

Code Connection

Ceiling Insulation Requirements Pertaining to Trusses in the IEC & IRC by WTCA Staff

Editor's Note: The 2003 IECC and Section N1100 in the 2003 IRC have been significantly modified in the 2004/2005 code cycle as evidenced in the 2004 Supplement and more changes are being proposed for the 2006 code editions. Although the concept of reducing the insulation requirement when full height insulation can extend over the wall top plate remains, the language describing it and the referenced tables have been entirely replaced and entire chapters eliminated.

The International Energy Conservation Code (IECC), 2003, includes the following definition in Chapter 2 - Definitions:

STANDARD TRUSS. Any construction that does not permit the roof/ceiling insulation to achieve the required R-value over the exterior walls.

Although an energy or raised heel truss is not specifically defined, there are important notes within:

- the IECC Sections 5 and 6 and
- the International Residential Code, 2003, Section N1102.1.2,

regarding lower insulation requirements when using raised heel trusses. Where trusses allow the full height of ceiling insulation over the exterior wall plate, the R-value requirements can be reduced from R-38 to R-30 or R-49 to R-38.

The R-value reduction for raised heels is not limited to wood truss or rafter construction. Cold-formed steel truss or C-shaped assemblies are affected as well.

Chapter 5 - Residential Building Design By Component Performance Approach 502.2.4.5 Truss/rafter construction. "Ceiling R-value" assumes standard truss or rafter construction. Where raised-heel trusses or other construction techniques are employed to obtain the full height of ceiling insulation over the exterior wall top plate, R-30 shall be permitted to be used where R-38 is required in the table, and R-38 shall be permitted to be used where R-49 is required.

Table 502.4 is divided into nine sections based upon window area percentage of gross exterior wall area. Table 502.4(2) is included (see Figure 1) to illustrate ceiling R-value requirements. The required R-38 value in zones 9-13 is allowed to be reduced to R-30 and the required R-49 value in zones 14-17 is allowed to be reduced to R-38, if raised heels are incorporated into the design.

502.2.4.18 steel-framed roof/ceiling construction. when truss-type, cold-formed steel framing is used in roof/ceiling construction, the roof/ceiling assembly shall meet the equivalent insulation R-values in table 502.2.4.18(1). when C-shaped, cold-formed steel framing is used in roof/ceiling construction, the steel roof/ceiling assembly shall meet the equivalent wood framed U_R-factors in table 502.2.4.18(2).

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TABLE 502.4(2)
PRESCRIPTIVE BUILDING ENVELOPE REQUIREMENTS, DETACHED ONE- AND TWO-FAMILY DWELLINGS
WINDOW AREA 12 PERCENT OF GROSS EXTERIOR WALL AREA

ZONE	HEATING DEGREE DAYS	MAXIMUM			MINIMUM			
		Roofing U-factor	Ceiling R-value	Exterior wall R-value	Floor R-value	Basement wall R-value	Slab perimeter R-value and depth	Crawl space wall R-value
1	0 - 499	Any	R-11	R-11	R-11	R-0	R-0	R-0
2	500 - 999	Any	R-19	R-11	R-11	R-0	R-0	R-4
3	1,000 - 1,499	0.75	R-19	R-11	R-11	R-0	R-0	R-5
4	1,500 - 1,999	0.75	R-19	R-11	R-11	R-4	R-0	R-5
5	2,000 - 2,499	0.65	R-19	R-13	R-11	R-5	R-0	R-5
6	2,500 - 2,999	0.60	R-16	R-13	R-13	R-5	R-0	R-5
7	3,000 - 3,499	0.60	R-30	R-13	R-15	R-6	R-0	R-6
8	3,500 - 3,999	0.60	R-30	R-13	R-19	R-8	R-4, 2 ft	R-10
9	4,000 - 4,499	0.55	R-38	R-13	R-19	R-9	R-4, 2 ft	R-12
10	4,500 - 4,999	0.50	R-38	R-14	R-19	R-9	R-5, 2 ft	R-16
11	5,000 - 5,499	0.45	R-38	R-16	R-19	R-9	R-6, 2 ft	R-16
12	5,500 - 5,999	0.45	R-38	R-17	R-19	R-9	R-6, 2 ft	R-16
13	6,000 - 6,499	0.40	R-38	R-18	R-19	R-10	R-6, 4 ft	R-16
14	6,500 - 6,999	0.40	R-49	R-21	R-19	R-10	R-7, 4 ft	R-17
15	7,000 - 8,499	0.40	R-49	R-21	R-19	R-10	R-9, 4 ft	R-17
16	8,500 - 9,999	0.40	R-49	R-21	R-19	R-16	R-9, 4 ft	R-17
17	9,000 - 12,999	0.40	R-49	R-21	R-19	R-16	R-11, 4 ft	R-17

For SI: 1 foot = 304.8 mm.

