When HVAC ducts are installed in a vented attic in any climate, encapsulate the HVAC ducts in attic insulation to protect them from temperature extremes in the unconditioned attic space.

- Install ductwork so that it is in direct contact with (i.e., laying on) the ceiling and/or truss lower cords.
- Use [metal](#), [flex](#), or [fiber board](#) ducts that are insulated to code. The duct insulation should include a vapor barrier cover.
- Mechanically fasten and mastic-seal all duct connections.
- Test total duct leakage. Add additional sealant if necessary.
- Completely encase the ducts in closed-cell spray polyurethane foam (ccSPF) to the desired foam depth.
- Install loose-fill insulation to cover the ducts and the attic floor to meet or exceed the code-required R value for attic insulation.
- This technique fulfills the DOE Zero Energy Ready Home program requirement that ducts be installed in conditioned space.

See the [Compliance Tab](#) for related codes and standards requirements, and criteria to meet national programs such as DOE's Zero Energy Ready Home program, ENERGY STAR Certified Homes, and Indoor airPLUS.
For homes with ducted heating and cooling systems, the best place to locate the duct system from an HVAC performance standpoint is within the conditioned space of the home, either in dropped ceilings, or between floors, or in a sealed and insulated basement, crawlspace, or attic. If the ducts must be located within a vented attic, one option for protecting the ducts and helping to minimize heat transfer between ducts and the unconditioned attic is to lay the ducts on the attic floor and cover them with the same blown insulation that is used to cover the attic floor.

If using this technique in the humid or marine climates, the ducts must be encapsulated with spray foam before installing the blown insulation. Use a compact duct layout. The ductwork should be installed so that it is in direct contact with the ceiling and/or truss lower chords. Metal, flex, or fiber board ducts can be used. The ducts should be covered with R-8 or higher duct insulation and the duct insulation should include a vapor barrier cover. All duct connections should be mechanically fastened and mastic-sealed. The ducts should be tested for total duct leakage and any leaks should be sealed. Once these preparations are made, the ducts can be encapsulated in closed-cell polyurethane spray foam then buried in loose-fill insulation (typically blown fiberglass or cellulose) at the same time that the attic floor is being insulated. The insulation levels should meet or exceed the code-required R value for attic insulation. Figure 1 shows a duct that is encapsulated in spray foam and then partially, fully, or deeply buried in blown attic insulation.

![Figure 1](https://example.com/figure1.png)

**Figure 1.** Buried ducts are laid on the floor of a vented attic then covered with spray foam and blown attic floor insulation (Steven Winter Associates 2013).

The effective R-value of a buried and encapsulated duct installation depends on the size of the ducts, the insulation value of the duct insulation, the thickness of the ccSPF insulation, and the depth of the loose-fill insulation. The effective R-values of 8-inch round ducts encapsulated with 1.5 inches of ccSPF are shown in Table 1 for three insulation depths and three common duct insulation levels (R-4.2, R-6, and R-8).

<table>
<thead>
<tr>
<th>Duct configuration</th>
<th>R-4.2 ducts</th>
<th>R-6 ducts</th>
<th>R-8 ducts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encapsulated (1.5 in.) and partially-buried beneath fiberglass</td>
<td>18.4</td>
<td>19.7</td>
<td>21.0</td>
</tr>
<tr>
<td>Encapsulated (1.5 in.) and fully-buried beneath fiberglass</td>
<td>22.6</td>
<td>23.8</td>
<td>25.0</td>
</tr>
<tr>
<td>Encapsulated (1.5 in.) and deeply-buried beneath fiberglass</td>
<td>29.6</td>
<td>30.3</td>
<td>31.1</td>
</tr>
</tbody>
</table>

**Table 1.** Effective R-values of Buried Ducts at Three Attic and Duct Insulation Levels (Steven Winter Associates 2013).

Typically, the duct design will consist of one or more main supply trunk(s) and perpendicular duct branches serving each of the ceiling registers. If the trunk is perpendicular to the truss bottom chords, then the duct branches can be parallel and rest directly on the ceiling drywall. If the main trunk is placed parallel to the ceiling supports, then the branches will need to run perpendicular to and rest on top of the truss chords. Either configuration will work, giving the designer the flexibility to select whichever method works best for a particular circumstance. In every case, a compact, low-profile duct layout should be designed.

The ccSPF may be installed before or after the ceiling gypsum board is installed. If the gypsum board is installed before the ducts are encapsulated, special care must be taken to fully encapsulate the ducts. The ccSPF may be installed to fully encapsulate and surround the duct. Or, the ducts may be laid on a piece of rigid foam board substrate, or laid directly on the ceiling drywall; in these cases, the spray foam in installed to encase the top and sides of the duct and to connect to the rigid foam or ceiling under the duct as shown in Figure 2.
How to Install Buried and Encapsulated Ducts after the Ceiling Is in Place

1. **Install ceiling gypsum board** prior to installing buried ducts (Figure 3).

2. **Install ductwork** across lower truss cords or rafters or resting on the ceiling drywall. Install insulated ducts that have a minimum of R-8 duct insulation and an integral vapor barrier. Install the ductwork in accordance with a low-profile compact duct design (Figure 4).

3. **Properly fasten and seal** ducts at all connections. To attach flex duct, pull back the outer liner, fasten the inner liner over the collar with a tool-tightened tension tie, and mastic seal the connection. Pull insulation and outer liner over the joint and seal to the attached duct or boot with mastic or foil tape (Figure 5). The outer liner should not be attached with a tie as shown here but should be connected with mastic or foil tape to avoid compressing the insulation.
layer is pulled over and sealed with mastic or foil tape. (Steven Winter Associates 2013).

4. **Test total duct leakage** with a duct blaster to ensure that the ducts have been adequately sealed (total duct leakage < 3 cfm25 per 100 ft2 of conditioned space) (Figure 6). Testing should be performed before encapsulation because it may be difficult to correct sealing issues after the application of spray foam.

![Figure 6. A duct blaster is used to test total duct leakage (Steven Winter Associates 2013).](image)

5. **Air-seal the ceiling plane penetrations**, including sealing the duct register boots to the gypsum board ceiling using canned spray foam (Figure 7).

![Figure 7. Duct boots and other ceiling penetrations are air-sealed using spray foam. (Steven Winter Associates 2013)](image)

6. **Apply at least 1.5 in of ccSPF to all duct surfaces**, including trunks, branches, and register boots. Where obstructions make the bottom of the duct inaccessible (such as when a wide trunk is placed on top of and perpendicular to the ceiling framing), the duct may be placed on 1.5-inch-thick XPS or polyisocyanurate insulation board. Ducts should be entirely encapsulated and sealed to the gypsum board or to the rigid insulation board with spray foam (Figure 8).

![Figure 8. Ducts encapsulated with spray foam.](image)
7. **Install loose-fill insulation to the specified depth**, and verify that the ducts are covered to the level desired (Figure 9). Fiberglass or other mineral fiber insulation must cover the ccSPF by at least 1.5 inches unless the foam is rated for exposure in attics or a separate ignition barrier is applied.

![Figure 9. Loose-fill attic insulation is installed to the specified depth. (Steven Winter Associates 2013)](image)

**How to Install Buried Ducts before Ceiling Is in Place**

1. **Install ductwork** across lower truss cords or rafters. Install insulated ducts that have a minimum of R-8 duct insulation and an integral vapor barrier. Install the ductwork in accordance with a low-profile compact duct design. Where ducts are running parallel to ceiling framing, provide temporary blocking to hang ducts approximately 2 inches above the ceiling plane to allow for the thickness of the spray foam. (Figure 8).

![Figure 8. These ducts were installed before the ceiling drywall was installed. Ducts are supported by temporary strapping across the lower truss cords. (Steven Winter Associates 2013)](image)

2. **Connect, seal, and test** ducts as described above in Steps 3 and 4.

3. **Encapsulate** ducts in spray foam as described above in Step 6.

4. **Install ceiling gypsum** board after installing ducts.
5. **Air seal** ceiling plane and install attic floor insulation as described in Steps 5 and 7 above. Fiberglass or other mineral fiber insulation must cover the ccSPF by at least 1.5 inches unless the foam is rated for exposure in attics or a separate ignition barrier is applied.
Ensuring Success

If buried and encapsulated ducts are to be used, duct design should be considered during the design stage in conjunction with framing design, so that the duct layout can be as compact as possible, with short, straight runs and a low profile, so that ducts lay on or as close to the ceiling as possible. Other best-practice measures include right-sizing the HVAC and using inboard registers which will result in less ductwork to bury.

