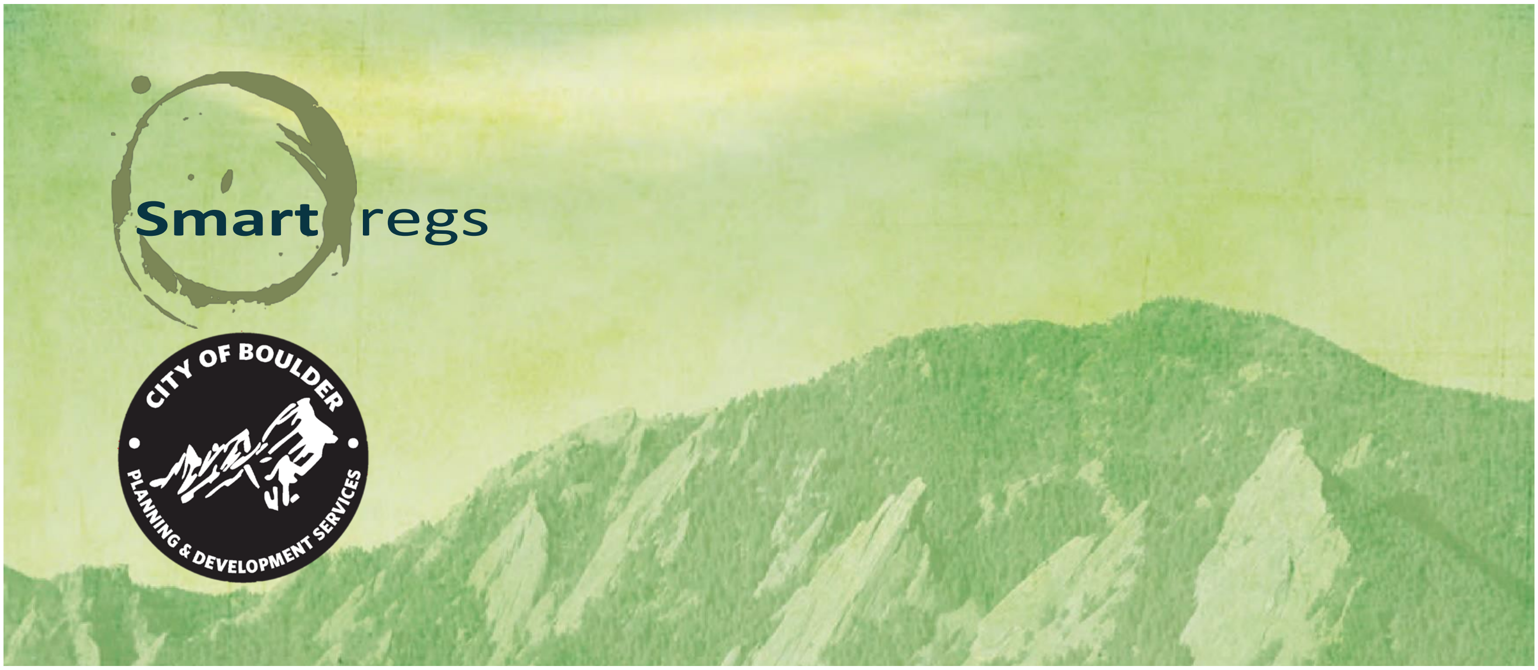

City of Boulder

SmartRegs Guidebook

October 2025

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SmartRegs Guidebook

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SmartRegs energy efficiency requirements for rental properties were adopted by the Boulder City Council on Sept. 21, 2010. The city's sustainability objectives met through these requirements include environ- mental health, economic vitality and social equity. By requiring a minimum level of energy performance, compliance with SmartRegs results in efficient residential rental properties that save energy. In addition, by establishing a minimum energy efficiency performance level, less efficient rental units are upgraded to meet this standard. Finally, by requiring property owners to upgrade rental properties, tenants have the potential to benefit from lower energy bills. As rental properties comprise approximately 50 percent of Boulder's housing stock, the SmartRegs requirements advance overall community sustainability objectives.

Scope

The SmartRegs ordinances became effective on Jan. 3 2011. The energy efficiency requirements for existing rental properties (Ordinance 7726) are required to be met by Jan. 2, 2019. This allows for an eight-year implementation period, the first three years of which (2011-2013) are marked by significant federal, state and local funding available to ease implementation cost to property owners. Rental units are encouraged to comply as early as possible. Beginning in January 2011, the City of Boulder and Boulder County offered residential energy efficiency services specifically designed for SmartRegs compliance.

Quick Notes

Jan. 3, 2011: SmartRegs became effective.

Jan. 2, 2019: Deadline for existing rental properties to meet requirements.

2011-2013: Lots of funding available to help with implementation costs.

Some buildings are exempt; see the info below.

Scope Exceptions

Exceptions to the scope are as follows:

1. Buildings that can be verified as meeting/exceeding the energy efficiency requirements of the Energy Conservation and Insulation Code, Chapter 10-7, B.R.C. 1981.

2. Any manufactured home.

3. Attached Accessory Dwelling Units as detailed in section 9-6-3, "Specific Use Standards Residential Uses." B.R.C. 1981.

Compliance Exceptions

Exceptions to compliance are as follows:

1. **Equivalent Performance:** Buildings achieving equivalent energy efficiency performance through the use of innovative materials, methods and/or equipment in accordance with the requirements of the ordinance. The code official will determine the relative values and effectiveness of innovative materials, methods and/or equipment in satisfying the intent and purpose of this code.

2. **Historic Buildings:** Upon a finding by the code official that the application of this section requires an exterior alteration to an individual landmark or a contributing building within an historic district established under chapter 9-11, "Historic Preservation," B.R.C. 1981, reasonable modifications in the award of prescriptive and performance points of this appendix that would not be eligible for a Landmark Alteration Certificate.

3. **Affordable Housing:** Rental dwelling units meeting the requirements for a permanently affordable unit, as follows:

A. Units weatherized after September 1994 according to state or federal subsidy program standards;

B. Units eligible for weatherization according to state or federal subsidy program standards that have applied for weatherization service: These units can be awarded an extension of one rental license cycle to reach compliance. The code official may approve additional time to achieve compliance if one rental license cycle is deemed to not be adequate;

- Units not qualifying for weatherization according to state or federal subsidy programs: an exception for one rental license cycle to achieve compliance. The code official may approve additional time to achieve compliance if one rental license cycle is deemed to not be adequate.

4. **Technically Impractical[1]:** Buildings where energy efficiency upgrades are technically impractical in accordance with International Property Maintenance Code (IPMC) sec. 105.1. Owners shall demonstrate equivalent code compliance as:

- Except as provided below owners shall make the energy efficiency improvements that are practical and shall purchase, for each rental license cycle, qualifying carbon offsets pro-rated for impractical improvements.

- If the building is the subject of an application for concept review, site review or a demolition permit, and the application shows that the building will be demolished or substantially remodeled within the next licensing period, the owner need not make energy efficiency improvements, but must purchase, for each rental license cycle until the demolition or substantial remodel is complete, carbon offsets for the improvements not made.

Compliance

Property owners can comply with the energy efficiency requirements by following either a performance or prescriptive path.

Performance Path

The performance path requires a Home Energy Rating System (HERS) score of 120 or lower. The HERS index will be used for the verification of energy performance. A HERS rating shall be per- formed by a rater accredited by the Residential Energy Services Network (RESNET).

Prescriptive Path

The SmartRegs prescriptive path involves a checklist designed as an alternative to the SmartRegs performance path. The checklist relies on trained and certified Rental Energy Efficiency Inspectors (City of Boulder Class "G" license). To meet the requirements, each unit must achieve 100 checklist points or more in addition to two mandatory points in the water conservation category.

1. Technically Impractical and Qualifying Carbon Offsets—The ordinance as adopted does not require properties to comply until the end of 2018, data collected in the early years of program implementation will provide further guidelines to assist property owners in applying for a technically impractical exception. If a unit is approved for this option, the purchase of qualifying carbon offsets will be required at the time the unit is identified as technically impractical.

Contractor Licensing

In order to inspect properties for SmartRegs energy efficiency requirements, a contractor must have the following certifications and licenses:

1. Performance path: Home Energy Rater, accredited by the Residential Energy Services Network (RESNET).

2. Prescriptive path: City of Boulder "G" licensed contractor. To obtain a City of Boulder "G" license, the inspector must be certified through a city sponsored training program and have one of the following certifications:

COB licensed D-9 or General A, B or C contractor (ICC Certified), OR
Qualified Licensed Design Professional (Architect or Engineer), OR
ICC Certified Combination Inspector, OR
ASHI or NAHI Certified Home Inspector, AND/OR
ICC Certified Residential or Commercial Energy Inspector, OR
RESNET Certification

More information on trainings and a list of certified inspectors can be found at www.bouldercolorado.gov/smartregs.

Photo by Glenn Asakawa

SmartRegs Prescriptive Path

The SmartRegs Prescriptive Path worksheet can be found on the following pages. Each dwelling unit must achieve 100 points or more from this list. An additional 2 points are required in the water conservation category.

How to fill this out and submit the documentation:

A worksheet is available: www.bouldercolorado.gov/smartregs. Inspectors should download the worksheet and fill out the base points in each category. The worksheet will configure a list of recommendations based on the base points by automatically calculating the largest potential point increases to reach compliance. The list will be sorted with lowest cost measures as primary recommendations. These recommendations are based on a set of general assumptions and should be used as a guide rather than an actual work scope for the unit. Each unit should work with a contractor to identify the priority measures specific to each unit for a more tailored route to compliance.

Once the final inspection is completed, the inspector should fill in the final points in the worksheet, sign, and submit to the city electronically.

The SmartRegs Prescriptive Path is an alternative to the SmartRegs Performance Path which requires that a rental unit ("Unit") achieve a Home Energy Rating System (HERS) Index of 120. The basis of the Prescriptive Path is the SmartRegs Prescriptive Checklist ("Checklist") which was designed to achieve a similar level of energy performance as the Performance Path. The Prescriptive Pathway is technical in nature and is designed for use by a City of Boulder licensed third-party inspector who must receive training from the City on the proper application of the Checklist. In order to maintain consistent Checklist scoring, the following Technical User's Guide was developed to provide instruction on the proper assessment and scoring protocols.

Compliance Process Overview

1. Inspector performs initial blower door testing, duct leakage testing (where applicable) and completes the SmartRegs Checklist to determine "Base" points. Where a Unit scores 100 points or above at the "Base" inspection, the Inspector will certify that the Unit has met the requirements of the SmartRegs Ordinance.

2. Where the Unit has less than 100 Base points, the owner should consider the costs and benefits of various available improvement options and determine the Unit's compliance pathway to 100 points.

3. Following implementation of improvements, the Inspector revisits and completes the Checklist to determine the "Final" points. The final inspection may include retesting of air infiltration or duct leakage where the owner is trying to achieve more points in these categories.

Quick Notes

Prescriptive Path: An alternative to the Performance Path; To be used by City of Boulder licensed, third-party inspectors.

