FortisBC Efficient Boiler Program
Boiler sizing & quality installation guidelines

1. Introduction

Achieving a quality boiler installation requires more than simply purchasing and installing high-efficiency models. Accurate boiler sizing, correct system design, proper installation, final commissioning and proper operation have a significant impact on occupant satisfaction and energy savings.

This document provides some guidelines to help ensure that your new boiler(s) are properly installed and correctly sized to optimize performance and minimize energy use. Guidance is also provided on the right-sizing methodology acceptable to FortisBC when boiler retrofit participants apply for the boiler right-sizing incentive.

2. General

The following general guidelines are recommended for all boiler installations:

2.1. All boilers must be installed by qualified contractors who hold the appropriate registration with the BC Safety Authority.

2.2. All boilers should be installed in compliance with all manufacturer instructions and federal and local codes for boiler system operations and maintenance safety.

2.3. Ensuring that your contractor adheres to the A**merican National Standards Institute (ANSI)/Air Conditioning Contractors of America (ACCA), Standard 5 (ANSI/ACCA 5), HVAC Quality Installation Specification** is highly recommended.

2.4. Boiler systems should be sized to meet the heating load of the building in order to ensure optimal performance. Refer to boiler right-sizing below.

2.5. Boilers and components included in the scope of ASHRAE 90.1 Table 6.8.1F Gas- and Oil-Fired Boilers, Minimum Efficiency Requirements should comply with the B.C. Energy Efficiency Standards Regulation or any superseding local appliance/equipment energy efficiency regulation such as the City of Vancouver Building By-Law.

3. Boiler right-sizing

A correctly sized boiler(s) is vital to ensure sufficient heat is available to meet the heating requirements of your building, while minimizing your natural gas consumption during the heating seasons. It also serves to avoid the installation of unnecessarily large boilers. FortisBC strongly encourages all applicants to engage the services of a qualified professional to review their thermal heating requirements and ensure their new boiler(s) is sized accordingly. Oversized boilers can short cycle, which may result in higher energy consumption and reduced life expectancy because of the added wear on the boiler due to short cycling. On the other hand, undersized boilers may not be able to meet the heating requirements of the building. A correctly sized boiler has an output capacity that is slightly greater than the maximum requirement of the heating system.

- In new construction, the building's heating load should be calculated and the boiler plant should be sized in accordance with the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Standard 90.1.
- For the purpose of obtaining the right-sizing incentive (retrofit applications only), the boiler plant should be sized based on the heating load, which can be estimated in accordance with one of the following two methods:
    a. full building heat load analysis
    b. historical gas consumption analysis

3.1. Full building heat load analysis

The building's heat load must be calculated in accordance with ASHRAE Standard 90.1, industry standards and computer-aided techniques. It is important to note that when sizing a boiler plant, one must consider all weather sensitive loads as well as all non-weather sensitive loads that will be carried by the boiler plant.

Weather sensitive loads must include the following:

1. conduction heat loss through the building envelope (e.g. walls, windows, doors, roof, floors, floor edge, etc.)
2. convection heat loss through infiltration of outside air into the building
3. convection heat loss through the introduction of ventilation air into the building

Non-weather sensitive loads may include the following:

1. domestic hot water
2. swimming pools and hot tubs
3. natural gas laundry equipment
4. any other non-space heating and ventilation loads

The heat load calculations must consider:

1. Both indoor and outdoor design temperatures for buildings based upon the B.C. Building Code requirements. ***The winter design temperature must be based upon the January 2.5 per cent winter design temperature for the specific location (B.C. Building Code Division B-Appendix C Table C-2)***.
2. The exposed surface areas, heat transmission coefficients (U-values) and temperature difference between the indoor and outdoor design air temperatures for each different component of the building envelope such as walls, roof, floor, windows and doors.
3. Infiltration rate (cubic feet per minute or litres per second) as determined by the number of air changes per hour (ACH) and the temperature difference between the indoor and outdoor design air temperatures.
4. Ventilation rate (cubic feet per minute or litres per second) and temperature difference between the outside air and supply air to the building system.
5. The total design heat load is equal to the sum of the conduction heat loss through the building envelope, the convection heat losses from infiltration, the convection heat losses from ventilation and any other non-weather sensitive loads that will be carried by the boiler plant.

