**Oil-Fired Boilers**

**Last Updated:** 07/31/2017

**Scope**

Choose the highest performing boiler that project funding will allow to meet the design heating load of the project. The highest performance boilers are sealed-combustion, direct vent boilers, which have efficiencies exceeding 95% AFUE. These are also the safest boilers to install within a home because they draw combustion air from and release combustion byproducts directly to the outdoors.

Calculate the heating load for the home and properly size the boiler and distribution system to meet this load. Look at the boiler’s output rating and if the design load is equal to or lower than the equipment’s lowest output rating, consider alternative heating equipment options that better match the design load of the home.

Select a boiler with a modulating burner for increased efficiency.


Set equipment control setting to optimize system efficiency. See the Building America report [Condensing Boilers – Control Strategies for Optimizing Performance](https://www.buildingamerica.gov) for guidance (Arena 2012).

For condensing boilers, install an outdoor reset control to match system output to actual load and recommend that homeowners not use a night-time temperature setback strategy. Select settings for the boiler reset curve and flow rates to optimize the performance of the system and to ensure that the return temperatures are low enough to promote condensing ([Arena 2012](https://www.buildingamerica.gov)).

Design an efficient zoned distribution system with a compact piping layout, insulated pipes, and correctly sized equipment for the radiators, baseboards, convectors, or radiant floor loop system. For hydro coil forced-air heating systems, design a compact duct layout following ACCA’s [Manual D](https://www.acca.org) duct sizing guidelines and install ducts properly in accordance with ACCA Manual D for maximum airflow and efficiency.

If you are participating in an energy-efficiency program, select a boiler whose efficiency complies with the requirements for your climate zone, as described in the Compliance tab.

To determine your climate zone, see the International Energy Conservation Code (IECC) climate zone map on the Climate tab.

See the [Compliance Tab](https://www.acca.org) 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

According to the U.S. Energy Information Administration (EIA), up to 11% of existing households use some form of hot water or steam heat. Boilers produce hot water that can be used to heat homes through several different distribution methods. The hot water can be sent through plastic pipe loops in the floor for radiant floor heat or through a metal radiator mounted along the wall or a baseboard radiator mounted near the floor. Hot water can also be directed from a combustion tank water heater to a coil in an air handler equipped with a fan to blow air across the coil and through supply air ducts to the home. Most combustion boilers are fueled by natural gas - see Gas-Fired Boilers. Fuel oil, propane, and wood are other fuel sources used in locations where natural gas is not readily available. The hot water for a boiler may be heated or preheated by a solar thermal water heating system, a ground-source (geothermal) heat pump, or an air-source heat pump. The boiler may heat water in a tank or it may be a tankless (or instantaneous) wall-hung model. Some boilers provide heat for a potable hot water tank in addition to providing hot water to room heaters, referred to as indirect water heating. Some newer, very efficient models combine space heating, water heating, and heat recovery ventilation.

For best performance, the heating system should be properly sized to match the heating design load of the home, as described below. If the home is constructed with high levels of insulation and air sealing, a smaller heating system can often be installed. When equipment is oversized, it can “short cycle” or turn on and off repeatedly before the demand is met, which can have negative impacts on energy use, comfort, and equipment durability.

The International Mechanical Code classifies boilers based on vent type - direct, mechanical, or atmospheric. The National Fuel Gas Code puts vented combustion appliances (furnaces and boilers) in four categories based on flue vent pressures, flue gas temperatures, and vent pipe materials. (See Gas Boilers for a more complete description of these categories.) Residential oil-fired boilers fall in either Category III or Category IV.

A Category III combustion appliance has a vent pipe that is under positive pressure and the appliance is non-condensing, meaning its flue gases only go through one heat exchanger then exit through the vent at temperatures above 140°F. Oil-fired boilers are typically Category III appliances (Figure 1). They vent through the wall or through the roof.

Category III and Category IV oil-fired boilers are both forced draft (also referred to as power vented) appliances meaning that they are 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.

Category IV boilers, like Category III boilers, vent their combustion exhaust gases outdoors through a sealed pipe so they cannot be back drafted. Category III and IV appliances should be installed as sealed-combustion/direct vent appliances, which means their combustion chamber is sealed off from the combustion appliance zone (CAZ), which is the room where the equipment is located, and they draw their combustion air from outside via a second vent pipe or concentric pipes that bring combustion air directly to the combustion chamber from outside. However, although manufacturers do not recommend it, they are sometimes installed as non-direct-vent appliances (where the exhaust pipe is installed but the pipe for incoming air is not installed) so the boiler draws its combustion air from the CAZ.

Many manufacturers of Category III boilers offer a direct vent kit that includes a second pipe to bring the outside air directly to the combustion chamber (see Figure 2). Because the flue gases for a Category III boiler are above 140°F, the pipes are made of metal. Category III oil-fired boilers can achieve efficiencies of about 80% to 90% AFUE.

