Amendment: Appendix A

Proponents:
Mark Jansen, Chair of Training & Education Committee
Brett Dillon, Chair of Technical Committee

Applies to:
2006 Mortgage Industry National Home Energy Rating Systems Standards

Proposed Amendment:

Delete Appendix A in its entirety and replace with attached document.

Background/Rationale:
The purpose of this amendment is to rewrite Appendix A to reflect the changes in Chapter 3 and Chapter 8 (Performance Testing) of the RESNET Standards, as well as enhance the insulation inspection and grading requirements with content created by the Technical Committee Chair's Insulation Industry Council, comprised of representatives of the North American Insulation Manufacturers Association, Cellulose Insulation Manufacturers Association, Reflective Insulation Manufacturers Association, Spray Polyurethane Foam Alliance, Insulation Contractors Association of America, Dow, CertainTeed, Bayer MaterialScience, Blown-In-Blanket Contractors Association, Structural Insulation Panel Association, Extruded Polystyrene Foam Association, Polyisocyanurate Insulation Manufacturers Association, and the National Insulation Contractors Exchange.

NATIONAL HOME ENERGY RATING TECHNICAL GUIDELINES
April 2012

Appendix A

ON-SITE VERIFICATION PROCEDURES FOR MINIMUM RATED FEATURES

ON-SITE VERIFICATION PROCEDURES FOR MINIMUM RATED FEATURES

This appendix is normative and contains requirements necessary for conformance to the RESNET Mortgage Industry National Home Energy Rating Systems Standards.

Conditioned Space

To determine whether a space is conditioned, assess the insulation placement in the walls or floor/ceiling assembly and whether the space is directly conditioned (fully ducted intentional HVAC supply or other intentional heat source).

The conditioned floor area includes all finished space within the insulated, conditioned space boundary, regardless of HVAC configuration, and includes unfinished spaces that are directly conditioned with intentional HVAC supply (or other intentional heat source). Conditioned floor area does not include spaces such as uninsulated basements or attics that are unfinished, if there is no intentional HVAC supply or if the HVAC supply is inadequate to be considered *directly conditioned space* according to the definition in Appendix B of these Standards. Conditioned floor area does not include heated garages.

A vented space (crawlspace, basement or attic) is considered unconditioned regardless of the location or existence of insulation. This is because the ambient temperature of the space is close to the outdoor ambient temperature or higher (in the case of attics in the cooling season).

An unvented crawl space, basement or attic may be considered either unconditioned, indirectly conditioned, or fully conditioned, based on the following criteria:

Unconditioned - Exterior walls are not insulated, floor/ceiling assembly is insulated, and any heating or plumbing distribution systems in the space is insulated. The intention in an unconditioned crawl space, basement or attic is to minimize the heating system losses into the space by means of the distribution and plumbing insulation, and to minimize heat flow through the insulated floor/ceiling assembly.

Conditioned, indirectly -Exterior walls are not insulated with floor/ceiling assembly insulated and distribution system in the space uninsulated, or exterior walls and roofline (attics) insulated with floor/ceiling assembly insulated or non-insulated and distribution system uninsulated. In an indirectly conditioned system, heating or cooling is unintentionally delivered to the space either through the floor/ceiling assembly or by unintentional losses from the heating/cooling system. Indirectly conditioned spaces are typically between the temperature of the outdoor ambient temperature and the indoor conditioned space temperature.

Conditioned, directly -Foundation walls insulated or uninsulated and basement or crawl space is intentionally or unintentionally conditioned, by means of a forced air heating or cooling system, hydronic heat, electric resistance, etc. Fully conditioned spaces are typically maintained at the same temperature as the above grade spaces. The distinction between indirectly and directly conditioned basement spaces may be difficult, but is important from a heat transfer perspective.

Conditioned floor area must not include spaces that are unfinished and indirectly conditioned, such as an unfinished basement with insulated walls or an unfinished, unvented attic space with an insulated roof when these spaces do not have terminal HVAC supply devices (or other intentional heat source). If these spaces contain terminal HVAC supply devices that provide less than 10 Btu/hour per square foot, or if there is less than 15 CFM of supply air for every 100 square feet of floor area, these spaces must not be included as conditioned floor area. If an attic, crawlspace or basement has a ceiling height less than 5', it must not be considered as conditioned floor area, even if directly conditioned.

If basement, crawl space or attic is determined to be fully conditioned, the floor between the house's ground floor and the basement or crawl space and the ceiling between a fully conditioned attic and the conditioned space below is considered an interior boundary with no associated heat transfer calculated.

Determine conditioned and indirectly conditioned volume of space by multiplying conditioned floor area by ceiling height. The house may need to be split into different spaces with different ceiling heights and added to each other for both conditioned and indirectly conditioned spaces. For areas with vaulted ceilings, volume must be calculated geometrically. In the case where a space is within the conditioned space boundary but is unfinished and indirectly conditioned, the volume of that space must be included in the conditioned volume of the home, even though the floor area is not included in the conditioned floor area calculation.

Measuring Building Components

Measure floor dimensions in accordance with ANSI Z765-2005 with the exception of Section 3 Paragraph 6 (floor areas with ceiling heights of less than 5' will be included in finished square footage). This exception must not apply to attics, crawlspaces or basements that have a ceiling height less than 5'.

For conditioned basements and crawl spaces, measure dimensions of basement walls and floor. Divide walls into above and below grade sections.

Measure the house or assembly element (window, wall, ceiling, etc.) to the nearest inch, and record the square footage to the nearest square foot. Use exterior measurements; those measurements should start at the exterior finished surface of the outside wall. Openings to the floor below should not be included in the square footage calculation, with the exception of stairways; stairways and associated landings are counted as square footage on the floor they descend from, not to exceed the area of the opening the stairs descend through. Do not include the "footprint" of protruding chimneys. Do include the “footprint” of other protrusions like a cantilever or bay window when it includes finished floor area. Do include the square footage of separate finished areas that are connected to the main body of the house by conditioned hallways or stairways.

Note to divide basement and crawl space walls into above and below grade.

Determine the perimeter of the slab foundation by measuring each dimension to the nearest inch and adding them together.

Measure linear perimeter of the walls to the nearest inch. Measure the interior wall height of the walls to the nearest inch. Use these measurements to calculate surface area.

Measure the linear perimeter of the ceiling area to the nearest inch and use these measurements to calculate surface area of the ceiling.

If a ceiling area is vaulted, it may be necessary to calculate dimensions geometrically.

Measure the surface area of the door(s) to the nearest inch, and record the area to the nearest whole square foot.

Measure the area of the window or skylight openings to the nearest inch. Calculate the area using the measured width multiplied by the height.

In an existing home, window openings are measured from the outside edge of the frame and include the frame and glazing.

Insulation

In order to meet the requirements of a Grade 1 or Grade 2, the insulation material must be installed according to the minimum general installation requirements, the minimum specific application requirements, and the minimum specific material requirements in this Appendix and the grading requirements for each type of insulation material.

Minimum General Installation Requirements:

1. Insulation must be installed to manufacturers’ recommendations and industry standards.
2. Insulation must be integral to or interior to and in substantial and permanent contact with the primary air barrier.
3. No air spaces must be allowed between different insulation types or systems.

    Exception: When claiming the R-value of an enclosed reflective air space in accordance with the ASHRAE Handbook-Fundamentals or ASTM C 1224.

4. Insulation must be installed to the required density and thickness necessary to achieve the required R-value.
5. Insulation must filled around obstructions including, but not limited to, framing, blocking, wiring, pipes, etc. without substantial gaps or voids

Minimum Specific Application Requirements:

1. Insulation installed in framed floor assemblies must be in substantial and permanent contact with the subfloor.

    Exception: When claiming the R-value of an enclosed reflective air space in accordance with the ASHRAE Handbook-Fundamentals or ASTM C 1224.

2. For rim or band joist applications, insulation must be in substantial and permanent contact with exterior framing; interior sheathing or air barrier is not required provided there is an air barrier on the exterior side.

3. Air permeable insulation installed in ventilated attics and sloped roofs must have an effective air barrier (wind block, air chute, or eave baffle) installed at the eave or soffit edge that extends up and beyond the surface of the insulation or to the ridge vent to prevent air movement through the insulation.

Minimum Specific Material Requirements:

Insulated Sheathing:

1. Edges and joints must be durably taped or otherwise air sealed.
2. Edges must be tightly fitted one another without substantial gaps.
3. Sheathing must be carefully fitted and durably taped or otherwise air sealed around obstructions.
4. When two or more layers of insulation are installed the joints must be staggered. Only the joints of the exterior layer must be required to be durably taped or otherwise air sealed.
5. Sheathing joints must be durable taped or otherwise air sealed and have the proper approvals if used as a Weather Resistive Barrier (WRB).

Batt Insulation:

1. Insulation must fill the cavity being insulated side to side, top to bottom.
2. Insulation must be enclosed on all six sides.

    Exceptions:

    a. Insulation installed in attics above ceilings must not require an air barrier on the exterior side.

b. Insulation installed under floors directly above an unvented crawl space must not require an air barrier on the exterior side.
c. Insulation installed in rim or band joists located in conditioned space must not require an air barrier on the interior side.
d. Insulation installed on conditioned basement and crawlspace walls where an air barrier material meeting code requirements for exposed applications and tested in accordance with ASTM E2178 or E283 is installed on the interior side.

