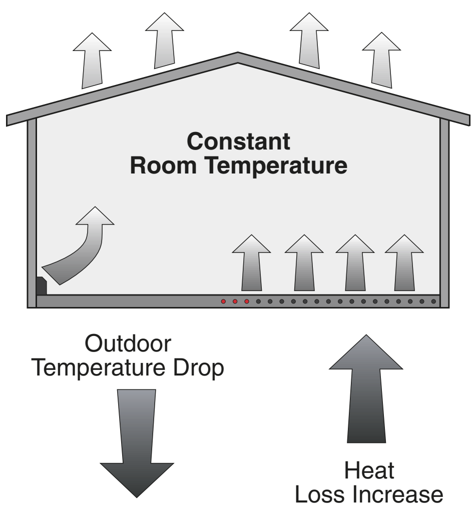
This essay is intended to give the designer and installer a better understanding of outdoor reset and the different types of outdoor reset strategies that are available. In particular, it describes the differences between a traditional Reset Ratio and a Characterized Heating Curve.

## Outdoor Reset

In order to properly control a heating system, the heat supplied to a building must equal the heat lost by the building. If too much heat is supplied, the building can overheat. If too little heat is supplied the building can cool off. The amount of heat lost by the building changes depending on the outdoor air temperature. As the outdoor air temperature drops, the amount of heat lost from the building increases. The amount of heat that the heating system can supply changes depending on the temperature of the supply water. As the temperature of the supply water increases, the amount of heat available from the heating system increases. This relationship holds true for any building and any hydronic heating system and is the basis for outdoor reset.

An outdoor reset control measures both the outdoor air temperature and the system supply water temperature. As the outdoor temperature drops, the control increases the supply water temperature to the system in order to meet the heating requirements of the building. The more information that the outdoor reset control has about the heating system, the more accurately the control can adjust the supply water temperature, and the more comfortable and efficient the heating system becomes.




## Reset Ratio

The traditional Reset Ratio method of controlling the supply water temperature is based only on the outdoor air temperature. With a Reset Ratio two points must be established that relate the outdoor air temperature and the supply water temperature. To determine these two points, four pieces of information are required as shown in the figure below. The Reset Ratio uses the Outdoor Starting Temperature, Supply Water Starting Temperature, Outdoor Design Temperature, and the Supply Water Design Temperature.

### Outdoor Starting Temperature

The Outdoor Starting Temperature is the outdoor air temperature at which the control is to provide the Supply Water Starting Temperature.

### Supply Water Starting Temperature

The Supply Water Starting Temperature is the supply water temperature required to maintain the building interior at the design indoor temperature when the outdoor air temperature is the same as the Outdoor Starting Temperature.

### Outdoor Design Temperature

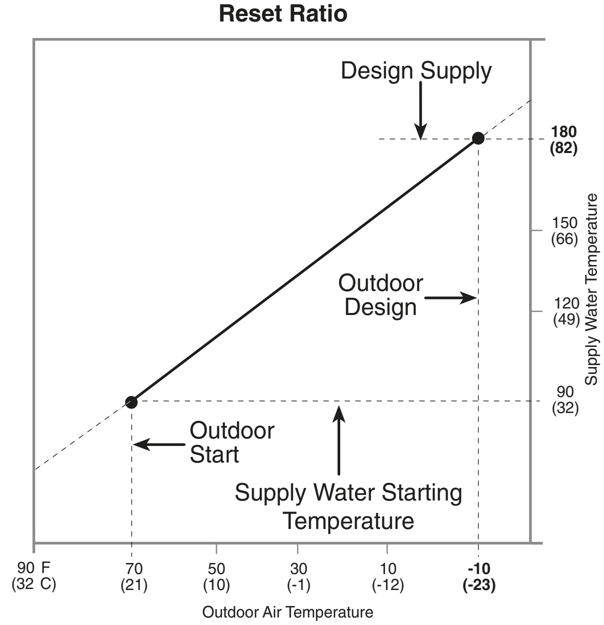
The Outdoor Design Temperature is the outdoor air temperature that is the typical coldest day of the year where the building is located. This temperature is used when doing the heat loss calculations for the building.

### Supply Water Design Temperature

The Supply Water Design Temperature is the supply water temperature that is used in the heat loss calculations for the heating system. This is the supply temperature that is required to heat the building at the Outdoor Design Temperature.

Once these two points have been determined, the system supply temperature is varied based on a straight line between these two points.

