Ducts in Interstitial Floor Framing

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Scope

Use the interstitial floor space between the conditioned levels of a home to provide space for HVAC ducts within the thermal envelope of the home

- Use the interstitial floor
  - If there is sufficient space in the floor cavities to house the ducts
  - If the ducts can be routed through the floor cavities, usually through open-web floor joists.

- Insulate and air seal the rim joists and integrate the insulation and air sealing boundaries with the home’s thermal envelope.

- During design, plan the path of the duct system to be housed in the floor cavity including truss type (e.g. open web) and modifications.
  - During design, work with both the HVAC contractor and the truss designer to ensure the duct sizes will fit, with adequate room for attachment, in the truss spacing, openings and/or webs.
  - Develop the thermal and air barrier detailing needed to separate the floor cavity from the outside and all adjacent unconditioned spaces.

- During construction, after the house is dried in, mark the path of the duct system.

- Mark the edges (rim joists) of the conditioned floor cavity, including exterior walls, and any attic knee walls, garage walls, and stair well walls.

- Identify areas where the duct crosses the edge of the conditioned floor cavity. Resolve conflicts.

- Install additional framing needed to support the thermal and air barriers at the edge of the floor cavity. Identify and seal framing between vertical chases and the floor cavity. Add air barrier material as needed.

- Ensure that a durable air barrier material covers the entire perimeter of the floor cavity and that this air barrier integrates with the whole house air barrier above and below. Seal all penetrations, edges, and joints.

- At mechanical rough-in, install the ducts in the floor cavity following guidelines for quality installation.

- Test the ducts for air tightness and repair air leaks.

- Seal all penetrations between the floor cavity and adjacent unconditioned spaces and building cavities.

- Install a durable and continuous layer of insulation along the floor cavity perimeter that aligns with the insulation above and below the floor cavity.

See the Compliance Tab for related codes and standards, and criteria to meet national programs such as ENERGY STAR, DOE’s Zero Energy Ready Home program, and EPA’s Indoor airPLUS.
Description

Building cavities, sometimes called interstitial spaces, include framed floor cavities between upstairs and downstairs conditioned rooms. This floor cavity space can be used to house supply and return ducts if there is adequate room to avoid compressing the duct and compromising air flow (in BASC see: “Sufficient Cavity Space for Flex Ducts”) and if there is an adequate unobstructed path for each duct. This is made possible largely by open-web floor joists that allow duct runs to go in perpendicular directions. This can be considered “interior ductwork” or “ducts in conditioned space” when the floor cavity is separated from adjacent unconditioned and outdoor spaces by thermal and air flow barriers that integrate with the other elements of the whole house thermal and air barriers.

While floor cavities normally fall within the exterior finishes of a house, they are not technically considered conditioned space because there is no intentional air exchange with the conditioned spaces above and below or the conditioned air distribution system. Additionally, they may be connected to the outdoors (Figure 1) or adjacent unconditioned spaces (Figure 2) such that outside or unconditioned air can move into the floor cavity.

They can be considered quasi-conditioned spaces if they have been sufficiently separated from adjoining exterior and unconditioned spaces by continuous thermal and air flow barriers that are integrated with the rest of the whole house thermal and air flow barriers (in BASC see: “Continuous Air Barrier in Exterior Walls”)

Separating the floor cavity from adjacent outside and unconditioned spaces requires sealing all penetrations in the rim joists that form the edges of the floor cavity and insulating the rim joists in a manner consistent with walls above and below or adjacent attic insulation (Figure 3). With this heat transfer and infiltration boundary in place, the floor cavity temperature will be more like the conditioned spaces above and below rather than like the adjacent unconditioned or exterior spaces. Ducts located in such insulated and air-sealed frame floor cavities can be classified as “interior ducts” or “ducts in conditioned space” for purposes of compliance with energy-efficiency programs like DOE’s Zero Energy Ready Home program. Program requirements may specify insulation location and R-value.

![Figure 1](image.png)

Figure 1. Unsealed, uninsulated rim joists allow outside air and heat into the floor cavity (image courtesy of BA-PIRC).
Figure 2. Uninsulated, unsealed, or missing rim joists allow attic air and heat into the floor cavity (image courtesy of BA-PIRC).