Return trunks and branches could be treated in the same manner; however, to keep the HVAC distribution system at a minimum, while simultaneously providing good comfort and proper airflow, the use of central returns is recommended. Return air paths from bedrooms and other spaces can be accommodated by low-profile jump ducts or other means.

To eliminate condensation concerns in moist or marine climates, ccSPF must be applied to all surfaces of the ductwork, or the ducts must be sealed to the ceiling gypsum board with ccSPF. All duct connections should be mastic sealed and ducts should be tested for leakage with a duct blaster before the ccSPF is applied.

Special attention is needed to ensure code compliance for buried & encapsulated ducts because they include spray foam insulation applied to ductwork. The 2009 IRC allows exposed installations of ccSPF in attics, but the spray foam must be specifically approved for installation without an ignition barrier. If the spray foam used is not specifically approved for exposed attic installations, at least 1.5 inch of mineral fiber insulation, such as loose-fill fiberglass or mineral wool, must cover the spray foam.
Buried and encapsulated ducts may be installed in all climate zones, including moist (A) and marine (C) climate zones. The ccSPF insulation mitigates condensation concerns in these climates.

All of Alaska is in Zone 7 except for the following boroughs in Zone 8:
Bethel, Northwest Arctic, Dillingham, Southeast Fairbanks, Fairbanks N. Star, Wade Hampton, Nome, Yukon-Koyukuk, North Slope

Zone 1 includes Hawaii, Guam, Puerto Rico, and the Virgin Islands
Training

Right and Wrong Images

Display Image: Right.ductwork is fully encapsulated.jpg
Ductwork is not fully encapsulated.

Ducts are held above the ceiling plane with strapping.
Right. Side-entry boots are used.

Wrong. Ducts are held from the rafters with strapping.
Display Image: Right. Ductwork is installed in direct contact with lower truss.jpg

Display Image: Wrong. Duct is hung between truss.jpg
CAD
None Available
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

HVAC System.
6.3 All supply and return ducts in unconditioned space, including connections to trunk ducts, are insulated to \( R \geq 6 \) \( \text{in ft} \) \( \text{of conditioned floor area} \).
6.4 Rater-measured total duct leakage meets one of the following two options. Alternative in Footnote 37: \( \text{in ft} ^{2} \).
6.4.1 Rough-in: The greater of \( 4 \text{ CFM} \text{per 100 sq. ft. of CFA} \) or \( 40 \text{ CFM} \text{per 100 sq. ft. of CFA} \), with air handler & all ducts, building cavities used as ducts, & duct boots installed. In addition, all duct boots sealed to finished surface, Rater-verified at final.
6.4.2 Final: The greater of \( 8 \text{ CFM} \text{per 100 sq. ft. of CFA} \) or \( 80 \text{ CFM} \text{per 100 sq. ft. of CFA} \), with the air handler & all ducts, bldg. cavities used as ducts, duct boots, & register grilles atop the finished surface (e.g., drywall, floor) installed.
6.5 Rater-measured duct leakage to outdoors the greater of \( 4 \text{ CFM} \text{per 100 sq. ft. of CFA} \) or \( 40 \text{ CFM} \text{per 100 sq. ft. of CFA} \).

Please see the ENERGY STAR Certified Homes Implementation Timeline for the program version and revision currently applicable in your state.

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

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 duct; duct leakage to outdoors \( \leq 3 \text{ CFM} \text{per ft} ^{2} \) 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 \( \leq 3 \text{ CFM} \text{per ft} ^{2} \) 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.


IECC R403.2/IRC N1103.2 Ducts.
IECC R403.2.1/IRC N1103.2.1 Insulation (Prescriptive). Supply ducts in attics shall be insulated to a minimum of R-8. All other ducts shall be insulated to a minimum of R-6.

Exception: Ducts or portions thereof located completely inside the building thermal envelope.

IECC R403.2.2/IRC N1103.2.2 Sealing (Mandatory). All ducts, air handlers, filter boxes, and building cavities used as ducts shall be sealed. Joints and seams shall comply with Section M1601.4 of the International Residential Code. [Exceptions may apply.]
Duct tightness shall be verified by either of the following:

1. **Post-construction test:** Leakage to outdoors shall be less than or equal to 8 cfm (226.5 L/min) per 100 ft\(^2\) (9.29 m\(^2\)) of conditioned floor area or a total leakage less than or equal to 12 cfm (339.8 L/min) per 100 ft\(^2\) of conditioned floor area when tested at a pressure differential of 0.1 inches w.g. (25 Pa) across the entire system, including the manufacturer’s air handler enclosure. All register boots shall be taped or otherwise sealed during the test.

2. **Rough-in test:** Total leakage shall be less than or equal to 6 cfm (169.9 L/min) per 100 ft\(^2\) of conditioned floor area when tested at a pressure differential of 0.1 inches w.g. (25 Pa) across the roughed in system, including the manufacturer’s air handler enclosure. All register boots shall be taped or otherwise sealed during the test. If the air handler is not installed at the time of the test, total leakage shall be less than or equal to 4 cfm (113.3 L/min) per 100 ft\(^2\) of conditioned floor area.

Exceptions: Duct tightness test is not required if the air handler and all ducts are located within conditioned space.

**IECC R403.2.3/IRC N1103.2.3 Building cavities (Mandatory).** Building framing cavities shall not be used as supply ducts.

**IECC R403.2/IRC N1103.2 Ducts.** Ducts and air handlers shall be in accordance with IECC R403.2.1 through R403.2.3 (IRC N1103.2.1-N1103.2.3).

**IECC R403.2.1/IRC N1103.2.1 Insulation (Prescriptive).** Same as 2009 IECC/IRC.

**IECC R403.2.2/IRC N1103.2.1 Sealing (Mandatory).** Ducts, air handlers, and filter boxes shall be sealed. Joints and seams shall comply with either the International Mechanical Code or International Residential Code, as applicable [Exceptions may apply.]

Exceptions:

1. Air-impermeable spray foam products shall be permitted to be applied without additional joint seals.

2. Where a duct connection is made that is partially inaccessible, three screws or rivets shall be equally spaced on the exposed portion of the joint so as to prevent a hinge effect.

3. Continuously welded and locking-type longitudinal joints and seams in ducts operating at static pressures less than 2 inches of water column (500 PA) pressure classification shall not require additional closure systems.

Duct tightness shall be verified by either of the following:

1. **Post-construction test:** Total leakage shall be less than or equal to 4 cfm (113.3 L/min) per 100 ft\(^2\) (9.29 m\(^2\)) of conditioned floor area when tested at a pressure differential of 0.1 inches w.g. (25 Pa) across the entire system, including the manufacturer’s air handler enclosure. All register boots shall be taped or otherwise sealed during the test.

2. **Rough-in test:** Total leakage shall be less than or equal to 4 cfm per (113.3 L/min) per 100 ft\(^2\) (9.29 m\(^2\)) of conditioned floor area when tested at a pressure differential of 0.1 inches w.g. (25 Pa) across the system, including the manufacturer’s air handler enclosure. All registers shall be taped or otherwise sealed during the test. If the air handler is not installed at the time of the test, total leakage shall be less than or equal to 3 cfm (85 L/min) per 100 ft\(^2\) of conditioned floor area.

   **Exception:** The total leakage test is not required for ducts and air handlers located entirely within the building thermal envelope.

**IECC R403.2.2.1/IRC N1103.2.2.1 Sealed air handler.** Air handler shall have a manufacturer’s designation for an air leakage of no more than 2 percent of the design air flow rate when tested in accordance with ASHRAE 193.

**IECC R403.2.3/IRC N1103.2.3 Building cavities (Mandatory).** Building framing cavities shall not be used as ducts or plenums.

**IECC R403.3/IRC N1103.3 Ducts.** Ducts and air handlers shall be in accordance with Sections R403.3.1 through R403.3.5 (IRC N1103.3.1-N1103.3.5).

**IECC R403.3.1/IRC N1103.3.1 Insulation (Prescriptive).** Supply and return ducts in attics shall be insulated to a minimum of R-8 where 3 inches (76 millimeters) in diameter and greater and R-6 where less than 3 inches (76 millimeters) in diameter. Supply and return ducts in other portions of the building shall be insulated to a minimum of R-6 where 3 inches (76 millimeters) in diameter or greater and R-4.2 where less than 3 inches (76 millimeters) in diameter.

   **Exception:** Ducts or portions thereof located completely inside the building thermal envelope.

**IECC R403.3.2/IRC N1103.3.2 Sealing (Mandatory).** Ducts, air handlers, and filter boxes shall be sealed. Joints and seams shall comply with either the International Mechanical Code or International Residential Code, as applicable.

