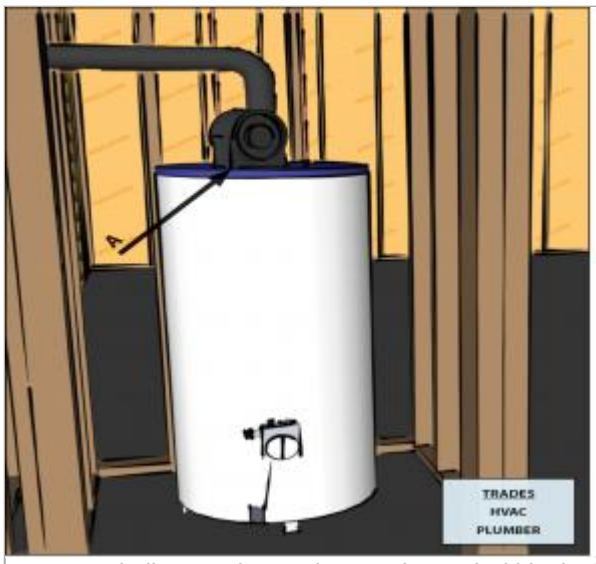
Direct Vent Equipment

Last Updated: 03/14/2016

Scope



Furnaces, boilers, and water heaters located within the home's pressure boundary are mechanically drafted or direct-vented

When specifying and installing combustion heating equipment, choose the highest efficiency equipment the project will allow. Select models that are direct vented meaning they are equipped with a pipe to bring combustion air directly from outside to the combustion chamber and they have a second sealed vent pipe to carry exhaust gases directly to the outside from the appliance.

- All combustion space and water heaters should be direct vented or mechanically drafted. Do not install naturally drafted combustion appliances within the conditioned space of the home.
- Ensure that all fireplaces and wood stoves located in conditioned spaces are vented to the outdoors and supplied with adequate combustion and ventilation air according to the manufacturers' installation instructions.

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.

Description

When installing combustion furnaces, boilers, and water heaters inside the home's pressure boundary (i.e., within the conditioned space of the home), the safest (and usually most energy efficient) type of equipment to install is a direct-vent, sealed-combustion appliance.

A direct-vent sealed-combustion furnace, boiler, or water heater brings combustion air directly from outdoors to the sealed combustion chamber through one sealed pipe and exhausts the byproducts of combustion (carbon dioxide and nitrogen) to the outdoors through a second sealed pipe (Figure 1). Because of this sealed combustion and sealed exhaust venting, the risk of backdrafting is eliminated. Combustion air (oxygen) enters the furnace through the sealed pipe and goes directly from the outdoors to the burner assembly. There it mixes with the fuel and is electronically ignited in the sealed combustion chamber. The heated air passes through a primary heat exchanger, which extracts most of the heat, and then through a secondary heat exchanger, where more heat is extracted, cooling the exhaust gases to the point that they condense. The condensed water and carbon dioxide exit through a condensate drain, while the remaining flue gases exit to the outside through the sealed exhaust pipe, which can be made of PVC because of the low temperature of the gases (Figure 2). Condensing furnaces have annual fuel utilization efficiencies (AFUE) of 90% to 98%.

The **National Fuel Gas Code** identifies four categories for combustion furnaces and water heaters (see Figure 3). The categories are based on combustion type (sealed or unsealed) and vent pipe temperature. Direct-vent sealed-combustion furnaces are Category 4 appliances. The flue and vent pipe are under a positive pressure, flue gases are under 140°F, and water vapor (a byproduct of combustion) is condensed into water liquid and drained to the outside through a condensate drain. Combustion air is piped directly to the burner, which is sealed off from the CAZ (sealed combustion) and the byproducts of combustion (carbon dioxide and nitrogen) are power exhausted to outdoors.

