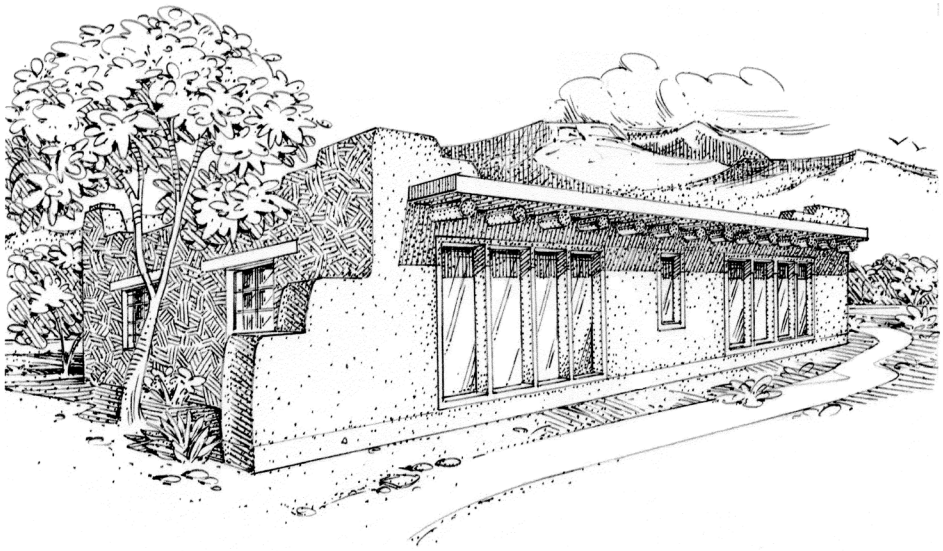
# 2018 NEW MEXICO RESIDENTIAL ENERGY CONSERVATION CODE
# Residential Applications Manual



**April 2022**
**V3.0**

**Energy Conservation and Management Division**
**Energy, Minerals and Natural Resources Department**

# RESIDENTIAL APPLICATIONS MANUAL

April 2022
V3.0

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The U.S. Department of Energy maintains an energy code website. With prior approval from the building official, electronic tools on the website may be used to demonstrate compliance with the 2018 New Mexico Residential Energy Conservation Code, which is based upon the 2018 International Energy Conservation Code.
**http://www.energycodes.gov/rescheck/**

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## Government or professional acronyms related to this Manual

**ASHRAE** **American Society of Heating, Refrigerating, and Air-Conditioning Engineers**
**CID** **Construction Industries Division**: A division of the New Mexico Regulation and Licensing Department that reviews and issues building permits outside of cities and counties which may modify the State code to some degree. The CID has locations in Santa Fe, Albuquerque, Las Cruces, and Roswell. Your energy calcs must be submitted with your drafted plan sets to a CID office to apply for a building permit.
**CZ** **Climate Zone.** A geographically based value which can be used to determine the amount of anticipated solar energy that should be considered in the design and construction of residential structures.
**ECMD** **The Energy Conservation and Management Division**. A division of the New Mexico Energy, Minerals and Natural Resource Department that serves as the State Energy Office that facilitates development of renewable energy and energy efficiency programs in New Mexico.
**IECC** **The International Energy Conservation Code**. The New Mexico Residential Applications Manual, this document, is largely based on this national code. Because states vary in their climatic, seismic and geological conditions, states may modify their local codes to some degree from this national code. The “I” codes cover Puerto Rico, Alaska, Hawaii, U.S. territories and the contiguous U.S. states. New Mexico currently uses the 2018 edition of the IECC, with modifications. Free viewing access to the IECC or purchase of the code document is available at https://codes.iccsafe.org.
**NMAC** **New Mexico Administrative Code.** The designation given to all New Mexico government administrative rules. The rules stipulate requirements for both the public and the state agency implementing the rules. The New Mexico Residential Energy Conservation Code and other construction codes can be found at https://www.srca.nm.gov/nmac-home/nmac-titles/title-14-housing-and-construction/chapter-7-building-codes-general/.

# INTRODUCTION

New Mexico has had in force an Energy Code for building construction since the 1970's. The New Mexico Construction Industries Commission most recently adopted the 2018 New Mexico Residential Energy Conservation Code (NMRECC 2018). The New Mexico code references the "International Energy Conservation Code 2018" (IECC 2018).

This publication does not intend to negate any of the standards found in NMRECC 2018. The changes are additions to the NMRECC 2018 intended to:

1. Allow the use of a worksheet to trade off R-values between various parts of the house, without increasing the energy use of the house.

2. Make it easier to demonstrate code compliance for non-standard homes.

3. Allow the use of the Passive Solar worksheet to qualify this type of home for code compliance.

**This applications manual is to be used in conjunction with the IECC 2018 code book. Call the Construction Industries Division (CID), if you don't have one or go to https://codes.iccsafe.org/ to purchase a copy.**

To use the Tradeoff Worksheet, the applicant must first determine the appropriate climate zone for the building site. A list of New Mexico towns and their respective climate zones are found in **Table 301.2** of the NMRECC 2018 14.7.6.11 NMAC. Their elevations, heating-degree-days (HDD), and cooling-degree-days (CDD) are included to assist in selecting a nearby location with similar climate. For truly remote locations, the applicant should select a town with similar north latitude and elevation. The town and climate zone should be entered in the appropriate sections.

The NM Residential Energy Conservation Code should be viewed only as a minimum standard. As such, the Code is not a design tool or rating system. Much better programs for these purposes exist outside of the Energy Conservation Code, and the applicant is strongly encouraged to use them.

## TRADEOFF WORKSHEET

The Tradeoff Worksheet is used to show compliance using the **Total UA alternative** as described in **Section R402.1.5** of the IECC 2018 and thus demonstrates compliance with the NMRECC 2018. It is a compliance demonstration method for the external portions of the building, the building thermal envelope. Interior walls and floors between heated spaces are not part of the building thermal envelope. The worksheet considers all of the parts of the building thermal envelope at once. The overall house, as designed, is compared to the same house using the requirements from Chapter 4 [RE] of the IECC 2018 code book. The worksheet and this manual do not cover other aspects of the code including proper installation of the thermal envelope with proper air barriers.

The applicant must first obtain the area and assembly U-Factor (U) of each thermal envelope component for the Proposed House. The assembly U is the steady-state U, or heat flow, of the components as assembled; e.g. a frame wall is comprised of insulation, studs, finishes, et cetera. At the ceiling (or roof), the area of the insulated portion and any skylights must be calculated separately. At the wall, the area and U of the insulated portion, windows and doors must also be calculated separately.

At the foundation, the areas and U depend upon the type of construction. For a slab on grade the area is the exposed perimeter of the slab times the depth. For floors over crawl spaces with insulated walls, the area and U is the area of the crawl wall. For insulated floors over un-insulated crawl spaces, the area is the area of the floor. For heated basements, the area is the area of the basement wall.

All features of the building having a unique U must be entered separately in the Worksheet. For example, some homes have two different kinds of doors, a solid wood unit at the entry, and French doors elsewhere. The same is true for ceilings and walls. If a proposed building has both a cathedral ceiling and a flat ceiling, each with different U, the area and U for each must be entered. If a proposed building has both log walls and frame gable walls, the area and U for each must be entered. Windows and doors must likewise be entered, and their respective areas subtracted from the gross area of the walls.

The U for the Proposed House should be obtained from manufacturer's product test data. If that is not available at time of permitting, it may be estimated from the tables in Appendix A and B. Manufacturer's data will be required at inspection. The areas and U for the building thermal envelope of the Proposed House are entered into the left section – Proposed House of the Tradeoff Worksheet. The UA for each component is calculated as the area multiplied by the U. The UA values can be summed for the total UA of the Proposed House.

The total areas of the Proposed House are also entered into the right section – Code House of the Worksheet. Following the instructions in the Introduction, the applicant must then determine the climate zone for the Proposed House. The town and climate zone should be entered in the appropriate sections. Once the appropriate climate zone is determined, the $U_{req}$ can be found in **Table 402.1.4** of Chapter 4 [RE] of the IECC 2018 for windows and doors (fenestration); skylights; ceilings; walls (including mass walls); and floors. These $U_{req}$ values are entered into the right side of the worksheet (the electronic spreadsheet version does this automatically). The UA of these components is calculated as the area of the component multiplied by the $U_{req}$. For slab on grade foundations, the UA alternative is not applicable and thus the requirements in **Table 402.1.2** shall be met and the UA is not included in the tradeoff worksheet or

added to the Total UA for the Proposed House. Like the Proposed House, all the UA values are summed to determine the total allowed heat transfer.

If the total of the UA values for the Proposed House is less than the sum of the UA values for the Code House, the design complies with this section. The IECC 2018 allows for area-weighted average maximum fenestration U-factors that vary by climate zone. However, the Solar Heat Gain Coefficient (SHGC) requirements in **Table 402.1.2** shall be met when using the Total UA Alternative method. If using the electronic version of the Tradeoff Worksheet, the box under the date will display “In Compliance” or ‘Not in Compliance” and includes a compliance check against the SHGC and Fenestration area-weighted maximum U-factor (AWU) requirements for specific climate zones.

2018 NEW MEXICO RESIDENTIAL ENERGY CONSERVATION CODE

## TRADEOFF WORKSHEET

| | | | |
|---|---|---|---|
| Project ID | | Building Floor Area | |
| Builder Name | | | |
| Builder Address | | | |
| Submitted by | | | |
| Building Address | | | |
| Town | | | |

Date: _____

Phone: _____

Climate Zone (3-7): 5
(numeric value only, no alpha character)

### PROPOSED HOUSE (Area and $R_o$ as designed)

**Ceiling**

| Description | Insulation R-Value | Area, ft² | x | $U_{assem}$ | = | UA |
|---|---|---|---|---|---|---|
| | | | x | | = | |
| | | | x | | = | |
| | | | x | | = | |
| Total | | - | | | | |

**Walls (Frame or Mass)**

| Frame Wall Description | Insulation R-Value | Area, ft² | x | $U_{assem}$ | = | UA |
|---|---|---|---|---|---|---|
| | | | x | | = | |
| | | | x | | = | |
| | | | x | | = | |
| | | | x | | = | |
| | | | x | | = | |
| Total | | - | | | | |
| **Mass Wall Description** | **Insulation R-Value** | **Area, ft²** | **x** | **$U_{assem}$** | **=** | **UA** |
| | | | x | | = | |
| | | | x | | = | |
| Total | | - | | | | |

**Skylights (Maximum AWU=0.75 in CZ 4 through 7)**

| Description | U-Factor | * Area, ft² | = | UA | AWU Compliant? |
|---|---|---|---|---|---|
| | | | = | 0.00 | |
| | | | = | 0.00 | |
| Total | | - | | | |

**Doors & Windows (Maximum AWU=0.48 in CZ 4 & 5 and 0.4 in 6 & 7)**

| Description | U-Factor | * Area, ft² | = | UA | AWU Compliant? |
|---|---|---|---|---|---|
| | | | = | 0.00 | |
| | | | | 0.00 | |
| | | | = | 0.00 | |
| Total | | - | | | |

**Crawlspace Wall (when applicable)**

| Description | Insulation R-Value | Area, ft² | x | $U_{assem}$ | = | UA |
|---|---|---|---|---|---|---|
| Total | | | x | | = | |

**Floor Over Crawlspace (when applicable)**

| Description | Insulation R-Value | Area, ft² | x | $U_{assem}$ | = | UA |
|---|---|---|---|---|---|---|
| Total | | | x | | = | |

**Basement Wall (when applicable)**

| Description | Insulation R-Value | Area, ft² | x | $U_{assem}$ | = | UA |
|---|---|---|---|---|---|---|
| Total | | | x | | = | |

**Totals**

| Total Roof, Wall, Foundation | |
|---|---|

### CODE HOUSE

**Ceiling**

Same As Your House — $U_{req.}$ from NMRECC

| Area, ft² | x | $U_{req.}$ | = | UA |
|---|---|---|---|---|
| - | x | 0.026 | = | - |

**Walls (Frame or Mass)**

Same As Your House — $U_{req.}$ from NMRECC

**Frame Walls**

| Area, ft² | x | $U_{req.}$ | = | UA |
|---|---|---|---|---|
| - | x | 0.06 | = | - |

^applies to mass walls with >50% external insulation, see 2018 IECC for other options

**Mass Walls**

| Area, ft² | x | $U_{req.}$^ | = | UA |
|---|---|---|---|---|
| - | x | 0.082 | = | - |

**Skylights**

| Solar Heat Gain Coeff. (SHGC) | = | NA |
|---|---|---|

| Area, ft² | x | Ureq. | = | UA |
|---|---|---|---|---|
| - | x | 0.55 | = | - |

**Doors and Windows**

| Solar Heat Gain Coeff. (SHGC) | = | NA |
|---|---|---|

| Area, ft² | x | Ureq. | = | UA |
|---|---|---|---|---|
| - | x | 0.3 | = | - |

**Crawlspace Wall**

| Area, ft² | x | $U_{req.}$ | = | UA |
|---|---|---|---|---|
| | x | 0.055 | = | - |

**Floor Over Crawlspace**

| Area, ft² | x | $U_{req.}$ | = | UA |
|---|---|---|---|---|
| | x | 0.033 | = | - |

**Basement Wall**

| Area, ft² | x | $U_{req.}$ | = | UA |
|---|---|---|---|---|
| | x | 0.05 | = | - |

**Totals**

| Total Roof, Wall, Found. | |
|---|---|

If the total for PROPOSED HOUSE is less than the total for CODE HOUSE, PROPOSED HOUSE is in compliance.

Note: an electronic version of this Worksheet that calculates the UA values can be found at: **www.emnrd.nm.gov/ecmd/energy-efficiency/**

## U-Factor and UA Calculations

The IECC 2018, **Section R402.1.5** states, "The UA calculation shall be performed using a method consistent with the ASHRAE *Handbook of Fundamentals* and shall include the thermal bridging effects of framing materials." The 2017 version of the ASHRAE Handbook is the version called for in the IECC 2018. An example and illustrative figure from the California Energy Commission illustrates use of the parallel-path method from the ASHRAE Handbook.

Figure 1

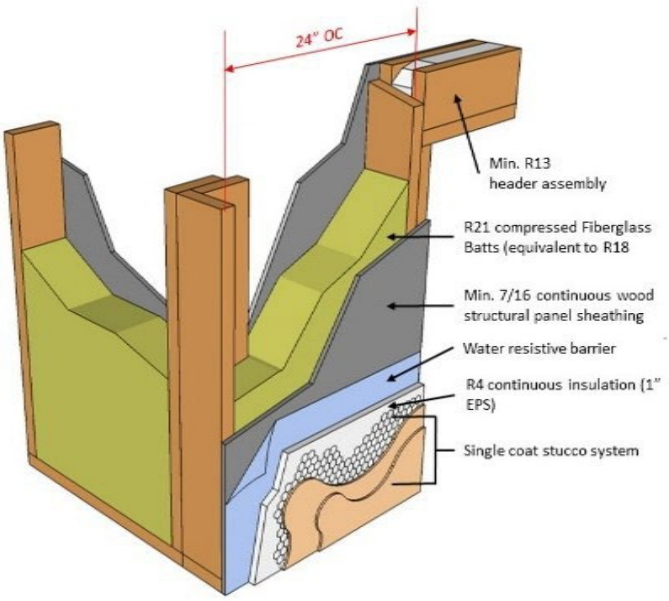



Figure 1 depicts an exterior wall system with a three-stud corner that achieves a U-factor of 0.047 with an exterior insulation of R-4, due to 24" stud spacing and R-13 header assemblies.

The construction assembly in the Assembly Components Table below assumes an exterior air film of R-0.17 (15 mph wind), a 3/8-inch layer of lightweight stucco (80 lb/ft$^3$) of R-0.08, building paper (vapor-permeable felt) of R-0.06, continuous insulation layer R-4, 7/16-inch OSB R-0.62, the cavity insulation (assume 5-1/4-inch high-density fiberglass batt R-21), 1/2-inch gypsum board of R-0.45, and an interior air film R-0.68. In addition, from the ASHRAE Handbook - For stud walls 16 in. on center (OC), the fraction of insulated cavity may be as low at 0.75, where the fraction of studs, plates and sills is 0.21 and the fraction of headers is 0.04. For studs 24 in. OC, the respective values are 0.78, 0.18 and 0.04. These fractions contain an allowance for multiple studs, plates, sills, extra framing around windows, headers and band joists.

Actual cavity depth is 3.5 inches for 2x4, 5.5 inches for 2x6 framed walls.

The second Assembly Components Table illustrates the same assembly U-factor calculated using the isothermal-planes method from the ASHRAE Handbook. When using the isothermal planes method, the fractional areas are only applied to the building layer that contains the studs and cavity-fill insulation (the interior of the wall). The average R-value for the layer ($R_{avg}$) is added to the R-values for the other layers (inner or interior and outer or exterior). $R_{avg}$ for this case is calculated as follows:

$U_{avg} = 0.78(1/21) + 0.18(1/5.445) + 0.04(1/(1.485+10+1.485))$

$U_{avg} = 0.0733$

$R_{avg} = 1/ U_{avg} = 13.645$

The final calculated assembly U-factor ($U_{assembly}$), using either the parallel path or isothermal planes method, is then entered into the $U_{assem}$ column of the appropriate section of the Tradeoff Worksheet (in this case the walls section) along with the appropriate area of the assembly minus fenestration products (windows, doors or skylights).

