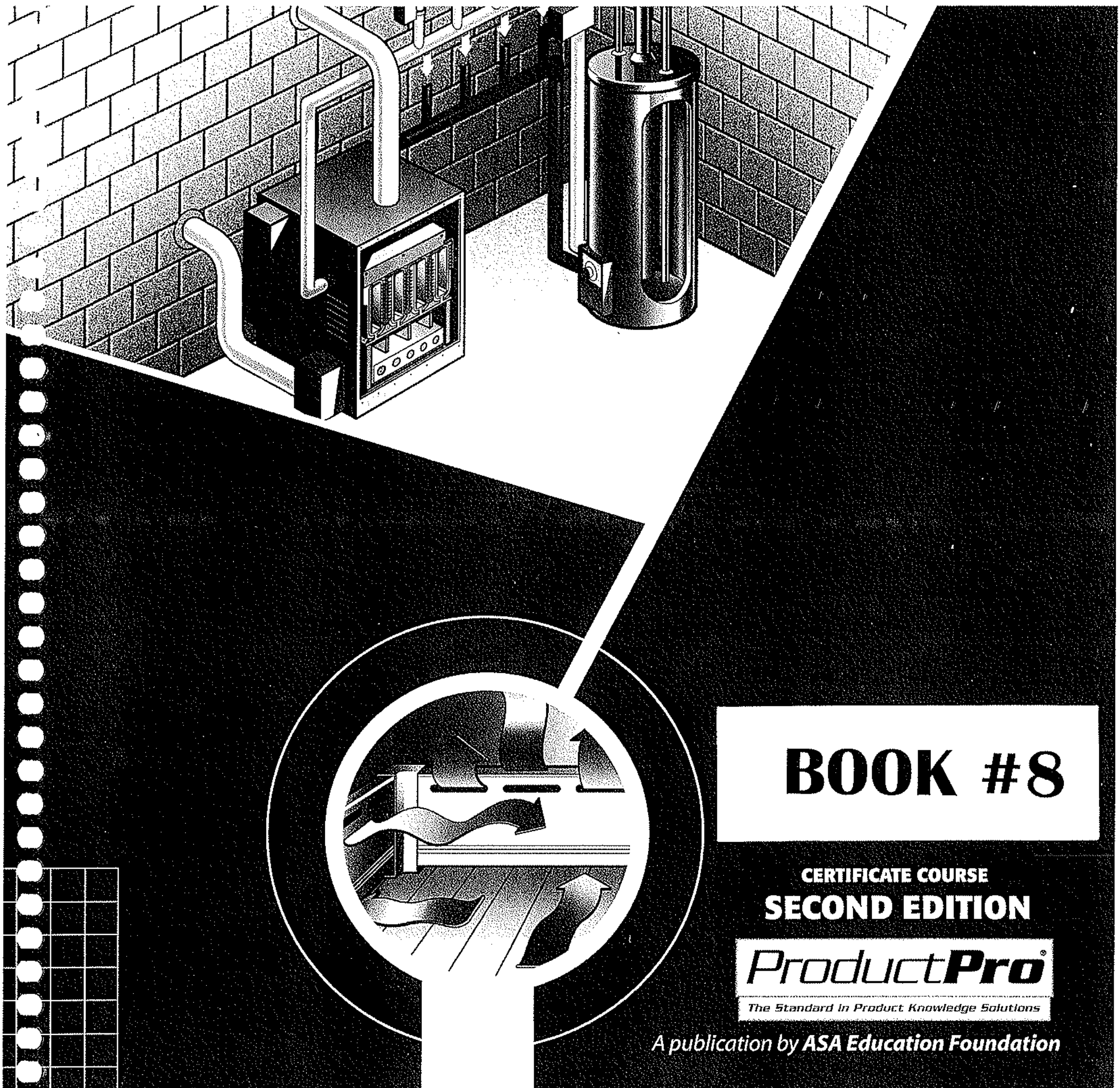
ASA UNIVERSITY

Specialty Products

Residential Hydronic Heating Systems©



BOOK #8

CERTIFICATE COURSE

SECOND EDITION

ProductPro®

The Standard in Product Knowledge Solutions

A publication by ASA Education Foundation

Specialty Products

Residential Hydronic Heating Systems©

from the

American Supply Association Education Foundation

Residential Hydronic Heating Systems© provides new warehouse, counter, and sales personnel with an overview of the operation and components of small hydronic heating systems. It is NOT intended to provide the kind of complex, technical data which would enable employees to plan or install hydronic systems. This course includes definitions of common industry terms, descriptions of the components and functions of residential hydronic heating systems, and other information that will help employees serve their customers more effectively when they come to purchase hydronic heating system products.

ProductPro®

The Standard in Product Knowledge Solutions

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Welcome to the *ProductPro® Product Knowledge Training* series!

The Plumbing-Heating-Cooling-Piping (PHCP) and Industrial PVF industry is an important business channel. The products we sell keep people healthy, comfortable, and productive. In the United States, there are 4,000 PHCP/ Industrial PVF wholesaler-distributor locations; they generate billions of dollars in wholesale sales. It is an exciting and very competitive industry, and running a successful company requires cooperative efforts from educated and motivated employees.

To sell products in such a competitive atmosphere, it is crucial that all employees understand the products we sell. All of us need to be knowledgeable enough to provide our customers with the products they need to keep their operations running smoothly and their employees productive.

What you will learn from this training

In the ProductPro® course, you will learn to correctly use basic terminology common in the hydronic heating industry. You will be able to describe the basic operation of a residential/small commercial hot water comfort heating system. You will learn that, like any other system, a residential hydronic system is a set of related components composed of many subsystems that make up the system as a whole. The subsystems of a hydronic system are boilers and chimney, vertical supply and return piping, horizontal supply and return piping, pump, and convectors. You will learn that in order to make the system work, all these subsystems must work together to produce the desired result of creating a heat source for air in a space. You will learn to read manufacturers' rating charts for components of residential hot water comfort heating systems. In addition, you will learn to help your customers choose the components needed for a residential hydronic heating system.

How the course is organized

The ProductPro® courses are divided into separate chapters. Within each chapter you will read about a particular category of product and then test your progress with a short quiz that you can correct yourself. The course provides a glossary of terms at the back of the book to help you develop the vocabulary needed to enhance your ability to communicate well with your customers and colleagues. The glossary terms are highlighted in the text.

At the end of each self-correcting quiz, you will find *Applying What You've Learned* exercises so you can use the new information that you have learned within your own company. Once you understand the basic concepts presented, know the important facts, and can confidently answer the questions correctly on all the quizzes, you are ready to take the final course exam.

THIS COURSE INCLUDES AN ONLINE FINAL EXAM

This course is limited to a single user. When you are ready to take the final exam to earn your Certificate of Completion, please contact ASA at info@asa.net. ASA staff will contact you about how to register for the final exam.

Some hints for successful course completion

Read the learning objectives

Read the learning objectives at the beginning of each chapter. They will tell you what you should know when you complete the chapter. Go back after you read the material and ask yourself whether you are confident in your command of the material. If you are not, reread anything that you did not understand. Ask your supervisor or colleagues questions to help clarify the material you did not "get" the first time.

Search for the important ideas

Use a highlighter marker or a pen to highlight or underline the most important points as you read. Think about how each idea relates to the rest of the chapter. Write notes in the margins about points you don't understand or about how the material you read applies to your own company.

Ask lots of questions

Ask your supervisor or mentor about any point you do not understand. Particular questions you'll want to ask include whether the products you are studying are carried by your company, how well they sell, and how important they are in the overall inventory.

Apply what you are learning to your job

Always think about what you have just read or learned. Compare your company's products to the products you have read about in the book. Do the *Applying What You've Learned* exercises using the real setting of your job.

Pace yourself in your studying

Don't try to complete the course all at once. You will remember what you learn more effectively if you make sure you understand each chapter thoroughly before you move on to the next.

Be proud of what you have accomplished
When you successfully complete the course, be sure to proudly display your course certificate. You earned it. Then consider moving on to the other courses in this series:

- *Domestic Water Heaters*©
- *Domestic Water Well Pumps*©
- *Sump, Sewage and Effluent Pumps*©
- *Residential Water Processing*©

Commit to learning something new every day
This course is just one step in developing your professional knowledge and your career skills. Read industry trade journals, study the manufacturers' literature, and attend any training the manufacturers offer. Listen to what company and industry experts says. Continue to enthusiastically take any additional training your company offers.

Visit the ASA Education Foundation website at www.asa.net regularly to find out about other learning opportunities to advance your career.

Acknowledgements

Developing new editions of the ProductPro® product knowledge training courses is an ambitious undertaking. During the creation and revision of this course, many individuals shared their expertise, input, and resources to significantly improve the interest and energy in the program.

We wish to thank Ken Rollings from Slakey Brothers who thoroughly and diligently reviewed the course text, quizzes, illustrations, and final exam to ensure accurate and highly readable instructions. We also wish to thank Colin Perry and Shaun Anderson from Rampart Supply, Inc. who carefully reviewed the course content. The reviewers' expertise and experience ensure that the content demonstrates a high level of real world application that immediately can be put to use in employees' day-to-day duties.

The Foundation expresses it very special gratitude to the visionaries who established and led the charge to develop the Karl E. Neupert Endowment Fund. Contributions that established the Fund were provided by hundreds of manufacturers, wholesalers, and individuals who recognized the need for a permanent endowment fund that would endure the ASA Education Foundation's ability to provide programs needed by the industry in perpetuity. Their generous contributions continue to make a major impact on the education and training opportunities available to the industry. We are deeply grateful for their commitment.

– The ASA Education Foundation

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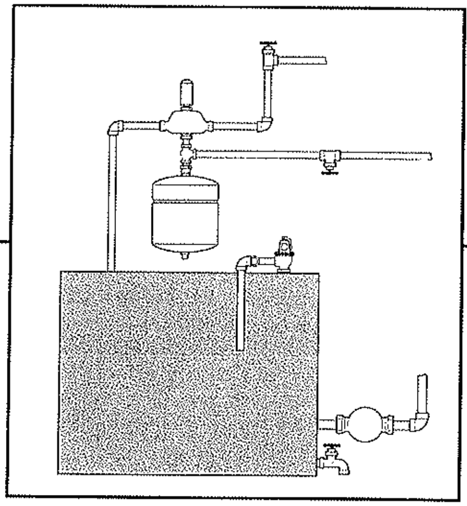
1 INTRODUCTION TO RESIDENTIAL HYDRONIC HEATING SYSTEMS

LEARNING OBJECTIVES

When you finish this Chapter, you will be able to:

1. Recognize common residential hydronic heating systems terms.
2. Compare and contrast radiation, convection, and conduction.
3. Explain how the importance of the "circle of warmth" in a heating system.
4. Describe the uses of hot water heating systems.



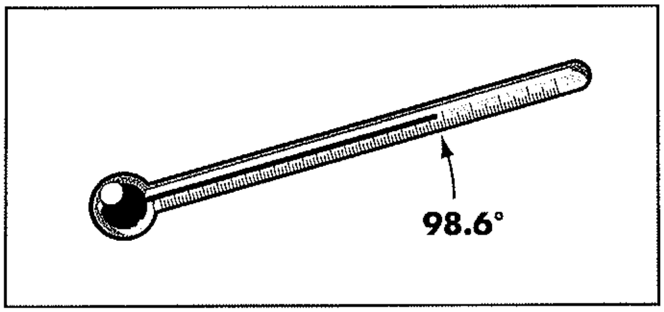
RESIDENTIAL HYDRONIC HEATING SYSTEMS

Comfort Heating Principles

In this section you will learn about some basic principles of comfort heating. Comfort heating began when cavemen discovered that they felt more comfortable if they slept close to a fire on a cool night.

One of the basic laws of nature is that heat always flows from a warmer body to a cooler one. The reverse is NEVER true.

THERMOMETER



SP 4.1.01

The human body is a warm body, a heat source. The food we eat is turned into the energy to keep our bodies operating and the heat to keep our bodies warm. Our "normal" body temperature is assumed to be 98.6° Fahrenheit (or 98.6°F), although your own body's normal temperature may vary slightly from that figure.

A body temperature significantly above or below the normal 98.6° is considered an indication of abnormal conditions in your body.

Through the centuries, human beings have learned to use clothing and various heat sources to help us keep our body temperature stable and in the normal range.

However, our bodies are subject to the same laws of nature as all other objects. Our bodies lose heat to our cooler surroundings. This is normal and necessary so that our bodies do not overheat.

If we lose heat faster than our bodies produce the heat, we "feel cold" and uncomfortable. Our bodies tell us we are getting too cold to operate properly.

Conversely, if our surroundings are warmer than our bodies, we do not give off enough heat, and we feel too warm.

Our feelings of being too cold or too warm are also affected by the humidity in the air and by the movement of air around us.

Under normal conditions, when our bodies become too warm, they perspire: they give off heat. If the perspiration evaporates off the skin quickly, the perspiration is not visible. This may occur, for example, in hot, dry climates.

But if the surrounding humidity is too high, perspiration will evaporate too slowly, or not at all, and we feel hot, sweaty and uncomfortable.

If there is excessive movement of air ("wind" or a "draft") around our bodies, the perspiration will evaporate too quickly, and we will feel cold.

Through the centuries human beings have learned how to create a living environment that allows us to lose body heat gradually, at a rate that we don't notice, so we do not "feel cold."

FEELING THE COLD

SP 4.1.02

A **COMFORT HEATING SYSTEM** is a system which is designed to maintain indoor living area temperatures at levels that allow the heat loss from the human body to occur at comfortable rates.

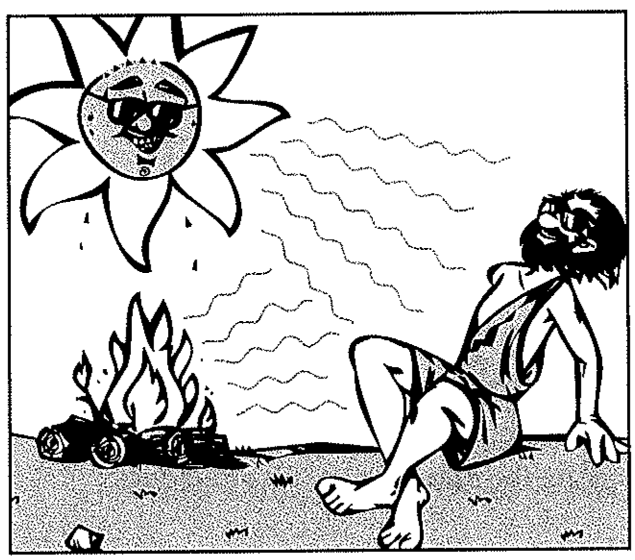
Sources of Heat Transfer

Cavemen learned to use both the sun and fire as sources of heat and comfort. By creating holes in the ceiling of their caves, they created a very primitive type of comfort heating system.

Fire transfers heat by means of heat rays (or heat waves). This transfer is called **RADIATION**. The sun also heats by radiation.

The heat rays given off or "radiated" by a fire or the sun travel like light waves through space.

HEATING BY RADIATION



SP 4.1.03

When these rays reach a cooler object (which may be a human body), the rays warm the portion of the object directly exposed to the heat rays.

One disadvantage of heating by radiation is that the heat waves do little to warm the air through which they travel, and the heat rays will not go through the object which is being warmed. This is why your back may remain cool while your face gets hot when you stand in front of a campfire; the heat rays are blocked by your body. It is also why your body feels cooler in the shade of a tree; the heat waves have been blocked by the tree.

One advantage of heating by radiation is that you are not dependent upon the surrounding air being warm; the heat rays will warm you directly even though the surrounding air is cool.

Early Comfort Heating Systems

Humans have been using comfort heating systems for centuries.

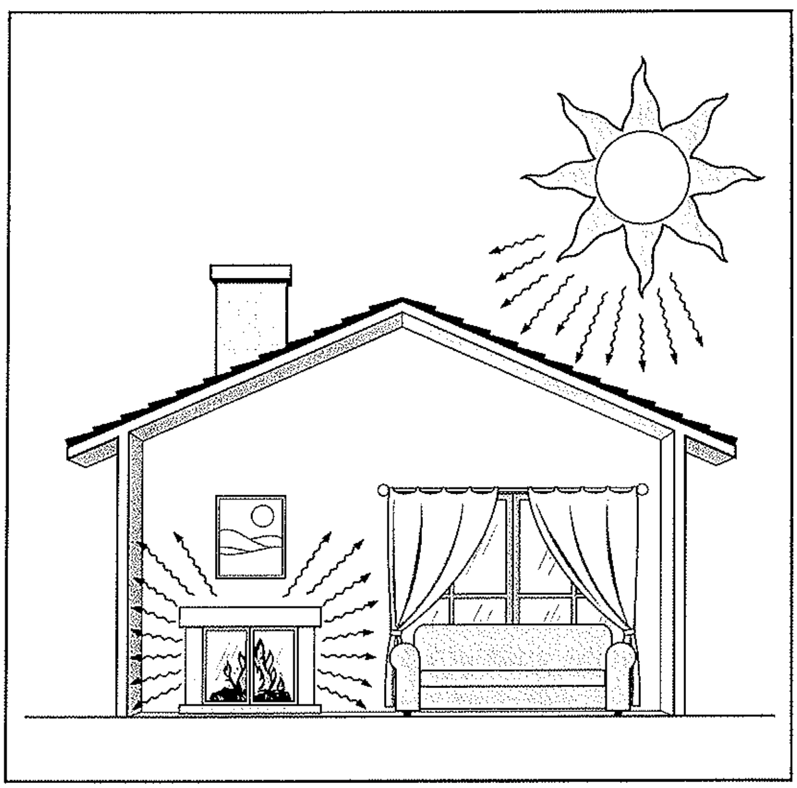
The ancient Romans built furnace pits beneath their floors, which were 12 to 14 inches thick. The fire heated the floors and warmed the villas. This heating system is an early example of a radiant heating system.

A **RADIANT HEATING SYSTEM** uses invisible heat rays or waves which travel from the heat source to the human body.

Fireplaces and wood stoves also heat by radiation.

The ancient also Chinese built ovens under their houses to provide heat.

HOUSE HEATED BY RADIATION

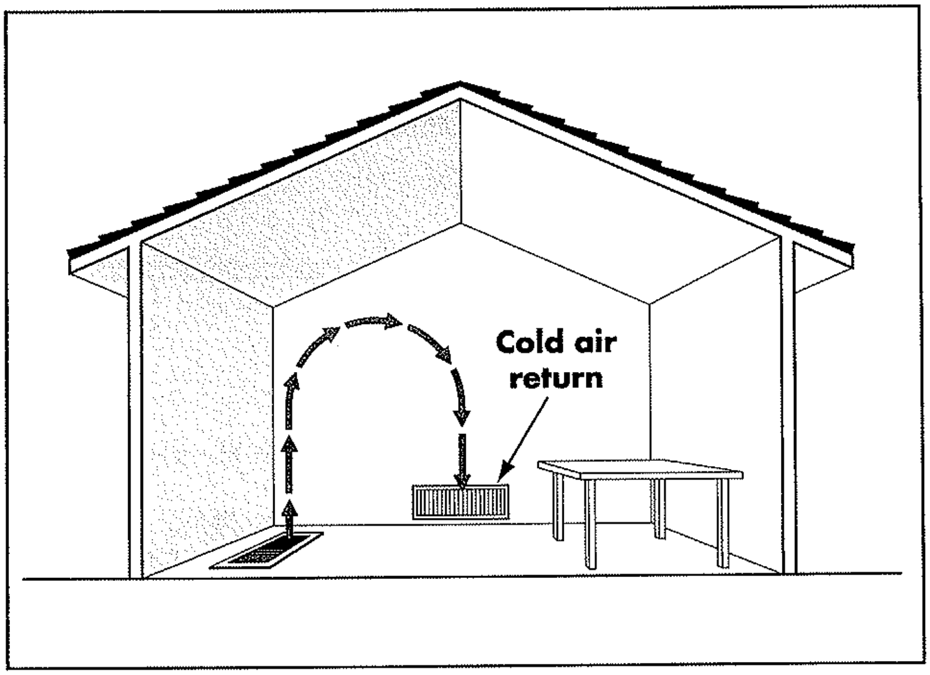


SP 4.1.04

These ovens were equipped with air passages that ran from the ovens to the rooms to be heated. Beds were placed directly over the warm air pipe outlets. This is an early example of a warm air heating system, which transfers heat by means of convection.

CONVECTION is the transfer of heat by circulation of the molecules in the material that is heated.

HOUSE HEATED BY CONVECTION



SP 4.1.05

We know that warm air rises, and as the air cools, it falls. This natural movement of warm air molecules creates convection currents. We can take advantage of natural convection to help surround us with warm air and to prevent the human body from losing too much heat too fast. Therefore we feel warm.

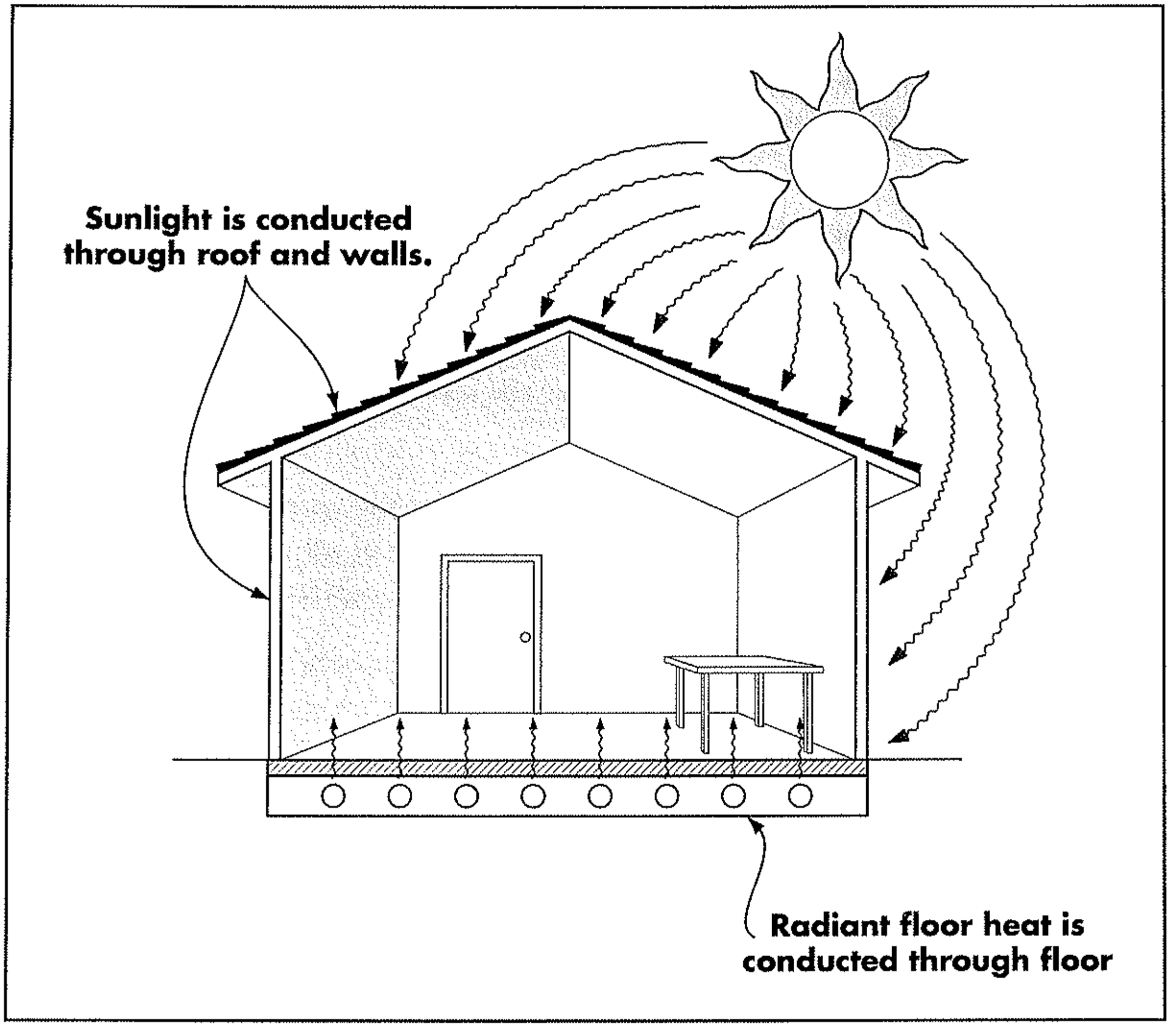
Another method of transferring heat is called conduction.