Figure 3. Thermal and air barriers at the rim joist block Infiltration into the floor cavity and integrate with the whole house thermal and air barriers in the walls above and below (image courtesy of BA-PIRC).

In addition to separating the floor cavity from the outside, it must be separated from any adjacent unconditioned space such as a vented attic (Figure 4) or crawl space, garage, vertical chase connected to a vented attic or crawl space, or wall enclosing a stair well (in BASC see: “Wind Washing,” and “Garage Rim/Band Joist adjoining Conditioned Space,”). It may be necessary to add framing to support thermal and air flow barriers. Observe local codes for fire rating requirements for sealants, materials, and assemblies.

Figure 4. Thermal and air barriers at rim joist or new blocking prevent Infiltration of unconditioned air into the floor cavity (image courtesy of BA-PIRC).

When the floor cavity extends over exterior space, follow guidelines for air sealing and insulating the cantilevered floors (in BASC see: “Cantilevered Floor”).

When the floor cavity extends into a vented attic, follow guidelines for sealing and insulating floor joist cavities under knee walls (in BASC see: “Attic Knee Walls”)

Generally, a floor cavity is not deep enough to accommodate both a supply duct system and a return duct system if the two systems must cross over each other. If only a portion of the duct system is located in the floor cavity, the remainder of the air distribution system including the air handler must be located in other conditioned spaces for the whole system to be classified “ducts in conditioned space” (See Compliance tab for details on requirement of the DOE Zero Energy Ready Home Program.) This could be in a utility room within the home or in an unvented, insulated crawlspace, an air-sealed, insulated basement, or an unvented, insulated attic. Also see: “Ducts in Conditioned Space” by Building Science Corporation).
Ducts located in floor cavities above a vented crawl space or unconditioned basement are not considered to be in conditioned space because they are not separated from unconditioned space by air and thermal barriers. In this case, see BASC guidance for “Floor above Unconditioned Basement or Vented Crawlspace”.

Note that this guide describes methods for installing ducts within floor cavities. The floor cavities themselves should not be used as supply or return ducts. See the Building America Solution Center (BASC) guide “Building Cavities Not Used as Supply or Return Ducts”) for more information.

How to Install Interior Ducts in Interstitial Floor Framing

**Step 1:** Using an integrated design process that includes input from the structural designer and mechanical contractor, develop a duct plan and the thermal and air barrier detailing needed to separate the floor cavity from the outside and all adjacent unconditioned spaces.

The duct plan should include the exact location of the floor cavity edge (where the thermal and air barriers will be installed), the location of all registers, junction boxes, plenums, and connections to elements of the air distribution not in the floor cavity. Also define the location of critical floor cavity structural elements and vertical chases passing through the floor cavity.

Consideration must be paid simultaneously to duct design and the structural design of the floor cavity. Duct dimensions and path must mesh with the direction and depth of floor framing members while providing for appropriate location of supply and/or return registers. In general, a straight duct trunk is paired with short, straight branch duct (runouts) to reach individual rooms.

Engineered openings provide a path for trunks or branch ducts running perpendicular to the framing members.

Clearly identify the perimeter of the floor cavity to be included within the whole house thermal and air barriers. Decide what materials will be used for the thermal and air barriers and how they will be installed. Incorporate details into wall sections in the construction documents, bid documents for each trade involved, and pre-construction reviews with trade contractors involved prior to implementation.

**Step 2:** After the house is dried in, mark the exact location of the edge of the floor cavity to be included in the whole house thermal and air barrier with colored tape, marker, etc. Identify the intersections between the floor cavity and the whole house thermal and air barriers which may involve attic knee walls, garage walls, and stair well walls. This should extend around the entire perimeter of the floor cavity including where the floor cavity extends over exterior space (cantilevers) and into vented attics.

Identify areas where additional framing is needed to support thermal and air barrier materials. Identify areas, if any, where the rim joist air barrier needs to be integrated with the whole house drainage plane or vapor barrier. These are complex details. This is the time to clarify how the details in the construction documents will be executed at every point along the floor cavity edge and at all penetrations. Resolve conflicts prior to beginning installation of thermal and air barriers.

**Step 3:** To be done in tandem with Step 2, mark the path of the duct system to ensure it does not cross the edge of the floor cavity. Resolve conflicts.