## Assembly Components for Figure 1 - Parallel-Path Method

| Layer | **Assembly Type: Wall 2x6 @ 24" OC Framing Material: Wood Assembly Components** | R-Value Cavity (Rc) | R-Value Frame (Rf) | R-Value Header (Rh) |
|---|---|---|---|---|
| 0 | Frame Factor | 78% | 18% | 4% |
| 1 | Outside Air Film | 0.17 | 0.17 | 0.17 |
| 2 | Building Paper | 0.06 | 0.06 | 0.06 |
| 3 | 3/8-Inch Single Coat Stucco | 0.08 | 0.08 | 0.08 |
| 4 | R4 Continuous Insulation (1" EPS) | 4.0 | 4.0 | 4.0 |
| 5 | 7/16-Inch Continuous Oriented Strand Board (OSB) Sheathing | 0.44 | 0.44 | 0.44 |
| 6 | R-21 Fiberglass Batts | 21.0 | -- | -- |
| 7 | Header Assembly – 2x Wood | | | 1.485 |
| 8 | Header Assembly – 2.5 Inches of R4 Foam | | | 10 |
| 9 | Header Assembly – 2x Wood | | | 1.485 |
| 10 | 2x6 Framing @ R-0.99/Inch | -- | 5.445 | -- |
| 11 | ½-Inch Gypboard | 0.45 | 0.45 | 0.45 |
| 12 | Inside Air Film | 0.68 | 0.68 | 0.68 |
| | Subtotal R-Values | 26.88 | 11.325 | 18.85 |
| | U-Factors (Frame % x 1/R) | 0.0290 | 0.0159 | 0.0021 |
| | Assembly U-Factor $(U_{Cavity} + U_{Frame} + U_{Header})$ | **$U_{assembly}$** | **0.047** | |

## Assembly Components for Figure 1 – Isothermal Planes Method

| Layer | **Assembly Type: Wall 2x6 @ 24" OC Framing Material: Wood Assembly Components** | R-Value Studs, Headers, Cavity | R-Value Inner/outer, Avg. Cavity/ Headers (R) | R-Value Header |
|---|---|---|---|---|
| 0 | Frame Factor | 78% | 100%=$\sum R+R_{avg}$ | 4% |
| 1 | Outside Air Film | | 0.17 | |
| 2 | Building Paper | | 0.06 | |
| 3 | 3/8-Inch Single Coat Stucco | | 0.08 | |
| 4 | R4 Continuous Insulation (1" EPS) | | 4.0 | |
| 5 | 7/16-Inch Continuous Oriented Strand Board (OSB) Sheathing | | 0.44 | |
| 6 | R-21 Fiberglass Batts | 21.0 | **13.645 ($R_{avg}$)** | |
| 7 | Header Assembly – 2x Wood | 1.485 | | |
| 8 | Header Assembly – 2.5 Inches of R4 Foam | 10.0 | | |
| 9 | Header Assembly – 2x Wood | 1.485 | | |
| 10 | 2x6 Framing @ R-0.99/Inch | 5.445 | | |
| 11 | ½-Inch Gypboard | | 0.45 | |
| 12 | Inside Air Film | | 0.68 | |
| | Total Assembly R-Value | | 19.525 | |
| | Assembly U-Factor (1/R) | **$U_{assembly}$** | **0.051** | |

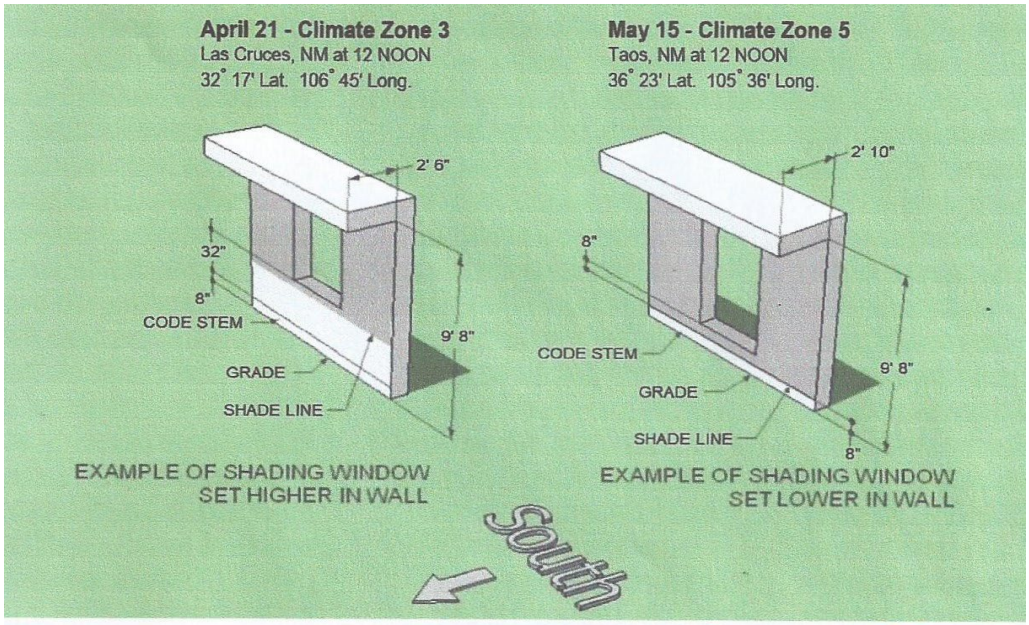
## PASSIVE SOLAR HEATING WORKSHEET

The Passive Solar Heating Worksheet is a compliance demonstration method for solar heated buildings that cannot demonstrate code compliance solely using the Tradeoff Worksheet. This may be the case for buildings that include passive solar heating features, due to the extra glass that may be incorporated.

The Passive Solar Heating Worksheet may be used for Direct Gain, Solar Mass Wall (also called Trombe Wall), and Attached or Enclosed Sunspace features. To qualify for use of this method, the solar features must meet all of the criteria found on the Passive Solar Heating Worksheet. These criteria have been found to include a very large percentage of passive solar heated buildings. For any passive solar heating feature meeting all of the criteria, the area of each system type is entered in the appropriate box on the Passive Solar Heating Worksheet. The same areas are entered on the Tradeoff Worksheet. However, the “R-value” and “Area/R” are not entered on the Tradeoff Worksheet for these passive solar features.

For buildings using combinations of the three passive solar heating systems, the area of each is entered in the appropriate box on the Passive Solar Heating Worksheet, and in the Tradeoff Worksheet. For Direct Gain passive solar heating features, all south-facing glass meeting the definition must be included on the sheets.

All solar features require overhangs or other external attached features to shade the south-facing glass during the summer. In the diagrams below, the shaded solar feature represents the sun angle and shadow on acceptable various dates for each climate zone (CZ). The projection factor must be calculated such that the overhang blocks the sun from the entire height of the south-facing glass.




| CZ | Sample Location | Sun Altitude from Shade Line | Shade to bottom of window on: |
|---|---|---|---|
| 3 | LAS CRUCES | 68.5° | APRIL 21 |
| 4 | ALBUQUERQUE | 70° | MAY 1 |
| 5 | TAOS | 72.75° | MAY 15 |
| 6 | CHAMA | 74.75° | MAY 31 |

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## PASSIVE SOLAR HEATING WORKSHEET

| | | | | | |
|---|---|---|---|---|---|
| Project ID | | Building Floor Area | | Date | |
| Builder Name | | | | | |
| Builder Address | | | | | |
| Submitted by | | | | Phone | |
| Building Address | | | | | |
| Town | | | | Climate Zone (3-7) | |

Items meeting the listed criteria may be presented for simplified code compliance as solar features. All boxes by the system type definitions must be checked to certify compliance. The area in square feet of such features should be entered here and on the Tradeoff Worksheet under Doors and Windows. The U-Factor column may be left blank on the Tradeoff Worksheet for these solar features. Solar feature glazings are not required to meet the specified SHGC requirements stated on the Tradeoff Worksheet and the 2018 NMECC. In addition, modified U-Factors for Direct Gain glazing is acceptable in CZ 3-6 (see Direct Gain checklist).

| **All Solar Features** | |
|---|---|
| Orientation within 25° east and 15° west degrees of true South. | |
| No significant obstructions to sun above 25° elevation, from bottom of feature. | |
| No significant obstructions to sun within 45° horizontal from the east and west edges of the solar feature. | |
| Solar features of all kinds no greater than 20% of heated floor area. | |
| N + E + W windows meet all requirements of the Tradeoff Worksheet and the 2018 NMECC. | |
| For CZ 3, overhangs or other external attached fixtures that prevent sun on south-facing glazing on April 21st. | |
| For CZ 4, overhangs or other external attached fixtures that prevent sun on south-facing glazing on May 1st. | |
| For CZ 5, overhangs or other external attached fixtures that prevent sun on south-facing glazing on May 15th. | |
| For CZ 6, overhangs or other external attached fixtures that prevent sun on south-facing glazing on May 31st. | |

| **Direct Gain** | | |
|---|---|---|
| | | |
| Double glazed (minimum) with a U-Factor ≤ 0.40 for CZ 3 or 4, or a U-Factor ≤ 0.32 for CZ 5 or 6. | | |
| For wood frame or non-mass built homes, if South windows greater than 8% of heated floor area, add thermal mass (at least 5x area of South glazing, at least 3" thick) | | |
| | | |
| TOTAL AREA DIRECT GAIN GLAZING | | $ft^2$ |

| **Solar Mass Walls** | | |
|---|---|---|
| Solid masonry wall, no vents. | | |
| TOTAL AREA MASS WALL GLAZING | | $ft^2$ |

| **Attached Sunspace** | | |
|---|---|---|
| Double glazed (minimum) with a U-Factor ≤ 0.40 for CZ 3 or 4, or a U-Factor ≤ 0.32 for CZ 5 or 6. | | |
| Mass area at least 3x glazing area (a 4" concrete slab floor may count toward this requirement). | | |
| Operable windows or doors to living space, at least 15% of sunspace glazing area. | | |
| TOTAL AREA SUN SPACE GLAZING | | $ft^2$ |

Note: In this worksheet, the symbol ≤ means a U-Factor that is less than or equal to the value immediately right of the symbol. An electric version of this Worksheet can be found at: www.emnrd.nm.gov/ecmd/energy-efficiency/

## BUILDING ASSEMBLY THERMAL DATA

This appendix contains *generic* information on thermal properties for selected building assemblies, for use in the Tradeoff Worksheet. $U_{assembly}$ values include the interactive effect of all the individual components in the total building assembly. For example, $U_{assembly}$ for a frame wall considers the studs, insulation, and interior and exterior sheathing (if any) and finishes. When available, thermal properties from the actual manufacturer of an assembly should be used instead of these generic values.

To achieve compliance, the inspectors will verify that the actual $U_{assembly}$ values are equivalent or better than those proposed. The following tables list $U_{assembly}$ (U-factors) for a variety of common assemblies. Unless otherwise indicated, data in Appendix A is from the California *2019 Residential Compliance Manual* and associated *Appendix JA4*.

**U-factors of Wood Framed Walls**

| | Cavity Insulation | Nominal Framing Size | | Rated R-value of Continuous Insulation [2] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | R-0 | R-2 | R-4 | R-5 | R-6 | R-7 | R-8 | R-10 | R-12 | R-15 |
| **Spacing** | | | | A | B | C | D | E | F | G | H | I | J |
| 16 in. OC | None | Any | | 0.356 | 0.209 | 0.146 | 0.127 | 0.113 | 0.101 | 0.092 | 0.078 | 0.067 | 0.056 |
| | R-11 | 2x4 | [1] 2 | 0.110 | 0.088 | 0.074 | 0.068 | 0.064 | 0.060 | 0.056 | 0.050 | 0.045 | 0.040 |
| | R-13 | 2x4 | 3 | 0.102 | 0.082 | 0.069 | 0.064 | 0.060 | 0.056 | 0.053 | 0.047 | 0.043 | 0.038 |
| | R-15 [1] | 2x4 | 4 | 0.095 | 0.077 | 0.065 | 0.060 | 0.056 | 0.053 | 0.050 | 0.045 | 0.041 | 0.036 |
| | R-19 | 2x6 | 5 | 0.074 | 0.063 | 0.055 | 0.051 | 0.049 | 0.046 | 0.044 | 0.040 | 0.037 | 0.033 |
| | R-20 | 2x6 | 6 | 0.071 | 0.060 | 0.052 | 0.049 | 0.047 | 0.044 | 0.042 | 0.039 | 0.036 | 0.032 |
| | R-21[1] | 2x6 | 7 | 0.069 | 0.059 | 0.051 | 0.048 | 0.046 | 0.043 | 0.041 | 0.038 | 0.035 | 0.031 |
| | R-22 | 2x6 | 8 | 0.072 | 0.062 | 0.054 | 0.051 | 0.048 | 0.045 | 0.043 | 0.037 | 0.036 | 0.033 |
| | R-23 | 2x6 | 9 | 0.067 | 0.057 | 0.049 | 0.047 | 0.044 | 0.042 | 0.040 | 0.037 | 0.034 | 0.030 |
| | R-25 | 2x6 | 10 | 0.065 | 0.055 | 0.048 | 0.045 | 0.043 | 0.040 | 0.039 | 0.035 | 0.036 | 0.032 |
| | R-19 | 2x8 | 11 | 0.065 | 0.057 | 0.051 | 0.048 | 0.045 | 0.043 | 0.041 | 0.038 | 0.035 | 0.032 |
| | R-22 | 2x8 | 12 | 0.061 | 0.053 | 0.047 | 0.045 | 0.043 | 0.041 | 0.039 | 0.036 | 0.033 | 0.030 |
| | R-25 | 2x8 | 13 | 0.057 | 0.050 | 0.044 | 0.042 | 0.040 | 0.038 | 0.037 | 0.034 | 0.032 | 0.029 |
| | R-30[1] | 2x8 | 14 | 0.056 | 0.049 | 0.044 | 0.041 | 0.040 | 0.038 | 0.036 | 0.033 | 0.031 | 0.028 |
| 24 in. OC | None | Any | 15 | 0.362 | 0.211 | 0.148 | 0.128 | 0.114 | 0.102 | 0.092 | 0.078 | 0.067 | 0.056 |
| | R-11 | 2x4 | 16 | 0.106 | 0.086 | 0.072 | 0.067 | 0.062 | 0.059 | 0.055 | 0.050 | 0.045 | 0.039 |
| | R-13 | 2x4 | 17 | 0.098 | 0.079 | 0.067 | 0.062 | 0.058 | 0.055 | 0.052 | 0.047 | 0.043 | 0.038 |
| | R-15 | 2x4 | 18 | 0.091 | 0.074 | 0.063 | 0.059 | 0.055 | 0.052 | 0.049 | 0.044 | 0.040 | 0.036 |
| | R-19 | 2x6 | 19 | 0.071 | 0.061 | 0.053 | 0.050 | 0.048 | 0.045 | 0.043 | 0.040 | 0.036 | 0.033 |
| | R-20 | 2x6 | 20 | 0.068 | 0.058 | 0.051 | 0.048 | 0.045 | 0.043 | 0.041 | 0.038 | 0.035 | 0.031 |
| | R-21[1] | 2x6 | 21 | 0.066 | 0.057 | 0.050 | 0.047 | 0.045 | 0.042 | 0.040 | 0.037 | 0.034 | 0.031 |
| | R-22 | 2x6 | 22 | 0.069 | 0.060 | 0.052 | 0.049 | 0.047 | 0.044 | 0.042 | 0.036 | 0.036 | 0.033 |
| | R-23 | 2x6 | 23 | 0.064 | 0.054 | 0.048 | 0.045 | 0.043 | 0.041 | 0.039 | 0.036 | 0.033 | 0.030 |
| | R-25 | 2x6 | 24 | 0.061 | 0.052 | 0.046 | 0.043 | 0.041 | 0.039 | 0.037 | 0.034 | 0.035 | 0.031 |
| | R-19 | 2x8 | 25 | 0.063 | 0.055 | 0.049 | 0.047 | 0.045 | 0.043 | 0.041 | 0.037 | 0.035 | 0.031 |
| | R-22 | 2x8 | 26 | 0.058 | 0.051 | 0.046 | 0.044 | 0.042 | 0.040 | 0.038 | 0.035 | 0.033 | 0.030 |
| | R-25 | 2x8 | 27 | 0.055 | 0.048 | 0.043 | 0.041 | 0.039 | 0.037 | 0.036 | 0.033 | 0.031 | 0.028 |
| | R-30[1] | 2x8 | 28 | 0.054 | 0.047 | 0.042 | 0.040 | 0.038 | 0.037 | 0.035 | 0.033 | 0.030 | 0.028 |

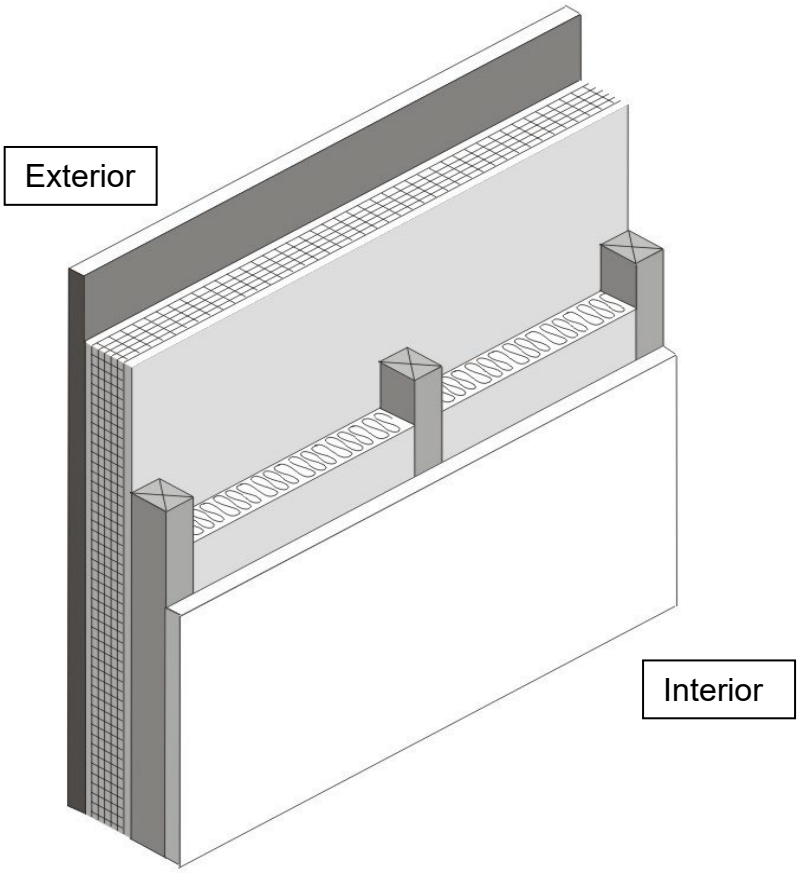
**Notes**

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.