An important difference between Category III and Category IV boilers is that Category IV boilers are condensing boilers that have a second heat exchanger (or sometimes one extra-large heat exchanger), which allows the combustion gases to cool and condense, releasing more heat in the boiler rather than sending it up the flue as water vapor (see Condensing Boilers). Because the flue gases are cooler (<140°F), they can be vented through the wall or roof by means of a PVC pipe rather than a chimney. Efficiencies for Category IV oil-fired boilers range from 90% to 93%.

The design of the piping distribution system can reduce energy usage and improve comfort because they allow for zoning. In general, distribution systems such as parallel or primary-secondary piping arrangements perform better than the simpler series piping where all heat emitters are connected to a single pipe loop. For more information on distribution, see Gas-Fired Boilers.

Boiler Controls

While older boilers are either on or off, newer boilers with multi-stage or modulating burners have adjustable output to better match heating loads. This reduces the number of on-off cycles (and cycling losses) and allows the boiler to operate for longer hours at lower firing rates, which improves efficiency. Non-modulating boilers have efficiencies of 85% to 90%. Boilers that operate in modulation mode rather than just on-off can improve average boiler efficiency by up to 8%. Higher-efficiency models are also equipped with electronic controllers that can increase equipment life, improve boiler efficiency, and enhance comfort, by adjusting boiler water temperature, creating time-delay relays, performing automatic post-purge, preventing warm-weather boiler operation, controlling the position of mixing valves, and controlling pump speeds. These controls can increase the efficiency of noncondensing boilers by 10% or more and reduce idle losses to 0.3%. Condensing gas boilers that are fully modulating and have advanced controls can achieve efficiencies ranging from 92% to 96%.

There are many settings that can be adjusted on a modern boiler to improve the efficiency and comfort performance of the equipment. These adjustments may provide better performance than the default factory settings.

An outdoor reset control, which matches the system output to the actual outdoor temperature conditions, will improve comfort for owners of both condensing and non-condensing equipment by preventing extreme spikes in indoor temperature when the outdoor temperatures are warmer than design conditions. If you install an outdoor reset, recommend that homeowners do not use a night-time temperature setback strategy unless special controls have been installed that can override the reset control.
Locate the outdoor sensor where it will not be exposed to a heat source such as direct sunlight or a dryer exhaust vent.

When installing an outdoor reset control with a noncondensing boiler, choose settings so that the return temperature to the boiler is no lower than 140°F to prevent condensing. However, when selecting the outdoor reset curve set points for a condensing boiler, choose settings so that the temperature of the water returning to the boiler is below 130°F. This ensures that the return temperatures are low enough to promote condensing, which will greatly increase the energy efficiency of the system (see Arena 2012 for more details). To ensure the return temperature is below 130°F, the supply temperature will likely have to be reduced to below the factory setting. Make sure the heat emitters used (baseboards, radiators, etc.) are properly sized based on the average temperature in the distribution loop. If undersized, they won’t release enough heat to the space and the water will return to the boiler at too high a temperature, preventing condensing. Radiant floor systems are typically set up to run at lower temperatures when installed, so they do not require additional adjustment to the boiler’s supply temperature.

If you are specifying toe kick heaters in homes that have condensing boilers with outdoor reset controls, make sure the toe kick model specified is capable of operating at low temperatures. Many of the toe kick heaters currently available will not operate below a supply temperature of 140°F. A properly designed and configured condensing hydronic system will have return temperatures below 130°F most of the year, leaving the occupants without heat in rooms with toe kick heaters.

In highly insulated, energy-efficient homes with correctly sized equipment, nighttime setback can cause comfort issues and customer complaints. A boiler that is correctly sized to meet the home’s design heating load will not have enough capacity to recover from the setback in a reasonable amount of time, especially if the system is designed with an outdoor reset control. Outdoor reset controls match the boiler’s supply temperature to the heating load based on the current outdoor conditions, severely hindering the system’s ability to raise the temperature in the space. If the boiler was set up with an outdoor reset control and no capability to override it, advise homeowners not to set their thermostat temperature back during nighttime hours. This is also recommended if the home is highly energy efficient and the boiler was sized to meet the design heating load.

If you know that the homeowner will employ a setback strategy or if you would like to provide that capability, you can install controls to speed up temperature recovery such as 1) a boost control that automatically raises the boiler output target temperature if heating demand is not satisfied within a set number of minutes, 2) an indoor sensor that works with the outdoor reset control to compensate for lags in response based on interior temperature, or 3) a simple manual override switch. Oversizing the heat emitters and possibly the boiler may be necessary to meet the additional load induced during periods of setback recovery.

If the boiler is oversized compared to the design load, oversizing the heat emitters will help reduce short cycling of the boiler. This may be the only option in situations where the smallest boilers are too large for the design load or there are several zones, each of which has very small loads compared to the boiler’s capacity. In these cases, oversizing the emitters will reduce cycling, improve response time, and increase efficiency. Note that many manufacturers set a maximum temperature difference between the boiler’s supply and return to protect the heat exchanger. Oversizing the heat emitter will result in an increase in the delta T, so make sure that you do not oversize to the point that the manufacturer’s limit is exceeded. If installing a non-condensing boiler, make sure that increasing the emitter does not result in return water temperatures below 140°F.