100 Points: A unit must score 100 or more base points to be compliant.

The Checklist: Allows for a less time-intensive "checklist audit."

Determining Points Via Tables

In general, the Checklist consists of a series of tables containing specifications of building components typical to the majority of the rental housing stock. In cases where the object of a section is a single data point, such as primary heating system efficiency, the Inspector should first determine the actual system efficiency. After determining the actual level of efficiency, the Inspector should find the most appropriate categorical value from the first row of the HEATING Table. In most cases, the Inspector will need to round the actual value to apply the Checklist. In general, for each building component on the Checklist points are determined by rounding up or down to the nearest available increment. This Guide offers instructions on the proper way to perform the rounding exercise for each type of building component. In the case of a 95% AFUE furnace, the Inspector would round up to 96% AFUE and award 19 points, as indicated in the column to the right of the category.


AHRI CERTIFIED www.ahridirectory.org

This furnace qualifies for AFUE Federal Energy Efficiency Tax Credit when placed in service between February 17 2009 and December 31 2010.

Certificate of Product Ratings

AHRI Certified Reference Number: 2008415 Date: 11/8/2010

Product: Residential Furnace Heating Equipment
Model Number: TUH1B040A9241A*
Manufacturer: TRANE
Trade/Brand name: XR 95

Rated as follows in accordance with Department of Energy (DOE) furnace test procedures as published in the latest edition of the Code of Federal Regulations, 10 CFR Part 430 and subject to verification of rating accuracy by AHRI-sponsored, independent, third party testing:

AFUE: 95.0%
Output Heating Capacity: 38 MBTUH

◂ EXAMPLE

HEATING Base: 19 Final: ____

SPECIFICATION	POINTS
Electric, Oil, or ASHP	0
Gas 65 AFUE or worse	0
Gas 80 AFUE	13
Gas 90 AFUE	17
Gas 96 AFUE	19
GSHP (COP 3.3)	29
GSHP (COP 4.1)	38
GSHP (COP 4.8)	43

In the case of a building component that may be comprised of multiple data points, such as the insulation value of walls, there are additional columns to allow the Inspector to account for multiple wall locations or assembly types. In these cases, the Inspector assigns points based upon estimated percentages of wall area for each category. For each section, the Inspector rounds to the nearest 25%.

In the example below, of the Unit's total wall area, 75% is above-grade and 25% is below grade in a finished basement. All of the walls are framed with 2 x 4's, including the furred wall in the finished basement. Of the above-grade walls, 2/3 were insulated during a renovation but 1/3 remains uninsulated. Therefore, the walls can be divided into the following three categories:

25% - above-grade, 2 x 4 wall, uninsulated,
50% - above-grade, 2 x 4 wall insulated to R-13, and
25% - insulated basement wall.

That configuration would be shown on the Checklist as:

WALLS Base: 16 Final:____

R-VALUE	25%	50%	75%	100%
No Insulation	(0)	0	0	0
R-3 Continuous (must be at least R-3)	3	6	9	12
R-5 Continuous	4	8	12	15
R-13 or Uninsulated Basement Wall	5	(10)	15	20
R-19 or Better	5	11	16	21
Shared Wall or Insulated Basement Wall	(6)	13	19	26

If the owner were to add insulation to the uninsulated walls, the Checklist for the final inspection would appear as follows.

WALLS Base: 16 Final: 21

R-VALUE	25%	50%	75%	100%
No Insulation	0	0	0	0
R-3 Continuous (must be at least R-3)	3	6	9	12
R-5 Continuous	4	8	12	15
R-13 or Uninsulated Basement Wall	5	10	(15)	20
R-19 or Better	5	11	16	21
Shared Wall or Insulated Basement Wall	(6)	13	19	26

A Decision-Making Tool

The Prescriptive Checklist functions as a decision-making tool for homeowners, auditors and retrofitters to identify the home-specific "low-hanging" fruit and turn "audits into action." Currently, most home energy efficiency programs for existing homes only award points for making improvements, but do not reward a home's existing conditions that enhance home energy performance. Under such a program, many homeowners would have to increase the energy efficiency of an already well-performing home to receive the same certification as a less-efficient home that made the same improvements.

The SmartRegs Prescriptive Pathway is fundamentally different: it functions as a simple "checklist audit," awarding and weighting points in much the same way as a performance-based approach. Under the Prescriptive Checklist, each home gets points for the performance of its existing systems and components. In addition, with a less time-intensive Checklist audit (compared to a full HERS rating) and simple air infiltration testing, landlords can clearly see the areas where energy upgrades are most needed. The design of the Prescriptive Pathway also allows landlords to weigh the potential impact and prioritize various improvement measures by comparing the cost and the additional points that would be earned. The formula is simple: the more points that a home can earn for a measure, the more impact that measure has on its overall carbon emissions.

Quick Notes
Walls

Thermal Boundary: Only thermal boundary walls need to be evaluated; Ignore partitions

Wall Location: Determine if walls are shared/not shared or insulated/uninsulated basement

Wall Construction: Identify framing material, any remodeling indicators, cavity insulation and/or continuous insulating material (if present)

Applying the Checklist Section 1: Walls

Step 1
Locate the Thermal Boundary

When completing the Checklist, Inspectors need only evaluate those walls that constitute the Unit's thermal boundary. Any partition walls that exist entirely within the thermal boundary of the Unit are to be ignored. Once the walls that comprise the Unit's thermal boundary have been identified, proceed to the following steps considering only those walls.

Step 2
Establish Wall Location

Shared Walls: Because heat transfer across a wall that separates two conditioned spaces is generally insignificant relative to heat transfer across other thermal boundary walls, the Inspector must determine which, if any, walls in the Unit are "shared walls" (also known as "adiabatic walls" or "demising walls"). For the purposes of the Checklist, in order to be considered a shared wall, the space on the opposite side of the evaluated wall must maintain a temperature (via thermostat control) that is reasonably similar to the temperature within the Unit. In other words, walls that separate the Unit from another residential dwelling, conditioned corridor, conditioned common space, or a conditioned commercial space should be considered shared walls. On the other hand, walls that separate the Unit from an unconditioned or occasionally conditioned space such as a garage or workshop should not be considered shared walls. Similarly, walls that separate the conditioned living space within the Unit from an unconditioned crawl space or base- ment should not be considered shared walls.

Basement Walls: Like shared walls, thermal boundary walls that separate conditioned living space from ambient earth are subject to different conditions than those that separate conditioned living space from ambient air. The Inspector must determine which, if any, walls are in part or entirely below-grade. On the Checklist, these walls are identified as "Basement Walls." This wall type is further divided into "Uninsulated Basement Wall" and "Insulated Basement Wall" categories. Basement wall assemblies containing any insulation, whether exterior or interior, continuous or located within the framing cavities of an interior furred wall, shall be considered insulated basement walls.

Step 3
Establish Wall Construction Characteristics

Evaluating the thermal performance characteristics of wall assemblies in existing structures can be challenging because it is not generally feasible to observe the presence, type, and/or quality of insulating materials that may be concealed within the wall cavities or behind the exterior cladding. In order to find the most appropriate Checklist categories for the exterior wall types, the Inspector must determine the following:

Is the wall constructed with 2x4 framing members or 2 x 6 framing members? This is usually most easily determined by examining the jamb of a window or door located within the wall in question. By determining the depth of the jamb, the depth of the internal framing can generally be deduced. A standard jamb for a window or door set in a 2 x 4 framed wall is 4-9/16" wide. A standard 2 x 6 jamb is 6-9/16" wide. If there are no windows or doors in a given wall, or if this test is otherwise impracticable, the cavity depth can be determined by removing an outlet or switch cover plate, then passing a barbed, non-conductive probe (nylon knitting needles make great wall probes) between the electrical box and the adjacent drywall. Taking great care not to touch the wires or contacts within the electrical box, slide the probe into the wall cavity, perpendicular to the plane of the wall, until it comes into contact with the inside face of the exterior wall sheathing. Mark the depth on the probe and withdraw it from the wall. If the mark is ~4" from the end of the probe, then the wall is likely constructed with 2 x 4 studs. If the mark is ~6" from the end of the probe, then the wall is likely constructed with 2 x 6 studs.

As many Boulder structures have had additions and/or remodels over the years, do not assume that because you have established the framing type for one wall, that the characteristics of all walls are known. Be mindful to look for indications of additions or remodels (e.g. changes in wall texture, changes in flooring material, updated windows, updated fixtures, etc.) that may hint at the presence of multiple types of wall assemblies in the same Unit. Additions or remodels that occurred after 1990 are more likely to feature 2 x 6 wall construction due to the building codes in force at the time the work was performed.[1]

Do the framing cavities contain insulation? Using the following procedure, the Inspector must determine whether or not the wall cavities contain insulation.

First, remove at least one of the following from every non-shared wall type that has been identified within the Unit:

- Light switch cover plate
- Electrical outlet cover plate
- Coaxial cable jack cover plate
- Register cover
- Phone jack cover plate
- Any other easily removable cover that gives access to the cavity behind the drywall.

Second, locate an opening large enough that a non-conductive probe may be passed into the wall cavity. In the event that the drywall fits very tightly against the electrical box, coaxial cable, etc., lightly trace the cover with a pencil to determine whether or not the opening could be enlarged sufficiently to allow the probe to pass into the wall cavity while still being hidden by the cover when it is replaced.

Third, pass the probe into the wall cavity, taking care to avoid contact with electrical wires or contacts, then attempt to snag any insulating material that may be located within the wall cavity. Carefully remove the probe in order to identify the presence and type of insulating material caught on the barb. Insulating materials most commonly found in wall cavities in Boulder include fiberglass batts, rockwool batts, or blown cellulose[2].

Is there fibrous insulating sheathing, continuous exterior rigid insulation board or insulated siding present? There are several reasons why a wall may be constructed with a continuous insulating material. Inspectors may find fibrous insulating sheathing board as a common component of wall assemblies. This material is common in Boulder structures constructed in the post-WWII building boom spanning from the late 1940's to the late 1960's. The presence of this material is most commonly discovered by observing an area of wall that lacks interior finish such as an unfinished mechanical room or an exterior gable end wall viewed from inside the attic. Per Table 1.2, the presence of a 1/2" layer of fibrous insulating board used as wall sheathing does not, on its own, qualify for any points on the Checklist.

Determining the presence of continuous exterior rigid insulation board or insulating siding will generally be accomplished from outside. The easiest way to identify the presence of these products above is to observe the intersection of the exterior sheathing/siding and the foundation walls. Because walls are generally designed such that the outside face of the framing members is coplanar with the outside face of the foundation walls, any exterior rigid insulation board can generally be observed by bending down to view the bottom edge of the wall sheathing. If a rigid insulation board material is observed, calculate the material's R-value by multiplying its depth by the RMaterial value from Table 1.2 on page 49.

Insulating siding products have been available since the late 1970's and typically consist of a standard aluminum or vinyl siding material that is bonded to a piece of rigid foam insulation (usually expanded polystyrene) backing material that matches the profile of the siding. These products' performance values generally range between R-3 and R-4. In the absence of manufacturer's data or a visible label indicating the material's R-value, the performance must be calculated by multiplying the average material depth by the RMaterial value from Table 1.2.