CONDUCTION occurs when heat is transferred, by contact, from one molecule to another. Molecules from a warm substance may transfer their heat to the molecules in a cooler substance if the two substances are touching or very close. The more dense the material being heated, the better it conducts heat.

Conducted heat is not transferred instantly. It takes some time for each molecule to be heated up and to transfer the heat to adjoining molecules.

The roof and the walls of a house will conduct the heat of the sun into the house in the summer or will conduct the heat from the inside to the outside in the winter. We insulate our houses to control heat transfer by conduction and convection.

HOUSE HEATED BY CONDUCTION



SP 4.1.06

Another example of heating by conduction is the use of under-floor hot water heat. The warmth of the water is conducted through the floor to our feet or our bodies.

Like the ancient Chinese, the Romans also heated some buildings by circulating hot water through the walls and floors. The hot water heated the floors and walls, which then radiated heat into the rooms. This is an early example of a hydronic heating system.

As discussed later in this chapter, hydronic systems use a fluid (generally water) to transfer heat to points of use.

Although the term "hydronic" is also used to cover steam heating systems, this course will only cover hot water heating systems.

Basic Kinds of Comfort Heating Systems

In the later part of this 20th century, we have traditionally thought in terms of two basic kinds of comfort heating systems: (1) hydronic heating systems and (2) hot air heating systems.

A **HYDRONIC HEATING SYSTEM** is a comfort heating system which uses a fluid (generally water) to transfer the heat to points of use.

A traditional hydronic system transfers heat by means of circulating hot water, by use of a pump, through piping systems to points of use and then heats the desired areas by radiation and convection.

A **HOT AIR HEATING SYSTEM**, also called *forced air heating system*, transfers heat by moving hot air, by use of a blower, through ducts to points of use and then heats the desired areas by convection or by movement of hot air through areas to be heated.

There are, however, hybrid approaches which use hot water coils to heat the water but use blowers and ducts to circulate hot air derived from the hot water coils. These hot water-coil/blower systems are not as common as either traditional hot water systems or traditional forced hot air systems but are used in some places.

Hot water flowing through a piping system to heat emitters is the most commonly used method of transferring heat in hot water systems used in residential or commercial buildings.

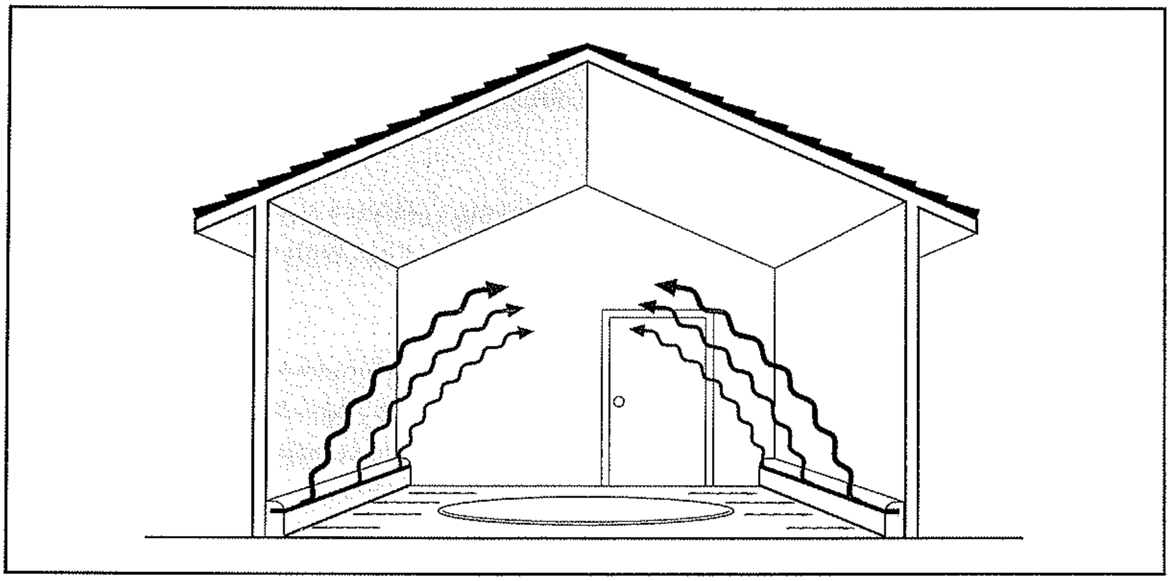
This course will discuss ONLY residential/small commercial systems.

Circle of Warmth

One design principle of residential/small commercial systems is the principle called "circle of warmth." The circle is created by placing the heat emitters, which actually radiate the heat from the warm water, around the outside of a room or building.

This circle of warmth helps to replace the heat lost through the walls, floors, ceilings, doors, and windows.

HOUSE HEATED BY CIRCLE OF WARMTH DESIGN



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Advantages of Circle of Warmth Design

The circle of warmth design used in the hot water heating system offers several advantages to the homeowner.

One advantage is that the outside walls of the room/building are kept warm, which helps keep the room temperature stable and comfortable, without hot spots or cold surfaces.

Because hot water systems depend mostly upon the natural air currents, rather than fan-induced forced air currents, there are fewer drafts, and the heat is more evenly distributed. Because the natural convection currents are less intense than fan-generated forced air currents, the heat feels gentler.

Without forced-air ducts to circulate air from room to room, there are no ducts or strong currents to carry dirt, allergens, odors, sounds, smoke or fire throughout the house.

In many cases, hot water heating is more economical than forced air heat.

The pipes that carry the hot water are smaller than air ducts and the hot water system is a closed system. This means that less heat is lost because there are no openings (such as duct seams) for heat to escape.

This greater efficiency of delivery is particularly important if the heat source must be located at some distance from the areas to be heated.

For this reason, hot water heating systems are very often used for apartment buildings and building complexes such as colleges and government buildings.

Another advantage of having a hot water system is that the system can be adapted to additional uses such as heating water for bathing and dishwashing, heating water for swimming pools, and using hot water coils (with a glycol additive) for snow melting on sidewalks and driveways.

In areas where winters are not severe, hot water heating systems sometimes use specially-modified hot water heaters (instead of boilers) to provide hot water for both household use and heating.

With a hot water system, it is relatively easy to provide for the fact that not all the house needs to be at the same temperature at the same time. Also the temperature of the water can be rather easily raised or lowered to match outside conditions, making cost of heating more easily controlled.

Some buildings use **ZONING**, the practice of heating and cooling areas within a structure separately. By using zoning, the temperature can be varied from area to area according to use. This allows the homeowner to react to variables such as wind and sun and to maintain an even comfort level throughout the home.

Hot water pipes require less space than air ducts. Pipe can easily be run through closets, through walls, and under floors.

When remodeling or adding space, it is easier to add new heat emitters (radiators, baseboard units, etc.) to a hot water system than to construct new ducts for a forced-air system.

Disadvantage of Circle of Warmth Design

One disadvantage of the traditional hot water heating system—which uses piping to carry the water to heat emitters—is that the system is less easy to adapt to conventional residential air conditioning because there are no ducts in place.

There are ways, however, to use hot water heat with regular ductwork by passing air over hot water coils and using a blower to move the warm air from the coils throughout the house.

Sometimes in large complexes or commercial buildings, chilled water is run through the pipes and used for cooling purposes. However, such systems are generally too expensive for residential use.

Heat Measurement

The Kinetic Molecular Theory of Matter provides an explanation of many characteristics of matter, including how heat works and why materials change from solid to liquid to gas. This theory states that all *matter*, or material that has mass, occupies space, and is convertible to energy, consists of tiny particles called **MOLECULES**. These particles are constantly moving and bouncing off each other like billiard balls.

The motion of molecules is responsible for the phenomenon of heat. Ancient people believed that heat was an invisible fluid that flowed from a hot object to a colder one. By the mid-18th century, however, scientists agreed that heat is the energy of molecules in motion.

According to the American Heritage Dictionary®, when used as a physics term, **HEAT** is "a form of energy associated with the motion of atoms or molecules and capable of being transmitted through solid and fluid media by conduction, through fluid media by convection, and through empty space by radiation."

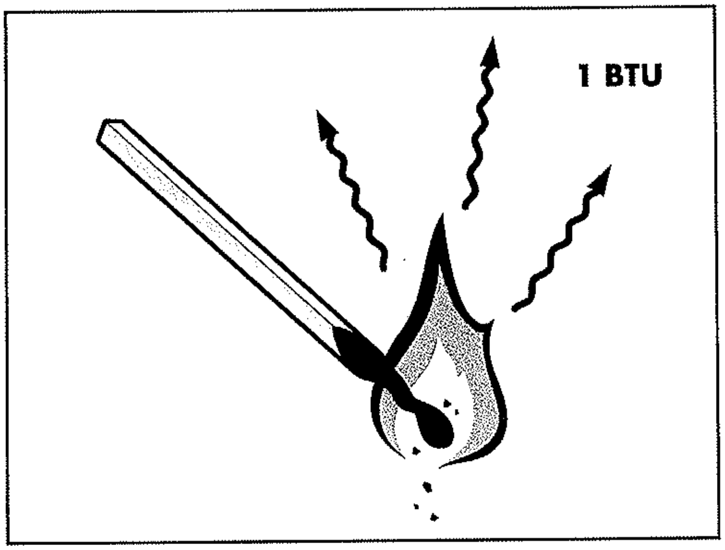
In other words, the faster the molecules are moving, the higher the temperature. Molecular structure helps explain why water boils at a high temperature. Water is capable of carrying a lot of heat. In fact, water is the material used as the basic standard for measuring quantities of heat in solids, liquids, or gases.

The standard unit used by the comfort heating industry for measuring heat is the British thermal unit or BTU.

A **BRITISH THERMAL UNIT (BTU)**, a standard unit of energy, is the exact amount of heat necessary to raise the temperature of one pound (1 lb.) of water by one degree Fahrenheit (1° F). The BTU is often used as a quantitative specification for the energy-producing or energy-transferring capability of heating and cooling systems such as furnaces, ovens, refrigerators, and air conditioners. For example, a very small apartment furnace might have a 75,000 or 100,000 BTU capacity while a big furnace for a big house might be 300,000 to 500,000 BTUs.

One BTU is approximately the amount of heat created when a kitchen match is burned. It takes 1 BTU to raise the temperature of 1 lb. water from 71° to 72° F.

LIT MATCHSTICK



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Calculating Heat Loss

In terms of comfort heating systems, we speak of *heat loss* or *calculated heat loss*. Buildings lose heat to the outdoors just as human bodies lose heat to the room and surrounding objects. Heat is required to replace the heat lost—that is to raise the temperature of the air in the building as the heat is lost and/or cold air is taken into the building.

The term **HEAT LOSS** means the rate at which heat is lost from a heated building to the outdoors. (All heating is figured on a "per hour" basis.) Heat loss is calculated in BTUs lost per hour: **BTUH**.

How much heat is lost from a building depends upon a number of conditions including:

- The temperature difference between the inside of the building and outdoors
- How much surface is exposed to the outdoors so that heat loss occurs
- The materials used in the construction of the building, including insulation
- Other weather conditions besides temperature, such as wind conditions

Design Heat Loss

The capacity of a heating system must be equal to the heat lost to the outside in order to maintain a comfortable temperature inside. In planning a heating system and in calculating the heating capacity of heating equipment needed, the design heat loss must be calculated.

DESIGN HEAT LOSS is based upon charts showing the normal low outside temperature for the specific locality in which the building to be heated is located. The term design heat loss expresses the total predicted heat loss over the heating season for a particular house design in a particular climate.

Heat loss calculation is beyond the scope of this course. The manufacturers of the heating equipment that your firm carries will provide you with charts and tables for calculating heat loss.

After calculating the total heat loss for the building, it is possible to calculate:

- how hot the water must be to provide the necessary heat.
- how much hot water, in **GALLONS PER MINUTE (GPM)**, must circulate through the pipes to carry that much heat.

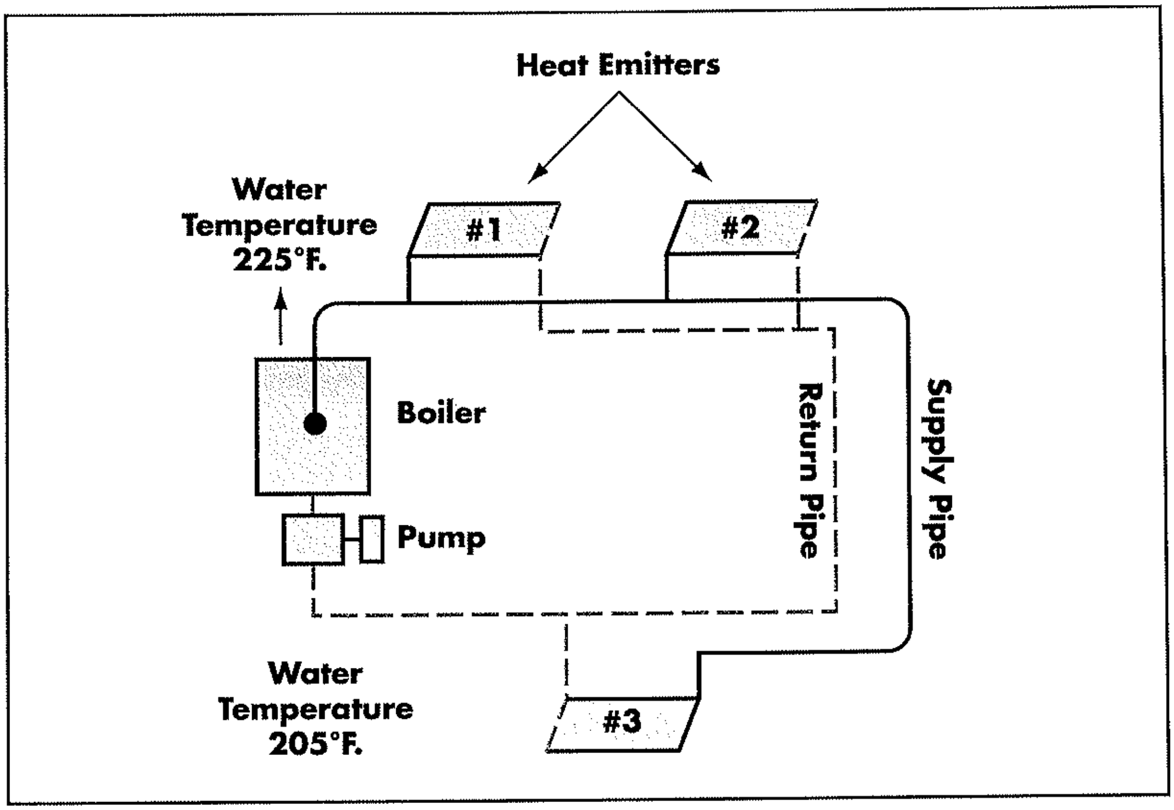
Water Temperature Difference

The water which returns to the boiler after circulating throughout the building is cooler than the water which left the boiler. The cooling of the water as it circulates in the room heating units is what heats the building.

The difference between the temperature of the water leaving the boiler and the temperature of the water returning to the boiler is called the **WATER TEMPERATURE DROP** (or Delta T or $\triangle$T). The water temperature drop is also called the *design water temperature drop* because the water temperature drop is chosen as part of the design of the heating system.

Most residential and small commercial hot water systems operate with a 20° design water drop. However, temperature drops greater than 20 degrees may be designed into hot water heating systems.

WATER TEMPERATURE DROP CYCLE



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Average Water Temperature

Although many residential hot water systems operate in the 120° to 130° Fahrenheit range, a residential or commercial heating system may operate at water temperatures higher than 212°, with a typical **maximum** of 250° F. We usually say that water boils at 212° F.

That is true, however, only if the water is under the normal atmospheric pressure conditions, such as in an open pot on the stove.

Water in the modern closed hot water heating system does NOT boil at 212° F because it is under pressure, and the system is full of water.

In calculations needed to choose heat emitters for the heating system, the figure used is the average water temperature.

The **AVERAGE WATER TEMPERATURE** is the average of the temperature of the water leaving the boiler and the water returning to the boiler when the system is operating correctly as it was designed to do.

The average water temperature is also called the *design water temperature.*

Another way of thinking of average water temperature is to remember that it is halfway between the temperature of the water leaving the boiler and the water coming back to the boiler after having completed circulation once around the building.

EXAMPLE:

Water leaving the boiler	130°F
Design temperature drop	20°F
Water returning to boiler	110°F (130° minus 20 degree temperature drop)
Average water temperature	120°F (Halfway between 130° and 110°)

- To find the halfway point: Divide the temperature drop by 2 (20 degree drop/2 = 10 degrees)
- Then subtract that figure from the temperature of the water leaving the boiler 130° F minus 10° = **120° F would be the average water temperature.**

The whole hot water heating system is designed around the average water temperature and water temperature drop. These figures tell how much heat we can get from the system.

REMEMBER:

One pound of water with a temperature drop of 1° F as it circulates produces one BTU of heat.

Therefore, if one pound of water has a temperature drop of 20° as it circulates, it gives off 20 BTUs.

We usually think about gallons, not pounds, of water circulating through the system.

- One pound of water with one degree drop = 1 BTU
- One gallon of water = 8.3 pounds
- Therefore ONE GALLON of water circulating with a temperature drop of ONE DEGREE would produce 8.3 BTUs of heat.

In a hot water heating system we do not use a gallon of water just once for heating. We continuously recirculate the hot water.

Therefore we must think in terms of continuous production of BTUs of heat.

We need to know how many BTUs are produced by so many gallons of water circulating through the system in a certain length of time, such as gallons per minute or hour.

We typically speak of BTUs per hour (BTUH).

Remember that if your flow rate is given in gallons per minute (gpm), you will have to convert gpm to gallons per hour (gph) to get BTUH.

EXAMPLE:

If a system circulated one gallon of water per minute (1 gpm) through a system with a one degree temperature drop, how many BTUs per hour (BTUH) would that produce?

8.3 BTUS PER GALLON X 60 MIN PER HOURS = 498 BTUH

Notice the above answer. The 498 BTUH is an important figure.

- 498 BTUH is the amount of heat given off by circulation through a system of one gallon of water per minute (1 gpm) with a one degree temperature drop.
- Using 498 BTUH per gallon is very awkward and requires pencil and paper or a calculator.
- Therefore, for ease of calculation, we generally round off the 498 to 500.

To calculate the number of gallons of water needed we generally say that one gallon per minute at a one degree temperature drop produces 500 BTUH.

1 GPM AT 10 DROP = 500 BTUH

REVIEW QUIZ – COMFORT HEATING PRINCIPLES *Answers appear on page 24*

DIRECTIONS: Carefully read each question and circle the correct answer. There is only one correct answer per question. When you have finished, check your answers.

1. In what direction does heat always move?
   a. From the cooler body to the warmer one
   b. From the warmer body to the cooler one
   c. From the center of a body to the outside of one
   d. From the outside of a body to the center of one

2. Most people typically feel cold when
   a. the temperature falls below 80 degrees.
   b. they perspire more than is needed to cool them.
   c. they lose heat faster than their body can develop it.
   d. the inside temperature is more than 30 degrees lower than the outside temperature.

3. A heating system which maintains living area temperatures at levels which allow body heat loss at a comfortable rate is called a
   a. comfort heating system.
   b. radiant heating system.
   c. convection heating system.
   d. conduction heating system.

4. Heat transfer by circulation of the molecules in the material (air) being heated is called
   a. radiation.
   b. conduction.
   c. convection.
   d. hydronic.

5. When a warm object touches a cold object, heat is transferred from one molecule to another in the substance being heated. What is the process called?
   a. Radiation
   b. Conduction
   c. Convection
   d. Transmission

REVIEW QUIZ – COMFORT HEATING PRINCIPLES

Answers appear on page 24

6. What is one purpose of creating the "circle of warmth" with a hot water heating system?
   a. To increase the overall heat in the residence
   b. To evenly distribute heat to every floor of the residence
   c. To replace the heat lost through the walls, floors, ceilings, doors, and windows
   d. To assure than the inside walls are warmer than the outside walls to reduce cost

7. All of the following are advantages of using natural convection currents over forced-air heating fans and ducts EXCEPT
   a. Fewer drafts
   b. More intense heat
   c. More even distribution of heat
   d. No currents to carry dirt, allergens, odors, sounds, smoke, fire

8. Why is remodeling easier with hot water heat?
   a. Hot water piping requires less space than air ducts.
   b. The temperature of the water is easily controlled to match weather conditions.
   c. The closed piping system delivers heat more efficiently over long distances.
   d. The traditional hot water piping system has no ducts and is easily used with conventional air conditioning systems.