**Reset Ratio**



## Characterized Heating Curve

The Characterized Heating Curve method of controlling the supply water temperature is based on both the outdoor air temperature and the type of heating system that is installed. When using a Characterized Heating Curve, four pieces of information are required. The Indoor Design Temperature, Outdoor Design Temperature, Supply Water Design Temperature and the type of Terminal Unit used by the heating system. This method of outdoor reset is more accurate than a Reset Ratio since the control takes into account the type of terminal unit that the heating system is using and the specific way in which that terminal unit transfers heat to the building. The type of terminal unit that is used has a large impact on the supply temperature to the system since each type of terminal unit delivers heat to the space in a different manner. As can be seen by the figure of the Characterized Heating Curve, the supply temperature during mild weather varies by a large degree depending on the type of terminal unit that is being used.

### Indoor Design Temperature

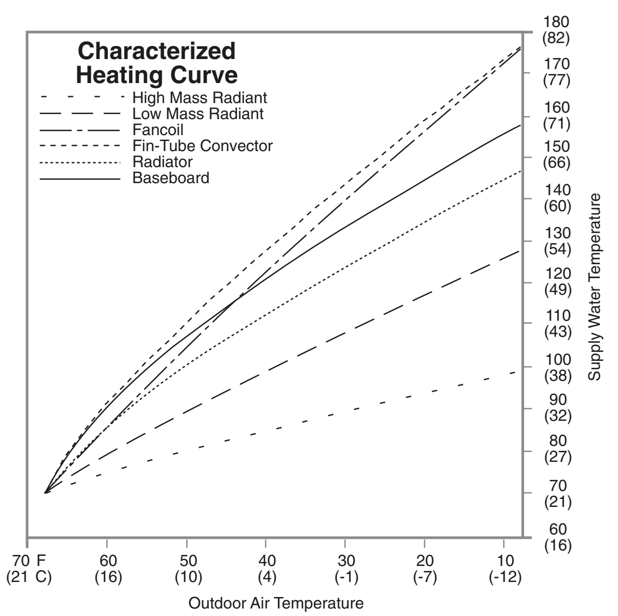
The Indoor Design Temperature is the indoor air temperature that was used when the heat loss calculations for the building were performed. This single setting replaces the Outdoor Starting Temperature and Supply Water Starting Temperature used by the Reset Ratio. This setting establishes the beginning of the Characterized Heating Curve.

### Outdoor Design Temperature

The Outdoor Design Temperature is the outdoor air temperature that is used in the heat loss calculations for the heating system. This is the typical coldest day of the year for the area in which the building is located. This temperature is used when doing the heat loss calculations for the building.

### Supply Water Design Temperature

The Supply Water Design Temperature is the supply water temperature that is used in the heat loss calculations for the heating system. This is the supply temperature that is required to heat the building at the Outdoor Design Temperature.




### Terminal Unit

When using a Characterized Heating Curve, the control requires the selection of a Terminal Unit. The Terminal Unit determines the shape of the Characterized Heating Curve according to how the Terminal Unit delivers its heat into the building space and how the Terminal Unit responds to changes in the supply water temperature. There are six common types of Terminal Units used in the hydronic heating industry. These six types of terminal units are discussed later in this essay.

The above figure shows the basic shapes of the Characterized Heating Curves for the six different types of terminal units. The supply water temperature requirements of most terminal units do not vary directly with outdoor air temperature. For this reason, a Reset Ratio is only a good estimation for the supply water temperature and is not an accurate match. When outdoor reset controls were first introduced, it was necessary to use a Reset Ratio since the electro mechanical devices used for outdoor reset could not provide a complex outdoor reset strategy. However, with today's microprocessor based outdoor reset controls, it is possible to include a number of different Characterized Heating Curves in a single outdoor reset control. The following explains the key differences between the types of terminal units and how they transfer heat to the building and the basic shapes of their Characterized Heating Curves.

## Methods of Heat Transfer

There are three main methods that are used by terminal units when transferring heat to the building space: radiant heat transfer, natural convection and forced convection.

### Radiant Heat Transfer

Radiant terminal units transfer heat directly by infrared radiation from the terminal unit and warms the people and objects in the space. The amount of heat that a radiant terminal unit delivers is related to the surface temperature of the radiant unit.

### Natural Convection

Natural convection terminal units rely on the natural movement of air as it is heated. The air around the unit is heated and rises. As the heated air rises, it is replaced by cooler air that is then heated. The heated air moves through the room and warms the people and objects. The rate at which the air moves across the terminal unit depends on the temperature of the unit. The hotter the unit, the greater the rate of natural convection.

### Forced Convection

In a Forced Convection terminal unit, air is moved across a heating element at a constant velocity by either a fan or a blower. This allows the terminal unit to be smaller. However, people may feel uncomfortable due to the cooling effect of air moving across their skin. In order to overcome this sensation, air in a forced convection system may be heated to a higher temperature than air in a natural convection system.