1. Bear in mind that 2 x 4 and 2 x 6 framing members are given as nominal, not actual, dimensions. In other words, for framing members manufactured after 1960, a "2 x 4" stud is actually 1-1/2" wide and 3-1/2" deep while a "2x6" stud is 1-1/2" wide and 5-1/2" deep. Those manufactured prior to 1960 may be closer to true 4" or 6" depths. Also, drywall thicknesses vary between 1/2", 5/8", and, in some fire-rated assemblies, 1". In some cases there may be a layer of exterior rigid insulation that gives the studs and jambs a deceptively wider appearance. This condition is addressed further in the insulation section.

2. Another hint to the presence of cavity insulation may be the discovery of kraft paper insulation facing that is visible in the cavity or caught on the probe's barb. Kraft paper-faced fiberglass or rockwool batts are common.

Step 4

Determine the Most Appropriate R-Value

For each wall type identified above, an appropriate R-Value must be selected from the Walls section of the Checklist. The Checklist offers a limited range of insulation values, so the Inspector must mark which value most nearly coincides with the observed characteristics of each wall type. The categories are defined as follows:

No Insulation: Any wall construction type that has no cavity insulation and either no continuous exterior insulation or continuous exterior insulation with an R-value less than 3. Examples: Exposed double-wythe brick walls, framed walls with no cavity insulation (including those with fibrous insulating sheathing board), or uninsulated concrete masonry walls.

>R-3 Continuous: Any wall construction that has no cavity insulation and exterior continuous insulation with an R-value between 3 and 4. Examples: Framed walls with insulated siding, framed or masonry walls with 1/2" polyisocyanurate continuous exterior insulation, and/or framed or masonry walls with 1" thick expanded polystyrene continuous exterior insulation.

R-5 Continuous: Any wall construction that has no cavity insulation and exterior continuous insulation with an R-value between 4 and 7. Examples: Framed or masonry walls with 1" extruded polystyrene continuous exterior insulation, framed or masonry walls with 1” polyisocyanurate continuous exterior insulation, or framed walls with 1/2" fibrous insulation sheathing board and R-3.5 insulated siding.

R-13: Any above-grade, 2 x 4 wall containing cavity insulation of any type other than closed-cell spray foam. Examples: 2 x 4 walls w/rock wool batts, fiberglass batts, dense-packed cellulose, or dense-packed fiberglass.

Uninsulated Basement Wall: Any uninsulated wall, or portion of a wall, that separates the conditioned living space of the Unit from ambient earth. Examples: Concrete or masonry foundation walls (exposed on the interior) with no exterior rigid insulation between the concrete and the adjacent earth, concrete or masonry foundation walls with interior furring but no cavity insulation and no exterior insulation, or rubble foundation walls.

>R-19: Any above-grade, 2 x 6 wall completely filled with cavity insulation of any type. Examples include: 2 x 6 walls with fiberglass batts, dense-packed cellulose, or dense-packed fiberglass.

Shared Wall: Any wall determined to be located between the Unit and another conditioned space (defined in greater detail above).

Insulated Basement Wall: Any insulated wall, or portion of a wall, that separates the conditioned living space of the Unit from ambient earth. Examples include: concrete or masonry foundation walls with exterior rigid insulation between the wall and the adjacent earth, or concrete or masonry foundation walls with interior furring containing any type of cavity insulation.

Other Wall Types: In the event that a wall assembly is encountered that does not appear to align with any of the categories prescribed on the Checklist, the wall assembly’s U-Value may be calculated and points may be assigned using Table 1.1 - Wall Points U-Value Alternate. Wall assembly U-Values shall be calculated using the process outlined in Appendix A.

Step 5

Assign Appropriate Percentages

Where multiple wall types are present within the Unit, their thermal performance characteristics must be assigned according to their representative portion of the total wall area. In order to maintain the simplicity of the Checklist, this value is divided into 25% increments. In reality, a given Unit may have more than four different wall types. In these cases the four most dominant types, by area, must first be identified. Then, rounding the nearest categorical value, the wall types must be assigned a presence of either: 0%, 25%, 50%, 75%, or 100%. The sum of the percentages indicated on the Checklist must equal 100%.

Step 6

Determine the Appropriate Number of Points

Assign the appropriate points for this section according to the procedure detailed in the introduction to the Technical User’s Guide. For walls where the U-Value was calculated according to the procedures detailed in Appendix A, points shall be assigned according to Table 1.1.

Table 1.1–Wall Points U-Value Alternate

WALLS Base:_____ Final:_____

U-VALUE	25%	50%	75%	100%
≥ 0.148	0	0	0	0
0.147 – 0.128	3	6	9	12
0.127 – 0.097	4	8	12	15
0.096 – 0.061	5	10	15	20
0.060 – 0.040	5	11	16	21
≤ 0.039	6	13	19	26

Table 1.2–Insulating Materials

Rigid Board	
Material	**$R_{Material}$ (R-Value per Inch of Depth)**
Fibrous Insulating Sheathing Board (Tuff-R or similar) – first layer	1.6 (improvement over plywood)
Fibrous Insulating Sheathing Board – any additional layers	2.5
Expanded Polystyrene (molded beads) – EPS	3.9
Extruded Polystyrene (blue or pink board or similar) - XPS	5.0
Cellular Polyisocyanurate (typically foil-faced)	6.5 (aged)

Batts	
Material	**$R_{Material}$**
Rock Wool (Loose or Batt)	3.0
Fiberglass Batt (Typical)	3.1

Loose Fill / Blown-In	
Material	**$R_{Material}$**
Loose Fiberglass	3.2
Dense-Packed Fiberglass	4.2
Loose Cellulose	3.3
Dense-Packed Cellulose	3.7

Spray Foam	
Material	**$R_{Material}$**
Open-Cell Polyurethane Foam	3.6
Closed-Cell Polyurethane Foam	6.8

Section 2: Windows / Fenestration

Step 1

Locate All Windows and Doors

All windows, skylights and doors located within the thermal boundary of the unit must be identified.

Step 2

Determine Predominant Fenestration Types Windows, skylights and doors must be included in the Checklist category that most nearly resembles windows charac-teristics. In the event that opaque doors represent 25% or more of the total fenestration area, the predominant door type

Quick Notes Windows

Thermal Boundary: All windows (including skylights and relevant doors) in the thermal boundary must be evaluated.

Predominant Types: If a Unit has more than four window/door types, the four most dominant types, by area, must first be identified.

be categorized according to its National Fenestration Rating Council (NFRC)-rated U-Factor or according to the equivalents provided in Table 2.1 (right). The Checklist provides the following window/fenestration types:

Single Metal (1.20 U-Factor): Windows constructed of a single layer of glass within a frame that consists primarily of a metal material (typically aluminum or steel). Any window or door with a determined U-Factor of 1.09 or greater shall be placed in this category.

Single Non-Metal (0.95 U-Factor): Windows constructed of a single layer of glass within a frame that consists primarily of a non-metal material (typically wood or vinyl). Any window or door with a determined U-Factor that ranges from1.08 to 0.89 shall be placed in this category.

Double Metal (0.80 U-Factor): Windows constructed of two layers of glass within a frame that consists primarily of a metal material (typically aluminum or steel). Any window or door with a determined U-Factor that ranges from 0.88 to 0.69 fits this category.

Double Non-Metal (0.55 U-Factor): Windows constructed of two layer of glass within a frame that consists primarily of a non-metal material (typically wood or vinyl). Any window or door with a determined U-Factor that ranges from 0.68 to 0.46 shall be placed in this category.

0.35 U-Factor: Windows or doors with NFRC-rated U-Factors that range from 0.45 to 0.33. Residential-type windows that have been installed since June, 2001 for which there is no available NFRC or manufacturers' data shall be categorized as 0.35 U-Factor windows.

Additionally, historically designated properties and properties older than 50 years with wooden window frames that rehabilitate and install storm panels will receive credit at the 0.35 U-Value level.

0.30 U-Factor: Windows or doors with NFRC-rated U-Factors that range from 0.32 to 0.26. Windows installed since 2010 that are ENERGY STAR qualified will have a U-Factor in this category or better.

<0.25 U-Factor: Windows or doors with NFRC-rated U-Factors that are 0.25 or less.

Step 3

Assign Appropriate Percentages

Where multiple fenestration types are present within the Unit, their thermal performance characteristics must be assigned according to their representative portion of the total window and door area. In the event that a given Unit has more than four window/door types, the four most dominant types, by area, must first be identified. Then, rounding the nearest categorical value, the window/door types must be assigned a presence of either 0%, 25%, 50%, 75%, or 100%. The sum of the percentages indicated on the Checklist must equal 100%.

Table 2.1 - Door/Window Equivalent Defaults

Door Type	Default Category
Uninsulated Metal	Single Metal
Uninsulated Metal w/ Storm	Single Metal
Insulated Metal	Double Non-Metal
Insulated Metal w/ Storm	Double Non-Metal
Wood	Double Non-Metal
Wood w/ Storm	Double Non-Metal
Insulated Non-Metal	0.35 U-Factor
Insulated Non-Metal w/ Storm	0.35 U-Factor

Step 4

Determine the Number of Points

Assign the appropriate number of points for this section according to the procedure detailed in the introduction to this user's guide.

Section 3: Ceilings

Step 1

Locate the Thermal Boundary

The Inspector must identify each of the flat and/or vaulted ceilings that constitute the upper portion of the Unit's thermal boundary. The Inspector should classify any portion of the Unit's thermal boundary that has a slope of 45° or less as a ceiling. Portions of the Unit's thermal boundary that have a slope of 46° or greater should be classified as walls. Any floor/ceiling assemblies that exist entirely within the Unit's thermal boundary are to be ignored. Once the ceilings that comprise the Unit's thermal boundary have been identified, proceed to the following steps to evaluate only those ceilings.

Step 2

Establish Ceiling Location

Shared Ceilings: Because heat transfer across a boundary that separates two conditioned spaces is generally insignificant relative to heat transfer across other thermal boundary areas, the Inspector must determine which, if any, ceiling areas in the Unit are "shared ceilings". For the purposes of the Checklist, to be considered a shared ceiling the space on the opposite side of the evaluated ceiling must maintain a temperature (via thermostat control) that is reasonably similar to the temperature within the Unit. In other words, ceilings that separate the Unit from another residential dwelling, a conditioned corridor, conditioned common space, or a conditioned commercial space should be considered shared ceilings. On the other hand, ceilings that separate the Unit from an unconditioned space such as an attic or deck should not be considered shared ceilings. Similarly, dropped or under-framed ceilings that separate the living space from a conditioned attic space should be ignored as they are not part of the Unit's thermal boundary.

