

Oil-Fired Boilers - Code Compliance Brief

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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.

¹For more information, see Small Commercial Building Re-Tuning: A Primer, (Cort et. al, 2013), PNNL-22731:

http://www.pnl.gov/main/publications/external/technical_reports/PNNL-22731.pdf .

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 UL² 726 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. 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:

System Volume (gallons)	Pressurized Diaphragm Type	Nonpressurized Type
10	1.0	1.5
20	1.5	3.0
30	2.5	4.5
40	3.0	6.0
50	4.0	7.5
60	5.0	9.0
70	6.0	10.5
80	6.5	12.0
90	7.5	13.5
100	8.0	15.0

- **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)
 - **2015 IRC, Section G2406 Appliance Location.** Appliances shall not be located in sleeping rooms, bathrooms, toilet rooms, storage closets, or surgical rooms, or in a space that opens only into such rooms or spaces.
- **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 control³ 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 NFPA31³ and combustion air openings shall be located at or above the elevation required in IRC Section R322.2.1 per **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:

Diameter of Connector (inches)	Galvanized Sheet Metal Gage Number	Minimum Thickness (inches)
Less than 6	26	0.019
6 to 10	24	0.024
Over 10 through 16	22	0.029

— **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.

Type of Connector	Minimum Clearance (inches)
Single-wall metal pipe connectors:	
— Oil and solid-fuel appliances	17
— Oil appliances listed for use with Type L vents	9
Type L vent piping connectors:	
— Oil and solid-fuel appliances	9
— Oil appliances listed for use with Type L vents	3

— **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 termination should conform to 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 343⁵ 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).

Piping Material	Maximum Horizontal Spacing (ft)	Maximum Vertical Spacing (ft)
ABS	4	10
CPVC (1-inch or less)	3	5
CPVC (1 ¼ inch)	4	10
Copper or copper alloy pipe	12	10
Copper or copper alloy tubing	6	10
PB pipe or tubing	2.67	4
PE pipe or tubing	2.67	4
PEX tubing	2.67	4
PP less than 1-inch pipe	2.67	4
PP more than 1 ¼ inches	4	10
PVC	4	10
Steel pipe	12	15
Steel tubing	8	10

– **2015 IRC, Section M2102.1 General.** If baseboard convectors are used, they should be installed in accordance with manufacturer’s installation instructions. Convectors should be supported independently of the hydronic piping.

– **2015 IRC, Section M2103 Floor Heating System.** Radiant floor heating systems shall have a thermal barrier in accordance with Section M2103.

- **IRC/M2103.2.1/IECC R403.4** Slab-on-grade installations should be insulated to a minimum of R-value of 5.
- **IRC M2103.2.2/IECC R403.4** 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.
- **Flashing/Moisture Control.** Verify that the design and specification of the weather-resistive covering, water-resistive 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 1/4 inch (6 millimeters) and a maximum opening size of 1/2 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 AAMA⁸ 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-resistive 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,⁸ Specification and the ACCA's Technician's Guide for Quality Installations, and ACCA Standard 9: HVAC Quality Installation Verification Protocols.⁹

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.

⁸ACCA Standard 5:
http://www.energystar.gov/ia/home_improvement/home_contractors/qispec.pdf .

⁹ACCA Standard 9:
http://www.energystar.gov/ia/home_improvement/home_contractors/QI_Verification_Protocols.pdf .

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:
 - ACCA Standard 5: HVAC Quality Installation, Specification: http://www.energystar.gov/ia/home_improvement/home_contractors/qispec.pdf
 - ACCA Technician's Guide for Quality Installation: A Compendium to ANSI/ACCA 5 Q1-2010 HVAC Quality Installation Specification, Air Conditioning Contractors of America, 2008.
 - ACCA Standard 9: HVAC Quality Installation Verification Protocols: http://www.energystar.gov/ia/home_improvement/home_contractors/QI_Verification_Protocols.pdf.
 - ACCA Manual J: Full Residential Load Calculation: <https://www.acca.org/standards/approved-software>
- For additional information and illustrations on boiler controls, see:
 - Boiler Reset Control Overview (ESC): <http://cleanboiler.org/learn-about/boiler-efficiency-improvement/efficiency-index/boiler-reset-control/>
 - Controls Guide for Oil-Fired Boilers: <https://basc.pnnl.gov/resource-guides/oil-fired-boilers>
- *Boilers, Baseboard Radiation, Finned Tube (Commercial) Radiation, and Indirect-Fired Water Heaters:*
http://www.ahrinet.org/App_Content/ahri/files/Certification/I=B=RBBaseboardRadiation.pdf
 Author: Air-Conditioning Heating and Refrigeration Institute
 Publication Date: April 2009
- *Case Study: Technology Solutions for New and Existing Homes Case Study: Boiler Control Replacement for Hydronically Heated Multifamily Buildings(2013):*
<https://basc.pnnl.gov/case-studies/technology-solutions-new-and-existing-homes-case-study-boiler-control-replacement>
 Author: ARIES
 Publication Date: November 2014
- "Connection of Vent Connectors to Chimneys for Liquid and Solid Fuel Appliances."
 Home Owners Network, Online at:
<https://www.homeownersnetwork.com/booktopic/connection-vent-connectors-chimneys-liquid-solid-fuel-appliances/#more-2695>.
- *Control and Safety Devices for Automatically Fired Boilers:*
[https://www.asme.org/products/codes-standards/csd1-2012-controls-safety-devices-automaticall-\(1\)](https://www.asme.org/products/codes-standards/csd1-2012-controls-safety-devices-automaticall-(1))
 Author: American Society of Mechanical Engineers,
 Publication Date: January 2012