   **Exceptions** [In 2015 IECC/IRC only; these exceptions were not included in the 2018 IECC/IRC.]

1. Air-impermeable spray foam products shall be permitted to be applied without additional joint seals.
2. For ducts having a static pressure classification of less than 2 inches of water column (500 Pa), additional closure systems shall not be required for continuously welded joints and seams, and locking-type joints and seams of other than the snap-lock and button-lock types.

IECC R403.3.2.1/IRC N1103.3.2.1 Sealed Air Handler. Air handlers shall have a manufacturer’s designation for an air leakage of no more than 2% of the design air flow rate when tested in accordance with ASHRAE 193.

IECC R403.3.3/IRC N1103.3.3 Duct testing (mandatory). Ducts shall be pressure tested to determine air leakage by one of the following methods:

1. Rough-in test. Total leakage shall be measured with a pressure differential of 0.1 inch water gage (25 Pa) across the system, including the manufacturer’s air handler enclosure if installed at the time of the test. All registers shall be taped or otherwise sealed during the test.

2. Post-construction test. Total leakage shall be measured with a pressure differential of 0.1 inch water gage (25 Pa) across the entire system, including the manufacturer’s air handler enclosure. Registers shall be taped or otherwise sealed during the test.

Exception:

A duct air leakage test shall not be required where the ducts and air handlers are located entirely within the building thermal envelope.

[New Exception added to 2018 IECC/IRC] A duct air leakage test shall not be required for ducts serving heat or energy recovery ventilators that are not integrated with ducts serving heating or cooling systems.

A written report of the results of the test shall be signed by the party conducting the test and provided to the code official.

IECC R403.3.4/IRC N1103.3.4 Duct leakage (Prescriptive). The total leakage of the ducts, where measured in accordance with Section R403.3.3, shall be as follows:

1. Rough-in test. The total leakage shall be less than or equal to 4 cfm per (113.3 L/min) per 100 ft$^2$ (9.29 m$^2$) of conditioned floor area where the air handler is installed at the time of the test. Where the air handler is not installed at the time of the test, the total leakage shall be less than or equal to 3 cfm (85 L/min) per 100 ft$^2$ of conditioned floor area.

2. Post-construction test: Total leakage shall be less than or equal to 4 cfm (113.3 L/min) per 100 ft$^2$ (9.29 m$^2$) of conditioned floor area.

IECC R403.3.5/IRC N1103.3.5 Building cavities (Mandatory). Building framing cavities shall not be used as ducts or plenums.

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

Ducts are designed, constructed, and installed in accordance with the provisions of IRC M1601 and M1602, ACCA Manual D, and manufacturers’ guidance.


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.)


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.

**Buried Ducts within Ceiling Insulation of Vented Attics in all Climate Zones - Code Compliance Brief**

**Overview:**

The intent of this brief is to provide code-related information about buried ducts within ceiling insulation of vented attics to help ensure that the measure will be accepted as being in compliance with the code. Providing notes for code officials on how to plan review and conduct field inspections can help provide jurisdictional officials with information for acceptance. Providing the same information to all builders, designers, and others is expected to result in increased compliance and fewer innovations being questioned at the time of plan review and/or field inspection.

Codes, standards, and regulations (CSRs) governing the design, construction, installation, commissioning, and operation of the built environment are intended to protect public health, safety and welfare. These documents change over time to
address new technology and safety challenges, so there is generally some lag time between the introduction of a technology into the market and the time it is specifically covered in model codes and standards developed in the voluntary sector. Development of a new code or standard can take 3 to 4 years from the initiation of the effort until the result is adopted. Typically this takes on the order of 4 to 5 years and in some cases due to recent efforts to reduce the frequency of adoptions at the state and local level it could be over 6 years before new provisions covering new technologies are adopted. So, those seeking to design and construct using new technologies and alternative methods, or needing to verify an installation’s safety may find it challenging to apply current CSRs to a new technology or method such as buried ducts within ceiling insulation. Even when codes provide specific criteria, those deploying the new technology must document compliance with the CSRs and those enforcing compliance must be able to verify it with their CSRs.

Ducts buried within ceiling insulation of vented attics are not addressed in the 2015 and prior versions of the International Energy Conservation Code (IECC) or International Residential Code (IRC). This measure was an identified code barrier because it was not explicitly addressed by the previous model codes (IECC/IRC). This lack of direction within the code led many jurisdictions to prohibit the use of buried ducts out of concerns of condensation and reduced energy efficiency. Fortunately, the Department of Energy Building America program has researched the buried duct concept in a variety of projects for over 15 years addressing these concerns. Recently under the Building America program, Home Innovation Research Labs, researched duct placement and insulation and potential for condensation issues for both partially and deeply buried ducts in ceiling insulation in vented attics in all climate zones. The new alternative methods were successfully installed, tested, and monitored and found to be nearly as effective as requiring that ducts be installed in conditioned spaces (inside the building thermal envelope[1] or inside the air barrier). New provisions have been incorporated into the 2018 IECC/IRC that provide new options that will likely reduce the cost of construction and increase the energy efficiency of a house with ducts in an attic. Burying ducts within ceiling insulation and tightly sealing the ducts are a less expensive and more energy efficient solution than creating a conditioned attic. Additionally, it is often a more practical and homeowner friendly solution than installing bulkheads in the ceiling to keep ducts in conditioned space.

These alternative methods are endorsed by Building America and were submitted to the International Code Council (ICC) as a proposed code changes for the 2018 IECC/IRC code cycle. The proposed code changes made it through the rigorous 2018 code development cycle and are now published as new provisions in the 2018 IECC and the energy chapter of the 2018 IRC. (The new code sections are listed below under the Plan Review section.)

How do builders, designers, and code officials comply with the new provisions? States and local jurisdictions can have unique adoption processes with their own legislative and regulatory adoption language and code adopting bodies that adopt different building codes and code versions (e.g., 2009, 2012, 2015, or newly published 2018 IECC/IRC). For states and local jurisdictions that have not adopted the 2018 IECC and/or IRC, one approach to overcome this barrier would be to reference the most recent version of the IECC/IRC for guidance. The building code (IRC/IECC) allows for alternative materials, design, and methods of construction and equipment not specifically prescribed by code and this would include consideration of new guidance published in more recent versions of model codes. Consequently, the code official has the authority and responsibility to review and approve the proposed design as satisfactory and compliant with the intent of the provisions of the code (per Section R104.11/IRC, Section R102.1/IECC) as a means of achieving code compliance. The alternative materials, design, and methods provision has been a long-standing allowance and this important tradition has been continued in every version of the IRC/IECC. The alternative methods section in the IECC/IRC is below:

2018/2015 IECC/IRC, Section R102.1/R104.11 Alternative Materials, Design and Method of Construction and Equipment. The code is not intended to prevent the installation of any material or prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative has been approved. The code official (CO) is permitted to approve an alternative material, design, or method of construction where the CO finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and the material, method, or work offered is for the purpose intended, or at least the equivalent of that prescribed in the code.

So why encourage moving the duct system back outside the building thermal envelope (outside the air barrier), which at first read appears to be contrary to the language in the codes that encourages moving the duct system inside the building thermal envelope? In short, buried ducts in vented attics, provides cost-effective, energy-efficient alternative solution to installing ducts inside conditioned space. This is particularly useful for avoiding challenges in many house configurations, including single-story, slab-on-grade, and two-story houses with complicated framing or open floor plans. Adapting house designs with standard interior ducts may require the addition of mechanical rooms, duct chases, dropped ceilings, soffits, or floors. The additional framing and associated air sealing may not be acceptable to buyers, and air-distribution performance can be adversely affected due to increased duct lengths and bends.

[1]The building thermal envelope is defined as the basement walls, exterior walls, floor, roof, and any other building elements that enclose conditioned space or provide a boundary between conditioned space and exempt or unconditioned space.

Moving the ducting outside the building thermal envelope using the alternate system requires the ducts to be insulated, sealed, installed close the ceiling in a vented attic, and covered with attic insulation to minimize energy loss. Based on Building America research, ducts insulated to a minimum R-8 with common duct insulation material, sealed with conventional duct sealing material, and covered with a minimum R-30 attic insulation performed without any condensation issues. Furthermore, research demonstrated that the attic duct area was reduced by 32% for supply ducts and 75% for
For more detailed information on the Building America research for buried ducts within ceiling insulation of vented attics, refer to the last section on Technical Validation and References of this code compliance brief. Consider encapsulating the ducts and installing a compact duct design which will increase energy savings even further. These resources include example duct designs, acceptable best practices, case studies, and a summary of research findings.