In order to be eligible for the right-sizing incentive (retrofit only), heat load analysis must be submitted as:

1. The output from a commercially available software package such as Carrier HAP, Elite Software Chvac, Trane TRACE, etc. or
2. Fully annotated Excel spreadsheets including all inputs, calculation details, outputs and labels/explanatory notes for all data points and/or calculations.

3.2. Historical gas consumption analysis

The building's heat load can be estimated using the building's historical gas consumption in the winter months. It is important to note that when sizing a boiler plant using the historical gas consumption method, one must consider the impact of weather variations to the historical gas consumption as well as all non-weather sensitive loads that will be carried by the boiler plant.

To determine the building's heat load using the historical gas consumption, one must:

1. Identify the building's historical monthly peak demand for natural gas (GJ/month or Btu/month) based on a minimum of three years average (or from the last major building renovation, whichever is more recent).
2. Determine the non-weather sensitive load (e.g. domestic hot water, pool, laundry, etc) of the building from the historical monthly peak demand for natural gas. Break down the historical monthly peak demand for natural gas between the weather sensitive load portion (e.g. space heating) and the non-weather sensitive load portion.

3. For the weather sensitive load portion, correct it with weather data such as heating degree-days (HDD), available from Environment Canada National Climate Data and Info Archive.[1] Please note that representable or the closest weather station to your building must be used for the weather data.

4. For the non-weather sensitive load portion, determine the specific load that is served by the boiler plant. The total heat load by the boiler plant is the sum of the weather-corrected space heating load and all non-weather sensitive loads that are carried by the boiler plant. Do not account for any load that is not carried by the boiler plant.

In order to be eligible for the right-sizing incentive (retrofit only), historical gas consumption analysis must be submitted as:

1. The output from a commercially available utility accounting software package such as RetScreen Plus, Metrix 4, etc. or

2. Fully annotated Excel spreadsheets including all inputs, calculation details, outputs and labels/explanatory notes for all data points and/or calculations.

4. Boiler installation and maintenance

Quality installation, operations and maintenance are key aspects of ensuring safe operation and capturing savings in high-efficiency boiler systems. A boiler that is properly installed, tested and commissioned operates as it was intended, maximizing comfort and natural gas savings. Conducting regular maintenance according to an established schedule also reduces boiler operating and energy costs, improves safety and extends the life of the boiler. The following guidelines should be considered and discussed with your qualified boiler installation professional.

4.1. Boiler installation

4.1.1. Boilers should be installed and commissioned by a manufacturer's authorized representative or qualified contractor to ensure the boiler system, its components and controls operate efficiently and as intended.

4.1.2. Equipment installed outdoors or in unconditioned spaces should be designed by the manufacturer for such installation.

4.1.3. Proper selection of the vent stack material is essential. Condensing boilers are classified as Category IV boilers. The additional heat recovery from the flue gases results in condensation of the flue gases, which may be acidic. Therefore, condensing boilers or mid-efficiency boilers where the flue gases may be subject to condensation should be vented through a Class II Type BH stack or a stack that complies with the manufacturer's recommendations. These stacks are made of stainless steel or PVC specifically designed and certified for use with condensing boilers and are resistant to corrosion from the condensate.

4.1.4. The boiler's combustion efficiency should be tested upon installation and the air/fuel mixture adjusted, if necessary, to ensure the boiler operates at its optimum efficiency level. The tests should examine:

1. boiler inlet return water temperature °C
2. boiler outlet supply water temperature °C
3. boiler room temperature °C
4. exhaust gas temperature °C
5. % CO2 in the exhaust
6. % CO in the exhaust
7. % O2 in the exhaust
8. % steady state combustion efficiency
9. boiler clocked firing rate (Btu/hr)
10. These tests ensure the boiler is set up correctly and is operating at optimum efficiency levels based on the manufacturer's recommended settings.

4.2. On-going maintenance

Once the boiler is installed, on-going maintenance ensures the boiler remains in good working order. Consult the manufacturer's manual for the recommended schedule of maintenance specific to your boiler. Save a copy of the boiler startup/inspection manual for later reference. **ASHRAE / ACCA Standard 180: Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems** also outlines some recommended boiler maintenance practices.