This table contains U-factors for wood framed walls, which are typical of low-rise residential buildings. If continuous insulation is not used, then choices are made from Column A. In this case, the insulation is installed in the cavity between the framing members. When continuous insulation is used, it is typically installed on the exterior side of the wall, but can also be used on the inside. The continuous insulation is typically a rigid polystyrene or polyisocyanurate foam insulation.

When this table is used, the R-value of continuous insulation shall be equal to or greater than the R-value published in the continuous insulation columns. Interpolation of the data is not acceptable.




Wood Framed Wall Assembly

**Assumptions:** Values in this table were calculated using the parallel heat flow calculation method, documented in the 2017 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, building paper of R-0.06, continuous insulation (if any), the cavity insulation / framing layer, ½ inch gypsum board of R-0.45, 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. 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. The thickness of the stucco is assumed to be reduced to 3/8 inch when continuous insulation is applied.

**U-factors of Structurally Insulated Wall Panels (SIPS)**

| | | | | Rated R-value of Continuous Insulation[5] | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Wood Framing Connection Type | Insulation Core | Typical Panel | | None | R-2 | R-4 | R-5 | R-6 | R-8 |
| (spline) | R-value[1] | Thickness | | A | B | C | D | E | F |
| OSB | R-14 | 4.5 in | 1 | 0.061 | 0.055 | 0.049 | 0.047 | 0.045 | 0.041 |
| Single 2x | R-14 | 4.5 in | 2 | 0.071 | 0.061 | 0.054 | 0.051 | 0.048 | 0.044 |
| Double 2x | R-14 | 4.5 in | 3 | 0.077 | 0.065 | 0.057 | 0.054 | 0.050 | 0.046 |
| I-joist | R-14 | 4.5 in | 4 | 0.070 | 0.060 | 0.053 | 0.051 | 0.048 | 0.044 |
| OSB | R-18[2] | 4.5 in | 5 | 0.053 | 0.045 | 0.041 | 0.039 | 0.037 | 0.034 |
| Single 2x | R-18[2] | 4.5 in | 6 | 0.061 | 0.052 | 0.047 | 0.045 | 0.042 | 0.039 |
| Double 2x | R-18[2] | 4.5 in | 7 | 0.066 | 0.056 | 0.050 | 0.048 | 0.045 | 0.041 |
| I-joist | R-18[2] | 4.5 in | 8 | 0.059 | 0.051 | 0.046 | 0.044 | 0.042 | 0.038 |
| OSB | R-22 | 6.5 in | 9 | 0.041 | 0.038 | 0.036 | 0.035 | 0.033 | 0.031 |
| Single 2x | R-22 | 6.5 in | 10 | 0.050 | 0.044 | 0.040 | 0.039 | 0.037 | 0.034 |
| Double 2x | R-22 | 6.5 in | 11 | 0.054 | 0.048 | 0.043 | 0.041 | 0.039 | 0.036 |
| I-joist | R-22 | 6.5 in | 12 | 0.048 | 0.043 | 0.039 | 0.038 | 0.036 | 0.033 |
| OSB | R-28 | 8.25 in | 13 | 0.032 | 0.030 | 0.029 | 0.028 | 0.027 | 0.026 |
| Single 2x | R-28 | 8.25 in | 14 | 0.039 | 0.036 | 0.033 | 0.032 | 0.031 | 0.029 |
| Double 2x | R-28 | 8.25 in | 15 | 0.043 | 0.039 | 0.035 | 0.034 | 0.033 | 0.030 |
| I-joist | R-28 | 8.25 in | 16 | 0.037 | 0.034 | 0.032 | 0.031 | 0.030 | 0.028 |
| OSB | R-33[3] | 6.5 in | 17 | 0.032 | 0.029 | 0.027 | 0.026 | 0.025 | 0.023 |
| Single 2x | R-33[3] | 6.5 in | 18 | 0.038 | 0.034 | 0.031 | 0.030 | 0.029 | 0.027 |
| Double 2x | R-33[3] | 6.5 in | 19 | 0.043 | 0.038 | 0.034 | 0.033 | 0.031 | 0.029 |
| I-joist | R-33[3] | 6.5 in | 20 | 0.036 | 0.033 | 0.030 | 0.029 | 0.028 | 0.026 |
| OSB | R-36 | 10.25 in | 21 | 0.026 | 0.024 | 0.023 | 0.023 | 0.022 | 0.021 |
| Single 2x | R-36 | 10.25 in | 22 | 0.032 | 0.030 | 0.028 | 0.027 | 0.026 | 0.024 |
| Double 2x | R-36 | 10.25 in | 23 | 0.035 | 0.032 | 0.030 | 0.029 | 0.028 | 0.026 |
| I-joist | R-36 | 10.25 in | 24 | 0.030 | 0.028 | 0.026 | 0.026 | 0.025 | 0.023 |
| OSB | R-44 | 12.25 in | 25 | 0.022 | 0.021 | 0.020 | 0.020 | 0.019 | 0.018 |
| Single 2x | R-44 | 12.25 in | 26 | 0.027 | 0.025 | 0.024 | 0.023 | 0.022 | 0.021 |
| Double 2x | R-44 | 12.25 in | 27 | 0.028 | 0.027 | 0.025 | 0.025 | 0.024 | 0.023 |
| I-joist | R-44 | 12.25 in | 28 | 0.025 | 0.024 | 0.022 | 0.022 | 0.021 | 0.020 |
| OSB | R-55[4] | 10.25 in | 29 | 0.020 | 0.019 | 0.017 | 0.016 | 0.016 | 0.016 |
| Single 2x | R-55[4] | 10.25 in | 30 | 0.024 | 0.022 | 0.021 | 0.021 | 0.020 | 0.019 |
| Double 2x | R-55[4] | 10.25 in | 31 | 0.028 | 0.025 | 0.023 | 0.023 | 0.022 | 0.021 |
| I-joist | R-55[4] | 10.25 in | 32 | 0.022 | 0.021 | 0.019 | 0.019 | 0.018 | 0.018 |

**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 polystyrene 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. Continuous insulation shall be at least R-2 and may be installed on either the inside or the exterior of the wall.

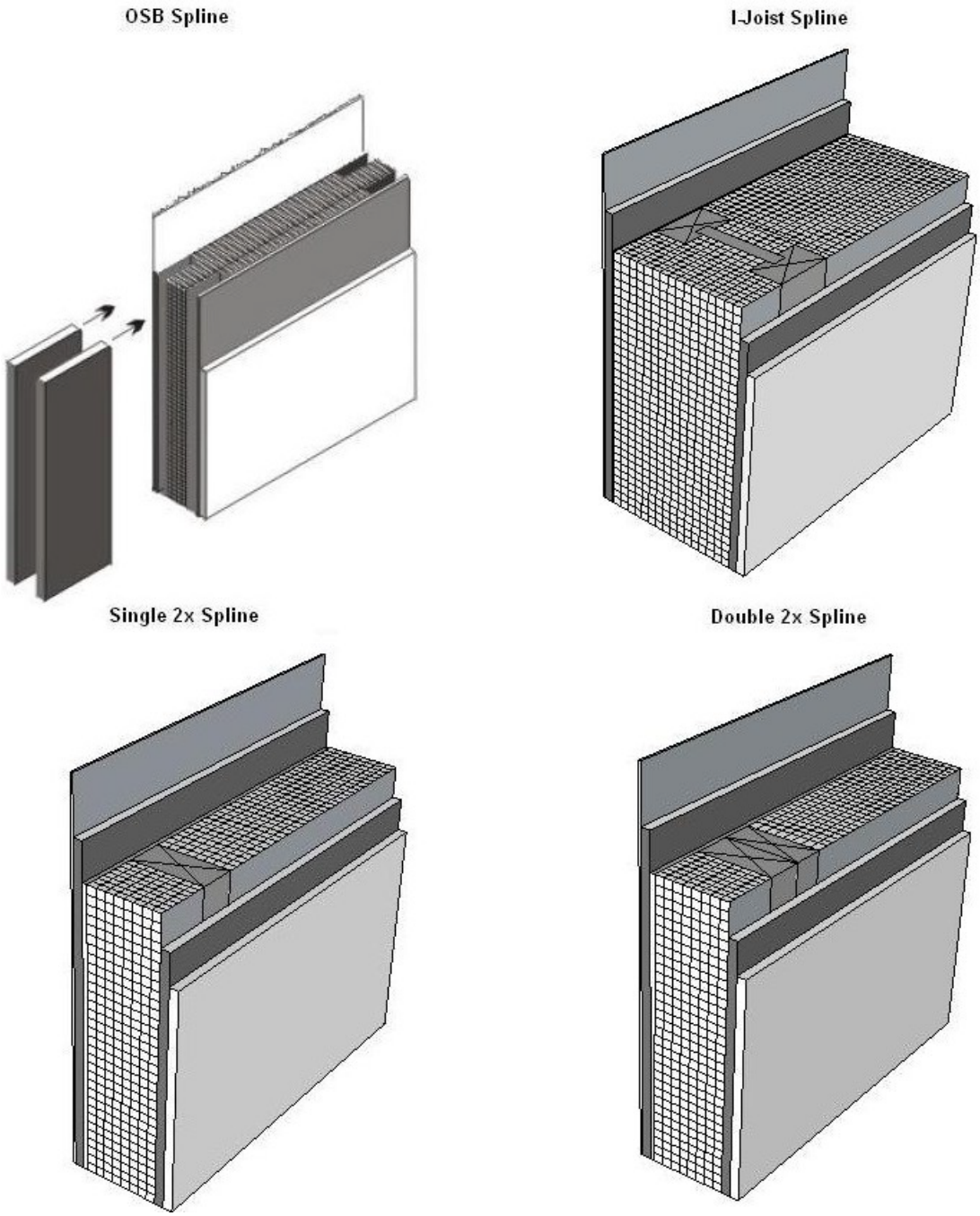
Structural insulated panels (SIPs) consist of a rigid insulation core, securely bonded between two structural facings, to form a structural sandwich panel. SIPs are considered a non-framed assembly usually with little or no structural framing that penetrates the insulation layer,

resulting in less thermal bridging across the insulation when compared to a conventional framed assembly.

This table gives U-factors for structurally insulated panels used in wall construction. This is a construction system that consists of rigid foam insulation sandwiched between two layers of plywood or oriented strand board (OSB). Data is provided for four variations of connecting two panels together.

If continuous insulation is not used, then choices are made from Column A. When continuous insulation is also used, this is typically installed on the exterior side of the wall but can also be used on the inside. The continuous insulation is typically a rigid polystyrene or polyisocyanurate foam insulation. Adding continuous insulation to a SIPS panel is highly unusual since the panel itself is mostly continuous insulation.

When this table is used, the R-value of continuous insulation shall be equal to or greater than the R-value published in the continuous insulation columns. Interpolation of the data is not acceptable.




Structurally Insulated Wall Panels (SIPS)

*This figure shows just one way that panels are connected. Other options exist.*

**Assumptions:** These data are calculated using the parallel path method documented in the 2017 ASHRAE Handbook of Fundamentals.

These calculations assume 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), 7/16 inch of OSB of R-0.44, insulation at carrying R-values (as specified), 7/16 inch of OSB of R-0.44, ½ inch gypsum board of R-0.45 (GP01), and in interior air film of R-0.68. A framing factor of 13 percent is assumed for wood spacers and 7 percent for

the OSB spline system. Framing includes the sill plate, the header and framing around windows and doors.

**U-factors of Metal Framed Walls for Residential Construction**

| | | | | Rated R-value of Continuous Insulation[2] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cavity Insulation | Nominal Framing | | R-0 | R-2 | R-4 | R-5 | R-6 | R-7 | R-8 | R-10 | R-12 | R-15 |
| Spacing | R-Value: | Size | | A | B | C | D | E | F | G | H | I | J |
| 16 in. OC | None | Any | 1 | 0.455 | 0.238 | 0.161 | 0.139 | 0.122 | 0.109 | 0.098 | 0.082 | 0.070 | 0.058 |
| | R-05 | 2x4 | 2 | 0.252 | 0.165 | 0.124 | 0.110 | 0.099 | 0.090 | 0.083 | 0.071 | 0.062 | 0.052 |
| | R-11 | 2x4 | 3 | 0.200 | 0.137 | 0.107 | 0.097 | 0.088 | 0.081 | 0.075 | 0.065 | 0.058 | 0.049 |
| | R-13 | 2x4 | 4 | 0.192 | 0.132 | 0.105 | 0.095 | 0.087 | 0.080 | 0.074 | 0.064 | 0.057 | 0.049 |
| | R-15 | 2x4 | 5 | 0.186 | 0.129 | 0.102 | 0.093 | 0.085 | 0.078 | 0.073 | 0.063 | 0.056 | 0.048 |
| | R-19 | 2x6 | 6 | 0.154 | 0.112 | 0.092 | 0.084 | 0.077 | 0.072 | 0.067 | 0.059 | 0.053 | 0.046 |
| | R-20 | 2x6 | 7 | 0.151 | 0.112 | 0.091 | 0.084 | 0.077 | 0.072 | 0.067 | 0.059 | 0.053 | 0.046 |
| | R-21[1] | 2x6 | 8 | 0.151 | 0.110 | 0.090 | 0.083 | 0.076 | 0.071 | 0.066 | 0.058 | 0.052 | 0.045 |
| | R-19 | 2x8 | 9 | 0.134 | 0.102 | 0.085 | 0.078 | 0.072 | 0.067 | 0.063 | 0.056 | 0.050 | 0.044 |
| | R-22 | 2x8 | 10 | 0.129 | 0.099 | 0.082 | 0.076 | 0.071 | 0.066 | 0.062 | 0.055 | 0.050 | 0.043 |
| | R-25 | 2x8 | 11 | 0.125 | 0.096 | 0.081 | 0.075 | 0.069 | 0.065 | 0.061 | 0.054 | 0.049 | 0.043 |
| | R-30[1] | 2x8 | 12 | 0.120 | 0.093 | 0.078 | 0.073 | 0.068 | 0.063 | 0.060 | 0.053 | 0.048 | 0.042 |
| | R-30 | 2x10 | 13 | 0.109 | 0.086 | 0.073 | 0.068 | 0.064 | 0.060 | 0.057 | 0.051 | 0.046 | 0.041 |
| | R-38[1] | 2x10 | 14 | 0.104 | 0.082 | 0.071 | 0.066 | 0.062 | 0.058 | 0.055 | 0.050 | 0.045 | 0.040 |
| | R-38 | 2 x 12 | 15 | 0.095 | 0.077 | 0.067 | 0.062 | 0.059 | 0.055 | 0.053 | 0.048 | 0.043 | 0.038 |
| 24 in. OC | None | Any | 16 | 0.449 | 0.236 | 0.161 | 0.138 | 0.121 | 0.108 | 0.098 | 0.082 | 0.070 | 0.058 |
| | R-05 | 2x4 | 17 | 0.243 | 0.161 | 0.122 | 0.108 | 0.098 | 0.089 | 0.082 | 0.070 | 0.062 | 0.052 |
| | R-11 | 2x4 | 18 | 0.189 | 0.131 | 0.104 | 0.094 | 0.086 | 0.079 | 0.073 | 0.064 | 0.057 | 0.048 |
| | R-13 | 2x4 | 19 | 0.181 | 0.127 | 0.101 | 0.092 | 0.084 | 0.078 | 0.072 | 0.063 | 0.056 | 0.048 |
| | R-15 | 2x4 | 20 | 0.175 | 0.123 | 0.099 | 0.090 | 0.082 | 0.076 | 0.071 | 0.062 | 0.055 | 0.047 |
| | R-19 | 2x6 | 21 | 0.144 | 0.107 | 0.088 | 0.081 | 0.075 | 0.070 | 0.065 | 0.058 | 0.052 | 0.045 |
| | R-20 | 2x6 | 22 | 0.141 | 0.106 | 0.087 | 0.080 | 0.074 | 0.069 | 0.065 | 0.057 | 0.051 | 0.044 |
| | R-21[1] | 2x6 | 23 | 0.141 | 0.105 | 0.086 | 0.080 | 0.074 | 0.069 | 0.064 | 0.057 | 0.051 | 0.044 |
| | R-19 | 2x8 | 24 | 0.126 | 0.097 | 0.081 | 0.075 | 0.070 | 0.065 | 0.061 | 0.055 | 0.049 | 0.043 |
| | R-22 | 2x8 | 25 | 0.121 | 0.094 | 0.079 | 0.073 | 0.068 | 0.064 | 0.060 | 0.054 | 0.048 | 0.042 |
| | R-25 | 2x8 | 26 | 0.117 | 0.091 | 0.077 | 0.071 | 0.067 | 0.063 | 0.059 | 0.053 | 0.048 | 0.042 |
| | R-30[1] | 2x8 | 27 | 0.112 | 0.088 | 0.075 | 0.069 | 0.065 | 0.061 | 0.057 | 0.052 | 0.047 | 0.041 |
| | R-30 | 2x10 | 28 | 0.102 | 0.081 | 0.070 | 0.065 | 0.061 | 0.058 | 0.055 | 0.049 | 0.045 | 0.039 |
| | R-38[1] | 2x10 | 29 | 0.096 | 0.077 | 0.067 | 0063 | 0.059 | 0.056 | 0.053 | 0.048 | 0.044 | 0.039 |
| | R-38 | 2 x 12 | 30 | 0.088 | 0.072 | 0.063 | 0.059 | 0.056 | 0.053 | 0.050 | 0.046 | 0.042 | 0.037 |