3. Faced batts must be stapled to the face of the studs or side stapled to the studs with no buckling of the stapling tabs or the tabs must be permitted to be left unstapled. Faced batt products without tabs and friction fit products must not be required to be stapled when installed in vertical walls
4. When side stapled, compression is permitted only along edges to the depth of the stapling tab.
5. Insulation must be closely fitted around obstructions including, but not limited to, framing, blocking, wiring, pipes, etc. to avoid substantial gaps, voids or compression.

Blown or Sprayed Loose Fill Insulation:

1. Insulation containment fabric or system that is side stapled must not be stapled more than ½ inch from the face of the stud.
2. Insulation must be rolled or trimmed flat to allow installation and contact with interior sheathing or finish material.
3. When loose-fill insulation is installed in an attic, attic rulers must be installed in accordance with IECC or applicable energy codes.
4. Insulation must fill the cavity being insulated, side to side, and top to bottom.
5. Insulation must be installed at a density sufficient to prevent settling over time.
6. Insulation must be enclosed on all six sides.

   Exceptions:
   a. Insulation installed in attics and ceilings must require an air barrier on the exterior or interior side.
   b. Insulation installed under floors that is directly above an unvented crawl space must not require an air barrier on the exterior side.
   c. Insulation installed in rim or band joists located in conditioned space must not require an air barrier on the interior side.

7. Insulation must be installed around obstructions including, but not limited to, framing, blocking, wiring, pipes, etc. as to avoid substantial gaps, voids or compression.

Open cell spray polyurethane foam (SPF) insulation:

1. Installers must meet the manufacturer's recommended training requirements and must complete the online health and safety training for SPF provided by the Center for Polyurethanes Industry.
2. Spray foam must be well-bonded to the substrate, including framing and sheathing.
3. Insulation, installed at a minimum thickness to be air impermeable per ASTM E283 or E2178 and in-contact with the substrate must be permitted to serve as the air barrier.
4. When insulation extends beyond the wall cavity it must be trimmed to allow installation and contact with interior sheathing or finish material.
5. Insulation must fill the cavity to within no more than ½ inch from the face of the studs.

   Exception: When the required R-value is met using a thickness that is less than the cavity depth.

Closed-cell spray polyurethane foam insulation:

1. Installers must meet the manufacturer's recommended training requirements and must complete the online health and safety training for SPF provided by the Center for Polyurethanes Industry.
2. Spray foam must be well-bonded to the substrate, including framing and sheathing.
3. Closed-cell Insulation, installed at thicknesses of 1.5 inches thick or more must be permitted to be an air-impermeable insulation when in-contact with the substrate.

   Exception: Thicknesses less than 1.5 inches considered air-impermeable with appropriate ASTM E-283 or ASTM E2178 data from manufacturer data sheet or ICC-ES Report.

Insulation Grading

Grading Criteria for Batt, Loose-fill, Open and Closed Cell Polyurethane Spray Foam Insulation and Insulated Sheathing

Grade 1 (Minor Defects)

Must meet the minimum installation requirements for the specific products above and the following:

Batt or Loose-fill Insulation

When installing batt, or loose-fill insulation, no more than 2% of the total insulated area (cavity) must be compressed or contain gaps or voids in the insulation. These areas must not be missing or compressed more than ½ inch of the nominal insulation thickness in any given location. Voids extending from the interior to exterior of the intended insulation areas must not be permitted.

Open-Cell Polyurethane Spray Foam Insulation (cavity not filled and not trimmed)

When installing open-cell polyurethane spray foam the average of all thickness measurements must be greater than the specified thickness required to obtain the specified R-value. No more than 2% of the insulated area must contain voids or be more than ¾ inch below the specified thickness. The minimum installed thickness must not be less than 1 inch below the specified thickness any point. Voids extending from the interior to the exterior of the intended insulation areas must not be permitted.

Closed-Cell Polyurethane Spray Foam

When installing closed-cell polyurethane spray foam the average of all thickness measurements must be greater than the specified thickness required to obtain the specified R-value. No more than 2% of the insulated area must contain voids or be greater than ½ inch less than the specified thickness. The minimum installed thickness must not be less than ¾ inch below the specified thickness at any point. Voids extending from the interior to exterior of the intended insulation areas must not be permitted.

Insulated Sheathing

Insulated sheathing insulation installations meeting the minimum installation, application, and material requirements above. Voids through interior to exterior of the intended insulation areas must not be permitted.

Grade 2 (Moderate Defects)

Must meet the minimum installation requirements for the specific products above and the following:

Batt or Loose-fill Insulation

When installing batt, or loose-fill insulation, no more than 15% of the total insulated area (cavity) must be compressed or contain gaps or voids in the insulation. These areas must not be missing or compressed more than 3/4 inch of the nominal insulation thickness in any given location. Voids through interior to exterior of the intended insulation areas must not be permitted.

Open-Cell Polyurethane Spray Foam Insulation (cavity not filled and not trimmed)

When installing open-cell polyurethane spray foam the average of all thickness measurements must be greater than the specified thickness required to obtain the specified R-value. No more than 15% of the insulated area must contain voids or be more than 1 inch below the specified thickness. The minimum thickness must not be less than 1.5 inches below the specified thickness at any point. Voids extending from the interior to the exterior of the intended insulation areas must not be permitted.

Closed-Cell Polyurethane Spray Foam

When installing closed-cell polyurethane spray foam the average of all thickness measurements must be greater than the specified thickness required to obtain the specified R-value. No more than 15% of the insulated area must contain voids or be greater than ½ inch below the specified thickness. The minimum installed thickness must not be less than 1 inch below the specified thickness at any point. Voids extending from the interior to exterior of the intended insulation areas must not be permitted.

Grade 3 (Substantial Defects)

Installations not complying with the minimum installation requirements and Grade 1 or Grade 2 requirements above must be considered a Grade 3 installation.

Grade 3 installations must be recorded and modeled as uninsulated.

Structural Insulated Panels (SIPs):

1. Sealing of panel joints must meet the manufacturer's recommended requirements regarding the use of mastics and/or expanding foam. If the manufacturer does not have specific joint sealing details use SIPA's typical joint sealing details. SIPA details are available at www.sips.org .
2. Use spray foam to seal penetrations through the SIP panels.
3. Any damaged area must be repaired.
4. All gaps and penetrations through SIPs including windows, doors, and foundation or roof connections must be air-sealed with expanding foam compatible with the SIP materials.

Grade 1 (Minor Defects)

Must meet the minimum installation requirements for SIP products above and the following:

1. SIP panels must be properly aligned and unsealed penetrations extending from the interior to exterior of the panels must not be permitted.
2. 2% or less of the total area of the SIPS panels have damage which is unrepaired, including but not limited to cutouts for electrical boxes, pipes and other penetrations.

Grade 2 (Moderate to Frequent Defects)

Must meet the minimum installation requirements for SIPS products above and the following:

1. Greater than 2% and less than 5% of the total area of the SIP panels have damage which is unrepaired, including but not limited to cutouts for electrical boxes, pipes and other penetrations.
2. SIP panels must be properly aligned and unsealed penetrations extending from the interior to exterior of the panels must not be permitted.

Grade 3 (Major Defects)

SIP panel installations not complying with the minimum installation requirements and Grade 1 or Grade 2 requirements above must be considered a Grade 3 installation.

Grade 3 installations must be recorded and modeled as uninsulated.

Reflective/Radiant Grading Criteria

Regarding thermal performance claims or R-values:

1. R-value claims for the air space adjacent to a reflective insulation product must be based on average cavity depth, heat flow direction which represents the application (wall, ceiling or floor), temperature of the airspace surfaces relative to the specific wall assembly, location of the airspace in the assembly, and design climate conditions.
2. When utilizing R-values from the ASHRAE Handbook of Fundamentals, the enclosed airspaces must be sealed cavities which do not to allow air flow in out of the cavity and must be moderately smooth.
3. All other R-value claims by the manufacturer for the assembly including the airspace must be based on ASTM C1224, the Standard Specification of Reflective Insulation. The assembly that is tested for thermal resistance must be representative of the field assembly.

Reflective Insulation in Ceilings, Walls and Floors:

Reflective insulation products include types with multiple layers, reflective bubble, and reflective foam – refer to the manufacturer's instructions for the product's installation details.

1. The products must be permitted to be either face or side (inset) stapled and must be permanently attached to the framing member;
2. When side or inset stapled, reflective insulation must be installed at the depth in the cavity to attain the required airspace(s). Refer to manufacturer's installation details for the specific application, including required airspace dimensions;

3. When face-stapled, the material width must match the framing width (e.g. 16” wide material is used for 16” on-center framing).

   Exception: Nonstandard cavity widths.

4. When face-stapled, the staple tabs must be aligned with the direction of the framing;
5. When reflective insulation is to serve as a vapor retarder, the tabs are over-lapped or taped when face-stapled. When inset stapled, the edges must be attached to the sides, top and bottom of the framing.
6. Reflective insulation and radiant barriers (sheet type) materials must not be laid directly on top of the attic floor or insulation materials installed above the ceiling.
7. Reflective insulation and radiant barriers installed under slabs must not claim R-values based on having an airspace.

Grade 1 (Minor Defects)
Must meet the minimum installation requirements above, except where noted.

2% or less of the area is not insulated such that the building envelope exterior sheathing (wall) is visible from the building’s interior.

Grade 2 (Moderate to Frequent Defects)
Must meet the minimum installation requirements above, except where noted.-

Greater than 2% and less than 10% of the area which is available for insulation is not insulated such that the building envelope exterior sheathing (wall) is visible from the building’s interior.

