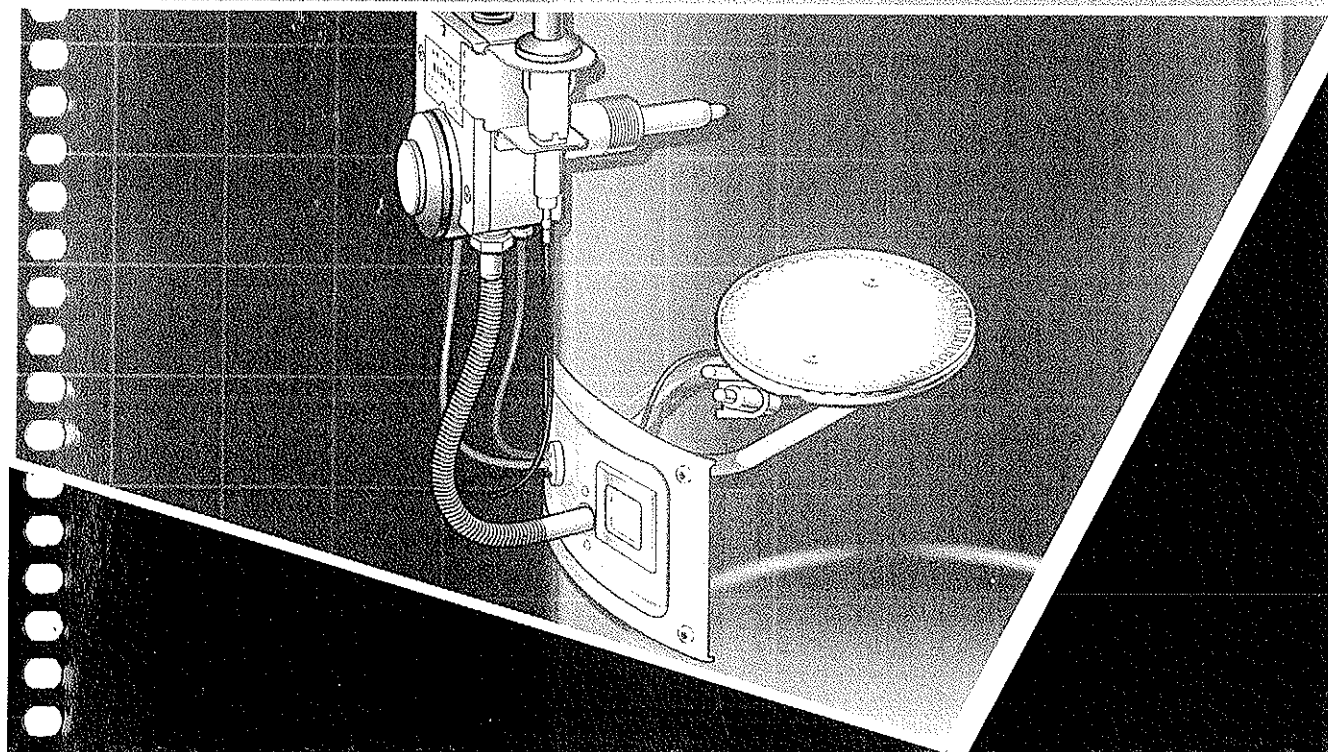
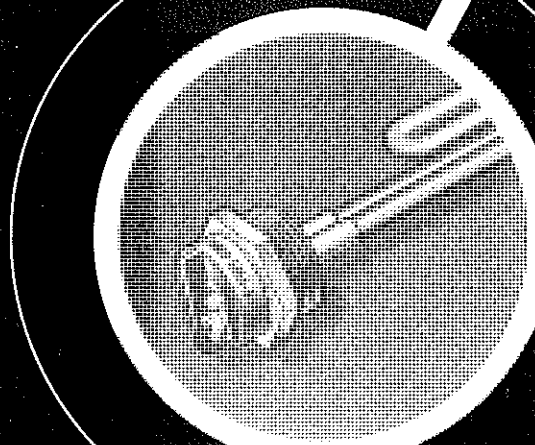
ASA UNIVERSITY