A Category 2 appliance is a naturally aspirating furnace with a vent temperature below 140°F that does some condensing of the flue gases and has negative pressure in the vent. Nearly all Category 2 appliances are huge commercial furnaces. A Category 3 appliance is a furnace with a vent temperature above 140°F (high enough to avoid condensation in the vent) and the vent has a positive static pressure.

Figure 1 - A direct-vent sealed-combustion furnace has dedicated pipes for combustion air and exhaust.

Figure 2 - Because the flue temperatures are cool, intake and exhaust ducts on a Category 4 direct-vent sealed-combustion condensing furnace can be made of PVC.

Figure 3 - The National Fuel Gas Code identifies four categories for combustion furnaces and water heaters based on combustion type (sealed or unsealed) and vent pipe temperature.

Category 1 combustion appliances are the oldest, least efficient type of combustion appliances. They have a flue gas temperature over 140°F and the flue pipe pressure is negative with respect to the space in which the appliance is located (referred to as the combustion appliance zone or CAZ). Category 1 appliances are either atmospheric or mechanically drafted. Atmospheric drafted (also called naturally drafted) furnaces use the heat in the flue to draw combustion air through the furnace and to lift combustion exhaust up and out of the chimney. Mechanically drafted category furnaces and water heaters use a small induced draft fan to pull air through the combustion chamber; however, the furnace still relies on flue temperatures to lift the combustion gases up the flue stack. Category 1 appliances are not direct vented (also known as sealed combustion); they are considered nondirect vented because there is no barrier between the burner and the CAZ. A Category 1 furnace or water heater draws its combustion and dilution air from the CAZ and the byproducts of combustion (carbon dioxide, nitrogen, and water vapor) are transported outside through the flue. Because Category 1 appliances draw their combustion air from the CAZ, they are susceptible to backdrafting.

Atmospheric draft furnaces have -efficiencies of 60% to 78%. These appliances are no longer sold in the United States but are still found operating in existing homes. Induced draft fan-equipped Category 1 furnaces have AFUEs of 78% to 83% and there are still models available on the market, although direct-vent furnaces are much higher efficiency and safer to operate. Natural draft water heaters are still sold, although safer and more efficient water heaters are available, such as power-vented models, which use a fan to push combustion gases out the flue, and direct-vent models, which use a sealed intake for combustion air and a sealed flue for exhaust gases.

Naturally drafted appliances are not recommended inside the home, especially in air-tight, high-efficiency homes, where exhaust fans or other combustion appliances such as fireplaces could depressurize the home and overcome the natural draft of an atmospherically vented appliance, thus backdrafting the appliance and pulling combustion gases into the living space.

Although most building scientists would not recommend them, naturally drafted furnaces, boilers, and water heaters are permitted by ENERGY STAR Version 3.0 in Climate Zones 1 through 3. If they are installed, the builder must ensure that adequate combustion air is supplied to the CAZ, as required by **NFPA 54, Sections 5.3.3 and 5.3.4**. (See the guide **Combustion Furnaces** for more about providing combustion air to the CAZ.) If atmospheric vented furnaces, boilers, or water heaters are installed, the rater must test the equipment using combustion safety test procedures for depressurization, spillage, draft pressure, and carbon monoxide (CO) concentrations in the flue and in the ambient air. Ambient CO concentration should be < 25 ppm (< 8 ppm is preferred). This combustion safety testing should be conducted according to the procedures of the **Building Performance Institute** or the ***Mortgage Industry National Home Energy Rating System's Standards***, Chapter 8 - 800 RESNET Standard for Performance Testing and Work Scope: Enclosure and Air Distribution Leakage Testing.

For additional guidance on how to conduct combustion safety testing, see the guide **Combustion Appliance Zone (CAZ) Testing**.

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Figure 4 - The natural draft and induced draft furnace are both Category I appliances that receive combustion air from the combustion appliance zone.