FIGURE 1.

TABLE 602.1.2(2)
COLD-FORMED STEEL ROOF/CEILING TRUSS U_R FACTORS

CAVITY INSULATION R-VALUE	CONTINUOUS INSULATION BETWEEN DRYWALL AND BOTTOM CHORD		
	R-0	R-2	R-5
R-13	0.0865	0.0616	0.0546
R-19	0.0597	0.0467	0.0426
R-26	0.0439	0.0364	0.0338
R-30	0.0382	0.0324	0.0303
R-38	0.0302	0.0265	0.0251
R-49	0.0235	0.0212	0.0203

FIGURE 5.

**TABLE 502.2.4.18(1)
TRUSS TYPE COLD-FORMED STEEL ROOF/CEILING
EQUIVALENT R-VALUES***

WOOD-FRAMED ROOF/CEILING R-VALUE*	TRUSS TYPE COLD-FORMED STEEL CAVITY AND CONTINUOUS INSULATION R-VALUE, 24 INCHES ON CENTER*
R-13	R-19, R-13 + R-3
R-19	R-26, R-19 + R-3
R-26	R-38, R-26 + R-3
R-30	R-38, R-30 + R-3
R-38	R-49, R-38 + R-5
R-49	Not applicable

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.
 a. This table applies to cold-formed, steel truss roof framing spaced at 24 inches on center and where the penetrations of the truss members through the cavity insulation do not exceed three penetrations of the truss members through the cavity insulation for each 4-foot length of the truss.
 b. As required by Section 502.2.4 and the tabular entry for "Ceiling R-value" shown in Tables 502.2.4(1) through 502.2.4(9).
 c. The cavity R-value requirements is listed first, followed by the continuous insulation R-value requirement.

FIGURE 2.

**TABLE 602.1.2.1(3)
MAXIMUM C-SHAPED, COLD-FORMED STEEL ROOF/CEILING
U_R FACTORS**

HEATING DEGREE DAYS	U _R FACTOR	
	16 inches o.c.	24 inches o.c.
0 - 499	0.0773	0.0742
500 - 1,499	0.0537	0.0519
1,500 - 1,999	0.0405	0.0390
2,000 - 3,999	0.0355	0.0342
4,000 - 6,499	0.0285	0.0274
6,500 - 12,999	0.0223	0.0215

For SI: 1 inch = 25.4 mm.

FIGURE 6.

**TABLE 602.1
SIMPLIFIED PRESCRIPTIVE BUILDING ENVELOPE THERMAL COMPONENT CRITERIA
MINIMUM REQUIRED THERMAL PERFORMANCE (U-FACTOR AND R-VALUE)**

CLIMATE ZONE	HEATING DEGREE DAYS	MINIMUM						
		Glazing U-factor	Ceiling R-value	Wall R-value	Floor R-value	Basement wall R-value	Sub perimeter R-value and depth	Crawl space wall R-value
1	0 - 499	Asy	R-13	R-11	R-11	R-0	R-0	R-0
2	500 - 999	0.90	R-19	R-11	R-11	R-0	R-0	R-4
3	1,000 - 1,499	0.75	R-19	R-11	R-11	R-0	R-0	R-5
4	1,500 - 1,999	0.75	R-26	R-13	R-11	R-5	R-0	R-5
5	2,000 - 2,499	0.65	R-30	R-13	R-11	R-5	R-0	R-6
6	2,500 - 2,999	0.60	R-30	R-13	R-19	R-6	R-4, 2 ft	R-7
7	3,000 - 3,499	0.55	R-30	R-13	R-19	R-7	R-4, 2 ft	R-8
8	3,500 - 3,999	0.50	R-30	R-13	R-19	R-8	R-5, 2 ft	R-10
9	4,000 - 4,499	0.45	R-38	R-13	R-19	R-8	R-5, 2 ft	R-11
10	4,500 - 4,999	0.45	R-38	R-16	R-19	R-9	R-6, 2 ft	R-17
11	5,000 - 5,499	0.45	R-38	R-18	R-19	R-9	R-6, 2 ft	R-17
12	5,500 - 5,999	0.40	R-38	R-18	R-21	R-10	R-9, 4 ft	R-19
13	6,000 - 6,499	0.35	R-38	R-18	R-21	R-10	R-9, 4 ft	R-20
14	6,500 - 6,999	0.35	R-49	R-21	R-21	R-11	R-11, 4 ft	R-20
15	7,000 - 8,499	0.35	R-49	R-21	R-21	R-11	R-13, 4 ft	R-20
16	8,500 - 8,999	0.35	R-49	R-21	R-21	R-18	R-14, 4 ft	R-20
17	9,000 - 12,999	0.35	R-49	R-21	R-21	R-19	R-18, 4 ft	R-20

For SI: 1 foot = 304.8 mm.