**Notes**

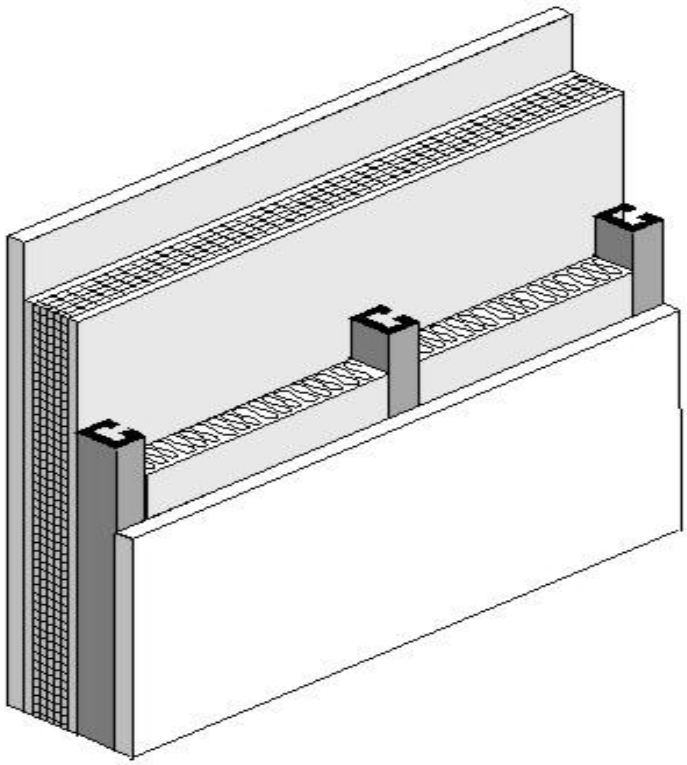
1. Higher density fiberglass batt is required in these cases.
2. Continuous insulation may be installed on either the inside or the exterior of the wall, or both.

This table contains U-factors for steel or metal framed walls in low-rise residential buildings where the thickness of the framing members is 18 gauge or thinner.

If continuous insulation is not used, then choices are made from Column A. In this case, the insulation is installed only in the cavity between the framing members. When continuous insulation is used, it is typically installed on the exterior side of the wall, but can also be used on

the inside. The continuous insulation is typically a rigid polystyrene or polyisocyanurate foam insulation.

When this table is used, the R-value of continuous insulation shall be equal to or greater than the R-value published in the continuous insulation columns. Interpolation of the data is not acceptable.



Metal Framed Wall

**Assumptions:** Values in this table were calculated using the zone calculation method documented in the 2017 ASHRAE Handbook of Fundamentals. 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, continuous insulation (if any), the insulation / framing insulation layer, 1/2 inch gypsum of R-0.45 gypsum board, 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 (software used by the California Energy Commission to calculate table values) used was 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. 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. The thickness of the stucco is assumed to be reduced to 3/8 inch when continuous insulation is applied.

**U-factors of Wood Framed Attic Roofs**

| | | | Rated R-value of Continuous Insulation[1] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Truss Spacing | R-Value of Attic Insulation | | None A | R-2 B | R-4 C | R-6 D | R-7 E | R-8 F | R-10 G | R-14 H |
| 16 in. OC | None | 1 | 0.300 | 0.187 | 0.136 | 0.107 | 0.097 | 0.088 | 0.075 | 0.058 |
| | R-11 | 2 | 0.079 | 0.068 | 0.060 | 0.053 | 0.051 | 0.048 | 0.044 | 0.037 |
| | R-13 | 3 | 0.071 | 0.062 | 0.055 | 0.050 | 0.047 | 0.045 | 0.041 | 0.036 |
| | R-19 | 4 | 0.049 | 0.045 | 0.041 | 0.038 | 0.037 | 0.035 | 0.033 | 0.029 |
| | R-21 | 5 | 0.042 | 0.039 | 0.036 | 0.034 | 0.032 | 0.031 | 0.030 | 0.026 |
| | R-22 | 6 | 0.043 | 0.039 | 0.037 | 0.034 | 0.033 | 0.032 | 0.030 | 0.027 |
| | R-25 | 7 | 0.038 | 0.035 | 0.033 | 0.031 | 0.030 | 0.029 | 0.028 | 0.025 |
| | R-30 | 8 | 0.032 | 0.030 | 0.028 | 0.027 | 0.026 | 0.025 | 0.024 | 0.022 |
| | R-38 | 9 | 0.026 | 0.024 | 0.023 | 0.022 | 0.022 | 0.021 | 0.020 | 0.019 |
| | R-44 | 10 | 0.021 | 0.020 | 0.019 | 0.019 | 0.018 | 0.018 | 0.017 | 0.016 |
| | R-49 | 11 | 0.020 | 0.019 | 0.019 | 0.018 | 0.018 | 0.017 | 0.017 | 0.016 |
| | R-60 | 12 | 0.017 | 0.016 | 0.016 | 0.015 | 0.015 | 0.015 | 0.014 | 0.013 |
| 24 in. OC | None | 13 | 0.305 | 0.189 | 0.137 | 0.108 | 0.097 | 0.089 | 0.075 | 0.058 |
| | R-11 | 14 | 0.076 | 0.066 | 0.058 | 0.052 | 0.050 | 0.047 | 0.043 | 0.037 |
| | R-13 | 15 | 0.068 | 0.060 | 0.054 | 0.048 | 0.046 | 0.044 | 0.041 | 0.035 |
| | R-19 | 16 | 0.048 | 0.043 | 0.040 | 0.037 | 0.036 | 0.034 | 0.032 | 0.029 |
| | R-21 | 17 | 0.043 | 0.040 | 0.037 | 0.034 | 0.033 | 0.032 | 0.030 | 0.027 |
| | R-22 | 18 | 0.041 | 0.038 | 0.036 | 0.033 | 0.032 | 0.031 | 0.029 | 0.026 |
| | R-25 | 19 | 0.037 | 0.034 | 0.032 | 0.030 | 0.029 | 0.028 | 0.027 | 0.024 |
| | R-30 | 20 | 0.031 | 0.029 | 0.028 | 0.026 | 0.025 | 0.025 | 0.024 | 0.022 |
| | R-38 | 21 | 0.025 | 0.024 | 0.023 | 0.022 | 0.021 | 0.021 | 0.020 | 0.018 |
| | R-44 | 22 | 0.021 | 0.020 | 0.019 | 0.019 | 0.018 | 0.018 | 0.017 | 0.016 |
| | R-49 | 23 | 0.019 | 0.019 | 0.018 | 0.017 | 0.017 | 0.017 | 0.016 | 0.015 |
| | R-60 | 24 | 0.016 | 0.016 | 0.015 | 0.015 | 0.014 | 0.014 | 0.014 | 0.013 |

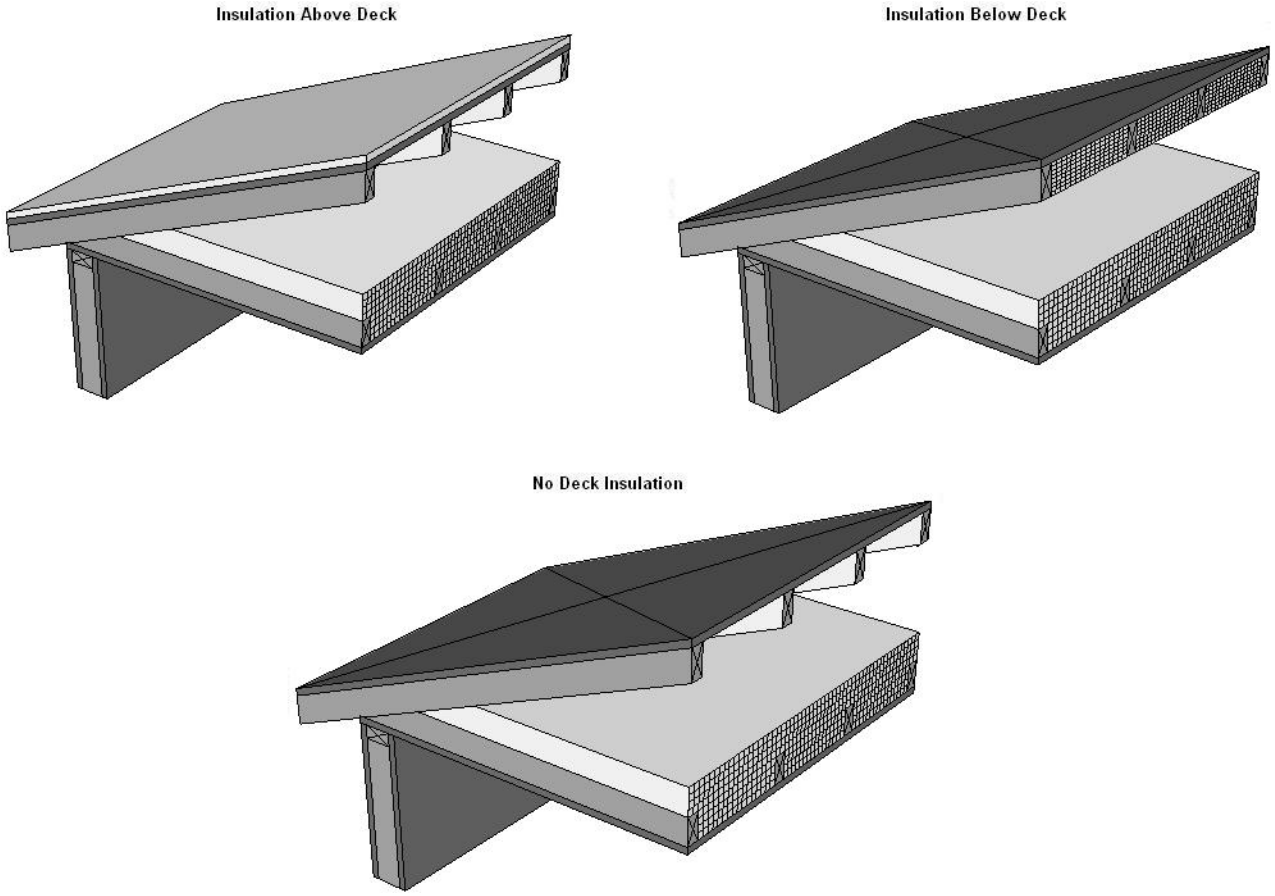
**Notes:**

1. Continuous insulation shall be located at the ceiling, below the bottom chord of the truss and be uninterrupted by framing.

This table contains thermal performance data (U-factors) for wood framed attics where the ceiling provides the air barrier and the attic is ventilated. Wood trusses are the most common construction for low-rise residential buildings. While the sketch shows a truss system with a flat ceiling, the data in this table may be used for scissor trusses and other non-flat trusses. If the bottom chord is not flat, then the slope should not exceed 4:12 for non-adhesive binder blown insulation. This table may also be used with composite trusses that have a wood top and bottom chord and metal struts connecting them.

For the most cases, values will be selected from column A of this table. Column A shall be used for the common situation where either batt or blown insulation is placed directly over the ceiling (and tapered at the edges). Builders or designers may increase thermal performance by adding a continuous insulation layer at the ceiling. The continuous insulation is typically a rigid polystyrene or polyisocyanurate foam insulation. Continuous insulation does not include the blown or batt insulation that is over the bottom chord of the truss (this is already accounted for in the U-factors published in Column A).

When this table is used, the R-value of continuous insulation shall be equal to or greater than the R-value published in the continuous insulation columns. Interpolation of the data is not acceptable.




Wood Framed Attic Roofs

This table shall not be used for cases where insulation is located at the roof of the attic. There are several situations in which this may be done. For example, in a sealed attic, foamed plastic may be sprayed onto the top chord of the trusses and onto the bottom of the upper structural deck (roof). The foam expands and cures with the intent of providing an airtight barrier and continuous insulation. Another case is where a plastic membrane or netting is installed above the ceiling (hanging below the roof deck) either in a ventilated or sealed (not ventilated) attic, and then either batt or blown insulation is installed over the netting. Since there are a number of issues related to these insulation techniques, local building official approval is required.

**Assumptions:** This data is calculated using the parallel path method documented in the 2017 ASHRAE Handbook of Fundamentals. These calculations assume an exterior air film of R-0.17, asphalt shingles of R-0.44, building paper of R-0.06, ½ inch of wood based sheathing (Custom), an attic air space (greater than 3.5 inch) with a R-0.80, the insulation / framing layer, continuous insulation (if any) ½ inch gypsum board of R-0.45, and an interior air film (heat flow up) of R-0.61. Wood 2x4 framing is assumed at the ceiling level. R-13 of attic insulation is assumed between the framing members; above that level, attic insulation is uninterrupted by framing. The framing percentage is assumed to be 10 percent for 16 inch on center and 7 percent for 24 inch

on center. 7.25 percent of the attic insulation above the framing members is assumed to be at half depth, due to decreased depth of insulation at the eaves.