Regular boiler maintenance should include:

4.2.1. Annual combustion analysis that measures and records:

1. combustion efficiency, per cent CO2, per cent O2, ppm NOX
2. flue gas temperature
3. periodic diagnostic check of the controls
4. regular visual check of system components including the condensate treatment/removal system
5. monitoring of the boiler water outlet temperature and investigating major changes in the boiler water outlet temperature
6. monitoring of the boiler water inlet temperature and investigating major changes in the boiler water inlet temperature
7. monitoring of the boiler room temperature and investigating major changes in the boiler room temperature
8. To ensure boilers remain in good working order, maintenance should only be performed by qualified personnel who are trained and licensed to perform boiler maintenance. This may include registered contractors, manufacturer's authorized representatives or properly trained maintenance staff.
9. be sure to record any problems noted and report them as soon as possible to your service technician

5. Additional considerations

Beyond the selection and installation of your new boiler(s) there are some additional considerations that should be reviewed with your boiler installer in order to ensure optimum performance.

5.1. Boiler controls

Boiler controls are an important component to ensuring your boiler(s) operates as efficiently as possible. Boiler automation and control systems ensure the boiler(s) only operates when needed and only produces the amount of heat required to heat the building. Two boiler control strategies that can significantly reduce energy consumption include:

5.1.1. **Outdoor reset controls** in space heating applications has the potential to reduce energy consumption significantly. Outdoor reset controls adjust the hot water supply temperature from the boiler based on the outside temperature. Outdoor reset decreases the hot water supply temperature as the outside temperature rises. As a result, the boiler does not have to heat the hot water as much, which means the boiler does not use as much energy. Since most boilers operate at part load conditions most of the time, outdoor reset controls can result in significant energy savings.The net effect is that the boiler is only as hot as it needs to be. Energy is wasted in keeping water hotter than it has to be and heat losses from hot water piping and the boiler are reduced. If the boilers also provide domestic hot water heating, a low limit for the boiler supply temperature is set that can provide domestic hot water.

5.1.2. **Boiler staging** is where two or more boilers are installed to meet the peak heating requirements of the building. But since the peak heating load only occurs a few times, one boiler can meet the heating requirements of the building most of the time. The controller only turns on one boiler until it cannot meet the heating demand of the building. It then turns on

[1] Environment Canada National Climate Data and Information Archive: http://www.climate.weatheroffice.gc.ca/Welcome_e.html

the second boiler to meet the peak heating load. This strategy uses the minimum amount of energy to meet the heating requirements of the building.

5.2. Hydronic systems

Hydronic heating systems use hot water for space heating by transferring heat from the hot water that flows through terminal devices. The hot water is generated by the boiler(s) while the terminal devices can include fan coils, in-floor radiant heating, hot water baseboards, hot water radiators and hot water radiant panels. The components, design and installation details of a hydronic system all contribute to the overall performance and efficiency of a boiler plant. To ensure that hydronic systems are operating properly and deliver the right amount of heat to the space as efficiently as possible, the following guidelines should be considered:

5.2.1. All hydronic systems should be designed so they can be balanced.

5.2.2. Multiple boiler systems should prevent heat loss through boilers when they are not in operation through the use of such items as draft dampers or shut-off valves interlocked with burners.

5.2.3. Pipes containing fluids with design operating temperatures outside the 13°C to 40°C range should be insulated as per ASHRAE 90.1 Table 6.8.3 (Minimum Pipe Insulation Thickness).

5.2.4. Boiler hot water distribution piping outside the building envelope should be insulated to the maximum requirements as per ASHRAE 90.1 Table 6.8.3 (Minimum Pipe Insulation Thickness). Insulation should be protected where it may be subjected to mechanical damage, weathering or condensation.

5.2.5. Seasonal pumping systems, such as hot water pumping systems, should have automatic controls or readily accessible and clearly labeled manual controls to shut down the pumps when they are not required.

5.2.6. Hydronic systems used with condensing boilers should be designed to maximize the efficiency of the boilers. Such hydronic systems return water to the boiler at or below 60°C allowing water vapour in the boiler flue gases to condense and thereby extracting additional heat energy. Return water temperatures above 60°C will not allow condensation to occur thereby foregoing the opportunity to recapture this energy, even if the boiler is a condensing model. Performance in this case will be more in line with that of a mid-efficiency boiler.