Grade 3 (Substantial Defects)

Installations not complying with the minimum installation requirements and Grade 1 or Grade 2 requirements above must be considered a Grade 3 installation.

Grade 3 installations must be recorded and modeled as uninsulated.

Attic Radiant Barriers:
Minimum Requirements:

1. Attic radiant barriers must be installed with an airspace adjacent to the low emittance (metallic) surface(s);
2. When the radiant barrier only has one low emittance surface, it must be on the bottom side (in the direction of the ceiling);
3. Attic and/or roof ventilation must be maintained. Roof, gable and soffit vents must not be covered.
4. The radiant barrier must be installed on gable ends.
5. The radiant barrier must be firmly secured.

Attic radiant barriers must be permitted to be installed using one of the following three methods

RB Method 1: Deck applied – aluminum faced oriented strand board or plywood; radiant barriers applied in this manner must be perforated.
RB Method 2: Draped – radiant barrier draped over the trusses or rafters;
RB Method 3; Truss applied – radiant barrier stapled to the bottom of the top cord of the roof truss or rafter.

Grade 1 (Minor Defects)
Must meet the minimum installation requirements above, except where noted.

1. 2% or less of the roof is bare wood or does not include low-emittance.
2. 2% or less of the surface has contaminates, particles or ink on the surface (e.g. dirt, printing of product identification, etc.) reduces effectiveness.
3. Radiant barrier is installed to cover the face of the rafter (Method 3 only).

Grade 2 (Moderate to Frequent Defects)
Must meet the minimum installation requirements above, except where noted.

1. 3% or greater and 10% or less of the roof is bare or does not include the radiant surface.
2. 3% or greater and 10% or less of the surface has contaminates, particles or printed information on the .
3. Radiant barrier is inset stapled (Method 3 only).

Grade 3 (Substantial Defects)
Installations not complying with the minimum installation requirements and Grade 1 or Grade 2 requirements above must be considered a Grade 3 installation.

Grade 3 installations must be recorded and modeled as uninsulated.

Additionally, radiant barrier installations which have the following issues must be deemed to be Grade 3:

1. Radiant barrier is not permanently attached;
2. Radiant barrier is not perforated (Method 1 only).

Interior Radiation Control Coatings (IRCCs)
IRCC materials are a liquid applied with an emittance of 0.25 or less.

Application Requirements:
1. The IRCCS must be in permanent contact with the underside of the roof deck and should cover the underside of all roof deck and gable surfaces.
2. The coating must render the application surface to an overall metallic finish that in some cases retains the texture characteristics of the wood surface.
3. The coating surface must be dry to the touch.

Grade 1 (Minor Defects)
Less than 2% of the surface is bare wood or discolored.

Grade 2 (Moderate to Frequent Defects)
Greater than 2% and equal to or less than 10% of the surface is bare wood or discolored.

Grade 3 (Substantial Defects)
Greater than 10% of the surface is bare wood or discolored.

Foundations

Crawl Spaces

A crawl space is typically defined as a foundation condition with a clear vertical dimension 4 feet high or less. Crawl spaces may be vented or unvented. Vented crawl spaces have some form of vent or louver in the crawl space walls, or are constructed in such a manner so that air moves freely from outside the walls to inside the crawl space. Unvented crawl spaces are constructed without any form of vents or louvers in the wall, and are constructed to exclude, to the greatest extent possible, air leakage from outside the walls to inside the crawl space. Crawl spaces may be accessed by a hatchway in the floor of the house or in the wall of the crawl space. To identify a crawl space, look for foundation vents and/or stairs leading up to floor levels from the outside of the building.

Basements

A full basement has characteristics similar to an unvented crawl space, except that the clear vertical dimension is typically greater than 4 feet. Stairs that lead from the main floor to a below grade space are an indication of a basement in a house, although a house may have a basement with access similar to a crawl space access.

A walkout basement, if fully conditioned, is typically considered partially slab on grade construction (where the floor level is above grade) and partially a basement (where the floor level is below grade).

Determine insulation type, thickness and R-value in walls. Wall insulation may be located inside foundation wall (studs and batts, foam under drywall, etc.), integral with foundation wall (insulated cores of block wall, insulating concrete block such as insulating formwork) or outside the foundation wall (rigid foam insulation).

Framed Floors

Floor area that is cantilevered over exterior unenclosed space above grade is considered floor to exterior. For example, in a two story house, the second story may extend horizontally further than the first story, creating some floor area that is exposed to the exterior.

Identify floors over an unconditioned garage.

Rim/Band Joist

The rim joist is the band joist around the perimeter of the floor joists over a basement or crawl space, or between 2 stories of a house.

From the basement or crawl space, visually identify and measure the depth of insulation at the rim joist. The insulation used is generally fiberglass batts, often folded in an L-shape and attached to the rim joist. Rigid board insulation may also be found.

Look for access to the area from a garage or a utility access trap door. Visually identify and measure insulation if it exists. If no access can be found, assume insulation exists at the rim joist between stories if:

- Insulation was found at the rim joist at the top of the crawl space or basement in the same house; or
- Insulation is found in the walls of the same house.

Otherwise, assume no rim joist insulation exists.

Slab on Grade

A slab on grade can be recognized by the absence of either a crawl space or basement. A slab on grade is constructed by placing a concrete slab directly on the ground as the floor for the house.

Covered -If floor is covered with wall-to-wall carpet, consider it covered. Floors with only area rugs are not considered covered.

Exposed -If the floor has tile, linoleum or wood, consider it exposed.

If present, slab perimeter insulation is usually installed on the outside of the slab and extends both above and below grade.

To identify slab perimeter insulation, look for a protective coating above grade as opposed to the usual exposed slab edge at any conditioned space(s).

Move a little bit of dirt away from an edge of the slab where conditioned space is located. If present, the rigid insulation around the perimeter of the slab may be seen. However, it may be difficult to visually verify the existence of slab perimeter insulation because of the protective covering which may be installed over the rigid insulation.

Slab insulation may also occur between the foundation wall and the slab itself, although this is harder to assess and verify. If the floor has carpeting, a sharp needle may be poked through the carpet near the baseboard on an outside wall. If the needle penetrates beyond the depth of the carpet, there is probably foam insulation between the slab and foundation wall.

Under slab insulation cannot be assumed to exist unless visually verified by a photograph of construction, at chase way, at sump opening or at plumbing penetrations.

Above Grade Walls

Identify the color of the wall as light, medium, or dark.

Check for insulation at plumbing outlet under sink or, in order of preference, remove cable outlet plate, telephone plate, electrical switch plates and/or electrical outlet plates on exterior walls.

Probe the cavity around the exposed plate with a non-metal device (such as a plastic crochet hook or wooden skewer). Determine type of insulation (fiberglass, cellulose insulation, foam, etc.). Inspect outlets/switch plates on each side of the house to verify that all walls are insulated. Insert the non-metallic probe into the cavity until it stops; withdraw the probe and subtract 1/2” for drywall to determine whether the cavity is framed with 2x4 or 2x6 framing.

Multiply the wall framing member size (in inches) by the R-value per inch. Be sure to use the actual thickness of the insulation when calculating the total insulation R-values. Use 3.5" for 2 x 4 walls and 5.5" for 2 x 6 walls constructed after 1945.

Parts of the house that were added later must be checked separately from the original walls.

Insulated sheathing may exist on walls, but can be difficult to verify. Walls with insulated sheathing may be thicker than walls without insulated sheathing. Visual verification of insulated sheathing may be found in the attic at the top of the wall, exterior wall penetrations, and at the connection between the foundation and the wall.

Wood framing

Wood framing is very common in residential construction. Wood studs are located 16" or 24" on center all along the wall. Knocking on the wall will give a "hollow" sound in the cavities between the studs and a "solid" sound at the stud locations.

Metal framing

Metal framing can be found in some newer residential construction. A strong magnet slid against the wall will hold to metal framing. Also check inside the attic at the edges for evidence of metal wall framing.

Masonry walls

Masonry walls include walls constructed of concrete or brick. A wood framed wall with brick veneer would not be considered a masonry wall. Also note the siding or finish material on the wall.

Foam core walls
Foam core walls are a sandwich panel consisting of a foam center with outer layers of structural sheathing, gypsum board or outer finish materials. Foam core panels may be structural (load bearing) or non-structural. Non-structural panels are frequently used in post and beam construction.

Log walls
Log walls are typically solid wood walls, using either milled or rough logs or solid timbers. Some homes may have the appearance of solid log walls, yet may actually be wood frame walls with siding that looks like solid logs inside and out. Some log walls are manufactured with insulated cores. Unless manufacturer's documentation is available or visual inspection of insulation type and thickness can be made, assume no added insulation exists in a log wall.

Wall to exterior -Walls border exterior space.

Wall to enclosed unconditioned space -Walls that border unconditioned attics, garages and crawl spaces.

If the dwelling's walls are constructed of concrete, masonry or brick, determine their type and thickness.

Solid concrete walls (placed)
Measure the thickness of the poured concrete wall in inches.

Concrete Masonry Unit
Cinder block or uninsulated concrete wall - hollow in the middle. May contain vermiculite or perlite insulation. Check for additional insulation (interior furring, foam board, foam fill).

Measure the thickness of the wall in inches.

