Multifamily Boiler Controls

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Scope

Install boiler controls in multifamily buildings per the manufacturer’s instructions. The controls should be installed by qualified contractors.

- Conform to applicable local codes for minimum temperature requirements during day and night time.
- Consult with the building manager regarding indoor air temperature targets and history before altering boiler control settings.
- If the building has a history of overheating, then alter boiler control settings (such as indoor temperature control set points and nighttime setbacks) to maximize comfort and energy savings.
  - Measure indoor air temperatures in a sample of apartments for a brief period of time. Based on these temperature data, re-adjust boiler settings.
  - Perform this task during the coldest part of the heating season.
  - It may need to be adjusted during milder winter conditions.

See the Compliance Tab for related codes and standards, and criteria to meet national programs such as ENERGY STAR Certified Homes, DOE’s Zero Energy Ready Home program, and EPA’s Indoor airPLUS.
Description

In multifamily housing, with hydronic heat provided by central boilers, the capability of a boiler controller to adjust the boiler and/or supply water temperature according to inputs such as outdoor and indoor temperatures as well as controller settings is important for achieving energy savings and comfort. Boiler controls can significantly reduce heating costs in multifamily housing. A recent study supported by DOE’s Building America program showed averaged utility bill reductions of 19% when central boilers in three apartment buildings were retrofit by adding boiler controls ([Hydronic Heating Retrofits for Low-Rise Multifamily Buildings, Boiler Control Replacement and Monitoring Study](#)).

![Figure 1](image-source: Levy Partnership 2014)

Figure 1. Modern controllers for apartment boilers allow remote tracking and control of temperatures and setbacks and can communicate with wireless temperature sensors in each apartment to maintain minimum temperatures while avoiding excessive temperatures and energy use. (Image source: Levy Partnership 2014)

Leading control strategies include the following.

Outdoor Reset

Outdoor reset control (ORC) is a popular type of multifamily boiler control strategy with variants for both steam and hot water heating. ORC has existed for perhaps as long as 50 years. It has been more prevalent in multifamily buildings, but is now becoming more common in single-family residential systems, in part because of legislation that went into effect in 2012 requiring improved boiler controls. ORC is one way to meet the requirements.

The basic concept behind ORC is that the amount of heat delivered to the building should vary in proportion to the outdoor temperature. For hot water systems, this takes the form of varying the supply water temperature from the boiler. For steam-heated buildings, this takes the form of varying the duration of the steam cycle (number of minutes per hour that steam is provided to heat emitters). In mild weather, proportionally lower water temperatures and less steam runtime allow heating systems with ORC to limit overheating and reduce fuel consumption. Lower water temperatures also reduce distribution losses from hydronic systems.
Multifamily hot water space heating systems can have multiple boilers, circulation loops, pumps, and valves. Reset control can be integrated with these components to achieve the desired supply temperature to the building.

Figure 2. Updated boiler controllers for apartment buildings with central hot water heating have been shown to cut energy use by 20% with a payback of less than three years. (Image source: Levy Partnership 2014)

The underlying logic behind ORC is shown in the reset curve or ratio. It specifies the variation of water temperature (boiler, system supply, system return, or other) with outdoor temperature. The steeper the curve (greater the slope’s magnitude), the sharper the drop in water temperature with each degree rise in outdoor temperature. The reset ratio is usually linear (but some control manufacturers use proprietary non-linear algorithms). In addition to adjusting the slope of the reset curve, the reset curve can be offset up or down depending on the heat loss characteristics of the building and to implement a setback such as for night time, or vacation mode in single-family homes.

One caveat with lowering water temperature is that many boilers, especially older ones, are not designed to accept return water temperatures below 120-130°F for extended periods of time. Risks of lower-temperature return water include possible condensation of corrosive flue gasses that can corrode the heat exchanger over time.

Condensing boilers, on the other hand, are well suited to accept low return water temperatures, and therefore take maximum advantage of ORC, because they are designed with materials that can withstand these conditions without deterioration. Other strategies such as mixing valves or injection pumps can maintain high return water temperature by recirculating some supply water or injecting controlled amounts of boiler water into the boiler return.

In addition, water temperature can be adjusted separately for night time and daytime; however, energy savings from this setback strategy are not proven. A sample outdoor reset control curve is given below where WWSD is “warm weather shut down” (i.e., above this temperature no heat is provided).

Indoor Temperature Cutoff

In this control strategy, which is overlaid on top of outdoor reset control, several temperature sensors are installed in apartments to measure indoor air temperature. If the average temperature of these apartments exceeds a predefined limit, the controller turns the boiler off to reduce overheating.
Boiler controllers can often communicate with an offsite server that stores logged temperature and boiler operation data and makes these historical data available on a website. The web-based system may allow remote operation and modification of the control parameters. If apartment temperature sensors are included, then it can provide real-time access to these data so that building operators can ensure the legally required minimum heating temperature is provided to each apartment, without resorting to a large safety factor, which wastes energy by maintaining the water temperature at excessively high temperatures. Access to these data can also assist in diagnosing heating system problems and addressing tenant complaints.