## Thermal Mass

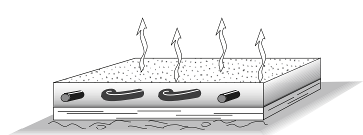
Each type of terminal unit has a different thermal mass. Thermal mass determines how much heat a terminal unit can store, and affects how long it takes the terminal unit to heat up and cool down. A terminal unit that has a high thermal mass takes a long time to heat up and continues to provide heat for a long period after water flow to it is shut off. Proper control of the supply temperature to a high mass terminal unit is required to prevent overshooting and undershooting of the room temperature. A terminal unit with a low thermal mass is relatively fast to heat up and cool down. This type of unit can provide heat very quickly when required. It also stops providing heat shortly after it is turned off. This type of terminal unit requires proper control of the supply temperature to prevent potential short cycling problems.

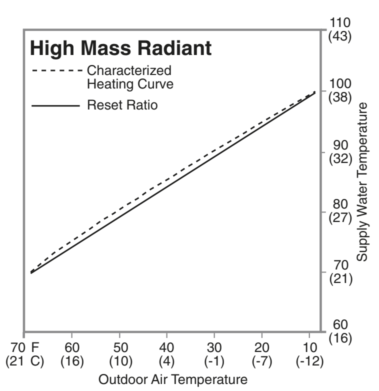
## Terminal Units

There are several different types of terminal units that are commonly used in the hydronic heating industry. Each of these terminal units behaves differently based on their method of heat transfer and their thermal mass. Because of this fact, the supply water temperature that is supplied to each type of terminal unit should be tailored, or characterized, to match its needs. In order to provide the best control of the heating system, the outdoor reset control should take this into account when adjusting the supply temperature. Only a control that operates with a Characterized Heating Curve is capable of doing this. A control that operates using a reset ratio cannot take into account the type of terminal unit that is being used in the heating system and therefore does not provide the same level of comfort and efficiency.

## High Mass Radiant

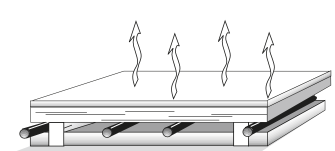
A high mass radiant system consists of tubing that carries the heated supply water embedded in a heat transfer material. Commonly, the tubing is embedded in either a thick layer of concrete or gypsum. The concrete or gypsum, tubing and water make up the thermal mass of the terminal unit. Because of the large amount of material that is heated, this type of system changes temperature relatively slowly. A radiant floor heating system transfers heat from the terminal unit to the building using 50% radiant heat transfer and 50% natural convection. Because of the large surface area associated with this type of system, the supply water temperature required to provide adequate heat to the building is quite low. Such a terminal unit has a heating curve that is relatively straight with a low design supply water temperature.

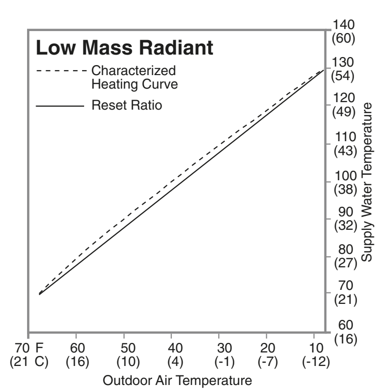





## Low Mass Radiant

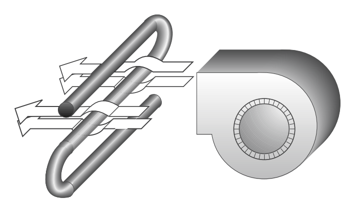
The tubing of a low mass radiant system can be attached directly to the underside of the floor with or without metal heat transfer plates. This is commonly referred to as a 'staple-up' radiant system. Alternatively, the tubing can be suspended in the joist space below the floor and used to heat the air on the underside of the floor. Another common method is to sandwich the tubing between the subfloor and the surface covering. Or the tubing can be embedded in a thin layer of gypsum or concrete. The thermal mass of this radiant system is substantially smaller than a high mass radiant system. A low mass radiant system is capable of responding faster than a high mass radiant system and is often required to operate with higher supply water temperatures. Such a terminal unit has a heating curve that is very similar to a high mass radiant terminal unit only with a higher design supply water temperature.