9. All of the following conditions affect actual heat loss EXCEPT
   a. Temperature difference
   b. Outside surface exposure
   c. Construction materials of the building
   d. Zoning restrictions in the residential area

REVIEW QUIZ – COMFORT HEATING PRINCIPLES *Answers appear on page 24*

10. What is meant by the term Delta T?
    a. The average of the temperature of the water leaving and the temperature of the water returning to the boiler
    b. The increase in the temperature of the water leaving and the temperature of the water returning to the boiler
    c. The difference in temperature between the water leaving boiler and the water returning to boiler
    d. The daily average of the temperature of the water in the boiler and hydronic heating system

11. What is the most common water temperature drop for a residential system?
    a. 20 degrees
    b. 25 degrees
    c. 30 degrees
    d. 35 degrees

12. What would be the average water temperature if the water leaves the boiler at 128° and has a 20 degree temperature drop?
    a. 108° F average water temperature
    b. 118° F average water temperature
    c. 120° F average water temperature
    d. 128° F average water temperature

13. How many BTUs would be given off if 2 lbs. of water circulated with a 20° drop?
    a. 20 BTUs
    b. 30 BTUs
    c. 40 BTUs
    d. 50 BTUs

14. How many BTUs would be produced if one gallon of hot water were circulated through the system with a 20° temperature drop?
    a. 100 BTUs
    b. 120 BTUs
    c. 166 BTUs
    d. 176 BTUs

REVIEW QUIZ – COMFORT HEATING PRINCIPLES

Answers appear on page 24

15. How many BTUs would be produced if two gallons were circulated with a 15° drop?
    a. 149 BTUs
    b. 230 BTUs
    c. 249 BTUs
    d. 259 BTUs

16. If a system circulated one gallon of water PER MINUTE (1 gpm) through a system with a one degree temperature drop, how many BTUs PER HOUR (BTUH) would that produce?
    a. 198 BTUH
    b. 298 BTUH
    c. 398 BTUH
    d. 498 BTUH

17. How many BTUH would result from circulating seven gallons per minute (7 gpm) through a system with a 20° temperature drop?
    a. 49, 720 BTUH
    b. 59,720 BTUH
    c. 69,720 BTUH
    d. 70,000 BTUH

18. With a 20° temperature drop, how many BTUH would one gpm produce?
    a. 5,000 BTUH
    b. 10,000 BTUH
    c. 15,00 BTUH
    d. 18,000 BTUH

19. What are the two most common kinds of comfort heating systems in use today?
    a. Convection and conduction
    b. Hydronic and radiant
    c. Hydronic and hot air
    d. Forced air and radiant

20. Why are hot water systems often used for apartment buildings and colleges?
    a. The closed piping system delivers heat more efficiently over long distances.
    b. The temperature is easier to control to match weather conditions.
    c. The hot water piping requires less space than air ducts.
    d. The traditional hot water piping system has no ducts.

REVIEW QUIZ – COMFORT HEATING PRINCIPLES

Answers appear on page 24

APPLYING WHAT YOU HAVE LEARNED:

By observing and asking questions, fill in the blanks. If you are not sure of the answers, ask your supervisor.

A. List at least three types of heating systems that your company sells.

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B. List at least three advantages of traditional hot water systems that your company would explain to its customers.

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ANSWERS TO REVIEW QUIZ

CHAPTER 1

INTRODUCTION TO COMFORT HEATING PRINCIPLES

Answers for INTRODUCTION TO COMFORT HEATING PRINCIPLES (pages 17 – 21)

1. b. From the warmer body to the cooler one
2. c. They lose heat faster than their body can develop it.
3. a. comfort heating system.
4. c. convection.
5. b. Conduction
6. c. To replace the heat lost through the walls, floors, ceilings, doors, and windows
7. b. More intense heat
8. a. Hot water piping requires less space than air ducts.
9. d. Zoning restrictions in the residential area
10. c. The difference in temperature between the water leaving boiler and the water returning to boiler
11. a. 20 degrees
12. b. 118° F average water temperature
13. c. 40 BTUs
14. c. 166 BTUs (8.3 BTUs per gallon x 20° drop)
15. c. 249 BTUs (8.3 x 2 x 15)
16. d. 498 BTUH (8.3 BTUs per gallon x 60 min. per hour)
17. c. 70,000 BTUH (500 BTUH/gallon x 7 gallons x 20 degrees)
18. b. 10,000 BTUH (20 x 500)
19. c. Hydronic and hot air
20. a. The closed piping system delivers heat more efficiently over long distances.

Applying what you have learned:

A. Depends on the company

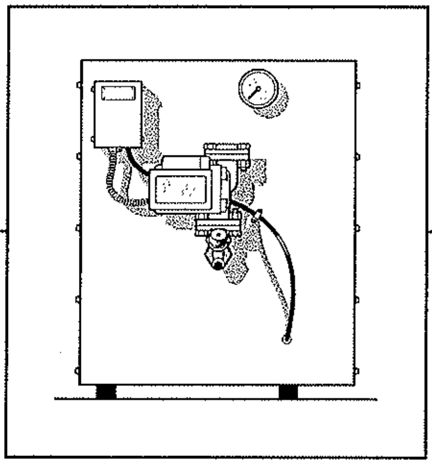
B. Depends on the company

2 INTRODUCTION TO BOILERS AND TANKS

LEARNING OBJECTIVES

When you finish this Chapter, you will be able to:

1. Describe the parts of a hot water heating system.
2. Explain how various types of boilers are used to heat water.
3. Discuss the Department of Energy (DOE) rating program and analyze the department's three different kinds of ratings: the input rating, the DOE heating capacity, and the net rating.
4. Summarize the operation of the two types of thermal expansion tanks: the conventional tank and the diaphragm tank.



BOILERS AND TANKS

Overview of Boilers

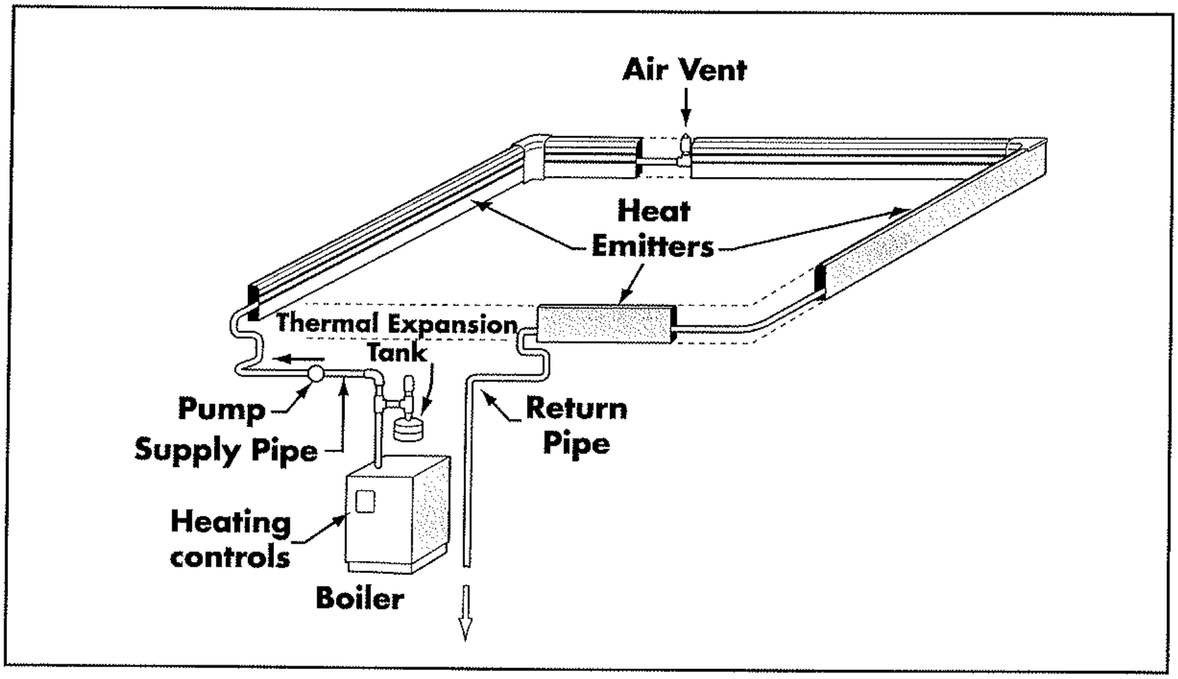
The parts that make up a hot water comfort heating system will be discussed in this section. How the system components are sized will be included.

The building for which the heating system is designed will determine the specific kinds and sizes of the system components. But all systems must have certain basic components.

Parts of a hot water heating system are:

- The boiler which heats the water
- The burner, if separate from the boiler
- The thermal expansion tank attached to boiler
- The booster pump(s) or circulator to circulate water
- The piping system through which the water moves
- The **RADIATION** (heat emitters in various forms such as radiators, radiant panels, and baseboard units) which transmit the heat from the water into the air of the rooms to be heated
- Various accessories, called **HYDRONIC SPECIALTIES**, to improve the performance of the system
- Heating controls to operate and regulate the system

HOT WATER HEATING SYTEM



SP 4.2.01

Boiler Basics

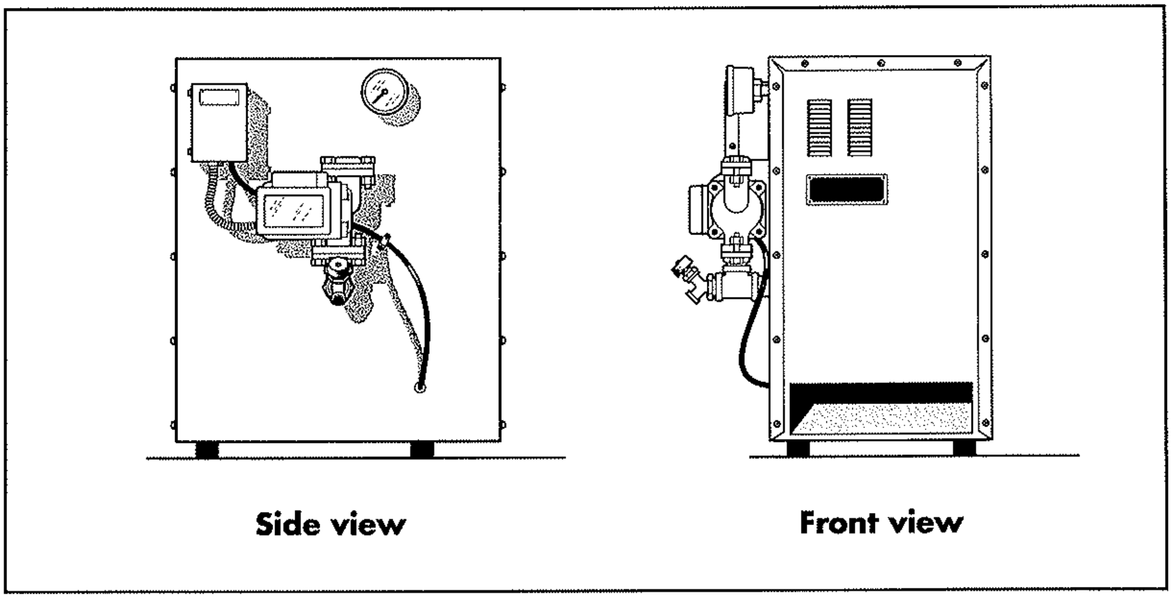
The hot water from the boiler circulates through the distribution piping system to the radiation components (radiators, baseboard units, radiant panels) which distribute the heat to desired areas.

The amount of heat provided by the heating system depends upon the temperature of the water as it leaves the boiler, the amount of water circulating, and the construction and design of the system itself.

The part of the heating system which provides the heat is called the boiler. A **BOILER** is a closed pressurized container in which a liquid is heated. The operating parts of the boiler are generally enclosed in an attractive cabinet for a residential boiler.

The code regulating construction of boilers is the **AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)** code. Local codes usually are modeled after the ASME code.

BOILERS



SP 4.2.02

Residential boilers may be powered by gas, fuel oil, or electricity. Commercial or industrial boilers sometimes use wood or coal.

By ASME code, boilers must be made of cast iron, steel, or copper.

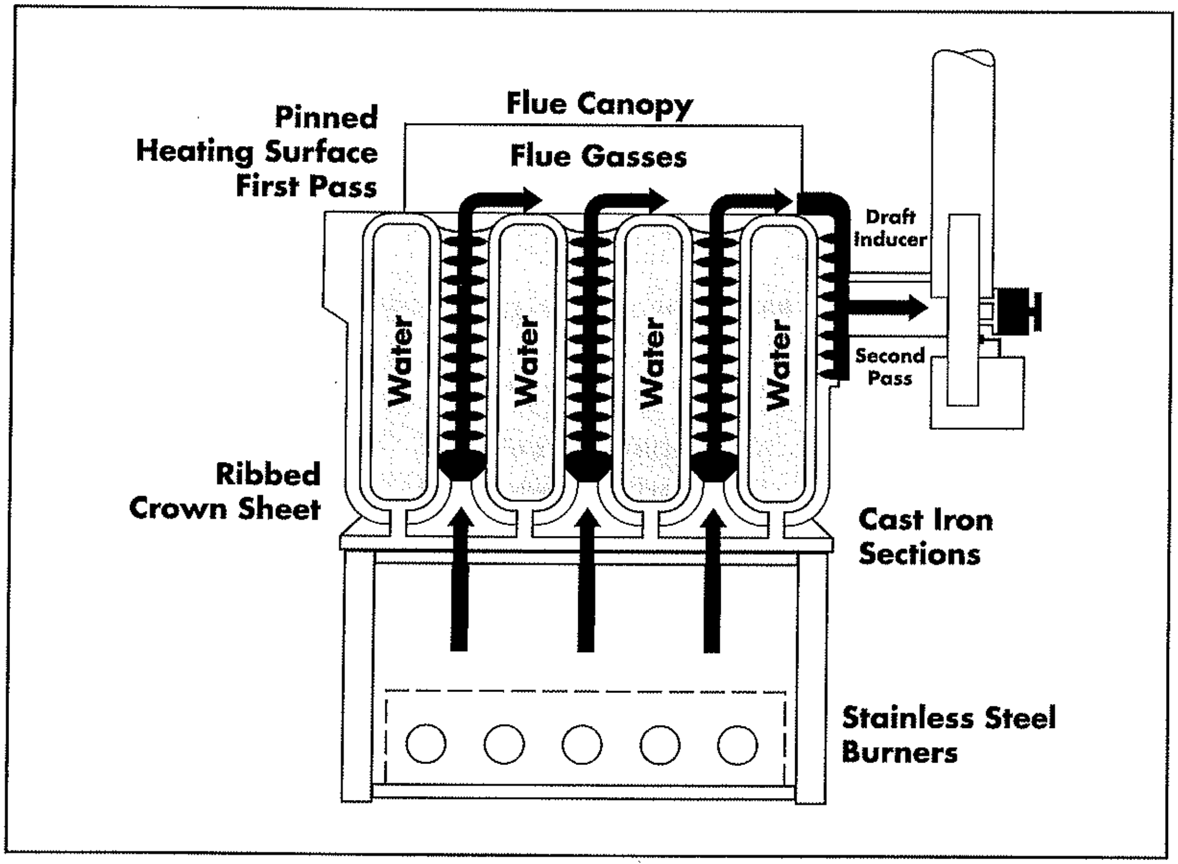
Hot water boilers for most homes or small commercial buildings are designed to operate at a maximum pressure of 30 **POUNDS PER SQUARE INCH (PSI)** or 30 psi and at temperatures of no higher than 250° F.

Types of Boilers

Boilers may heat the water in one of several different ways.

- A **WATER TUBE BOILER** is basically a steel shell with tubes inside. The water runs through these tubes, which are surrounded by hot flue gases. The gases heat the water.
- A **FIRE TUBE BOILER** reverses the process. The tubes contain the hot flue gases and the water surround the hot tubes.
- An **ELECTRIC BOILER** uses electric heating elements (insulated to prevent short circuits) inside the water tank to heat the water.
- A **CAST IRON BOILER** is composed of several cast iron sections which contain the water. Hot gases move vertically between these sections.
- A **FLASH BOILER** has a copper-finned heat exchanger mechanism containing some water. The heat exchanger is surrounded by hot flue gases.
- A **CONDENSING BOILER** uses all the energy created by combustion by capturing the heat from the exhaust, through condensing the moisture in the exhaust gas. To work, the return water must be lower than the exhaust gas dew point (less than 136° F).

CAST IRON BOILER



SP 4.2.03

Boiler Ratings

Boilers for residential use must conform to a rating program sponsored by the **DEPARTMENT OF ENERGY (DOE)**. Under this program, boilers are given three different kinds of ratings: the input rating, the DOE heating capacity, and the net rating.

The **INPUT RATING** indicates the amount of heat energy from fuel put into the boiler.

This rating is generally given in thousands of BTUs per hour using the abbreviation "BTUH" or using the abbreviation "MBH."

ONE MBH = 1000 BTUH

The "M" refers to the prefix "mil" which means "thousand" as in "millennium" meaning a thousand years.

"B" refers to BTUs; "h" refers to hour.

To convert **MBH** to **BTUH**:

Multiply the MBH by 1000 by moving the decimal point 3 places to the *right*.

EXAMPLES:

25.5 MBH = 25,500 BTUH
48.0 MBH = 48,000 BTUH

To convert BTUH to MBH:

Divide the MBH by 1000 by moving the decimal point 3 places to the left.

EXAMPLES:

25,500 BTUH = 25.5 MBH
48,000 BTUH = 48.0 MBH

If boiler burns 1 gallon of fuel oil which provides 140,000 BTUH of heat, then the input rating would be 140,000 BTUH (140 MBH).

Rating charts will show this in one of three ways:

1 gph (gallon of oil per hour)

OR

140,000 BTUH

OR

140 MBH

The second rating is the **DOE HEATING CAPACITY**. This rating refers to the actual amount of heat available for distribution through the piping system to heat the building. Technically, this figure is the amount of heat generated minus the amount of heat lost up the smoke stack/chimney. This rating is also measured in BTUH or MBH. For larger boilers, this is called *output* or *gross output*.

The third rating is the **NET RATING**. This figure, also in BTUH or MBH, indicates the amount of heat available at the radiation (baseboard heat emitters, radiant panels, radiators) after theoretical allowances for heat lost in piping and pickup from cold starts.

This figure may be shown on the chart as "I=B=R net water rating" or "net water rating."

I=B=R stands for Institute of Boiler and Radiator Manufacturers, a function of the Hydronics Institute, which is the organization that tests and rates boilers and other hydronic equipment. All boilers rated by I=B=R have ASME approval.

The net rating is more important than heating capacity when choosing a boiler.

The net rating is the MOST important rating used when selecting the proper size boiler.

To properly select a boiler, the calculated heat loss of the building or area to be heated must be known. The net rating of the boiler chosen must be **at least as great as** the heat loss of the area to be heated.

For example, if the building heat loss is figured at 35,000 BTUH, the net rating of the boiler must be at least 35,000 BTUH.

Look at the sample boiler rating chart below.

MODEL A BOILER RATINGS

Boiler Model Number	Input (MBH)	DOE Heating Capacity (MBH)	I=B=R Net Rating (MBH)	AFUE% (Annual Fuel Utilization Efficiency)
A3	62	52	45	85%
A4	96	81	70	84%
A5	130	108	94	83%
A6	164	137	119	83%

In addition to the three ratings already mentioned above, the U.S. Department of Energy requires that manufacturers provide consumers with efficiency ratings, much like the auto industry's Estimated Miles Per Gallon.

These boiler efficiency figures are calculated estimates called the **ANNUAL FUEL UTILIZATION EFFICIENCY (AFUE)**. These figures may also be shown on charts with the heading "DOE Seasonal Efficiency."

The AFUE figures are given in percentages (%) to help consumers determine which boilers are more efficient in fuel usage. Higher percentages indicate more efficient boilers.

The Federal Trade Commission requires that a fact sheet showing comparative AFUEs must be available (upon request) from the wholesaler for every residential model sold (see chart above).

Boiler Requirements

All hot water boilers must be fitted with a **SAFETY RELIEF VALVE** to relieve excess pressure. At a predetermined pressure the valve opens and discharges water at a rate which will prevent further buildup of pressure. The safety relief valve is sometimes called a *pressure relief valve.*

All safety relief valves must be rated and installed according to the *ASME Boiler and Pressure Vessel Code.*

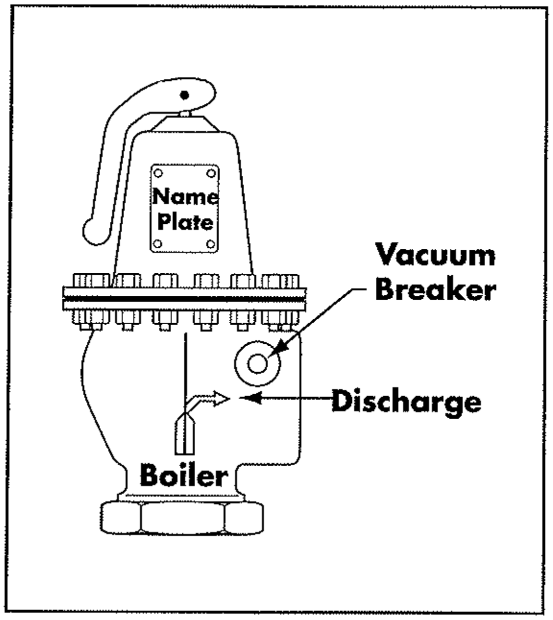
ASME also requires that all hot water boilers have a combination temperature and pressure gauge called a **BOILER GAUGE.**

The temperature reading tells the water temperature in the boiler.

The pressure reading shows pressure in the boiler when the system is filled with **cold water**, and then it shows the higher pressure when the water is heated.

The pressure in the boiler must be great enough for effective operations, but not greater than the maximum pressure for which the boiler is rated.

BOILER SHOWING SAFETY RELIEF VALVE



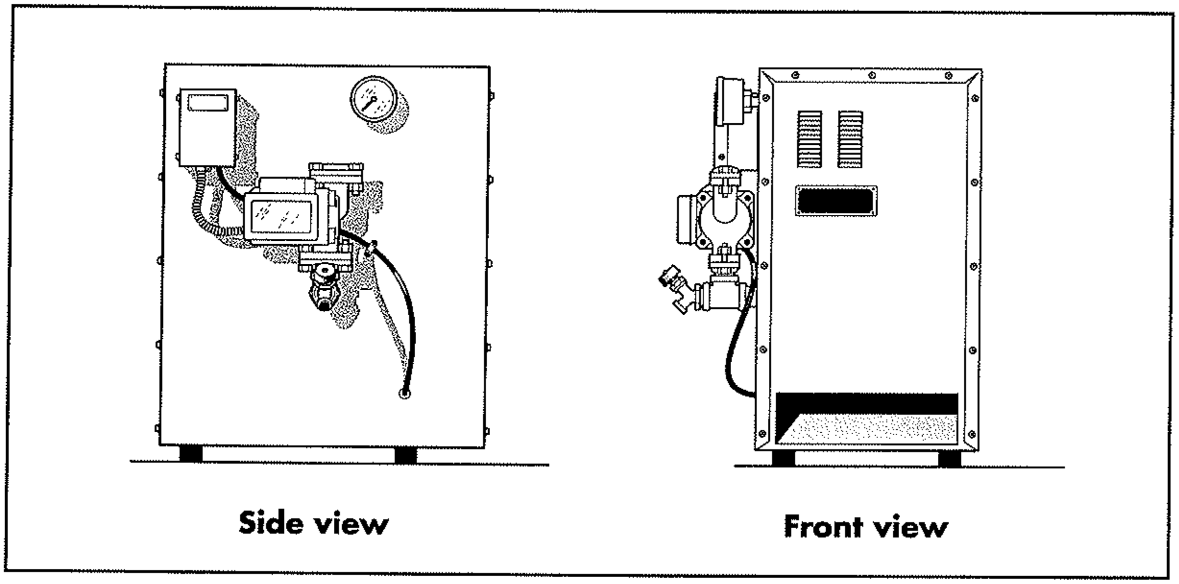
SP 4.2.04

A boiler may be purchased separately—without burner or controls—or as a packaged boiler.