## U-factors of Wood Framed Rafter Roofs

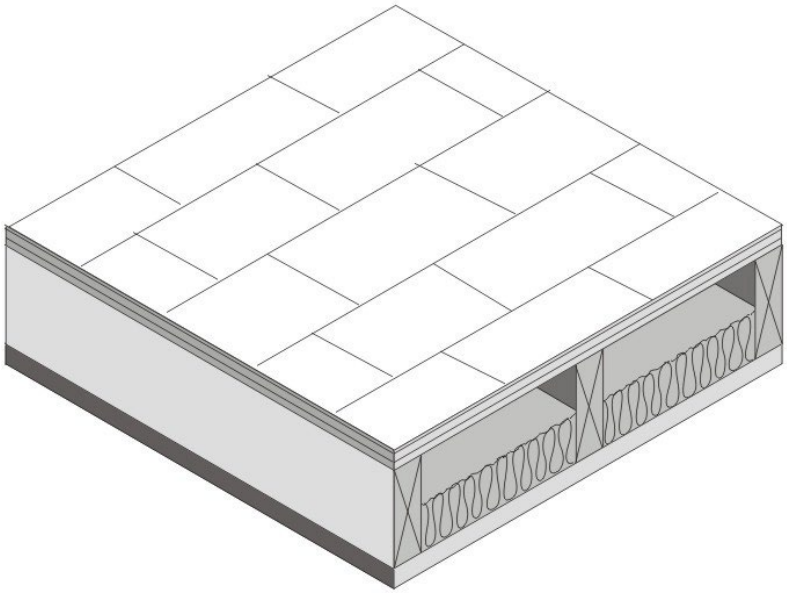
| | | | | Rated R-Value of Continuous Insulation[5] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | R-Value of | Nominal | | | | | | | | | |
| Rafter | Cavity | Framing | | None | R-2 | R-4 | R-6 | R-7 | R-8 | R-10 | R-14 |
| Spacing | Insulation | Size | | A | B | C | D | E | F | G | H |
| 16 in. OC | None | Any | 1 | 0.297 | 0.186 | 0.136 | 0.107 | 0.096 | 0.088 | 0.075 | 0.058 |
| | R-11[2] | 2x4 | 2 | 0.084 | 0.072 | 0.063 | 0.056 | 0.053 | 0.050 | 0.046 | 0.039 |
| | R-13[2] | 2x4 | 3 | 0.075 | 0.065 | 0.058 | 0.052 | 0.049 | 0.047 | 0.043 | 0.037 |
| | R-15[2] | 2x4 | 4 | 0.068 | 0.060 | 0.053 | 0.048 | 0.046 | 0.044 | 0.040 | 0.035 |
| | R-19[2] | 2x4 | 5 | 0.075 | 0.065 | 0.058 | 0.052 | 0.049 | 0.047 | 0.043 | 0.037 |
| | R-19[2,3] | 2x4 | 6 | 0.062 | 0.055 | 0.050 | 0.045 | 0.043 | 0.041 | 0.038 | 0.033 |
| | R-11 | 2x6 | 7 | 0.076 | 0.066 | 0.058 | 0.052 | 0.050 | 0.047 | 0.043 | 0.037 |
| | R-13 | 2x6 | 8 | 0.069 | 0.061 | 0.054 | 0.049 | 0.047 | 0.044 | 0.041 | 0.035 |
| | R-15 | 2x6 | 9 | 0.062 | 0.055 | 0.050 | 0.045 | 0.043 | 0.041 | 0.038 | 0.033 |
| | R-19[2] | 2x6 | 10 | 0.056 | 0.050 | 0.046 | 0.042 | 0.040 | 0.039 | 0.036 | 0.031 |
| | R-21[2] | 2x6 | 11 | 0.052 | 0.047 | 0.043 | 0.040 | 0.038 | 0.037 | 0.034 | 0.030 |
| | R-19[2] | 2x8 | 12 | 0.051 | 0.046 | 0.042 | 0.039 | 0.038 | 0.036 | 0.034 | 0.030 |
| | R-21 | 2x8 | 13 | 0.048 | 0.044 | 0.040 | 0.037 | 0.036 | 0.035 | 0.032 | 0.029 |
| | R-22 | 2x10 | 14 | 0.044 | 0.040 | 0.037 | 0.035 | 0.034 | 0.033 | 0.031 | 0.027 |
| | R-25 | 2x10 | 15 | 0.041 | 0.038 | 0.035 | 0.033 | 0.032 | 0.031 | 0.029 | 0.026 |
| | R-30[4] | 2x10 | 16 | 0.036 | 0.034 | 0.031 | 0.030 | 0.029 | 0.028 | 0.026 | 0.024 |
| | R-30 | 2x12 | 17 | 0.035 | 0.033 | 0.031 | 0.029 | 0.028 | 0.027 | 0.026 | 0.023 |
| | R-38[4] | 2x12 | 18 | 0.029 | 0.027 | 0.026 | 0.025 | 0.024 | 0.024 | 0.022 | 0.021 |
| | R-38[4] | 2x14 | 19 | 0.028 | 0.027 | 0.025 | 0.024 | 0.023 | 0.023 | 0.022 | 0.020 |
| 24 in. OC | None | Any | 25 | 0.237 | 0.161 | 0.122 | 0.098 | 0.089 | 0.082 | 0.070 | 0.055 |
| | R-11[2] | 2x4 | 26 | 0.081 | 0.070 | 0.061 | 0.055 | 0.052 | 0.049 | 0.045 | 0.038 |
| | R-13[2] | 2x4 | 27 | 0.072 | 0.063 | 0.056 | 0.050 | 0.048 | 0.046 | 0.042 | 0.036 |
| | R-15[2] | 2x4 | 28 | 0.065 | 0.058 | 0.052 | 0.047 | 0.045 | 0.043 | 0.039 | 0.034 |
| | R-19[2] | 2x4 | 29 | 0.072 | 0.063 | 0.056 | 0.050 | 0.048 | 0.046 | 0.042 | 0.036 |
| | R-19[2,3] | 2x4 | 30 | 0.059 | 0.053 | 0.048 | 0.044 | 0.042 | 0.040 | 0.037 | 0.032 |
| | R-11 | 2x6 | 31 | 0.075 | 0.065 | 0.058 | 0.052 | 0.049 | 0.047 | 0.043 | 0.037 |
| | R-13 | 2x6 | 32 | 0.067 | 0.059 | 0.053 | 0.048 | 0.046 | 0.044 | 0.040 | 0.035 |
| | R-15[2] | 2x6 | 33 | 0.060 | 0.054 | 0.048 | 0.044 | 0.042 | 0.041 | 0.038 | 0.033 |
| | R-19[2] | 2x6 | 34 | 0.054 | 0.049 | 0.044 | 0.041 | 0.039 | 0.038 | 0.035 | 0.031 |
| | R-21[2] | 2x6 | 35 | 0.049 | 0.045 | 0.041 | 0.038 | 0.036 | 0.035 | 0.033 | 0.029 |
| | R-19[2] | 2x8 | 36 | 0.049 | 0.045 | 0.041 | 0.038 | 0.036 | 0.035 | 0.033 | 0.029 |
| | R-21 | 2x8 | 37 | 0.046 | 0.042 | 0.039 | 0.036 | 0.035 | 0.034 | 0.032 | 0.028 |
| | R-22 | 2x10 | 38 | 0.043 | 0.040 | 0.037 | 0.034 | 0.033 | 0.032 | 0.030 | 0.027 |
| | R-25 | 2x10 | 39 | 0.039 | 0.036 | 0.034 | 0.032 | 0.031 | 0.030 | 0.028 | 0.025 |
| | R-30[4] | 2x10 | 40 | 0.034 | 0.032 | 0.030 | 0.028 | 0.027 | 0.027 | 0.025 | 0.023 |
| | R-30 | 2x12 | 41 | 0.033 | 0.031 | 0.029 | 0.028 | 0.027 | 0.026 | 0.025 | 0.023 |
| | R-38 [4] | 2x12 | 42 | 0.028 | 0.027 | 0.025 | 0.024 | 0.023 | 0.023 | 0.022 | 0.020 |
| | R-38[4] | 2x14 | 43 | 0.027 | 0.026 | 0.024 | 0.023 | 0.023 | 0.022 | 0.021 | 0.020 |

**Notes:**

1. Rigid foam board used for cavity insulation must fill the entire cavity between the rafters and be sealed properly to prevent air gaps, and must be secured properly to prevent any future discrepancies in the construction assembly.
2. This assembly is only allowed where ventilation is provided between the bottom of the roof deck and the top of the insulation meeting CBC requirements or with enforcement agency official's approval of rafter attic assemblies with no ventilation air spaces.
3. This assembly requires insulation with an R-value per inch 5.6 or larger (k-factor 1.8 or less). This is board type insulation, mostly Isocyanurate. Medium density spray polyurethane foam may also be used to meet this requirement if the quality installation procedures and documentation in Reference Joint Appendix JA7 are followed, Documentation from Directory of Certified insulation materials must be provided to show compliance with this assembly.
4. Higher density fiberglass batt is needed to achieve the indicated U-factor. R-30 must be achieved with less than 8.25 inch full thickness. R-38 must be achieved with less than 10.25 inch thickness (R-30c, R-38c).
5. Continuous insulation shall be located at the ceiling or at the roof and be uninterrupted by framing. In climate zones 1 and 16 the insulating R-value of continuous insulation materials installed above the roofs waterproof membrane shall be multiplied by 0.8 before choosing the table column for determining assembly U-factor.

This table contains thermal performance data (U-factors) for wood framed rafter roofs. This is a common construction in low-rise residential 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. Whether there is an air space above the insulation depends on local climate conditions and may not be required in some building permit jurisdictions. Filling the entire cavity of framed rafter assemblies with loose-fill mineral fiber and wool, cellulose, or open cell spray foam (ocSPF) may require prior approval by the local building official.

For the some cases, U-factors will be selected from Column A of this table; this case covers insulation placed only in the cavity. When continuous insulation is installed either at the ceiling or at the roof, then U- factors from other columns may be selected. The continuous insulation is typically a rigid polystyrene or polyisocyanurate foam insulation, but can also include mineral wool or other suitable materials.



Wood Frame Rafter Roof

When this table is used, the R-value of continuous insulation shall be equal to or greater than the R-value published in the continuous insulation columns. Interpolation of the data is not acceptable.

**Assumptions:** These data are calculated using the parallel path method documented in the 2017 ASHRAE Handbook of Fundamentals. These calculations assume an exterior air film of R-0.17, asphalt shingles of R-0.44, building paper of R-0.06, 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, closed cell spray foam (ccSPF), and ocSPF), 1/2 inch gypsum of R-0.45, 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.

## U-factors of Structurally Insulated Panels (SIPS) Roof/Ceilings

| Wood Framing Connection Type (spline) | Insulation Core R-value[1] | Typical Panel Thickness | | Rated R-Value of Continuous Insulation[4,5] None | R-2 | R-4 | R-5 | R-7 | R-8 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | A | B | C | D | E | F |
| OSB | R-22 | 6.5 in | 1 | 0.041 | 0.038 | 0.035 | 0.034 | 0.032 | 0.031 |
| Single 2x | R-22 | 6.5 in | 2 | 0.044 | 0.040 | 0.037 | 0.036 | 0.033 | 0.032 |
| Double 2x | R-22 | 6.5 in | 3 | 0.046 | 0.042 | 0.038 | 0.037 | 0.034 | 0.033 |
| I-joist | R-22 | 6.5 in | 4 | 0.043 | 0.039 | 0.036 | 0.035 | 0.033 | 0.032 |
| OSB | R-28 | 8.25 in | 5 | 0.033 | 0.031 | 0.029 | 0.028 | 0.027 | 0.026 |
| Single 2x | R-28 | 8.25 in | 6 | 0.034 | 0.032 | 0.030 | 0.029 | 0.027 | 0.027 |
| Double 2x | R-28 | 8.25 in | 7 | 0.037 | 0.034 | 0.031 | 0.030 | 0.028 | 0.028 |
| I-joist | R-28 | 8.25 in | 8 | 0.033 | 0.310 | 0.029 | 0.028 | 0.027 | 0.026 |
| OSB | R-33[2] | 6.5 in | 9 | 0.030 | 0.027 | 0.026 | 0.025 | 0.024 | 0.023 |
| Single 2x | R-33[2] | 6.5 in | 10 | 0.031 | 0.029 | 0.027 | 0.026 | 0.025 | 0.024 |
| Double 2x | R-33[2] | 6.5 in | 11 | 0.034 | 0.031 | 0.029 | 0.028 | 0.026 | 0.025 |
| I-joist | R-33[2] | 6.5 in | 12 | 0.031 | 0.028 | 0.027 | 0.026 | 0.025 | 0.024 |
| OSB | R-36 | 10.25 in | 13 | 0.026 | 0.025 | 0.024 | 0.023 | 0.022 | 0.022 |
| Single 2x | R-36 | 10.25 in | 14 | 0.028 | 0.026 | 0.025 | 0.024 | 0.023 | 0.022 |
| Double 2x | R-36 | 10.25 in | 15 | 0.029 | 0.028 | 0.026 | 0.025 | 0.024 | 0.023 |
| I-joist | R-36 | 10.25 in | 16 | 0.027 | 0.025 | 0.024 | 0.023 | 0.022 | 0.022 |
| OSB | R-44 | 12.25 in | 17 | 0.021 | 0.020 | 0.019 | 0.019 | 0.018 | 0.018 |
| Single 2x | R-44 | 12.25 in | 18 | 0.023 | 0.022 | 0.021 | 0.021 | 0.020 | 0.019 |
| Double 2x | R-44 | 12.25 in | 19 | 0.025 | 0.023 | 0.022 | 0.022 | 0.021 | 0.020 |
| I-joist | R-44 | 12.25 in | 20 | 0.022 | 0.021 | 0.020 | 0.020 | 0.019 | 0.019 |
| OSB | R-55[3] | 10.25 in | 21 | 0.017 | 0.016 | 0.016 | 0.016 | 0.016 | 0.016 |
| Single 2x | R-55[3] | 10.25 in | 22 | 0.019 | 0.018 | 0.018 | 0.018 | 0.017 | 0.016 |
| Double 2x | R-55[3] | 10.25 in | 23 | 0.021 | 0.020 | 0.019 | 0.019 | 0.018 | 0.017 |

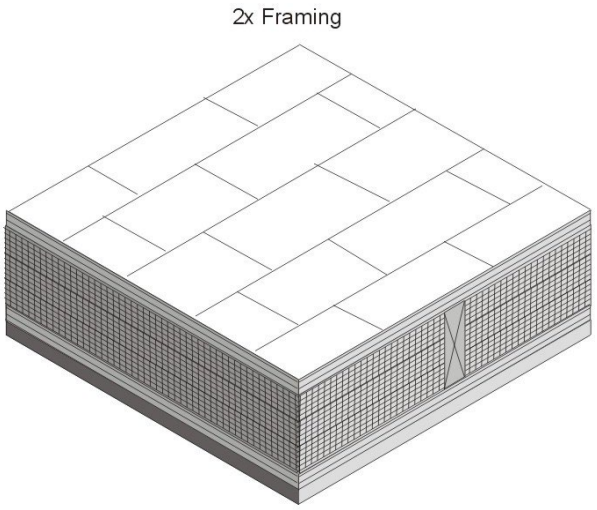
| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| I-joist | R-55[3] | 10.25 in | **24** | 0.018 | 0.017 | 0.017 | 0.017 | 0.016 | 0.016 |
| Steel | R-14 | 48 in | **25** | 0.075 | 0.065 | 0.058 | 0.055 | 0.049 | 0.047 |
| Framing | R-22 | 48 in | **26** | 0.057 | 0.051 | 0.046 | 0.044 | 0.041 | 0.039 |
| | R-28 | 48 in | **27** | 0.047 | 0.043 | 0.040 | 0.039 | 0.035 | 0.034 |
| | R-36 | 48 in | **28** | 0.043 | 0.040 | 0.037 | 0.036 | 0.033 | 0.032 |

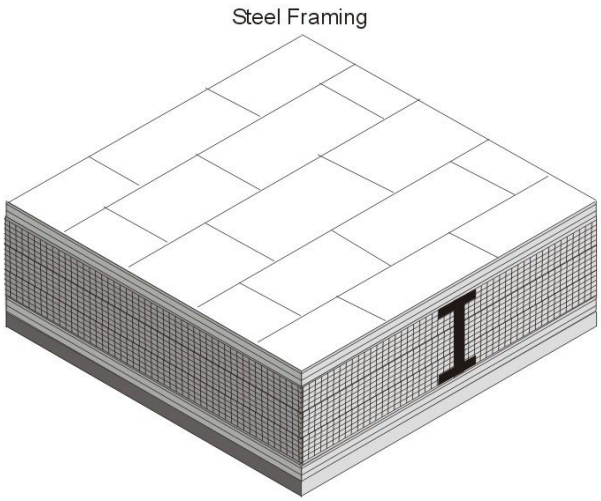
**NOTES:**

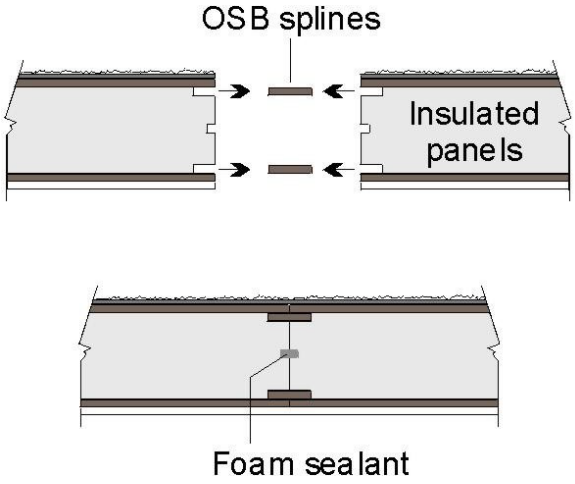
1. The insulation R-value must be at least R-21.7 in order to use this table. This table assumes molded expanded polystyrene (EPS) unless noted otherwise. Although other insulation types are used by some SIP manufacturers, such as polyurethane and extruded expanded insulation (XPS), EPS is the most common insulation used in SIP construction.
2. R-33.2 is achievable using polyurethane insulation in 6.5" panels.
3. R-55.3 is achievable using polyurethane insulation in 10.25" panels.
4. Continuous insulation shall be at least R-2 and may be installed on either the inside or the exterior of the roof/ceiling.
5. In climate zones 1 and 16 the insulating R-value of continuous insulation materials installed above the roof waterproof membrane shall be multiplied times 0.8 before choosing the table column for determining assembly U-factor.

