembly type, framing configuration, and cavity insulation from the appropriate Reference Joint Appendix JA4 table. The thickness for the proposed required R-value of ocSPF insulation shall meet or exceed the thickness specified in Table 4.1.7.

Alternatively, the R-value of the installed insulation shall be based on the verified thickness at an R-value of 3.6 per inch. Approved compliance software shall make appropriate adjustments to account for the R-value and U-factor effects of the ocSPF assembly.

Nominal Thickness: ocSPF sprayed into framed cavities or on flat surfaces will expand with variable thicknesses, visibly appearing as undulations on the surface of the insulation. The average thickness of the foam insulation must meet or exceed the required R-value. Depressions in the foam insulation surface shall not be greater than 1-inch less of the required thickness provided these depressions do not exceed 10% of the surface area being insulated.

#### **Filling of Framed Assemblies:**

ocSPF insulation shall completely fill cavities of 2x4 inch framing or less. Cavities greater than 2x4 inch framing dimensions may be filled to the thickness necessary to meet the required R-value used for compliance provided that the bottom and top plates of vertical framing and both ends of horizontal framing, including band and rim joists, are sprayed to completely fill the cavity adjacent to and in contact with the framing to a distance of 5.5 inches away from the framing for ocSPF insulation, or filled to a distance equal to the thickness meeting ASTM testing as an air barrier.

ccSPF insulation is not required to fill the cavities of framed assemblies provided the installed thickness of insulation conforms to compliance documentation and the bottom and top plates of vertical framing and both ends of horizontal framing, including band and rim joists, are sprayed to completely fill the cavity adjacent to and in contact with the framing to a distance of 2.0 inches away from the framing for ccSPF insulation, or filled to a distance equal to the thickness meeting ASTM testing as an air barrier.

Air Barrier: ocSPF installed as an air barrier shall be a minimum of 5.5 inches in thickness; alternatively, ocSPF insulation shall be installed at a thickness that meets an air permeance no greater than 0.02 L/s-m<sup>2</sup> at 75 Pa pressure differential when tested in accordance to ASTM E2178 or ASTM E283.

*Table 4.1.7 Required Thickness of SPF Insulation to Achieve Specified R-values*

Thickness of SPF Insulation	11	13	15	19	21	22	25	30	38
Required thickness of ccSPF Insulation (inches)	2.00	2.25	2.75	3.50	3.75	4.00	4.50	5.25	6.75
Required thickness of ocSPF Insulation (inches)	3.0	3.5	4.2	5.3	5.8	6.1	6.9	8.3	10.6

- **Change 2:**

**Table 4.2.2 – U-factors of Wood Framed Rafter Roofs**

16 inch OC	2x4	<b>20</b>	0.074	0.064	0.057	0.051	0.049	0.046	0.043	0.036
Loose- fill mineral fiber and wool, ocSPF or Cellulose Insulation <sup>2,5</sup>	2x6	<b>21</b>	0.052	0.047	0.043	0.040	0.038	0.037	0.034	0.030
	2x8	<b>22</b>	0.041	0.038	0.035	0.033	0.032	0.031	0.029	0.026
	2x10	<b>23</b>	0.033	0.031	0.029	0.028	0.027	0.026	0.025	0.023
	2x12	<b>24</b>	0.028	0.027	0.025	0.024	0.023	0.023	0.022	0.020
24 inch OC	2x4	<b>44</b>	0.071	0.062	0.055	0.050	0.047	0.045	0.042	0.036
Loose- fill mineral fiber and wool, ocSPF or Cellulose Insulation <sup>2,5</sup>	2x6	<b>45</b>	0.050	0.045	0.042	0.038	0.037	0.036	0.033	0.029
	2x8	<b>46</b>	0.039	0.036	0.034	0.032	0.031	0.030	0.028	0.025
	2x10	<b>47</b>	0.032	0.030	0.028	0.027	0.026	0.025	0.024	0.022
	2x12	<b>48</b>	0.026	0.025	0.024	0.022	0.022	0.022	0.021	0.019

**Notes:**

2. This assembly is allowed where ventilation is provided between the bottom of the roof deck and the top of the insulation meeting CBC ventilation requirements and can be used with rafter attic assemblies with no ventilation air spaces.