The lists and provisions provided in each section below are intended to target the main code sections and provisions. Words and terms that are italicized, appear in code text and the Chapter 2 definition applies. Other references, code sections, standards, testing methods, etc., that affect the technology or other assemblies, or functions of the building may exist.

**Plan Review:**

Plan review is a process of reviewing building plans, construction documents, and technical validation. This section lists the applicable code requirements and code sections in the 2015 and 2018 IECC/IRC and details helpful for plan review regarding the provisions to meet the requirements for buried ducts within ceiling insulation of vented attics in all climate zones.

**2015/2018 IECC, Section 103.1 General.** Construction documents, technical reports or other supporting data shall be submitted in one or more sets with each application for a permit. The documents shall be prepared by a **registered design professional** where required by the statues of the jurisdiction in which the project is to be constructed. Where special conditions exist, the **code official** is authorized to require necessary construction documents to be prepared by a registered design professional.

**2015 IRC, Section R104.1 General.** The **code official** has authority to render interpretations of this code and to adopt policies and procedures in order to clarify the application of its provisions. Such interpretations, policies and procedures shall be in conformance with the intent and purpose of this code.

**Section R104.11.1 Tests.** Whenever there is insufficient evidence of compliance with the provisions of this code, or evidence that a material or method does not conform to the requirements of this code, or in order to substantiate claims for alternative materials or methods, the **code official** has authority to require tests as evidence of compliance to be made at no expense to the jurisdiction. Test methods shall be as specified in this code or by other recognized test standards. In the absence of recognized and accepted test methods, the **code official** shall approve the testing procedures. Tests shall be performed by an approved agency. Reports of such tests shall be retained by the **code official** for the period required for retention of public records.

**Section R103.2/N1101.5 Information on construction documents.** Construction documents should include:

- Duct design and construction materials
- Compliance path chosen with applicable compliance report documentation: R-value or U-factor calculation method, if a performance path is being used, insure that ducts are being modeled properly (R-25 where deeply buried.)
- R-values of supply and return ducts and duct air sealing details and sealant(s) (e.g., mastic, approved tape, caulking) on building plans and/or construction documents
- Ceiling assembly R-value and air sealing details and sealant(s) including location of continuous air barrier on building plans and/or construction documents

**Section R103.3/R106.3 Examination of Documents,** the **code official** must examine or cause to be examined construction documents for code compliance.

**2015/2018 IECC/IRC, Section R403.3.2/N1103.3.2 Sealing (mandatory).** Ducts, air handlers, and filter boxes shall be sealed. Joints and seams shall comply with either the International Mechanical Code or IRC, as applicable.

**2015 IECC/IRC Exceptions ONLY (these exceptions were voted for approval to delete in the 2018 code version):**

1. Air-impermeable spray foam products shall be permitted to be applied without additional joint seals.
2. For ducts having a static pressure classification of less than 2 inches of water column (500 Pa), additional closure systems shall not be required for continuously welded joints and seams, and locking-type joints and seams of other than the snap-lock and button-lock types.

**Section R403.3.2.1/N1103.3.2.1 Sealed Air Handler.** Air handlers shall have a manufacturer’s designation for an air leakage of no more than 2% of the design air flow rate when tested in accordance with ASHRAE 193.

**Section R403.3.3/N1103.3.3 Duct testing (mandatory).** Ducts shall be pressure tested to determine air leakage by one of the following methods:
1. **Rough-in test.** Total leakage shall be measured with a pressure differential of 0.1 inch water gage (25 Pa) across the system, including the manufacturer’s air handler enclosure if installed at the time of the test. All registers shall be taped or otherwise sealed during the test.

2. **Post-construction test.** Total leakage shall be measured with a pressure differential of 0.1 inch water gage (25 Pa) across the entire system, including the manufacturer’s air handler enclosure. Registers shall be taped or otherwise sealed during the test.

**Exception:**

A duct air leakage test shall not be required where the ducts and air handlers are located entirely within the building thermal envelope. A written report of the results of the test shall be signed by the party conducting the test and provided to the code official. (Because the ducts will be installed outside the building thermal envelope, this exception would not apply.)

**New Exception added to 2018 IECC/IRC**

A duct air leakage test shall not be required for ducts serving heat or energy recovery ventilators that are not integrated with ducts serving heating or cooling systems.

**Section R403.3.4/N1103.3.4 Duct Leakage (Prescriptive).** The total leakage of the ducts, measured in accordance with Section R403.3.3/N1103.3.3, shall be as follows:

- **Rough-in test.** The total leakage shall be less than or equal to 4 cubic feet per minute (113.3 L/min) per 100 square feet (9.29 m²) of conditioned floor area where the air handler is installed at the time of the test. Where the air handler is not installed at the time of the test, the total leakage shall be less than or equal to 3 cubic feet per minute (85 L/min) per 100 square feet (9.29 m²) of conditioned floor area.

- **Post-Construction test.** Total leakage shall be less than or equal to 4 cubic feet per minute (113.3 L/min) per 100 square feet (9.29 m²) of conditioned floor area.

**Section R403.3.5/N1103.3.5 Building Cavities (mandatory).** Building framing cavities should not be used as ducts or plenums.

**Section R403.3.6/N1103.3.6 Ducts buried within ceiling insulation.** Where supply and return air ducts are partially or completely buried in ceiling insulation, such ducts shall comply with all of the following:

1. Supply and return ducts shall have an insulation R-value of not less than R-8.

2. At all points along each duct, the sum of the ceiling insulation R-value against and above the top of the duct, and against and below the bottom of the duct, shall be not less than R-19, excluding the R-value of the duct insulation.

3. In Climate Zones 1A, 2A, 3A, the supply ducts shall be completely buried within ceiling insulation, insulated to an R-value of not less than R-13 and in compliance with the vapor retarder requirements of Section 604.11 of the International Mechanical Code or Section M1601.4.6 of the IRC, as applicable.

**Exception:** Sections of supply duct that are less than 3 feet (914 mm) from the supply outlet shall not be required to comply with these requirements.

**Section R403.3.6.1 Effective R-value of deeply buried ducts.** Where using a simulated energy performance analysis, sections of ducts that are:

- installed in accordance with Section R403.3.6
- located directly on or within 5.5 inches (140 mm) of the ceiling surrounded with blown-in attic insulation having an R-value of R-30 or greater and
- located such that the top of the duct is not less than 3.5 inches (89 mm) below the top of the insulation
- shall be considered as having an effective duct insulation R-value of R-25.

**Section R403.3.7 Ducts located in conditioned space.** For ducts to be considered as inside a conditioned space, such ducts shall comply with either of the following requirements:

1. The duct system shall be located completely within the continuous air barrier and within the building thermal envelope.

2. The ducts shall be buried within ceiling insulation in accordance with Section R403.3.6 and all of the following conditions shall exist:

2.1 The air handler is located completely within the continuous air barrier and within the building thermal envelope.
2.2 The duct leakage, as measured by either a rough-in test of the ducts or a post-construction total system leakage test to outside the building thermal envelope in accordance with Section R403.3.4, is less than or equal to 1.5 cubic feet per minute (42.5 L/min) per 100 square feet (9.29 m²) of conditioned floor area served by the duct system.

2.3 The ceiling insulation R-value installed against and above the insulated duct is greater than or equal to the proposed ceiling insulation R-value less the R-value of the insulation on the duct.

In addition to allowing ducts to be buried within ceiling insulation, this provision sets the requirements for ducts to be considered within conditioned space. The DOE Zero Energy Ready Home National Program[1] defines ducts inside conditioned space states, "Duct distribution systems located within the home's thermal and air barrier boundary or optimized to achieve comparable performance." Item "1)" under R403.3.7 provides for that with the established code definitions. However, it also allows a comparable performance alternative to that includes buried ducts with provision for condensation avoidance for humid climates. Research has shown that almost all of the benefit of locating ducts inside conditioned space can be achieved by locating the air handler in conditioned space but locating ducts tested to be essentially leak-free in a vented attic buried under ceiling insulation. Section R403.3.7 provides for these conditions in that: the air handler must be located completely within the continuous air barrier and within the building thermal envelope; the ducts must be tested to an extremely low but still measurable level of leakage; the sum of the duct R-value and the ceiling insulation immediately above the duct is unchanged from the prescriptive or proposed ceiling insulation amount that would have otherwise been installed; and duct condensation avoidance in humid climates is provided for by referring back the provisions of Section R403.3.6.

Building Thermal Envelope Assembly (ceiling provisions)

2015/2018 IECC/IRC, Section R402.1.2/N1102.1.2 Insulation Criteria. The building thermal envelope must meet the requirements of Table R402.1.2/N1102.1.2, based on the climate zone specified in Chapter 3 and the building assemblies associated with the vented attic (ceilings) that are considered part of the building thermal envelope. (Per Building America research, a minimum R-30 attic insulation installed over the top of the ducts would be required.) Again, it should be noted, depending upon the code, location, and climate zone, the minimum R-value for attic insulation could be higher than R-30.