Structural insulated panels (SIPs) consist of a rigid insulation core, securely bonded between two structural facings, to form a structural sandwich panel. SIPs are considered a non-framed assembly usually with little or no structural framing that penetrates the insulation layer, resulting in less thermal bridging across the insulation when compared to a conventional framed assembly.

This table gives U-factors for structurally insulated panels used in ceiling and roof constructions. Data is provided for three variations of this system. The system labeled “Wood Framing” uses wood spacers to separate the plywood or OSB boards and provide a means to connect the panels with mechanical fasteners. The system labeled “Steel Framing” uses steel framing members and mechanical fasteners at the joints. The system labeled “OSB Spline” uses splines to connect the panels so that framing members do not penetrate the insulation.






SIPS Roof/Ceiling

Data from Column A will be used in most cases, since it is quite unusual to add continuous insulation to a panel that is basically all insulation anyway. If insulation is added, however, then the U-factor is selected from one of the other columns. When this table is used, the R-value of continuous insulation shall be equal to or greater than the R-value published in the continuous insulation columns. Interpolation of the data is not acceptable.

**Assumptions:** The wood framing and OSB spline data are calculated using the parallel path method documented in the 2017 ASHRAE Handbook of Fundamentals. Assemblies with metal framing are calculated using the ASHRAE Zone Calculation Method which is also documented in the 2017 ASHRAE Handbook of Fundamentals. These calculations assume an exterior air film of R-0.17, asphalt shingles of R-0.44, building paper of R-0.06, 7/16 inch of OSB of R-0.69, the rigid insulation of R-3.85 per inch, another layer of 7/16 inch of OSB, ½ inch gypsum board of R-0.45, an R-value of 0.99 per inch is assumed for the wood frame and an interior air film (heat flow up diagonally) of R-0.62. If an additional layer of insulation is used, this may be installed on either the interior or exterior of the SIPS panel assembly.

## Standard U-factors for Wood-Framed Floors with a Crawl Space

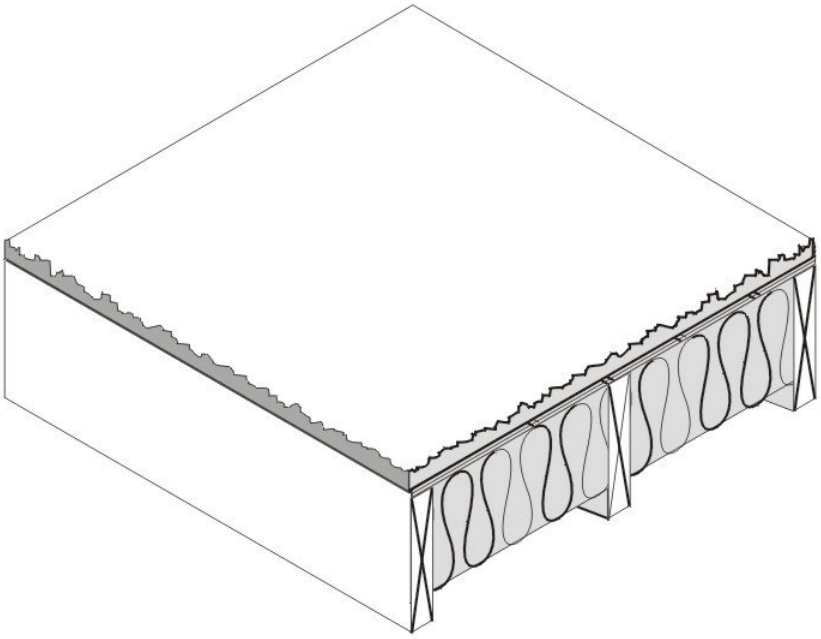
| Framing Spacing | Nominal Framing Size | R-Value Cavity Insul. | | Rated R-value of Continuous Insulation R-0 | R-2 | R-4 | R-6 | R-7 | R-8 | R-10 | R-14 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | A | B | C | D | E | F | G | H |
| 16 in. OC | Any | None | 1 | 0.097 | 0.081 | 0.070 | 0.061 | 0.058 | 0.055 | 0.049 | 0.041 |
| | 2 x 6 | R-11 | 2 | 0.049 | 0.045 | 0.041 | 0.038 | 0.037 | 0.035 | 0.033 | 0.029 |
| | | R-13 | 3 | 0.046 | 0.042 | 0.039 | 0.036 | 0.035 | 0.033 | 0.031 | 0.028 |
| | | R-19 | 4 | 0.037 | 0.034 | 0.032 | 0.030 | 0.029 | 0.029 | 0.027 | 0.024 |
| | 2 x 8 | R-19 | 5 | 0.037 | 0.034 | 0.032 | 0.030 | 0.029 | 0.029 | 0.027 | 0.024 |
| | | R-22 | 6 | 0.034 | 0.032 | 0.030 | 0.028 | 0.027 | 0.027 | 0.025 | 0.023 |
| | 2 x 10 | R-25 | 7 | 0.031 | 0.029 | 0.028 | 0.026 | 0.025 | 0.025 | 0.024 | 0.022 |
| | | R-30 | 8 | 0.028 | 0.026 | 0.025 | 0.024 | 0.023 | 0.023 | 0.022 | 0.020 |
| | 2 x 12 | R-38 | 9 | 0.024 | 0.023 | 0.022 | 0.021 | 0.020 | 0.020 | 0.019 | 0.018 |
| 24 in. OC | Any | None | 10 | 0.098 | 0.082 | 0.070 | 0.062 | 0.058 | 0.055 | 0.049 | 0.041 |
| | 2 x 6 | R-11 | 11 | 0.049 | 0.045 | 0.041 | 0.038 | 0.036 | 0.035 | 0.033 | 0.029 |
| | | R-13 | 12 | 0.045 | 0.041 | 0.038 | 0.035 | 0.034 | 0.033 | 0.031 | 0.028 |
| | | R-19 | 13 | 0.037 | 0.034 | 0.032 | 0.030 | 0.029 | 0.028 | 0.027 | 0.024 |
| | 2 x 8 | R-19 | 14 | 0.036 | 0.034 | 0.032 | 0.030 | 0.029 | 0.028 | 0.027 | 0.024 |
| | | R-22 | 15 | 0.033 | 0.031 | 0.029 | 0.028 | 0.027 | 0.026 | 0.025 | 0.023 |
| | 2 x 10 | R-25 | 16 | 0.030 | 0.029 | 0.027 | 0.026 | 0.025 | 0.024 | 0.023 | 0.021 |
| | | R-30 | 17 | 0.027 | 0.026 | 0.024 | 0.023 | 0.023 | 0.022 | 0.021 | 0.020 |
| | 2 x 12 | R-38 | 18 | 0.023 | 0.022 | 0.021 | 0.020 | 0.020 | 0.020 | 0.019 | 0.017 |

**Notes:**

1. In order to use the U-factors listed in this section, exterior raised-floor insulation shall be installed between floor joists with a means of support that prevents the insulation from falling, sagging or deteriorating. Two approaches that accomplish this are:
2. Nailing insulation hangers 18 inches apart prior to rolling out the insulation. Hangers are heavy wires up to 48 inches long with pointed ends, which provide positive wood penetration.
3. Attaching wire mesh to form a basket between joists to support the insulation. Mesh is nailed or stapled to the underside of the joists.

This table contains U-factors for wood framed floors built over a ventilated (natural ventilation) crawlspace. This construction is common for low-rise residential buildings.

If continuous insulation is not used, then choices are made from Column A. In this case, the insulation is installed only between the framing members. Continuous insulation is not common for wood floors over a crawlspace, but if credit is taken, the insulation may be installed either above or below the framing members. The continuous insulation is typically a rigid polystyrene or polyisocyanurate foam insulation.



*Wood Framed Floor with a Crawl Space*

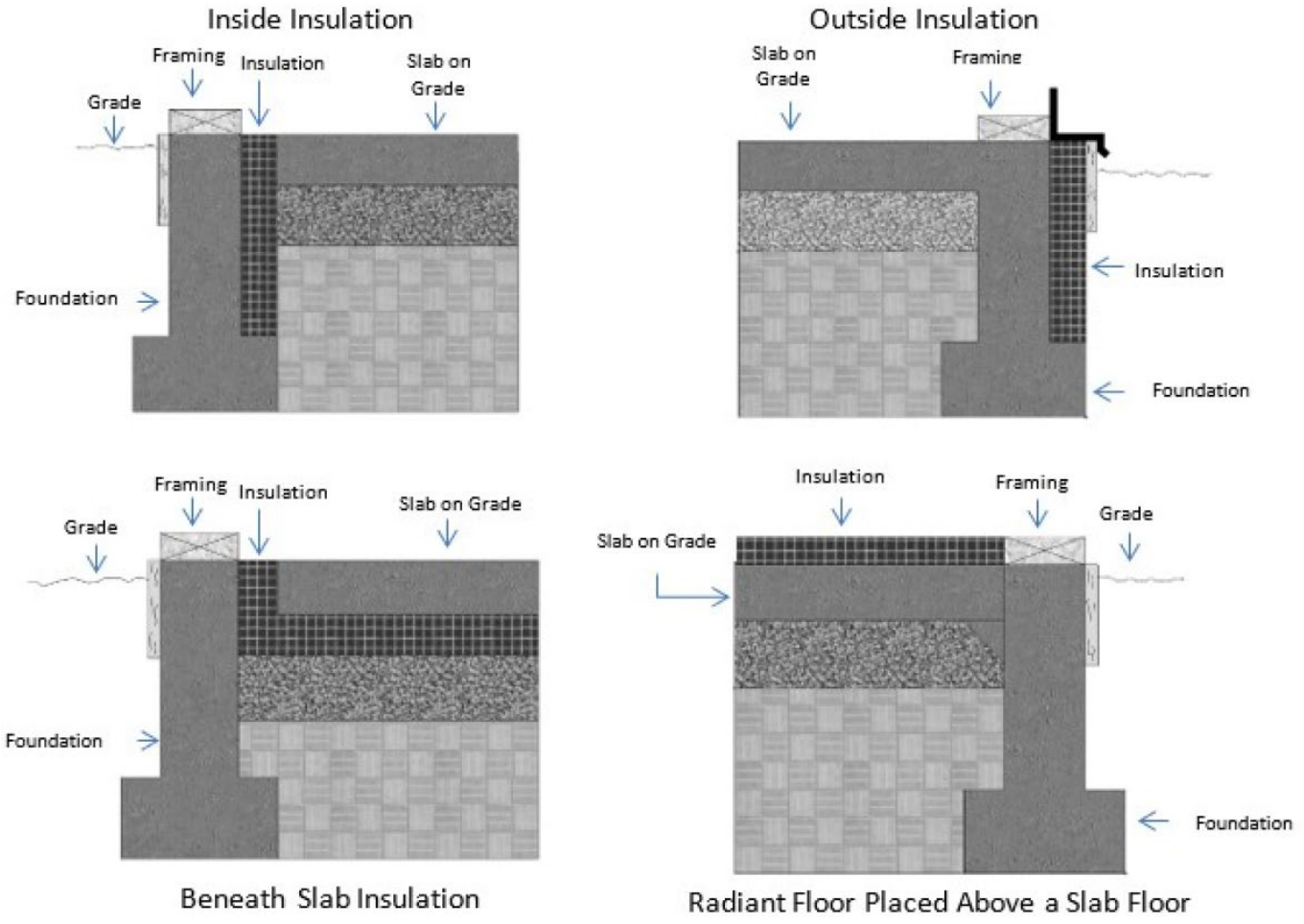
When this table is used, the R-value of continuous insulation shall be equal to or greater than the R-value published in the continuous insulation columns. Interpolation of the data is not acceptable.

**Assumptions:** Calculations use the ASHRAE parallel heat flow method documented in the 2017 ASHRAE Handbook of Fundamentals. These calculations assume an exterior air film of R-0.17, a vented crawlspace for an effective R-6, a continuous insulation layer (if any), the insulation / framing layer, 5/8 inch wood based sheathing (Custom), carpet and pad of R-2.08, and an interior air film (heat flow down) of R-0.92. The framing factor is assumed to be 10 percent for 16 inch stud spacing and 7 percent for 24 inch spacing.

**Slab on Grade Floors (Heated and Unheated)**

Slab on grade construction is very common for low-rise residential buildings. The 2018 New Mexico Residential Code does not provide a UA compliance option and thus the R-Value and insulation depth requirements from Table R402.1.2 of the 2018 IECC shall be met for climate zones 4-7.

The figures below demonstrate insulation placement options for slab on grade homes, with the two top figures demonstrating options for unheated slabs and the two bottom figures demonstrating an option for an in-slab radiant heating system and a radiant heating system placed above the slab. The latter being more common with home renovations than new construction.




For heated slabs in all climate zones, an R-5 insulation shall be added to the underside of the slab or radiant flooring (if installed above the slab) in addition to the edge insulation R-Value listed in Table R402.1.2 of the 2018 IECC. Heated slab edge insulation is required along the entire parameter of heated slab including areas between heated and unheated spaces like garages. The additional slab edge insulation for heated slabs is not required to extend below the slab depth.

### Fenestration Products (Doors, Windows and Skylights)

Any U-factor used in the Trade-off Worksheet should be based on the manufacturer's labeled U-factor for the product. Fenestration products that do not have a U-factor, SHGC or Visible Transmittance (VT) label shall use the values in the following tables or Tables R303.1.3(1), R303.1.3(2) and R303.1.3(3) of the 2018 IECC.

### Default Glazed Window, Glass Door and Skylight U-Factors

| Frame Type | Window and Glass Door | | Skylight | |
|---|---|---|---|---|
| | Single Pane | Double Pane | Single | Double |
| Metal | 1.20 | 0.80 | 2.00 | 1.30 |
| Metal with Thermal Break | 1.10 | 0.65 | 1.90 | 1.10 |
| Nonmetal or Metal Clad | 0.95 | 0.55 | 1.75 | 1.05 |
| Glazed Block | 0.60 | | | |

### Default Opaque Door U-Factors

| Door Type | Opaque U-Factor |
|---|---|
| Uninsulated Metal | 1.20 |
| Insulated Metal | 0.60 |
| Wood | 0.50 |
| Insulated, nonmetal edge, not exceeding 45% glazing, any glazing double pane | 0.35 |

### Default Glazed Fenestration SHGC and VT

| | Single Glazed | | Double Glazed | | Glazed Block |
|---|---|---|---|---|---|
| | Clear | Tinted | Clear | Tinted | |
| SHGC | 0.8 | 0.7 | 0.7 | 0.6 | 0.6 |
| VT | 0.6 | 0.3 | 0.6 | 0.3 | 0.6 |

## BUILDING MATERIAL THERMAL DATA

This section contains thermal data for selected building materials. This data can often be used to estimate the thermal performance of building assemblies.

New materials are being developed and may also be appropriate. They must be laboratory tested, to determine the actual R-value, and approved by the New Mexico Construction Industries Division (CID). Check with CID before using alternative materials.

