Scope

Install the highest performing furnace that project funding will allow, to meet the heating load of the project. The highest performance combustion furnaces are sealed-combustion, direct-vent, condensing gas furnaces, with an Annual Fuel Utilization Efficiency (AFUE) exceeding 94%. These furnaces draw combustion air from and release combustion byproducts directly to the outdoors.


Properly size the furnace and blower for the design heating and cooling load of the home, based on the Air Conditioning Contractors of America (ACCA) Manual J heating and cooling load calculations and Manual S sizing guidelines.

If the design load is equal to or lower than the selected furnace’s lowest output rating, consider alternative heating equipment options that better match the design load of the home.

Design an efficient air distribution system with a compact layout in accord with ACCA Manual D. Install ducts properly for maximum airflow and efficiency.

If you are participating in an energy-efficiency program such as ENERGY STAR or DOE Zero Energy Ready Homes, select a furnace that complies with the requirements for your climate zone, as described below. To determine your climate zone, see the International Energy Conservation Code (IECC) climate zone map.

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

Forced air furnaces are the most common heating source in America ([EIA 2013](https://www.eia.gov)). Forced air furnaces are typically fueled by natural gas. Propane and fuel oil are used for new homes in some locations where natural gas is not readily available. Oil furnaces have slightly lower efficiencies than gas furnaces. Electric furnaces are not described here; although they achieve high operating efficiencies, other fuels are typically used at the electric generating plant to produce the electricity and there are transmission losses so they are considered inefficient from an electricity generation and transmission standpoint. In homes with very low loads, electric resistance heaters might be an option.

Forced air furnaces are often configured with an add-on indoor refrigerant cooling coil installed in the air handler on the supply air side of the burner. Some hybrid systems combine a gas furnace with a heat pump for heating and cooling. As ducted and ductless heat pumps with variable refrigerant flow technology reach higher efficiencies over broader temperature ranges and at operating capacities ranging from 25% to 100% to better match low-load conditions, they offer an increasingly plausible alternative to combustion furnaces.

Furnaces are classified in the [International Mechanical Code](https://www.iccsafe.org) and in the [National Fuel Gas Code](https://www.nfpa.org). Understanding the descriptions of these furnace types based on both codes is important with respect to safety and efficiency.

The 2009 (and 2012) International Mechanical Code classifies furnaces based on vent type: direct, mechanical, or atmospheric, as described in the [2009](https://www.iccsafe.org) and [2012 IMC](https://www.iccsafe.org), Chapter 2, Definitions:

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

The [2012 National Fuel Gas Code](https://www.nfpa.org) (NFPA 54) puts furnaces in four categories based on flue vent pressures, flue gas temperatures (relates to condensing or non-condensing), and vent pipe materials, as shown in Table 1.

<table>
<thead>
<tr>
<th>Flue Negative Pressure</th>
<th>Flue Positive Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Non-Condensing</strong></td>
<td></td>
</tr>
<tr>
<td>Category I Vented Appliance</td>
<td>An appliance that operates with a nonpositive vent static pressure and with a vent gas temperature that avoids excessive condensate production in the vent.</td>
</tr>
<tr>
<td>Category III Vented Appliance</td>
<td>An appliance that operates with a positive vent static pressure and with a vent gas temperature that avoids excessive condensate production in the vent.</td>
</tr>
<tr>
<td><strong>Condensing</strong></td>
<td></td>
</tr>
<tr>
<td>Category II Vented Appliance</td>
<td>An appliance that operates with a nonpositive vent static pressure and with a vent gas temperature that can cause excessive condensate production in the vent.</td>
</tr>
<tr>
<td>Category IV Vented Appliance</td>
<td>An appliance that operates with a positive vent static pressure and with a vent gas temperature that can cause excessive condensate production in the vent.</td>
</tr>
</tbody>
</table>

Table 1. The National Fuel Gas Code (NFPA 54) identifies four categories for combustion furnaces and water heaters based on combustion type (sealed or unsealed), vent pipe pressure, and vent pipe temperature.

A **Category I** furnace operates with the flue at negative pressure with respect to the combustion appliance zone (CAZ), i.e., the room in which the furnace is located, and the stack temperature is hot enough to avoid condensation in the vent. The burner draws its combustion air from the CAZ. The combustion chamber is also open to the CAZ; i.e., if you are standing next to the furnace, you can peer in and see the burner and the flames.