5. Loose-fill mineral fiber and wool, ocSPF or cellulose insulation shall fill the entire cavity. Cellulose shall have a binder to prevent sagging. Alternatively, ocSPF may use the procedure described in JA4, Section 4.1.7.

This table contains thermal performance data (U-factors) for wood framed rafter roofs. This is a common construction in low-rise residential buildings and in Type V nonresidential buildings. The rafters may be either flat or in a sloped application. Insulation is typically installed between the rafters. With this construction, the insulation is in contact with the ceiling and there is typically a one-inch air gap above the insulation so that moisture can be vented. CBC, Section R806, requires specified ventilation and insulation clearance. In addition, this section allows for unvented attic assemblies. Filling the entire cavity of framed rafter assemblies with loose-fill mineral fiber and wool, cellulose, or ocSPF may require prior approval by the local building official.

**Assumptions:** These data are calculated using the parallel path method documented in the 2005 ASHRAE Handbook of Fundamentals. These calculations assume an exterior air film of R-0.17, asphalt shingles of R-0.44 (AR02), building paper of R-0.06 (BP01), ½ inch of wood based sheathing (Custom), continuous insulation (optional), the insulation / framing layer with an air space of R-0.76 or R-0.80 (except for loose-fill mineral fiber and wool, cellulose, ccSPF, and ocSPF), 1/2 inch gypsum of R-0.45 (GP01), and an interior air film (heat flow up diagonally) of R-0.62. The continuous insulation may also be located at the ceiling, between the drywall and the framing. The framing percentage is assumed to be 10 percent for 16 inch OC and 7 percent for 24 inch. OC. The thickness of framing members is assumed to be the actual size of 3.50, 5.50, 7.25, 9.25, and 11.25 inches for 2x4, 2x6, 2x8, 2x10, and 2x12 nominal sizes. High-density batt insulation is assumed to be 8.5 inch thick for R-30 and 10.5 inch thick for R-38. The R-value of sprayed foam and cellulose insulation is assumed to be R-3.6 per inch.

- **Change 3:**

**Table 4.2.5 – U-factors of Metal Framed Rafter Roofs**

16 inch OC	2x6	<b>17</b>	0.099	0.083	0.071	0.062	0.058	0.055	0.050	0.041
Loose- fill mineral fiber and wool,	2x8	<b>18</b>	0.087	0.074	0.065	0.057	0.054	0.051	0.047	0.039
ocSPF or Cellulose Insulation <sup>2,5</sup>	2x10	<b>19</b>	0.077	0.067	0.059	0.053	0.050	0.048	0.044	0.037
	2x12	<b>20</b>	0.069	0.061	0.054	0.049	0.047	0.044	0.041	0.035
	2x14	<b>21</b>	0.064	0.057	0.051	0.046	0.044	0.042	0.039	0.034
24 inch OC	2x6	<b>38</b>	0.081	0.070	0.061	0.055	0.052	0.049	0.045	0.038
Loose- fill mineral fiber and wool,	2x8	<b>39</b>	0.070	0.061	0.055	0.049	0.047	0.045	0.041	0.035
ocSPF or Cellulose Insulation <sup>2,5</sup>	2x10	<b>40</b>	0.061	0.054	0.049	0.045	0.043	0.041	0.038	0.033
	2x12	<b>41</b>	0.054	0.049	0.044	0.041	0.039	0.038	0.035	0.031
	2x14	<b>42</b>	0.049	0.045	0.041	0.038	0.036	0.035	0.033	0.029

**Notes:**

2. This assembly is allowed where ventilation is provided between the bottom of the roof deck and the top of the insulation meeting CBC ventilation requirements and can be used with rafter attic assemblies with no ventilation air spaces.

5. Loose-fill mineral fiber and wool, ocSPF or cellulose insulation shall fill the entire cavity. Cellulose shall have a binder to prevent sagging. Alternatively, ocSPF may use the procedure described in JA4, Section 4.1.7.

This table contains pre-calculated U-factors for metal-framed rafter roofs where the ceiling is the air barrier. This construction assembly is similar to that covered by Table 4.2.2 except that metal framing members are substituted for the wood-framing members. The rafters may be either flat or in a sloped application. Insulation is typically installed between the rafters. With this construction, the insulation is in contact with the ceiling and there is typically a one-inch air gap above the insulation so that moisture can be vented. CBC, Section R806, requires specified ventilation and insulation clearance. In addition, this section allows for unvented attic assemblies. Filling the entire cavity of framed rafter assemblies with loose-fill mineral fiber and wool, cellulose, or ocSPF may require prior approval by the local building official.