### Physical Properties of Select Building Materials[1]

| Description | R-value | Thickness (1ft. =1.0, 1in.=.083) | Conductivity | Density | Specific Heat |
|---|---|---|---|---|---|
| Asphalt Shingle & Siding | 0.44 | | | 70.0 | 0.35 |
| Building Paper, Permeable Felt | 0.06 | | | | |
| Plywood 1/2 in. | 0.63 | 0.0417 | 0.0667 | 34.0 | 0.29 |
| Gypsum Board 1/2 in. | 0.45 | 0.0417 | 0.0926 | 50.0 | 0.26 |
| Built-up Roofing 3/8 in. | 0.33 | 0.0313 | 0.0939 | 70.0 | 0.35 |
| Plywood 3/4 in. | 0.94 | 0.0625 | 0.0667 | 34.0 | 0.29 |
| Plywood 5/8 in. | 0.78 | 0.0521 | 0.0667 | 34.0 | 0.29 |
| OSB 7/16 in. | 0.44 | 0.0365 | 0.0667 | 34.0 | 0.29 |
| Carpet with Fibrous Pad | 2.08 | | | | 0.34 |
| Particle Board Low Density 3/4 in. | 1.39 | 0.0625 | 0.0450 | 75.0 | 0.31 |
| Stucco 1 in. | 0.20 | 0.0833 | 0.4167 | 116.0 | 0.20 |
| Wood, Soft 4 in. | 5.00 | 0.3333 | 0.0667 | 32.0 | 0.33 |
| Wood, Hard 3/4 in. | 0.68 | 0.0625 | 0.0916 | 45.0 | 0.30 |
| Heavy Wt. Dried Aggregate 4 in. | 0.44 | 0.3333 | 0.7576 | 140.0 | 0.20 |
| Heavy Wt. Undried Aggregate 4 in. | 0.32 | 0.3333 | 1.0417 | 140.0 | 0.20 |
| 1/2 in. Acoustic Tile | 1.26 | 0.0417 | 0.0330 | 18.0 | 0.32 |
| Air Layer 4 in. or more, Horizontal Roof | 0.92 | 1.0000 | 0.4167 | 120.0 | 0.20 |
| Carpet with Fibrous Pad | 2.08 | | | | 0.34 |
| Concrete | 0.11 | 0.0833 | | 144.0 | 0.20 |
| Light Weight CMU | 0.35 | | | 105.0 | 0.20 |
| Medium Weight CMU | 0.35 | | | 115.0 | 0.20 |
| Normal Weight CMU | 0.35 | | | 125.0 | 0.20 |
| Earth (Soil) | 3.00 | 1.5000 | 0.5000 | 85.0 | 0.20 |
| Adobe 10 in. | 2.78 | 0.8333 | | | |
| Adobe 14 in. | 3.89 | 1.1667 | | | |
| Logs 6 in. | 7.50 | 0.5000 | 0.0667 | 32.0 | 0.33 |
| Logs 12 in. | 14.99 | 1.0000 | 0.0667 | 32.0 | 0.33 |
| Earth 12 in. | 2.00 | 1.0000 | 0.5000 | 85.0 | 0.20 |
| Vented crawlspace | 6.00 | NA | NA | NA | NA |
| 7/8” layer of stucco of R-0.18 | 0.18 | 0.0729 | 0.4167 | 116.0 | 0.20 |
| Straw bale (laid flat) | 1.55 | 0.0833 | | | |
| Straw bale (laid on edge) | 1.85 | 0.0833 | | | |
| Light straw-clay | 1.48 | 0.0833 | | 20 | |
| Acoustic tile + Metal | 0.50 | 0.0417 | 0.0330 | 18.0 | 0.32 |

[1]All values from CA Energy Commission 2019 Residential Compliance Manual except for Adobe 10 and 14 inch data from NM Energy Conservation Code Applications Manual, 1978 and straw bale and light straw clay material data from the 2018 IRC.

## Selected Insulating Materials and Air Film R-Values

| Insulation | |
|---|---|
| Fiberglass Batt | R- 3.03 - 4.35 per inch |
| Expanded Polystyrene, Extruded (XPS) | R- 4.00 - 5.56 per inch |
| Expanded Polystyrene, Molded Beads (EPS) | R- 3.85 - 4.35 per inch |
| Cellular Polyurethane | R- 3.45 - 7.14 per inch |
| Cellular Polyisocyanurate | R- 5.89 - 6.67 per inch |
| Loose Fill Cellulose Fiber (attic) | R- 3.13 - 3.70 per inch |
| Loose Fill Cellulose (wall cavity) | R- 3.57 - 3.70 per inch |
| Surface Air Film Inside | |
| Heat Flow Up Nonreflective (ceilings) | R- 0.61 entire item |
| Heat Flow Down Nonreflective (ceilings) | R- 0.92 entire item |
| Heat Flow Horizontal Nonreflective (walls) | R- 0.68 entire item |
| Surface Air Film Outside | |
| Any Surface Position, 15 mph, Winter | R- 0.17 entire item |
| Any Surface Position, 7-1/2 mph, Summer | R- 0.25 entire item |

Source: 2017 ASHRAE Handbook of Fundamentals

## TAPERED INSULATION PERFORMANCE

Heat loss through building components is proportional to the U-value, which is equal to 1/(R-value). The result is that the equivalent R-value of tapered insulation is not the average of the minimum and maximum R-values, but rather the inverse of the weighted "average" of the U-values. This can be calculated by an exact equation:

Equivalent Insulation

R-Value = $(R_b-R_a)/(\ln(R_b/R_a))$,

where:

$R_b$ is the R-value at the thickest
$R_a$ is the R-value at the thinnest
ln is natural log.

The following presents the results of this equation in a simple tabular form:

2009 NEW MEXICO ENERGY CONSERVATION CODE

**TAPERED INSULATION**

R-VALUE[a] OF UNIFORM INSULATION WITH EQUIVALENT PERFORMANCE[b]

| <<<<R-value @ thinnest section (Ra) | R-Value at thickest section (Rb)>>>> | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 |
| 1 | 6.34 | 7.46 | 8.53 | 9.56 | 10.57 | 11.56 | 12.53 | 13.48 | 14.41 | 15.33 | 16.24 |
| 5 | 10.82 | 12.43 | 13.95 | 15.42 | 16.83 | 18.20 | 19.54 | 20.85 | 22.13 | 23.39 | 24.63 |
| 10 | 14.43 | 16.37 | 18.20 | 19.96 | 21.64 | 23.27 | 24.85 | 26.40 | 27.91 | 29.38 | 30.83 |
| 15 | 17.38 | 19.58 | 21.64 | 23.60 | 25.49 | 27.31 | 29.07 | 30.79 | 32.46 | 34.10 | 35.70 |
| 20 | ****** | 22.41 | 24.66 | 26.80 | 28.85 | 30.83 | 32.74 | 34.60 | 36.41 | 38.18 | 39.91 |
| 25 | ****** | ****** | 27.42 | 29.72 | 31.91 | 34.03 | 36.07 | 38.05 | 39.98 | 41.86 | 43.71 |
| 30 | ****** | ****** | ****** | 32.44 | 34.76 | 36.99 | 39.15 | 41.24 | 43.28 | 45.27 | 47.21 |

a. Rb-values are in the following units: $(°F•ft^2•h)/Btu$

b. Equivalent Insulation R-Value=(Rb-Ra)/(ln(Rb/Ra)), where Rb is thickest, Ra is thinnest.

**TRADEOFF WORKSHEET SAMPLE # 1**

The next page features a Tradeoff Worksheet filled in for a sample adobe solar house. In the top section, general information on the project is entered.

The climate zone, 5B (remember only use the numeric value in the Tradeoff Worksheet), was determined by finding Santa Fe in the list of New Mexico towns in 14.7.6.11 NMAC of the 2018 NM Residential Energy Conservation Code.

The Proposed House is 1,544 $ft^2$, with a flat roof. It has 4 $ft^2$ of skylight, giving a net of 1,540 $ft^2$ for the ceiling area. The ceiling will be insulated with R-30 fiberglass batt insulation in 24" on center joists. Appendix A, Table: U-factors of Wood Framed Rafter Roofs, page 16 lists the $U_{assembly}$ for this combination (assembly 40 with no continuous insulation) to be U-0.034. Assuming the skylight has no manufacturer's data, we are forced to use the default data in Appendix A, Table: Default Glazed Window, Glass Door and Skylight U-Factors which lists the U-factor of a metal frame with thermal break, double glazed skylight as U-1.10.

The perimeter of the house is 212 linear feet and the walls are 8 ft. high. This makes the total wall area 1,696 $ft^2$. For the adobe wall, see Appendix B, Table: Physical Properties of Select Building Materials for some of the building material R-Values, and Appendix A for other materials and the interior and exterior air film R-Values. This example is using a 10" adobe (R-2.78) with R-10 continuous insulation on the exterior. From the 2017 ASHRAE Handbook of Fundamentals, the total assembly U-Factor can be calculated with a simple one dimensional analysis by adding the inverse R-Values (U-factors): $U_{assembly}=(1/R_{adobe})+(1/R_{insulation})+ (1/R_{stucco})+ (R_{plaster})+(R_{air\text{-}ext.})+(R_{air\text{-}int.})$. Assuming an exterior air film of R-0.17, and interior air film of R-0.68 and an interior wall finish of 1/2 in. lightweight plaster (R-0.19) and an exterior wall finish of 7/8 in. stucco (R-0.18). From this we get a $U_{assembly}$ of 0.071.

This house has 300 $ft^2$ of wood frame double glazed windows and 96 $ft^2$ of solid wood doors. Again, as with the skylights, if we assume the windows and doors lack manufacturer's data, we look to Appendix A for the default U-Factor. A wood frame double glazed window has a default of U-0.55 and a solid wood door has a default U-Factor of U-0.5. Manufacturer's data should be used, if available.

Subtracting the windows and doors from the total wall area, the area of the adobe wall is 1,300 $ft^2$.

The area of the slab edge insulation is not applicable to the Total UA calculation since the prescribed insulation requirements in the Code are mandatory. In addition, with a slab on grade design, the crawlspace wall, floor over crawlspace and basement wall sections are left blank in the Tradeoff Worksheet.

To calculate the UA of the Proposed House, the area of each building component is multiplied by the $U_{assembly}$ value. The electronic Tradeoff Worksheet automatically calculates the UA for each assembly and sums the values for a whole house total UA of 362.06. The electronic Tradeoff Worksheet also automatically fills in and calculates the applicable U and UA for each assembly based on the climate zone entered for the site. This includes the maximum area weighted average U-factor for fenestration products in each climate zone. The AWU Compliant? box identifies if that criteria is met while the box in the upper right, under the date box, identifies if the sum of the propose house UA or Total UA is compliant with the required Total UA. A SHGC compliance check is also provided on

the right side of the electronic Tradeoff Worksheet, however, in this example that check is not applicable (NA) in the selected climate zone.

The electronic Tradeoff Worksheet uses values from **Tables R402.1.2** and **R402.1.4** and **Section R402.5** of the 2018 IECC for establishing compliance status.

Note that the $U_{req}$ of 0.082 is from the Mass Wall U-Factor column, and only applies to when more than half of the insulation is on the external side of the wall.

Since the total UA for the Proposed House is more than the total UA for the Code House, the thermal envelope is NOT in compliance. Furthermore, the AWU for all fenestration products are not in compliance, which shows that the default values for these products are not adequate to show compliance in this climate zone.

If we now propose the home with fenestration products that have manufacturer's performance data that exceeds the performance of the default values, we can again use the Tradeoff Worksheet to verify code compliance. Assume we find windows with a U-Factor of U-0.29 and a Skylight U-Factor of U-0.55. For aesthetics, we will try to stick with the solid wood door in the first iteration to see if upgrading the windows and skylights is sufficient.

Again, the Proposed House total UA is greater than the Code House total UA and so the whole house UA is still not in compliance, however the changes did bring the AWU values for the skylights and the windows and doors into compliance even with the doors still estimated with the default values.

Since the doors cover such a small area, upgrading the doors may not be enough to bring the entire house UA into compliance. In the final iteration, we add an R-14 continuous insulation layer to the ceiling roof area of the house. In New Mexico this is often provided as a spray foam application to the exterior of the roof and provides both an insulating and water barrier to the roof. This eliminates the need for the shingles listed in the assembly products for this roof type but since the shingle have little impact on the overall U-Factor, the U-Factor value of U-0.023 listed in the table on page 16 for this combination (assembly 40 with R-14 continuous insulation) is used in the worksheet.

Finally, this assembly change brings the entire house UA into compliance with the code UA for this house.

2018 NEW MEXICO RESIDENTIAL ENERGY CONSERVATION CODE

## TRADEOFF WORKSHEET

| | | | |
|---|---|---|---|
| Project ID | Adobe SF | Building Floor Area | 1,544 |
| Builder Name | John Doe Builders | | |
| Builder Address | 1001 Builder Road | | |
| Submitted by | John Doe | | |
| Building Address | 100 Solar Drive | | |
| Town | Santa Fe | | |

Date: 5/18/2021

**Not in Compliance**

Phone: 505-555-1234

Climate Zone (3-7): 5
(numeric value only, no alpha character)

### PROPOSED HOUSE (Area and $R_o$ as designed)

**Ceiling**

| Description | Insulation R-Value | Area, ft² | x | $U_{assem}$ | = | UA |
|---|---|---|---|---|---|---|
| Wood Framed Rafter | 30.0 | 1540 | x | 0.034 | = | 52.36 |
| | | | x | | = | |
| | | | x | | = | |
| Total | | 1,540 | | | | |

**Walls (Frame or Mass)**

| Frame Wall Description | Insulation R-Value | Area, ft² | x | $U_{assem}$ | = | UA |
|---|---|---|---|---|---|---|
| | | | x | | = | |
| | | | x | | = | |
| | | | x | | = | |
| | | | x | | = | |
| | | | x | | = | |
| Total | | - | | | | |

| Mass Wall Description | Insulation R-Value | Area, ft² | x | $U_{assem}$ | = | UA |
|---|---|---|---|---|---|---|
| Adobe 10" w/R-10 continuous | R-10 | 1,300 | x | 0.071 | = | 92.30 |
| | | | x | 0.111 | = | |
| Total | | 1,300 | | | | |

**Skylights (Maximum AWU=0.75 in CZ 4 through 7)**

| Description | U-Factor | * Area, ft² | = | UA | AWU Compliant? |
|---|---|---|---|---|---|
| metal - double with thermal break default | 1.1 | 4 | = | 4.40 | No |
| | | | = | 0.00 | |
| Total | | 4 | | | 1.10 |

**Doors & Windows (Maximum AWU=0.48 in CZ 4 & 5 and 0.4 in 6 & 7)**

| Description | U-Factor | * Area, ft² | = | UA | AWU Compliant? |
|---|---|---|---|---|---|
| wood dbl pane wind. | 0.55 | 300 | = | 165.00 | No |
| wood door- solid | 0.5 | 96 | = | 48.00 | |
| Total | | 396 | | | 0.54 |

**Crawlspace Wall (when applicable)**

| Description | Insulation R-Value | Area, ft² | x | $U_{assem}$ | = | UA |
|---|---|---|---|---|---|---|
| Total | | | x | | = | |

**Floor Over Crawlspace (when applicable)**

| Description | Insulation R-Value | Area, ft² | x | $U_{assem}$ | = | UA |
|---|---|---|---|---|---|---|
| Total | | | x | | = | |

**Basement Wall (when applicable)**

| Description | Insulation R-Value | Area, ft² | x | $U_{assem}$ | = | UA |
|---|---|---|---|---|---|---|
| Total | | | x | | = | |

**Totals**

| | |
|---|---|
| Total Roof, Wall, Foundation | 362.06 |

### CODE HOUSE

**Ceiling**

Same As Your House — $U_{req.}$ from NMRECC

| Area, ft² | x | $U_{req.}$ | = | UA |
|---|---|---|---|---|
| 1,540 | x | 0.026 | = | 40.04 |

**Walls (Frame or Mass)**

Same As Your House — $U_{req.}$ from NMRECC

**Frame Walls**

| Area, ft² | x | $U_{req.}$ | = | UA |
|---|---|---|---|---|
| - | x | 0.06 | = | - |

^applies to mass walls with >50% external insulation, see 2018 IECC for other options

**Mass Walls**

| Area, ft² | x | $U_{req.}$^ | = | UA |
|---|---|---|---|---|
| 1,300 | x | 0.082 | = | 106.60 |

**Skylights**

| Solar Heat Gain Coeff. (SHGC) | = | NA |
|---|---|---|

| Area, ft² | x | Ureq. | = | UA |
|---|---|---|---|---|
| 4 | x | 0.55 | = | 2.20 |

**Doors and Windows**

| Solar Heat Gain Coeff. (SHGC) | = | NA |
|---|---|---|

| Area, ft² | x | Ureq. | = | UA |
|---|---|---|---|---|
| 396 | x | 0.3 | = | 118.80 |

**Crawlspace Wall**

| Area, ft² | x | $U_{req.}$ | = | UA |
|---|---|---|---|---|
| | x | 0.055 | = | - |

**Floor Over Crawlspace**

| Area, ft² | x | $U_{req.}$ | = | UA |
|---|---|---|---|---|
| | x | 0.033 | = | - |

**Basement Wall**

| Area, ft² | x | $U_{req.}$ | = | UA |
|---|---|---|---|---|
| | x | 0.05 | = | - |

**Totals**

| | |
|---|---|
| Total Roof, Wall, Found. | 267.64 |

If the total for PROPOSED HOUSE is less than the total for CODE HOUSE, PROPOSED HOUSE is in compliance.