Windows

Framing Type
Examine each window or skylight frame in order to determine the type of material used. Open the window and examine it to see whether the frame is made of metal, wood, or vinyl. Tap the frame with fingernail or knuckle to test if it's vinyl or metal. Wood frames are usually thicker than metal.

If the window or skylight is dual-pane or multiple-pane and is metal framed, determine if a thermal break is present by looking for two separated metal extrusions connected by a rubber spacer. Ask the customer for documentation if you can't tell.

Some wood windows may have vinyl or aluminum cladding. Check both the inside and outside, since some windows will have vinyl cladding on one side only.

Glazing Type
Check all windows in the house for number of panes and existence of tint and/or low-e coating.

To determine whether the windows are single-paned or multiple-paned:

- Look at frame width and spacers;
- Look at reflections;
- Look at edge thickness.

To determine if glazing has a tint or low-e coating:

- Check the customer's product literature if available;
- Perform a "match test" - there should be one reflection per pane or coating, including low-e and tinting (e.g., a double-paned window with low-e and tint should show 4 reflections);
- Compare to glazing samples with and without tinting;
- Compare the windows within the space, since tinting is often applied only to certain windows in a house;
- Look for a low-e label or etching on the glass
- Use a low-e detector.

Use a compass (adjusted for magnetic deviation and declination) to determine orientation of all windows.

Identify shading of windows or skylights by external shade screens, house overhangs/ awnings, and shade from trees and other buildings.

External Shade Screens
The most common screen is an insect screen that covers some or all of the window. If it is a full-coverage type screen, assume it is a shade screen. Compare samples of the screen's mesh pattern to those of a window screen sample to determine the type and shading coefficient of the screen.

If you cannot determine the Solar Heat Gain Coefficient (SHGC) of the screen, use an SHGC of 0.31 as a default.

Projection (Overhang)
The shading impact of an overhang can be found by measuring the distance of the projection from the exterior wall surface and the distance (height) between the top of the window and the bottom edge of the overhang.

Measure the length of the overhangs over each exterior wall.

Measure the height above the window to the bottom edge of the overhang.

Exterior Shading
Full- Consider a SHGC of 0.35 for an entire side of a house as being roughly equivalent to having a shade screen over a window. For trees and/or bushes to equal this effect, there should be a very dense amount of trees and/or bushes along the entire side of the house that shade both its vertical and horizontal surfaces almost totally.

Partial- Based on the above definition for full shading, partial shading provides a SHGC of 0.61 and is considered to be anything in between full and none (no shading).

None- No shading indicates there may be small plants or shrubs only.

To determine Solar Heat Gain Coefficient and U-factor of windows and skylights, check product information and consult NFRC guide. Look for an NFRC label on new windows (it will display full window U-value and SHGC). If no label can be found but customer has documentation, look up product information in NFRC Certified Products Directory to determine these values, or consult manufacturer's literature.

Doors
Determine if the exterior door(s) is fiberglass, metal, or wood by making a close inspection of its texture, distinguishing the sound produced when knocking on it, and checking its side view.

Judge whether the exterior door(s) is insulated (or not) by its sound, temperature transfer, labeling, or thermal break.

Sound - Insulated/solid door will sound dull when knocked on. An uninsulated/hollow door will sound hollow.

Heat transfer - Feel the inside and outside of the door with flat palms. Insulated/solid door will less readily transfer heat. The inside will feel warmer in cold outside weather and cooler in hot outside weather than an uninsulated/hollow door.

Labeling - Check the side view of the door at the hinges for a descriptive label.

Thermal break - Check the side view of metal doors for thermal breaks.

Ceiling
If the ceiling has attic space above (even if the ceiling is vaulted, as in a scissor truss) it is considered ceiling to attic. If there is a vaulted ceiling check it's angle against the angle of the roof -- if the ceiling angle is gentler there is attic space above the ceiling. Also check for an attic access, either separate or from an attic over another part of the house.

Framed ceilings fall into two categories:

Roof on exposed beams or rafters - when you look up from inside the room, you will see exposed beams or rafters.

Finished framed ceiling -if the ceiling is framed (has no attic space above it, but you cannot see the rafters because the ceiling is finished with drywall, plaster, paneling, etc.) consider it a finished framed ceiling.

Determine the framing member size for framed ceilings exposed to unconditioned spaces.

Check the framing by looking for an access through an attic over another part of the house or by looking at the rafters from the outside.

Attic

Determine if the attic is conditioned, indirectly conditioned or unconditioned. Also verify if a radiant barrier is present. In order to be classified as a Radiant Barrier, the product must have an emissivity level less than 0.10. Typically, paint products are an Interior Radiation Control Coating, not a Radiant Barrier.

Roof

Identify the color of the roof as light, medium or dark. Also check for a special reflective roof coating.

Identify the type of roofing surface. Some common types include:

- Asphalt shingle;
- Pebble/gravel built-up roof;
- Tile roof;
- Wood shingle roof;
- Rubber roof/roof coating;
- Metal.

Skylight

Determine the orientation of the lower edge of the skylight. Use this direction as the orientation of the skylight.

Measure the tilt of the skylight relative to horizontal. This can be done with a level and angle finder instrument, or geometrically with a protractor (from the ceiling length and heights).

HVAC

Air ducts may be insulated with insulation blankets or rigid insulation board. Inspect the duct or pipe insulation for R-value labeling (printed on the insulation by the manufacturer). If the insulation is not marked with the R-value, identify type and measure the thickness of the insulation to determine R-value. Check for internal insulation by tapping on the exterior and listening to the sound.

Air ducts may be located in the attic, crawl space, basement or in a conditioned area. You must locate and differentiate between supply and return ducts. Ducts may be located in more than one area (e.g., some return ducts in attic and some in conditioned space, etc.).

If the air handler is used as part of the home's ventilation system, record the wattage of the air handler fan (wattage = volts x amperes).

Forced air - a central fan unit connected to ducts which supply heated or cooled air to each room in the home. Forced air systems have supply and return duct work. Supply ducts typically run to each room; return duct work may come from each room or from one or more central locations in the home.

Forced hot water - heated water is pumped through a series of radiator elements to supply heat. The radiator elements may be conventional radiators, baseboard "fin tube" radiators, cast iron baseboards or radiant hot water panels located at the baseboards or on walls or ceilings.

Hot water radiant system - heated water is circulated through plastic or metal tubing which is installed in a concrete slab or finished floor or, occasionally, in walls or ceilings.

Unit heater/air conditioner - heating or cooling is supplied directly from a heating or cooling device located within the space it serves. Window air conditioners and through-the-wall heaters are common examples. Unitary equipment typically has no distribution system.

Steam heating - steam systems utilize a distribution system with cast iron radiators connected to a boiler that creates steam. The steam rises into the radiators through one set of pipes, condenses into water, and drains back to the boiler through another set of pipes.

Electric radiant system - electric cables are installed in concrete floor slabs or in the ceiling. Electric current is passed through the cables, causing them to heat up, heating the floor or ceiling assembly which radiates the heat to the space. Electric radiant systems may also be comprised of individual radiant panels mounted on the walls or ceilings.

Baseboard electric resistance - electric elements are installed in baseboard enclosures. Electric current is passed through the electric element to provide heat to the space.

Heating systems may use natural gas, propane, oil, electricity, or some other fuel. Typically the homeowner will know what type of heating fuel is used. Cooling is typically driven by electricity, however some cooling equipment may use natural gas or propane. Look for electric cables and dedicated fuses or circuit breakers for the cooling equipment or gas lines running to the equipment. Note that gas equipment will also have electric cables to power some of the components. Be sure to distinguish between refrigerant lines and possible gas supply lines.

Oil - look for a large storage tank (typically oblong-shaped) or fill pipes which would indicate a buried tank. Oil is typically supplied to the heating equipment via a 1/4" - 3/8" copper line. A fuel filter may be evident in the line.

Natural gas - look for a meter connected to piping on the exterior of the home. Piping to the heating equipment is typically done with ½" - 1" iron piping.

Propane - look for storage tank(s) (typically cylindrical-shaped). Large tanks may be buried with a 12" - 18" cap exposed above grade. Fuel is typically supplied to equipment through 1/4" - 3/8" diameter copper piping.

Electric - look for large gauge cables running to a central piece of equipment or look at circuit breaker panel for circuits marked for resistance heat circuits (electric resistance or electric radiant systems).

Other fuels - include coal, wood, processed wood pellets, or other combustible products.

Determine the type of control systems. There may be separate controls for the heating and cooling systems.

Thermostat controls may be programmable. Note types of features available and/or utilized.

Check nameplate for efficiency rating. If the nameplate is missing, use appropriate directories to determine an appropriate default value.

SEER is used to measure the efficiency of central air conditioning and air source heat pump systems. AFUE is used to measure the efficiency of furnaces and boilers. EER is used to determine the efficiency of room air conditioners and ground source heat pumps. Check nameplate for SEER or AFUE rating.

Furnace - comprised of a combustion chamber and heat exchanger (natural gas, propane or oil) or an electric resistance element (electric) and a fan which forces air across the heat exchanger or resistance element to provide heat in a forced air system.

Fan coil unit - hot water from a boiler, domestic water heater, or heat pump is circulated through a coil. A fan blows air over the coil to provide heating. This device is used in a forced air system.

Boiler - this device creates hot water or steam, and can be powered by any fuel type. Can be used with forced air (in conjunction with a fan coil unit), forced hot water, steam, or hot water radiant slab systems.