A **PACKAGED BOILER** is pre-assembled with burner, controls, and possibly the booster pump. The boiler is ready for hookup to piping system, fuel line, and wiring.

Check your manufacturer's catalog to find out what the boiler packages offered there include.

BOILERS



SP 4.2.05

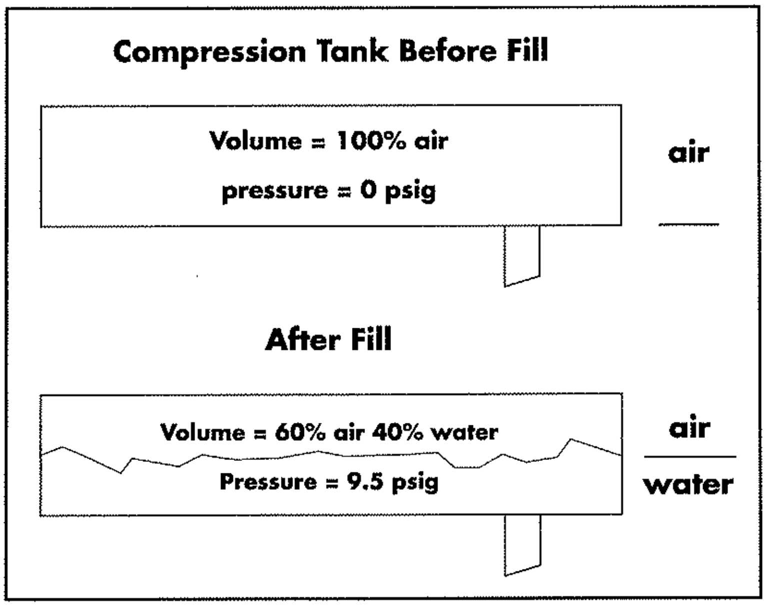
Overview of Tanks

The water in the system expands as it is heated. To allow for this expansion, some type of tank is used to hold the extra water. In the past an open expansion tank was used.

Now it is more common to use a **THERMAL EXPANSION TANK**, also called a *compression tank* or a *closed expansion tank*.

As the water expands up into the tank, the cushion of air is compressed. This compression of the air also helps maintain proper pressure in the system.

THERMAL EXPANSION TANK



SP 4.2.05a

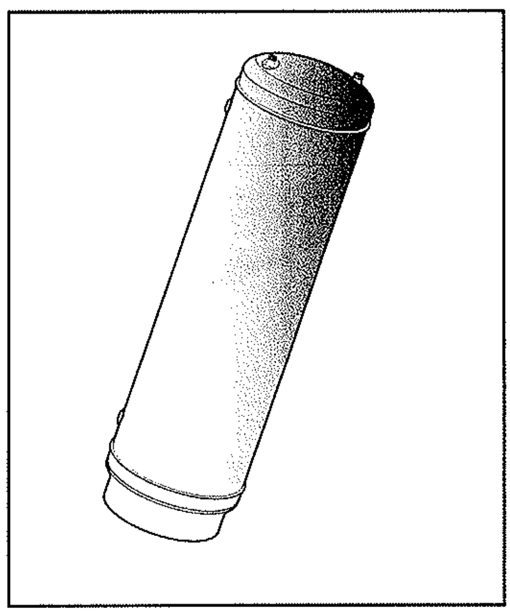
Types of Thermal Expansion Tanks

There are two types of thermal expansion tanks: the conventional tank and the diaphragm tank.

The **CONVENTIONAL THERMAL EXPANSION TANK** is a tank containing a cushion of air which allows the water to expand into the tank from the system. As the heated water expands, the cushion of air is compressed.

The conventional tank has no separating device between the air and the water and eventually the water will absorb some of

THERMAL EXPANSION TANK



SP 4.2.06

the air. If too much air is absorbed, the tank becomes waterlogged and must be recharged with air in order to maintain air space for the water to expand and to maintain proper working pressure.

Waterlogging may also occur if air leaks out of the tank if the proper air control fittings are not properly installed. Various air control fittings are available for use with compression tanks.

If your firm sells conventional thermal expansion tanks, consult your manufacturer's catalogs regarding air control fittings.

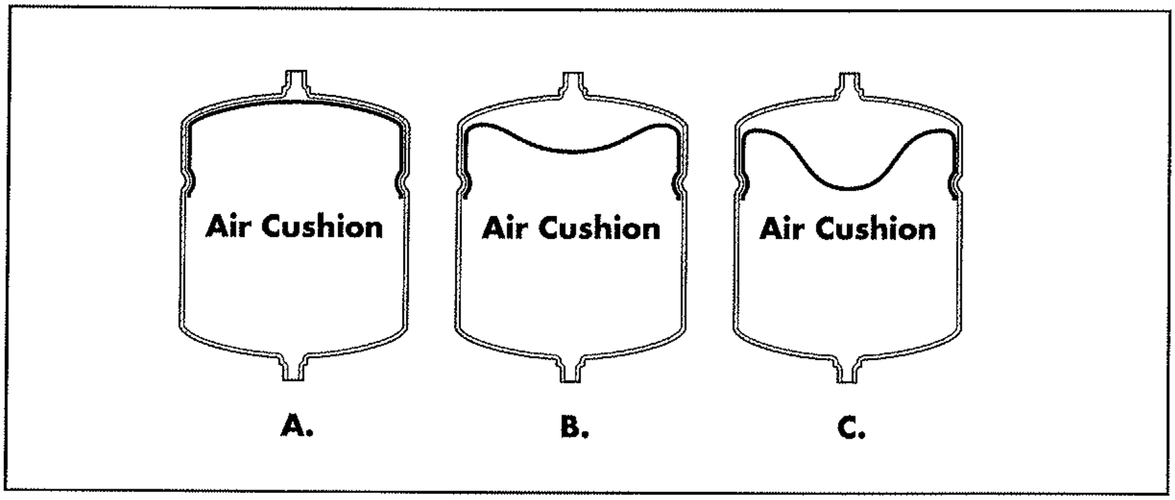
The second type of thermal extansion tank is the **DIAPHRAGM** or **BLADDER EXPANSION TANK** which has a flexible diaphragm separating the water from the air so that air can not be absorbed by the water. This prevents waterlogging.

The diaphragm thermal expansion tank comes from the factory precharged with air. When the tank is first installed near the boiler, the air pressure keeps the diaphragm pushed against the inside of the tank (Position A).

As the heating system is filled, some water flows into the air cushion tank (Position B).

As the water becomes heated, it expands and presses against the diaphragm, which flexes and allows the expanding water to compress the air cushion to allow for the expansion of the water. The heated water in the system expands and some flows into the tank (Position C).

DIAPHRAGM TANK



SP 4.2.07

The tank must be properly sized for the boiler and the system.

It is important to follow the instructions and charts provided by the manufacturers for sizing.

Look at the following hypothetical sizing chart.

TANK SIZING CHART

Fill Pressure 12 psi Relief Pressure 30psi Average System Temperature 125° F				
Boiler Net Output	Type of Radiation			
1000s of BTUH	Finned Tube Baseboard or Radiant Panel	Convectors	Radiators Cast Iron	Baseboard Cast Iron
25	A15	A15	A15	A15
50	A15	A15	B30	B30
75	B30	B30	B30	C60
100	B30	B30	C60	C60

The left column lists boiler output in thousands of BTUH. The letter-number combinations are the tank model numbers.

When the system is filled with fresh water, that water contains some air. As the water heats, some of this air is released.

If the released air gets into the main piping system, it causes the system to make noise or gurgle. If too much air gets into the system, the flow of hot water can be slowed or stopped.

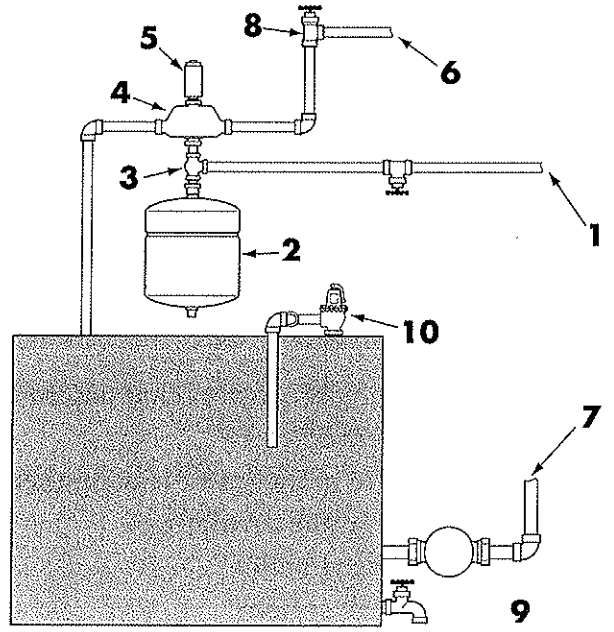
The only place in the system where there **should be** air is in the tank. Therefore, various forms of air control fittings are available for attachment to the tank and/or the boiler.

AIR CONTROL FITTINGS are boiler or tank fittings designed to prevent the air from getting into the main piping system and to direct the air into the air cushion tank.

Air control fittings frequently come as part of a package with a packaged boiler or an air cushion tank. Check your manufacturer's catalog to find the appropriate fittings.

HYDRONIC HEATING SYSTEM

1. **Water Supply**
2. **Air Cushion Tank**
3. **Automatic Fill Valve**
4. **Air Purger**
5. **Float Vent**
6. **System Supply Main**
7. **System Supply Main**
8. **Flow Check**
9. **Circulating Pump**
10. **Relief Valve**



SP 4.2.08

REVIEW QUIZ – BOILERS AND TANKS

Answers appear on page 44

DIRECTIONS: Carefully read each question and circle the correct answer. There is only one correct answer per question. When you have finished, check your answers.

1. All of the following are parts a hot water comfort heating system EXCEPT
   a. Boiler
   b. Thermal expansion tank
   c. Booster pump
   d. Pump curve

2. All of the following are factors that determine how much heat is provided by the heating system EXCEPT
   a. Temperature of the water leaving the boiler
   b. Amount of water circulating
   c. Location of the boiler
   d. Design of the system

3. Residential boilers may use any of the following fuels to heat water EXCEPT
   a. Diesel oil
   b. Gas
   c. Fuel oil
   d. Electricity

4. What are the maximum operating pressure and the maximum water temperature for most residential hot water boilers?
   a. 20 psi and 250° F
   b. 30 psi and 250° F
   c. 30 psi and 200° F
   d. 35 psi and 300° F

5. The DOE input rating refers to the amount of
   a. heat energy circulating in the system.
   b. heat available to heat the building.
   c. heat energy (from fuel) put into the boiler.
   d. heat available at the radiation to heat the rooms.

REVIEW QUIZ – BOILERS AND TANKS

Answers appear on page 44

6. What is the important rating used in selecting a boiler?
   a. Net rating
   b. Heating capacity
   c. Input rating
   d. Boiler rating

7. The purpose of the AFUE is to
   a. write the code for boiler construction.
   b. provide ratings for various hydronic products.
   c. develop a system to test heat emission of boilers.
   d. help consumers estimate efficiency in fuel usage.

8. According to the rating chart below, if a house had a heat loss of 100,000 BTUH, which would the best model boiler for that house?

MODEL A BOILER RATINGS

Boiler Model Number	Input (MBH)	DOE Heating Capacity (MBH)	I=B=R Net Rating (MBH)	AFUE% (Annual Fuel Utilization Efficiency)
A3	62	52	45	85%
A4	96	81	70	84%
A5	130	108	94	83%
A6	164	137	119	83%

a. Model A3
b. Model A4
c. Model A5
d. Model A6

REVIEW QUIZ – BOILERS AND TANKS

Answers appear on page 44

9. In which type of boiler has a copper-finned heat exchanger containing some water surrounded by hot flue gases?
   a. Water tube boiler
   b. Flash boiler
   c. Fire tube boiler
   d. Electric boiler

10. What is the BTUH rating if a boiler has an input rating of 120 MBH?
    a. 120 BTUH
    b. 1,200 BTUH
    c. 12,000 BTUH
    d. 120,000 BTUH

11. What are the two purposes of the air control fittings?
    a. to allow for the expansion of the water as it heats and to maintain pressure in the system.
    b. to keep air out of the main piping system and direct it into the air cushion tank.
    c. to separate the water from the air and prevent the air from being absorbed by the water.
    d. to allow for the expansion of the water and prevent the water from being absorbed.

12. Which measurement does a boiler gauge show?
    a. Amount of air and water in boiler
    b. Water temperature and pressure in boiler
    c. Efficiency rating of boiler
    d. Estimated amount of heat loss in boiler

13. Why does an expansion tank become waterlogged?
    a. The air may leak out of the tank or too much air is absorbed into the water.
    b. The diaphragm prevents the air from being absorbed by the water.
    c. The pressure in the boiler is greater than the maximum pressure for which the boiler is rated.
    d. The valve opens and discharges water at a rate which prevents further buildup of pressure.

REVIEW QUIZ – BOILERS AND TANKS

Answers appear on page 44

Use the hypothetical sizing chart below to answer Questions 14 and 15. The left column lists boiler output in thousands of BTUH. The letter-number combinations are the tank model numbers.

TANK SIZING CHART

Fill Pressure 12 psi Relief Pressure 30psi Average System Temperature 125° F				
Boiler Net Output	Type of Radiation			
1000s of BTUH	Finned Tube Baseboard or Radiant Panel	Convectors	Radiators Cast Iron	Baseboard Cast Iron
25	A15	A15	A15	A15
50	A15	A15	B30	B30
75	B30	B30	B30	C60
100	B30	B30	C60	C60

14. If boiler output is 75,000 BTUH and you are using cast iron baseboard emitters, what model tank would you use?
    - a. Either Model A15 or B30
    - b. Model A15
    - c. Model B30
    - d. Model C60

15. If boiler output is 50,000 BTUH and you are using finned tube baseboard emitters, what model would you use?
    - a. Either Model A15 or B30
    - b. Model A15
    - c. Model B30
    - d. Model C60

REVIEW QUIZ – BOILERS AND TANKS

Answers appear on page 44

APPLYING WHAT YOU HAVE LEARNED:

By observing and asking questions, fill in the blanks. If you are not sure of the answers, ask your supervisor.

A. List at least three types of heating systems that your company sells.

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B. List at least three advantages of traditional hot water systems that your company would explain to its customers.

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ANSWERS TO REVIEW QUIZ

CHAPTER 2

INTRODUCTION TO BOILERS AND TANKS

Answers for INTRODUCTION TO BOILERS AND TANKS (pages 38 – 42)

1. d. Pump curve
2. c. Location of the boiler
3. a. Diesel oil
4. b. 30 psi and 250° F
5. c. heat energy (from fuel) put into the boiler.
6. a. Net rating
7. d. help consumers estimate efficiency in fuel usage.
8. d. Model A6
9. b. Flash boiler
10. d. 120,000 BTUH
11. b. To keep air out of the main piping system and direct it into the air cushion tank.
12. b. Water temperature and pressure in boiler.
13. a. The air may leak out of the tank or too much air is absorbed into the water.
14. d. C60
15. b. A15

Applying what you have learned:

A. Depends on the company

B. Depends on the company

3 INTRODUCTION TO PIPING AND RADIATION

LEARNING OBJECTIVES

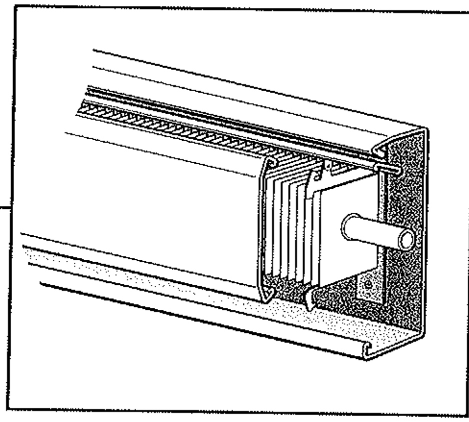
When you finish this Chapter, you will be able to:

1. Discuss the four common types of piping systems used in hot water heating systems.

2. Compare and contrast radiation, convection, and conduction.

3. Explain how the importance of the "circle of warmth" in a heating system.

4. Describe the uses of hot water heating systems.



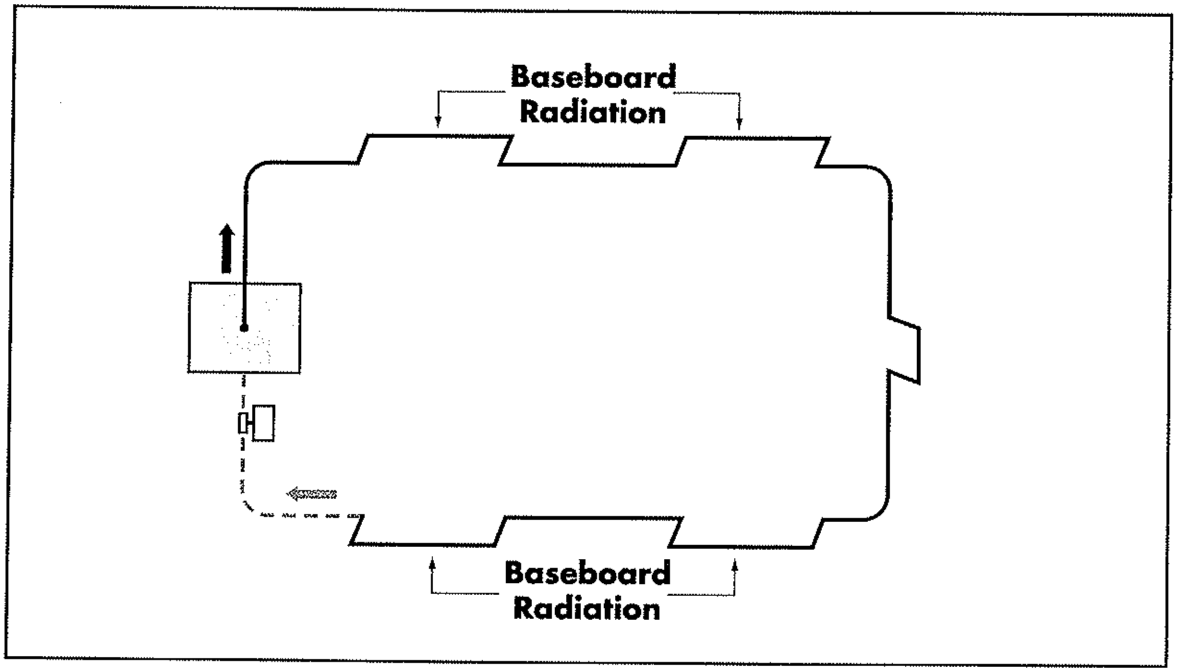
PIPING AND RADIATION

Overview of Piping

After the heat loss has been determined for individual rooms and for the whole building, the system designer draws up a **PIPING LAYOUT**, to scale, showing the location of the boiler and all the heat emitters and the piping arrangement which will connect the boiler and the heat emitters. From this drawing an accurate measurement of pipe lengths can be made.

In a piping layout, the **SUPPLY PIPE**, which supplies hot water to the emitters from the boiler, is often shown with a solid line. The **RETURN PIPE**, which returns cooled water to the boiler is often shown by a broken line.

PIPING LAYOUT



SP 4.3.01

There are four common types of piping systems used in hot water heating systems: (1) series loop systems, (2) one-pipe systems, (3) two-pipe systems, and (4) radiant panel systems.

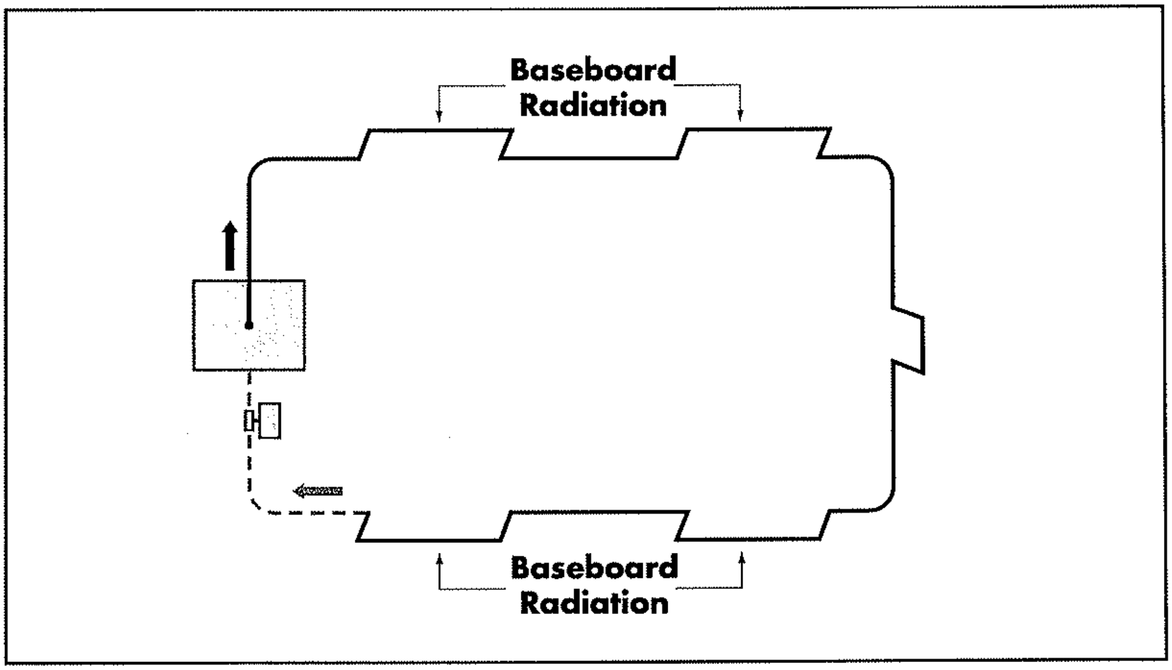
Series Loop Piping System

The most common system in use in houses and small buildings is the series loop system.