FIGURE 3.

**TABLE 602.1.2.1(1)
MAXIMUM COLD-FORMED STEEL ROOF/CEILING TRUSS
U_R FACTORS**

HEATING DEGREE DAYS	U _R FACTOR
0 - 499	0.0742
500 - 1,499	0.0504
1,500 - 1,999	0.0372
2,000 - 3,999	0.0323
4,000 - 6,499	0.0257
6,500 - 12,999	0.0200

FIGURE 4.

**TABLE 602.1.2.1(4)
C-SHAPED, COLD-FORMED STEEL ROOF/CEILING U_R FACTORS***

FRAMING*	SPACING	R-13	R-19	R-26	R-30	R-38	R-49
		16 inches o.c.	0.1328	0.0530	0.0387	0.0336	0.0265
2 x 4	0.1328	0.0667	0.0456	0.0386	0.0295	0.0223	
2 x 6	0.1328	0.1208	0.0585	0.0475	0.0345	0.0251	
2 x 8	0.1328	0.1208	0.1094	0.1017	0.0998	0.0277	
2 x 10	0.1328	0.1208	0.1094	0.1017	0.0473	0.0311	
2 x 4	0.1129	0.0510	0.0376	0.0327	0.0260	0.0202	
2 x 6	0.1129	0.0610	0.0428	0.0366	0.0284	0.0216	
2 x 8	0.1129	0.0994	0.0517	0.0429	0.0320	0.0237	
2 x 10	0.1129	0.0994	0.0873	0.0816	0.0357	0.0257	
2 x 12	0.1129	0.0994	0.0873	0.0816	0.0403	0.0280	

For SI: 1 inch = 25.4 mm.

a. Linear interpolation is permitted for determining U-factors which are between those given in the table.
 b. Applies to steel framing up to a maximum thickness of 0.064 inches (1.64 mm).

FIGURE 7.

**TABLE N1102.1
SIMPLIFIED PRESCRIPTIVE BUILDING ENVELOPE THERMAL COMPONENT CRITERIA
MINIMUM REQUIRED THERMAL PERFORMANCE (U-FACTOR AND R-VALUE)**

BUILDING LOCATION	MAXIMUM GLAZING U-FACTOR (See Table N1102.1)	MINIMUM INSULATION R-VALUE (See Table N1102.1)					
		Ceilings	Walls	Floors	Basement walls	Sub perimeter R-value and depth	Crawl space walls
Climate Zone	HDD						
1	0-499	Asy	R-13	R-11	R-11	R-0	R-0
2	500-999	0.90	R-19	R-11	R-11	R-0	R-4
3	1,000-1,499	0.75	R-19	R-11	R-11	R-0	R-5
4	1,500-1,999	0.75	R-26	R-13	R-11	R-5	R-5
5	2,000-2,499	0.65	R-30	R-13	R-11	R-5	R-6
6	2,500-2,999	0.60	R-30	R-13	R-19	R-6	R-4, 2 ft
7	3,000-3,499	0.55	R-30	R-13	R-19	R-7	R-4, 2 ft
8	3,500-3,999	0.50	R-30	R-13	R-19	R-8	R-5, 2 ft
9	4,000-4,499	0.45	R-38	R-13	R-19	R-8	R-5, 2 ft
10	4,500-4,999	0.45	R-38	R-16	R-19	R-9	R-6, 2 ft
11	5,000-5,499	0.45	R-38	R-18	R-19	R-9	R-6, 2 ft
12	5,500-5,999	0.40	R-38	R-18	R-21	R-10	R-9, 4 ft
13	6,000-6,499	0.35	R-38	R-18	R-21	R-10	R-9, 4 ft
14	6,500-6,999	0.35	R-49	R-21	R-21	R-11	R-11, 4 ft
15	7,000-8,499	0.35	R-49	R-21	R-21	R-11	R-13, 4 ft
16	8,500-8,999	0.35	R-49	R-21	R-21	R-18	R-14, 4 ft
17	9,000-12,999	0.35	R-49	R-21	R-21	R-19	R-18, 4 ft

For SI: 1 Btu/hr · ft² · °F = 5.678 W/m² · K, 1 hr · ft² · °F/Btu = 0.1762 m² · K/W.