For both condensing and noncondensing boilers, a warm weather shutoff turns off the boiler when the temperature setting is exceeded by the outdoor temperature. Boilers commonly come from the factory with the shutoff set between 68°F and 72°F. In locations with large day-night temperature swings or in spring and fall in homes that use a setback, if the shutoff is set too low, warm midmorning outside temperatures could prevent the heat from coming on even if it is still cold inside. Make sure the warm weather shutoff setting is no lower than the desired indoor winter temperature. For example, if 70°F is the normal setting, the warm weather shutoff should be no lower than 70°F.

Make sure your system includes an automatic post-purge control, which keeps the system pump on for several minutes after the boiler stops firing to disperse the heat still residing in the mass of the boiler.

Some boiler manufacturers have started offering controls that can limit the boiler’s maximum input. This can be especially useful if the boiler is used for both space heating and domestic hot water and one load is significantly less than the other. This limit reduces cycling in situations where the boiler’s maximum firing rate is significantly higher than the demand, for example when the water heater is calling for heat but the space heater is not.

Heat dumping is a strategy that diverts excess boiler heat to the domestic hot water (DHW) tank after the space heating demand is satisfied. Studies have shown this technique can greatly improve overall system efficiency (Butcher 2011).

See the Building America report Condensing Boilers – Control Strategies for Optimizing Performance for additional guidance on setting boiler controls.
How to Select and Install a Boiler

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


3. Design an efficient distribution system that allows for zoning.

4. Properly size the boiler by first calculating the heating load of the home. Calculate heat load as described in the ASHRAE Fundamentals Handbook. Many software products are also available that can guide you through the calculations, and several boiler manufacturers include sizing guidelines or software on their web sites. If the design load is equal to or lower than the selected boiler’s lowest output rating, consider alternative low-load heating equipment options that better match the design load of the home.

5. Install the boiler as a direct-vent installation where combustion air is piped directly to the boiler combustion chamber from outside. If the boiler 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. See methods for calculating and providing combustion air in the guide Combustion Furnaces.

6. Select appropriate vent piping in accordance with the National Fuel Gas Code (see the Compliance tab).
7. Set the equipment control settings to optimize system efficiency as described above and in Arena 2012.

8. If your boiler heats a hydro coil for forced air heating, see Compact Air Distribution and Proper Sizing of HVAC Ducts.

9. After the boiler is installed and before the initial filling, fill the system with water plus a cleaning solution. Allow this to circulate for several hours to remove grease, oil, and chemicals from solder and flux. Drain then fill with clean water. If the city water is corrosive, include an initial treatment. If properly installed, the boiler should operate indefinitely without needing additional water or cleaning.

10. For condensing boilers, ensure that condensate drains properly to the sewer or directly outdoors. Because the condensate is highly acidic, follow local code requirements regarding pretreatment of condensate before disposing to the sewer. Protect the condensate line from freezing. Provide a secondary (emergency) drain pan constructed of durable material.

11. Verify correct boiler operation by testing the outdoor reset control, and evaluating the boost control if one is installed.
Ensuring Success

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

Verify that the boiler is not oversized for the home’s heating load.

For Category IV boilers, ensure that the horizontal portion of the exhaust vent pipe slopes slightly toward the boiler. Ensure that the condensate line drains to a sewer or outdoors. If condensate is drained to outdoors then protect the drain from freezing by either insulation or heat tape. Also ensure that a drain pan is installed under the boiler as a backup measure.

After installation, inspect to verify the following in accord with 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. These standards address quality installation and commissioning requirements for vapor compression cooling systems, heat pumps, and combustion and hydronic heating systems.

- Verify that any baseboard emitters installed are large enough to deliver the capacity needed.
- Ensure a minimum of a 20°F temperature differential between the supply and return temperatures under design conditions.
- Ensure that the temperature setting on the boiler reset curve is below the boiler’s high limit setting.
- Verify that the warm weather shutoff is high enough to prevent no-heat situations during the swing seasons.
- Verify that the outdoor reset sensor has been placed away from any exhaust vents including kitchen, bath, dryer, and mechanical system vents and that it will not be in direct sunlight during any portion of the day.
Climate

**ENERGY STAR Certified Homes** (Version 3, Rev 08) makes mandatory direct vent or mechanically drafted combustion appliances in all climate zones except IECC Climate Zones 1 through 3 where naturally drafted appliances are allowed. Where naturally drafted appliances are allowed, a combustion safety test must be performed. ENERGY STAR allows gas and oil furnaces and boilers to be ≥ 80% AFUE in Climate Zones 1, 2, and 3. In Climate Zones 4-8, ENERGY STAR requires that gas furnaces be ≥ 90% AFUE, oil furnaces be ≥ 85% and ENERGY STAR labeled, and boilers be ≥ 85% and ENERGY STAR labeled.

The **DOE Zero Energy Ready Home National Program Requirements** allows ≥ 80% furnaces and boilers in Climate Zones 1 and 2 only. In Climate Zones 3 and 4 (except marine climate zone 4), furnaces and boilers must have an AFUE of ≥ 90% and in Climate Zones 5 through 8 (plus marine climate zone 4), furnaces and boilers must have an AFUE ≥ 94%.