The **SERIES LOOP PIPING SYSTEM** uses one continuous loop with all the heat emitters (usually baseboard) making up parts of the loop. All the water flows from the boiler through the supply side of the pipe, then through each heat emitter in the series, and finally through the return side of the pipe to the boiler.

Because there is no large main pipe with feeder pipes attached, the series loop system is sometimes called a *mainless system*.

SERIES LOOP PIPING SYSTEM



SP 4.3.02

The major advantage of the series loop piping system is that it is considerably less expensive than other types of systems because it requires less pipe, fewer fittings, and less labor to install it.

However there are two possible drawbacks to the series loop system:

1. It is not possible to control the amount of, or the temperature of, water flowing through one or a few emitters without affecting the whole system. For that reason, dampers are installed on the emitters to help in controlling the amount of heat given out.

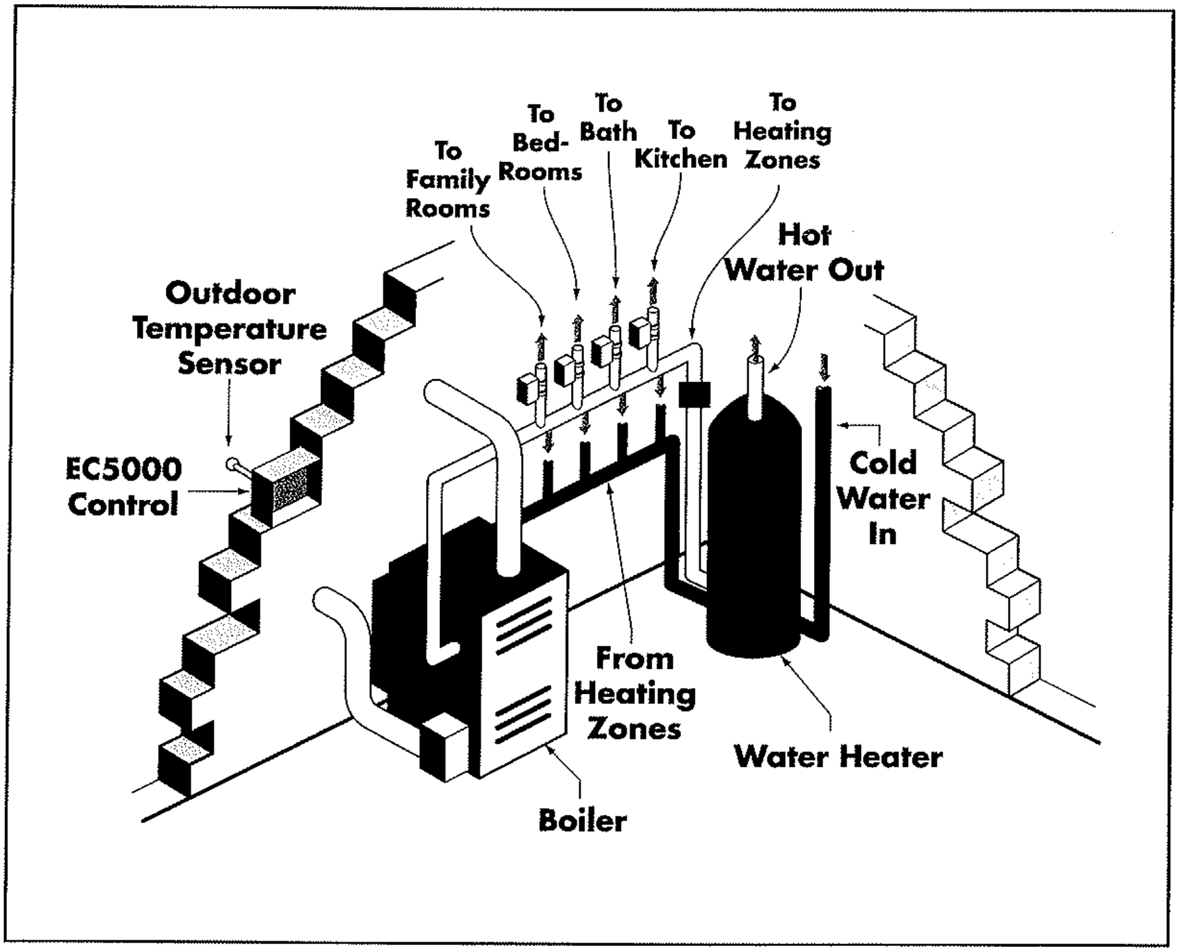
2. The diameter of the water tubes in the baseboard heat emitters limits the amount of water that can flow through the whole system, since all of the water flows through all of the heat emitters. Therefore, the amount of heat available is limited because of the limits on water flow.

However, for small buildings, the lower cost of the series loop outweighs the disadvantages. Also, the drawbacks of the series loop can be overcome somewhat by dividing the series loop into several separate circuits or zones for better control of water flow and temperature.

One complete pipe loop between the supply main and the return main of the boiler is called a **CIRCUIT**. A series loop may have several circuits.

If a system uses more than one thermostat, each section which has its own thermostat is called a **ZONE**.

BOILER AND WATER HEATER



SP 4.3.03

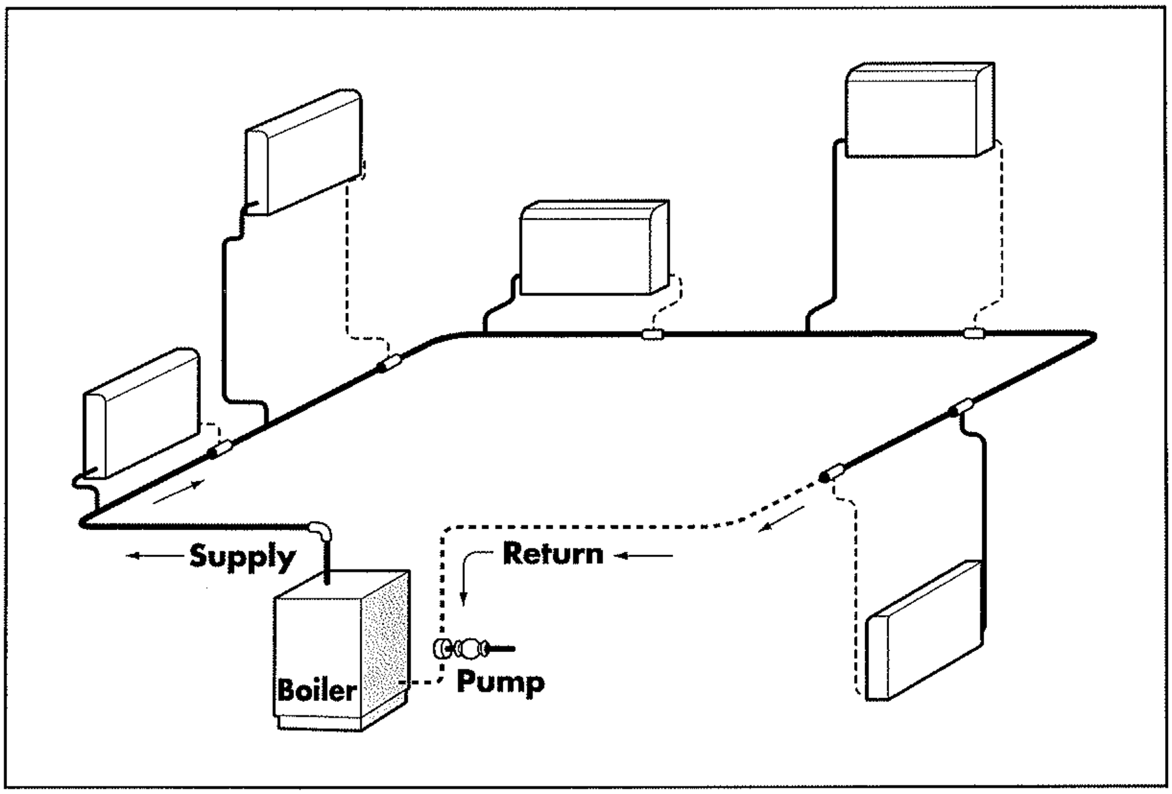
Using multiple circuits and/or multiple zones in a series loop system increases the ability to control the amount of heat available in each section and allows the system to carry more heat than a single loop of pipe.

One-Pipe System

The second most common piping system in small buildings is the **ONE-PIPE SYSTEM**.

A one-pipe system or *monoflow system* uses one continuous pipe, called a **MAIN**, making a loop from the supply side to the return side of the boiler. Each heat emitter is connected to the main by two branch pipes called **RISERS**.

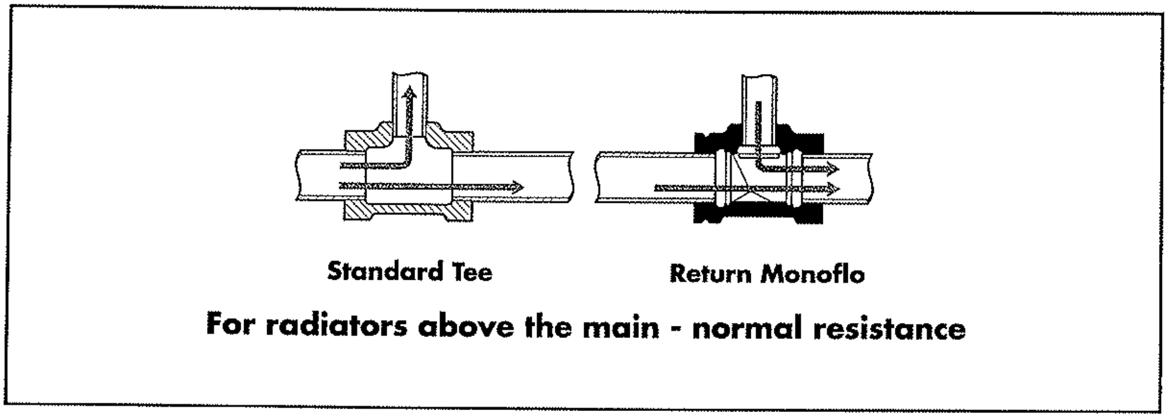
ONE PIPE FORCED AIR HOT WATER HEATING SYSTEM



SP 4.3.04

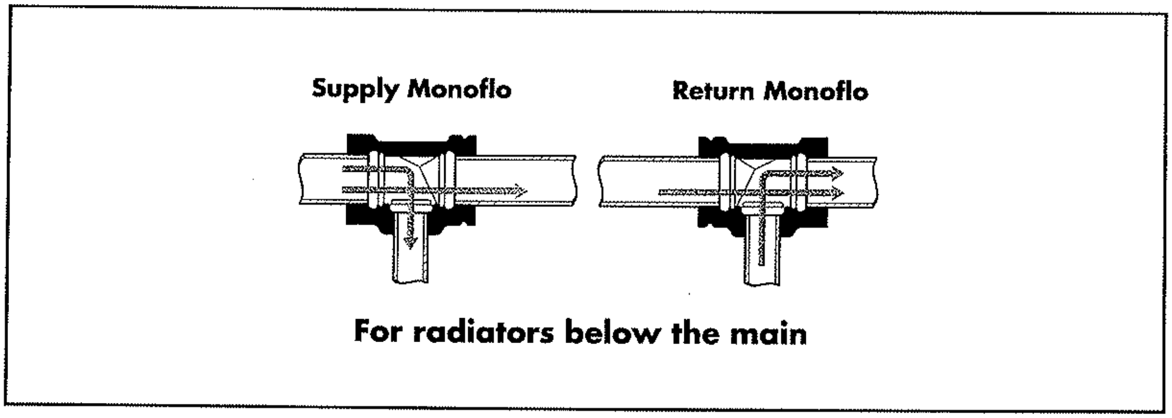
One riser is the supply riser and the other is the return riser. The risers must be connected to the main with special tees, called **ONE-PIPE FITTINGS**, which divert some of the water from the main into the heat emitters.

UPFEED SYSTEM



SP 4.3.05

DOWNFEED SYSTEM



SP 4.3.06

If the heat emitter units are above the main, called an **UPFEED SYSTEMS**, one of the special fittings is required. In a **DOWNFEED SYSTEM**, two one-pipe fittings are needed.

Various manufacturers make one-pipe fittings. Consult your manufacturer's catalog regarding use and sizing of one-pipe fittings.

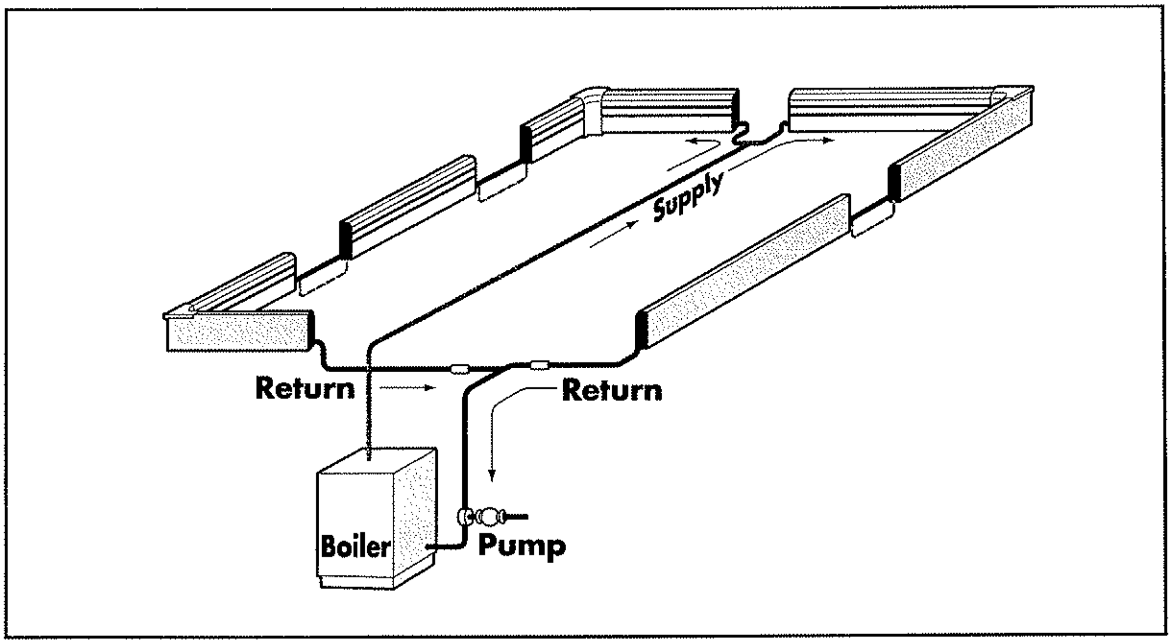
One-pipe systems have an advantage over series loop systems because the amount of heat to each room can be controlled by using a **BALANCING VALVE** on the riser to regulate hot water flow.

However, the additional piping, pipe and installation costs may make the one-pipe system more expensive than the series loop.

Like a series loop system, the one-pipe system may use multiple circuits. A **MULTIPLE CIRCUIT SYSTEM** uses more than one complete loop of pipe to connect heat emitters and boiler.

Multiple circuits may provide better control over the amount of heat delivered. Multiple circuits are necessary where a single long run of small diameter piping may develop more internal friction than the pump may overcome.

SERIES LOOP BASEBOARD SYSTEM



SP 4.3.07

Two-Pipe System

In commercial buildings and older homes, a two-pipe system may be used. In a **TWO-PIPE SYSTEM**, one main carries heated water from the boiler to the emitters but a second main carries cooled water from the emitters back to the boiler.

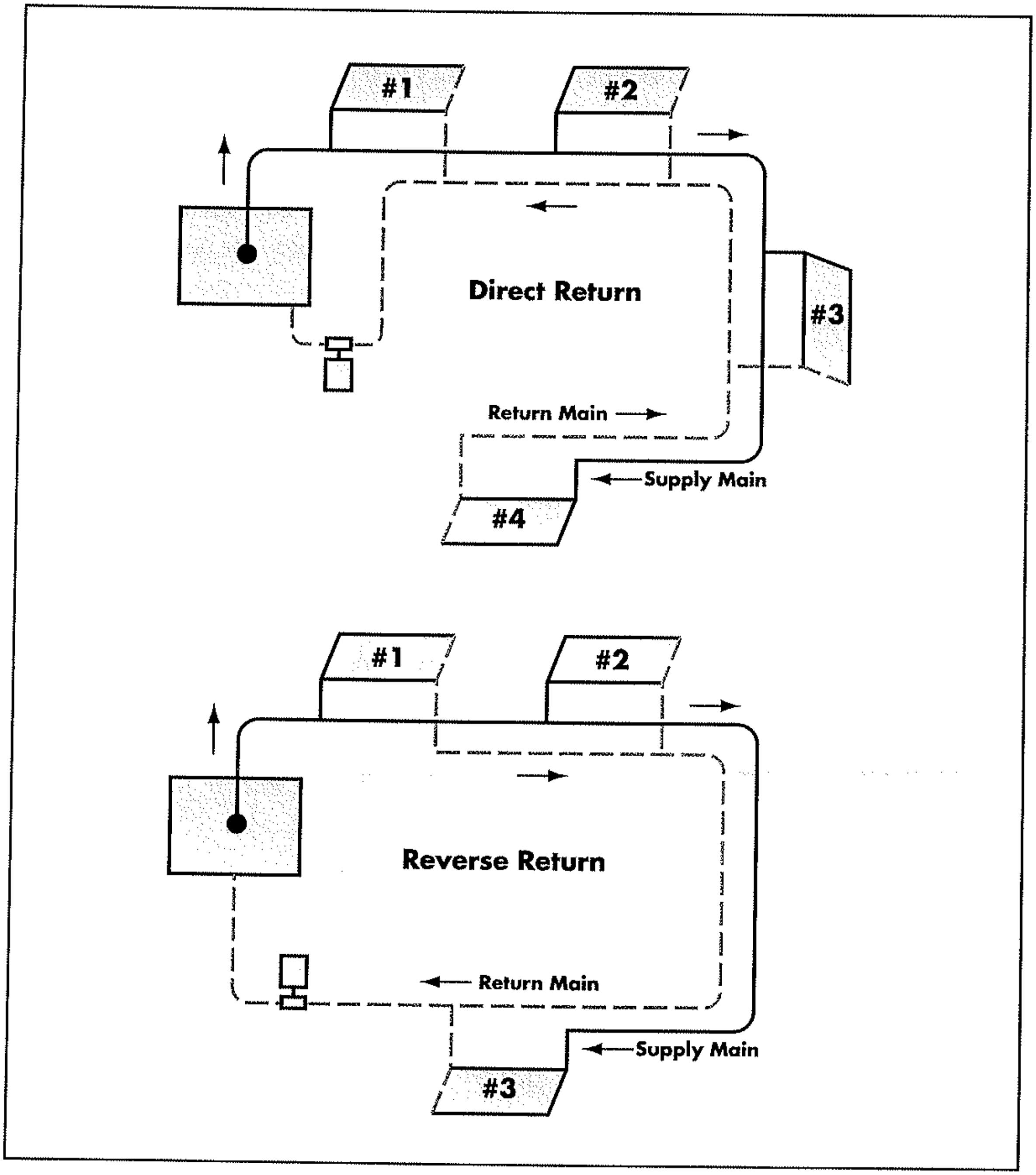
There are two kinds of two-pipe systems: the **REVERSE RETURN SYSTEM** and the **DIRECT RETURN SYSTEM**.

In the reverse return system, the emitters are connected to the return main in the reverse order from the way they are connected to the supply main. That is, the heat emitter that is first on the supply main is the last connection on the return main.

Because of the way this system is hooked up, the distance the water travels to each unit is approximately the same and this provides even flow to each heat emitter. It also makes it possible to control each heat emitter individually.

In a direct return system, the first heat emitter on the supply main is also the first heat emitter to return water. Direct return systems require more complicated balancing procedures.

REVERSE RETURN SYSTEM/DIRECT RETURN SYSTEM



SP 4.3.08

Radiant Panel System

A RADIANT PANEL SYSTEM circulates the hot water through a series of coils embedded in the floor (or sometimes the ceiling). The floor acts as the heat emitter.

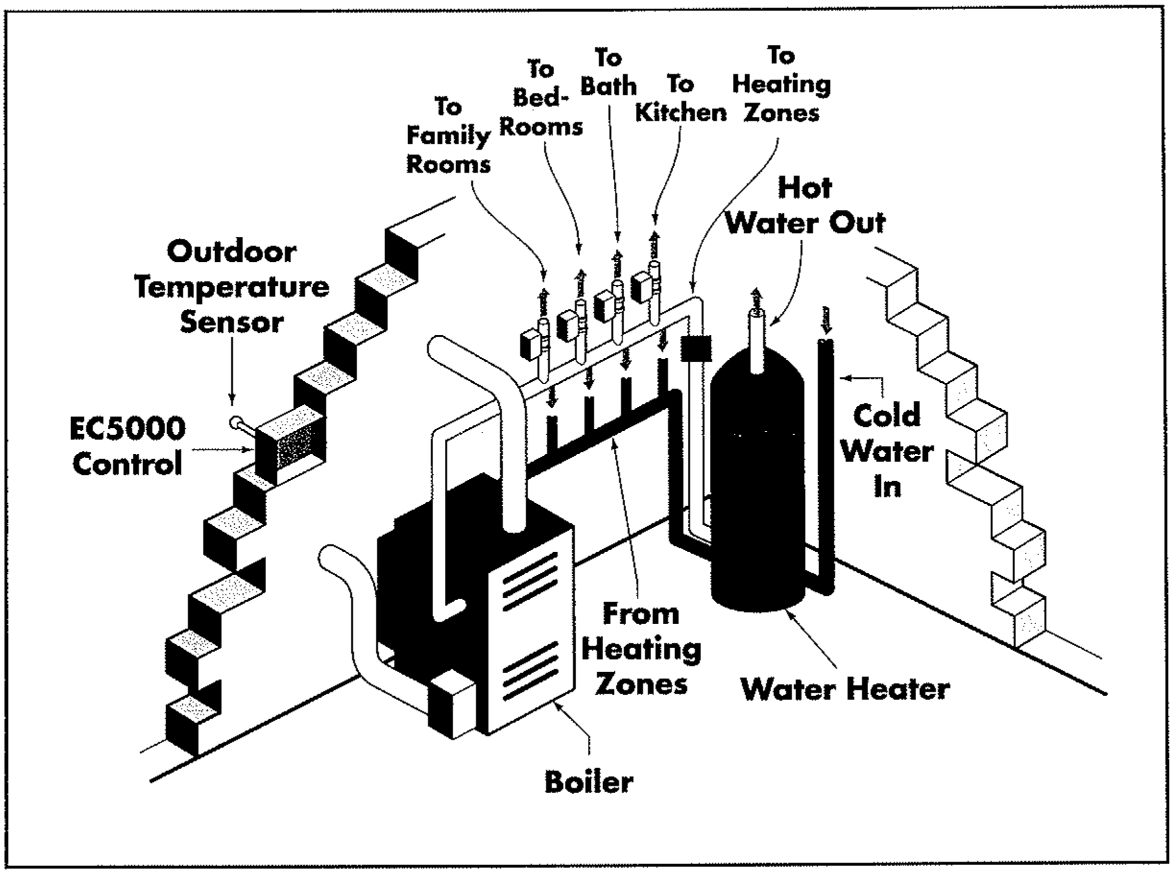
We will discuss radiant panel systems in more detail later in this manual when we discuss radiation.