Split system central air source heat pump - these systems move energy from one location to another using the vapor compression cycle. They are electrically driven, and can provide heating in winter and cooling in summer by reversing the direction of heat flow. Split system heat pumps consist of an outdoor unit and an indoor air handling unit, resembling a furnace. These systems require ductwork for air distribution. Most air source heat pumps incorporate electric resistance supplemental heat in the indoor section. However, some heat pump systems use fossil fuel furnace for supplemental heating. These are known as "dual fuel" or add-on systems.

Single package central air source heat pump - a single package central heat pump is similar to a split system, except it combines the functions of the indoor and outdoor units into one cabinet, usually mounted on the roof or on the ground. It also requires a separate distribution system. These are uncommon in single-family residences, however they are sometimes found in multi-family dwellings.

Ground source heat pumps - are coupled to the ground through the use of a water well sometimes the same well as used for domestic water (known as "open loop" which water or a water/antifreeze mixture is circulated (known as "closed loop"). Look for 3/4" or larger diameter piping going to and from the heat pump. Circulating pumps may be installed in this piping (closed loop systems) or the pump for the water well may be used for circulating water through the heat pump (open loop). The same piece of equipment can be used in either open or closed loop applications, however given the same piece of equipment, closed loop applications typically have lower efficiency ratings than open loop applications. Ground source heat pumps can also utilize a direct expansion of the refrigerant with copper piping buried in the ground. Look for 0.25" - 0.50" copper piping leading from the unit to the outdoors with no outdoor unit.

Split system central air conditioner - similar to a split system air source heat pump. Consists of an outdoor unit and a coil in the forced air distribution system, usually in a fossil fuel furnace. These systems are electrically powered and provide cooling.

Single packaged central air conditioner - similar to single packaged air source heat pumps, providing cooling only.

Ductless air source heat pump - a single packaged air source heat pump designed to be installed without a distribution system. Provides both heating and cooling.

Window/through-the-wall air conditioner - a single packaged ductless air conditioner designed to be installed without a distribution system.

Direct evaporative cooler - is used primarily in very dry climates. Evaporative coolers work by blowing air over a damp pad or by spraying a fine mist of water into the air. Direct evaporative coolers add moisture to the home.

Indirect evaporative cooler - evaporation takes place on only one side of a heat exchanger.

Absorption cooler - this is a gas air conditioner. Look for a cooling tower, an exhaust pipe, a gas burner to evaporate refrigerant and a heat exchanger similar to an electric air conditioner.

Unitary space heater - these are fossil fuel burning heaters which have individual controls and no distribution system. They may be equipped with a fan for forcing air circulation over a heat exchanger, or they may use simple convective forces. These heaters are typically mounted on outside walls in order to facilitate venting and can use natural gas, kerosene, propane, or other types of fossil fuel.

Note whether systems are located in conditioned or unconditioned space. The location of the heat exchanger unit (e.g., furnace, air conditioner evaporator coil, or heat pump evaporator coil in cooling mode) determines the location of the system.

Domestic Water Heating

Storage Water Heater

These water heaters are the most common type. Water is heated in an insulated tank that typically ranges in capacity from 30 to 75 gallons. Storage water heaters may use electric resistance, gas, propane, oil or electric heat pump.

Storage electric -look for rigid or flexible 240 A/C conduit, UL seal, no vent, no burner or pilot tubing. Thermostats are usually hidden behind metal access doors. Often there is both an upper and a lower thermostat.

Storage gas -look for a vent connection (top of tank), gas connector and line valve, thermostat, burner and pilot tubing, burner compartment doors, and "AGA" seal rating plate. Most gas water heaters have legs to lift the unit above the floor level to provide combustion air to the burner.

Storage propane -look for the same features as those listed for gas water heaters. Also, look for a rating plate or tag that states "For Use with LP Gas Only."

Storage oil -look for features that are similar to a gas water heating storage system. In addition, oil systems are usually furnished with draft regulators which are attached to the vent pipe between the tank and chimney (hinged metal flap with counterweight to allow for variations in flue gas pressure). Vent dampers may also be apparent on the vent pipe.

Storage heat pump -water heaters remove heat from the air in the room where they are located and then release the heat to the water in the storage tank. Look for the same features as those found on electric water heating systems. In addition, there will be a fan, condenser and evaporator. Also, the system may be one single unit, or may be a split system.

Combination DHW/furnace system - natural gas combo systems use heat drawn from a hot water tank circulating through an air handling module to heat the space.

Geothermal heat pump de-superheaters - devices which utilize heat pump cycle superheater to heat domestic hot water. Look for insulated lines between air handler unit and storage water heater tank.

Look for the water heater's rating plate and product literature. Some water heaters will list their EF right on the rating plate.

If the water heater is wrapped and there is no accessible information, approximate the age of the unit and use a default efficiency.

If accessible, record the Make and Model #.

Look up the EF rating of that model in an appropriate efficiency rating directory.

If the EF rating is not listed in the directory use a default from the RESNET Standards based on the estimated age of the water heater.

Instantaneous Water Heaters
These water heaters heat water on demand, instead of storing pre-heated water in a large tank. They are usually small units, with storage of no more than 2 gallons, and are often attached to a wall close to the point of use. Instantaneous water heaters may be used in addition to a primary storage water heater to serve fixtures in a distant location of the house, so check for a main storage unit as well. Determine if the instantaneous heater uses gas or electricity.

Instantaneous gas - look for a connector and line valve, vent connection, thermostat, burner and pilot tubing, and AGA seal. Check whether unit has a pilot light or intermittent ignition device.

Instantaneous electric - look for the absence of a gas line, vent or pilot light. Look for a UL seal.

De-superheater - check for this supplementary heat source, often found on geothermal heat pump HVAC systems.

Check the unit's nameplate for the RE (Recovery Efficiency). If a gas model, note whether there is a standing pilot light.

Visually determine if the water heater is wrapped with exterior insulation. If so, measure thickness of the wrap and determine R-value.

Determine whether water heater is located in conditioned or unconditioned space.

Determine whether pipe insulation is installed on all 3/4" or larger, non-recirculating hot water mains. Measure thickness of insulation and identify material to determine R-value.

Solar Water Heating

Identify whether a solar domestic hot water system exists. These systems collect and store solar thermal energy for domestic water heating applications. If a solar water heating system exists, determine system type. For systems manufactured after Jan. 1, 1995, system type, energy factor (EF), and other performance characteristics must be determined from the SRCC label (usually affixed to the solar storage tank) and by referring to SRCC literature. For systems lacking an SRCC label, energy factor and other performance characteristics can be determined using a certified HERS modeling tool, or appropriate default values. Identify as passive or active. Base your evaluation on these criteria:

Passive - No purchased electrical energy is required for recirculating water through a passive solar collector. Three types of passive systems are integrated collector storage (ICS), thermosiphon systems and self-pumped systems.

- *Integrated Collector Storage (ICS)* - consists of a single unit which incorporates both collector and water storage. An example is the common "bread box" design. Storage is usually outside the conditioned space.
- *Thermosiphon* - consists of a flat-plate solar collector and hot water storage tank. Instead of using a pump, circulation of the fluid is achieved by natural convection action. The storage tank must be located above the collector, and is usually outside the conditioned space.
- *Self-pumped* - circulates fluid from storage to collectors without purchased electrical energy. Photovoltaic and percolating systems are examples of self-pumped systems. The storage tank is usually inside the conditioned space.

Active -Also known as pumped systems.

- *Pumped* -purchased electrical energy input is required for operation of pumps or other components. The storage tank is usually inside the conditioned space.

Determine the area of the collector.

Determine the orientation of the solar collector by taking a compass reading (adjusting for magnetic deviation and declination) in the direction toward which the collector faces.

Determine the tilt of the collector. A site selection and angle finder instrument can be used to determine the tilt of the collector. Geometric calculations based on horizontal length and vertical height measurements can also be used.

Look for SRCC label. Check for SRCC system and component name plates. Refer to the Directory of SRCC Certified Solar Collector and Water Heating System Ratings, or other SRCC literature for energy factor (EF) and other performance data.

Determine the R-value of insulation installed on pipes.

Identify the type of solar collector by checking for the SRCC label or manufacturer's information.

To determine the size of the storage tank refer to documentation or a label indicating the tank capacity.

Note if storage is inside or outside of conditioned space.

Photovoltaics

Determine the orientation of the photovoltaic array taking a compass reading (adjusted for magnetic deviation and declination) in the direction the array faces.

Determine the tilt of the array by using an angle finder instrument or geometric calculation.

Determine the area of the array and the peak power wattage using the information on the SRCC label or manufacturer's literature.

Determine the efficiency of the inverter using the manufacturer's literature.

Lighting

The ratio of Qualifying light fixtures to all light fixtures in Qualifying light fixture locations must be determined and recorded.

Appliances

Refrigerator energy use for the Rated Home must be determined from either Refrigerator Energy Guide Labels, the California Energy Commission Appliance Database, or the age-based defaults from Table 303.4.1.7.2.5(1) of Chapter 3 of the RESNET Standards. If the refrigerator is not installed at the time of final inspection, the default value from the RESNET Standard must be used.

The fuel source for cooking must be determined and recorded in the software tool used for the rating.

If the clothes dryer is installed at the time of final inspection, the Efficiency Factor (lbs of dry clothes/kWh) from the California Energy Commission Appliance Database must be recorded in the software tool used for the rating. If the clothes dryer is not installed at the time of the final inspection, the default value of 3.01 for electric clothes dryers or 2.67 for gas clothes dryers must be used.