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

---

IECC Climate Zone Map

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

Warm-Humid below white line

Marine (C) Dry (B) Moist (A)
Training

Right and Wrong Images
None Available
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.


Comply with all relevant sections of the applicable International Residential Code, including pertinent sections of Chapter 13: General Mechanical System Requirements, Chapter 14: Heating and Cooling Equipment, Chapter 20 Boilers and Water Heaters, Chapter 21 Hydronic Piping, Chapter 22 Special Piping and Storage Systems, and Chapter 24 Fuel Gas.


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.

2009 IECC

403.1 Each heating and cooling system should have its own thermostat.

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.

403.3 Mechanical system piping capable of carrying fluids >105°F or < 55°F must be insulated to at least R-3.

403.6 Heating equipment sizing shall be in accordance with Section M1401.2 of the International Residential Code.

2012 IECC

R403.1 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.

R403.2 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.

R403.3 Mechanical system piping capable of carrying fluids >105°F or < 55°F must be insulated to at least R-3. Piping insulation exposed to weather must be protected from damage cause by sunlight, moisture, equipment, and wind. The protection cannot be provided by adhesive tape.

R403.6 Heating and cooling equipment shall be sized in accordance with ACCA Manual S based on building loads calculated in accordance with ACCA Manual J or other approved heating and cooling calculation methods.

2015 and 2018 IECC

R403.1 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.

R403.2 Hot water boilers that supply heat to the building through one- or two-pipe heating systems shall have an outdoor setback control that lowers teh boiler water temperature based on teh outdoor temperature.

R403.3 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 403.3.2 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.

R403.4 Mechanical system piping capable of carrying fluids >105°F or < 55°F must be insulated to at least R-3. Piping insulation exposed to weather must be protected from damage cause by sunlight, moisture, equipment, and wind. The protection cannot be provided by adhesive tape.

R403.7 Heating and cooling equipment shall be sized in accordance with ACCA Manual S based on building loads calculated in accordance with ACCA Manual J or other approved heating and cooling calculation methods.


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.


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>
<thead>
<tr>
<th>Appliance</th>
<th>Type of Venting System</th>
<th>NFPA Section Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Listed Category I 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>Listed chimney lining system for gas venting</td>
<td></td>
<td>12.6.1.3</td>
</tr>
<tr>
<td>Special gas vent listed for these appliances</td>
<td></td>
<td>12.5.4</td>
</tr>
<tr>
<td>Category III appliances Category IV appliances</td>
<td>As specified or furnished by manufacturers of listed appliances</td>
<td>12.5.2 12.5.4</td>
</tr>
<tr>
<td>Listed combination gas- and oil-burning appliances</td>
<td>Type L 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.

See the National Fuel Gas Code for additional relevant requirements.

RESNET Mortgage Industry National Home Energy Rating Systems Standards

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

U.S. Department of Energy Zero Energy Ready Home
The U.S. Department of Energy’s Zero Energy Ready Home National Program Requirements 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, 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>HVAC Equipment</th>
<th>Hot Climates (2012 IECC Zones 1,2,3)</th>
<th>Mixed Climates (2012 IECC Zones 3, 4 except Marine)</th>
<th>Cold Climates (2012 IECC Zones 4 Marine 5,6,7,8)</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>16</td>
<td>13</td>
</tr>
<tr>
<td>HSPF</td>
<td>8.2</td>
<td>9</td>
<td>10d2</td>
</tr>
<tr>
<td>Geothermal Heat Pump</td>
<td>1.4 cfm/W; no heat exchange</td>
<td>1.4 cfm/W; no heat exchange</td>
<td>1.2 cfm/W; heat exchange with 60% GBE</td>
</tr>
<tr>
<td>Mechanical Ventilation System</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Exhibit 1: ENERGY STAR Reference Design Home**

**Exhibit 2: Mandatory Requirements for All Certified Homes**

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

When sizing the furnace, the listed output heating capacity should be between 100% and 140% of the design total heat loss or the next larger nominal size if a larger size is dictated by the cooling system selection.


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.

(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...
Oil-Fired Boilers - Code Compliance Brief

Overview:

The intent of this brief is to provide code-related information about oil-fired boilers 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 reviews and conduct field inspections can help builders or remodelers design installations and prepare construction documents, and provide jurisdictional officials with information for reviews, inspection and 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.

A boiler typically uses a fuel such as natural gas, propane, or fuel oil in a vented combustion chamber, much like a furnace. Whereas a furnace directly transfers heat from combustion to supply air in the air distribution unit, a boiler heats a secondary transfer fluid (typically water, but sometimes steam) that is, in turn, pumped through a radiation/convection system located throughout a building or home. The hot water can also be used to heat air via a coil and blower. Boilers are more commonly used in commercial construction than residential construction, but they may be more prevalent in residential construction in some areas of the country in older homes. Boilers are typically between 75% and 90% efficient in the primary process of heating the water, but any un-insulated hot water piping through unconditioned spaces will lower the overall efficiency of space heating.¹

In addition to the boiler unit, an oil-fired boiler requires a feed water supply, a boiler loop/heat delivery system (e.g., hydronic radiators), fuel storage, fuel supply equipment, and a temperature control system. The chapters of the International Residential Code (IRC) that are likely relevant to the installation of an oil-fired boiler include Chapter 13, General Mechanical System Requirements; Chapter 14, Heating and Cooling Equipment; Chapter 20, Boilers and Water Heaters; Chapter 21, Hydronic Piping; Chapter 22, Special Piping and Storage Systems; and Chapter 24, Fuel Gas.