Older Category I furnaces use an open draft hood that allows dilution air to enter the vent pipe and mix with the exhaust gases (Figure 1). A draft diverter at the base of the flue protects the flame from downdrafts coming down the chimney or flue. These older furnaces are not mechanically drafted but are called natural draft (or atmospheric draft) because they rely entirely on high flue temperatures (relative to outside temperatures) to draw exhaust gases up and out of the flue. Because so much of the heat goes up the chimney, natural draft furnaces have very low Annual Fuel Utilization Efficiency (AFUE) ratings, usually 70% or less.

A newer type of Category I furnace replaced the draft hood with a small fan, referred to as an induced draft fan, which pulls air through the combustion chamber, although the furnace still relies on flue temperatures to lift the combustion gases up the flue stack (Figure 2). The induced draft fan helps to prevent back drafting on startup and assists in getting the draft started. Once the vent pipe gets up to temperature (140°F+) and a draft is established, the pressure inside the vent pipe becomes negative with
respect to the CAZ. Depending on the model, the induced draft fan may turn off, but will continue to spin due to airflow. Category 1 furnaces that incorporate an induced draft fan typically have cleaner or more complete combustion than their older counterparts and therefore expel less pollutants into the air. The byproducts of an 80%+ furnace are CO2, N, and H2O. Category 1 induced draft furnaces typically have efficiencies of 80% to 86%.

An induced draft fan-equipped furnace is considered a mechanically drafted furnace, according to the IMC. However, because it relies on negative flue pressure to carry away combustion byproducts, it can, like the naturally drafted furnace, have the potential to backdraft. Backdrafting, when combustion gases spill down into the CAZ rather than going out the flue, can occur if the CAZ becomes depressurized with respect to the flue. This could occur if multiple exhaust fans and the dryer or the fireplace are operating at the same time.

Never install a Category I furnace using the CAZ as the return air plenum; duct the return plenum to return registers in other parts of the house. The return air side of the forced air furnace should have no communication with the CAZ at all. The blower in Category I furnaces is meant to move a high volume of air against a relatively high pressure (approximately 0.5 inch water column (IWC) static pressure or 125 Pascals). The pressure in the vent pipe in a gas, forced-air Category I furnace when it is 30°F outdoors is about -4 Pascals (0.016 IWC). Figure 3 shows a poorly configured Category I furnace that has no return ducts, the return is open at the base of furnace and draws in air from the room around it. Because Category I furnaces have an open combustion chamber (the burners are visible in the photo), the big blower fan can easily overcome the small induced-draft fan and back draft the furnace pulling carbon monoxide into the open return on the furnace and distributing it throughout the house via the supply ducts.

**ENERGY STAR for Homes (Version 3, Rev 08)** permits naturally drafted furnaces in IECC climates zones 1 through 3 and **DOE Zero Energy Ready Home program** permits them in climates zones 1 and 2, if they have an AFUE of ≥80%. However, all ≥80% AFUE furnaces available today are induced draft fan equipped or direct vent furnaces. When naturally drafted or induced draft fan equipped furnaces are installed, a combustion safety test must be performed. (See **Direct Vent Equipment** for more on combustion safety testing of combustion heating equipment.)

---

**Figure 1.** A naturally drafted Category I gas furnace with a draft hood. (Image courtesy of Calcs Plus)
Category II applies to some commercial furnaces but no residential furnaces.

A Category III furnace has a vent pipe that is under positive pressure and the furnace is non-condensing, meaning its flue gases only go through one heat exchanger then exit through the vent at temperatures above 140°F. A Category I appliance vents through the wall or roof and is forced draft, meaning it is equipped with a combustion fan that is located before the burner to push air through the combustion chamber and out of the vent. The fan is continually operating when the burner is firing so the vent stack pressure is always positive.

Most Category III furnaces are high-efficiency oil furnaces with gun type burners that force the fuel oil through a nozzle that emits the oil in an atomizing spray that mixes well with air for a more efficient burn (Figure 4). These oil furnaces have an efficiency range of 82% to 88%.

