



# residential hydronic heating

## h.e.l.p. sheet

### overview

*Using hot water to heat your home, hydronic heating systems are considered to be of better quality than others and may add to your home's market value. This h.e.l.p. sheet describes the advantages, design considerations and equipment for hydronic heating systems.*

### How hydronic heating systems work

Water is first heated in a boiler by either natural gas, oil, electricity, propane or solid fuel. The heated water is then circulated to a heat transfer device where it emits the heat before returning to the boiler for re-heating.

### Advantages

#### Even heat

Hydronic heating systems often provide more even heat than other systems. A steady supply of warm water through the heating unit results in a constant supply of heat to the home. Even when the circulating pump shuts off, the mass of water in the system will continue to emit heat until the water cools.

#### Space savers

A small volume of hot water will deliver the same amount of heat as a large volume of warm air. Heating air, rather than water, requires ductwork many times larger than a water-filled pipe.

#### Zoned

Different sections of the home can be kept at different temperatures. The boiler can be located anywhere, as long as protection against freezing is adequate.

### Other uses

When properly equipped, the hydronic heating system can be used to heat domestic water (i.e. water for cooking, washing and bathing), and for a variety of heating purposes outside the home, including heating greenhouses and garages, swimming pools, spas and hot tubs and snow-melting systems for steps, sidewalks and driveways.

Water heating and snow-melting systems use a heat exchanger placed between the boiler and the required secondary fluid (in the case of snow melting, the secondary fluid would be an anti-freeze solution).

### Disadvantages

With the exception of fan-coil systems, residential hydronic systems cannot provide cooling, humidification, air filtration, or forced air circulation. Excessive heat gains, from sources such as sunlight through a window, can't be easily transferred from one area to another. As with any plumbing system, damage can result in the event of leaks.

## Design alternatives

The design of a hydronic heating system is more complex than that of other systems, and can be more expensive to install than most other systems. Operating costs will be higher than for simpler systems unless good design and proper operation and maintenance of the system and all its components are carried out. These factors will give the maximum system performance and economy.

A wide variety of heat distribution methods and equipment are available when choosing a hydronic heating system. Some of these choices include:

### Baseboard convectors

This system consists of a length of pipe (usually copper) with attached "fins" (usually aluminum) that increase the surface area of the piping to improve heat transfer. You can buy them with or without a sheet metal cover. With the cover they are installed at a low level along a wall; without the cover they can be concealed in an architectural enclosure, recessed into floors or areas where they won't be subject to damage or corrosion.

### Radiators

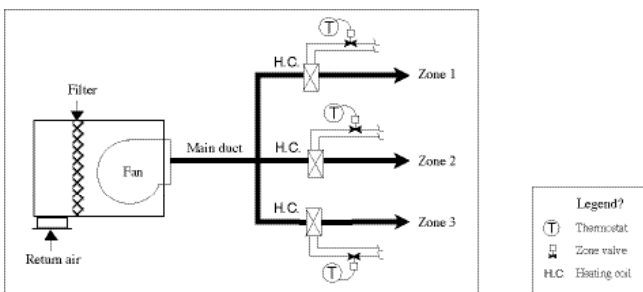
Radiators are large cast-iron units usually only found in older buildings. They were designed to provide full heating capacity at a lower temperature than baseboard convectors. You should use caution with radiators, as they may overheat, risking burns to those who come in contact with them.

### Cast-iron baseboards

These low-profile convector radiators have a lower heat output and a substantially higher cost than baseboard convectors. They operate at the same temperature as cast-iron radiators.

### Hot water/forced air fan and coils

As shown in *Figure 1*, these are fans designed with one or more hot water coils, either in the same enclosure as the fan, or mounted separately in the distribution ductwork.



**Figure 1**

*Hot water/forced air fan and coils*

### Kick-space heaters

Designed to be installed horizontally under kitchen cabinets or bathroom vanities, these are small fan-coil units.

### Radiant floors

These systems have hot water piping or tubing installed in or under the floor, allowing the warm floor to heat the room. To maintain comfort, the floor surface temperature should not exceed 29°C (85°F).

## Equipment

Hydronic heating systems consist of several components.

### Boiler

The boiler, or hot water generator, does not boil the water, but simply reheats it prior to being conducted to the heat emitting units. Boilers are generally rated on input and/or output in British thermal units per hour (Btu/h), or in kilowatts (1 kW = 3,412 Btu/h). Boiler output should be adequate to offset building design heat loss, piping losses (if they run through unheated space), plus any additional heating needs such as swimming pools or hot tubs. The boiler should not be too large for the area it's heating.