Step 3

Establish Ceiling Const. Characteristics

For those ceilings that are not considered shared ceilings, their thermal performance characteristics must be determined. Evaluating these characteristics in an attic-type assembly can generally be accomplished by locating an attic access hatch and observing the ceiling insulation from above. In some cases the attic may only be accessible via a hatch or vent on the building's exterior or via a hatch located in another Unit. Vaulted or cathedral ceilings present a greater challenge as their cavities are generally not accessible, much like an exterior wall. In order to assign the appropriate points in this section, the Inspector should determine:

Is the Ceiling an Attic-type or Vaulted Assembly? Attic-type ceiling assemblies are those where the inside face of the roof sheathing is substantially removed from the top face of the framing members that support the ceiling finish material. In a vaulted ceiling assembly, the inside face of the roof sheathing material is typically in direct contact with the top face of the framing members that support the ceiling finish. In general, an attic-type assembly will allow a layer of insulating material to lie continuously over the top of the framing members that support the ceiling finish material where vaulted ceiling assemblies cannot accommodate any layers of continuous insulation unless that material is installed against the outside face of the roof sheathing material.

Step 4

Determine the Most Appropriate R-Value

For each ceiling assembly identified above, an appropriate category must be selected from the Ceilings section of the Checklist. The Checklist offers a limited range of insulation values, so Inspectors must determine which value most nearly coincides with the observed characteristics of each identified ceiling type. The categories are defined as:

For Attic-type Assemblies: Access the attic area via the attic hatch or an exterior vent. Determine the type(s) of insulation present and establish the associated depths. Be sure to note the depth and spacing of the ceiling's framing members that may be concealed beneath the insulation.[1]

Assign the Appropriate R-Value. Based on the assessment, determine the appropriate R-Value from the Checklist. The categories are defined as follows:

No Insulation: Attic is uninsulated

R-19: Attic is insulated with material labeled as achieving R-19

R-30: Attic is insulated with material labeled as achieving R-30

>R-38: Attic is insulated with material labeled as achieving R-38 or greater

Other Ceiling Types: Where no label is visible or where the attic is insulated in part or entirely with loose fill material, the attic assembly's U-Value may be calculated and points may be assigned using Table 3.5 - Ceiling Points U-Value Alternate. The ceiling assembly U-Value shall be calculated using the process outlined in Appendix B.

Quick Notes
Ceilings

Thermal Boundary: Any portion of the thermal boundary with a slope of 45° or less is a ceiling.

Vaulted Ceilings: Evaluating vaulted ceilings can be tricky. The process is similar to that of evaluating walls.

Predominant Types: The four most dominant ceiling types, by area, must first be identified.

1 In some cases, there may be an inaccessible attic space either because no access is available or because the access hatch is located inside another unit. When the access is located within another unit, the Inspector should work

For Vaulted Ceiling Assemblies: Assessing the thermal characteristics of a vaulted ceiling assembly presents the same challenges as assessing existing walls. As such, the process is very similar to that performed in the wall section above. Vaulted ceiling assemblies should be assessed by:

A. Determine the framing depth because there usually are not any fenestration penetrations through a vaulted ceiling, determining the depth of the framing members is usually not possible without probing the ceiling cavity. Even where there is a skylight present, the depth of the ceiling framing can be difficult to ascertain because skylights are generally mounted on a curb that gives the ceiling assembly a deceptively thick appearance.

In some cases it may be possible to assess the depth of a vaulted ceiling's framing members by observing the eaves or outriggers at the Unit's exterior. Generally, however, vaulted ceiling framing depth should be determined by removing a light fixture or duct register cover, and then passing a non-conductive probe between the electrical box or duct boot and the adjacent drywall. Taking great care not to touch the wires or contacts within the electrical box, slide the probe into the ceiling cavity, perpendicular to the plane of the ceiling, until it comes into contact with the inside face of the exterior roof sheathing. Then mark the depth on the probe and withdraw it from the ceiling. If the mark is ~8" from the end of the probe, then the ceiling is likely constructed with 2 x 8 rafters. If the mark is ~10" from the end of the probe, then the ceiling is likely constructed with 2 x 10 rafters, and so on.

As many Boulder structures have had additions and/or remodels, do not assume that because you have established the framing depth for one vaulted ceiling type, that you know the characteristics of all vaulted ceilings. Look for indications of additions or remodels (e.g. changes in ceiling texture, flooring material, updated windows, newer fixtures, etc.) that may hint at the presence of different ceiling construction in certain areas.

B. Determine if framing cavities contain insulation. With the following procedure, the Inspector must determine whether or not ceiling cavities contain insulation. Remove at least one of the following from every non-shared, vaulted ceiling type that has been identified within the Unit: light fixture base; register cover; or any other easily removable cover that gives access to the cavity behind the ceiling finish material.

Locate an opening large enough that the non-conductive probe may be passed into the ceiling cavity. In the event that the drywall fits very tightly against the electrical box, duct boot, etc, then lightly trace the cover with a pencil to determine whether or not the opening could be enlarged sufficiently to allow the probe to pass into the ceiling cavity while still being hidden by the fixture or register cover when it is replaced.

Pass the probe into the ceiling cavity, taking care to avoid contact with any electrical wires or contacts, and then attempt to snag any insulating material that may be located within the ceiling cavity. Carefully remove the probe in order to confirm the presence and type of any insulating material caught on the barb. Insulating materials most commonly found in vaulted ceiling cavities in Boulder include fiberglass batts, rockwool batts, or blown cellulose.

C. Determine if there is continuous exterior rigid insulation present. In some cases, exterior rigid insulation board may be installed on top of the roof sheathing and below the roofing material. Typically, the fascia boards and flashings will conceal this insulation on sloped roofs. On flat roofs, tapered rigid insulation is typically installed on top of the roof sheathing and beneath a rubberized roofing membrane in order to direct rainwater toward drains or scuppers. In instances where the ceiling R-Value is calculated using the procedures below, flat-roofed structures with un-vented ceiling cavities that feature exterior tapered rigid insulation may be credited as having R-4 continuous insulation in addition to any other insulation values present in the ceiling assembly.

Determine the appropriate R-Value. Based on the assessment, determine the appropriate R-Value from the Checklist. The categories are defined as follows:

No Insulation: Vaulted ceiling cavities are uninsulated and no continuous exterior insulation is present.

R-19: Vaulted ceiling cavities are 7-1/4" deep or less and the cavities are filled with any type of fibrous insulation.

R-30: Vaulted ceiling cavities are 9-1/4" to 10" deep and the cavities are filled with any type of fibrous insulation.

>R-38: Attic vaulted ceiling cavities are 11-1/4" deep or greater and the cavities are completely filled with any type of fibrous insulation.

Other Ceiling Types: In the event that a vaulted ceiling assembly is encountered that does not appear to align with any of the prescribed values given by the checklist, the assembly's U-Value may be calculated and points may be assigned using Table 3.5—Ceiling Points U-Value Alternate. The vaulted ceiling assembly U-Value shall be calculated using the process outlined in Appendix C.

Step 5

Assign Appropriate Percentages

Where multiple ceiling types are present within the Unit, their thermal performance characteristics must be assigned according to their representative portion of the total ceiling area. In order to maintain the simplicity of the Checklist, this value is divided into 25% increments. In the event that a given Unit has more than four ceiling types, the four most dominant types, by area, must first be identified. Then, rounding the nearest categorical value, the ceiling types must be assigned a presence of either 0%, 25%, 50%, 75%, or 100%. The sum of the percentages indicated on the Checklist must equal 100%.

Step 6

Determine the Appropriate Number of Points

Assign the appropriate number of points for this section according to the procedure detailed in the introduction to the Technical User's Guide. For attics or vaulted ceilings where the U-Value was calculated according to the procedures detailed in Appendix C, points shall be assigned according to Table 3.5

Table 3.5–Ceiling Points U-Value Alternate

CEILING Base:_____ Final:_____

U-VALUE	25%	50%	75%	100%
≥ 0.089	0	0	0	0
0.088 – 0.046	6	12	18	24
0.045 – 0.032	6	13	19	26
0.031 – 0.025	7	13	20	26
≤ 0.024	7	14	20	27

Section 4: Infiltration

Step 1

Calculate the Volume of Conditioned Space

The Inspector must calculate the volume (in cubic feet) of the Unit's conditioned space. For the purposes of this analysis, the conditioned volume includes all space within the Unit's primary air barrier, including the volume of any interior floor structures[1]. Typically, this calculation can be done by following these steps:

A. Calculate the total conditioned floor area by measuring the floor area that falls within the Unit's primary air barrier. For Units with multiple levels with varying areas or ceiling heights, it is advisable to measure and record the conditioned floor area of each level.

Quick Notes
Infiltration

Conditioned Space: All space within the Unit's primary air barrier must be calculated

Geometries: It may be easier to individually calculate the volume of geometric elements, such as cathedral ceilings.

Get ready to do some math.

B. For each level, multiply the conditioned floor area by the average distance from the top face of the floor to the top face of the floor above. In other words, the volume of any floor structures separating two levels should be included in the total conditioned volume calculation.

C. For one-story Units or for the top level of multi-story Units, calculate the conditioned volume by multiplying the conditioned floor area by the average distance from the top face of the floor to the inside face of the ceiling finish material; this is typically the primary air barrier of the ceiling assembly.

D. Where complex geometries exist, such as cathedral ceilings, it may be easiest to break out these areas and calculate their volumes individually.

E. Sum all of the volumes that were calculated for each level and/or complex geometric shape.

Step 2

Conduct Blower Door Depressurization Test

The Inspector shall perform a blower door depressurization test using the protocol described in Section 8 of ASTM Standard E779-10, with modifications per Appendix A of the Mortgage Industry National HERS Standards 2006. The procedure is detailed on the following page. The following protocol shall be followed in preparing the Unit for testing:

A. Set any atmospherically-vented water heaters within the Unit to the "Pilot" setting or otherwise ensure that the water heaters do not activate during the test procedure. Set any furnace power switches to the "Off" position.

B. Configure the Unit per Appendix A of the Mortgage Industry National HERS Standards 2006, as Appendix E.

1. Uninhabitable conditioned spaces such as conditioned crawl spaces or conditioned attics must have their volumes included in this calculation. Similarly, unconditioned basements where the thermal boundary is located at the floor separating the main living space and the basement should not have their volumes included in this calculation. Bear in mind that taking measures such as insulating and conditioning a crawl space in order to comply with the requirements of SmartRegs will result in different volumes used in the base case and final case infiltration testing.

C. Insert the blower door assembly through a penetration in the Unit's envelope. This is typically achieved through a door to the outside, though it may be through a window or other opening where a door to outside is not available (such as in some multifamily buildings where Unit doors access conditioned common hallways). Where a sufficiently large opening is not available, and/or the Unit is suspected to be substantially "tight," or the Unit has a very small interior volume, it may be necessary to use a duct blaster apparatus in lieu of a blower door. Once the apparatus is installed, configure the device to perform a fan depressurization test per the manufacturer's instructions.

D. Leave blower door cover installed until a baseline indoor/outdoor pressure difference (ΔP) is recorded.

E. Install a length of tubing such that it passes through the building envelope, connecting the interior and exterior space. Position the exterior end of the tubing such that it is sheltered from wind (including that induced by the blower door apparatus) and is free of obstructions such as dirt, snow or water. In general, the exterior end of the tube should remain on the same side of the Unit and in the general vicinity of the blower door apparatus. Attach the interior end of the tubing to the Reference Tap on Channel A of the manometer.