The relevant energy-efficiency sections of the International Energy Conservation Code (IECC) and IRC (Chapter 11, Energy Efficiency) that relate to oil-fired boilers include Section R403, Systems (IECC) and N1103, Systems (IRC). For existing buildings, new heating and cooling systems that are part of a remodel or alteration, replacement, or repair must comply with Section R403 (IECC)/N1103 (IRC). The IECC/IRC requirements related to boilers for versions 2009, 2012, and 2015 have mostly remained the same except for the addition of an outdoor setback control requirement on hot water boilers that controls the water temperature based on the outdoor temperature. This specific requirement, which was added in the 2015 version of the codes, is detailed below under the Plan Review and Field Inspection sections.

The focus of this brief is on boiler efficiency, sizing requirements, controls, combustion air, and pipe insulation for the 2015 version of the IRC/IECC.


Plan Review:

Per the 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 requirements for "oil-fired boilers."

Construction Documentation. Review the construction documents to identify the equipment, system controls, design, and ventilation choices to the equipment

- 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 system equipment types, sizes and efficiencies
  - Equipment and system controls
  - Duct sealing, duct and pipe insulation and location
  - Air sealing details
  - Flashing and moisture control


2015 IRC requirements for oil-fired boiler installations are found throughout Chapter 13, General Mechanical System Requirements; Chapter 14, Heating and Cooling Equipment; Chapter 20, Boilers and Water Heaters; Chapter 21, Hydronic Piping; Chapter 22, Special Piping and Storage Systems; and Chapter 24, Fuel Gas. This section lists the applicable IRC and IECC code sections.

- **General Installation Provisions.** Review the construction documents for equipment installation.

  — **2015 IRC, Section M14101, M2001 General.** Oil-fired Boilers should be listed and labeled in accordance with UL 2726 and should be installed:

  1. In accordance with the manufacturer’s instructions M2001.1
  2. On level platforms in accordance with Section M1305.1.4.1
  3. With proper clearances as specified per boiler’s listing and label M2001.2
  4. With shutoff valves in the supply and return piping per Section M2001.3
  5. With operating and safety controls in accordance with Section M2002
  6. So openings in exterior walls are flashed in accordance with Section R703.4
  7. To protect the potable water supply in accordance with section P2902
  8. So air intake openings are located are in accordance with section R303.5.1
  9. With circuit breakers that are sized in accordance with equipment data plate per manufacturer’s installation instructions and electrical connections that conform to requirements of Section G2410 of the IRC
  10. With expansion tanks that have been specified to meet minimum capacity requirements per Section M2003.1 and, M2003.2. Minimum requirements (as listed in Table M2003.2) are specified below:

<table>
<thead>
<tr>
<th>System Volume (gallons)</th>
<th>Pressurized Diaphragm Type</th>
<th>Nonpressurized Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>20</td>
<td>1.5</td>
<td>3.0</td>
</tr>
<tr>
<td>30</td>
<td>2.3</td>
<td>5.5</td>
</tr>
<tr>
<td>40</td>
<td>3.0</td>
<td>8.5</td>
</tr>
<tr>
<td>50</td>
<td>4.0</td>
<td>10.5</td>
</tr>
<tr>
<td>60</td>
<td>5.0</td>
<td>13.0</td>
</tr>
<tr>
<td>70</td>
<td>6.0</td>
<td>15.5</td>
</tr>
<tr>
<td>80</td>
<td>7.5</td>
<td>18.5</td>
</tr>
<tr>
<td>90</td>
<td>8.0</td>
<td>21.0</td>
</tr>
<tr>
<td>100</td>
<td>8.0</td>
<td>24.0</td>
</tr>
</tbody>
</table>

- **Mounting.** Verify equipment is correctly supported and installed in the structure.

  — **2015 IRC, Section M1305.1.4.1 Ground Clearance.** Equipment and applications supported from the ground should be level and firmly supported on a concrete slab or other approved material extending not less than 3 inches (76 millimeters) above the adjoining ground. Such support should be in accordance with the manufacturer’s installation instructions. Appliances suspended over the floor should have a clearance of not less than 6 inches (152 millimeters) from the ground.

- **2015 IRC, Section M1307.3 Elevation of ignition source.** Installations within a garage should have ignition source raised 18 inches from the floor, and the boiler should be protected from impact (IRC M1307.3)

- **Equipment Controls.** Review the construction documents and confirm that controls have been installed in accordance with manufacturer installation instructions, which should include control diagrams and operating instructions.