- **Change 4:**

**Table 4.3.1 – U-factors of Wood Framed Walls**

16 inch OC	2x4	<b>14</b>	0.103	0.085	0.073	0.064	0.060	0.056	0.051	0.042
Loose- fill mineral fiber and wool,	2x6	<b>15</b>	0.071	0.062	0.055	0.050	0.047	0.045	0.042	0.036
ocSPF or Cellulose Insulation <sup>3</sup>	2x8	<b>16</b>	0.056	0.050	0.046	0.042	0.040	0.039	0.036	0.031
	2x10	<b>17</b>	0.045	0.041	0.038	0.035	0.034	0.033	0.031	0.028
	2x12	<b>18</b>	0.038	0.035	0.033	0.031	0.030	0.029	0.028	0.025

24 inch OC	2x4	32	0.099	0.083	0.071	0.062	0.058	0.055	0.050	0.041
Loose- fill mineral fiber and wool, ocSPF or Cellulose Insulation <sup>3</sup>	2x6	33	0.069	0.059	0.054	0.049	0.047	0.044	0.041	0.035
	2x8	34	0.054	0.049	0.044	0.041	0.039	0.038	0.035	0.031
	2x10	35	0.044	0.040	0.037	0.035	0.034	0.033	0.031	0.027
	2x12	36	0.036	0.034	0.031	0.030	0.029	0.028	0.026	0.024

**Notes:**

3. Loose-fill mineral fiber and wool, ocSPF or cellulose insulation shall fill the entire cavity. Cellulose shall have a binder to prevent sagging.

**Assumptions:** Values in this table were calculated using the parallel heat flow calculation method, documented in the 2005 ASHRAE Handbook of Fundamentals. The construction assembly assumes an exterior air film of R-0.17, a 7/8 inch layer of stucco of R-0.18 (SC01), building paper of R-0.06 (BP01), continuous insulation (if any), the cavity insulation / framing layer, ½ inch gypsum board of R-0.45 (GP01), and an interior air film 0.68. The framing factor is assumed to be 25 percent for 16 inch stud spacing and 22 percent for 24 inch spacing. Loose-fill mineral fiber and wool, ocSPF and cellulose insulation are assumed to entirely fill the cavity and have a thermal resistance of R-3.6 per inch. Actual cavity depth is 3.5 inch for 2x4, 5.5 inch for 2x6, 7.25 inch for 2x8, 9.25 inch for 2x10, and 11.25 inch for 2x12. High density R-30 insulation is assumed to be 8.5 inch thick batt and R-38 is assumed to be 10.5 inch thick.