One of the advantages of hot water heat is the ability to provide different amounts of heat to several parts of the building by zoning.

A **ZONED SYSTEM** allows the flow of heat to different parts of the building to be regulated by thermostat. The system may use either individual zone circulator pumps or a single system circulator and multiple **ZONE VALVES** (electric or non-electric).

Do not confuse zones with multiple circuits. A zoned system may have one or more circuits.

ZONED SYSTEM



SP 4.3.09

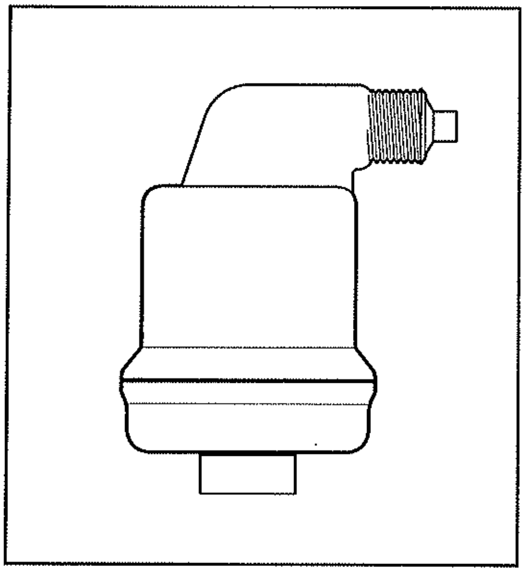
Steel pipe, copper tubing, or plastic tubing are commonly used in hot water comfort heating systems. Galvanized pipe is NOT recommended.

For the heating industry, copper tubing is specified by nominal pipe size. This is different from the air conditioning industry which specifies copper tubing by outside diameter, which is 1/8" more than the nominal size.

If the radiation is radiant floor tubing, the tubing may be:

- Soft copper
- Rubber: ethylene propylene diene monomer (EPDM)
- Polyethylene (plastic): either high density polyethylene (HDPE) or cross-linked polyethylene, called **PEX TUBING**
- Composite: made of a thin aluminum (usually) layer sandwiched between two layers of plastic

AIR VENT



SP 4.3.10

Air vents should be used at the high points of any piping system to allow the air that is released by the hot water to rise to the top of the system to be vented out.

Air in the pipes makes noise and can cause disruption of the heat delivery.

Overview of Radiation

The heat carried in the water in the piping system is released into the rooms to be heated through **RADIATION OUTLET DEVICES**.

Radiation transfers the heat into the rooms, partly by radiation and partly by convection.

Individual units such as baseboard units, which are used around the walls of a room to provide the *circle of warmth* referred to earlier, are often called heat emitters.

The other major kind of radiation is the radiant panel system, which is usually radiant floor heating, in which hot water tubing is placed under the floor in such a way that the whole floor is warm and radiates heat into the room.

Emitters should be placed so that a comfortable, uniform temperature is maintained everywhere in the room, without cold walls or cold drafts.

It is important for emitters to be installed under areas of glass. Installations under the glass make up for the high rate of heat loss from the glass and prevent cold downdrafts of air from the glassed area.

If it is not possible to place the emitters under the glass areas, the next best location is along the outside walls which do not have glass areas. It may be necessary to use both under-glass placement and around the wall placement.

The basic idea is to provide a circle of warmth around the room.

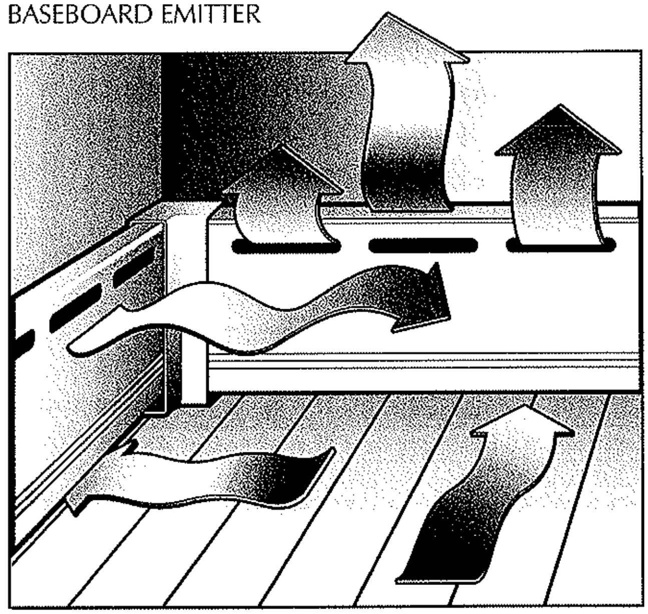
Types of Heat Emitters

The kinds of emitters now sold for residential and small commercial use are baseboard units, finned tube units, and convectors. Cast iron radiators, though still in use in many buildings, are rarely sold now for new homes.

Most of the radiation sold for residential use is baseboard. The **BASEBOARD EMITTER** unit replaces the conventional baseboard trim along the floor of the room to be heated.

Baseboard is usually installed on a series loop piping system.

BASEBOARD EMITTER



Cold air in the bottom
Hot air out the top

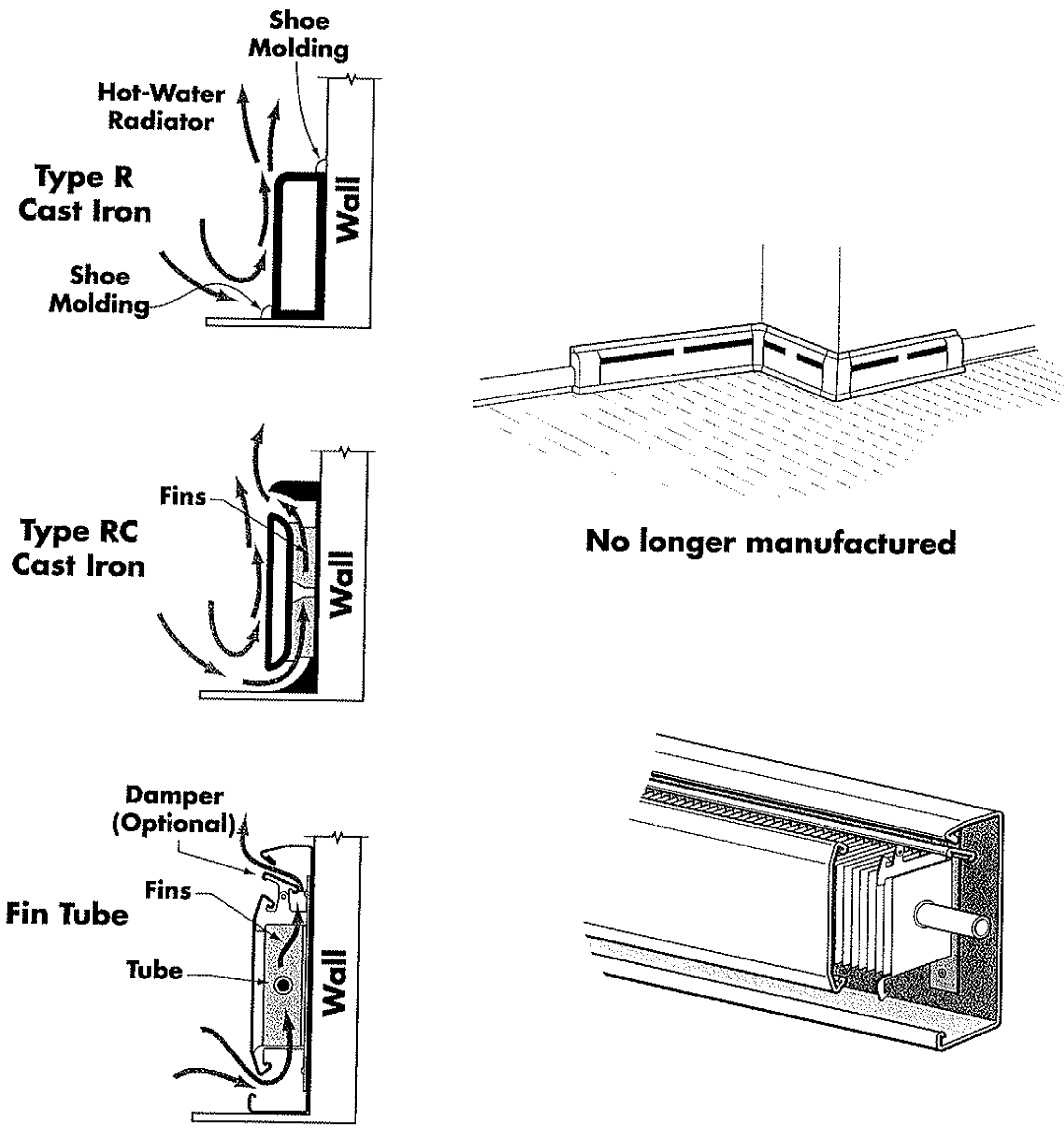
SP 4.3.11

There are two kinds of baseboard emitters sold: (1) cast iron and (2) finned tube baseboard.

Cast iron baseboard has hollow cast iron sections through which the hot water can circulate. Air inlet and outlet openings allow air to circulate around the hollow sections.

Finned tube baseboard is a tube, generally made of copper, with attached fins (usually aluminum). The whole tube is surrounded by a metal cover with top and bottom openings for air circulation.

CAST IRON AND FINNED TUBE BASEBOARDS



Basic Classes of Residential Type Basebord Emitters.

SP 4.3.12

Cast iron baseboard is manufactured in sections 12-inch, 18-inch, and 24-inch lengths. This allows for on-site assembly as needed.

Baseboard is I=B=R rated in BTUH output per linear foot of baseboard.

Each rating is approved for a specific water temperature and water flow rate.

Water flow rates are generally given at either one gpm (500 lb./hr) or four gpm (2000 lb./hr).

If the system flow rate is less than four gpm (2000 lb/hr), you must use the one gpm (500 lb/hr) rating. If the system flow rate is four gpm OR ABOVE, use the four gpm rating. If the flow rate is unknown, use the one gpm rating.

To find how many feet of baseboard is needed:

- Determine the output of the baseboard model at desired system water temperature and expected flow rate.
- Divide the calculated heat loss of the room by the BTUH output of the baseboard considered. This will give you the minimum length of baseboard needed.

EXAMPLE 1:

The room heat loss is 6400 BTUH.
Output of Baseboard model #A is 800 BTUH per linear feet
(At the known system temperature and flow rate)

You would need 8 feet of baseboard.
(6400 BTUH heat loss / 800 BTUH output/feet = 8 feet)

EXAMPLE 2:

The room heat loss is 7250 BTUH.
Output of Baseboard model #A is 800 BTUH per linear feet
(At the known system temperature and flow rate)

You would need 9 feet of baseboard.
(7250 BTUH heat loss / 800 BTUH output/feet = 9 feet)

Look at the hypothetical rating chart below. Then solve the three problems that follow. (Answers appear on page 60.)

MODEL B RADIATION BASEBOARD

Flow Rate in gpm	Water Ratings BTUH/ Linear Foot at Average Water Temperatures Shown				
	180° F	190° F	200° F	210° F	220° F
1 gpm*	580	640	710	770	840
4 gpm**	610	680	750	810	890

**One gpm = 500 lb / hr **Four gpm = 2000 lb / hr*

ASSUME: THE ROOM HAS A HEAT LOSS OF 5300 BTUH

PROBLEM 1:

System design water temperature: 210 0 F / Water flow rate: 4 gpm
How many feet of Model number B baseboard would be needed?

____

PROBLEM 2:

System design water temperature: 220° F / Water flow rate: 4 gpm
How many feet would be needed?

____

PROBLEM 3:

System design water temperature: 210 degrees / Water flow rate: 1 gpm
How many feet would you need?

____

Answers to Problems:

1. 6.5 feet (5300 / 810 = 6.5 feet)
2. 6 feet [rounded] (5300 / 890 = 5.95 feet)
3. 7 feet [rounded] (5300 / 770 = 6.88 feet)

Commercial buildings may use commercial **FINNED TUBE UNITS,** which are very much like finned tube baseboard except that the units are larger and they have considerably greater output than finned tube baseboard.

Like baseboard, commercial finned units are rated in BTUH per foot based upon system water temperature and flow rate.

The size of the unit, the type of metal, the number of tiers of heating elements, and the number of fins per foot also determine output of the unit.

Convectors Recirculate Air

A **CONVECTOR** is an emitter consisting of a finned heating element enclosed in a casing or cabinet with top and bottom openings placed to promote circulation of room air without use of a fan. The convector recirculates the room air, passing it over the heating element.

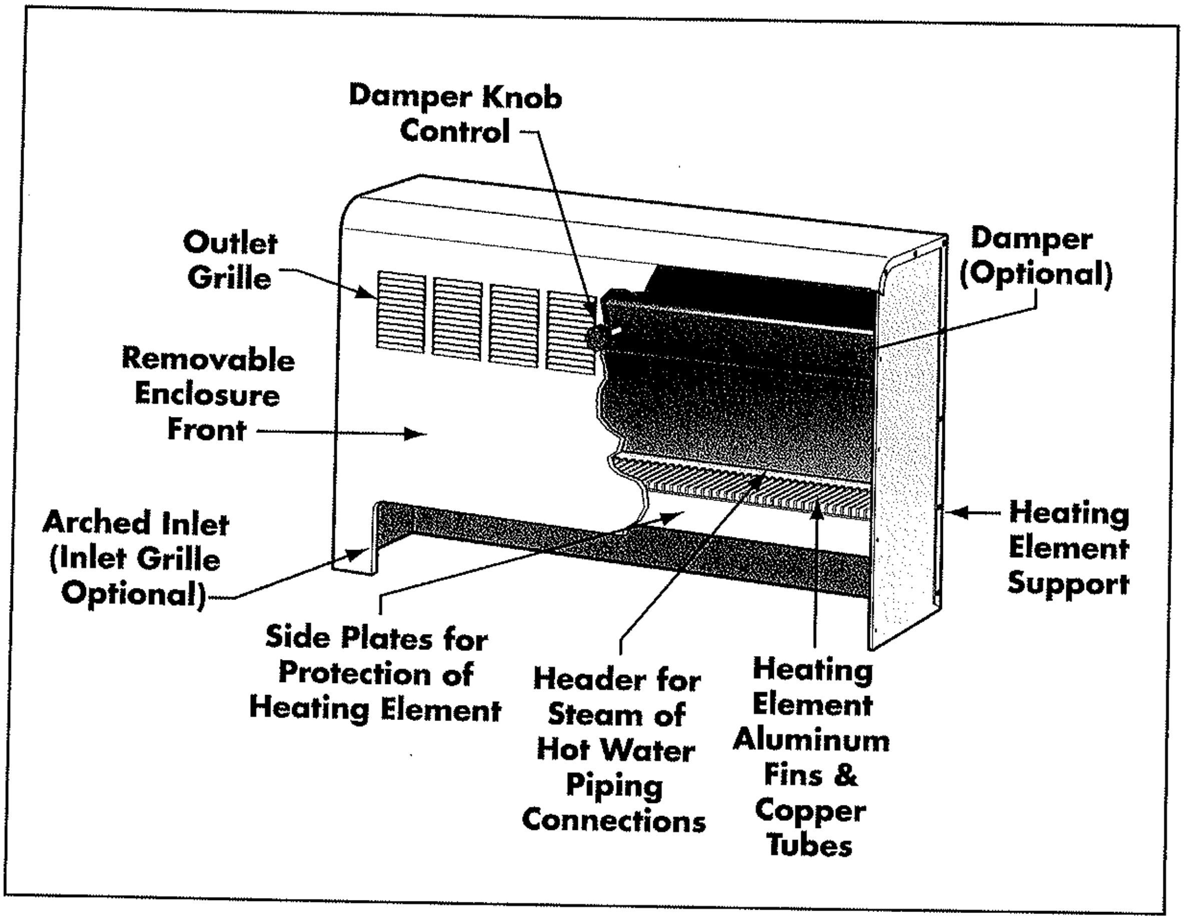
Convectors may be used in small commercial buildings or, occasionally, in homes. As the name suggests, a convector heats more by convection than by radiation.

Convectors cannot be installed on a series loop system. A one-pipe or a two-pipe system is needed.

The convector cabinet may be free standing, wall hung, or partially or fully recessed in the wall, depending upon placement and use.

The heating capacity of the convector is determined by the size of the heating element, the height and depth of the cabinet, and the placement of the air outlet. Generally larger units produce more output.

CONVECTOR CABINET



SP 4.3.13

The room air enters at floor level, passes over the heating element, and leaves the cabinet through a grill at the top of, or top front of, the cabinet.

Ratings for convectors are usually expressed in MBH for specific water temperatures and water temperature drops.

ONE MBH = 1000 BTUH

The chart below shows the output, in MBH, of several models at 210° F average water temperature with a 20° temperature drop.

The physical dimensions of the cabinets are also shown, since the dimensions affect output and must also be considered in terms of space available in the room. In larger rooms it is better to install two convectors, for better distribution of warmth.

CONVECTOR RATINGS

Front Outlet Types	20° Temp Drop		Average Water Temp 210°		65° Entering Air	
Model & Height (in.)	Depth (in.)	Length				
		20″	24″	28″	32″	36″
C–18	4	1.9	2.3	2.7	3.1	3.6
	6	2.6	3.3	3.9	4.6	5.3
	8	3.3	4.2	5.2	6.2	7.1
C–20	4	2.0	2.6	3.1	3.6	4.2
	6	3.0	3.7	4.5	5.3	6.0
	8	3.6	4.7	5.6	6.6	7.6
C–24	4	2.3	2.9	3.5	4.2	4.8
	6	3.5	4.4	5.3	6.2	7.1
	8	4.3	5.2	6.2	7.3	8.2
Models: Height & Depth		MBH (Thousands of BTUH)				

Notice that model C-20 with a cabinet 24" long and 6" deep will produce 3.7 MBH at average water temperature of 210 0 F. with a 20 0 water temperature drop in the system.

Multiply 3.7 MBH x 1000 to get BTUH: 3.7 MBH = 3,700 BTUH

Use the information in the Convector Ratings table on the preceding page to solve the problems that follow. Assume that the wall space in the room is limited. You will need 6,000 BTUH.

Answers appear below!

PROBLEM 1:

What is the <u>shortest</u> (in length) model that would give you 6,000 BTUH? Also specify what model, height and depth would be needed.

____

PROBLEM 2:

How could you get 6,000 BTUH with two convectors, Model C-20?

____

PROBLEM 3:

How many BTUH would be produced by Model C-18 if it were 32" long and 8" deep?

____

PROBLEM 4:

How many BTUH would be produced by Model C-20 if it were 36" long and 6" deep?

____

Answers to Problems:

1. Model C-24 / 28" long, 24"high, and 8" deep (6.2 MBH or 6,200 BTUH)
2. With two at least 20" long each. That is 12" longer than one Model C-24 above
3. 6,200 BTUH (6.2 MBH)
4. 6,000 BTUH (6.0 MBH)

Evaluating Cast Iron Radiators

Cast iron radiators have been used in older buildings, but they are not often used in new construction. Your firm may handle radiators for replacement in older systems.

The rating of a cast iron radiator is based on **EQUIVALENT DIRECT RADIATION (EDR)** per square foot of heating surface. The BTUH output of this square foot rating will depend on the system water temperature. (See chart below.)

To learn to size radiators for a heating system, consult your manufacturer's catalogs and training materials.

According to the chart on the right, by how many degrees would you have to increase system water temperature to increase the E.D.R. output by 20 BTUH? The system water temperature must be increased by 10° F.

HEAT EMISSION RATES FOR CAST IRON RADIATORS

System Design or Average Water Temperature	Heat Emission (Output) Rates BTUH per Square Feet of Surface
170° F	150
175° F	160
180° F	170
185° F	180
190° F	190
195° F	200
200° F	210

Radiant Floor Heating

Another important type of radiation is radiant floor heating. **RADIANT FLOOR HEATING** makes use of hot water flowing through flexible tubing which is attached to or embedded in the floor.

The surfaces in the room are warmed by radiated heat from the floor, and the air in the room is warmed by coming in contact with the room surfaces.