**Step 4:** Per construction documents and any resolutions resulting from Steps 2 and 3, install additional framing needed to support the thermal and air barriers at the edge of the floor cavity and at openings in the floor cavity for vertical chases.

**Step 5:** Working around the entire edge of the floor cavity and all penetrations, install a durable air barrier material that continues or integrates with the whole house air barrier above and below. Seal all penetrations, edges, seams, and joints. In BASC, see “Continuous Air Barrier in Exterior Walls”.

**Step 6:** At mechanical rough-in, install the ducts in the floor cavity following guidelines for quality installation. Never modify a structural member to accommodate a duct. Resolve conflicts by adjusting the duct design. Conduct preliminary duct leakage testing on the ducts. Mark leaks. Work with the mechanical contractor to eliminate leakage while the floor cavity is still open to the space below.

**Step 7:** Prior to installing insulation, seal all penetrations between the floor cavity and outside space, unconditioned spaces, and building cavities.

**Step 8:** Install a durable and continuous layer of insulation that aligns with the insulation above and below the floor cavity. In BASC see: “Attic Knee Walls”, “Garage Rim/Band Joist Adjoining Conditioned Space”, and “Continuous Air Barrier in Exterior Walls”.
Ensuring Success

Do not operate portable combustion heaters in the house once air sealing has commenced.

Make every effort to seal all penetrations and sections of the floor cavity edge prior to drywall installation on the ceiling below while the floor cavity is still accessible from below. Upon completion, the floor cavity should be substantially air tight with no part of the cavity interior evident in a visual inspection.

Avoid placing recessed lighting fixtures in the ceiling plane below a floor-mounted duct run. For nearby recessed fixtures, select models that are Insulation Contact and Air Tight (ICAT)-rated to reduce heat transfer to ducts.

Ultimately the vertical duct dimension must be less than the minimum vertical clearance along its path within the floor cavity. Vertical clearance may be affected by horizontal blocking, cross bracing, plumbing, and wiring runs. Plan for a generous vertical allowance to accommodate unforeseen horizontal elements and minor inaccuracies in duct construction.

During design, mock up duct sections and floor framing during design. Small inaccuracies in duct construction are common and can increase vertical duct dimension beyond the allowance in a tightly designed floor cavity. For example, a mock-up can help ensure that the design dimensions of junction boxes allow adequate clearance for installing the flex duct collars.

During Step 2, mock up a portion of the thermal and air barrier installation at the floor cavity edge. Review with each trade contractor involved to ensure responsibilities are mutually understood.

Ideally, all ducts, including those in floor cavities, should be well built, thoroughly sealed, and insulated to ensure conditioned air is delivered to the intended space at the correct temperature (in BASC, see “Sealed and Insulated Flex Ducts”, “Sealed and Insulated Fiber Board Ducts”, and “Sealed and Insulated Metal Ducts”)

Rather than waiting until the finish mechanical work is done, conduct a duct leakage test after mechanical rough-in but prior to closing up the floor cavity. All duct air-sealing materials should be thoroughly dry and hardened. Install a temporary air barrier (e.g., card board) wherever a portion of the duct system is missing, such as at the supply and/or return plenums, if the air handler has not been set. Seal the temporary air barrier in place with tape or duct mask so that no air can pass through the opening during testing. If higher-than anticipated air leakage is measured, use the duct testing fan to very slightly pressurize the ducts in the floor cavity. Leakage sites can be detected by feeling for air flow at duct connections or using smoke detection pencils. It is best to have the mechanical contractor on site during this test to make repairs as they are found. If that is not possible, mark the leakage sites on the duct work to reduce confusion during repairs. Do not retest the duct system until all sealants are dry and hardened.
Climate

Guide contents are applicable to all climates. See the Compliance tab for climate-zone-specific requirements for insulation and air sealing.
Training

Right and Wrong Images


Display Image: 2018-Ferrier-X-FramingZlpWallEngineeredFloorTrusses.JPG
Compliance

The Compliance tab contains both program and code information. Code language is excerpted and summarized below. For exact code language, refer to the applicable code, which may require purchase from the publisher. While we continually update our database, links may have changed since posting. Please contact our webmaster if you find broken links.

ENERGY STAR Certified Homes, Version 3/3.1 (Rev. 09)

National Rater Field Checklist

Thermal Enclosure System.