Specialty Products

Domestic Water Heaters©





BOOK #5

CERTIFICATE COURSE

THIRD EDITION

ProductPro®

The Standard in Product Knowledge Solutions

A publication by **ASA Education Foundation**

Specialty Products

Domestic Water Heaters©

from the

ASA Education Foundation

Domestic Water Heaters© provides new warehouse, counter, and sales personnel with an overview of the operation and components of domestic water heaters. It is NOT intended to provide the kind of complex, technical data which would enable employees to design or install water heaters. This course includes definitions of common industry terms, descriptions of the components and functions of domestic water heaters, and other information that will help employees serve their customers more effectively.

ProductPro®
The Standard in Product Knowledge Solutions

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ASA Education Foundation

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 pro-vide 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 is designed to give you an overview of domestic water heaters. The course includes definitions of common industry terms, descriptions of the major types of water heaters, and information on similarities and differences in water heaters. It also provides information that can help you guide your customers who want or need to change their systems.

Some of the products reviewed in this course may not be a part of your company's current inventory. Other products which may be stocked by your company may not be discussed in this course. Always refer to manufacturers' literature and recommen-dations on the products your company sells if unsure about a particular product.

To do your job well, it is important that you learn the details about specific items stocked by your company. The most complete and accurate information can be found in manufacturers' catalogs and materials. Be certain to spend time studying those materials.

How the course is organized

The ProductPro® courses are 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 Certificate of Completion, please contact ASA at info@asa.net. You will be contacted about how to register for the exam.

Seven simple hints for successful course completion

1. **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 chapter and ask yourself whether you are confident in your command of the material. If you are not, re-read anything that you did not understand.
2. **Search for the important ideas**
   Use a highlighter 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 book margins about points you don't understand or about how the material you read applies to your own company.
3. **Ask 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 your company's overall inventory.
4. **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.
5. **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 more on to the next. Take some time to "plug in" what you have just studied before acquiring more new information.
6. **Be proud of what you have accomplished**
   When you successfully complete the course, be sure to download, print, and proudly display your Certificate of Completion. You earned it!
7. **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 say. 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 are grateful to George Kusterer with Eagle River Consulting, who acted as the primary author of this edition. Also of special value were those reviewers, such as Glenn Mesick of Bradford White Corp., Andy Nord of Nord Consulting, and Russell Atchetee of Coburn Supply Co. Inc., who thoroughly and diligently reviewed the course text, quizzes, illustrations, and final exam to ensure accurate and highly readable information. Their 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 ensure 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

Impact on Distributors by Department of Energy Final Rule on Water Heater Efficiency—Effective April 16th, 2015

The efficiency standards as set forth by DOE (Department of Energy), which take effect on April 16th, 2015, have a significant impact on the distributor and their employees. Employees will have to be re-trained in order to better understand the new and sometimes complex technology.

Product Changes—Residential

Electric water heaters:

1. Heaters will require additional insulation to meet the new efficiency requirements, which will increase both the diameter and height. This will necessitate additional warehouse space. This will also hold true for heat pump water heaters.
2. Additional insulation may be required on piping and fittings.
3. Electric heaters above 55 gallons of storage may not meet the new standard and will require the installation of a heat pump water heater.

Gas water heaters:

1. Like the electric heaters, gas water heaters will require additional insulation, which will also increase tank size, as well as the addition of a flue damper, and an electronic ignition (no more standing pilots).
2. Storage tanks greater than 55 gallons must be high efficiency (90%+) using condensing combustion technology, which will require line voltage circuitry (120VAC) as well as a means of disposing the condensate from the heater.

Oil-fired heaters:

1. Currently there are a few manufacturers that have product that already meets the new DOE Standard. Others will most likely add additional insulation, flues, or a new combustion system to meet the new standard.