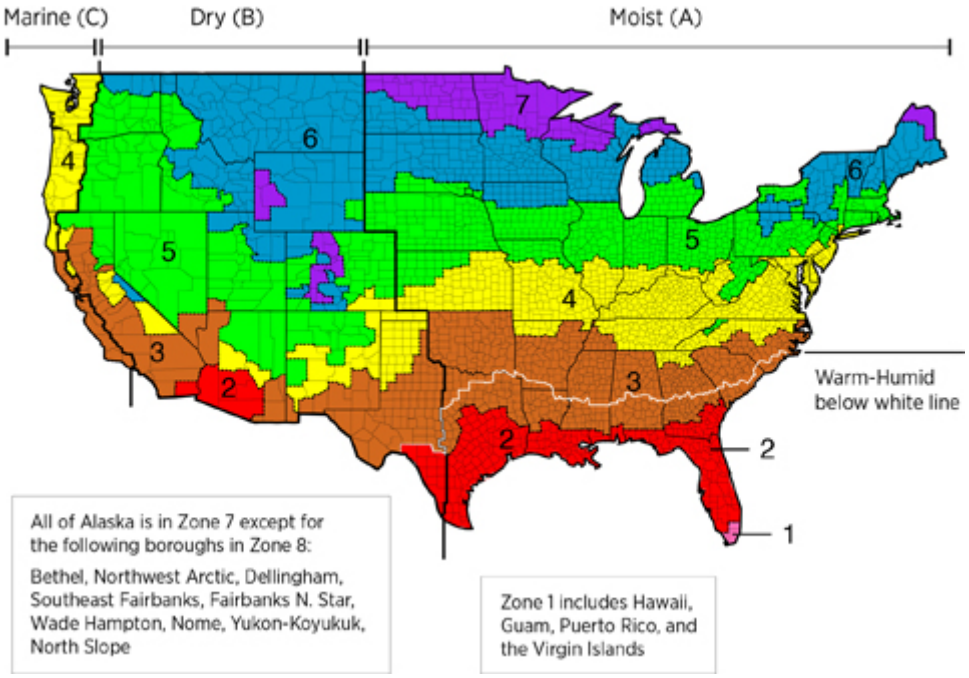
Figure 5 - The raised hood at the base of the vent stack on this water heater shows that it is an atmospheric vented gas water heater.

Ensuring Success

When furnaces, boilers, and water heaters are installed within the home's pressure boundary (i.e., within the thermal envelope), this equipment should be direct-vent/sealed-combustion equipment. ENERGY STAR permits non-direct-vented combustion appliances in **Climate Zones 1, 2, and 3**. If atmospheric-vented furnaces, boilers, or water heaters are installed in a confined space or an air-tight building, two fresh air supply ducts or openings must be installed to provide combustion air in the combustion appliance zone (CAZ as required by **NFPA 54, Sections 5.3.3 and 5.3.4**. If the furnace, boiler, or water heater to be installed is atmospheric or mechanically vented and draws its combustion air from the combustion appliance zone, the rater must test the equipment using the Building Performance Institute (BPI 2012) or RESNET-approved procedures for depressurization, spillage, draft pressure, and CO concentration in the ambient air and in the flue. Ambient CO concentration should be < 25 ppm (< 8 ppm is preferred).

Climate

See the Compliance tab for climate-zone-specific criteria for the ENERGY STAR for Homes and DOE Zero Energy Ready Home programs.



Training

Right and Wrong Images

None Available

CAD

None Available

Compliance

The Compliance tab contains both program and code information. Exact code language is copyrighted and 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.

DOE Zero Energy Ready Home

The U.S. Department of Energy (DOE) Zero Energy Ready Home Program requires that builders comply with EPA's Indoor airPLUS Program. The **Indoor airPLUS checklist** (Item 5.1) requires that builders meet certain requirements for fuel-burning and space-heating appliances that are located in conditioned space.