Issues

One risk of systems using apartment temperatures is that tenants using supplemental heating (or cooling) could affect temperature sensor readings inadvertently or intentionally in an effort to obtain more (or less) heat. However, the averaging of all apartment temperatures minimizes the impact any one apartment can have on the system.

Materials

A typical boiler control system will include all equipment, materials, and manuals necessary for its use, including the controller, outdoor temperature sensor, and for systems with indoor cutoff, indoor temperature sensors, pipe temperature sensors, a wireless receiver and networking devices. If mixing valves are also to be controlled, an additional controller and sensors will be required. Other measures discussed under “Ensuring Success” will require additional components.

Who Does the Work

Local codes may require a licensed boiler contractor to perform this work.

Metrics

The data collected from the boiler controller or utility bills can be used to calculate energy savings by comparing periods when the controller is operated with and without selected features.
Ensuring Success

Because altering boiler control settings require special skills, it must be performed by a qualified contractor. Manufacturer installation instructions must be followed. The following measures are important for health and safety and performance issues.

Health and Safety:

Manufacturer's Instructions. Equipment manufacturer's instructions should be followed.

Electrical Hazards. Potentially hazardous voltages exist in control cabinets and electrically actuated control components. These components should be handled only by qualified electrical or instrumentation service people.

Hot Surfaces. Many hot surfaces exist in a boiler area and even non-heated surfaces can become uncomfortably warm; therefore, care must be exercised to prevent burns and other thermal hazards when near the boiler.

Performance issues. Indoor air temperatures in a sample of apartments should be measured for a short period of time (a few days to a week) to verify the performance of control settings and to quantify changes. Based on these temperature readings, boiler settings should be readjusted. The contractor should preferably perform this task during the coldest part of the heating season, but may need to revisit the setting during milder winter conditions.

Other opportunities. While working in the boiler room, other opportunities for improvements to the heating system performance and safety should be considered, including pipe insulation, combustion safety testing, and boiler tuning and cleaning. Also, consider adding mixing valves or injection pumps to the system to enable resetting to lower supply temperatures than the boiler alone can be reset to.
Climate

Boiler control settings are dependent on the climate characteristics and heat loss of the building. The colder the climate, the more potential there is for energy savings; however, mild climates can experience significant savings as well if existing controllers are poorly adjusted.
Training

Right and Wrong Images
None Available
Local ordinances often require residential property owners to provide functioning heating systems that are capable of heating habitable spaces to minimum temperatures delineated in the ordinance for day and night.

2009 and 2012 IECC
R403.1 A programmable thermostat is required for each heating system.

2015 and 2018 IECC
R403.1 A programmable thermostat is required for each heating system.

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

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.)

2009 and 2012 IRC
N1103.1 A programmable thermostat is required for each heating system.

2015 and 2018 IRC
N1103.1 A programmable thermostat is required for each heating system.

N1103.2 Hot water boilers that supply heat to the building through one- or two-pipe systems shall have an outdoor setback control that decreases the boiler water temperature based on the outdoor temperature.

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.
Case Studies

1. **Technology Solutions for New and Existing Homes Case Study: Boiler Control Replacement for Hydronically Heated Multifamily Buildings**
   - **Author(s):** ARIES
   - **Organization(s):** ARIES
   - **Publication Date:** November, 2014
   - Case study describing a heating system retrofit in an existing apartment building complex which included advanced boiler controls and reduced heating gas consumption by about 20%.

References and Resources*

1. **2009 IECC - International Energy Conservation Code**
   - **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 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.

   - **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.

4. **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.

5. **2015 IECC - International Energy Conservation Code**
   - **Author(s):** International Code Council
   - **Organization(s):** ICC
   - **Publication Date:** January, 2015
   - 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.
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.

8. 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.

9. Heat Pumps and Hydronics - A Great Team for High-Performance Homes
Author(s): Butler
Organization(s): Energy Vanguard
Publication Date: January, 2011
Article discussing the advantages of using heat pumps instead of furnaces in high-performance homes.

10. Hydronic Heating Retrofits for Low-Rise Multifamily Buildings: Boiler Control Replacement and Monitoring
Author(s): Dentz, Henderson, Varshney
Organization(s): ARIES, Levy Partnership
Publication Date: September, 2014
Report summarizing the status of a central hydronic heating system project in multifamily housing at the conclusion of the 20112012 heating season.

11. 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.

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

13. Optimizing Hydronic System Performance in Residential Applications
Author(s): Arena, Faakye
Organization(s): CARB, Steven Winter Associates, SWA
Publication Date: October, 2013
Research study using modeling to determine optimal combination(s) of components/pumps, high efficiency heat sources, plumbing configurations and controls that result in the highest overall efficiency for a hydronic system.

*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.
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