• **Change 5:**

**Table 4.3.3 – U-factors of Metal Framed Walls for Nonresidential Construction**

Spacing	Cavity Insulation R-Value:	Nominal Framing Size	Rated R-value of Continuous Insulation <sup>2</sup>									
			R-0	R-2	R-4	R-6	R-7	R-8	R-10	R-12	R-14	
			A	B	C	D	E	F	G	H	I	
16 in. OC	None	Any	<b>1</b>	0.458	0.239	0.162	0.122	0.109	0.098	0.082	0.072	0.062
	R-5	2x4	<b>1A</b>	0.351	0.206	0.146	0.113	0.102	0.092	0.078	0.067	0.059
	R-11	2x4	<b>2</b>	0.244	0.155	0.118	0.096	0.087	0.080	0.069	0.062	0.054
	R-13	2x4	<b>3</b>	0.217	0.151	0.116	0.094	0.086	0.079	0.068	0.060	0.054
	R-15	2x4	<b>4</b>	0.211	0.148	0.114	0.093	0.085	0.078	0.068	0.060	0.053
	R-19	2x6	<b>5</b>	0.183	0.134	0.106	0.087	0.080	0.074	0.065	0.057	0.051
	R-21 <sup>1</sup>	2x6	<b>6</b>	0.178	0.131	0.104	0.086	0.079	0.073	0.064	0.057	0.051
	R-19	2x8	<b>7</b>	0.164	0.123	0.099	0.083	0.076	0.071	0.062	0.055	0.050
	R-22	2x8	<b>8</b>	0.160	0.121	0.098	0.082	0.075	0.070	0.062	0.055	0.049
	R-25	2x8	<b>9</b>	0.158	0.120	0.097	0.081	0.075	0.070	0.061	0.055	0.049
	R-30 <sup>1</sup>	2x8	<b>10</b>	0.157	0.119	0.096	0.081	0.075	0.070	0.061	0.054	0.049
	R-30	2x10	<b>11</b>	0.140	0.109	0.090	0.076	0.071	0.066	0.058	0.052	0.047
	R-38 <sup>1</sup>	2x10	<b>12</b>	0.139	0.109	0.089	0.076	0.070	0.066	0.058	0.052	0.047
	R-38	2 x 12	<b>13</b>	0.124	0.099	0.083	0.071	0.066	0.062	0.055	0.050	0.045
	Loose-fill mineral fiber and wool, ocSPF or Cellulose Insulation <sup>3</sup>	2 x 4	<b>14</b>	0.218	0.152	0.116	0.094	0.086	0.079	0.069	0.060	0.054
		2 x 6	<b>15</b>	0.179	0.132	0.104	0.086	0.079	0.074	0.064	0.057	0.051
		2 x 8	<b>16</b>	0.157	0.119	0.096	0.081	0.075	0.070	0.061	0.054	0.049
		2 x 10	<b>17</b>	0.138	0.108	0.089	0.075	0.070	0.066	0.058	0.052	0.047
2 x 12		<b>18</b>	0.123	0.099	0.082	0.071	0.066	0.062	0.055	0.050	0.045	
24 in. OC	None	Any	<b>24</b>	0.455	0.238	0.161	0.122	0.109	0.098	0.082	0.072	0.062
	R-5	2x4	<b>24A</b>	0.333	0.200	0.143	0.111	0.100	0.091	0.077	0.067	0.059
	R-11	2x4	<b>25</b>	0.210	0.148	0.114	0.093	0.085	0.078	0.068	0.060	0.053
	R-13	2x4	<b>26</b>	0.203	0.144	0.112	0.092	0.084	0.077	0.067	0.059	0.053

R-15	2x4	<b>27</b>	0.197	0.141	0.110	0.090	0.083	0.076	0.066	0.059	0.052
R-19	2x6	<b>28</b>	0.164	0.123	0.099	0.083	0.076	0.071	0.062	0.055	0.050
R-21 <sup>1</sup>	2x6	<b>29</b>	0.161	0.122	0.098	0.082	0.076	0.070	0.062	0.055	0.049
R-19	2x8	<b>30</b>	0.153	0.117	0.095	0.080	0.074	0.069	0.060	0.054	0.049
R-22	2x8	<b>21</b>	0.149	0.115	0.093	0.079	0.073	0.068	0.060	0.053	0.048
R-25	2x8	<b>32</b>	0.147	0.114	0.093	0.078	0.072	0.068	0.060	0.053	0.048
R-30 <sup>1</sup>	2x8	<b>33</b>	0.146	0.113	0.092	0.078	0.072	0.067	0.059	0.053	0.048
R-30	2x10	<b>34</b>	0.130	0.103	0.086	0.073	0.068	0.064	0.057	0.051	0.046
R-38 <sup>1</sup>	2x10	<b>35</b>	0.128	0.102	0.085	0.072	0.068	0.063	0.056	0.050	0.046
R-38	2 x 12	<b>36</b>	0.115	0.093	0.079	0.068	0.064	0.060	0.053	0.048	0.044
Loose-fill mineral fiber and wool, ocSPF or Cellulose Insulation <sup>3</sup>	2 x 4	<b>37</b>	0.204	0.145	0.112	0.092	0.084	0.078	0.067	0.059	0.053
	2 x 6	<b>38</b>	0.167	0.125	0.100	0.083	0.077	0.071	0.063	0.056	0.050
	2 x 8	<b>39</b>	0.146	0.113	0.092	0.078	0.072	0.067	0.059	0.053	0.048
	2 x 10	<b>40</b>	0.128	0.102	0.085	0.072	0.068	0.063	0.056	0.050	0.046
	2 x 12	<b>41</b>	0.114	0.093	0.078	0.068	0.063	0.060	0.053	0.048	0.044

#### Notes

3. Loose-fill mineral fiber and wool, ocSPF and cellulose insulation shall fill the entire cavity. Cellulose shall have a binder to prevent sagging.