### Circulator

The circulator, or circulating pump, is an electrically driven pump that forces the water through the boiler and/or the piping system. Some systems have more than one circulator in order to serve separate systems (e.g. domestic hot water), areas or zones of the home.

### Zone valves

Rather than have separate pumps for different zones, one circulator may serve several zones, with each zone regulated by a zone valve controlled by its own thermostat. Most residential zone valves are electric and operate on 24-volt alternating current. Pneumatic valves and self-contained hydraulically activated thermostat/valve units are also available.

### Expansion tank

Water expands when heated and contracts when cooled. This tank is a reservoir for the change in volume.

### Air elimination devices

Air in a hydronic system reduces heating performance. Several devices are used to remove air from the piping system and return it to the atmosphere. An air venting device should be installed at each high point in the system where air can gather.

## Heat transfer devices

These may include radiators, convectors, fan-coil units or radiant floors.

## Heat exchangers

These transfer heat to water or, in the case of snow-melting systems, to an anti-freeze solution.

## Mixing valve

Some systems or parts of systems (i.e. radiant floors) require cooler water than is supplied by the boiler. A mixing valve blends cooler return water with hot boiler water to obtain the system temperature required.

## Controls

Standard low-voltage (24 V AC) or newer programmable electronic thermostats can be used to provide temperature control. Thermostats are usually connected to, and control, the zone valves. When the valve is fully open, an end switch on the zone valve turns on the boiler and circulator.

There are two basic boiler control strategies: variable temperatures if the boiler is used for space heating only, and constant temperature if the boiler is also used to heat water, swimming pools or hot tubs. This second method is often referred to as a summer/winter hook-up.

## Piping

Copper piping is used most commonly to distribute the hot water. If piping is embedded in a concrete slab it may be made of iron, steel, synthetic rubber or plastic.

## Pipe insulation

To prevent heat losses and to ensure that heat is delivered to spaces where it is required, insulate pipes running through unheated areas, such as crawlspaces. Moulded fiberglass pipe insulation is often used.

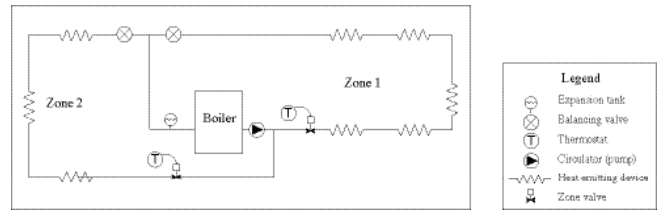
## Distributing the water

There are four basic piping systems used in hydronic heating to distribute heated water throughout your home.

### 1. One-pipe series loop system

The simplest hydronic heating piping system is a single pipe that runs through a number of rooms, with heating devices inserted in the system wherever needed. No individual room control is possible within a loop, as a valve anywhere in the loop regulates flow to all heating units.

It is possible to divide the home into a number of zones, with each zone being a series loop serving rooms of similar purpose and exposure. For example, a series loop could serve two or more bedrooms on the same side of the house. As



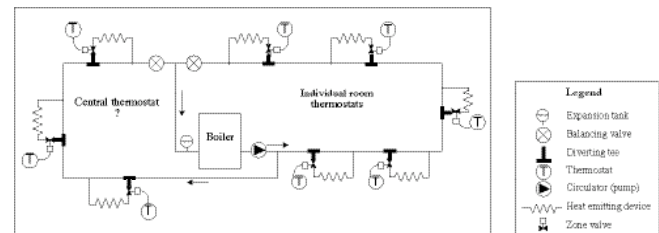
**Figure 2**

*One-pipe series loop system*

shown in *Figure 2*, a balancing valve should be used in each loop of this multi-loop system, even when thermostatically controlled zone valves are used. Each series loop circuit should be provided with shut-off valves and drain valve in the boiler room for isolation in the event of leaks.

### 2. One-pipe system with diverting tees

This system is similar to the series loop system in that a single pipe is used, but the heating units are installed in side circuits off the main pipe. A special pipe fitting, called a diverting or distributor tee, is installed in the piping to force the water to divert out of the main pipe through a branch containing the heating device, then back to the main piping loop.