Below are the prescriptive compliance paths (R-value computation, u-Factor alternative, and total UA alternative). The Performance based and Energy Rating Index (ERI) compliance paths are not addressed in detail in this brief, however, these paths could be used to demonstrate compliance to these alternative methods through whole-building modeling.

Section R402.1.3/N1102.1.3 R-Value Computation. Insulation material used in layers, such as framing cavity insulation, or continuous insulation should be summed to compute the corresponding component R-value. Computed R-values should not include an R-value for other building materials or air films.


Excerpt from the Insulation Requirements by Component Table R402.1.2/N1102.1.2

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4 Except Marine</th>
<th>5 and Marine 4</th>
<th>6</th>
<th>7, 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling R-value</td>
<td>30</td>
<td>38</td>
<td>38</td>
<td>49</td>
<td>49</td>
<td>49</td>
<td>49</td>
</tr>
</tbody>
</table>

Section R402.1.4/N1102.1.4 U-Factor Alternative. An assembly with a U-factor equal to or less than that specified in Table R402.1.4/N1102.1.4 should be permitted as an alternative to the R-value in Table R402.1.2/N1102.1.2.

Excerpt from the Equivalent U-factor Table R402.1.4/N1102.1.4

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4 Except Marine</th>
<th>5 and Marine 4</th>
<th>6</th>
<th>7, 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling U-factor</td>
<td>0.035</td>
<td>0.030</td>
<td>0.030</td>
<td>0.026</td>
<td>0.026</td>
<td>0.026</td>
<td>0.026</td>
</tr>
</tbody>
</table>

Section R402.1.5/N1102.1.5 Total UA Alternative. Where the total building thermal envelope UA, the sum of U-factor times assembly area, is less than or equal to the total UA resulting from multiplying the U-factors in Table R402.1.4/N1102.1.4 by the same assembly area as in the proposed building, the building would be considered to be in compliance with the Table R402.1.2/N1102.1.2. The UA calculation shall be performed using a method consistent with the ASHRAE Handbook of Fundamentals and include the thermal bridging effects of framing materials.

Section R402.2.3/N1102.2.3 Eave baffle. For air-permeable insulation in vented attics, a baffle should be installed adjacent to soffit and eave vents. Baffles should maintain an opening equal or greater than the size of the vent. The baffle...
should extend over the top of the attic insulation. The baffle should be permitted to be any solid material.

**Section R402.2.4/N1102.2.4 Access Hatches and Doors.** Any access hatches or doors from conditioned spaces to unconditioned spaces such as attics must also be insulated to a level equivalent to the insulation on the surrounding surfaces (minimum R-30 insulation). In addition the access hatch or door must also be provided with weatherstripping in gaskets to minimize air leakage. Access should be provided to all equipment that prevents damaging or compressing the insulation. A wood-framed or equivalent baffle or retainer is required to be provided when loose-fill insulation is installed, the purpose of which is to prevent the loose-fill insulation from spilling into the living space when the attic access is opened, and to provide a permanent means of maintaining the installed R-value of the loose-fill insulation.

Exception: Vertical doors that provide access from conditioned to unconditioned spaces can be permitted to meet the fenestration requirements of Table R402.1.2/N1102.1.2 based upon the applicable climate zone specified in Chapter 3.

**Air Sealing/Air Leakage Control**

**2015/2018 IECC/IRC, R402.4/N1102.4 Air Leakage.** The building thermal envelope should be constructed to limit air leakage.

1. **Section R402.4.1/N1102.4.1 Building Thermal Envelope.** The sealing methods between dissimilar materials should allow for differential expansion and contraction.

2. **Section R402.4.1.1/N1102.4.1.1 Installation.** The components listed in the Air Barrier and Insulation Installation Table (Table R402.4.1.1 of the IECC and Table N1102.4.1.1 of the IRC.) should be installed in accordance with the manufacturer’s instructions and the criteria listed as the applicable method of construction. Below are the General Requirements and components from the table that are applicable to sealing and insulating ducts and ceiling assemblies (vented attics).

**2015/2018 IRC/IECC, Air Barrier and Insulation Installation Table R402.4.1.1/N1102.4.1.1**

- **Continuous air barrier** (defined as a combination of materials and assemblies that restrict or prevent the passage of air through the building thermal envelope.)— Confirm that construction documents specify a continuous air barrier for the building components associated with the insulation of the ceiling (vented attic).

- **Ceiling/attic** – The air barrier in any dropped ceiling/soffit should be aligned with the insulation and any gaps in the air barrier sealed. Access openings, drop down stairs or knee wall doors to unconditioned attic spaces should be sealed.

- **Shafts/penetrations** – Duct shafts, utility penetrations, and flue shaft openings to the exterior or unconditioned space are sealed.

- **Recessed lighting** – Recessed lighting fixtures installed in the ceiling (vented attic) are sealed to the drywall. The fixtures installed are air tight and IC rated.

- **HVAC register boots** – HVAC register boots that penetrate the ceiling (vented attic) are sealed to the subfloor or drywall.

- **Concealed sprinklers** – When required are sealed, concealed fire sprinklers should only be sealed in a manner that is recommended by the manufacturer. Caulking or other use adhesive sealants should not be used to fill voids between fire sprinkler cover plates and the ceiling.

**FIELD INSPECTION:**

Per the 2015/2018 IECC, **Section R104 Inspections**, construction or work for which a permit is required is subject to inspection. Construction or work is to remain accessible and exposed for inspection purposes until approved. (In 2018 IECC, the wording was changed from “accessible” to “visible”.) Required inspections include footing and foundation, framing and rough-in, plumbing rough-in, mechanical rough-in, and final inspection.

**Section R104.2.4 Mechanical Rough-In Inspection.** Inspections at mechanical rough-in shall verify compliance as required by the code and approved plans and specifications as to installed duct system, insulation and corresponding R-values, system air leakage control, and testing. Because the duct system should be installed at the ceiling and then the attic insulation applied over the top of the ducts, this inspection might also include the inspection of the attic sealing and insulation R-values and installation at the same time or performed at final inspection.

In the IRC, **Section R109 Inspections**, the wording is somewhat different in that for onsite construction the building official, upon notification from the permit holder or his agent, can make, or cause to be made, any necessary inspections. Further details are provided for inspections regarding foundation, plumbing, mechanical, gas and electrical, floodplain, frame and masonry, and final inspections. Any additional inspections are at the discretion of the building official.

This section provides details for inspecting to the specific provisions for buried ducts in vented attics where one or more specific type of inspection per the IECC or IRC may be necessary to confirm compliance. Verifying code compliance would typically be at the mechanical rough-in and final inspection.
2015/2018 IECC, Section R303.1 Identification. Materials, systems and equipment shall be identified in a manner that will allow determinations of compliance with applicable provisions of the code.

2015/2018 IECC, Section R303.1.1 Building thermal envelope insulation. An R-value identification mark should be applied by manufacturer to each piece of building thermal envelope insulation that is 12 inches or greater in width. Insulation installers should provide a certification that indicates the type, manufacturer and R-value of insulation installed in each element of the building thermal envelope. For blown-in or sprayed fiberglass and cellulose insulation, the initial installed thickness, settled thickness, and settled R-value, installed density, coverage area and number of bags installed should be indicated on the certification. Insulation installer should sign, date, and post the certificate in a conspicuous location on job site.

2015/2018 IECC Section R303.1.1.1 Blown-in or sprayed roof and ceiling insulation. The thickness of blown-in or sprayed fiberglass and cellulose ceiling insulation should be written in inches (mm) on markers that are installed not less than one for every 300 square feet throughout the attic space. Markers should be affixed to the trusses or joists and marked with the minimum initial installed thickness with numbers not less than 1 inch in height. Markers should face the attic access opening. Thickness and installed R-value of sprayed polyurethane foam insulation shall be indicated on the certification proved by the insulation installer.

2015/2018 IECC Section R303.1.1.2 Insulation mark installation. Insulating materials shall be installed such that the manufacturer’s R-value mark is readily observable at inspections.

2015/2018 IECC Section R303.1.1.4 Insulation product rating. Thermal resistance R-value of insulation shall be determined in accordance with Part 460 of US-FTC CFR Title 16

Inspections should provide verification in the following areas:

- Ductwork: verify all joints and seams in ductwork are properly sealed, and the duct tightness report is complete, verify that duct insulation is installed in accordance with manufacturer’s installation instructions and that the manufacturer’s R-value mark is readily available and meets the approved R-value specified in approved construction documents.