2. Fully-Aligned Air Barriers. At each insulated location below, a complete air barrier is provided that is fully aligned as follows:

Floors: At exterior vertical surface of floor insulation in all climate zones and, if over unconditioned space, also at interior horizontal surface including supports to ensure alignment. Alternatives in Footnotes 11 & 12.

Footnote 10) EPA highly recommends, but does not require, an air barrier at the interior vertical surface of floor insulation in Climate Zones 4-8.

Footnote 12) Alternatively, an air barrier is permitted to be installed at the exterior horizontal surface of the floor insulation if the insulation is installed in contact with this air barrier, the exterior vertical surfaces of the floor cavity are also insulated, and air barriers are included at the exterior vertical surfaces of this insulation.

DOE Zero Energy Ready Home (Revision 07)

Exhibit 1 Mandatory Requirements.

Exhibit 1, Item 1) Certified under the ENERGY STAR Qualified Homes Program or the ENERGY STAR Multifamily New Construction Program.

Exhibit 2, Item 2) Ceiling, wall, floor, and slab insulation shall meet or exceed 2015 IECC levels and achieve Grade 1 installation, per RESNET standards.

Exhibit 1, Item 3) Duct distribution systems located within the home’s thermal and air barrier boundary or an optimized location to achieve comparable performance.

Exhibit 2 DOE Zero Energy Ready Home Target Home.

The U.S. Department of Energy’s Zero Energy Ready Home program allows builders to choose a prescriptive or performance path. The DOE Zero Energy Ready Home prescriptive path requires builders to meet or exceed the minimum HVAC efficiencies listed in Exhibit 2 of the National Program Requirements (Rev 07), as shown below. The DOE Zero Energy Ready Home performance path allows builders to select a custom combination of measures for each home that is equivalent in performance to the minimum HERS index of a modeled target home that meets the requirements of Exhibit 2 as well as the mandatory requirements of Zero Energy Ready Home Exhibit 1.

Exhibit 2, Insulation and Infiltration) Insulation levels shall meet the 2012 (or 2015) IECC and achieve Grade 1 installation per RESNET standards. Whole house leakage must be tested and meet the following infiltration limits:

- Zones 1-2: ? 3 ACH50;
- Zones 3-4: ? 2.5 ACH50;
- Zones 5-7: ? 2 ACH50;
- Zone 8: ? 1.5 ACH50;
- Attached dwellings: ? 3 ACH50.

Footnote 14) Exceptions and alternative compliance paths to locating 100% of forced-air ducts in home’s thermal and air barrier boundary are:

1. Up to 10’ of total duct length is permitted to be outside of the home’s thermal and air barrier boundary.

2. Ducts are located in an unvented attic, regardless of whether this space is conditioned with a supply register.

3. Ducts are located in a vented attic with all of the following characteristics: [Note that in either of these designs the HVAC equipment must still be located within the home’s thermal and air barrier boundary.]
   1. In Moist climates (Zones 1A, 2A, 3A, 4A, 5A, 6A and 7A per 2015 IECC Figure R301.1) and Marine climates (all “C” Zones per 2015 IECC Figure R301.1), minimum R-8 duct insulation with an additional minimum 1.5” of closed-cell spray foam insulation encapsulating the ducts; duct leakage to outdoors ? 3 CFM25 per 100 ft2 of conditioned floor area (in addition to meeting total duct leakage requirements from Section 4.1 of the ENERGY STAR HVAC Rater checklist); and ductwork buried under at least 2” of blown-in insulation.

   2. In Dry climates (all “B” Zones per 2015 IECC Figure R301.1), minimum R-8 duct insulation; duct leakage to outdoors ? 3 CFM25 per 100 ft2 of conditioned floor area (in addition to meeting total duct leakage requirements from Section 4.1 of the ENERGY STAR HVAC Rater checklist); and ductwork buried under at least 3.5” of blown-in insulation.
4. Systems which meet the criteria for “Ducts Located in Conditioned Space” as defined by the 2018 IECC Section R403.3.7
5. Jump ducts which do not directly deliver conditioned air from the HVAC unit may be located in attics if all joints, including boot-to-drywall, are fully air sealed with mastic or foam, and the jump duct is fully buried under the attic insulation.
6. Ducts are located within an unvented crawl space.
7. Ducts are located in a basement which is within the home’s thermal boundary.
8. Ductless HVAC system is used.