New technology brings change that will impact the distributor. In order to support the new technology, the distributor faces a few challenges:

1. Training employees on the new technology so they better assist their customers.
2. Training employees on the proper and safe handling of the new appliances.
3. The new technology may require additional components for installation such as condensate pumps and venting material, pipe, and fittings.

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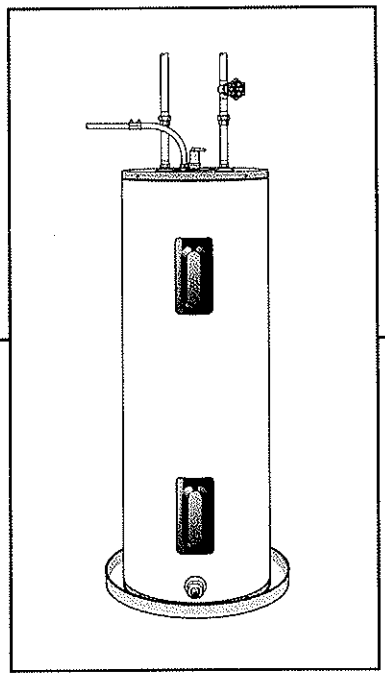
1 OVERVIEW OF WATER HEATERS

LEARNING OBJECTIVES

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

1. Identify the four segments of the water heater market.
2. Explain how water heaters are classified.
3. Compare and contrast the major types of water heaters.
4. Explain the history and importance of appliance efficiency standards.
5. List and describe the basic components of water heaters.



WATER HEATERS

Understanding the Water Heater Market

All the water used in homes in the United States comes from either ground water sources, such as wells, or surface water sources, such as lakes, streams, or reservoirs. According to the *U.S. Geological Survey* in 2005, about 20% of domestic water comes from ground sources. The remaining 80% comes from a surface water source.

Each person in the U.S. uses an average of about 100 gallons of water per day. This includes baths, showers, cooking, clothes and dish washing, grooming, and waste disposal. The toilet is largest user of household water; the second largest user is the shower.

AVERAGE DAILY WATER USE

Gallons of Water Usage	
Toilets	35 gallons
Baths/Showers	30 gallons
Clothes washing	20 gallons
Miscellaneous use	16 gallons
Dishwashing	15 gallons

SP 1.1.11

With the exception of the toilet flush, all household water activities involve either the use of hot water or have the potential to use hot water. That means that 64% of our average water usage involves the hot water heating system in homes.

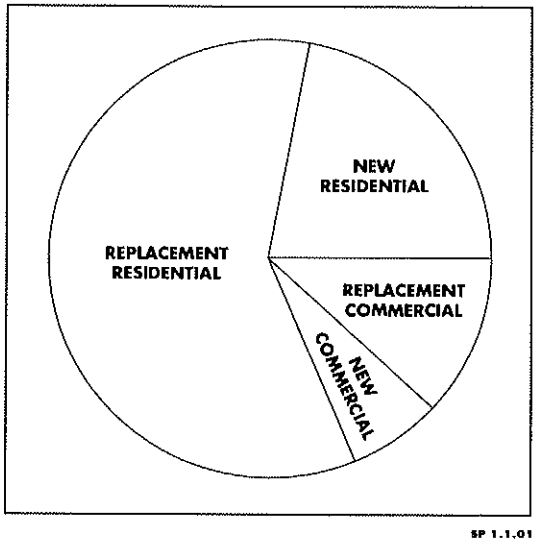
Water heaters are one of the largest segments of the plumbing industry market. In fact, plumbing wholesalers provide about 50 percent to 60 percent of all water heaters sold.

A **WATER HEATER** is an appliance for supplying hot water for domestic or commercial purposes other than for space heating. Basically, water heaters are classified for residential or commercial use.

In this course, we will discuss the different types of heaters, how they function, and their appropriate applications. There are four segments in the water heater market:

1. residential (new homes and apartments)
2. commercial
3. replacement for residential (homes and apartments)
4. replacement for commercial

WATER HEATER SEGMENTS



Residential or Commercial Use

How a water heater is classified (as either residential or commercial) is determined by the **BRITISH THERMAL UNIT (BTU)**. A BTU is the amount of heat required to raise the temperature of one pound of water by one degree Fahrenheit.