2018 NEW MEXICO RESIDENTIAL ENERGY CONSERVATION CODE

# TRADEOFF WORKSHEET

| | | | |
|---|---|---|---|
| Project ID | Adobe SF | Building Floor Area | 1,544 |
| Builder Name | John Doe Builders | | |
| Builder Address | 1001 Builder Road | | |
| Submitted by | John Doe | | |
| Building Address | 100 Solar Drive | | |
| Town | Santa Fe | | |

Date: 5/18/2021

**Not in Compliance**

Phone: 505-555-1234

Climate Zone (3-7): 5
(numeric value only, no alpha character)

## PROPOSED HOUSE (Area and $R_o$ as designed)

### Ceiling

| Description | Insulation R-Value | Area, ft² | x | $U_{assem}$ | = | UA |
|---|---|---|---|---|---|---|
| Wood Framed Rafter | 30.0 | 1540 | x | 0.034 | = | 52.36 |
| | | | x | | = | |
| | | | x | | = | |
| Total | | 1,540 | | | | |

### Walls (Frame or Mass)

| Frame Wall Description | Insulation R-Value | Area, ft² | x | $U_{assem}$ | = | UA |
|---|---|---|---|---|---|---|
| | | | x | | = | |
| | | | x | | = | |
| | | | x | | = | |
| | | | x | | = | |
| | | | x | | = | |
| Total | | - | | | | |

| Mass Wall Description | Insulation R-Value | Area, ft² | x | $U_{assem}$ | = | UA |
|---|---|---|---|---|---|---|
| Adobe 10" w/R-10 continuous | R-10 | 1,300 | x | 0.071 | = | 92.30 |
| | | | x | 0.111 | = | |
| Total | | 1,300 | | | | |

### Skylights (Maximum AWU=0.75 in CZ 4 through 7)

| Description | U-Factor | * Area, ft² | = | UA | AWU Compliant? |
|---|---|---|---|---|---|
| metal - double with thermal break default | 0.55 | 4 | = | 2.20 | Yes |
| | | | = | 0.00 | |
| Total | | 4 | | | 0.55 |

### Doors & Windows (Maximum AWU=0.48 in CZ 4 & 5 and 0.4 in 6 & 7)

| Description | U-Factor | * Area, ft² | = | UA | AWU Compliant? |
|---|---|---|---|---|---|
| wood dbl pane wind. | 0.29 | 300 | = | 87.00 | Yes |
| wood door- solid | 0.5 | 96 | = | 48.00 | |
| Total | | 396 | | | 0.34 |

### Crawlspace Wall (when applicable)

| Description | Insulation R-Value | Area, ft² | x | $U_{assem}$ | = | UA |
|---|---|---|---|---|---|---|
| Total | | | x | | = | |

### Floor Over Crawlspace (when applicable)

| Description | Insulation R-Value | Area, ft² | x | $U_{assem}$ | = | UA |
|---|---|---|---|---|---|---|
| Total | | | x | | = | |

### Basement Wall (when applicable)

| Description | Insulation R-Value | Area, ft² | x | $U_{assem}$ | = | UA |
|---|---|---|---|---|---|---|
| Total | | | x | | = | |

### Totals

| | |
|---|---|
| Total Roof, Wall, Foundation | 281.86 |

## CODE HOUSE

### Ceiling

Same As Your House — $U_{req.}$ from NMRECC

| Area, ft² | x | $U_{req.}$ | = | UA |
|---|---|---|---|---|
| 1,540 | x | 0.026 | = | 40.04 |

### Walls (Frame or Mass)

Same As Your House — $U_{req.}$ from NMRECC

**Frame Walls**

| Area, ft² | x | $U_{req.}$ | = | UA |
|---|---|---|---|---|
| - | x | 0.06 | = | - |

^applies to mass walls with >50% external insulation, see 2018 IECC for other options

**Mass Walls**

| Area, ft² | x | $U_{req.}$^ | = | UA |
|---|---|---|---|---|
| 1,300 | x | 0.082 | = | 106.60 |

### Skylights

| Solar Heat Gain Coeff. (SHGC) | = | NA |
|---|---|---|

| Area, ft² | x | Ureq. | = | UA |
|---|---|---|---|---|
| 4 | x | 0.55 | = | 2.20 |

### Doors and Windows

| Solar Heat Gain Coeff. (SHGC) | = | NA |
|---|---|---|

| Area, ft² | x | Ureq. | = | UA |
|---|---|---|---|---|
| 396 | x | 0.3 | = | 118.80 |

### Crawlspace Wall

| Area, ft² | x | $U_{req.}$ | = | UA |
|---|---|---|---|---|
| | x | 0.055 | = | - |

### Floor Over Crawlspace

| Area, ft² | x | $U_{req.}$ | = | UA |
|---|---|---|---|---|
| | x | 0.033 | = | - |

### Basement Wall

| Area, ft² | x | $U_{req.}$ | = | UA |
|---|---|---|---|---|
| | x | 0.05 | = | - |

### Totals

| | |
|---|---|
| Total Roof, Wall, Found. | 267.64 |

If the total for PROPOSED HOUSE is less than the total for CODE HOUSE, PROPOSED HOUSE is in compliance.

2018 NEW MEXICO RESIDENTIAL ENERGY CONSERVATION CODE

## TRADEOFF WORKSHEET

| | | | |
|---|---|---|---|
| Project ID | Adobe SF | Building Floor Area | 1,544 |
| Builder Name | John Doe Builders | | |
| Builder Address | 1001 Builder Road | | |
| Submitted by | John Doe | | |
| Building Address | 100 Solar Drive | | |
| Town | Santa Fe | | |

Date: 5/18/2021

**In Compliance**

Phone: 505-555-1234

Climate Zone (3-7): 5 (numeric value only, no alpha character)

### PROPOSED HOUSE (Area and $R_o$ as designed)

**Ceiling**

| Description | Insulation R-Value | Area, ft² | x | $U_{assem}$ | = | UA |
|---|---|---|---|---|---|---|
| Wood Framed | 30.0 | 1540 | x | 0.023 | = | 35.42 |
| Rafter with | 14 cont. | | x | | = | |
| R-14 continuous foam roof | | | x | | = | |
| Total | | 1,540 | | | | |

**Walls (Frame or Mass)**

| Frame Wall Description | Insulation R-Value | Area, ft² | x | $U_{assem}$ | = | UA |
|---|---|---|---|---|---|---|
| | | | x | | = | |
| | | | x | | = | |
| | | | x | | = | |
| | | | x | | = | |
| | | | x | | = | |
| Total | | - | | | | |

| Mass Wall Description | Insulation R-Value | Area, ft² | x | $U_{assem}$ | = | UA |
|---|---|---|---|---|---|---|
| Adobe 10" w/R-10 | R-10 | 1,300 | x | 0.071 | = | 92.30 |
| continuous | | | x | 0.111 | = | |
| Total | | 1,300 | | | | |

**Skylights (Maximum AWU=0.75 in CZ 4 through 7)**

| Description | U-Factor | * Area, ft² | = | UA | AWU Compliant? |
|---|---|---|---|---|---|
| metal - double with | 0.55 | 4 | = | 2.20 | Yes |
| thermal break default | | | = | 0.00 | |
| Total | | 4 | | 0.55 | |

**Doors & Windows (Maximum AWU=0.48 in CZ 4 & 5 and 0.4 in 6 & 7)**

| Description | U-Factor | * Area, ft² | = | UA | AWU Compliant? |
|---|---|---|---|---|---|
| wood dbl pane wind. | 0.29 | 300 | = | 87.00 | Yes |
| wood door- solid | 0.5 | 96 | = | 48.00 | |
| Total | | 396 | | 0.34 | |

**Crawlspace Wall (when applicable)**

| Description | Insulation R-Value | Area, ft² | x | $U_{assem}$ | = | UA |
|---|---|---|---|---|---|---|
| Total | | | x | | = | |

**Floor Over Crawlspace (when applicable)**

| Description | Insulation R-Value | Area, ft² | x | $U_{assem}$ | = | UA |
|---|---|---|---|---|---|---|
| Total | | | x | | = | |

**Basement Wall (when applicable)**

| Description | Insulation R-Value | Area, ft² | x | $U_{assem}$ | = | UA |
|---|---|---|---|---|---|---|
| Total | | | x | | = | |

**Totals**

| | |
|---|---|
| Total Roof, Wall, Foundation | 264.92 |

### CODE HOUSE

**Ceiling**

Same As Your House — $U_{req.}$ from NMRECC

| Area, ft² | x | $U_{req.}$ | = | UA |
|---|---|---|---|---|
| 1,540 | x | 0.026 | = | 40.04 |

**Walls (Frame or Mass)**

Same As Your House — $U_{req.}$ from NMRECC

**Frame Walls**

| Area, ft² | x | $U_{req.}$ | = | UA |
|---|---|---|---|---|
| - | x | 0.06 | = | - |

^applies to mass walls with >50% external insulation, see 2018 IECC for other options

**Mass Walls**

| Area, ft² | x | $U_{req.}$^ | = | UA |
|---|---|---|---|---|
| 1,300 | x | 0.082 | = | 106.60 |

**Skylights**

| Solar Heat Gain Coeff. (SHGC) | = | NA |
|---|---|---|

| Area, ft² | x | Ureq. | = | UA |
|---|---|---|---|---|
| 4 | x | 0.55 | = | 2.20 |

**Doors and Windows**

| Solar Heat Gain Coeff. (SHGC) | = | NA |
|---|---|---|

| Area, ft² | x | Ureq. | = | UA |
|---|---|---|---|---|
| 396 | x | 0.3 | = | 118.80 |

**Crawlspace Wall**

| Area, ft² | x | $U_{req.}$ | = | UA |
|---|---|---|---|---|
| | x | 0.055 | = | - |

**Floor Over Crawlspace**

| Area, ft² | x | $U_{req.}$ | = | UA |
|---|---|---|---|---|
| | x | 0.033 | = | - |

**Basement Wall**

| Area, ft² | x | $U_{req.}$ | = | UA |
|---|---|---|---|---|
| | x | 0.05 | = | - |

**Totals**

| | |
|---|---|
| Total Roof, Wall, Found. | 267.64 |

If the total for PROPOSED HOUSE is less than the total for CODE HOUSE, PROPOSED HOUSE is in compliance.

**TRADEOFF WORKSHEET SAMPLE # 2**

The next page features a Tradeoff Worksheet filled in for a sample wood frame house. In the top section, general information on the project is entered.

The climate zone, 3B (remember only use the numeric value in the Tradeoff Worksheet), was determined by finding Roswell in the list of New Mexico towns in 14.7.6.11 NMAC of the 2018 NM Residential Energy Conservation Code.

The Proposed House is 1,750 $ft^2$, with a pitched roof. It has 9 $ft^2$ of skylight, giving a net of 1,741 $ft^2$ for the ceiling area. The ceiling will be insulated with R-38 fiberglass batt insulation in standard trusses, 16 inches OC. Appendix A, Table: U-factors of Wood Framed Attic Roofs, page 14 lists the $U_{assembly}$ for this combination (assembly 9 with no continuous insulation) to be U-0.026. The skylights are assumed to comply with the code U-Factor and SHGC values listed **Table R402.1.2** of the 2018 IECC or U-0.55 and SHGC-0.25 respectively.

The perimeter of the house is 235 linear feet and the walls are 8 feet high. This makes the total wall area 1,880 $ft^2$. The wall is 2x6 frame construction, 24 inches OC, with R19 insulation in the cavity and R5 continuous insulation on the exterior. From the U-Factors for Wood Framed Walls table we get a $U_{assembly}$ of U-0.05 (assembly 19 with R-5 continuous insulation).

This house has 150 $ft^2$ of vinyl frame double glazed windows that again are assumed to meet the U-Factor and SHGC code values (verified with manufacturer's data) and 96 $ft^2$ of solid wood doors. The windows are compliant with the code values in **Table R402.1.2** so they are assigned a U-Factor of U-0.32 and a SHGC of 0.25. Lacking manufacturer's data for the wood door we refer to Appendix A, page 24, and assign the default U-Factor of U-0.50 to the door area.

Subtracting the windows and doors from the total wall area, the area of the wood frame wall is 1,634 $ft^2$.

No slab edge insulation is being proposed.

To calculate the UA of the Proposed House, the area of each building component is multiplied by the $U_{assembly}$ value. The electronic Tradeoff Worksheet automatically calculates the UA for each assembly and sums the values for a whole house total UA of 275.92. The electronic Tradeoff Worksheet also automatically fills in and calculates the applicable U and UA for each assembly based on the climate zone entered for the site. This includes the maximum area weighted average U-factor for fenestration products in each climate zone. The AWU Compliant? box identifies if that criteria is met (if applicable) while the box in the upper right, under the date box, identifies if the sum of the propose house UA or Total UA is compliant with the required Total UA. A SHGC compliance check is also provided on the right side of the electronic Tradeoff Worksheet.

The electronic Tradeoff Worksheet uses values from **Tables R402.1.2** and **R402.1.4** and **Section R402.5** of the 2018 IECC for establishing compliance status.

Since the total UA for the Proposed House is less than the total UA for the Code House, the thermal envelope is in compliance.

2018 NEW MEXICO RESIDENTIAL ENERGY CONSERVATION CODE

## TRADEOFF WORKSHEET

| | | | |
|---|---|---|---|
| Project ID | Wood Frame House | Building Floor Area | 1,750 |
| Builder Name | Stick Builders | | |
| Builder Address | 111 Calle Bosque | | |
| Submitted by | Joe Woods | | |
| Building Address | 200 Central Drive | | |
| Town | Roswell | | |

Date: 5/18/2021

**In Compliance**

Phone: 505-555-4321

Climate Zone (3-7): 3
(numeric value only, no alpha character)

### PROPOSED HOUSE (Area and $R_o$ as designed)

**Ceiling**

| Description | Insulation R-Value | Area, ft² | x | $U_{assem}$ | = | UA |
|---|---|---|---|---|---|---|
| Wood Truss, Attic | 38.0 | 1741 | x | 0.026 | = | 45.27 |
| | | | x | | = | |
| | | | x | | = | |
| Total | | 1,741 | | | | |

**Walls (Frame or Mass)**

| Frame Wall Description | Insulation R-Value | Area, ft² | x | $U_{assem}$ | = | UA |
|---|---|---|---|---|---|---|
| 2x6, 24 in. OC | 19.0 | 1,634 | x | 0.050 | = | 81.70 |
| | | | x | | = | |
| | | | x | | = | |
| | | | x | | = | |
| | | | x | | = | |
| Total | | 1,634 | | | | |

| Mass Wall Description | Insulation R-Value | Area, ft² | x | $U_{assem}$ | = | UA |
|---|---|---|---|---|---|---|
| | | | x | | = | |
| | | | x | | = | |
| Total | | - | | | | |

**Skylights (Maximum AWU=0.75 in CZ 4 through 7)**

| Description | U-Factor | * Area, ft² | = | UA | AWU Compliant? |
|---|---|---|---|---|---|
| metal - double with | 0.55 | 9 | = | 4.95 | #N/A |
| thermal break default | | | = | 0.00 | |
| Total | | 9 | | | 0.55 |

**Doors & Windows (Maximum AWU=0.48 in CZ 4 & 5 and 0.4 in 6 & 7)**

| Description | U-Factor | * Area, ft² | = | UA | AWU Compliant? |
|---|---|---|---|---|---|
| Vynl. dbl pane window | 0.32 | 300 | = | 96.00 | #N/A |
| wood door- solid | 0.5 | 96 | = | 48.00 | |
| Total | | 396 | | | 0.36 |

**Crawlspace Wall (when applicable)**

| Description | Insulation R-Value | Area, ft² | x | $U_{assem}$ | = | UA |
|---|---|---|---|---|---|---|
| Total | | | x | | = | |

**Floor Over Crawlspace (when applicable)**

| Description | Insulation R-Value | Area, ft² | x | $U_{assem}$ | = | UA |
|---|---|---|---|---|---|---|
| Total | | | x | | = | |

**Basement Wall (when applicable)**

| Description | Insulation R-Value | Area, ft² | x | $U_{assem}$ | = | UA |
|---|---|---|---|---|---|---|
| Total | | | x | | = | |

**Totals**

| | |
|---|---|
| Total Roof, Wall, Foundation | 275.92 |

### CODE HOUSE

**Ceiling**

Same As Your House — $U_{req.}$ from NMRECC

| Area, ft² | x | $U_{req.}$ | = | UA |
|---|---|---|---|---|
| 1,741 | x | 0.030 | = | 52.23 |

**Walls (Frame or Mass)**

Same As Your House — $U_{req.}$ from NMRECC

**Frame Walls**

| Area, ft² | x | $U_{req.}$ | = | UA |
|---|---|---|---|---|
| 1,634 | x | 0.06 | = | 98.04 |

^applies to mass walls with >50% external insulation, see 2018 IECC for other options

**Mass Walls**

| Area, ft² | x | $U_{req.}$^ | = | UA |
|---|---|---|---|---|
| - | x | 0.098 | = | - |

**Skylights**

| Solar Heat Gain Coeff. (SHGC) | = | 0.25 | | |
|---|---|---|---|---|
| Area, ft² | x | Ureq. | = | UA |
| 9 | x | 0.55 | = | 4.95 |

**Doors and Windows**

| Solar Heat Gain Coeff. (SHGC) | = | 0.25 | | |
|---|---|---|---|---|
| Area, ft² | x | Ureq. | = | UA |
| 396 | x | 0.32 | = | 126.72 |

**Crawlspace Wall**

| Area, ft² | x | $U_{req.}$ | = | UA |
|---|---|---|---|---|
| | x | 0.136 | = | - |

**Floor Over Crawlspace**

| Area, ft² | x | $U_{req.}$ | = | UA |
|---|---|---|---|---|
| | x | 0.047 | = | - |

**Basement Wall**

| Area, ft² | x | $U_{req.}$ | = | UA |
|---|---|---|---|---|
| | x | 0.091 | = | - |

**Totals**

| | |
|---|---|
| Total Roof, Wall, Found. | 281.94 |

If the total for PROPOSED HOUSE is less than the total for CODE HOUSE, PROPOSED HOUSE is in compliance.