**Assumptions:** Values in this table were calculated using the zone calculation method. The construction assembly assumes an exterior air film of R-0.17, a 7/8 inch layer of stucco of R-0.18, building paper of R-0.06 (BP01), continuous insulation (if any), the insulation / framing layer, 1/2 inch gypsum of R-0.45 gypsum board (GP01), and an interior air film 0.68. The steel framing is assumed to be 0.0747 inch thick with a 15 percent knock out. The framing factor is assumed to be 25 percent for 16 inch stud spacing and 22 percent for 24 inch spacing. The EZFrame internal default framing percentages are 15 percent for 16 inch stud spacing and 12 percent for 24 inch spacing. To account for the increased wall framing percentage the frame spacing input to the EZ Frame program is reduced to 13.218 inches for 16 inch stud spacing and 15.231 inches for 24 inch stud spacing. Loose-fill mineral fiber and wool, ocSPF and cellulose insulation are assumed to entirely fill the cavity and have a thermal resistance of R-3.6 per inch. Actual cavity depth is 3.5 inch for 2x4, 5.5 inch for 2x6, 7.25 inch for 2x8, 9.25 inch for 2x10, and 11.25 inch for 2x12. High density R-30 insulation is assumed to be 8.5 inch thick batt and R-38 is assumed to be 10.5 inch thick.

- **Change 6:**

**Table 4.3.4 – U-factors of Metal Framed Walls for Residential Construction**

16 inch OC	2 x 4	<b>14</b>	0.177	0.131	0.104	0.094	0.086	0.079
Loose-fill mineral fiber and wool, ocSPF or Cellulose Insulation <sup>3</sup>	2 x 6	<b>15</b>	0.152	0.119	0.095	0.087	0.080	0.074
	2 x 8	<b>16</b>	0.121	0.098	0.082	0.076	0.070	0.066
	2 x 10	<b>17</b>	0.105	0.087	0.074	0.069	0.064	0.060
	2 x 12	<b>18</b>	0.092	0.077	0.067	0.063	0.059	0.056

24 inch OC	2 x 4	<b>37</b>	0.182	0.133	0.105	0.095	0.087	0.080
Loose-fill mineral fiber and wool, ocSPF or	2 x 6	<b>38</b>	0.146	0.112	0.092	0.084	0.078	0.072
Cellulose Insulation <sup>3</sup>	2 x 8	<b>39</b>	0.121	0.097	0.081	0.075	0.070	0.066
	2 x 10	<b>40</b>	0.101	0.084	0.072	0.067	0.063	0.059
	2 x 12	<b>41</b>	0.087	0.074	0.064	0.060	0.057	0.054

**Notes:**

3. Loose-fill mineral fiber and wool ocSPF and cellulose insulation shall fill the entire cavity. Cellulose shall have a binder to prevent sagging.

**Assumptions:** Values in this table were calculated using the zone calculation method. The construction assembly assumes an exterior air film of R-0.17, a 7/8 inch layer of siding or stucco averaging R-0.18, building paper of R-0.06 (BP01), continuous insulation (if any), the insulation / framing insulation layer, 1/2 inch gypsum of R-0.45 gypsum board (GP01), and an interior air film 0.68. The framing factor is assumed to be 25 percent for 16 inch stud spacing and 22 percent for 24 inch spacing. To account for the increased wall framing percentage, the frame spacing input to the EZ Frame program is reduced to 13.218 inches for 16 inch stud spacing and 15.231 inches for 24 inch stud spacing. The stud web thickness is assumed to be 0.038 inches, which is a 50/50 mix of 18 gauge and 20 gauge C-channel studs. This value was confirmed to be representative of low-rise residential construction by polling several California-based light-gauge steel structural engineers and light-gauge steel framers. Loose-fill mineral fiber and wool, ocSPF and cellulose insulation are assumed to entirely fill the cavity and have a thermal resistance of R-3.6 per inch. Actual cavity depth is 3.5 inch for 2x4, 5.5 inch for 2x6, 8 inch for 2x8, 10 inch for 2x10, and 12 inches for 2x12. High density R-30 insulation is assumed to be 8.5 inch thick batt and R-38 is assumed to be 10.5 inches thick.