- Ensure proper thickness of duct insulation

- Ensure proper tightness of duct system
  - 1.5 cfm/100ft² if qualifying as in conditioned space
  - 4 cfm/100ft² @ 25Pa if

- Ceiling assembly: verify all joints, seams, holes, and penetrations are caulked, gasketed, weather-stripped, or otherwise sealed.

- Ceiling assembly: ensure that the appearance of the installed ceiling insulation matches that specified in the approved construction documents.

- If the R-value or U-factor approach for compliance was used in the documentation, ensure that the installed insulation meets the minimum R-value or maximum U-factor required for the ceiling and climate zone per the approved construction documents.

- Ensure proper depth of attic insulation

- Ensure a total of R-19 above and/or below the buried ducts

- Ensure that the continuous air barrier is properly installed. Confirm that the air barrier is aligned with the insulation in any dropped ceiling/soffit and sealed.

Technical Validation/Reference Materials:

This section provides additional information and helpful resources.


Author(s): ICC
Organization(s): ICC www.iccsafe.org
Publication Dates: May 2014 / October 2017

This code establishes 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.
This code for residential buildings 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.

- **Compact Buried Ducts in Hot-Humid Climates**

  Author(s): D Mallay  
  Organization(s): Home Innovation Research Labs  
  Publication Date: January 2016

  A system of compact, buried ducts provides a high-performance and cost-effective solution for delivering conditioned air throughout the building. This report outlines research activities that are expected to facilitate adoption of compact buried duct systems by builders. The results of this research would be scalable to many new house designs in most climates and markets, leading to wider industry acceptance and building code and energy program approval.

- **Measure Guideline: Buried and/or Encapsulated Ducts**

  Author(s): Shapiro, Zoeller, Mantha  
  Organization(s): CARB  
  Publication Date: August 2013

  Document covering the technical aspects of buried and insulated ducts, as well as the advantages, disadvantages, and risks of buried and insulated ducts compared to alternative strategies.

- **Building America Top Innovations 2013 Profile: Buried and Encapsulated Ducts**

  Author(s): PNNL  
  Organization(s): PNNL  
  Publication Date: September 2013

  Case study providing information about buried and encapsulated ducts.

- **Technology Solutions Case Study: Buried and Encapsulated Ducts, Jacksonville, Florida**

  Author(s): CARB  
  Organization(s): CARB  
  Publication Date: November, 2013

  Case study exploring how using buried and/or encapsulated ducts can reduce duct thermal losses in existing homes.


- **ACCA Manual J – Residential Load Calculation, Air Conditioning Contractors of America, 2011.**  

- **ACCA Manual S – Residential Equipment Selection, Air Conditioning Contractors of America, 2013.**  

- **ACCA Standard 5: HVAC Quality Installation Specification, Air Conditioning Contractors of America, 2010.**  
  [http://www.energystar.gov/ia/home_improvement/home_contractors/qispec.pdf](http://www.energystar.gov/ia/home_improvement/home_contractors/qispec.pdf)

- **ACCA Standard 9: HVAC Quality Installation Verification Protocols, Air Conditioning Contractors of America, 2009.**  

BASC Related Guides:

Plan Review:

This section lists the applicable code requirements and details helpful for plan review regarding the provisions to meet the requirements for buried ducts within ceiling insulation of vented attics in all climate zones. This brief covers the 2015 and 2018 IECC/IRC provisions specific to this measure. The lists and provisions provided in each section below are intended to target the main code sections and provisions. Other references, code sections, standards, testing methods, etc., that affect the technology or other assemblies, or functions of the building may exist.

2015/2018 IECC, Section 103.1 General. Construction documents, technical reports or other supporting data shall be submitted in one or more sets with each application for a permit. The documents shall be prepared by a registered design professional where required by the statues of the jurisdiction in which the project is to be constructed. Where special conditions exist, the code official is authorized to require necessary construction documents to be prepared by a registered design professional.

2015 IRC, Section R104.1 General. The code official has authority to render interpretations of this code and to adopt policies and procedures in order to clarify the application of its provisions. Such interpretations, policies and procedures shall be in conformance with the intent and purpose of this code.

Section R104.11.1 Tests. Whenever there is insufficient evidence of compliance with the provisions of this code, or evidence that a material or method does not conform to the requirements of this code, or in order to substantiate claims for alternative materials or methods, the code official has authority to require tests as evidence of compliance to be made at no expense to the jurisdiction. Test methods shall be as specified in this code or by other recognized test standards. In the absence of recognized and accepted test methods, the code official shall approve the testing procedures. Tests shall be performed by an approved agency. Reports of such tests shall be retained by the code official for the period required for retention of public records.

Section R103.2/N1101.5 Information on construction documents. Construction documents should include:

- Duct design and construction materials
- Compliance path chosen with applicable compliance report documentation: R-value or U-factor calculation method, if a performance path is being used, insure that ducts are being modeled properly (R-25 where deeply buried.)
- R-values of supply and return ducts and duct air sealing details and sealant(s) (e.g., mastic, approved tape, caulking) on building plans and/or construction documents
- Ceiling assembly R-value and air sealing details and sealant(s) including location of continuous air barrier on building plans and/or construction documents

Section R103.3/R106.3 Examination of Documents, the code official must examine or cause to be examined construction documents for code compliance.

2015/2018 IECC/IRC, Section R403.3.2/N1103.3.2 Sealing (mandatory). Ducts, air handlers, and filter boxes shall be sealed. Joints and seams shall comply with either the International Mechanical Code or IRC, as applicable.

2015 IECC/IRC Exceptions ONLY (these exceptions were voted for approval to delete in the 2018 code version):

1. Air-impermeable spray foam products shall be permitted to be applied without additional joint seals.
2. For ducts having a static pressure classification of less than 2 inches of water column (500 Pa), additional closure systems shall not be required for continuously welded joints and seams, and locking-type joints and seams of other than the snap-lock and button-lock types.

Section R403.3.2.1/N1103.3.2.1 Sealed Air Handler. Air handlers shall have a manufacturer’s designation for an air leakage of no more than 2% of the design air flow rate when tested in accordance with ASHRAE 193.

Section R403.3.3/N1103.3.3 Duct testing (mandatory). Ducts shall be pressure tested to determine air leakage by one of the following methods:
1. **Rough-in test.** Total leakage shall be measured with a pressure differential of 0.1 inch water gage (25 Pa) across the system, including the manufacturer’s air handler enclosure if installed at the time of the test. All registers shall be taped or otherwise sealed during the test.

2. **Post-construction test.** Total leakage shall be measured with a pressure differential of 0.1 inch water gage (25 Pa) across the entire system, including the manufacturer’s air handler enclosure. Registers shall be taped or otherwise sealed during the test.

**Exception:**

A duct air leakage test shall not be required where the ducts and air handlers are located entirely within the building thermal envelope. A written report of the results of the test shall be signed by the party conducting the test and provided to the code official. (Because the ducts will be installed outside the building thermal envelope, this exception would not apply.)

**New Exception added to 2018 IECC/IRC**

A duct air leakage test shall not be required for ducts serving heat or energy recovery ventilators that are not integrated with ducts serving heating or cooling systems.

**Section R403.3.4/N1103.4 Duct Leakage (Prescriptive).** The total leakage of the ducts, measured in accordance with Section R403.3.3/N1103.3.3, shall be as follows:

- **Rough-in test.** The total leakage shall be less than or equal to 4 cubic feet per minute (113.3 L/min) per 100 square feet (9.29 m²) of conditioned floor area where the air handler is installed at the time of the test. Where the air handler is not installed at the time of the test, the total leakage shall be less than or equal to 3 cubic feet per minute (85 L/min) per 100 square feet (9.29 m²) of conditioned floor area.

- **Post-Construction test.** Total leakage shall be less than or equal to 4 cubic feet per minute (113.3 L/min) per 100 square feet (9.29 m²) of conditioned floor area.

**Section R403.3.5/N1103.3.5 Building Cavities (mandatory).** Building framing cavities should not be used as ducts or plenums.

**Section R403.3.6/N1103.3.6 Ducts buried within ceiling insulation.** Where supply and return air ducts are partially or completely buried in ceiling insulation, such ducts shall comply with all of the following:

1. Supply and return ducts shall have an insulation R-value of not less than R-8.
2. At all points along each duct, the sum of the ceiling insulation R-value against and above the top of the duct, and against and below the bottom of the duct, shall be not less than R-19, excluding the R-value of the duct insulation.
3. In Climate Zones 1A, 2A, 3A, the supply ducts shall be completely buried within ceiling insulation, insulated to an R-value of not less than R-13 and in compliance with the vapor retarder requirements of Section 604.11 of the International Mechanical Code or Section M1601.4.6 of the IRC, as applicable.