If the clothes washer is installed at the time of final inspection, the capacity of the clothes washer from the manufacturer's data, the California Energy Commission Appliance Database, or the EPA ENERGY STAR website must be recorded in the software tool used for the rating. If the clothes washer is not installed at the time of the final inspection, the default value of 2.874 cubic feet must be used. The Modified Energy Factor of the clothes dryer, if installed, must be determined from the Energy Guide Label and recorded in the rating software tool. If the clothes dryer is not installed, a default value of 0.817 must be used. The Labeled Energy Rating of the clothes dryer (kWh/yr) must be determined from the Energy Guide Label and recorded in the rating software tool. If the clothes dryer is not installed, a default value of 704 kWh/yr must be used.

If the dishwasher is installed at the time of final inspection, the place setting capacity must be determined and recorded in the rating software tool or a default value of 12 place settings for standard sized dishwashers and 8 place settings for compact dishwashers must be used. The Energy Factor of the dishwasher must be determined using the California Energy Commission Appliance Database, or by dividing 215 by the labeled kWh/yr from the Energy Guide label, and must be recorded in the rating software tool. If the dishwasher is not installed at the time of the final inspection, the default Energy Factor from the RESNET Standards must be used.

If ceiling fans are installed at the time of final inspection, the labeled cfm/watt at medium speed must be determined and recorded in the rating software tool. If the information is unavailable, the default value from the RESNET Standards must be used.

Air Leakage

Use the testing protocol described in Chapter 8 of these Standards. There are three acceptable airtightness test procedures: single-point test, multi-point test and the repeated single point test. The building may be tested by either pressurizing or depressurizing, following the testing device manufacturer's instructions for set up and operation. Use caution when deciding how and whether to test homes with potential airborne contaminants such as fireplace ash, mold or asbestos.

The following protocol must be followed in preparing the building enclosure for testing:

1. **Doors and windows between conditioned space and the exterior or unconditioned spaces:** Must be closed and latched.
2. **Attached garages:** All exterior garage doors and windows must be closed and latched unless the blower door is installed between the house and the garage, in which case all exterior garage windows and doors must be opened.
3. **Crawlspaces:** If conditioned, interior access doors and hatches between the house and the crawlspace must be opened and crawlspace exterior access doors, vents and hatches must be closed. If unconditioned, interior access doors and hatches must be closed. For testing purposes, crawl-space vents must be open.
4. **Attics:** If conditioned, interior access doors and hatches between the house and the conditioned attic must be opened; and attic exterior access doors and windows must be closed. If unconditioned, interior access doors and hatches must be closed and exterior access doors, dampers or vents must be left in their as found position and their position during testing must be recorded on the test report.
5. **Interior Doors:** Must be open within the Conditioned Space Boundary. See the definition of "Conditioned Space Boundary" for clarification.
6. **Suspended grid ceiling:** One tile must be removed to provide pressure relief and avoid damage during induced pressure differences.
7. **Chimney dampers and combustion-air inlets on solid fuel appliances:** Must be closed. Take precautions to prevent ashes or soot from entering the house during testing. Although the general intent of this standard is to test the building in its normal operating condition, it may be necessary to temporarily seal openings to avoid drawing soot or ashes into the house. Any temporary sealing must be noted in the test report.
8. **Combustion appliance flue gas vents:** Must be left in their normal appliance-off condition.
9. **Fans:** Any fan or appliance capable of inducing airflow across the building enclosure must be turned off including, but not limited to, clothes dryers, attic fans, kitchen and bathroom exhaust fans, outdoor air ventilation fans, air handlers, and crawl space and attic ventilation fans. For continuously operating ventilation systems seal the air opening.
10. **Non-motorized dampers which connect the conditioned space to the exterior or to unconditioned spaces:** Dampers must be left as found. If the damper will be forced open or closed by the induced test pressure, that fact must be reported in the test report.
11. **Motorized dampers which connect the conditioned space to the exterior (or to unconditioned spaces):** The damper must be placed in its closed position and must not be further sealed.
12. **Un-dampered or fixed-damper intentional openings between conditioned space and the exterior or unconditioned spaces:** Must be left open or fixed position, however, temporary blocking must be removed. For example: fixed-damper ducts supplying outdoor air for intermittent ventilation systems (including central-fan-integrated distribution systems) must be left in their fixed-damper

position. ***Exception:*** Un-dampered supply-air or exhaust-air openings of *continuously operating* mechanical ventilation systems must be sealed (preferably seal at the exterior of enclosure) and ventilation fans must be turned off as specified above.

13. **Whole building fan louvers/shutters:** Must be left as found. (If there is a seasonal cover, install it.)
14. **Evaporative coolers:** The opening to the exterior must be covered or sealed.
15. **Operable window trickle-vents and through-the-wall vents:** Must b**e closed.**
16. **Supply registers and return grilles: Must be** left open and uncovered.
17. **Plumbing drains with p-traps:** Must be sealed or filled with water if empty.
18. **Combustion appliances:** Must remain off during the test.
    For test purposes, if a dryer is not attached the dryer exhaust opening should not be sealed off but this fact should be noted in the test report.

Maintain the above conditions throughout the test. If during the test, induced pressures affect operable dampers, seasonal covers, etc. then reestablish the set-up and consider reversing direction of fan flow.

Install the blower door system in an exterior doorway or window that has unrestricted access to the building and no obstructions to airflow within five feet of the fan inlet. Avoid installing the system in a doorway or window exposed to the wind.

It is permissible to use a doorway or window between the conditioned space and unconditioned space as long as the unconditioned space has an unrestricted air pathway to the outdoors. For example, an attached garage or porch can be used as the unconditioned space; in that case, be sure to open all exterior windows and doors of the unconditioned space to the outdoors.

Install the pressure gauge(s), fans and tubing connections according to equipment manufacturer's instructions.

Record the indoor and outdoor temperatures in degrees Fahrenheit to an accuracy of 10 degrees Fahrenheit.

Record the elevation of the building site with an accuracy of 2000 feet; this may be omitted at elevations less than 5000 feet above sea level.

If ***ACH50***, i.e., air changes per hour @ 50 Pa, will be calculated, record the ***building volume.***

For single-point testing, choose and record a ***time averaging period*** of at least 10 seconds to be used for measuring pressures: With the blower door fan sealed and off, measure and record 5, independent, ***average baseline building pressure readings*** with respect to outside to a resolution of 0.1 Pa.

6. Subtract the smallest baseline measurement from the largest recorded above and record this as the ***baseline range***.

7. Airtightness tests with a baseline range less than 5.0 Pa, will be considered a ***Standard Level of Accuracy*** Test. Airtightness tests with a baseline range between 5.0 Pa and 10.0 Pa will be considered a ***Reduced Level of Accuracy*** Test and the results will be adjusted using Section 802.8 of these Standards. A one point test cannot be performed under this standard if the baseline range is greater than 10.0 Pa. Record the level of accuracy for the test as ***standard*** or ***reduced***, as appropriate. The baseline test may be repeated employing a longer time averaging period in order to meet the desired level of accuracy.
8. Re-measure the baseline building pressure using the same time averaging period recorded in Step 1. This measurement is defined as the ***Pre-Test Baseline Building Pressure***. If desired for greater accuracy, a longer time averaging period may be used. As an alternative, the median value of the 5 average baseline building pressure readings taken in Step 1 may be used in lieu of re-measuring the baseline building pressure. Record the ***Pre-Test Baseline Building Pressure***.
9. Unseal the blower door fan. Turn on and adjust the fan to create an induced building pressure of approximately 50 Pa. Induced building pressure must be defined as the (unadjusted) building pressure minus the pre-test baseline building pressure. If a 50 Pa induced building pressure cannot be achieved because the blower door fan does not have sufficient flow capacity, then achieve the highest induced building pressure possible with the equipment available.
10. A one-point test may only be performed if the maximum induced building pressure is at least 15 Pa or four times the baseline pressure, whichever is larger. If the maximum induced building pressure is less than 15 Pa, recheck that the house set up is correct and determine if any basic repairs are needed prior to further testing or modeling of the building. A multi-point test may be attempted, or multiple fans may be used. If using multiple fans, follow the manufacturer's instruction for measurement procedures.
11. Measure and record the unadjusted building pressure and nominal (not temperature and altitude corrected) fan flow using the same averaging period used in Step 4. Record the unadjusted building pressure (with 0.1 Pa resolution), nominal fan flow (with 1 CFM resolution), fan configuration (rings, pressurization or depressurization, etc), fan model and fan serial number.
12. Turn off the fan.
13. If your pressure gauge has the capability to display the induced building pressure (i.e. "baseline adjustment" feature) and adjust the fan flow value to an induced building pressure of 50 Pa (i.e. "@50 Pa" feature), then follow the manometer manufacturer's procedures for calculating the results of a one-point test and record the following values: induced building pressure, nominal CFM50, fan configuration, fan model and fan serial number.

For multi-point and repeated single point testing, follow the procedures in Chapter 8 of these Standards.

After testing is complete, return the building to its as found conditions prior to the test. For example, make sure that any combustion appliance pilots that were on prior to testing remain lit after testing.

It is recommended all pressure equipment be field checked for calibration more frequently than is required in these standards, i.e., monthly, quarterly, etc.

Duct Leakage

Duct leakage may be measured by either pressurizing or depressurizing the duct system. Tests measure either total leakage or leakage to the outside. Total leakage includes all leaks in the air distribution system and leakage to the outside only refers to leaks to outside the conditioned space.