F. Install a second length of tubing connecting the blower door fan pressure tap to the Input Tap on Channel B of the manometer.

G. Configure the manometer to conduct a fan depressurization test per the manufacturer's instructions.

H. Measure the baseline ΔP with the fan opening covered and the fan off.

I. Calibrate the manometer to establish the baseline ΔP as the test zero point.

J. Following blower door manufacturer's instructions, perform a single-point depressurization test at a calibrated ΔP of 50 Pascals, then record the fan flow rate ("CFM50"). If the flow rate is varying dramatically due to wind or other mitigating factors, it may be necessary to take an average flow rate over a period of time. Further, a multipoint depressurization test, though not required, is highly advised, especially when that test is computer-assisted. The results of these tests tend to be more accurate and provide a greater depth of information about the nature of air infiltration in the Unit.

K. Return water heaters to previous temperature setting and return furnace switch to the "On" position.

Step 3

Calculate the ACHn

Calculate the Unit's Infiltration Rate in Air Changes per Hour at 50 Pascals ΔP WRT Outdoors (ACH_{50}). Once the Unit's CFM_{50} value has been determined, calculate the Unit's ACH_{50} value by applying the equation below:

$$ACH_{50} = \frac{CFM_{50} * 60}{\text{UNIT VOLUME}}$$

Calculate the Unit's Infiltration Rate in Natural Air Changes per Hour (ACHn). The Inspector must apply the following procedure in order to determine the Unit's ACHn. Determine the appropriate value for "n" from Table 4.1.

	# of Stories Above Grade				
Wind Exposure	**1**	**1.5**	**2**	**2.5**	**3**
Well-shielded	22.2	20.0	17.8	16.6	15.5
Normal	18.5	16.7	14.8	13.9	13.0
Exposed	16.7	15.0	13.3	12.5	11.7

Calculate the Unit's ACHn by applying this equation:

$$ACHn = \frac{ACH_{50}}{n}$$

Step 4

Determine the Number of Points

The ACHn value should be rounded to the nearest categorical value. Rounding shall be performed as shown on the next page.

- **0 POINTS:** Units with an ACHn of 1.21 or more
- **2 POINTS:** ACHn of 1.20 to 0.98
- **4 POINTS:** ACHn of 0.97 to 0.63
- **6 POINTS:** ACHn of 0.62 to 0.36
- **7 POINTS:** ACHn of 0.35 or less
  Must be ventilated per ASHRAE Standard 62.2

Section 5: Slab / Foundation

Quick Notes
Foundation

Thermal Boundary: Generally, a foundation's thermal boundary is located at the building component across which the greatest temperature differentials occur during the heating season.

Step 1

Locate the Thermal Boundary

The bottom portion of the thermal boundary can be located in a variety of places depending on the nature of Unit's foundation and the location of any insulating material. In general, the thermal boundary is located at the building component across which the greatest temperature differentials occur during the heating season. For any portion of a Unit that lies over a crawl space containing space heating equipment or distribution systems (whether insulated or not), the Inspector should consider the thermal boundary to be located at the foundation walls.

Step 2

Determine the Applicable Category

Once the thermal boundary has been defined, determine which of the Checklist categories best describe the identified thermal boundary location(s). The categories are as follows:

Slab-on-Grade: This category applies to any portion of a Unit's floor that consists of a concrete slab resting atop ambient soil where the top face of the slab is 12 inches or less below grade.

Below-Grade Slab (Basement Slab): This category applies to any portion of a Unit's floor that consists of a concrete slab resting atop ambient soil where the top face of the slab is more than 12" below grade.

Foundation Walls (Crawl Space): This category applies to Units located atop a directly or indirectly conditioned crawl space. For the purposes of the Checklist, any crawl space that contains space heating equipment and/or heating ductwork (whether insulated or not) is considered to be an indirectly-conditioned crawl space, regardless of the presence of crawl space vents.

Framed Floor: This category applies to any portion of a Unit's floor that is located atop a vented crawl space that is not conditioned and that contains no heating equipment, and/or heating ductwork.

Step 3

Determine the Predominant R-Value(s)

Slab-on-Grade: The Checklist provides two potential insulation locations for slab-on-grade floors; slab-edge insulation and under-slab insulation.

Slab-Edge Insulation: This refers to any continuous insulation material that lies between the slab's perimeter and the ambient air or soil adjacent to the slab. This insulation may be located on the exterior face of the foundation wall or between the inside face of the foundation wall and the outer perimeter of the slab. In either case, in order to be credited as slab-edge insulation, the insulation must start at the top face of the slab and descend at least 12" below grade. In order to minimize the penalty for existing slab-on-grade structures that lack slab-edge insulation, points have been awarded on the Checklist for R-0 or no insulation. R-Values for slab-on-grade floors that are insulated in accordance with the criteria above shall be calculated per the equation below using the $R_{Material}$ values from Table 1.2.

$$R_{Total} = (R_{Material} * DEPTH_{Material})$$

$R_{Material}$ = R-Value per inch of the continuous insulation material located at the slabedge or under-slab

Determine the most appropriate category. The Checklist categories are defined as follows:

Slab-Edge: >R-5: Slab-on-grade floors with slab-edge insulation meeting the criteria above and having an insulating value between R-5 and R-9. Note that any material with an insulating value of less than R-5 does not meet these requirements. As such, the commonly present ½" – ¾" thick fibrous material meant to allow for slab expansion/contraction does not have an insulating value that meets the requirements of this category.
Slab-Edge: >R-10: Slab-on-grade floors with slab-edge insulation meeting the criteria above and having an insulating value of R-10 or greater.

Under-Slab Insulation: Under-slab insulation refers to any continuous insulation material that lies between the bottom face of the slab and the ambient soil below the slab. As this insulation is not typically visible to the Inspector, its presence can only be established by the Unit owner. The Inspector should use their reasonable judgment in determining whether or not to credit the Unit as having under-slab insulation. In general, this type of insulation was only installed in projects built since the late 1970s, in particular those projects designed based on passive solar design principles. Points for under-slab insulation are only available for those slab-on-grade floors that also have slab-edge insulation.

Slab-Edge: >R-10 AND Under-Slab: >R-10: Slab-on-grade floor assemblies that have BOTH slab-edge insulation meeting the criteria above with an insulating value of R-10 or greater AND under-slab insulation meeting the criteria above with an insulating value of R-10 or greater.

Below-Grade Slab (Basement Slab): Because soil that is greater than 12" below grade typically maintains temperatures that are higher than the ambient air temperature during the heating season, winter heat loss across these slabs is not as significant slabs-on-grade. For this reason, all below-grade slabs are awarded points on the Checklist.

Foundation Walls (Crawl Space): As indicated in Step 1, for any portion of a Unit that lies over a crawl space containing space heating equipment or distribution systems (whether insulated or not), the Inspector should consider the thermal boundary to be located at the foundation walls. This is because a significant amount of heat is being lost to this area from the furnace/boiler cabinet, pipes serving a hydronic space heating system, and/or heating ductwork. Framed floor insulation is not credited in these situations because insulating in this location serves only to further ensure that this unintentionally lost energy is unable to reach the Unit's habitable space. When analyzing crawl space walls, insulation located on the interior or exterior face of the foundation walls qualifies. R-Values for foundation walls shall be calculated per the equation below using the $R_{Material}$ values from Table 1.2.

$$R_{Total} = (R_{Material} * DEPTH_{Material})$$

$R_{Material}$ = R-Value per inch of the continuous insulation material located at the slabedge or under-slab.

Inspectors must note that points are not to be awarded for crawl spaces which are fitted with foundation wall insulation but which lack a properly lapped and sealed vapor retarder and adequate ventilation. In order to earn points for crawl space wall insulation, crawl spaces must meet the requirements of Section R408.3 of the 2006 International Residential Code (IRC). The requirements for "Unvented crawl space" are as follows:"

1. Exposed earth is covered with a continuous vapor retarder. Joints of the vapor retarder shall overlap by 6 inches (152 mm) and shall be sealed or taped. The edges of the vapor retarder shall extend at least 6 inches (152 mm) up the stem wall and shall be attached and sealed to the stem wall; and
2. One of the following is provided for the under-floor space:
   - 2.1. Continuously operated mechanical exhaust ventilation at a rate equal to 1 cfm (0.47 L/s) for each 50 ft2 (4.7m2) of crawlspace floor area, including an air pathway to the common area (such as a duct or transfer grille), and perimeter walls insulated in accordance with Section N1102.2.8;
   - 2.2. Conditioned air supply sized to deliver at a rate equal to 1 cfm (0.47 L/s) for each 50 ft2 (4.7 m2) of under-floor area, including a return air pathway to the common area (such as a duct or transfer grille), and perimeter walls insulated in accordance with Section N1102.2.8;
   - 2.3. Plenum complying with Section M1601.4, if under-floor space is used as a plenum.

Determine the most appropriate category. The checklist categories are defined as follows:

R-0: Foundation wall assemblies that include no insulation on the interior or exterior.
R-2: Foundation wall assemblies that include interior and/or exterior insulation with an insulating value within the range of R-2 to R-6.
R-11: Foundation wall assemblies that include interior and/or exterior insulation with an insulating value within the range of R-7 to R-18.
>R-19: Foundation wall assemblies that include interior and/or exterior insulation with an insulating value of R-19 or greater.

Framed Floor: Those portions of a Unit's framed floor that lie over an unconditioned space (including unconditioned crawl space or basement volumes provided that those volumes contain no space heating equipment or distribution systems) should be assigned points under this category. The Checklist provides the following framed floor insulation categories:

Framed Floor: R-0: Framed floors assemblies, over unconditioned space, that include no cavity insulation.

Framed Floor: R-13: Framed floors assemblies, over unconditioned space, that include cavity insulation with an insulating value within a range of R-7 to R-19.

Framed Floor: R-25: Framed floors assemblies, over unconditioned space, that include cavity insulation with an insulating value within a R-20 to R-37 range.

Framed Floor: >R-38: Framed floors assemblies, over unconditioned space, that include cavity insulation with an insulating value of R-38 or greater.

Shared Floor: Framed floor assemblies that lie between the Unit and another conditioned space such as another dwelling unit, conditioned common space, or commercial space.

Other Floor Assemblies: In the event that a framed floor assembly is encountered that does not appear to align with any of the prescribed values given by the checklist or where the framed floor assembly includes continuous insulation, the assembly's U-Value may be calculated and points may be assigned using Table 5.3d - Framed Floor Points U-Value Alternate. The framed floor assembly U-Value shall be calculated using the process outlined in Appendix D.

Step 4

Assign Appropriate Percentages

The total percentage for all categories in the Slab/Foundation section of the Checklist must equal 100%. Foundation Wall category shall be assigned its percentage of the total floor area according to the area of the framed floor above the crawl space, not the area of the foundation walls. Where appropriate, this percentage may be further sub-divided to accommodate multiple foundation wall types.