**Exception:** Sections of supply duct that are less than 3 feet (914 mm) from the supply outlet shall not be required to comply with these requirements.

**Section R403.3.6.1 Effective R-value of deeply buried ducts.** Where using a simulated energy performance analysis, sections of ducts that are:

- installed in accordance with Section R403.3.6
- located directly on or within 5.5 inches (140 mm) of the ceiling surrounded with blown-in attic insulation having an R-value of R-30 or greater and
- located such that the top of the duct is not less than 3.5 inches (89 mm) below the top of the insulation
- shall be considered as having an effective duct insulation R-value of R-25.

**Section R403.3.7 Ducts located in conditioned space.** For ducts to be considered as inside a conditioned space, such ducts shall comply with either of the following requirements:

1. The duct system shall be located completely within the continuous air barrier and within the building thermal envelope.
2. The ducts shall be buried within ceiling insulation in accordance with Section R403.3.6 and all of the following conditions shall exist:
   2.1 The air handler is located completely within the continuous air barrier and within the building thermal envelope.
2.2 The duct leakage, as measured by either a rough-in test of the ducts or a post-construction total system leakage test to outside the building thermal envelope in accordance with Section R403.3.4, is less than or equal to 1.5 cubic feet per minute (42.5 L/min) per 100 square feet (9.29 m²) of conditioned floor area served by the duct system.

2.3 The ceiling insulation R-value installed against and above the insulated duct is greater than or equal to the proposed ceiling insulation R-value less the R-value of the insulation on the duct.

In addition to allowing ducts to be buried within ceiling insulation, this provision sets the requirements for ducts to be considered within conditioned space. The DOE Zero Energy Ready Home National Program[1] defines ducts inside conditioned space states, "Duct distribution systems located within the home's thermal and air barrier boundary or optimized to achieve comparable performance." Item "1)" under R403.3.7 provides for that with the established code definitions. However, it also allows a comparable performance alternative to that includes buried ducts with provision for condensation avoidance for humid climates. Research has shown that almost all of the benefit of locating ducts inside conditioned space can be achieved by locating the air handler in conditioned space but locating ducts tested to be essentially leak-free in a vented attic buried under ceiling insulation. Section R403.3.7 provides for these conditions in that: the air handler must be located completely within the continuous air barrier and within the building thermal envelope; the ducts must be tested to an extremely low but still measurable level of leakage; the sum of the duct R-value and the ceiling insulation immediately above the duct is unchanged from the prescriptive or proposed ceiling insulation amount that would have otherwise been installed; and duct condensation avoidance in humid climates is provided for by referring back the provisions of Section R403.3.6.

Building Thermal Envelope Assembly (ceiling provisions)

2015/2018 IECC/IRC, Section R402.1.2/N1102.1.2 Insulation Criteria. The building thermal envelope must meet the requirements of Table R402.1.2/N1102.1.2, based on the climate zone specified in Chapter 3 and the building assemblies associated with the vented attic (ceilings) that are considered part of the building thermal envelope. (Per Building America research, a minimum R-30 attic insulation installed over the top of the ducts would be required.) Again, it should be noted, depending upon the code, location, and climate zone, the minimum R-value for attic insulation could be higher than R-30.

Below are the prescriptive compliance paths (R-value computation, u-Factor alternative, and total UA alternative). The Performance based and Energy Rating Index (ERI) compliance paths are not addressed in detail in this brief, however, these paths could be used to demonstrate compliance to these alternative methods through whole-building modeling.

Section R402.1.3/N1102.1.3 R-Value Computation. Insulation material used in layers, such as framing cavity insulation, or continuous insulation should be summed to compute the corresponding component R-value. Computed R-values should not include an R-value for other building materials or air films.

Section R402.1.4/N1102.1.4 U-Factor Alternative. An assembly with a U-factor equal to or less than that specified in Table R402.1.4/N1102.1.4 should be permitted as an alternative to the R-value in Table R402.1.2/N1102.1.2.

Section R402.1.5/N1102.1.5 Total UA Alternative. Where the total building thermal envelope UA, the sum of U-factor times assembly area, is less than or equal to the total UA resulting from multiplying the U-factors in Table R402.1.4/N1102.1.4 by the same assembly area as in the proposed building, the building would be considered to be in compliance with the Table R402.1.2/N1102.1.2. The UA calculation shall be performed using a method consistent with the ASHRAE Handbook of Fundamentals and include the thermal bridging effects of framing materials.

Section R402.2.3/N1102.2.3 Eave baffle. For air-permeable insulation in vented attics, a baffle should be installed adjacent to soffit and eave vents. Baffles should maintain an opening equal or greater than the size of the vent. The baffle

---

Excerpt from the **Insulation Requirements by Component Table R402.1.2/N1102.1.2**

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4 Except Marine</th>
<th>5 and Marine 4</th>
<th>6</th>
<th>7, 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling R-value</td>
<td>30</td>
<td>38</td>
<td>38</td>
<td>49</td>
<td>49</td>
<td>49</td>
<td>49</td>
</tr>
</tbody>
</table>

Excerpt from the **Equivalent U-factor Table R402.1.4/N1102.1.4**

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4 Except Marine</th>
<th>5 and Marine 4</th>
<th>6</th>
<th>7, 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling U-factor</td>
<td>0.035</td>
<td>0.030</td>
<td>0.030</td>
<td>0.026</td>
<td>0.026</td>
<td>0.026</td>
<td>0.026</td>
</tr>
</tbody>
</table>

---

should extend over the top of the attic insulation. The baffle should be permitted to be any solid material.

**Section R402.2.4/N1102.2.4 Access Hatches and Doors.** Any access hatches or doors from conditioned spaces to unconditioned spaces such as attics must also be insulated to a level equivalent to the insulation on the surrounding surfaces (minimum R-30 insulation). In addition the access hatch or door must also be provided with weatherstripping in gaskets to minimize air leakage. Access should be provided to all equipment that prevents damaging or compressing the insulation. A wood-framed or equivalent baffle or retainer is required to be provided when loose-fill insulation is installed, the purpose of which is to prevent the loose-fill insulation from spilling into the living space when the attic access is opened, and to provide a permanent means of maintaining the installed R-value of the loose-fill insulation.

Exception: Vertical doors that provide access from conditioned to unconditioned spaces can be permitted to meet the fenestration requirements of Table R402.1.2/N1102.1.2 based upon the applicable climate zone specified in Chapter 3.

**Air Sealing/Air Leakage Control**

**2015/2018 IECC/IRC, R402.4/N1102.4 Air Leakage.** The building thermal envelope should be constructed to limit air leakage.

- **Section R402.4.1/N1102.4.1 Building Thermal Envelope.** The sealing methods between dissimilar materials should allow for differential expansion and contraction.
- **Section R402.4.1.1/N1102.4.1.1 Installation.** The components listed in the Air Barrier and Insulation Installation Table (Table R402.4.1.1 of the IECC and Table N1102.4.1.1 of the IRC.) should be installed in accordance with the manufacturer’s instructions and the criteria listed as the applicable method of construction. Below are the General Requirements and components from the table that are applicable to sealing and insulating ducts and ceiling assemblies (vented attics).

**2015/2018 IRC/IECC, Air Barrier and Insulation Installation Table R402.4.1.1/N1102.4.1.1**

- **Continuous air barrier** (defined as a combination of materials and assemblies that restrict or prevent the passage of air through the building thermal envelope.)– Confirm that construction documents specify a continuous air barrier for the building components associated with the insulation of the ceiling (vented attic).
- **Ceiling/attic** – The air barrier in any dropped ceiling/soffit should be aligned with the insulation and any gaps in the air barrier sealed. Access openings, drop down stairs or knee wall doors to unconditioned attic spaces should be sealed.
- **Shafts/penetrations** – Duct shafts, utility penetrations, and flue shaft openings to the exterior or unconditioned space are sealed.
- **Recessed lighting** – Recessed lighting fixtures installed in the ceiling (vented attic) are sealed to the drywall. The fixtures installed are air tight and IC rated.
- **HVAC register boots** – HVAC register boots that penetrate the ceiling (vented attic) are sealed to the subfloor or drywall.
- **Concealed sprinklers** – When required are sealed, concealed fire sprinklers should only be sealed in a manner that is recommended by the manufacturer. Caulking or other use adhesive sealants should not be used to fill voids between fire sprinkler cover plates and the ceiling.