Total duct leakage is tested with a duct leakage testing device attached to the HVAC system and is used to pressurize (or depressurize) the distribution system, including the air handler, to a 25 Pa pressure difference with reference to the outside.

Duct leakage to the outside is tested with a blower door and duct testing device. The blower door is used to create a 25 Pa pressure difference with reference to the outside while the duct testing device is used to equalize the pressure between the distribution system and the conditioned space.

When ducts are in conditioned space, with 100% of the system visible and the system is fully ducted (i.e., no building cavities are used to transport air), the ducts do not have to be tested and the ducts may be assumed to have no leakage to outside the conditioned space.

To prepare the home for the duct leakage test, first adjust the HVAC system controls so that the air handler fan does not turn on during the test.

Next, turn off any fans that could change the pressure in either the conditioned space or any spaces containing ducts or air handlers (bathroom fans, clothes dryers, kitchen vent hood, attic fan, etc.). Turn off all vented combustion appliances if there is a possibility that the space containing the appliance will be depressurized during the test procedure.

Remove all filters from the duct system and air handler cabinet. If the duct leakage testing system is installed at a central return grille, also remove the filter from that grille. Any intentional openings into the duct system such as combustion air or ventilation ducts must be left in their normal non-ventilation operating position. Motorized dampers should be closed.

If ducts run through unconditioned spaces such as attics, garages or crawlspaces, open vents, access panels, doors, or windows between those spaces and the outside to eliminate pressure changes due to duct leakage during the test procedure.

Supply registers and return grilles must be temporarily sealed in some manner so as to allow for the pressurization of the duct system.

Zone and bypass (not balancing) dampers must be set to the open position to allow uniform pressures throughout the duct system.

If testing for total leakage, fully open at least one door, window, or comparable opening between the house and the outside to prevent changes in building pressure while conducting the test.

If testing for leakage to the outside, all exterior doors and windows between the house and the spaces outside the building enclosure (including garages) must be closed. Interior doors must be opened.

To install the duct leakage testing device, attach the duct leakage tester system to the largest return grille closest to the air handler. Use the manufacturer's recommended installation procedure that is consistent with the mode (i.e. pressurization vs. depressurization) of the test being performed. Be sure the remaining opening in the return grille is temporarily sealed.

When testing a duct system with 3 or more returns, installation of the duct leakage tester at the air handler cabinet may be a better attachment location.

Document the attachment location of the duct leakage testing system.

Select a location to measure duct pressure. Choose one of the following three locations to measure duct pressure:

- The largest supply register closest to the air handler, or
- The main supply trunk line, or
- The supply plenum can be used if the duct leakage tester is installed at a central return.

Document the duct pressure measurement location.

Insert a pressure probe into the duct system at the chosen measurement location. If measuring at the supply trunk line or supply plenum, you must use a static pressure probe (be sure the probe is pointing into the air stream). If measuring at a supply register, you may use a static pressure probe, or you may simply insert a straight pressure probe or the end of a piece of flexible tubing.

Install the pressure gauge and tubing connections in accordance with the manufacturer's instructions and the test mode (pressurization vs. depressurization) being used. The duct system pressure should be measured with reference to the inside of the building. Turn on and configure the pressure gauge for the test procedure being performed.

Procedure for conducting a total duct leakage test
Select the appropriate range (e.g. flow ring) of the duct leakage testing fan and configure the flow gauge to match the selected range.
Turn on the duct leakage testing fan and increase fan speed until the duct system has been pressurized to 25 Pa (+/- 0.5 Pa). Measure and record the duct pressure reading (0.1 Pa resolution) and the fan flow reading (1 CFM resolution) using a 5 second averaging period. Also record the fan configuration (range), fan model and fan serial number. Be sure the fan is being operated according to the manufacturer's instructions.

If 25 Pa of duct pressure cannot be achieved because the duct testing fan does not have sufficient flow capacity, then achieve the highest duct pressure possible with the equipment available and record the values above.

Note: If your pressure gauge has the capability to adjust the fan flow value to a duct pressure of 25 Pa (i.e. @25 Pa feature), then follow the manufacturer's procedures for conducting a one-point total leakage test, and record the following values: duct pressure, CFM25 (or fan flow in CFM and pressure in Pa if 25 Pa not achieved), fan configuration, fan model and fan serial number. If your gauge does not have an @25 feature and the measured duct pressure was not exactly 25 Pa, calculate and record CFM25 as: $\text{CFM25} = (25\ \text{Pa}/\ \text{duct pressure})^{0.6} \times \text{fan flow}$.

Turn off the duct testing fan.

Procedure for conducting a duct leakage to the outside test
Install the blower door system in an exterior doorway that has unrestricted access to the building and no obstructions to air flow within five feet of the fan inlet. The blower door fan should be installed in a configuration that is consistent with the mode of the duct leakage test (i.e. pressurization vs. depressurization).

Install the pressure gauge(s), fan and tubing connections as per manufacturer's instructions.

With both the blower door and duct leakage fans sealed, measure the baseline building pressure with reference to outside using a 5 second averaging period.

Unseal the blower door fan. Turn on the blower door fan and pressurize the building by 25 Pa (+/- 0.5 Pa) from the measured baseline building pressure (i.e. change the building pressure by 25 Pa). **Note:** If your pressure gauge has the capability to display the induced building pressure (i.e. baseline adjustment feature), then follow the manufacturer's procedures for pressurizing the building by 25 Pa.

With the blower door fan continuing to run, unseal the duct leakage testing fan and select the appropriate range on the duct leakage testing fan. Configure the duct leakage testing system gauge to match the selected range.

Turn on the duct leakage testing fan and increase fan speed until the duct system pressure reads 0.0 (+/- 0.1 Pa). **Note:** The duct system pressure should be measured with reference to the inside of the building.

Re-check the blower door pressure gauge and if necessary, re-adjust the blower door fan to maintain a 25 Pa pressurization. **Note:** If the blower door fan is being operated with a “cruise control” feature, it is not necessary to recheck the blower door pressure gauge.

Return to the duct leakage pressure gauge and if necessary, re-adjust the duct leakage testing fan until the duct system pressure reads 0.0.

Record the following values: building pressure, duct pressure, CFM of flow through the duct testing fan, duct testing fan configuration, duct testing fan model and serial number. Calculate and record CFM25: $CFM25 = (25\ Pa/\ building\ pressure)^{.6}$ x duct leakage fan flow.

Turn off both the blower door and duct leakage testing fans.

Note: If the blower door system is unable to pressurize the building to 25 Pa because the blower door fan does not have sufficient flow capacity, then you will need to conduct the test at the highest achievable building pressure and adjust the measured duct leakage by using the equation $CFM25 = (25\ Pa/\ building\ pressure)^{.6}$ x duct leakage fan flow.

Note: If the duct testing fan was unable to create a pressure difference of zero between the duct system and the building (while the blower door is pressurizing the building to 25 Pa) because the duct testing fan does not have sufficient flow capacity, then the test will need to be performed at a lower building pressure and adjust the measured duct leakage by using the equation $CFM25 = (25\ Pa/\ building\ pressure)^{.6}$ x duct leakage fan flow.

Ventilation Air Flow Testing

The purpose of these test procedures are to measure the air flows through whole house ventilation systems and local exhausts. The test procedures treat the air flows into and out of the grille being measured separately. The Air Flow Resistance method may only be used on systems that do not have multiple branches in the ventilation air duct system.

Flows into grilles

A powered flow hood may be used to test ventilation flow into grilles, consisting of a flow capture device placed over the grille to be measured. This element needs to be large enough to cover the whole grille and be airtight. This device will also need to measure the static pressure inside the flow capture element and a manometer to measure the pressure differences between the flow capture element and the room. The powered flow hood will also need a variable speed fan to move air through the flow capture element and the flow meter.

Place the flow capture element over the grille to be tested. Turn on the air flow assisting fan and adjust the airflow until there is a neutral pressure (0 Pa) between the flow capture element and the room. Record the air flow through the air flow meter.

The Air Flow Resistance method measures the pressure difference across a flow capture element with a known air flow resistance. A rectangular user fabricated box can be used if the size of the hole is not greater than half the size of the box in each direction and the distance from the hole to the grill is at least as large as the larger dimension of the hole.

Place the flow capture element over the grille to be measured. Ensure there is air tight seal around the grille and the flow device so that all of the air entering the grill goes through the device.

Measure the pressure difference (ΔP) between the flow capture element and the room at a corner of the inlet side of the box. The hole in the flow capture device should be sized so that the pressure difference is between 1 and 5 Pa.

Calculate the air flow using the manufacturer's calibration of the air flow resistance device.

For user fabricated devices that do not have a manufacturer's calibration, the following equations may be used to calculate the air flow.

Air Flow (cfm) = Open Area $\times 1.07 \times (\Delta P)^{0.5}$; for Area in in^2, ΔP in Pa
Air Flow (L/s) = Open Area $\times 0.078 \times (\Delta P)^{0.5}$; for Area in cm^2, ΔP in Pa

Air flows out of grilles
The powered flow hood may be used to test air flow out of grilles, following the same procedures in the section "**Air flows into grilles**", but with the fan and flowmeter set up to measure the flow out of the grille.

The Bag Inflation method requires the use of a bag of a known volume, a method to hold the bag open (typically a lightweight frame of wood, plastic or metal wire), a shutter to start the air flow and a stopwatch.