The temperature requirements for water heaters will depend on how the water will be used. Water heaters with up to 75,000 BTU capacity are classified for residential use. Units above the level are considered commercial units.

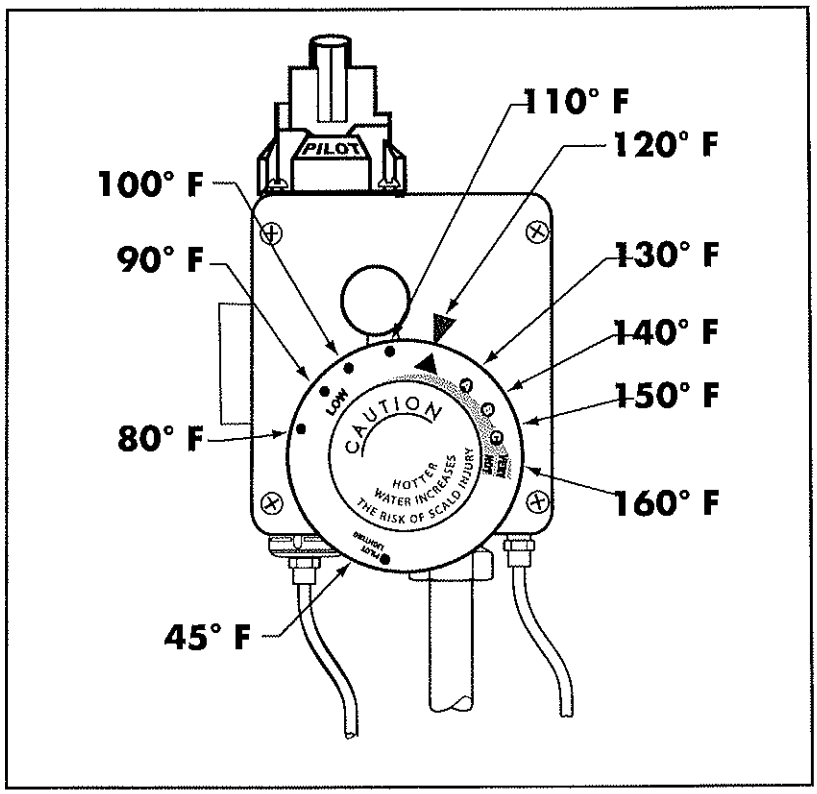
Another way of looking at the heat requirements is by the temperature of the water once it is heated. Commercial users usually need a water temperature of 180° F. Residences seldom need hot water above 120° F. For safety reasons, the current recommended temperature setting to prevent scalding is 120° F for residences.

Storage type water heaters including indirect heaters have been around for many years and they rely on the precision of the water temperature control. These temperature controls were never designed to control the water temperature at the point of use. The misconception has led many to set heaters temperature control at 120° F (49° C) and incorrectly assume the water temperature will not exceed this value. Even temperatures at 120° F can produce scalding injuries after only three minutes of exposure.

The solution to the problem is a simple one. The installation of a water tempering or anti-scald device on the outlet of the water heater is a proactive measure that will ensure the safety of the occupants and, as an added benefit, will increase the usable stored water as well as the delivery and recovery. When installing these devices it is important to follow the manufacturer's instructions.

Note: Most water heater manufacturer's and various plumbing codes require that the thermostatic control on the water heater should never be used to control the final temperature of the water to the point of use (International Plumbing Code, Uniform Plumbing Code, and International Residential Code).