**Field Inspection:**

**FIELD INSPECTION:**

Per the **2015/2018 IECC, Section R104 Inspections**, construction or work for which a permit is required is subject to inspection. Construction or work is to remain accessible and exposed for inspection purposes until approved. (In 2018 IECC, the wording was changed from “accessible” to “visible”.) Required inspections include footing and foundation, framing and rough-in, plumbing rough-in, mechanical rough-in, and final inspection.

**Section R104.2.4 Mechanical Rough-In Inspection.** Inspections at mechanical rough-in shall verify compliance as required by the code and approved plans and specifications as to installed duct system, insulation and corresponding R-values, system air leakage control, and testing. Because the duct system should be installed at the ceiling and then the attic insulation applied over the top of the ducts, this inspection might also include the inspection of the attic sealing and insulation R-values and insulation installation at the same time or performed at final inspection.

In the **IRC, Section R109 Inspections**, the wording is somewhat different in that for onsite construction the building official, upon notification from the permit holder or his agent, can make, or cause to be made, any necessary inspections. Further details are provided for inspections regarding foundation, plumbing, mechanical, gas and electrical, floodplain, frame and masonry, and final inspections. Any additional inspections are at the discretion of the building official.

This section provides details for inspecting to the specific provisions for buried ducts in vented attics where one or more specific type of inspection per the IECC or IRC may be necessary to confirm compliance. Verifying code compliance would typically be at the mechanical rough-in and final inspection.

**2015/2018 IECC, Section R303.1 Identification.** Materials, systems and equipment shall be identified in a manner that
will allow determinations of compliance with applicable provisions of the code.

**2015/2018 IECC, Section R303.1.1 Building thermal envelope insulation.** An R-value identification mark should be applied by manufacturer to each piece of building thermal envelope insulation that is 12 inches or greater in width. Insulation installers should provide a certification that indicates the type, manufacturer and R-value of insulation installed in each element of the building thermal envelope. For blown-in or sprayed fiberglass and cellulose insulation, the initial installed thickness, settled thickness, and settled R-value, installed density, coverage area and number of bags installed should be indicated on the certification. Insulation installer should sign, date, and post the certificate in a conspicuous location on job site.

**2015/2018 IECC Section R303.1.1.1 Blown-in or sprayed roof and ceiling insulation.** The thickness of blown-in or sprayed fiberglass and cellulose ceiling insulation should be written in inches (mm) on markers that are installed not less than one for every 300 square feet throughout the attic space. Markers should be affixed to the trusses or joists and marked with the minimum initial installed thickness with numbers not less than 1 inch in height. Markers should face the attic access opening. Thickness and installed R-value of sprayed polyurethane foam insulation shall be indicated on the certification proved by the insulation installer.

**2015/2018 IECC Section R303.1.1.2 Insulation mark installation.** Insulating materials shall be installed such that the manufacturer’s R-value mark is readily observable at inspections.

**2015/2018 IECC Section R303.1.1.4 Insulation product rating.** Thermal resistance R-value of insulation shall be determined in accordance with Part 460 of US-FTC CFR Title 16

Inspections should provide verification in the following areas:

- **Ductwork:** verify all joints and seams in ductwork are properly sealed, and the duct tightness report is complete, verify that duct insulation is installed in accordance with manufacturer’s installation instructions and that the manufacturer’s R-value mark is readily available and meets the approved R-value specified in approved construction documents.

- **Ensure proper thickness of duct insulation**

- **Ensure proper tightness of duct system**
  - 1.5 cfm/100ft² if qualifying as in conditioned space
  - 4 cfm/100ft² @ 25Pa if

- **Ceiling assembly:** verify all joints, seams, holes, and penetrations are caulked, gasketed, weather-stripped, or otherwise sealed.

- **Ceiling assembly:** ensure that the appearance of the installed ceiling insulation matches that specified in the approved construction documents.

- If the R-value or U-factor approach for compliance was used in the documentation, ensure that the installed insulation meets the minimum R-value or maximum U-factor required for the ceiling and climate zone per the approved construction documents.

- **Ensure proper depth of attic insulation**

- **Ensure a total of R-19 above and/or below the buried ducts**

- **Ensure that the continuous air barrier is properly installed.** Confirm that the air barrier is aligned with the insulation in any dropped ceiling/soffit and sealed.

**Technical Validation(s):**

**Technical Validation/Reference Materials:**

This section provides additional information and helpful resources.


Author(s): ICC
Organization(s): ICC [www.iccsafe.org](http://www.iccsafe.org)
Publication Dates: May 2014 / October 2017

This code establishes 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.
This code for residential buildings 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.

**Compact Buried Ducts in Hot-Humid Climates**

Author(s): D Mallay  
Organization(s): Home Innovation Research Labs  
Publication Date: January 2016

A system of compact, buried ducts provides a high-performance and cost-effective solution for delivering conditioned air throughout the building. This report outlines research activities that are expected to facilitate adoption of compact buried duct systems by builders. The results of this research would be scalable to many new house designs in most climates and markets, leading to wider industry acceptance and building code and energy program approval.

**Measure Guideline: Buried and/or Encapsulated Ducts**

Author(s): Shapiro, Zoeller, Mantha  
Organization(s): CARB  
Publication Date: August 2013

Document covering the technical aspects of buried and insulated ducts, as well as the advantages, disadvantages, and risks of buried and insulated ducts compared to alternative strategies.

**Building America Top Innovations 2013 Profile: Buried and Encapsulated Ducts**

Author(s): PNNL  
Organization(s): PNNL  
Publication Date: September 2013

Case study providing information about buried and encapsulated ducts.

**Technology Solutions Case Study: Buried and Encapsulated Ducts, Jacksonville, Florida**

Author(s): CARB  
Organization(s): CARB  
Publication Date: November, 2013

Case study exploring how using buried and/or encapsulated ducts can reduce duct thermal losses in existing homes.


  [http://www.energystar.gov/ia/home_improvement/home_contractors/qispec.pdf](http://www.energystar.gov/ia/home_improvement/home_contractors/qispec.pdf)


**BASC Related Guides:**

- Duct Leakage to the Outdoors, [https://basc.pnnl.gov/resource-guides/duct-leakage-outdoors](https://basc.pnnl.gov/resource-guides/duct-leakage-outdoors)
Access to some references 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.

Case Studies

1. **Building America Top Innovations 2013 Profile: Buried and Encapsulated Ducts**
   - Author(s): PNNL
   - Organization(s): PNNL, CARB, Steven Winter Associates
   - Publication Date: September, 2013
   - Case study on a DOE Building America 2013 top innovation describing research by the Consortium for Advanced Residential Buildings (CARB), a Building America research team led by Steven Winter Associates, on HVAC ducts located in vented attics that are encapsulated in foam and buried in attic insulation.

2. **Technology Solutions Case Study: Buried and Encapsulated Ducts, Jacksonville, Florida**
   - Author(s): CARB
   - Organization(s): CARB
   - Publication Date: November, 2013
   - Case study exploring how using buried and/or encapsulated ducts can reduce duct thermal losses in existing homes.

References and Resources*

1. **2008 Building Energy Efficiency Standards: Residential Compliance Manual**
   - Author(s): California Energy Commission
   - Publication Date: January, 2008
   - Document intended to help owners, designers, builders, inspectors, examiners, and energy consultants comply with and enforce California’s 2008 energy efficiency standards for low-rise residential buildings.

2. **Measure Guideline: Buried and/or Encapsulated Ducts**
   - Author(s): Shapiro, Zoeller, Mantha
   - Organization(s): CARB, Steven Winter Associates, SWA
   - Publication Date: August, 2013
   - Document covering the technical aspects of buried and insulated ducts (BEDs), as well as the advantages, disadvantages, and risks of BEDs compared to alternative strategies.

3. **Reducing Thermal Losses and Gains With Buried and Encapsulated Ducts in Hot-Humid Climates**
   - Author(s): Shapiro, Magee, Zoeller
   - Organization(s): CARB, Steven Winter Associates, SWA
   - Publication Date: February, 2013
   - Report including an overview of the buried duct research and information the retrofit methodology used to install and test the three existing duct systems, including short- and long-term data collection.

   - Author(s): ASTM
   - Publication Date: January, 2013
   - This specification covers the classification, composition, physical properties, and dimensions of mineral fiber (rock, slag, or glass) blanket intended for use as thermal insulation on surfaces at various temperature ranges.

*Publication dates are shown for formal documents. Dates are not shown for non-dated media. Access dates for referenced, non-dated media, such as web sites, are shown in the measure guide text.

Contributors to this Guide

The following authors and organizations contributed to the content in this Guide.

Steven Winter Associates, lead for the Consortium for Advanced Residential Buildings (CARB), a DOE Building America Research Team