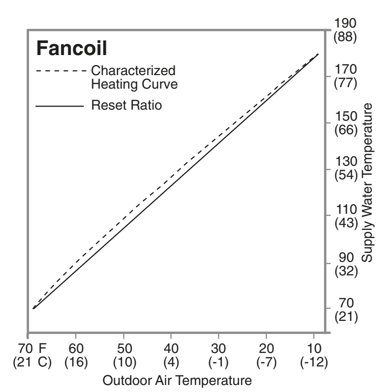





## Fancoils

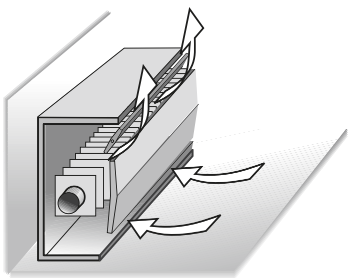
A fancoil incorporates a hydronic heating coil and either a fan or a blower. Air is heated when it is forced across the heating coil by the fan or blower. This type of unit uses forced convection as its method of heat transfer to the building. Since the heating coil is usually as small as possible, a fan coil must operate with a high supply water temperature. This is also required in order to keep the occupants of the building comfortable. Fancoils have a very low thermal mass and respond very rapidly. A fancoil's heating curve is relatively straight with a high design supply water temperature.

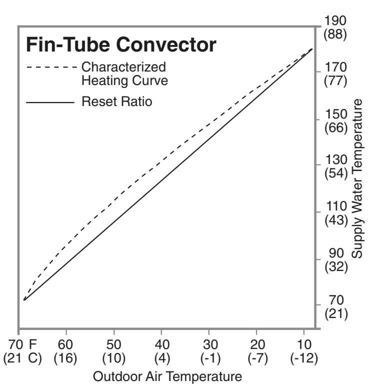




### Fin-Tube Convectors

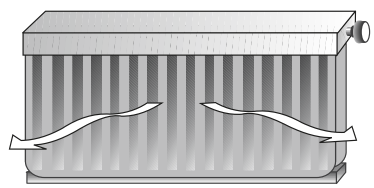
A fin-tube convector consists of a tube carrying the supply water encased in fins. This is also commonly referred to as just "fin-tube". As the water passes through the tube, heat is transferred to the fins. As the fins increase in temperature, the air surrounding the fins is heated which causes it to rise. The heated air is then replaced by cool air. Convectors use this natural convection to heat the air in the room which in turn heats the objects and occupants. Convectors are a low mass terminal unit and require supply temperatures that are high enough to produce the necessary amount of natural convection. The heating curve for a convector is relatively steep at low supply water temperatures and gradually flattens out as the amount of natural convection increases with higher supply water temperatures.

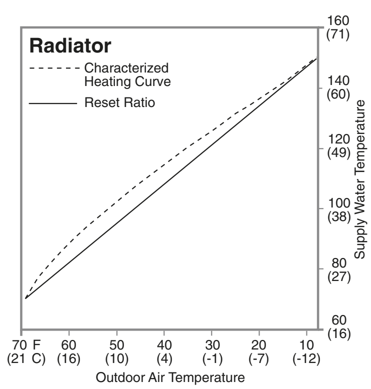





### Radiator

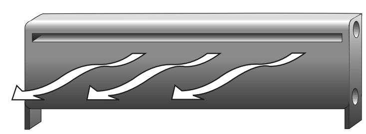
A radiator is typically a free standing or wall mounted terminal unit. Because of their design, radiators have a large amount of exposed surface area for their size. Some of the heat that a radiator delivers to a room is through radiant heating. However, due to the design of the radiator, there is a large amount of natural convection. Because of the metal and water content, older cast iron radiators have a relatively high thermal mass when compared to convectors or baseboards. Even after a radiator has been turned off, it continues to provide heat into a room for a period of time as the thermal mass cools. Radiators also have a relatively steep heating curve during mild conditions. Due to the additional heat transfer from natural convection at higher supply temperatures, the heating curve flattens out as it nears the design conditions.

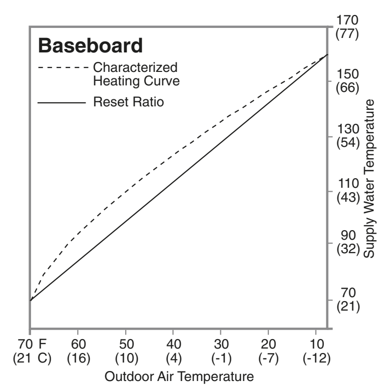





### Baseboard

A baseboard terminal unit is characterized by its low profile and flat surface. Baseboards have a relatively small water content. This type of terminal unit is typically mounted around the perimeter of a room with only its front and top exposed to the room. A baseboard provides heat to the room through radiant heat transfer but the majority of the heat transfer is still through natural convection. The shape of the heating curve for a baseboard is very similar to that of a radiator. However, since a baseboard has a relatively small surface area, it is often designed to operate with higher supply temperatures.






Not all heating terminal units behave in the same manner. Because of this fact, applying a generic outdoor reset strategy, such as a Reset Ratio, cannot provide the maximum performance and comfort from the heating system. A reset strategy that is customized to the heating system, such as a Characterized Heating Curve, will provide better performance and comfort.



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