Step 5

Determine the Appropriate Number of Point

Assign the appropriate number of points according to the procedure detailed in the intro to the Technical User's Guide.

Section 6: Duct Leakage

Step 1

Determine the Unit's Rate of Duct Leakage to Outside at 25 Pascals ΔP ("CFM25")

The Inspector shall perform a duct leakage to outside test using the protocol described in Annex B of ASHRAE Standard 152-2004, with modifications per Appendix A of the Mortgage Industry National HERS Standards 2006, including RESNET Formal Interpretation 2006-002. The procedure is detailed in Appendix F.

For Units where all ducts are located within the conditioned envelope (i.e., on the inside of the thermal boundary and primary air barrier), AND where the Unit has achieved a tested air infiltration rate below 3.0 ACH50, the maximum number of points available may be awarded WITHOUT performing a duct leakage to outside test.

Step 2

Calculate the Unit's Area-Normalized Rate of Duct Leakage to Outside ("CFM25 per 100 square feet")

Determine the Unit's area-normalized rate of duct leakage to outside by performing this calculation:

$$CFM_{\text{per 100 SF}} = \frac{CFM_{25}}{A_{\text{Unit}} / 100}$$

CFM25 = Rate of duct leakage to outside in cubic feet per minute at 25 Pascals, AUnit = Area of Unit is square feet

Step 3

Determine the Appropriate Number of Points

In order to determine the appropriate number of points to be assigned on the Checklist, the CFM per 100 SF value should be rounded to the nearest categorical value. Rounding shall be performed as follows:

Units with a duct leakage to outside rate of ...

0 points: 70 CFM per 100 SF or greater

4 points: 50 to 69 CFM per 100 SF

9 points: 30 to 49 CFM per 100 SF

14 points: 11 to 29 CFM per 100 SF

17 points: 10 CFM per 100 SF or less and Units that have no ducts

Section 7: Distribution System

To determine the appropriate number of points to award in this section, the Inspector must identify the space heating delivery systems present within the Unit. Typically, these will be either a network of ducts in the case of a forced-air heating system or a network of pipes in the case of a "radiant" system (hot water baseboard, steam radiator, radiant floor, etc.). Units primarily heated by electric resistance baseboards are automatically awarded the maximum number of points in this category. For this section there are two critical pieces of information that must be ascertained about the components of the delivery system—location and insulation.

Location: In this section, location refers to whether the ducts or pipes are located inside or outside of the Unit's thermal boundary (i.e., in conditioned or unconditioned space). The Inspector must judge the percentage of the delivery system that falls into both categories.

Insulation: The Inspector must then determine what percentage of the ducts or pipes that are located in unconditioned space (outside of the thermal boundary) are wrapped in insulation (R-4 minimum).

Once these two items have been established, the Inspector shall assign the appropriate number of points for this section according to the procedure detailed in the introduction to the Technical User's Guide.

Section 8: Heating

In order to assign points in this section of the Checklist, the Inspector must determine the primary heating system's fuel type and efficiency. Where the Annual Fuel Utilization Efficiency ("AFUE") is not available for a natural gas furnace, refer to Table 8.1 or consult the AHRI Directory to determine the appropriate category. The Coefficient of Performance ("COP") for a ground source heat pump must be determined using the values listed in the Air-Conditioning, Heating, and Refrigeration Institute ("AHRI", formerly "ARI") Directory of AHRI Certified Water-to-Air and Brine-to-Air Heat Pumps. If unable to determine the Annual Fuel Utilization Efficiency for mechanical equipment using the AHRI Directory, consult Table 8.1 and/or Table 8.2 in order to assign "Default Values for Mechanical System Efficiency" based on the equipment's characteristics or vintage. Points for this section shall be awarded as follows:

0 POINTS: Electric baseboard heating systems, electric furnaces and boilers, air source heat pumps, fuel oil furnaces and boilers, natural gas furnaces with an AFUE of 74% or less

13 POINTS: Natural gas furnaces with an AFUE of 75% to 84%

17 POINTS: Natural gas furnaces with an AFUE of 85% to 93%

19 POINTS: Natural gas furnaces with an AFUE of 94% or greater

29 POINTS: Ground source heat pumps with a COP of 3.3 to 3.7

38 POINTS: Ground source heat pumps with a COP of 3.8 to 4.4

43 POINTS: Ground source heat pumps with a COP of 4.5 or greater

Table 8.1 – Natural Gas Furnace / Boiler Default Efficiencies (Characteristic-based)

Efficiency (AFUE)	Typical Characteristics
<70%	metal flue pipe, draft hood or draft diverter, no inducer motor, ribbon burner, standing pilot
~80%	metal flue pipe, inducer motor tied to flue, no draft hood or diverter, no ribbon burner, advanced heat exchanger, electronic ignition
>90%	PVC flue pipe (typically flue pipe AND combustion air intake both present), secondary condensing heat exchanger
>96%	same as above – increased efficiency can only be verified by the ENERGY GUIDE sticker (if present), consulting the AHRI Directory, or consulting the manufacturer's data

Section 9: Cooling

In order to assign points in this section of the Checklist, the Inspector must first determine whether or not there is a cooling system present in the Unit. If any of the cooling systems identified below are present, the primary cooling system type and efficiency must be determined. Where the Seasonal Energy Efficiency Ratio (SEER) is not available for a Direct Expansion (DX) air conditioning unit or air-source heat pump, refer to Table 9.1 or consult the AHRI Directory to determine the appropriate category. The Energy Efficiency Ratio (EER) for a ground source heat pump must be determined using the values listed in the Air-Conditioning, Heating, and Refrigeration Institute (AHRI, formerly ARI) Directory of AHRI Certified Water-to-Air and Brine-to-Air Heat Pumps. If unable to locate the equipment in the AHRI Directory, consult the manufac-

Table 8.2 Default Values for Mechanical System Efficiency (Age-based)

Mechanical Systems	Units	Pre-1960	1960-1969	1970-1974	1975-1983	1984-1987	1988-1991	1992 to present
Heating:								
Gas Furnace	AFUE	0.60	0.60	0.65	0.68	0.68	0.76	0.78
Gas Boiler	AFUE	0.60	0.60	0.65	0.65	0.70	0.77	0.80
Oil Furnace or Boiler	AFUE	0.60	0.65	0.72	0.75	0.80	0.80	0.80
Air-Source Heat Pump	HSPF	4.50	4.50	4.70	5.50	6.30	6.80	6.80
Ground-Water Geothermal Heat pump	COP	2.70	2.70	2.70	3.00	3.10	3.20	3.50
Ground-Coupled Geothermal Heat Pump	COP	2.30	2.30	2.30	2.50	2.60	2.70	3.00

turer's specifications to find the appropriate EER under AHRI specified operating conditions. Points for this section shall be awarded as follows:

0 POINTS: DX air conditioners w/SEER of 12 or less

4 POINTS: DX air conditioners w/SEER of 13 and Ground source heat pumps with an EER of 13.6 or greater

6 POINTS: DX air conditioners w/SEER of 14 to 15, direct evaporative coolers, units with no A/C systems

7 POINTS: DX air conditioners w/SEER of 16 to 17

8 POINTS: DX air conditioners w/SEER of 18 or greater and indirect evaporative coolers

Table 9.1 - Air Conditioner Default Efficiencies

Type	Vintage	Efficiency (SEER)
Window Unit	1970's and earlier	6.5
Window Unit	1980's	7.5
Window Unit	1990's	8.5
Window Unit	2000's	10
Central A/C	1970's and earlier	6.5
Central A/C	1980's	8
Central A/C	Federal Minimum Standard from 1992 to 2005	10
Central A/C	Federal Minimum Standard from 2006 to Present	13
Central A/C – ENERGY STAR Qualified	2009 and later	14.5

Section 10: Whole House Fans

Units that feature an operating whole-house fan should be awarded 2 points in this section of the Checklist. The Inspector must turn on the whole-house fan to ensure that it is in working condition.

Section 11: Lighting

Step 1

Determine % of High-Efficacy Light Bulbs

1 . Record the number of incandescent and CFL or LED lamps in the Unit. Consider lamps in permanent fixtures only; temporary lamps (e.g. floor lamps and table lamps) are not to be counted for this point.

2.Calculate the percentage of high-efficacy lighting by applying the following equation.

$$HEL = 100 \left(\frac{Lamps_{HE}}{Lamps_{Total}} \right)$$

HEL = % of Unit's lighting that is high-efficacy (pin-based fluorescent,CFL,LED, tubular skylights)

$Lamps_{HE}$ = Total number of lamps that qualify as high-efficacy

$Lamps_{Total}$ = Total number of lamps

Tubular Skylights: Count as one high efficiency light bulb in this equation

Step 2

Determine the Appropriate Number of Points

In order to determine the appropriate number of points to be assigned on the Checklist, the HEL percentage should be rounded to the nearest categorical value. Rounding shall be performed as follows:

0 POINTS: Units with HEL of 12% or less

2 POINTS: Units with HEL of 13% to 37%

4 POINTS: Units with HEL of 38% to 62%

6 POINTS: Units with HEL of 63% to 87%

7 POINTS: Units with HEL of 88% or greater

Section 12: Water Heating

In order to assign points in this section of the Checklist, the Inspector must determine the primary domestic water heating (DWH) system's fuel type and efficiency. Where the Energy Factor (EF) is not available for a water heater, refer to Table 12.1 or consult the AHRI Directory to determine the appropriate category. Points for this section shall be awarded as follows:

0 POINTS: Electric DWH systems, fuel oil DWH systems, heat pump DWH systems, and storage-type, natural gas DWH systems with an EF of 0.58 or less

1 POINT: Storage-type, natural gas DWH systems with an EF of 0.59 to 0.61

2 POINTS: Storage-type, natural gas DWH systems with an EF of 0.62 to 0.81

6 POINTS: Storage-type, natural gas DWH systems with an EF of 0.82 or greater and on-demand, natural gas DWH systems

0 POINTS: Indirect-fired DWH tanks linked to natural gas boilers with an AFUE of 70% or less

3 POINTS: Indirect-fired DWH tanks linked to natural gas boilers with an AFUE of 78% to 82%

5 POINTS: Indirect-fired DWH tanks linked to natural gas boilers with an AFUE of 90% or greater

Table 12.1 - Water Heater Default Efficiencies

Type	Vintage	Efficiency (EF)
Storage, typical	1980's and earlier	0.58
Storage, typical	1990's and 2000's	0.59
Storage, ENERGY STAR	2000's	0.62
Storage, ENERGY STAR	2011 and later	0.67

Section 13: Refrigeration

Locate Refrigerators, Freezers, Ice Makers

The Inspector must identify all refrigeration equipment in the Unit. This includes, but is not limited to, refrigerators, freezers, ice makers, beverage centers, and wine chillers. Refrigeration equipment located in garages, basements and other unconditioned or semi-conditioned spaces should be included in the inspection.