Completely empty the bag of air and place a shutter over its opening. Rapidly withdraw the shutter and start the stopwatch. When the bag is completely full stop the stopwatch. Calculate the airflow by dividing the bag volume by the elapsed time. Calculate the air flow in cfm as 8 X bag volume in gallons/number of seconds. Repeat measurement one or more times and average the results.

Bags made from thinner material often do not fill uniformly because the air flow from the register blows them about too much.   If the bag sides flap a lot and measuring the same register twice gives results that differ by more than 20%, then try a bag with thicker material.

Bags that fill in under two seconds will have increased errors because of resolution issues in timing how fast the bag is filled. Conversely, bags that are too large for a given register flow will have increased leakage around the edges of the bag before it fills completely and may not generate enough pressure to push a bag into its final shape. Aim for a fill time of 2 to 20 seconds.

Passive Solar

Concrete slabs and basement walls when uninsulated or insulated on the exterior can be considered as thermal storage mass when combined with solar gain from south fenestration. Note type of thermal mass: concrete, brick, tile, water.

South fenestration is defined as fenestration oriented between 45E SE to 45E SW.

Slab-on-grade construction in climates with more than 3600 HDD (Base 65) may not be considered solar storage mass unless properly insulated (edge, perimeter, or under slab).

A solar direct gain system can reduce heating, cooling, and lighting energy requirements through proper sizing, placement, orientation, and/or control of windows, skylights, shading devices, and solar storage mass within the building.

To determine aperture area, measure width and height of south-facing glazing and indicate tilt angle. Note glass type(s) (e.g., double glazing) and presence of night insulation (if any).

Determine orientation with a compass reading (adjusted for magnetic deviation and declination).

Determine the type of thermal mass, its thickness and dimensions. Determine if the mass will be lit by direct solar rays between the hours of 9:00 a.m. and 3:00 p.m. during the winter. Note any trees or other obstructions to solar gain.

A greenhouse or solarium creates a South-glazed buffer zone between the house and the exterior and can help heat the living area. They may be used in conjunction with thermal mass (such as bricks or drums filled with water) to store heat and reradiate it at night.

Thermal mass systems consist of solar-exposed heavyweight materials with high heat capacitance and relatively high conductance (high thermal diffusivity) such as masonry, brick, concrete, tile, stone, or water placed in the same zones(s) as the solar collection area(s). These elements may be integral with the building or distinct elements within the building.

Distinct components:

Trombe wall -uses a heat storage mass placed between the glass and the space to be heated. Measure area of storage mass, determine material, thickness, and capacitance.

Water wall -replaces the existing wall, or parts of it, with containers that hold water.

Thermosiphon air panel (TAP) -has one or more glazing layers of glass or plastic, an air space, an absorber, another air space, and (often) an insulated backing. These are similar in appearance to active flat-plate collectors, often mounted vertically on walls, or ground-mounted, so that the living space is higher than the collector to facilitate convection from the TAP to the house.

Comprehensive Home Energy Rating

If a Comprehensive Home Energy Rating is being performed, the following procedures are considered part of the minimum rated features required to produce a Comprehensive Home Energy Rating.

Gas Leakage Testing

If there is a noticeable odor indicating gas buildup within the home, the occupants and Comprehensive Home Energy Rater or Building Performance Auditor (Auditor) must leave the house and the appropriate authorities and utility providers must be notified from outside the home. The Auditor should use a gas detector upon entry into the home to detect the presence of natural gas. If gas is suspected or confirmed, ensure that switches are not operated while exiting and no ignition concerns are present. The audit must not proceed until the proper authorities have deemed it safe to re-enter the home.

If there is no noticeable odor indicating gas buildup within the home, the Auditor must determine if there are gas leaks in the fittings and connections of natural gas appliances within the home and natural gas/liquid propane supply lines following these protocols.

Equipment needed:

- Combustible gas detector capable of measuring 20 ppm
- Leak detection fluid (non-corrosive)

Inspect all fittings and joints in supply lines and appliance connectors and confirm suspected leaks with leak-detection fluid.

Worst Case Depressurization Test

This test procedure measures the pressure in the Combustion Appliance Zone

(CAZ) and provides visual evidence of spillage potential.

If there are any vented combustion appliances that use indoor air to vent combustion gases and which are not classified as a category 3 or 4 according to NFPA standard 54, then a worst case depressurization test must be performed using the following protocol.

Check the combustion appliance zone for the presence of flammable or explosive material near a combustion source.

Visually inspect venting system for proper size and horizontal pitch and determine there is no blockage or restriction, leakage, corrosion or other deficiencies that could cause an unsafe condition.

Inspect burners and crossovers for blockage and corrosion. Inspect furnace heat exchangers for cracks, openings or excessive corrosion.

Close all the exterior doors and windows of the home. Close fireplace damper(s) if fireplace is present. Close any interior doors between the CAZ and the remainder of the house, ensuring that all vented appliances and exhaust fans have been turned off.

Measure the baseline pressure difference between the CAZ with reference to (WRT) outside (ambient) and baseline CO levels. Set the gauge to read pressure and record the baseline pressure.

Turn on all exhaust fans in the home (kitchen range hood, bath exhaust, clothes dryer, etc.) that exhaust air outside the building envelope.

Record pressure in CAZ with reference to Outside.

Turn on the air handler. Record pressure in CAZ with respect to outside. If air handler makes the CAZ more positive (or less negative), turn it off. If the air handler is kept on, close interior doors to any rooms that have no return registers.

If fireplace is present install blower door and set to exhaust 300 CFM to simulate fireplace in operation.

Record net change in pressure difference within the CAZ WRT outside between baseline and worst case depressurization conditions. Record the position of doors and conditions of fans and air handler. When the net change in CAZ pressure is lower (more negative) than the limits specified below, the work scope must specify remediation through pressure balancing, duct sealing, and/or other pressure-relief measures, as applicable.

Turn on vented combustion appliance with the smallest Btu capacity. Operate appliance for 5 minutes then measure CO levels according to the carbon monoxide test procedure below, and check appliance draft using a smoke pencil at the draft diverter. If the smoke is not fully drawn up the flue, the appliance has spillage under worst case depressurization. Record if there is any spillage and record CO levels. When spillage occurs or CO exceeds the limits specified below in section 9, the work scope must specify remediation, including equipment repair or replacement, and/or building pressure remediation, as applicable. If both spillage and high CO are found during the test, the homeowner should be notified of the conditions and that it needs immediate remediation.

Turn on all the other combustion appliances, one at a time, within the CAZ and repeat the previous step on each of them.

If spillage or high CO occurs in any appliance(s) under worst case depressurization, retest that appliance(s) under natural conditions. Turn off the combustion appliances. Turn off the exhaust fans. Open the interior doors. Let the vent cool. Test CO and spillage under natural conditions.

CAZ Pressure Limits:

- -15 Pa for pellet stoves with exhaust fans and sealed vents
- -5 Pa for Atmospheric vented oil or gas system (classified as a category 1 or 2 according to NFPA standard 54, such as oil power burner; fan-assisted or induced-draft gas; solid-fuel–burning appliance other than pellet stoves with exhaust fans and sealed vents)

If ambient CO levels exceed 35 ppm at any time, stop any testing and turn the combustion appliances off. Open all the exterior doors and windows. No one should enter the home until the CO levels drop below 35 ppm.

Carbon Monoxide Testing

Test all spaces (including attached garages, crawlspaces, basements) containing combustion appliances for carbon monoxide using the following protocols.

Carbon Monoxide (CO) testing of ambient air must be performed continuously while performing a Worst Case Depressurization Test and/or under natural conditions.

Equipment used must:

- Be capable of measuring carbon monoxide (CO) levels from 0 to 2,000 ppm(parts per million)
- Have a resolution of 1 ppm
- Have an accuracy rate of + 5 ppm
- Be calibrated annually by the manufacturer (or using manufacturer's instructions) and evidence of the calibration must be submitted to the Rating Provider Quality Assurance Designee

Zero the carbon monoxide meter outside the building away from any combustion outlets or automobile traffic areas.

Take a measurement of CO levels within the home upon entering to establish a baseline. Do not measure near combustion appliances while they are operating. If ambient CO levels are higher than 35 ppm during normal appliance operation, turn off the appliance, ventilate the space, and evacuate the building. The building may be reentered once ambient CO levels have gone below 35 ppm.

For atmospherically-vented appliances:

- Take a measurement of vent gases upstream of (before they reach) the draft diverter.
- Appliance must operate for at least 5 minutes before taking sample.
- Take sample during worst-case depressurization test and/or under natural conditions. Record the CO level.

For direct- or power-vented appliances:

- Sample must be taken at vent termination.
- Appliance must operate for at least 5 minutes before taking sample.
- Take sample during worst-case depressurization test and/or under natural conditions. Record the CO level.

For LP- or natural gas ovens:

- Open a window or door to the outside.
- Remove any foil or cooking utensils within the oven.
- Verify that the oven is not in self-cleaning mode.
- Turn oven on to highest temperature setting.
- Close the oven door and begin monitoring the CO levels in the kitchen, 5 feet from the oven at countertop height. Record CO levels.
- Measure the CO levels within the oven vent.
- Samples must be taken while burner is firing.
- Operate burner for at least 5 minutes while sampling flue gases.
- If CO levels are higher than 100 ppm, repeat the flue gas sampling until the CO levels stop falling.
- Record the steady state CO reading in ppm and turn off oven.