Category III furnaces vent their exhaust gases outside through a sealed pipe so they cannot be back drafted. They are typically installed as sealed combustion/direct vent appliances, meaning they draw their combustion air directly from outside. The pipe for the incoming air may be a separate pipe from the exhaust pipe or it may be the outer circle of a concentric pipe-within-a-pipe where the inner pipe is the exhaust vent. Although it is not recommended, Category III furnaces are sometimes installed as non-
direct vent appliances where the combustion air is drawn from the CAZ and enters the furnace through a port on the combustion chamber, while exhaust gases vent to the outside via the single vent pipe.

**Figure 4.** The Category III oil furnace above is sealed combustion, the vent is under positive pressure, and the vent pipe is at a high temperature. (Image courtesy of Calcs Plus)

**Category IV** furnaces are combustion appliances that have a vent pipe under positive pressure and flue gases under 140ºF. The vent exhaust is so low temperature because all Category IV appliances are equipped with a secondary heat exchanger where heat is further extracted from the combustion air as the water vapor (a byproduct of combustion) cools and condenses to liquid water. This liquid is drained to the outside through a condensate drain. The condensate is highly acidic (pH <3) so local code may require that it be pretreated before disposing to the sewer. Because the combustion gases are directed through a secondary heat exchanger, more heat is extracted, enabling gas-fired Category IV furnaces to achieve efficiencies of >90% AFUE. Category IV oil-fired furnaces can achieve efficiencies of 95% AFUE. Category IV furnaces with two-stage motors for high and low capacity can achieve AFUEs greater than 94%.

Like Category III furnaces, Category IV furnaces are forced-draft, meaning they are equipped with a fan to pull air through the combustion chamber and push the byproducts of combustion out of the furnace through a vent pipe; the vent pipe is sealed so they cannot be back drafted (Figure 5).

Category IV furnaces should be installed as sealed-combustion/direct vent appliances, which means their combustion chamber is sealed off from the CAZ and they draw their combustion air from outside via a second vent pipe that brings combustion air directly to the combustion chamber from outside the home. Because nearly all of the heat in the combustion gases is removed by the two heat exchangers, the vent pipe for Category IV furnaces can be made of PVC (see Figure 6). Manufacturers do not recommend installing Category IV furnaces as non-direct vent furnaces that draw their combustion air from the compliance zone. Always install the second vent pipe to bring combustion air in from outside.

**Figure 5.** This Category IV Furnace is direct vent with a separate vent pipe to bring combustion air directly into the combustion chamber from outside the home. (Image courtesy of Calcs Plus)
Figure 6. In a Category IV furnace, the two heat exchangers pull most of the heat from the combustion gases so PVC is an acceptable vent pipe material. The two pipes are for incoming combustion air and outgoing exhaust gases.

**ENERGY STAR for Homes (Version 3, Rev 08)** requires furnaces in IECC Climate Zones 4 through 8 to be direct vent or mechanically drafted and requires that gas furnaces have an AFUE > 90% and that oil furnaces have an AFUE of > 85% and be ENERGY STAR-certified.

The **DOE Zero Energy Ready Home program** permits > 80% gas furnaces in Climate Zones 1 and 2. In Climate Zones 3 and 4, furnaces must have an AFUE of > 90%. In Climate Zones 5 through 8, gas furnaces must be AFUE > 94%, in other words, a direct-vent, two-stage furnace since these are the only kind that can reach AFUEs > 94%. See the Compliance tab for more details.

**How to Select and Install a Furnace**

1. Choose the highest performing furnace that projects costs will allow, to meet the design heating load of the project. If you are participating in an energy-efficiency program, select a furnace that complies with the requirements for your climate zone, as described in the Compliance tab.

2. Install in accordance with the manufacturers’ instructions and relevant standards including ACCA **Standard 5: HVAC Quality Installation Specification** and the ACCA’s **Technician’s Guide for Quality Installations** and ACCA **Standard 9: HVAC Quality Installation Verification Protocols**.

3. Select a furnace that is properly sized to meet the design heating and cooling load of the home, based on the ACCA **Manual J** heating and cooling load calculations and **Manual S** sizing guidelines. If the design load is equal to or lower than the furnace’s lowest output rating, consider alternative heating equipment options that better match the design load of the home.

4. Design an efficient air distribution system with a compact layout in accord with the ACCA **Manual D**. Install ducts properly for maximum airflow and efficiency in accord with ACCA Manual D. See also the Building America Solution Center guides on **duct installation, insulation, and air sealing**.