2009 IECC
Table 402.4.2, Air barrier and thermal barrier: Exterior wall insulation is installed in substantial contact and continuous alignment with the air barrier. Air permeable insulation is not used as a sealing material.
Section 403.2.3 Building cavities (Mandatory). Building framing cavities cannot be used as supply ducts.
Section 403.2.1 Insulation (Prescriptive). Supply ducts in attics are insulated to a minimum of R-8. All other ducts in unconditioned spaces or outside the building envelope are insulated to at least R-6.

2012 IECC
Section R403.2.1 Insulation (Prescriptive). Supply ducts in attics are insulated to a minimum of R-8. All other ducts in unconditioned spaces or outside the building envelope are insulated to at least R-6.
Section R403.2.3 Building cavities (Mandatory). Building framing cavities cannot be used as supply ducts or plenums.
The IECC 2012 requires new construction to have a tested air tightness with whole house air leakage not to exceed 5 ACH50 for Climate Zones 1 and 2. An even tighter restriction of 3 ACH50 is mandatory for Climate Zones 3 through 8. IECC 2012 has language in Table R402.4.1.1 that may be interpreted that floor cavities are required to be insulated and air sealed from unconditioned spaces, however floor cavities are not specifically mentioned. Without more specific language addressing floor cavities, code enforcement is more likely to be missed. Florida code has adopted more specific language that requires an “Air barrier on perimeter of floor cavities between floors” for multi-story homes.
Table R402.4.1.1, Air barrier and thermal barrier: A continuous air barrier is installed in the building envelope including rim joists and exposed edges of insulation. Breaks or joints in the air barrier are sealed. Air permeable insulation is not used as a sealing material.

2015 IECC
Table R402.4.1.1 requires that a continuous air barrier be installed in the building envelope including at the junction of the top plate and the tops of exterior walls, all kneewalls, all rim joists, and at any exposed edges of insulation in floors.
R403.3.1 Insulation (Prescriptive). Supply ducts in attics are insulated to a minimum of R-8. All other ducts in unconditioned spaces or outside the building envelope are insulated to at least R-6.
Section R403.3.5 Building cavities (Mandatory) Framing cavities in buildings cannot be used as ducts or plenums.

2018 IECC
Table R402.4.1.1 (Mandatory) requires that a continuous air barrier be installed in the building envelope including at the junction of the top plate and the tops of exterior walls, all kneewalls, all rim joists, and at any exposed edges of insulation in floors.
Section R403.3.1 Insulation (Prescriptive). Supply ducts in attics are insulated to a minimum of R-8. All other ducts in unconditioned spaces or outside the building envelope are insulated to at least R-6. Exception to R403.3.1: ducts inside the whole house thermal envelope.
Section R403.3.5 Building cavities (Mandatory) Framing cavities in buildings cannot be used as ducts or plenums.

Section R101.4.3 (Section R501.1.1 in 2015 and 2018 IECC). Additions, alterations, renovations, or repairs shall conform to the provisions of this code, without requiring the unaltered portions of the existing building to comply with this code. (See code for additional requirements and exceptions.)

2009 IRC
Section M1601.1.1 Above-ground duct systems. Stud wall cavities and spaces between solid floor joists cannot be used as supply air plenums.
Table N1102.4.2, Air barrier and thermal barrier: Exterior wall insulation is installed in substantial contact and continuous alignment with the air barrier. Air permeable insulation is not used as a sealing material.

2012 IRC
Section M1601.1.1 Above-ground duct systems. Stud wall cavities and spaces between solid floor joists cannot be used as supply air plenums. Stud wall cavities in building envelope exterior walls cannot be used as air plenums.

Table N1102.4.1.1, Air barrier and thermal barrier: A continuous air barrier is installed in the building envelope including rim joists and exposed edges of insulation. Breaks or joints in the air barrier are sealed. Air permeable insulation is not used as a sealing material.

**2015 IRC**

N1102.4.1.1 Air Barrier and Insulation Installation, Ceiling/attic: Air barrier in any dropped ceiling/soffit is substantially aligned with insulation and any gaps are sealed. General requirements: A continuous air barrier is installed in the building envelope; breaks and joints in the air barrier are sealed. Air-permeable insulation is not used as an air-sealing material.