Completion of the ENERGY STAR checklists (which is a DOE Zero Energy Ready Home requirement) now satisfies the following Indoor airPLUS requirements:

- Mechanically draft or direct vent all gas- and oil-fired furnaces, boilers, and water heaters located in conditioned spaces (HVAC-R 10.1)
- Fireplaces that are not mechanically drafted or direct-vented to the outdoors must meet the maximum allowed exhaust flow or pressure differential (HVAC-R 10.2).

Additional Indoor airPLUS Requirements

Do not install any unvented combustion space-heating appliances.

Ensure naturally drafted fuel-burning appliances located in conditioned spaces are installed in compliance with ASHRAE 62.2-2010 (Section 6.4) or conduct a worst case depressurization combustion air zone (CAZ) test according to an established protocol.

Ensure that all fireplaces and other fuel-burning and space-heating appliances located in conditioned spaces are vented to the outdoors and supplied with adequate combustion and ventilation air according to the manufacturers' installation instructions.

Meet the following energy efficiency and emissions standards and restrictions for all fireplaces and other fuel-burning and space-heating appliances located in conditioned spaces:

- Traditional masonry fireplaces designed for open fires are not permitted, with the exception of "masonry heaters" as defined by ASTM E1602 and Section 2112.1 of the 2012 International Building Code (i.e., fireplaces engineered to store and release substantial portions of heat generated from a rapid burn).
- Factory-built wood-burning fireplaces shall meet the certification requirements of UL 127 and emission limits found in the EPA Standard for New Residential Wood Heaters.
- Natural gas and propane fireplaces shall be mechanically drafted or direct vented, as defined by NFPA 54, Section 3.3.108, have a permanently affixed glass front or gasketed door and comply with ANSI Z21.88/CSA 2.33.
- Wood stove and fireplace inserts as defined in Section 3.8 of UL 1482 shall meet the certification requirements of that standard, and they shall meet the emission requirements of the EPA Standards for New Residential Wood Heaters and WAC 173-433-100 (3).
- Pellet stoves shall meet the requirements of ASTM E1509.
- Decorative gas logs as defined in K.1.11 of NFPA 54 (the National Fuel Gas Code) are not permitted.

Note: Unfinished basements and crawlspaces (except raised pier foundations with no walls) and attached garages that are air-sealed to the outside and intended for use as work or living space are considered "conditioned spaces" for the purpose of this requirement.

Exception: Houses with no combustion heating equipment located in conditioned spaces.

ENERGY STAR Certified Homes

ENERGY STAR Certified Homes (Version 3/3.1, Revision 08), Rater Field Checklist

10. Combustion Appliances
10.1 Furnaces, boilers, and water heaters located within the home's pressure boundary are mechanically drafted or direct-vented. See Footnote 56 for alternatives.[54, 55, 56]

Footnotes:

(54) The pressure boundary is the primary enclosure boundary separating indoor and outdoor air. For example, a volume that has more leakage to outside than to conditioned space would be outside the pressure boundary.

(55) Per the 2009 International Mechanical Code, a direct-vent appliance is one that is constructed and installed so that all air for combustion is derived from the outdoor atmosphere and all flue gases are discharged to the outside atmosphere; a mechanical draft system is a venting system designed to remove flue or vent gases by mechanical means consisting of an induced draft

portion under non-positive static pressure or a forced draft portion under positive static pressure; and a natural draft system is a venting system designed to remove flue or vent gases under nonpositive static vent pressure entirely by natural draft.

(56) Naturally drafted equipment is allowed within the home's pressure boundary in Climate Zones 1-3 if the Rater has followed Section 805 of RESNET's Standards, encompassing ANSI/ACCA 12 QH-2014, Appendix A, Sections A3 (Carbon Monoxide Test) and A4 (Depressurization Test for the Combustion Appliance Zone), and verified that the equipment meets the limits defined within.

ENERGY STAR Revision 08 requirements are required for homes permitted starting 07/01/2016.

2009 & 2012 International Residential Code

Chapter 14 Heating and Cooling equipment covers general requirements, installation, clearances, and location. Chapter 24 Fuel Gas is extracted from the International Fuel Gas Code with modifications and covers gas piping systems, appliances, venting systems, and combustion air configurations.