**Figure 3**

*One-pipe system with diverting tees*

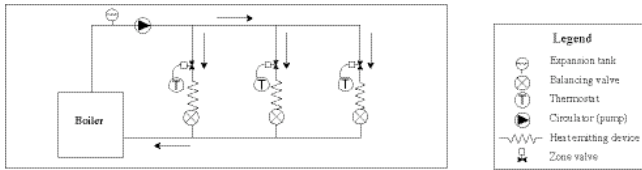
As shown in *Figure 3*, a balancing valve, or preferably a thermostatic control valve installed in each room, provides the individual control lacking in the series loop system.

A similar performance can be obtained by using ordinary tees and reducing the size of the by-pass piping.

In the series loop and diverting tee systems, water temperature becomes progressively cooler as it passes through the successive heating units. These units must be selected accordingly. The living room should be served first, or from a separate loop, and the bedroom served near the end of the loop. Otherwise you could have a bedroom that is too warm and a living room that is too cool.

### 3. Two-pipe direct return system

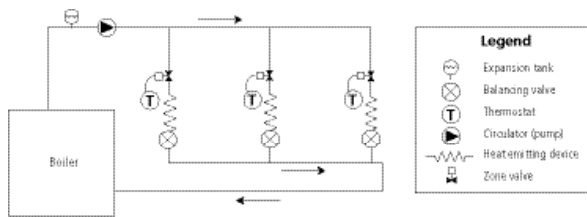
Two-pipe systems result in the same water temperature to all heating units, making balancing and temperature control easy. These systems are more expensive and are not common in residential buildings. *Figure 4* illustrates a two-pipe direct return system, which requires balancing valves to ensure adequate flow through all heating zones.



**Figure 4**  
*Two-pipe direct return system*

### 4. Two-pipe reverse return system

As shown in *Figure 5*, the two-pipe reverse return system has less need for balancing valves, as the total supply and return length is the same for all units, and the system tends to be inherently balanced.



**Figure 5**  
*Two-pipe reverse return system*

## Controlling the temperature

How you control your temperature depends on whether your hydronic heating is used only for space heating or both space and water heating.

### Space heating

When a boiler is used for space heating, the simplest control strategy is to have the thermostat control the burner and circulator together. This adjusts the heating capacity to the heating needs and provides the lowest operating costs.

A second method used residentially is to always keep the boiler hot and have the thermostat turn the circulator on and off. Operating costs may rise, however, through increased losses from escaped heat (stand-by losses).

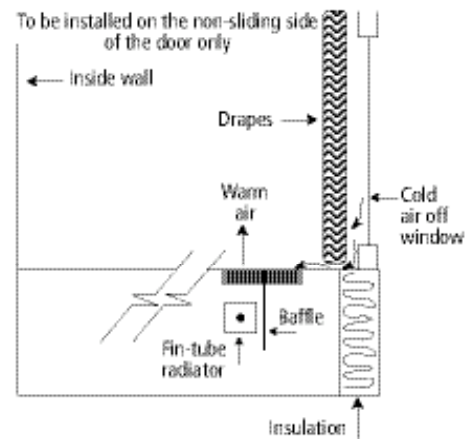
A third method is to continuously adjust the boiler temperature [minimum setting 50°C (122°F)] using an outdoor thermostat located on the north side of the house. The room thermostat is then used to turn the zone valve on and off. This method, termed boiler water reset, is more energy-efficient than the single-temperature option.

### Space and water heating

If your boiler is also used to heat domestic water, it must be maintained at full temperature, even when heating isn't needed. This leads to increased operating costs from high stand-by losses. From an efficiency standpoint, a separate water heater is generally preferable.

If the house has been designed to energy efficiency standards such as a BC Hydro Power Smart New Home and R2000, the space heating load may not be much greater (and could even be less) than the domestic water heating load. In this case, the boiler could be sized for the larger of the two loads. A priority valve would direct most or all of the hot boiler water to the domestic water heater as needed. An energy-efficient house will not cool off appreciably during the relatively short time needed to reheat the domestic water tank, and as the boiler is not oversized for either space or domestic water heating needs, seasonal heating efficiency is not compromised.

## Installation hints

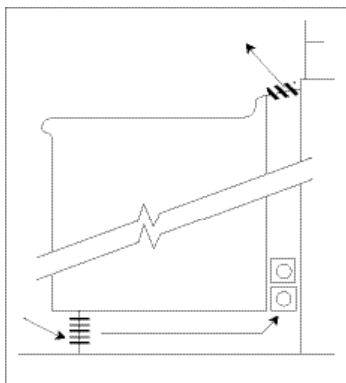


**Figure 6**  
*Drop-in heater in front of a patio door*

A hydronically heated home can be made more comfortable and convenient by keeping in mind these suggestions.