SCALDING POTENTIAL



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Types of Water Heating Options

There are two main types of water heating options:

1. direct-fired
2. indirect-fired

Alternative types of water heating options include:

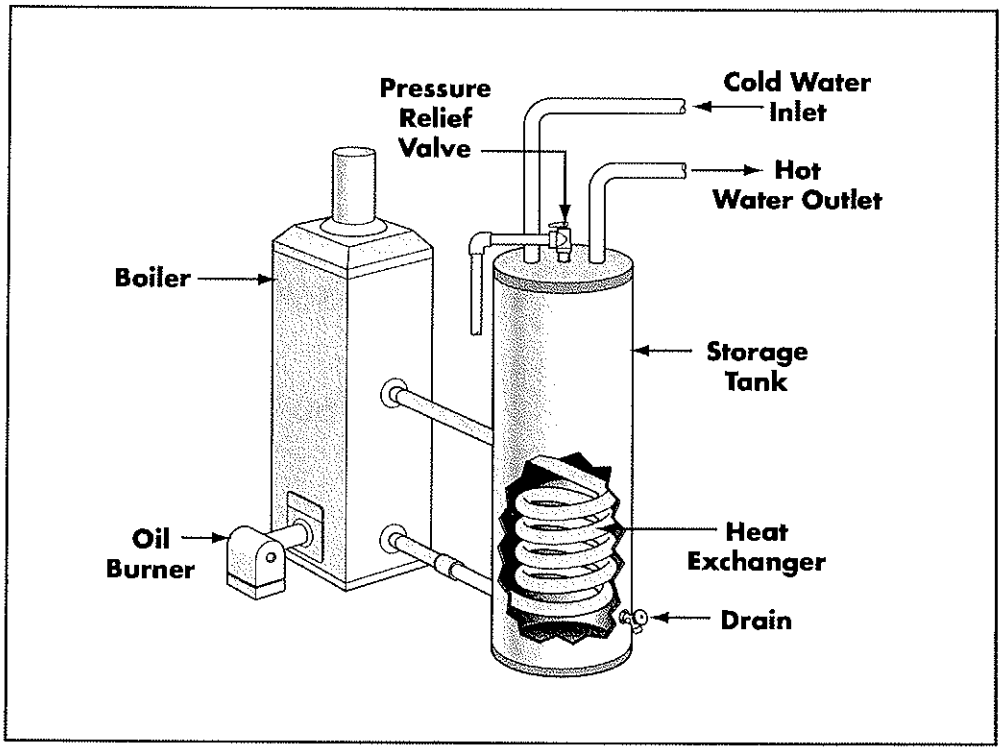
1. Solar
2. Ground

In a **DIRECT-FIRED** water heater, the water is heated directly by an electric element or a flame (oil- or gas-fired). You'll usually find a direct-fired water heater in a home with a warm air furnace. The oil or gas is burned in a **COMBUSTION CHAMBER** under the water storage tank, and hot **FLUE** gases heat the water in the tank.

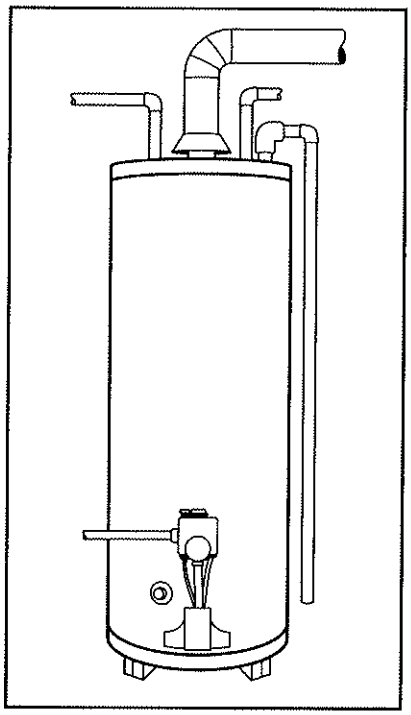
In an **INDIRECT-FIRED** water heating system, the water is heated by hot water from the boiler. In many oil-heated homes, you may find an indirect-fired system that is also tankless. A tankless, indirect-fired water heating system can work in conjunction with either a hot water boiler or a steam boiler.