5. Install the furnace per the manufacturer’s instructions. A direct-vent installation where combustion air is piped directly to the furnace combustion chamber from outside is preferable. If the furnace must use the CAZ for combustion air, verify that required combustion air is provided in the CAZ and perform a combustion safety test after installation. If a Category I furnace is installed, do not use the CAZ as the return air plenum; duct the return to another room. If the combustion appliance (furnace, boiler, water heater) is a Category I appliance, verify that the minimum amount of combustion and dilution air is provided in the CAZ. For an explanation of how to calculate the combustion air needed for the CAZ, see the guide **Combustion Appliance Zone (CAZ) Testing**.

6. For condensing furnaces, ensure that the condensate drains properly. The condensate line can be routed to an existing sewer or septic system. Ideally, this can be done with a simple gravity line, but many applications will require a condensate pump. Either way, it is important to protect the condensate line from freezing. The condensate is fairly acidic, with a pH of 3 or 4. To ensure that the condensate won’t corrode metallic fittings downstream, some local codes require passing it through a neutralizer containing granular calcium carbonate or a similar material to raise its pH before discharge. Provide a secondary (emergency) drain pan constructed of durable material.
Ensuring Success

Choose a Category IV high-efficiency, sealed-combustion, direct vent system furnace whenever possible.


Size the furnace and ducts as described in ACCA Manual D and Manual S.

For Category I furnaces (not recommended), before installation, calculate the required adequate combustion air for the selected furnace model and verify that the amount is provided in the CAZ.

If the furnace is a Category I furnace, a BPI- or RESNET-certified rater should perform a combustion safety test after installation.

For Category IV furnaces, ensure that the horizontal portion of the exhaust vent pipe slopes slightly toward the furnace. Ensure that the condensate line drains to a sewer or septic tank or as directed by the local jurisdiction. If the condensate drains to the outdoors, insulate the line or wrap it with heat tape to protect it from freezing. Consider pretreating the condensate to reduce its acidity and corrosiveness. Also ensure that a drain pan is installed under the furnace as a backup measure.
Climate

Warm Climates

In warm climates, central forced air systems are typically sized to the cooling load, not the heating load; thus, the furnace may be oversized for the heating load. A significantly oversized combustion furnace may continuously cycle on and off, rather than operating at steady state for long periods. Repeated short cycling is energy inefficient and can rust out the internal parts of the furnace due to the formation of condensation if the furnace repeatedly heats and cools too quickly. In warm climates, stay within ACCA Manual S oversizing limits for gas and oil furnaces. Select a furnace that combines a large blower with a smaller heating capacity. Or consider an alternative heating and cooling option such as ducted or ductless heat pumps.

See the Compliance tab for climate-zone-specific criteria for ENERGY STAR Certified Homes, Version 3/3.1 (Rev. 09) and the DOE Zero Energy Ready Home (Revision 07) program.

To determine your climate zone, see the International Energy Conservation Code (IECC) 2012 climate zone map.
Training

Right and Wrong Images

Display Image: 2019-Amaris-10-Utility Room.jpg
Compliance

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

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

The ENERGY STAR Reference Design Home is the set of efficiency features modeled to determine the ENERGY STAR ERI [energy rating index] Target for each home pursuing certification. Therefore, while the features below are not mandatory, if they are not used then other measures will be needed to achieve the ENERGY STAR ERI Target. In addition, note that the Mandatory Requirements for All Certified Homes, Exhibit 2 [see list below], contain additional requirements such as total duct leakage limits, minimum allowed insulation levels, and minimum allowed fenestration performance. Therefore, EPA recommends that partners review the documents in Exhibit 2 prior to selecting measures.

Please note that the Reference Design Home HVAC efficiencies for Version 3.1 differ from those for Version 3.0. Please see the ENERGY STAR Certified Homes Implementation Timeline for the program version and revision currently applicable in your state.