**2018 IRC**

Section N1102.4.1.1 Air Barrier and Insulation Installation, Ceiling/attic: Air barrier in any dropped ceiling/soffit is substantially aligned with insulation and any gaps are sealed. General requirements: A continuous air barrier is installed in the building envelope; breaks and joints in the air barrier are sealed. Air-permeable insulation is not used as an air-sealing material. Rim joists must be included in the whole house air barrier and insulated.

**Retrofit:** 2009, 2012, 2015, and 2018 IRC

Section N1101.3 (Section N1107.1.1 in 2015 and 2018 IRC). Additions, alterations, renovations, or repairs shall conform to the provisions of this code, without requiring the unaltered portions of the existing building to comply with this code. (See code for additional requirements and exceptions.)

Appendix J regulates the repair, renovation, alteration, and reconstruction of existing buildings and is intended to encourage their continued safe use.
References and Resources*

   Author(s): International Code Council
   Organization(s): ICC
   Publication Date: January, 2009
   Code establishing a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems and service water heating systems in homes and commercial businesses.

2. 2009 IRC - International Residential Code for One and Two Family Dwellings
   Author(s): International Code Council
   Organization(s): ICC
   Publication Date: January, 2009
   Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

   Author(s): International Code Council
   Organization(s): ICC
   Publication Date: January, 2012
   Code establishing a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems and service water heating systems in homes and commercial businesses.

4. 2012 IRC - International Residential Code for One and Two Family Dwellings
   Author(s): International Code Council
   Organization(s): ICC
   Publication Date: January, 2012
   Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

5. 2015 IECC - International Energy Conservation Code
   Author(s): International Code Council
   Organization(s): ICC
   Publication Date: May, 2014
   Code establishing a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems and service water heating systems in homes and commercial businesses.

6. 2015 IRC - International Residential Code for One and Two Family Dwellings
   Author(s): International Code Council
   Organization(s): ICC
   Publication Date: May, 2014
   Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

7.
8. **2018 IRC - International Residential Code for One and Two Family Dwellings**
   - **Author(s):** International Code Council
   - **Organization(s):** ICC
   - **Publication Date:** August, 2017
   - Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

   - **Author(s):** Baechler, Gilbride, Hefty, Cole, Love
   - **Organization(s):** Pacific Northwest National Laboratory, Oak Ridge National Laboratory
   - **Publication Date:** February, 2011
   - Guide describing measures that builders in the cold and very cold climates can take to build homes that have whole-house energy savings of 40% over the Building America benchmark with no added overall costs for consumers.

10. **Critical Seal (Spray Foam at Rim Joist)**
    - **Author(s):** Building Science Corporation
    - **Organization(s):** Building Science Corporation
    - **Publication Date:** September, 2009
    - Information sheet about air sealing.

11. **DOE Zero Energy Ready Home National Program Requirements (Rev. 07)**
    - **Author(s):** U.S. Department of Energy
    - **Organization(s):** DOE
    - **Publication Date:** May, 2019
    - Standard requirements for DOE’s Zero Energy Ready Home national program certification.

12. **Ducts in Conditioned Space**
    - **Author(s):** Building Science Corporation
    - **Organization(s):** Building Science Corporation
    - **Publication Date:** May, 2009
    - Brochure with information about ducts in conditioned space.

13. **ENERGY STAR Certified Homes, Version 3/3.1 (Rev. 09) National Program Requirements**
    - **Author(s):** U.S. Environmental Protection Agency
    - **Organization(s):** EPA
    - **Publication Date:** September, 2018
    - Webpage with links to documents providing the program requirements and checklists for ENERGY STAR Certified Homes (Ver. 3/3.1, Rev. 09).

14. **Opportunities for Energy Conservation and Improved Comfort From Wind Washing Retrofits in Two-Story Homes - Part II**
    - **Author(s):** Withers, Cummings
    - **Organization(s):** FSEC
    - **Publication Date:** September, 2010
    - Research study finding significant wind washing potential in 40% of homes in the study area.

15. **Thermal Enclosure System Rater Checklist Guidebook**
    - **Author(s):** U.S. Environmental Protection Agency
    - **Organization(s):** EPA
    - **Publication Date:** October, 2011
    - Guide describing details that serve as a visual reference for each of the line items in the Thermal Enclosure System Rater Checklist.
Contributors to this Guide

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