Determine the Annual Energy Consumption of the Equipment ("kWh/yr")

The annual energy consumption of the refrigeration equipment may be determined in several ways. The ENERGY GUIDE data for newer equipment can often be found by consulting the manufacturer's Website or by searching one of the following websites: www.appliances.energy.ca.gov and/or www.energystar.gov.

When the rated annual energy consumption of the equipment is unavailable, an estimate may be made by plugging the piece of equipment into an electricity usage monitoring device for as long as feasible (preferably over an hour). The device should provide an estimate of equipment's energy consumption in kilowatt hours per year ("kWh/yr").

In instances where the ENERGY GUIDE data is not available and where monitoring the equipment's energy consumption is not feasible, determine the appropriate value using one of the following two options:

A. Use the ENERGY STAR Refrigerator Retirement Savings Calculator, (www.energystar.gov/index.cfm?fuseaction=refrig.calculator) to estimate the energy consumption based on the unit type, age, and volume.

B. Determine the appropriate value from Table 13.1.

Table 13.1 - Refrigerator Consumption Defaults

Manufactured prior to 2000	750 kWh/yr
Manufactured in 2000 or later	650 kWh/yr
ENERGY STAR Manufactured prior to 2000	650 kWh/yr
ENERGY STAR manufactured in 2000 or later	450 kWh/yr

Once a reasonable kWh/yr value has been established for each piece of refrigeration equipment associated with the Unit, the values should be added together to determine the total kWh/yr.

Determine the Appropriate Number of Points

In order to determine the appropriate number of points to be assigned on the Checklist, the total kWh/yr should be rounded to the nearest categorical value. Rounding shall be performed as follows:

0 POINTS: Units with a total kWh/yr of 701

2 POINTS: Units with a total kWh/yr of 501 to 700

3 POINTS: Units with a total kWh/yr of 351 to 500

4 POINTS: Units with a total kWh/yr of 350 or less

Section 14: Solar Thermal

Units featuring operational solar thermal systems for space and/or domestic water heating shall be awarded points according to the amount of collector surface area. The method for calculating the appropriate number of points is provided below. Points for flat-plate collectors should be determined as follows:

$$\text{Checklist Points} = 8\left(\frac{(\mathbf{W}\text{Plate} * \mathbf{L}\text{Plate}) * (\#\text{ of Plates})}{20}\right)$$

WPlate = width of one flat-plate collector
LPlate = length of one flat-plate collector

Points for evacuated tube collectors should be determined by:

$$\text{Checklist Points} = 8\left(\frac{(\text{DTube} * \text{LTube}) * (\text{\# of Tubes})}{15}\right)$$

DTube = diameter of one evacuated tube
LTube = length of one evacuated tube

Section 15: Photovoltaics

NOTE: A unit must earn 70 prescriptive pathway points in other categories to be eligible for points in this category. Units featuring solar photovoltaic (PV) systems for on-site electricity generation shall be awarded points according to the rated output of the array, in kW. Points should be calculated according the following equation:

$$\text{Checklist Points} = 44\left(\frac{(\text{OPanel}) * (\text{\# of Panels})}{1000}\right)$$

OPanel = the rate output of one panel

Section 16: Occupant Behavior

The Inspector shall award points in the Occupant Behavior section of the Checklist as follows:

1 POINT: **Real Time Energy Monitoring Device:** Any device that provides instant feedback on the Unit's rate of electricity consumption

Programmable thermostat; provide operation / training manual: A manual which describes how to efficiently operate the systems in the house that regulate energy efficiency [e.g. heating/cooling, lighting controls, windows] systems in the property must be on-site and accessible to tenants

Tenant attends Energy Conservation Class: A certificate verifying that the tenant attended an energy conservation class must be provided to the inspector. For class info see: **www.bouldercolorado.gov/smartregs**

Section 17: Other

The Inspector shall award points in the "Other" section of the Checklist as follows:

1 POINT: **Heat Pump Desuperheater;** Only Unit's that are heated and cooled via a ground source heat pump are eligible to earn this point. A "Heat Pump Desuperheater" is a secondary heat exchanger that captures "waste" heat from a heat pump and uses it for domestic water heating.

3 POINTS: **Electronically Commutated Motor (ECM);** In order to earn this point, the blower motor of the Unit's primary air handler must be an electrically-efficient ECM motor. Electrically efficient furnaces are denoted with an "e" on the AHRI Certificate.

DISCRETIONARY: **Passive Solar Design;** In order to earn points in this category, a Unit owner must prove to the City of Boulder that the Unit is properly oriented and designed such that it meets a significant portion of its annual heating demands with passive solar gain. Once approved, the City of Boulder will determine the appropriate number of points to be awarded.

DISCRETIONARY: **Innovative Practice;** In order to earn points in this category, a Unit owner must prove to the City of Boulder that the Unit significantly reducing carbon dioxide emissions utilizing a means that is not directly addressed by any other section of the Checklist. Once approved, the City of Boulder will determine the appropriate number of points to be awarded.

Section 18: Mandatory Water Conservation

Two points in this section are required in addition to the 100 point Checklist. The Inspector shall award points in the Mandatory Water Conservation section as follows:

Low Flow Showerhead: In this category, 1 point is awarded when the average flow rate of all of the showerheads within the unit are 2.0 GPM or less. The average flow rate for all showerheads must be less than or equal to 2.0 gallons per minute (gpm). If the flow rate is not labeled on the showerhead, the inspector can do the following:

1. Turn the fixture on to its normal position
Place a container under the fixture and collect the water for 10 seconds.

2. Measure the quantity of water in the container and convert the measurement to gallons (e.g., 0.25 gallons).

3. Multiply the measured quantity of water by 6 to calculate the flow rate in gallons per minute (0.33 gal x 6 = 2.0 GPM).

Low Flow Lavatory Faucets: In this category, 1 point is awarded when the average of all the lavatory faucets within the unit are 1.5 GPM or less. The average flow rate for all lavatory faucets must be less than or equal to 1.5 gallons per minute (gpm). To measure the flow rate:

1. Turn the fixture on to its normal position.

2. Place a container under the fixture and collect the water for 10 seconds.

3. Measure the quantity of water in the container and convert the measurement to gallons (e.g., 0.25 gallons).

4. Multiply the measured quantity of water by 6 to calculate the flow rate in gallons per minute (0.25 gal x 6 = 2.0 GPM).

Self Closing Faucet Valves: In this category, 1 point is awarded when all faucets are installed with a self closing valve which automatically turns the water off after a certain period of time.

High-Efficiency or Dual-Flush Toilet: In this category, 2 points are awarded when the average rate of gallons per flush (gpf) for all of the toilets, including dual-flush toilets, in the unit are 1.28 gpf or less. When determining the flush rate for dual-flush toilets, use the following equation:

ENERGY STAR Washing Machine: In this category, 2 points are awarded for an ENERGY STAR washing machine. ENERGY STAR labels must stay on the equipment for inspection by a HERS rater or Class G inspector during inspection.

ENERGY STAR Dishwasher: In this category, 2 points are awarded for an ENERGY STAR dish washer. ENERGY STAR labels must remain on the equipment for inspection by a HERS rater or Class G inspector during final inspection.

Appendix A: Wall Assembly U-Value

Determine the assembly's Framing Factor ("FF"). FF is an approximation of the percentage of wall surface area that is represented by the framing members versus the wall surface area that is represented by cavity space. Select the appropriate FF from Table 1.1a.

Table 1.1a - Wall Framing Factor Defaults

Stud Spacing	Number of Plates	Plate Height	FF
16" on-center framing (typical)	3	8'	0.23
24" on-center framing	3	8'	0.20
16" on-center framing (typical)	3	10'	0.22
24" on-center framing	3	10'	0.19

Determine the total cavity insulation R-Value (R_{Cavity}). Using the $R_{Material}$ values (from Table 1.2) for the cavity insulation material(s) present, calculate the total cavity R-Value using the equation below[1].

$$R_{Cavity} = (R_{Material1} * Depth_{Material1}) + (R_{Material2} * Depth_{Material2}) + \ldots$$

$R_{Material1}$ = R-Value per inch of the first cavity insulation material present in the wall assembly
$R_{Material2}$ = R-Value per inch of a second cavity insulation material if present in the wall assembly

Determine the total continuous insulation R-Value (RContinuous). Using the RMaterial values (from Table 1.2) for the continuous insulation material(s) present, calculate the total continuous R-Value using the equation below.

$$R_{Continuous} = (R_{Material1} * Depth_{Material1}) + (R_{Material1} * Depth_{Material2}) + \ldots$$

$R_{Material1}$ = R-Value per inch of the first cavity insulation material present in the wall assembly
$R_{Material2}$ = R-Value per inch of a second cavity insulation material if present in the wall assembly

Determine the framing area R-Value ($R_{Framing}$). Select the appropriate $R_{Framing}$ value from Table 1.2a.

Table 1.2a - Wall Stud R-Value

Nominal Dimensions	Actual Depth	$R_{Framing}$
2x4	3.5"	4.38
2x6	5.5"	6.88
2x8	7.25"	9.06

Calculate the assembly's U-Value. Perform the calculation below to determine the U-Value of the wall assembly.

$$\text{U-Value} = \frac{1 - FF}{2.24 + R_{Cavity} + R_{Continuous}} + \frac{FF}{2.24 + R_{Framing} + R_{Continuous}}$$

1 Uninsulated 2x4 cavities shall be assigned an RCavity of 1.03. Uninsulated 2x6 cavities shall be assigned an RCavity of 1.62.

Appendix B: Attic Ceiling Assembly U-Value

Determine the assembly's Framing Factor (FF). FF is an approximation of the percentage of ceiling surface area that is represented by the framing members versus the ceiling surface area that is represented by cavity space. Select the appropriate FF from Table 3.1b.

Table 3.1b - Attic Framing Factor Defaults

Framing Spacing	FF
16" on-center framing (typical)	0.14
24" on-center framing	0.11

Determine the total cavity insulation R-Value (R_{Cavity}). In the case of an attic assembly, all insulation that is located in the cavity between the framing members is considered to be cavity insulation. Using the RMaterial values (from Table 1.2) for the cavity insulation material(s) present, calculate the total cavity R-Value using this equation:

$$R_{Cavity} = (R_{Material1} * Depth_{Material1}) + (R_{Material2} * Depth_{Material2}) + \ldots$$

$R_{Material1}$ = R-Value per inch of the first cavity insulation material present in the attic ceiling assembly

$R_{Material2}$ = R-Value per inch of a second cavity insulation material if present in the attic ceiling assembly

Determine the total continuous insulation R-Value ($R_{Continuous}$). In the case of an attic assembly, all insulation that runs uninterupted over the top of the framing members is considered to be continuous insulation. Using the RMaterial values (from Table 1.2) for the continuous insulation material(s) present, calculate the total continuous R-Value using this equation:

$$R_{Continuous} = (R_{Material1} * Depth_{Material1}) + (R_{Material2} * Depth_{Material2}) + \ldots$$

$R_{Material1}$ = R-Value per inch of the first cavity insulation material present in the attic ceiling assembly

$R_{Material2}$ = R-Value per inch of a second cavity insulation material if present in the attic ceiling assembly

Determine the framing area R-Value ($R_{Framing}$). Select the appropriate $R_{Framing}$ value from Table 1.2a.