2009 and 2012 International Mechanical Code

Comply with all relevant sections. Note, Chapter 2 - Definitions defines categories of combustion appliances based on venting type.

ACCA Standards

ACCA Standard 5: HVAC Quality Installation Specification, ANSI/ACCA 5 QI-2010, details nationally recognized criteria for the proper installation of residential and commercial HVAC systems, including forced air furnaces, boilers, air conditioners, and heat pumps. The Standard covers aspects of design, installation, and distribution systems, as well as necessary documentation. The ***Technician's Guide for Quality Installation***, produced by ACCA, explains the HVAC Quality Installation (QI) Specification and provides detailed procedures for the steps technicians must complete and document to show compliance with the HVAC QI Specification.

ACCA Standard 9: HVAC Quality Installation Verification Protocols, ANSI/ACCA 9 QIVP-2009, specifies the protocols to verify the installation of HVAC systems in accordance with ACCA Standard 5. The protocols provide guidance to contractors, verifiers, and administrators who participate in verification efforts using independent objective and qualified third parties to ensure that an HVAC installation meets the requirements in Standard 5.

National Fuel Gas Code (NFPA-5 2012)

The products of combustion from a gas-fired furnace (non-condensing) are vented out of the building using specific types of vent pipes made up of different materials depending on the flue gas temperatures, as specified in ANSI Z223.1, the National Fuel Gas Code (NFPA-5 2012), "Table 12.5.1 Type of Venting System to Be Used." Table 2 shows appropriate venting materials for residential vented combustion appliances, excerpted from the NFPA Table 12.5.1.

Table 2. Acceptable Venting Types for Different Combustion Appliance Types, excerpted from NFPA 54 2012, the National Fuel Gas Code, Table 12.5.1.

Appliance	Type of Venting System	NFPA Section Location
Listed Category 1 Appliances	Type B Gas Vent	12.7
Listed appliances equipped with draft hood	Chimney	12.6
Appliances listed for use with Type B gas vent	Single-wall metal pipe	12.8
	Listed chimney lining system for gas venting	12.6.1.3
	Special gas vent listed for these appliances	12.5.4
Category III appliances Category IV appliances	As specified or furnished by manufacturers of listed appliances	12.5.2 12.5.4
Listed combination gas- and oil-burning appliances	Type L vent Chimney	12.7 12.6
Direct vent appliances		12.3.5

See the National Fuel Gas Code for additional relevant requirements.

Rooms Containing Fuel-Burning Appliances - Code Compliance Brief

Overview:

The intent of this brief is to provide code-related information about rooms containing fuel-burning appliances to help ensure that the measure will be accepted as being in compliance with the code. Providing notes for codes officials on how to plan review and conduct field inspections can help builders or remodelers with proposed designs and provide jurisdictional officials with information for acceptance. Providing the same information to all interested parties (e.g., code officials, builders, designers, etc.) is expected to result in increased compliance and fewer innovations being questioned at the time of plan review and/or field inspection.

As houses are being built "tighter" to meet stricter air leakage requirements (e.g., climate zones 1-3 at 5 ACH/50 [air changes per hour at 50 Pa]) and climate zones 3-8 at 3 ACH/50 in the 2015 International Energy Conservation Code (IECC) and International Residential Code (IRC), concern has risen for installing natural-draft gas *appliances*[1] (*vented*[2] *or direct-vented appliances*[3]) in these tighter homes without dealing with issues related to back-drafting due to possible increased negative pressure near the *combustion*[4] *appliance* and drawing carbon monoxide into the building. For example, this scenario could potentially occur in a somewhat tight home tested at 900 cfm (cubic feet per minute) (e.g., a 2000-square foot home with 9-foot ceiling heights = 18,000 cubic feet/volume) by turning on one exhaust fan (e.g., 300 cfm), which could depressurize the home to the point that no natural-draft gas *appliance* could safely draft under these conditions [5].