  — **2015 IECC/IRC, Section R403.1/N1103.1.** Each heating and cooling system should have its own thermostat. Each thermostat controlling the primary heating and cooling system should be a programmable thermostat.

  - **Hot water boilers that supply heat to the building through one- or two-pipe heating systems should have an outdoor reset control that lowers the boiler water temperature based on the outdoor temperature per R403.2/N1103.2.**

- **Equipment Sizing.** Verify that the boiler is sized based on building loads calculated in accordance with ACCA Manual J or other approved methods (IRC M1401.3, IECC R403.6 (2009, 2012) and IECC 403.6/R403.7.

  — **2015 IECC/IRC, Section R403.7/N1103.7.** Heating and cooling equipment shall be sized in accordance with ACCA Manual S based on building loads calculated in accordance with ACCA Manual J or other approved heating and cooling calculation methods.
Ventilation. Oil-fired boilers should be provided with combustion air in accordance with NFPA31\(^3\) and combustion air openings shall be located at or above the elevation required in IRC Section R322.2.1 per \textit{2015 IRC M1701}. Boilers can be vented with a conventional chimney system or through a balanced flue system for direct venting through the wall. Review the construction documents and verify that the ventilation system has been installed in accordance with manufacturer installation instructions.

— **2015 IRC, Section M1801 General.** Fuel-burning appliances shall be vented to the outdoors in accordance with their listing and label and manufacturer's installation instructions. Venting systems shall consist of approved chimneys or vents, or venting assemblies that are integral parts of labeled appliances.

— **2015 IRC, Section M1803.2 Chimney and Vent Connectors for oil and solid fuel appliances.** Connectors shall be constructed of factory-built chimney material, Type L vent material or single-wall metal pipe having resistance to corrosion and heat and thickness not less than that of galvanized steel as specified in Table M1803.2 of the IRC as shown below:

<table>
<thead>
<tr>
<th>Diameter of Connector (inches)</th>
<th>Galvanized Sheet Metal Gage Number</th>
<th>Minimum Thickness (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 6</td>
<td>26</td>
<td>0.019</td>
</tr>
<tr>
<td>Over 6</td>
<td>24</td>
<td>0.024</td>
</tr>
</tbody>
</table>

— **2015 IRC, Section M1803.3 Clearance.** Vent connectors must be provided clearance from combustibles per IRC M1803.3.4 (see below table) or any reduced clearance acceptable to NFPA 31.

<table>
<thead>
<tr>
<th>Type of Connector</th>
<th>Minimum Clearance (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-wall metal pipe connectors:</td>
<td></td>
</tr>
<tr>
<td>Oil and solid-fuel appliances</td>
<td>17</td>
</tr>
<tr>
<td>Oil appliances listed for use with Type L vents</td>
<td>9</td>
</tr>
<tr>
<td>Type L vent piping connectors:</td>
<td></td>
</tr>
<tr>
<td>Oil and solid-fuel appliances</td>
<td>9</td>
</tr>
<tr>
<td>Oil appliances listed for use with Type L vents</td>
<td>3</td>
</tr>
</tbody>
</table>

— **Conventional Chimney Venting**

2015 IRC, Section M1801.2 Draft requirements. A venting system should satisfy the draft requirements of the appliance in accordance with the manufacturer's installation instructions, and should be constructed and installed to develop a positive flow to convey combustion products to the outside atmosphere. When venting an oil-fired appliance to a masonry chimney, the resizing should be done in accordance with NFPA 31.

— **Direct Venting**

2015 IRC, Section G2427.8 Venting system termination location. The location of the venting system shall satisfy the requirements of IRC G2427.8 with specified distances from forced air inlets, windows, doors, gravity inlets, based on size of equipment, listed in G2427.8 and diagramed in Appendix C of the IRC.

2015 IRC, Section G2427.9 Condensation drainage. Condensate drainage system should be installed to collect and dispose of condensate from venting system.

— **Storage and Supply**

2015 IRC, Section M2201 Oil Tanks. Supply tanks should be listed and labeled, and should conform to storage requirements per Section M2201.

2015 IRC, Section M2204 Oil Pumps and Valves. Oil pumps and valves should be listed and labeled in accordance and comply with UL 343\(^5\) and UL 843,\(^6\) respectively. Oil pumps should be positive displacement types that automatically shut off the oil supply when stopped, and the pressure at the oil supply inlet should not be greater than 3 pounds per square inch (IRC M2204.2, IRC M2204.3).
Hydronic Piping and Distribution systems. Review the construction documents and confirm the specified sizes, capacities, and R-value of insulation.

— *2015 IRC, Section M2101*. Hydronic piping should be installed per IRC M1308 and IRC M2101, and materials should conform to Table M2101.1 of the IRC. Pipe and fittings should be rated for use at the operating temperature and pressure of the hydronic system. Piping Supports should be of material and strength adequate to support the piping and should be supported at intervals not exceeding the spacing specified in Table M2101.9 of the IRC (see table below).