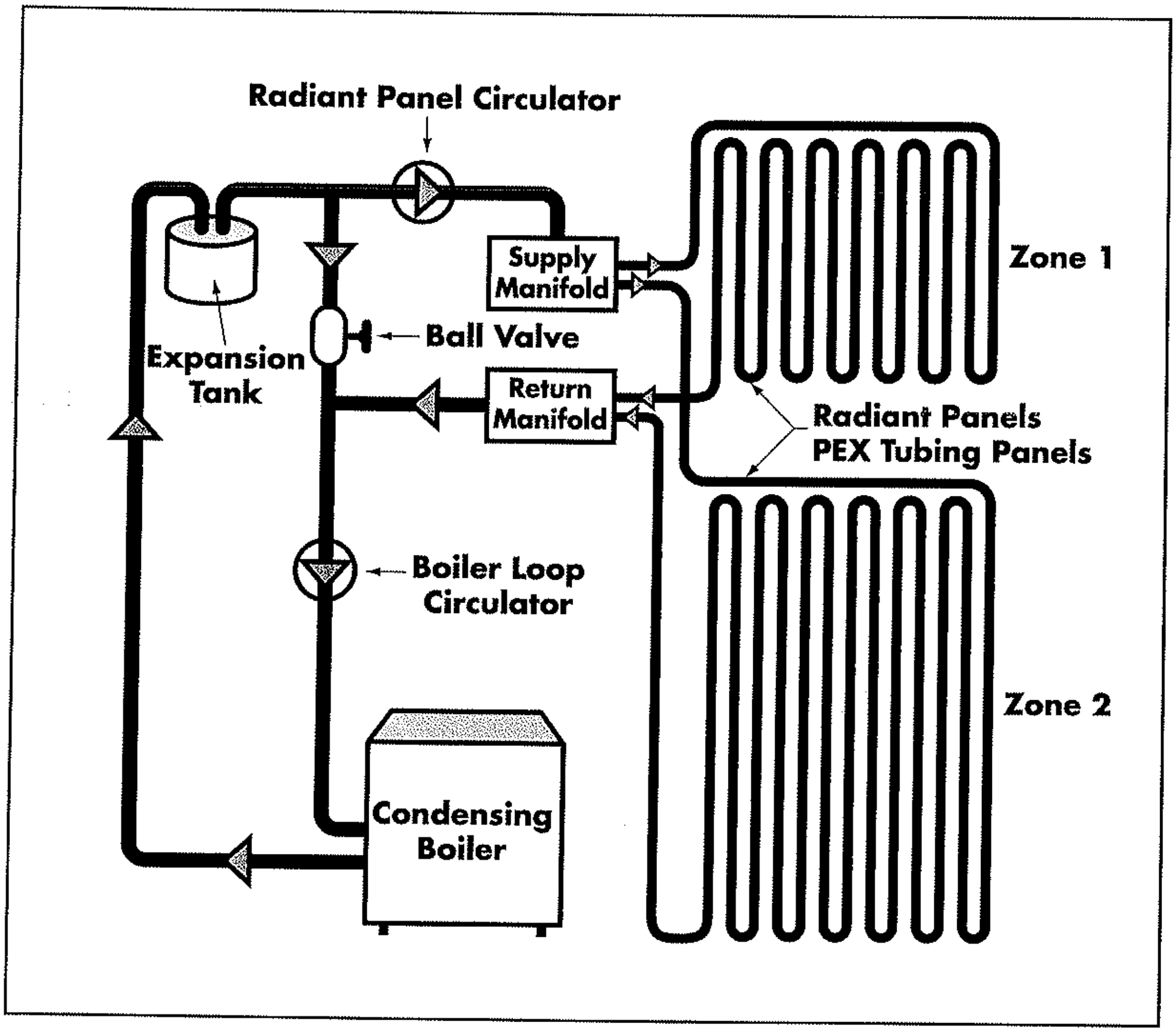
One important reason for using radiant floor heating is that lower water temperatures can be used. If the system is properly designed, the floor surface temperature will be evenly warm but will be only a few degrees warmer than the temperature of the air in the room.

Another advantage is that the air near the floor—which would naturally be colder using a forced air heating system—is comfortably warm using radiant floor heat. The cooler air will be near the ceiling, which is farther away from the warm floor.

Radiant floor heating is especially appropriate for buildings built on concrete slabs, but it is also possible, with proper thermal mass materials, to use radiant heating with wood floors and suspended floors. Suspended floors are floors which have open spaces, such as crawl spaces or basements, beneath them.

The pattern in which the tubing is laid depends upon the layout of the room and the use to which it is put.

CONDENSING BOILER SYSTEM



SP 4.3.14

The tubing is generally embedded in some kind of **THERMAL MASS**, which is usually a dense concrete-like material poured as a sub-floor or a finished floor. The thermal mass stores heat, distributes between the tubes, and transfers it to the surface of the floor.

The thermal mass may be concrete, lightweight concrete (with bubbles in it caused by a foaming agent), or gypsum cement, which is lighter than concrete.

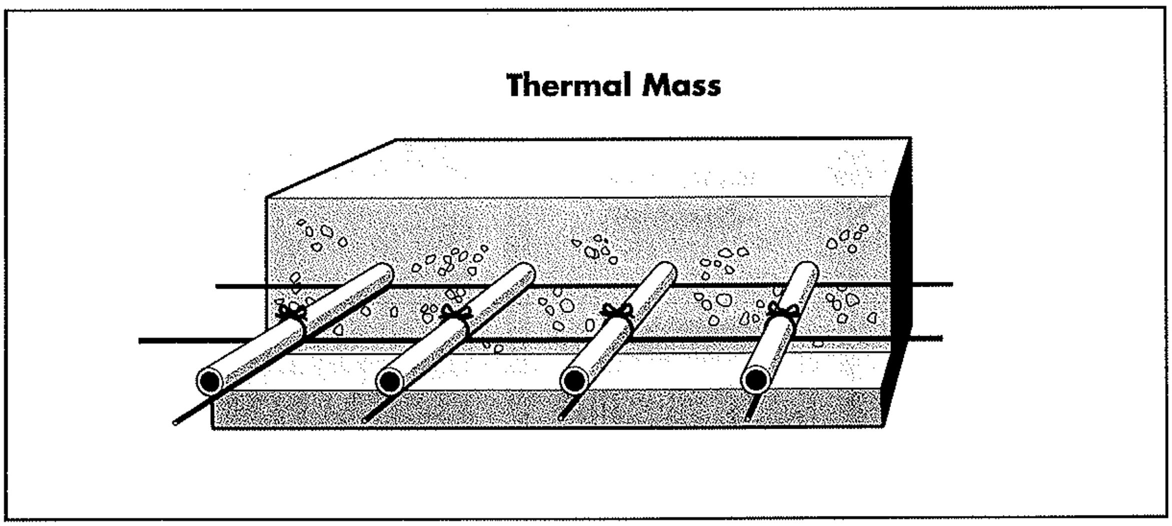
As mentioned previously, the tubing may be soft copper, rubber, plastic (PE, PEX, PEX-AL-PEX, or PBB), or a composite of plastic and metal.

The type, size, and placement of tubing depend upon the overall system design and the temperature of the water. The tubing should be flexible enough to be laid in one continuous pattern with no joints.

Tubing may be tied to wire mesh to keep it from floating to the top of the concrete thermal mass, or it may be stapled or otherwise fastened to the underneath of a floor or subfloor.

To avoid heat build up, hot water tubing should not be placed in areas which will be under low, heavy furniture such as appliances, large bookcases, and entertainment centers. For the same reason, tubing should not be laid under food storage cabinets, as heat can cause spoilage.

THERMAL MASS



SP 4.3.15

Because the temperature of the floor is so important to the heating of the room, a very important variable which must be considered when planning a radiant floor heating system is the type of floor covering that will be used in the room. The owner of the building must be consulted on the matter of floor coverings.

Any covering placed upon the surface of the flooring could block some of the heat and require the water temperature to be raised. While ceramic tile and vinyl floor covering have only small effects on the radiation of the heat, carpeting and carpet pads can have a very significant effect on the design water temperature. The thicker the carpet, the hotter the water will have to be to make up for the blockage of heat.

The insulative quality of floor coverings are measured according to their **R-VALUES**. The type of floor covering and the thickness both affect the R-value. The higher the R-value, the more likely the covering will require higher water temperatures.

R - VALUES (APPROX.) OF FLOOR COVERINGS

Floor Covering	Thickness	R-Value
Vinyl, Tile	–	0.2
Hardwood	3/8 inch	0.5
	3/4 inch	1.0
Rubber pad	1/4 inch	0.3
	1/2 inch	0.6
Urethane pad	1/4 inch	1.0
	1/2 inch	2.0
Carpet*	1/8 inch	0.6
	1/4 inch	1.0
	1/2 inch	1.4
	3/4 inch	1.8
	1 inch	2.2

** For wool carpets, multiply the R-value given by 1.5*

There are many factors and considerations that go into designing a radiant floor heating system. A well planned system can provide years of comfort for the people using the room or building.

To learn more about radiant floor heating systems, contact your manufacturers for assistance and take any training they offer. Further information about radiant floor heating is available from the **RADIANT PANEL ASSOCIATION (RPA)** and the **HYDRONICS INSTITUTE OF GAMA**.

REVIEW QUIZ – PIPING AND RADIATION

Answers appear on page 74

DIRECTIONS: Carefully read each question and circle the correct answer. There is only one correct answer per question. When you have finished, check your answers.

1. A scale drawing showing the location of the boiler and the heat emitters and piping arrangement which will connect the boiler and heat emitters is called a
   a. two-pipe system.
   b. series loop system.
   c. piping layout.
   d. hydronic layout.

2. All of the following are common types of piping systems used in hot water heating systems EXCEPT
   a. Series loop systems
   b. One-pipe systems
   c. Radiant panel systems
   d. Combined panel systems

3. What is the major advantage of series loop systems over other piping systems?
   a. They are less expensive.
   b. They are easier to install.
   c. They last 30 percent longer.
   d. They control the flow of water.

4. Which of the following is a drawback of the series loop piping system?
   a. It has one continuous pipe from the supply side to the return side of the boiler with heat emitters connected to the main by risers.
   b. The size of the water tube in the heat emitter limits the amount of water flow and therefore the amount of available heat.
   c. The amount of heat to each room can be controlled by using a balancing valve in the riser.
   d. The system diverts some of the water from the main into the heat emitters.

REVIEW QUIZ – PIPING AND RADIATION

Answers appear on page 74

5. Which of the following is an advantage of multiple zones and multiple circuits?
   a. They allow for better control of heat delivered in each section.
   b. They use a balancing valve in the riser to control the amount of heat to each room.
   c. They employ one continuous pipe from the supply side to the return side of the boiler with heat emitters connected to the main by risers.
   d. They reduce cost by circulating hot water through coils in the floor or the ceiling.

6. In what type of system is heat flow controlled to allow for differing amounts of heat in various parts of the building?
   a. Multiple circuit system
   b. Direct return system
   c. Zoned system
   d. Radiant panel system

7. All of the following kinds of pipe or tubing are used for hot water comfort heating systems EXCEPT
   a. Steel pipe
   b. Copper tubing
   c. Concrete
   d. Composite

8. Where should air vents be placed in the piping system?
   a. At the lowest points in the system
   b. At the highest points in the system
   c. At even intervals throughout the system
   d. At the top and bottom of the system

9. In a radiant panel system, where should heat emitters be located?
   a. Above areas of glass and/or along outside walls of the room
   b. Above areas of glass and/or along inside walls of the room
   c. Under areas of glass and/or along outside walls of the room
   d. Under areas of glass and/or along inside walls of the room

REVIEW QUIZ – PIPING AND RADIATION

Answers appear on page 74

10. All of the following kinds of heat emitters are usually sold for new residential and small commercial use EXCEPT
    a. Baseboard units
    b. Finned tube units
    c. Convectors
    d. Conductors

11. What is a heat emitter with a finned heating element in a cabinet with openings to cause air to circulate called?
    a. Conductor
    b. Convector
    c. Baseboard unit
    d. Two-pipe system

12. What is one advantage of using radiant floor heat?
    a. Lower water temperatures can be used
    b. Higher water temperatures can be used
    c. Less expensive than other types of systems
    d. Less difficult to install than other types of systems

13. How many BTUHs does one MBH equal?
    a. 100
    b. 1,000
    c. 1,500
    d. 2,000

14. Which piping system is likely to be less expensive than other types of systems because it probably requires less pipe, fewer fittings, and lower labor costs?
    a. Series loop system
    b. One-pipe system
    c. Two-pipe system
    d. Multiple circuit system

15. What would be the total R-Value of combining a 3/4 inch wool carpet with a 1/2 inch rubber pad?
    a. 3.0
    b. 3.3
    c. 3.6
    d. 3.8

REVIEW QUIZ – PIPING AND RADIATION

Answers appear on page 74

16. Use the chart below to answer the question. Assume the following:

Heat loss of 7000 BTUH
Design water temperature of 200° F
Water flow rate: 1 gpm

How many feet (rounded) of Model B Radiation Baseboard would this room need?

MODEL B RADIATION BASEBOARD

Flow Rate in gpm	Water Ratings BTUH/ Linear Foot at Average Water Temperatures Shown				
	180° F	190° F	200° F	210° F	220° F
one gpm*	580	640	710	770	840
four gpm**	610	680	750	810	890

**One gpm = 500 lb / hr* ***Four gpm = 2000 lb / hr*

a. 8 feet
b. 9 feet
c. 10 feet
d. 11 feet

REVIEW QUIZ – PIPING AND RADIATION

Answers appear on page 74

APPLYING WHAT YOU HAVE LEARNED:

By observing and asking questions, fill in the blanks. If you are not sure of the answers, ask your supervisor.

A. Describe the types of radiant floor heating systems that your company sells.

____

____

____

B. Explain to a customer how series loop piping system works. Would you typically recommend this system to a customer? Why or why not?

____

____

____

ANSWERS TO REVIEW QUIZ

CHAPTER 3

INTRODUCTION TO PIPING AND RADIATION

Answers for INTRODUCTION TO PIPING AND RADIATION (pages 68 – 72)

1. c. piping layout.
2. d. Combined panel systems
3. a. They are less expensive.
4. b. The size of the water tube in the heat emitter limits the amount of water flow and therefore the amount of available heat.
5. a. They allow for better control of heat delivered in each section.
6. c. Zoned system
7. c. Concrete
8. b. At the highest points in the system.
9. c. Under areas of glass and/or along outside walls of the room
10. d. Conductors
11. b. Convectors
12. a. Lower water temperatures can be used
13. b. 1,000
14. a. Series loop system
15. b. 3.3
16. c. 10 feet

Applying what you have learned:

A. Depends on the company

B. Depends on the company

4 OVERVIEW OF PUMPS, SPECIALTIES, CONTROLS

LEARNING OBJECTIVES

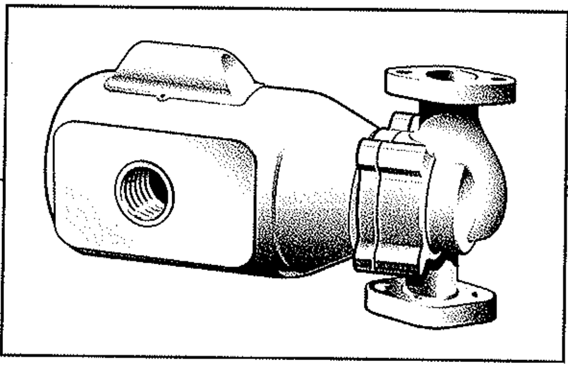
When you finish this Chapter, you will be able to:

1. Compare and contrast gravity circulation systems and forced circulation systems.

2. Explain how pump capacity is measured.

3. Determine how many gpm will be needed to produce proper heat.

4. Calculate the amount of head required of the circulator pump for a particular system.



PUMPS, SPECIALTIES, CONTROLS

Circulation Systems

In order to heat the building, the water must flow smoothly throughout the piping system.

There are two methods used to create circulation of the heated water through the heating system: gravity circulation systems and forced circulation systems.

A **GRAVITY CIRCULATION SYSTEM** uses the force of gravity to cause circulation. Gravity systems are not very efficient and are rarely installed today. However, there are still many gravity systems in existence, and it is helpful to understand how they work.

Gravity systems operate because hot water is lighter in weight than cold water.

Think of the piping system as a vertical (up and down) loop, with the boiler at the bottom of the loop and the heat emitters at the top of the loop.

In a gravity system the **heat emitters must always be above the boiler.** The hot water coming from the boiler expands, becomes lighter in weight, and rises in the vertical supply pipe.

At the same time, the cooled heavier water, having given off its heat at the heat emitters, flows down (pulled by gravity) the vertical return pipe.

The heating and cooling of the water—with the resulting changes in water weight—creates the circulation in the system.

Because the pressure in the gravity system is low, circulation is slower and more water must flow through the building to get enough heat. Therefore the pipes must be considerably larger than in a forced circulation system.

Almost all of the hot water systems being installed today use the forced circulation system because it heats more efficiently. In a **FORCED CIRCULATION SYSTEM,** a pump is used to help create the pressure necessary to move the water from one place to another.

In the residential system or small commercial building, small capacity booster pumps, often called **CIRCULATORS**, are used.

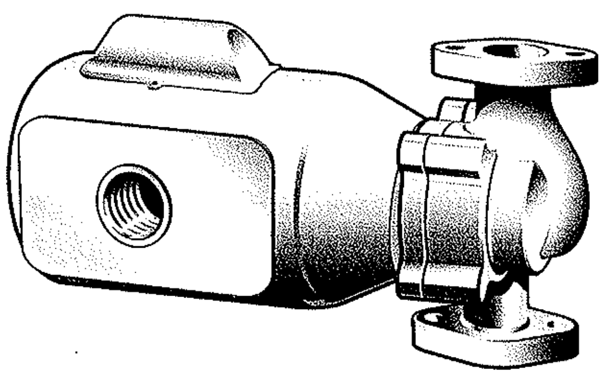
Overview of Pumps

Pumps are rated in terms of pump capacity and pump head.

- **PUMP CAPACITY** is the number of gallons of water per minute (gpm) a pump can move.
- **PUMP HEAD** (sometimes called *head pressure*) is a measure of the amount of pressure (energy) a pump can develop to move water against the resistance (friction) caused by the passage of water through piping or tubing.

Pump head is measured in feet of water.

PUMP HEAD



SP 4.4.01

Pump Performance Curve

A pump performance curve, often called simply a **PUMP CURVE**, shows the relationship between pump capacity and pump head.

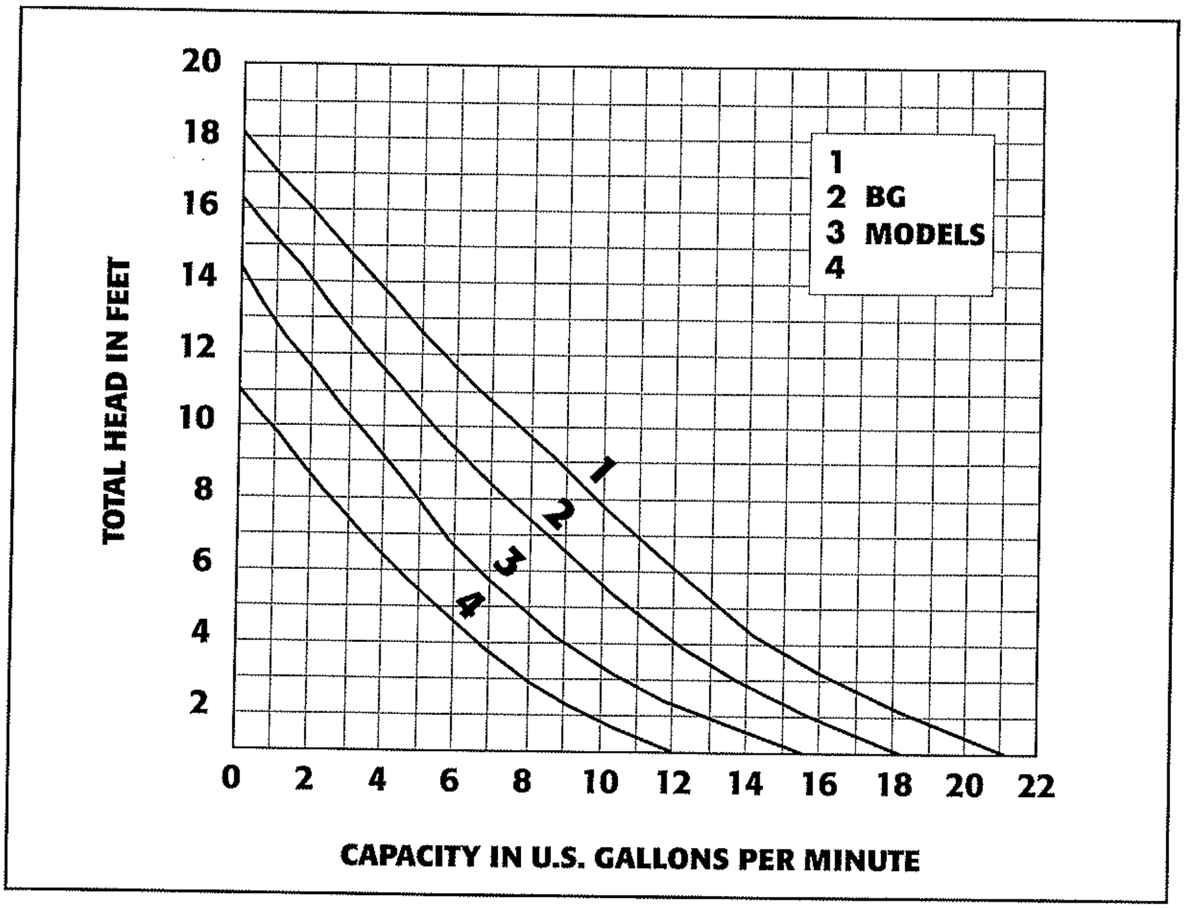
- As the capacity of the pump (gpm) increases, the pump head pressure (feet of head) decreases.
- As pump head increases, the pump capacity decreases.

We say that pump capacity and pump head are "inversely related." That is, as one goes up, the other goes down.

Look at the pump curve below.

The **point of intersection** between the line representing gpm and the line representing head must always be **below the curve** representing the pump model if that model is to be used.

PUMP HEAD



SP 4.4.02

You will remember that one gpm x one degree temperature drop = 500 BTUH.

To determine how many gpm will be needed to produce the proper heat:

STEP 1: Multiply 500 x degrees of water temperature drop.

The answer is the number of BTUH produced by circulation of ONE gpm at the system temperature drop

STEP 2: Divide the total calculated heat loss for the building by the answer from Step 1.

The answer is the TOTAL gpm (pump capacity) needed to produce the desired heat for the system.

EXAMPLE:

Design temperature drop 20° / Calculated heat loss = 48,000 BTUH

STEP 1: 500 BTUH x 20 0 = 10,000 BTUH

STEP 2: 48,000/10,000 = 4.8 gpm needed (Pump capacity)

Note: Because most residential heating systems use a 20 0 temperature drop, the 10,000 BTUH figure is standard.

So in most systems: heat loss / 10,000 = gpm needed

Pressure Drop

To determine how much pump head is required, it is necessary to determine how much friction is created when the water flows through the piping. The pump must have enough head to overcome this friction and keep the water moving.

As the water moves through the system, the amount of head pressure is reduced (energy is used up by overcoming the friction). This friction-caused loss of pressure between two points in the system is called **PRESSURE DROP**.

The loss of pressure between the beginning of the supply pipe and the end of the return pipe is the pressure drop for the system.

If the same size and length pipe is used but the amount of water (in gpm) flowing through the pipe is increased, the pressure drop will increase. (More water means more friction).

Pressure drop will **decrease** if the same flow rate of water (gpm) is maintained but the pipe size (but not the length) is **increased**. (A larger pipe means less friction.)

Measurement of Pressure Drop

If pressure drop were measured in feet of water, the measurements would be very small decimals which are difficult to work with. Therefore, pressure drop is often measured in milinches of water.

One **MILINCH** is the amount of pressure produced by 0.001 (one thousandth) inch of water.

1 milinch = pressure from 1/1000 of an inch of water (0.001)

OR

1 milinch = pressure from 1/12,000 of a foot of water

OR

12,000 milinches = pressure from 1 foot (12 inches) of water

The amount of pump head required is equal to the amount of pressure drop in the heat emitters plus pressure drop in piping and fittings. Tables are available from pipe and fittings manufacturers showing pressure drop in various pipe diameters and pipe fittings.