### Hot Climates (2009 IECC Zones 1,2,3)  
### Mixed and Cold Climates (2009 IECC Zones 4,5,6,7,8)

<table>
<thead>
<tr>
<th>Cooling Equipment (Where Provided)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Cooling equipment modeled at the applicable efficiency levels below:</td>
<td>• 14.5 SEER / 12 EER AC, Heat pump (See Heating Equipment)</td>
</tr>
<tr>
<td>80 AFUE gas furnace, 80 AFUE oil furnace, 80 AFUE boiler, 8.2 HSPF / 14.5 SEER / 12 EER air-source heat pump with electric or dual-fuel backup</td>
<td>13 SEER AC, Heat pump (See Heating Equipment)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Heating Equipment</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Heating equipment modeled at the applicable efficiency levels below, dependent on fuel and system type:</td>
<td>90 AFUE gas furnace, 85 AFUE ENERGY STAR oil furnace, 85 AFUE ENERGY STAR boiler, Heat pump, with efficiency as follows:</td>
</tr>
<tr>
<td>90 AFUE gas furnace, 85 AFUE ENERGY STAR oil furnace, 85 AFUE ENERGY STAR boiler, Heat pump, with efficiency as follows:</td>
<td></td>
</tr>
<tr>
<td>CZ 4: 8.5 HSPF / 14.5 SEER / 12 EER air-source electric or dual-fuel backup</td>
<td>CZ 5: 9.25 HSPF / 14.5 SEER / 12 EER air-source electric or dual-fuel backup</td>
</tr>
<tr>
<td>CZ 6: 9.5 HSPF / 14.5 SEER / 12 EER air-source electric or dual-fuel backup</td>
<td>CZ 7-8: 3.5 COP / 17.1 EER ground-source electric or dual-fuel backup</td>
</tr>
</tbody>
</table>

**Version 3.0 - Exhibit 1: ENERGY STAR Reference Design Home** (Source: ENERGY STAR Certified Homes, Version (Rev. 09))

<table>
<thead>
<tr>
<th>Cooling Equipment (Where Provided)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Cooling equipment modeled at the applicable efficiency levels below:</td>
<td>• 15 SEER / 12 EER AC, Heat pump (See Heating Equipment)</td>
</tr>
<tr>
<td>80 AFUE gas furnace, 80 AFUE oil furnace, 80 AFUE boiler, 8.2 HSPF / 15 SEER / 12 EER air-source heat pump with electric or dual-fuel backup</td>
<td>13 SEER AC, Heat pump (See Heating Equipment)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Heating Equipment</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Heating equipment modeled at the applicable efficiency levels below, dependent on fuel and system type:</td>
<td>95 AFUE ENERGY STAR gas furnace, 85 AFUE ENERGY STAR oil furnace, 90 AFUE ENERGY STAR gas boiler, 86 AFUE ENERGY STAR oil boiler, Heat pump, with efficiency as follows:</td>
</tr>
<tr>
<td>95 AFUE ENERGY STAR gas furnace, 85 AFUE ENERGY STAR oil furnace, 90 AFUE ENERGY STAR gas boiler, 86 AFUE ENERGY STAR oil boiler, Heat pump, with efficiency as follows:</td>
<td></td>
</tr>
<tr>
<td>CZ 4: 8.5 HSPF / 15 SEER / 12 EER air-source electric or dual-fuel backup</td>
<td>CZ 5: 9.25 HSPF / 15 SEER / 12 EER air-source electric or dual-fuel backup</td>
</tr>
<tr>
<td>CZ 6: 9.5 HSPF / 15 SEER / 12 EER air-source electric or dual-fuel backup</td>
<td>CZ 7-8: 3.5 COP / 17.1 EER ground-source electric or dual-fuel backup</td>
</tr>
</tbody>
</table>

**Version 3.1 - Exhibit 1: ENERGY STAR Reference Design Home** (Source: ENERGY STAR Certified Homes, Version (Rev. 09))

Exhibit 2 of the National Program Requirements for ENERGY STAR Certified Homes Version 3/3.1 (Rev. 09) requires that homes complete the following checklists:

<table>
<thead>
<tr>
<th>Party Responsible</th>
<th>Mandatory Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rater</td>
<td>Completion of National Rater Design Review Checklist</td>
</tr>
<tr>
<td></td>
<td>Completion of National Rater Field Checklist</td>
</tr>
<tr>
<td>HVAC System Designer</td>
<td>Completion of National HVAC Design Report</td>
</tr>
<tr>
<td>HVAC Installing Contractor</td>
<td>Completion of National HVAC Commissioning Checklist</td>
</tr>
<tr>
<td>Builder</td>
<td>Completion of National Water Management System Builder Requirements</td>
</tr>
</tbody>
</table>

Exhibit 2: Mandatory Requirements for All Certified Homes Version 3/3.1 (Source: ENERGY STAR Certified Homes, Version (Rev. 09))
National Rater Field Checklist

HVAC System.
10.1 Furnaces, boilers, and water heaters located within the home's pressure boundary are mechanically drafted or direct-vented. Alternatives in Footnote 57.