In an attempt to deal with these combustion issues, an entirely new section in the 2015 IECC/IRC regarding fuel-burning *appliances* basically requires the *appliance* to be isolated from the *building thermal envelope*,[6] located either outside or within a separate room if the fuel-burning appliance is supplied by open combustion air ducts. The room must be insulated and sealed off from the rest of the conditioned space. Furthermore, a NEW Appendix 'RA' has been added providing for a Code Official's option to require a Combustion Appliance Zone (CAZ) test to verify "manufacturer's operational parameters" for venting byproducts of combustion in a "tight" <5 ACH/50 (air changes per hour) home.

This brief provides an overview of the requirements and further details of approving the actual "room," based on equipment choices and location of installed equipment, approving the "open combustion air ducts" as to the installation, insulation and sealing of the ducts, and any other ducts or water lines in the "room."

[1]"Appliance" is defined in the 2015 IECC/IRC as any apparatus or device that uses a fuel or raw material to produce light, heat, power, refrigeration, or air conditioning.
[2]"Appliance, vented" is defined as an appliance designed and installed in such a manner that all of the products of combustion are conveyed directly from the appliance to the outside atmosphere through an approved chimney or vent system.
[3]

"Direct-vent appliance" is defined as an appliance that is constructed and installed so that all air for combustion is derived directly from the outside atmosphere and all flue gases are discharged directly to the outside atmosphere.
[4]"Combustion" is defined as in the context of the code referring to rapid oxidation of fuel accompanied by the production of heat or heat and light.
[5]Article on *"IECC/IRC Code Conflict Regarding House Depressurization"*, Journal of Light Construction, Doug Garrett, Building Performance and Comfort, Inc., September 2013, **http://www.jlconline.com/projects/energy-efficient/iecc-irc-code-conflict-regardign-house-depressurization_o**.
[6]"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.

Plan Review:

Per the ***2015 IECC/IRC, Section R103.3/R106.3, Examination of Documents.*** The code official/building official must examine, or cause to be examined, construction documents for code compliance.

This section lists the applicable code requirements followed by details helpful for plan review regarding the provisions to meet the requirement for "rooms containing fuel-burning appliances." The first bullet item below is the code requirement itself. The remaining bullets are items to meet the requirement.

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- ***2015 IECC/IRC, Section R402.4.4/N1102.4.4, Rooms Containing Fuel-Burning Appliances.*** In Climate Zones 3 through 8, where **open combustion air ducts** provide combustion air to **open combustion fuel-burning *appliances***, the appliances and combustion air opening shall be located **outside the *building thermal envelope*** or enclosed in a roomthat is **isolated from inside the thermal envelope**. Such "rooms" must be sealed and insulated in accordance with the envelope requirements of *the Insulation and Fenestration Requirement by Component Table R402.1.2/N1102.1.2*, where the walls, floors and ceilings meet not less than the basement wall R-value requirement. The door into the room should be fully gasketed and any water lines and ducts in the room insulated according to Section R403 (IECC)/Section N1103 (IRC) regarding Systems. The combustion air duct(s) should be insulated to a minimum of R-8 where it passes through conditioned space.

  Exceptions:

  1. Direct vent appliances with both intake and exhaust pipes installed continuous to the outside.
  2. Fireplaces and stoves complying with Section R402.4.2 (IECC)/N1102.4.2 (IRC) and Section R1006 (IRC).

  — **Construction Documentation**. Review the construction documents to identify the equipment, system controls, design, and ventilation choices for combustion air or supply air to equipment. If combustion air *vented appliances* will be installed, confirm the provisions of the code provided in this brief.

  - ***2015 IECC/IRC, Section R103.2/N1101.5 Information on Construction Documents.*** Construction documents should include:
    - Insulation materials and their R-values
    - Mechanical system design criteria
    - Mechanical and service water-heating system and equipment types, sizes, and efficiencies
    - Equipment and system controls
    - Duct sealing, duct and pipe insulation and location
    - Air sealing details.