- Install some extra capacity in the bathroom, as most people prefer bathrooms to be fairly warm.

- Install a floor drop-in heater, or even a length of finned tube piping recessed into the floor in front of glass patio doors, to offset the chill caused by the large glass area. As shown in **Figure 6**, positioning the drop-in unit about 20 cm (8 inches) from the wall and only under the non-opening side of the door will prevent damage from foot traffic and ensure adequate drapery clearance.
- Install a return air grille in the floor at the opposite side of the room to improve the removal of cold air off the floor and circulation over the heating element. Frequently cleaning the grille to remove collected dust and dirt will keep air circulating properly.

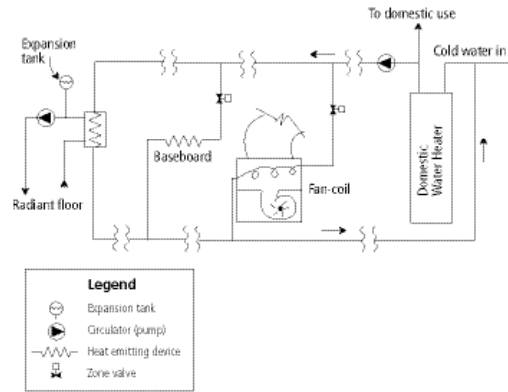


**Figure 7**  
*Finned tubing installed behind kitchen cabinet*

- **Figure 7** shows finned tubing installed behind kitchen cabinets along the outside wall. Grilles in the kick-space and along the back of the counter – slightly raised to prevent water entry from the counter top – will improve air circulation.
- You can have safety and convenience outdoors with a hot-water to anti-freeze heat exchanger and piping system under steps, sidewalks and driveways to melt snow and ice. Careful control is required, however, to control operating costs.

## Combining hydronic heating with gas or oil

A combo system uses a gas or oil-fired domestic water heater for both space and domestic water heating. In operation, domestic hot water is drawn off to heat air in a fan-coil unit or to provide hot water for baseboard convectors or a radiant floor. The fan-coil units are designed to use the 60°C (140°F) hot water typically produced in a



**Figure 8**  
*Combo heating system*

domestic water heater. Manufacturers of baseboard convectors can provide performance data for a similar operating temperature.

All the hot water piping and tubing, including the heat exchanger tubing, should comply with plumbing code requirements if they are subject to the same temperatures and pressures as the domestic water supply system (i.e. use type K or L copper tube, not type M).

With radiant floors, a water-to-water heat exchanger should be interposed between the domestic water and the floor heating water, as in most cases 60°C (140°F) water is too hot for floor heating.

Whenever the space heating side of the system is isolated from the domestic side, an expansion tank is required on the space heating side, as it is now a closed system. As a closed system separated from domestic water pressure, the space heating side can be operated at a much lower system pressure. There are advantages to the isolated system and lower pressure; there is less strain on pipe and fittings, and in the event of a leak on the space heating side, there is only a limited amount of water, at relatively low pressure, to leak out.

Special conditions prevail for combo systems. Check with your municipal building inspection department for details.

## Selection considerations

If you are thinking about installing a hydronic heating system in your home, consider the following:

- How many zones do you want? A home should be zoned into areas according to function, usage, and outdoor and solar exposure.
- As a minimum, bedrooms should be zoned separately from living/dining areas.

- Rooms with a southern exposure should be zoned separately from rooms with other exposures, particularly when south-facing rooms have a large amount of glass.
- Do you want a radiant floor system? Families with young children often prefer this system. The warm floors are enjoyed particularly in areas where heavy carpets and underlay aren't used.
- Radiant floors have lower water temperature requirements than convection units and these must be on separate zones.

## Summary

A hydronic heating system, if properly installed and maintained, can add comfort and value to your home.

To obtain additional information and advice on hydronic heating systems, including radiant floors, contact:

### **The Residential Hot Water Heating Association**

199 – 916 West Broadway  
Vancouver, B.C. V5Z 1K7  
Phone/Fax: 604 414-0100

Some manufacturers and distributors of hydronic heating equipment also have design manuals available.

## Installation

This h.e.l.p. sheet is designed as a general guide.

Please ensure that installations meet your requirements, manufacturers' instructions and all applicable codes, standards and regulations. BC Hydro is not responsible for installations.