Footnote 57) Naturally drafted equipment is allowed within the home's pressure boundary in Climate Zones 1-3 if the Rater has followed Section 802 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.

DOE Zero Energy Ready Home (Revision 07)

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

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

Exhibit 2: DOE Zero Energy Ready Home Target Home

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>AFUE</td>
<td>80%</td>
<td>90%</td>
<td>94%</td>
</tr>
<tr>
<td>SEER</td>
<td>18</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>HSPF</td>
<td>8.2</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Geothermal Heat Pump</td>
<td>2.8 cfm/W</td>
<td>ENERGY STAR EER and COP Criteria</td>
<td>1.2 cfm/W; heat exchange with 60% SRE</td>
</tr>
<tr>
<td>ASHRAE 62.2 Whole-House Mechanical Ventilation System</td>
<td>no heat exchange</td>
<td>no heat exchange</td>
<td>heat exchange with 60% SRE</td>
</tr>
</tbody>
</table>

DOE ZERH Target Home HVAC Equipment Requirements *(Source: DOE Zero Energy Ready Home (Revision 07)).*


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.


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.


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

2009 IECC

403.1 Each heating and cooling system should have its own thermostat. If the primary heating system is a forced-air furnace at least one thermostat must be programmable.

403.2 Ducts - Insulate supply ducts in attics to at least R-8 and all other ducts to at least R-6.

Duct tightness shall be verified as described in 403.2.2 Sealing.
403.6 Heating equipment sizing shall be in accordance with Section M1401.2 of the International Residential Code.

2012 IECC

403.1 Each heating and cooling system should have its own thermostat. If the primary heating system is a forced-air furnace at least one thermostat must be programmable.

403.2 Ducts - Insulate supply ducts in attics to at least R-8 and all other ducts to at least R-6. Duct tightness shall be verified as described in 403.2.2 Sealing. The air handler shall have a manufacturer’s designation showing air leakage is no more than 2% of the design air flow rate when tested in accordance with ASHRAE 193.

403.6 Heating equipment sizing shall be in accordance with ACCA Manual S and J.

2015 and 2018 IECC

403.1 Each heating and cooling system should have its own thermostat. If the primary heating system is a forced-air furnace at least one thermostat must be programmable.

Section 403.3.1 Insulation (Prescriptive). Supply and return ducts in attics insulated to at least R-8 if 3 inches in diameter or more or R-6 if less than 3 inches. All other ducts insulated to at least R-6 if 3 inches in diameter or more and R-4.2 if less than 3 inches.

Duct tightness verified as described in R403.3.2 Sealing. The air handler shall have a manufacturer’s designation showing air leakage is no more than 2% of the design air flow rate when tested in accordance with ASHRAE 193.

403.7 Heating equipment sizing shall be in accordance with ACCA Manual S and J.


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.)

ACCA Standards

**ACCA Manual S: Residential Equipment Selection**, ANSI/ACCA 3-Manual S-2004, provides information on how to select and size heating and cooling equipment to meet Manual J loads based on local climate and ambient conditions at the building site. Manual S covers sizing strategies for all types of cooling and heating equipment, as well as comprehensive manufacturers’ performance data on sensible, latent, or heating capacity for various operating conditions.

**ACCA Manual D: Residential Duct Systems**, ANSI/ACCA 1-Manual D-2011, provides ANSI-recognized duct sizing principles and calculations that apply to all duct materials; the system operating point (supply cfm and external static pressure) and airway sizing for single-speed and multi-speed (ECM) blowers; a method for determining the impact of duct friction and fitting pressure drop on blower performance and air delivery; and equivalent length data.


**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.

**RESNET Mortgage Industry National Home Energy Rating Systems Standards**

Procedures and technical standards by which home energy ratings are conducted including home energy audits.

**National Fuel Gas Code (NFPA-54 2015)**

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-54 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.