<table>
<thead>
<tr>
<th>Piping Material</th>
<th>Maximum Horizontal Spacing (ft)</th>
<th>Maximum Vertical Spacing (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABS</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>CPVC (1-inch or less)</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>CPVC (1 ¼ inch)</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Copper or copper alloy pipe</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>Copper or copper alloy tubing</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>PB pipe or tubing</td>
<td>2.67</td>
<td>4</td>
</tr>
<tr>
<td>PEX tubing</td>
<td>2.67</td>
<td>4</td>
</tr>
<tr>
<td>PEX tubing</td>
<td>2.67</td>
<td>4</td>
</tr>
<tr>
<td>PP more than 1 ¼ inches</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>PVC</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Steel pipe</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>Steel tubing</td>
<td>8</td>
<td>10</td>
</tr>
</tbody>
</table>

— *2015 IRC, Section M2103* Floor Heating System. Radiant floor heating systems shall have a thermal barrier in accordance with Section M2103. Slab-on-grade installations should be insulated to a minimum of R-value of 5. Suspended floor installations should be insulated to a minimum of R-value of 11.

— *2015 IECC/IRC, Section R403.4/N1103.4*. Mechanical system piping capable of carrying fluids >105°F or <55°F must be insulated to at least R-3. Piping insulation exposed to weather must be protected from damage caused by sunlight, moisture, equipment, and wind. The protection cannot be provided by adhesive tape.

Flash/Moisture Control. Verify that the design and specifications of the weather-resistant covering, water-resistant barrier, flashing, and drainage are specified on the construction documents and meet applicable codes.

— *2015 IRC, Section R303.6* Outside Opening Protection. Air exhaust and intake openings that terminate outdoors should be protected with corrosion-resistant screens, louvers, or grills having a minimum opening size of ¼ inch (6 millimeters) and a maximum opening size of ½ inch (13 millimeters), in any direction. Openings should be protected against local weather conditions. Outdoor air exhaust and intake openings should meet the provisions for exterior wall opening protection in accordance with this code.

— *2015 IRC, Section R703.4* Flashing. Approved corrosion-resistant flashing should be applied shingle-fashion to prevent water from entering into wall cavities or from penetrating into building structural framing components. Self-adhered flashing must comply with AAMA® 711. Fluid-applied membranes used as flashing in exterior walls should comply with AAMA 714. The flashing should extend to the surface of the exterior wall finish or to the water-resistant barrier. For this code, approved corrosion-resistant flashings should be installed at all wall and roof intersections.

Potable Water System Protection. Verify that potable water connections to the equipment are correct.

— *2015 IRC, Section P2902.1 General*. A potable water supply system should be designed and installed as to prevent contamination from non-potable liquids, solids, or gases being introduced into the potable water supply. Connections should not be made to a potable water supply in a manner that could contaminate the water supply or provide cross-connection between the supply and a source of contamination except where approved methods are installed to protect the potable water supply. Cross-connections between an individual water supply and a potable public water supply should be prohibited.

Mechanical System Ducts. If ducts are employed as part of the installation, review the construction documents and confirm the specified R-value of insulation for air ducts.

Insulation.

— *2015 IECC/IRC, Section R403.3.1/N1103.3.1 Insulation*.
  - Supply and return ducts installed in attics should be insulated to R-8 if ducts are 3 inches in diameter or to R-6 if ducts are <3 inches in diameter.
  - Supply and return ducts installed in other portions of the building should be insulated to R-6 if ducts are 3 inches in diameter R-4.2 if ducts are <3 inches in diameter.

Exception: Ducts or portions thereof located completely inside the building thermal envelope.
Duct Leakage/Air Sealing. Review the construction documents and confirm that the appropriate level of duct sealing is used based on the code to be applied. Be aware that current codes require duct tightness beyond just mechanical sealing of joints and that leakage be verified via field testing, and supporting documentation be provided to the code official. The code official should consider transmitting the jurisdictional requirements during the plan review phase.

— 2015 IECC/IRC, Section R403.3.2/N1103.2.2 Sealing. Ducts, air handlers, and filter boxes should be sealed. Joints and seams should comply with the International Mechanical Code or IRC, Section M1601.4.1, as applicable.

Exceptions:

Application of air-impermeable spray foam products should be permitted without additional joint seals.

For ducts having a static pressure classification of less than 2 inches of water column (500 Pa), additional closure systems should 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.

Existing Buildings and Replacement. New boilers that are part of an addition shall comply with new construction sections of the code (i.e., IRC sections R403.1, R403.2, R403.3, R503.5, and R403.6). An exception is, when ducts are used as part of an existing heating and cooling system and are extended to an addition, a duct system with less than 40 linear feet in the unconditioned spaces does not need to be tested. Replacement boilers should be installed in accordance with relevant standards including ACCA Standard 5: HVAC Quality Installation, Specification and the ACQA's Technician's Guide for Quality Installations, and ACCA Standard 9: HVAC Quality Installation Verification Protocols.

2UL (Underwriters Laboratory) is a global independent safety science company that certifies, validates, tests, inspects, audits, and advises and trains.