Table 3.2b - Attic Framing R-Value

Nominal Dimensions	Actual Depth	$R_{Framing}$
2x4	3.5"	4.38
2x6	5.5"	6.88
2x8	7.25"	9.06
2x10	9.25"	11.56
2x12	11.25"	14.06

Calculate the assembly's U-Value. Perform the calculation below to determine the U-Value of the wall assembly[1].

$$\text{U-Value} = \frac{1 - FF}{1.67 + R_{Cavity} + R_{Continuous}} + \frac{FF}{1.67 + R_{Framing} + R_{Continuous}}$$

1 The constant value, 1.67, in the equation represents the estimated R-Value of the interior gypsum board, as well as the interior and exterior air films.

Appendix C: Vaulted Ceiling Assembly U-Value

Determine the assembly's Framing Factor (FF). FF is an approximation of the percentage of ceiling surface area that is represented by the framing members versus the ceiling surface area that is represented by cavity space. Select the appropriate FF from Table 3.3c.

Table 3.3c - Vaulted Ceiling Framing Factor Defaults

Framing Spacing	FF
Dimensional Lumber	
16" on-center framing (typical)	0.14
24" on-center framing	0.11
Truss Joist	
16" on-center framing (typical)	0.08
24" on-center framing	0.07

Determine the total cavity insulation R-Value (R_{Cavity}). Using the RMaterial values (from Table 1.2) for the cavity insulation material(s) present, calculate the total cavity R-Value using this equation:

$$R_{Cavity} = (R_{Material1} * Depth_{Material1}) + (R_{Material2} * Depth_{Material2}) + \ldots$$

$R_{Material1}$ = R-Value per inch of the first cavity insulation material present in the ceiling assembly

$R_{Material2}$ = R-Value per inch of a second cavity insulation material if present in the ceiling assembly

Determine the total continuous insulation R-Value ($R_{Continuous}$). Using the $R_{Material}$ values (from Table 1.2) for any continuous exterior insulation material(s) present, calculate the total continuous R-Value using this equation:

$$R_{Continuous} = (R_{Material1} * Depth_{Material1}) + (R_{Material1} * Depth_{Material2}) + \ldots$$

$R_{Material1}$ = R-Value per inch of the first cavity insulation material present in the ceiling assembly

$R_{Material2}$ = R-Value per inch of a second cavity insulation material if present in the ceiling assembly

Determine the framing area R-Value ($R_{Framing}$). Select the appropriate $R_{Framing}$ value from Table 3.4c.

Table 3.4c - Vaulted Ceiling Framing R-Value

Nominal Dimensions	Actual Depth	$R_{Framing}$
2x4	3-1/2"	4.38
2x6	5-1/2"	6.88
2x8	7-1/2"	9.06
2x10	9-1/4"	11.56
2x12	11-1/4"	14.06
12" Truss Joist	11-7/8"	8.00

Calculate the assembly's U-Value. Perform the calculation below to determine the U-Value of the ceiling assembly[1]

$$\text{U-Value} = \frac{1 - FF}{1.67 + R_{Cavity} + R_{Continuous}} + \frac{FF}{1.67 + R_{Framing} + R_{Continuous}}$$

1 The constant value, 1.67, in the equation represents the estimated R-Value of the interior gypsum board, as well as the interior and exterior air films.

Appendix D: Framed Floor Assembly U-Value

Determine the assembly's Framing Factor ("FF"). FF is an approximation of the percentage of ceiling surface area that is represented by the framing members versus the ceiling surface area that is represented by cavity space. Select the appropriate FF from Table 5.1d.

Table 5.1d - Framed Floor Framing Factor Defaults

Framing Spacing	FF
Dimensional Lumber	
16" on-center framing (typical)	0.14
24" on-center framing	0.11
Truss Joist	
16" on-center framing (typical)	0.08
24" on-center framing	0.07

Determine the total cavity insulation R-Value ("R_{Cavity}"). Using the RMaterial values (from Table 1.2) for the cavity insulation material(s) present, calculate the total cavity R-Value using this equation:

$$R_{Cavity} = (R_{Material1} * Depth_{Material1}) + (R_{Material1} * Depth_{Material2}) + \ldots$$

RMaterial1 = R-Value per inch of the first cavity insulation material present in the floor assembly

RMaterial2 = R-Value per inch of a second cavity insulation material if present in the floor assembly

Determine the total continuous insulation R-Value ("$R_{Continuous}$"). Using the $R_{Material}$ values (from Table 1.2) for any continuous exterior insulation material(s) present, calculate the total continuous R-Value using this equation:

$$R_{Continuous} = (R_{Material1} * Depth_{Material1}) + (R_{Material1} * Depth_{Material2}) + \ldots$$

RMaterial1 = R-Value per inch of the first cavity insulation material present in the floor assembly

RMaterial2 = R-Value per inch of a second cavity insulation material if present in the floor assembly

Determine the framing area R-Value ("$R_{Framing}$"). Select the appropriate $R_{Framing}$ value from Table 5.2d.

Table 5.2d - Floor Framing R-Value

Nominal Dimensions	Actual Depth	$R_{Framing}$
2x4	3-1/2"	4.38
2x6	5-1/2"	6.88
2x8	7-1/2"	9.06
2x10	9-1/4"	11.56
2x12	11-1/4"	14.06
12" Truss Joist	11-7/8"	8.00

Calculate the assembly's U-Value. Perform the calculation below to determine the U-Value of the assembly[1].

$$\text{U-Value} = \frac{1 - FF}{3.66 + R_{Cavity} + R_{Continuous}} + \frac{FF}{3.66 + R_{Framing} + R_{Continuous}}$$

1 The constant value, 1.67, in the equation represents the estimated R-Value of the interior gypsum board, as well as the interior and exterior air films.

Determine the appropriate number of points on the Checklist according to Table 5.3d.

Table 5.3d

U-VALUE	25%	50%	75%	100%
≥ 0.112	0	0	0	0
0.111 – 0.052	3	5	8	11
0.051 – 0.037	3	6	9	12
0.036 – 0.024	4	7	11	14
≤ 0.023	4	8	11	15

Appendix E: Infiltration Rate Testing Procedure

Adapted from the Mortgage Industry National HERS Standard 2006.

Leave all supply registers and return grills open and uncovered.

Leave all bathroom and kitchen fans open (i.e., in their normal operating condition). Only a permanently installed back draft damper in its normal condition may impede the flow of air.

Leave any combustion air ducts or louvers to the exterior open. If a homeowner or builder has sealed them off, open them for the test.

Leave any make-up air ducts with in-line dampers (e.g., for large kitchen exhaust fans or combustion air) as-is (unsealed). Only a permanently installed back draft damper or motorized damper in its normal condition may impede the flow of air.

Leave the dryer vent as-is, whether or not the dryer is in place during the test. Only a permanently installed back draft damper in its normal condition may impede the flow of air.

Leave open any outside air duct supplying fresh air for intermittent ventilation systems (including a central-fan-integrated distribution system).

Operable crawl-space vents, where present, are to be left in the open position.

Open all interior doors within the conditioned space, including doors to conditioned basements. Closet doors may be left closed unless the closet contains windows or access to the attic or crawl space.

Leave louvered openings of a whole-house fan as is.

Close all doors to the exterior or unconditioned spaces; if any door to the exterior or unconditioned space lacks weather-stripping at testing time, it can be temporarily taped off.[1]

Close and latch all windows.

Close chimney dampers.

Either seal or fill with water plumbing drains with p-traps that may be empty.

Seal off exterior duct openings to continuously operating fresh-air or exhaust-air ventilation systems (preferably at the exterior envelope).

Close any adjustable window trickle ventilators and/or adjustable through-the-wall vents.

If an evaporative cooler (*or whole-house fan*) has been supplied with a device used to seal openings to the exterior during the winter, that device should be installed for the test.

1 Doors that connect the Unit to conditioned common space within a multifamily building are to be left closed.

Appendix F: Duct Leakage Testing Procedure

The following protocol shall be followed in preparing the Unit for testing:

1. Open all of the Unit's interior doors that separate conditioned spaces from one another (e.g., bathroom doors, bedroom doors, etc.) to ensure equal pressures throughout the Unit.

   Exception: Leave closed doors that connect the Unit to conditioned common space within a multifamily building.

2. Close all exterior doors that separate conditioned spaces from unconditioned spaces (e.g., front door, sliding glass doors, and doors to garage or unconditioned basement, etc.).

3. Adjust the HVAC system controls to ensure that the system does not turn on during the test.

4. Insert the blower door assembly through a penetration in the Unit's envelope. This is typically achieved through a door to outside, though it may be through a window or other opening where a door to outside is not available (such as in some multifamily buildings where Unit doors access conditioned common hallways). Where a sufficiently large opening is not available, and/or the Unit is suspected to be substantially "tight," or the Unit has a very small interior volume, it may be necessary to use a duct blaster apparatus in lieu of a blower door. Once the apparatus is installed, configure the device to perform a fan depressurization test per the manufacturer's instructions.

5. Install a length of tubing such that it passes through the building envelope, connecting the interior and exterior space. Position the exterior end of the tubing such that it is sheltered from wind (including that induced by the blower door apparatus) and is free of obstructions such as dirt, snow or water. In general, the exterior end of the tube should remain on the same side of the Unit and in the general vicinity of the blower door apparatus. Attach the interior end of the tubing to the Reference Tap on Channel A of the blower door manometer.

6. Install a second length of tubing connecting the blower door fan pressure tap to the Input Tap on Channel B of the blower door manometer.

7. Configure blower door manometer to conduct a fan pressurization test per the manufacturer's instructions.

8. Cover and seal all supply and return registers/grilles within the Unit.

9. Remove furnace air filter and replace filter cover.

10. Remove furnace cabinet cover to reveal blower and return plenum entry. Connect duct blaster apparatus directly to furnace cabinet or largest (preferably nearby) return air grille, being sure to follow manufacturer's instructions. The duct blaster should be installed such that no significant air leaks exist at the connection to the furnace cabinet or return air grille.

11. Install a length of tubing connecting the Input Tap on Channel A of the duct blaster manometer to a duct-pressure probe installed in the supply duct system via the nearest supply register.

12. Install a final length of tubing connecting the duct blaster fan pressure tap to the Input Tap on Channel B of the duct blaster manometer.

13. Configure the duct blaster manometer to conduct a duct pressurization test per the manufacturer's instructions.

14. Using the blower door, pressurize the Unit to 25 Pascals WRT outside.

15. If duct pressure reading goes negative, slowly bring up duct blaster fan speed until duct pressure equals 0 Pascals WRT Unit pressure (duct blaster manometer channel A), installing flow reducing plates and adjusting manometer configuration as necessary.

16. Record duct blaster airflow volume at 25 Pascals ΔP WRT outside ("CFM25").

17. Replace furnace filter and return HVAC system to previous settings.