Heat emitters manufacturers provide pressure drop information about emitter units. Pump manufacturers provide charts to be used in calculating system pressure drop in order to size circulators.

Circulator pumps must be sized in relation to the length and diameter of the piping, since the system pressure drop depends upon flow rate, length of the circuit, and pipe diameters.

If a packaged boiler is purchased, the properly sized circulator may come with the package. Then only pipe sizing is needed.

Static Pressure

Because the heating system is a closed system totally filled with water, there is no atmospheric pressure to be overcome. The static pressure from the weight of the standing water is balanced because water is at the same height on both sides of the pump.

STATIC PRESSURE is the pressure created by the weight of the water in vertical pipes. Each foot of water weighs 0.43 lbs. Multiply 0.43 times height of the water in the vertical pipes to find static pressure in foot of water.

STATIC PRESSURE HAS NO EFFECT UPON THE REQUIRED HEAD OF THE PUMP IN A CLOSED SYSTEM.

Sizing charts, such as the one that follows on page 83, may be used to match the circulator to the pipe size.

In a baseboard system, the pipe size used for the circuit matches the pipe size of the tube running through the baseboard. This is generally 3/4" pipe.

Because the pipe size in the circuit and the baseboard is the same, the pressure drop through the heat emitters is accounted for in the total equivalent length of the circuit, which is shown on the piping layout.

Pipe Sizing

Remember that pumps are sized by capacity (usually in gpm) and head (in foot of water) they can produce.

- From your system design you will know the pump capacity you need because you know how to calculate the gpm needed to overcome heat loss.
- You will know, from the piping layout, the total length of the circuit. If there are multiple circuits, use the longest circuit.
- You know what size baseboard pipe is available, and that determines the circuit pipe size.

PIPE SIZING/PUMP HEAD PRESSURES FOR BASEBOARD SYSTEMS

Circuit Pipe Size	Circuit Capacity in Gallons Per Minute						
1/2"	2.3	2.0	1.9	1.8	1.7	1.7	1.6
3/4"	5.0	4.3	4.1	3.8	3.7	3.6	3.4
Head	Total Length (feet) of Circuit (from piping layout)						
4 feet	35	45	50	60	65	70	75
5 feet	45	60	65	70	80	90	95
6 feet	55	70	80	90	100	110	120
7 feet	65	90	100	110	120	130	140
8 feet	75	100	110	130	140	150	160

You NEED to know the head required of the circulator pump for your system.

EXAMPLE:

Total System Length = 150 feet
Pump Capacity (Flow Rate) Needed = 3.6 gpm
Pipe size through baseboard = 3/4"

STEP 1: Find 3/4" circuit pipe size

STEP 2: Read across to 3.6 gpm capacity

STEP 3: Read down the column to 150 feet length

STEP 4: Read left to find pump head needed = 8 feet

You will need a circulator pump with 3.6 gpm capacity and capable of producing 8 feet of head. You will be able to find such a circulator by using pump curves provided by the manufacturer.

SAMPLE PROBLEMS

Use the chart on the previous page to solve the following problems. The answers appear on page 85.

PROBLEM 1:

Pipe size in baseboard is 1/2"
Gpm needed is 2.2 gpm / Circuit total length is 45 feet

How much head is needed? ______________________

PROBLEM 2:

Consider a pump with 5 feet of head
You need 2 gpm

What is the longest circuit the pump could handle with 1/2" pipe?

____

PROBLEM 3:

You need 3.8 gpm / The longest circuit is 70 feet long with 3/4" pipe

How much head will you need? ______________________

PROBLEM 4:

You need 4 gpm for an 80 feet circuit
Based upon the chart shown, what pipe size would be best and why?

____

Answers to Problems:

1. 5 feet (Use the 2.3 gpm)
2. 60 feet
3. 5 feet
4. 3/4" pipe (4 gpm is too much for 1/2" pipe)

Allowances for Pressure Drops

When using radiation other than baseboard, allowances must be made for additional pressure drop in the emitters. The pressure drop must be added to the length of circuit.

Also, pressure drops for vertical riser pipes must be considered. The pressure drops for emitters are published by the heat emitter manufacturers.

For tables to use in sizing pumps and pipes for one-pipe and two-pipe systems, radiant floor panels, and for other kinds of emitters, check the catalogs and sales materials from the manufacturers of the radiation and circulator pumps your firm sells.

Hydronic Specialties

Accessories which improve the performance of the major parts of the system (boiler, piping, heat emitters) are called **HYDRONIC SPECIALITES**.

Various manufacturers produce hydronic specialties under their own trade names.

Some of the common specialties have been discussed earlier in connection with the parts of the system on which they are used.

Some of the specialties are:

AIR CONTROL DEVICES for eliminating air from the system. These include:

- Air separating devices and air venting devices for the boiler and thermal expansion tank
- Air vents for emitters and pipes

Other specialties are designed to control flow of water coming into the system, including:

- **PRESSURE REDUCING VALVES** used to reduce the pressure of water coming into the system if the incoming water is under greater pressure than the water in the system
- **FILL VALVES** to control the flow of water into the system as it is being filled. A manual bypass may allow for quick filling
- **BALANCING VALVES**, or balancing cocks, are usually installed at the end of each circuit and manually adjusted to equalize water distribution in multiple circuit systems
- **ZONE VALVES** and **ZONE PUMPS**, operated by thermostats, control water flow in individual zones of a zoned system
- **FLOW CHECK VALVES** prevent gravity circulation of water if pump is shut off

All of these specialties are used for flow control of the water in the system.

One-pipe fittings for connecting emitters to one-pipe systems are considered specialties.

Sometimes circulator pumps, thermal expansion, boiler gauges and other accessories are considered specialties and are shown in specialty catalogs.

From time to time your customers may ask for hydronic specialties. It is important that you become familiar with the various specialties produced by YOUR manufacturers.

You will also need to know the specialties by proprietary trade name.

Study your manufacturer's catalogs for this important information.

Heating Controls

Like other heating systems, a hot water comfort heating system must have controls.

The **HEATING CONTROL SYSTEM** is a system of regulating devices used to keep the heating system operating within prescribed limits, for both water and combustion.

There are four kinds of heating control systems:

1. Electro-mechanical control systems (used for most residential systems)
2. Electronic control systems
3. Pneumatic control systems
4. Fluidic control systems

It is not possible to go into detail about heating controls here. For information about control selection, installation, or wiring, consult your heating control system manufacturer.

REVIEW QUIZ – PUMPS, SPECIALTIES, CONTROLS

Answers appear on page 94

DIRECTIONS: Carefully read each question and circle the correct answer. There is only one correct answer per question. When you have finished, check your answers.

1. In a gravity circulation system, where are the heat emitters always located?
   a. Above the boiler
   b. Below the boiler
   c. Inside the tank
   d. Outside the tank

2. How are pumps, including circulators, rated?
   a. Capacity and thermal mass
   b. Heat loss and capacity
   c. Thermal mass and heat loss
   d. Capacity and pump head

3. Assume the design water temperature drop is 20° and heat loss is 32,000 BTUH. For the system to produce adequate heat, how many gpms must the pump produce?
   a. 1.2 gpms
   b. 2.2 gpms
   c. 3.2 gpms
   d. 4.2 gpms

4. How is the pressure drop in hot water heating systems usually measured?
   a. BTUHs
   b. Milinches
   c. Gpms
   d. Gross output

5. If the diameter of the piping is kept the same but the length of the piping system is increased, how is the pressure drop of the system affected?
   a. The pressure remains the same.
   b. The pressure increases.
   c. The pressure decreases.
   d. The pressure is unaffected.

REVIEW QUIZ – PUMPS, SPECIALTIES, CONTROLS

Answers appear on page 94

6. If the length of the piping is kept the same but the diameter used is increased, how is the pressure drop of the system affected?
   a. The pressure remains the same.
   b. The pressure increases.
   c. The pressure decreases.
   d. The pressure is unaffected.

7. What does the pressure drop in the heat emitters (radiation) plus the pressure drop in the piping and fittings determine?
   a. Pump head rating of the circulator needed
   b. Number of thermals units needed
   c. Pump capacity of the system
   d. Static pressure caused in the system

Use the information in the following chart to answer questions 8-10.

PIPE SIZING/PUMP HEAD PRESSURES FOR BASEBOARD SYSTEMS

Circuit Pipe Size	Circuit Capacity in Gallons Per Minute						
1/2″	2.3	2.0	1.9	1.8	1.7	1.7	1.6
3/4″	5.0	4.3	4.1	3.8	3.7	3.6	3.4
Head	Total Length (feet) of Circuit (from piping layout)						
4 feet	35	45	50	60	65	70	75
5 feet	45	.60	65	70	80	90	95
6 feet	55	70	80	90	100	110	120
7 feet	65	90	100	110	120	130	140
8 feet	75	100	110	130	140	150	160

REVIEW QUIZ - PUMPS, SPECIALTIES, CONTROLS

Answers appear on page 94

8. The design water temperature drop is 20°. Heat loss is 20,000 BTUH. How many gpms must the pump produce?
   a. 1.5 gpms
   b. 2.0 gpms
   c. 2.5 gpms
   d. 3.0 gpms

9. The piping through the baseboard is 1/2" piping. The total system is 55 feet long. How many feet of head will the pump need?
   a. 3 feet
   b. 4 feet
   c. 5 feet
   d. 6 feet

10. If the homeowner tells the builder to increase the size of the room and the heat loss increases to 35,000 BTUH, could you still use 1/2" piping baseboard?
    a. Yes, because the chart indicates it is acceptable.
    b. Yes, because the total length of the circuit is not affected.
    c. No, because the chart indicates it is not acceptable.
    d. No, because the total length of the circuit has changed.

REVIEW QUIZ – PUMPS, SPECIALTIES, CONTROLS *Answers appear on page 94*

APPLYING WHAT YOU HAVE LEARNED:

By observing and asking questions, fill in the blanks. If you are not sure of the answers, ask your supervisor.

A. Explain the purpose of pressure reducing valves to a customer.

____

____

____

B. Describe the sizing pumps and pipes your company sells.

____

____

____

THIS COURSE INCLUDES AN ONLINE FINAL EXAM

This course is limited to a single user. When you are ready to take the final exam to earn your Certificate of Completion, please contact ASA at info@asa.net. ASA staff will contact you about how to register for the final exam.

ANSWERS TO REVIEW QUIZ

CHAPTER 4

OVERVIEW OF PIPES, SPECIALITIES, CONTROLS

Answers to REVIEW OF PIPES, SPECIALTIES, CONTROLS (pages 88 – 91)

1. a. Above the boiler
2. d. Capacity and pump head
3. c. 3.2 gpm
4. b. Milinches
5. b. The pressure increases.
6. c. The pressure decreases.
7. a. Pump head rating of the circulator needed
8. b. 2.0 gpms
9. c. 5 feet
10. c. No, because the chart indicates it is not acceptable.

Applying what you have learned:

A. Pressure reducing valves reduce the amount of pressure of the water coming into the system.

B. Depends on the company

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GLOSSARY OF TERMS

A.F.U.E.: *SEE* Annual Fuel Utilization Efficiency.

Air control devices: Hydronic specialties for eliminating air from the system. Includes boiler and tank fittings and vents for heat emitters and piping. *SEE* Air control fittings.

Air control fittings: Boiler or tank fittings designed to prevent air from getting into the piping system and to direct air into the air cushion tank.

Thermal expansion tank: A tank used to hold extra water as the heated water expands and to maintain desired system pressure. *Also called an expansion tank or a compression tank. SEE* Conventional tank; Diaphragm tank.

American Society of Mechanical Engineers (ASME): The organization that writes code for boiler construction. ASME International, Three Park Avenue, New York, NY 10016-5990. Telephone: 800.843.2763.

Annual Fuel Utilization Efficiency (AFUE): An efficiency rating given to boilers by the manufacturer, required by the U.S. Department of Energy (DOE).

ASME: *SEE* American Society of Mechanical Engineers.

Average water temperature: The average of the temperature of the water leaving the boiler and the water returning to the boiler. *Also called the design water temperature.*

Balancing valves: Valves used to equalize water distribution in multiple circuit systems.

Baseboard heat emitter: Radiation which replaces conventional baseboard trim along the floor of the room to be heated.

Boiler: A closed pressurized container in which a liquid is heated.

Boiler gauge: A gauge which measures water temperature and pressure within the boiler.

Booster pump: *SEE* Circulator.

British thermal unit (BTU): The amount of heat necessary to raise the temperature of one pound (1 lb.) of water by one degree F.

BTU: *SEE* British Thermal Unit.

BTUH: British thermal units lost per hour. Unit of measurement used to calculate heat loss and rate hydronic system components.

BTUH to gpm: *Step One*: Multiply 500 x the number of degrees in the water temperature drop (usually 20 degrees). *Step Two:* Divide the total calculated heat loss for the building by the answer from Step One (The answer to Step One will usually be 10,000 for residential systems). This will give you the pump capacity (gpm) needed to produce the needed amount of heat.

BTUH to MBH: Divide BTUH by 1000. (Move decimal in BTUH 3 places to the left.) *Example:* 8200 BTUH is equal to 8.2 MBH

Calculated heat loss: *SEE* Heat loss.

Cast iron boiler: A boiler with several cast iron sections attached to each other through which the water flows, with fire below to heat the water.

Circulator: A small capacity pump to circulate water in a closed hot water comfort heating system. *Also called a booster pump.*

Circuit: One complete pipe loop connecting the supply pipe, the heat emitters, and the return pipe to the boiler.

Comfort heating system: A system which is designed to maintain living area temperatures at levels that allow heat loss from the human body to occur at a comfortable rate.

Compression tank: *SEE* Air cushion tank.

Conduction: Transferring heat, by contact, from one molecule to another within the material heated.

Convection: Transferring heat by circulation of molecules in the material that is heated. For example, heat transfer by circulation of molecules of heated air.

Convector: A radiation heat emitter consisting of a finned heating element enclosed in a cabinet designed to promote air circulation.

Conventional thermal expansion tank: An thermal expansion tank with no separating device between the air cushion and the water.

Design heat loss: The amount of heat lost from a building as calculated on the basis of charts showing the normal low outside temperature for the specific locality. *SEE ALSO* Heat loss.

Design water temperature: *SEE* Average water temperature.

Design water temperature drop: *SEE* Water temperature drop.

Diaphragm expansion tank: An expansion with a flexible diaphragm separating the water from the air.

Direct return system: A two-pipe system in which the heat emitters are connected to the return pipe in the same order in which they are attached to the supply pipe.

DOE: U.S. Department of Energy.

Downfeed system: A system in which the supply pipe is above the heat emitters.

EDR: Equivalent Direct Radiation

Electric boiler: A boiler which uses electric heating elements to heat the water.

Emitter: *SEE* Radiation.

Equivalent Direct Radiation (EDR): A rating system for rating heat emission (output) of cast iron radiators. One square foot of Equivalent Direct Radiation = 240 BTUH.

Finned tube unit: A radiation emitter, usually used in commercial buildings, which is made up of one or several metal tubes with fins attached to increase heat transfer surface. The tube may be installed with or without a cover.

Fire tube boiler: A boiler with hot gas tubes immersed in the water to heat the water.

Flash boiler: A boiler which has water-filled copper coils surrounded by fire and hot gases.

Flow check valves: Valves to prevent gravity circulation of water when the booster is shut off.

Flow control valves: Valves that prevent unwanted flow from occurring in an "off" zone when another zone is calling for heat.

Forced air heating system: *SEE* Hot air heating system.

Forced circulation system: A hot water comfort heating system which uses a circulator (booster pump) to circulate the water.

Gpm: Gallons per minute.

Gravity circulation system: A hot water comfort heating system which uses the difference in the weight of hot water and cold water to create flow due to the force of gravity.

Gross output: *SEE* Heating capacity.

Head pressure: *SEE* Pump head.

Heat loss: The rate at which heat is lost from a heated building to the outdoors. Heat loss calculation is based on many factors. Heat loss is measured in BTUs per hour (BTUH). *Also called calculated heat loss or design heat loss.*

Heating capacity: The actual amount of heat available for distribution throughout the piping system to heat the building. Technically, this figure is the amount of heat generated **minus** the amount of heat lost up the smoke stack/chimney. This term (heating capacity) is used primarily for residential boilers. *For larger boilers, this is called output or gross output.*

Heating control system: A system of regulating devices used to keep the heating system operating within the prescribed limits (water and combustion limits).

Hot air heating system: A comfort heating system which transfers heat by moving hot air, by use of a blower, through ducts to points of use and then heats the desired areas by convection. *Also called forced air heating system.*

Hydronic heating system: A comfort heating system which uses a fluid (generally water) to transfer the heat to points of use.

Hydronic specialties: Accessories (valves, air control devices, etc.) which improve the performance of the major components (boiler, emitters, piping) of a hydronic heating system.

Hydronics Institute of GAMA: Organization with information about hydronic heating. The Hydronics Institute is comprised of more than 60 manufacturers of hydronic heating equipment. It became of division of the Gas Appliance Manufacturers Association (GAMA) in 1995. Hydronics Institute Division, 35 Russo Place Berkeley Heights, NJ 07922. Telephone: 908.464.8200.

I=B=R: *SEE* Institute of Boiler and Radiator Manufacturers.

I=B=R net water rating: *SEE* Net rating.

Input rating: The amount of heat energy from fuel (usually given in BTUH) put into the boiler.

Institute of Boiler and Radiator Manufacturers (I=B=R): A function of the Hydronics Institute. I=B=R provides ratings for various hydronic products.

Main: The large pipe in a piping system which feeds other smaller circuit pipes or risers.

Mainless system: *SEE* Series loop system.

MBH: Thousand BTUs per hour. One MBH = 1000 BTUH.

MBH to BTUH: Multiply MBH X 1000. (Move decimal in the MBH 3 places to the right) For example, 125 MBH = 125,000 BTUH.

Milinch: A measure of pressure or pressure drop. One milinch is equal to the pressure produced by 0.001 (1/1000) of an inch of water. One milinch = pressure of 1/1000 inch of water or 12,000 milinches = pressure produced by one foot (12 inches) of water.

Monoflo fittings: *SEE* One-pipe fittings.

Monoflo system: *SEE* One-pipe system.

Multiple circuit system: A piping system which uses more than one complete loop to connect emitters and boiler. *NOT the same as a zoned system.*

Net rating: The amount of heat available for radiation after theoretical allowances are made for heat lost in piping and in pickup from cold starts. The net rating is used for residential boiler selection. *Also called Net water rating or I=B=R net water rating.*

Net water rating: *SEE* Net rating.

One-pipe fittings: Special tee fittings which divert part of the water from the main into the risers on a one-pipe system. *Sometimes called monoflo fittings.*

One-pipe system: A piping system using one continuous pipe (or main) making up both the supply and return pipe, with emitters connected to the main by vertical risers. *Sometimes called a monoflo system.*

Output: *SEE* Heating capacity.

Piping layout: A scale drawing showing the location of the boiler, emitters, and piping system.

Piping system: The combination of supply pipe (which takes heated water from the boiler) and the return pipe (which returns cooled water to the boiler) and the various associated fittings and valves attached to these pipes.

Packaged boiler: A boiler which is preassembled by the manufacturer with burner, circulator, and controls, and is ready for hookup to piping, fuel line, and wiring.

Pressure drop: The friction-caused loss of pressure between any two points in the piping system. Measured in milinches per foot of pipe, or in feet of water. (12,000 milinches = 1 foot).

Pressure reducing valve: A valve designed to reduce the pressure of water coming into the system if the incoming water is under greater pressure than the water already in the system.

Pressure relief valve: *SEE* Safety relief valve.

Psi: Pounds per square inch. A measure of pressure or weight.

Pump: *SEE* Circulator.

Pump capacity: The number of gallons per minute (gpm) a pump can move.

Pump curve: A graph/chart showing the relationship between the amount of water (capacity in gpm or gph) a pump can move and the amount of pressure (head) pump can develop. *Also called a pump performance curve.*

Pump head: The amount of pressure a pump can develop to move water against the resistance (friction) caused by the passage of water through piping or tubing. Pump head is usually measured in feet of water. *Sometimes called head or head pressure.*

R-values: Comparative values that indicate the insulative qualities of various floor coverings. R-values are used in planning radiant floor heating systems.

Radiant floor heating: A radiant panel system which uses flexible tubing under the floor to carry the hot water and produce radiant heating in the room above.

Radiant heating system: A heating system which depends upon the use of invisible heat rays which travel from the heat source to human body.

Radiant Panel Association: Organization providing information about radiant panel heating. Radiant Panel Association, PO Box 717, Loveland, CO 80539. Telephone: 1-800-660-7187

Radiant panel system: A heating system which circulates the hot water through a series of flexible tubes or coils embedded in (or attached under) the floor or ceiling.

Radiation: Output devices *(often called emitters)* used to transfer heat from the water into the rooms to be heated. Also: Heat transfer by means of invisible heat rays or heat waves.

Return pipe: The pipe which returns cooled water to the boiler from the radiation.

Reverse return system: A two-pipe system in which emitters are connected to the return main in reverse order from the way they are connected to the supply main.

Risers: Small vertical pipes which connect radiation emitters (baseboard or convectors) to a main in a one- or two-pipe system.

Safety relief valve: A valve on a boiler that will open to prevent buildup of excess pressure. *Also called a pressure relief valve.*

Series loop piping system: A piping system using a continuous pipe loop with the water passing through the supply pipe, each emitter in series, the return pipe, and back to boiler.

Static pressure: The amount of pressure (measured in feet of water) created by the weight of the water in the vertical pipes of the system.

Supply pipe: The pipe which supplies hot water from the boiler to the radiation.

Thermal mass: A dense concrete-like material poured as a sub-floor or a finished floor when using radiant floor heating. The thermal mass stores heat, distributes heat between the tubes or coils, and transfers the heat to the surface of the floor.

Two-pipe system: A system which has one pipe as a supply main and a separate pipe for a return main.

Upfeed system: A system in which the supply pipe is below the emitters.

Water temperature drop: The difference between the temperature of the water leaving the boiler and the temperature of the water returning to the boiler. The temperature is chosen as part of the design of the system, *so it is sometimes called the design water temperature drop.*

Water tube boiler: A boiler containing a fire pot with water tubes running through it to heat the water.

Zone: A section of the piping system which is regulated by a separate zone thermostat and controlled by zone valves.

Zone pump: An integral part of any hydronic system. Pumps are used to send water to an area of the hydronic system when it is called for, or to keep the flow of water in the system.

Zone valves: Valves, operated by thermostats, to control flow in individualized section (zones) of a zoned system.

Zoned system: A heating system which uses two or more thermos-tats to control the heat in several section (zones) of the system independently.

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