3Illustrations of boiler reset controls found at: http://cleanboiler.org/learn-about/boiler-efficiency-improvement/efficiency-index/boiler-reset-control/

4The National Fire Protection Association (NFPA) is a nonprofit organization devoted to eliminating death, injury, property and economic loss due to fire. The NFPA 31 Standard is for the Installation of Oil-Burning Equipment is located online: http://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=31

5UL 343 found online: http://ulstandards.ul.com/standard/?id=343.

6UL 842 found online: http://ulstandards.ul.com/standard/?id=842&edition=10&doctype=ulstd.

7AAMA - American Architectural Manufacturers Association L (Underwriters Laboratory) is a global independent safety science company that certifies, validates, tests, inspects, audits, and advises and trains.


Field Inspection:

Per the IECC, Section R104, Inspections, construction or work for which a permit is required is subject to inspection. Construction or work is to remain accessible for inspection purposes until the inspection is complete and the work approved. Required inspections include footing and foundation, framing and rough-in work, plumbing rough-in, mechanical rough-in, and final inspection.

Per the IRC, Section R109, Inspections, the wording is somewhat different in that, for onsite construction, from time to time 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 the foundation, plumbing, mechanical, gas and electrical, floodplain, frame and masonry, and final inspection. Any additional inspections are at the discretion of the building official.

This section provides details for inspecting to the specific provisions for oil-fired boilers where one or more specific type of inspection per the IECC or IRC may be necessary to confirm compliance. Inspections should provide verification in the following areas:

- Boiler is properly located and mounted, and connections are made per approved construction documents. Proper clearances are maintained for hazardous or noxious fumes.
- Verification that appropriate thermostats and outside-air heating-water-reset controls are installed per the approved construction document.
- Confirmation that shut-off valves are readily accessible and that piping is properly installed and insulated.
All intake and exhaust openings are properly located and flashed to prevent moisture incursion.

If employed, radiant system is installed in accordance with manufacture's installation instructions and R-values of insulation meet the approved R-value per construction documents.

If ducts are used in the installation, verify that joints and seams in ductwork are properly sealed, and the duct tightness report is complete and has been submitted per jurisdictional requirements. If ducts are employed, duct insulation is installed in accordance with manufacturer's installation instructions, the manufacturer's R-value mark is readily available, and meets the approved R-value per construction documents.

Verify that the oil tank or tanks are listed and labeled and conform to approved construction documents.

Verify that pumps are listed and labeled and conform to approved construction documents.

**Technical Validation(s):**

- To ensure optimal boiler installations, refer to the following guides:

- For additional information and illustrations on boiler controls, see:

  
  Author: Air-Conditioning Heating and Refrigeration Institute
  
  Publication Date: April 2009

  
  Author: ARIES
  
  Publication Date: November 2014


  
  Author: American Society of Mechanical Engineers,
  
  Publication Date: January 2012
More Info.

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. **Technology Solutions Case Study: Optimizing Hydronic System Performance in Residential Applications, Ithaca, New York**
   - **Author(s):** CARB
   - **Organization(s):** CARB
   - **Publication Date:** November, 2013
     - Case study about maximizing efficiency of hydronic systems in single and multifamily buildings.

References and Resources*

1. **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.

2. **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...

3. **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.

   - **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.

5. **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, condominiums, town houses and manufactured homes.

6. **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.

7.
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.

8. 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.

9. ASHRAE Handbook - Fundamentals
Author(s): ASHRAE
Organization(s): ASHRAE
Publication Date: January, 2017
Guidebook covering basic principles and data used in the HVAC&R industry.

10. Boilers, Baseboard Radiation, Finned Tube (Commercial) Radiation, and Indirect-Fired Water Heaters
Author(s): Air-Conditioning Heating and Refrigeration Institute
Organization(s): Air-Conditioning Heating and Refrigeration Institute
Publication Date: April, 2009
This directory contains the I=B=R Ratings for cast-iron, steel, aluminum and copper boilers, baseboard and finned tube radiation, indirect-fired water heaters, effective as of the date of this publication.

11. 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.

12. 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.

13. 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.

Author(s): International Code Council
Organization(s): ICC
Publication Date: January, 2012
Standard document with information about the international fuel gas code.

15. Manual B - Balancing and Testing Air and Hydronic Systems
Author(s): Air Conditioning Contractors of America
Organization(s): Air Conditioning Contractors of America
Publication Date: January, 2009
Standard technical manual with information about HVSC balancing, testing air and hydronic systems.

Author(s): Arena
Organization(s): CARB, Steven Winter Associates, SWA
Publication Date: May, 2013
Document intended for designers and installers of hydronic heating systems interested in maximizing the overall system efficiency of condensing boilers when coupled with baseboard convectors. It is applicable to new and retrofit projects.

17.
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.

18. Modern Hydronic Heating for Residential and Light Commercial Buildings
Author(s): Siegenthaler
Organization(s): Delmar CENGAGE Learning
Publication Date: January, 2012
Book with in-depth information about hydronic systems for residential and commercial buildings.

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.

21. Performance of Combination Hydronic Systems
Author(s): Butcher
Organization(s): ASHRAE
Publication Date: December, 2011
Article investigating how a linear input/output relationship can be used as a simple model of the performance of a combination hydronic heating system over heating only, DHW only, and combined loads.

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.