  — ***Insulation.*** Review the construction documents and confirm that the insulation R-values specified meet or exceed the minimum insulation requirements for the "room."

  2015 IECC/IRC, Insulation and Fenestration Requirements by Component Table R402.1.2/N1102.1.2

  Code Compliant Minimum Insulation Levels for the "Room"

Climate Zone	3	4 except Marine	5 and Marine 4	6	7, 8
Ceiling R-Value	38	49	49	49	49
Wood Frame Wall R-Value	20 or 13+5	20 or 13+5	20 or 13+5	20 or 13+5	20+5 or 13+10
Floor R-Value	19	19	30	30	38
Basement Wall R-Value[a]	5/13	5/13	15/19	15/19	15/19

  Note: The actual code provision does not explicitly address requirements for any windows, skylights, slab-on-grade, or the door leading into the "room." If the "room" has any windows or skylights or is located as part of the building thermal envelope where one or more of the walls are exterior walls on a slab-on-grade foundation, then those components should meet the minimum insulation and fenestration values per Table R402.1.2/N1102.1.2. Also, because the "room" is to be isolated from the rest of the home, it should have an exterior type door (i.e., insulated door), not an internal door (i.e., hollow core) and should not have any grills or openings in it.

  a The basement wall R-values are the minimum insulation requirements for the "room." The first R-value is continuous insulation with no thermal breaks; the second R-value is cavity insulation between studs or framing members.

  — **Air Sealing/Air Leakage Control**. The same air sealing provisions of the building thermal envelope apply to the "room."

  - ***2015 IRC/IECC, Air Barrier and Insulation Installation Table R402.4.1.1/N1102.4.1.1***
    - ***Continuous air barrier***[7] – Confirm that construction documents specify a continuous air barrier for the building components that define the "room" to include the ceiling, walls, and floor.
    - ***Doors.*** Confirm the will meet the minimum insulation requirements for the "material" and threshold.

Climate Zone	3	4 except Marine	5 and Marine 4	6	7, 8
Ceiling, Wood Frame Walls, Floor R-Value[a]	5/13	5/13	15/19	15/19	15/19

  a The first R-value is continuous insulation with no thermal breaks; the second R-value is cavity insulation between studs or framing members.

  — **Combustion Air Requirements.** There are five distinct methods in the IECC/IRC residential provisions where open combustion air ducts, provide combustion air, ventilation, and dilution air to fuel-burning appliances. To assist with which method would need to be met and that applies to an open combustion appliance in regards to where the air is being obtained for combustion, ventilation, and dilution of flue gases for the appliance and would result in having to meet the new provision for the "room," each method is listed below and states whether the requirement (method) must be met (applies or does not apply). Only one of the methods applies to the ***2015 IECC/IRC, Section R402.4.4/N1102.4.4, Rooms Containing Fuel-Burning Appliances***. Chapter 24, Fuel Gas, in the 2015 IRC is extracted from the 2015 edition of the International Fuel Gas Code (IFGC). The numbers in parentheses after each section number are the section numbers of the corresponding text in the IFGC, and the language in red and underlined explains why a particular method does or does not apply.

  1. ***G2407.5 (304.5) Indoor Combustion Air.*** ((NO! IECC/IRC R402.4.4/N1102.4.4 DOES NOT APPLY, as all the combustion air is obtained by way of abundant "indoor volume" in the home.))
     i. ***G2407.5.1 (304.5.1) Standard Method.*** The minimum required volume shall be 50 cubic feet per 1000 Btu/h (4.8 m^3/kW) of the appliance input rating.
     ii. ***G2407.5.2 (304.5.2) Known Air-Infiltration-Rate Method.*** Where the air infiltration rate of a structure is known, the minimum required volume shall be determined per the equations cited in this section.