FIGURE 8.

Figure 2 includes the equivalent insulation R-values for cold-formed steel framing. Note that values for cavity or cavity plus continuous insulation are included in the table. Continuous insulation is insulation installed between drywall and bottom chord.

Although not explicitly stated, one can assume that the reduction in R-value requirements of 502.2.4.5 for raised heels would go from R-30 to R-38 for cold-formed steel trusses before the equivalent R-values from Table 502.2.4. 18(1) would be applied (see Figure 2). In the case of steel assemblies, the raised heel provision will mitigate the higher insulation requirements due to the higher thermal conductivity of steel compared to wood.

Chapter 6 - Simplified Prescriptive Requirements For Detached One- & Two-Family Dwellings & Group R-2, R-4 Or Townhouse Residential Buildings 602.1.2 Ceilings. The required "Ceiling R-value" in Table 602.1 assumes standard truss or rafter construction, and shall apply to all roof/ceiling portions of the building thermal envelope, including cathedral ceilings. Where the construction technique allows the required R-value of ceiling insulation to be obtained over the exterior wall top plate, R-30 shall be permitted to be used where R-38 is required in the table, and R-38 shall be permitted to be used where R-49 is required.

The simplified prescriptive method allows the same reduction as the Component Performance Method given in Chapter 5 for zones 9-17 as illustrated in Figure 3.

602.1.2.1 Steel-framed ceiling. The maximum required U_R-factor for cold-formed steel truss roof/ceiling assemblies shall be in accordance with table 602.1.2.1(1) and compliance shall be determined by using the U_R-factor in table 602.1.2.1(2). This table applies to cold-formed steel truss roof framing spaced at 24 inches (609 mm) on center and where the penetrations of the truss members through the cavity insulation do not exceed three penetrations for each 4-foot (1220 mm) length of the truss. The maximum required U_R-factor for C-shaped cold-formed steel roof/ceiling assemblies shall be in accordance with table

602.1.2.1(3) and compliance shall be determined by using the U_R -factor in table 602.1.2.1(4)

Steel ceiling framing under the prescriptive method requires verification by comparing the maximum combined thermal transmittance value based up-on heating degree days (see Figures 4 & 6) compared to the combined thermal transmittance value of how the assembly is insulated (see Figures 5 & Figure 7).

As in the case of the method described in Chapter 5, in the case of steel assemblies, the raised heel provision will mitigate the higher insulation requirements due to the higher thermal conductivity of steel compared to wood.

IRC Chapter 11 - Energy Efficiency N1102.1.2 Ceilings. the required ceiling R-value. in table N1102.1 assumes standard truss or rafter construction and shall apply to all roof/ceiling portions of the building thermal envelope, including cathedral ceilings. where the construction technique allows the required R-value of ceiling insulation to be obtained over the wall top plate, R-30 shall be permitted to be used where R-38 is required and R-38 shall be permitted to be used where R-49 is required.

The energy requirements in-cluded in IRC Section 11 address the issue of the dif-ference in thermal conductivity of wood versus steel for wall framing with steel but do not include similar provisions for ceiling framing with steel.

EXAMPLE FOR COLD-FORMED STEEL TRUSS ROOF/CEILING ASSEMBLY:

Zone 13, Heating Degree Days = 6,000-6,499, R-38 Ceiling required (per Table 602.1).

Per Table 602.1.2.1(1) Max $U_R = 0.0257$ for 4,000-6,499 Heating Degree Days

Per Table 602.1.2.1(2) compliance for R-38 would require $U_R = 0.0251$

This requires continuous insulation between the drywall and the bottom chord of the truss with an R-value of 5.

R-38 is required for the cavity insulation per the table.

The raised heel reduction of 602.1.2 is applied: R-38 required, R-30 permitted.

The total assembly R-value then equals 35 (30 plus the continuous insulation of 5).

EXAMPLE FOR WOOD TRUSS ROOF/CEILING ASSEMBLY:

Zone 13, Heating Degree Days = 6,000-6,499, R-38 Ceiling required (per Table 602.1).

The raised heel reduction of N1102.1.2 is applied: R-38 required, R-30 permitted. The R-38 cavity insulation may be reduced from R-38 to R-30.

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