See the National Fuel Gas Code for additional relevant requirements.
<table>
<thead>
<tr>
<th>Appliance</th>
<th>Type of Venting System</th>
<th>NFPA Section Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Listed Category 1 Appliances</td>
<td>Type B Gas Vent</td>
<td>12.7</td>
</tr>
<tr>
<td>Listed appliances equipped with draft hood</td>
<td>Chimney</td>
<td>12.6</td>
</tr>
<tr>
<td>Appliances listed for use with Type B gas vent</td>
<td>Single-wall metal pipe</td>
<td>12.8</td>
</tr>
<tr>
<td></td>
<td>Listed chimney lining system for gas venting</td>
<td>12.6.1.3</td>
</tr>
<tr>
<td></td>
<td>Special gas vent listed for these appliances</td>
<td>12.5.4</td>
</tr>
<tr>
<td>Category III appliances</td>
<td>As specified or furnished by manufacturers of listed appliances</td>
<td>12.5.2  12.5.4</td>
</tr>
<tr>
<td>Category IV appliances</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Listed combination gas- and oil-burning appliances</td>
<td>Type I vent Chimney</td>
<td>12.7  12.6</td>
</tr>
<tr>
<td>Direct vent appliances</td>
<td></td>
<td>12.3.5</td>
</tr>
</tbody>
</table>

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

   Author(s): PNNL  
   Organization(s): PNNL  
   Publication Date: January, 2011  
   Case study describing a building project in the cold and very-cold climate zones.

2. Technology Solutions Case Study: Combustion Safety for Appliances Using Indoor Air  
   Author(s): NSTAR, PARR  
   Organization(s): NSTAR, PARR  
   Publication Date: May, 2014  
   Case study describing a method for evaluating safe installation and operation of combustion appliances in homes undergoing energy efficiency upgrades where indoor air is used for combustion and venting.

3. Technology Solutions Case Study: Improving the Field Performance of Natural Gas Furnaces  
   Author(s): PARR  
   Organization(s): PARR  
   Publication Date: November, 2013  
   Case study describing field study of gas furnaces, and recommendations for installation.

4. Technology Solutions Case Study: Replacement of Variable-Speed Motors for Furnaces  
   Author(s): CARB  
   Organization(s): CARB  
   Publication Date: February, 2013  
   Case study illustrating how to replace variable speed furnace motors.

References and Resources*

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

2. 2009 International Mechanical Code  
   Author(s): International Code Council  
   Organization(s): ICC  
   Publication Date: January, 2009  
   Code containing 2009 ICC language for mechanical draft systems.

3. 2009 IRC - International Residential Code for One and Two Family Dwellings  
   Author(s): International Code Council  
   Organization(s): ICC  
   Publication Date: January, 2009  
   Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

4. 
2012 IECC - International Energy Conservation Code  
**Author(s):** International Code Council  
**Organization(s):** ICC  
**Publication Date:** January, 2012  
*Code establishing a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems and service water heating systems in homes and commercial businesses.*

5. **2012 International Mechanical Code**  
**Author(s):** International Code Council  
**Organization(s):** ICC  
**Publication Date:** April, 2011  
*Internationally, code officials recognize the need for a modern, up-to-date mechanical code addressing the design and installation of mechanical systems through requirements emphasizing performance. The International Mechanical Code®, in this 2009 edition, is designed to meet these needs through model code regulations that safeguard the...*

6. **2012 IRC - International Residential Code for One and Two Family Dwellings**  
**Author(s):** International Code Council  
**Organization(s):** ICC  
**Publication Date:** January, 2012  
*Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.*

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

8. **2015 International Mechanical Code**  
**Author(s):** International Code Council  
**Organization(s):** ICC  
**Publication Date:** May, 2014  
*Standard addressing the design and installation of mechanical systems through requirements emphasizing performance, public health, and safety.*

9. **2015 IRC - International Residential Code for One and Two Family Dwellings**  
**Author(s):** International Code Council  
**Organization(s):** ICC  
**Publication Date:** May, 2014  
*Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.*

**Author(s):** International Code Council  
**Organization(s):** ICC  
**Publication Date:** November, 2017  
*Code establishing a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems, and service water heating systems in homes and commercial businesses.*

11. **2018 International Mechanical Code**  
**Author(s):** International Code Council  
**Organization(s):** ICC  
**Publication Date:** August, 2017  
*Standard addressing the design and installation of mechanical systems through requirements emphasizing performance, public health, and safety.*

12. **2018 IRC - International Residential Code for One and Two Family Dwellings**  
**Author(s):** International Code Council  
**Organization(s):** ICC  
**Publication Date:** August, 2018  
*Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.*
2018 IRC - International Residential Code for One and Two Family Dwellings
Author(s): International Code Council
Organization(s): ICC
Publication Date: August, 2017

Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

13. ACCA Manual D - Residential Duct Systems
Author(s): Air Conditioning Contractors of America
Organization(s): Air Conditioning Contractors of America
Publication Date: December, 2013

Standard outlining industry procedure for sizing residential duct systems.

14. ACCA Manual J - Residential Load Calculation
Author(s): Air Conditioning Contractors of America
Organization(s): Air Conditioning Contractors of America
Publication Date: January, 2011

Standard covering equipment sizing loads for single-family-detached homes, small multi-unit structures, condominums, town houses and manufactured homes.

15. ACCA Manual S - Residential Equipment Selection
Author(s): Air Conditioning Contractors of America
Organization(s): Air Conditioning Contractors of America
Publication Date: April, 2013

Standard covering sizing strategies for all types of cooling and heating equipment, as well as how to use comprehensive manufacturer’s performance data on sensible, latent, or heating capacity for various operating conditions.

16. ACCA Standard 5: HVAC Quality Installation Specification
Author(s): Air Conditioning Contractors of America
Organization(s): Air Conditioning Contractors of America
Publication Date: January, 2015

Standard providing a universally accepted definition for quality installation for residential and commercial heating, ventilating, and air conditioning applications.

17. ACCA Standard 9: HVAC Quality Installation Verification Protocols
Publication Date: January, 2016

Document detailing the requirements, roles, and obligations for participants in an organized effort, ensuring that HVAC installations comply with the ANSI/ACCA 5 QI – 2010 (HVAC Quality Installation Specification) QI Standard.

Author(s): Gilbride, Baechler, Hefty, Hand, Love
Organization(s): Pacific Northwest National Laboratory, Oak Ridge National Laboratory
Publication Date: August, 2011

Report providing information about energy-efficient heating, ventilation, and cooling (HVAC) equipment options to help homeowners cut their energy use, reduce their carbon footprint, and increase their homes comfort, health, and safety.

19. Controls and Safety Devices for Automatically Fired Boilers
Author(s): American Society of Mechanical Engineers
Organization(s): American Society of Mechanical Engineers
Publication Date: January, 2012

Standard covering requirements for the assembly, installation, maintenance, and operation of controls and safety devices on automatically operated boilers directly fired with gas, oil, gas-oil, or electricity, having fuel input ratings under 12,500,000 Btu/hr.

20. EIA Residential Energy Consumption Survey 2009
Author(s): EIA
Organization(s): EIA
Publication Date: January, 2009

Federal statistics about national energy consumption in residential homes.

21. How to Perform a Heat-Loss Calculation Part I
Author(s): Holladay
Organization(s): Green Building Advisor
Publication Date: April, 2012

Website blog with guidance about calculating heat-loss.
Measure Guideline: Condensing Boilers - Optimizing Efficiency and Response Time During Setback Operation
Author(s): Arena
Organization(s): CARB, Steven Winter Associates, SWA
Publication Date: February, 2014
Report providing step-by-step instructions for heating contractors and hydronic designers for selecting the proper control settings to maximize system performance and improve response time when using a thermostat setback.

23. Mortgage Industry National Home Energy Rating Systems Standards
Author(s): RESNET
Organization(s): RESNET
Publication Date: January, 2013
RESNET standards aimed to ensure that accurate and consistent home energy ratings are performed by accredited home energy rating providers through their raters nationwide.

Author(s): National Fire Protection Association
Organization(s): National Fire Protection Association
Publication Date: January, 2018
Code outlining minimum safety requirements for the design and installation of fuel gas piping systems in homes and other buildings.

Author(s): Air Conditioning Contractors of America
Organization(s): ACCA
Publication Date: January, 2010
The Technician’s Guide equips practitioners with the knowledge to properly implement all of the measurement procedures required in the HVAC QI Specification.

*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.

Calcs-Plus
Pacific Northwest National Laboratory
Home Innovation Research Labs, a DOE Building America Research Team