There are three variations: internal tankless coil, external tankless coil, and tankless coil with storage tank. The two types of water heating options are shown below.

DIRECT - FIRED AND INDIRECT - FIRED HEATERS



SP 1.4.08 Indirect-Fired



SP 1.1.03 Direct-Fired

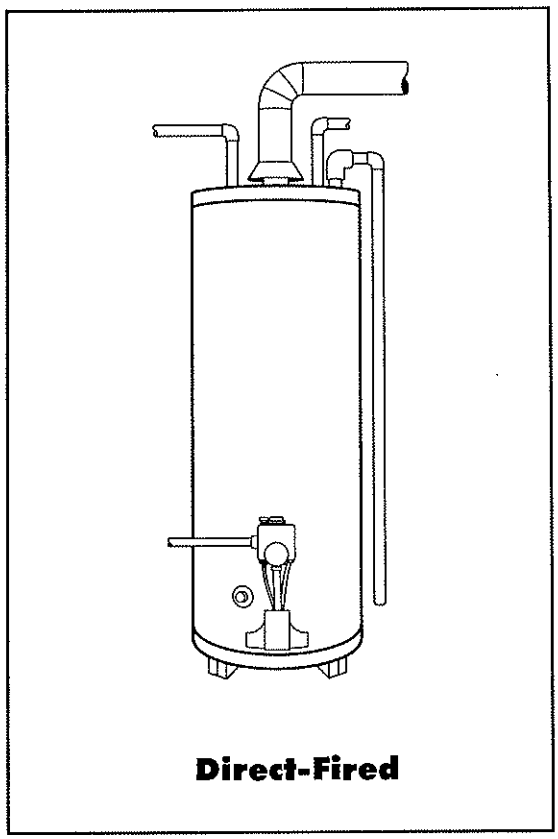
Direct-fired Water Heater

The majority of water heaters sold to both residential and **COMMERCIAL MARKET** are the direct-fired type.

A direct-fired water heater is one in which the method of heating is located in the same basic structure where the actual heating takes place.

To the right is an example of the structure of a direct water heater, sometimes called an **AUTOMATIC STORAGE HEATER**.

DIRECT - FIRED HEATER

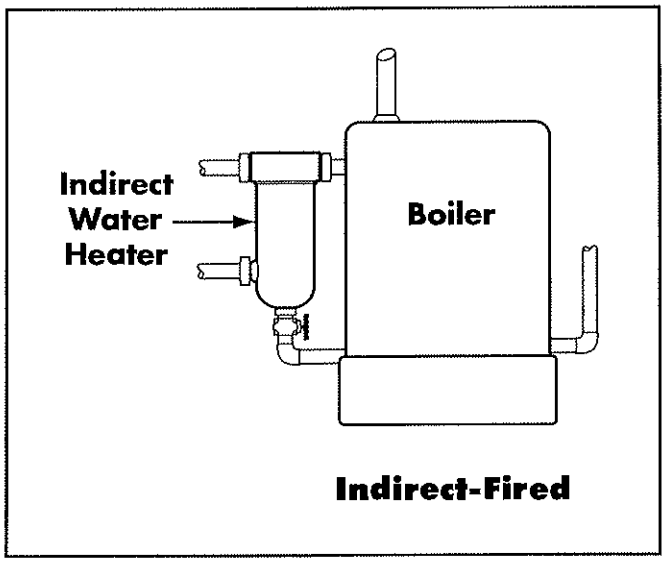


SP 1.1.03

Indirect-fired Water Heater

Unlike a direct-fired unit, an "indirect-fired" unit is a heater in which combustion products do not come in contact with the material to be heated. Heating is accomplished by conduction from the heated surface. An indirect-fired heating system is one in which the heat source is located apart from the heating process.

INDIRECT - FIRED HEATER



SP 1.1.04

An indirect water heater uses the **BOILER** to heat a fluid that's circulated through a heat exchanger in the storage tank. The energy stored by the water tank allows the boiler to turn off and on less often, which saves energy.

HEAT TRANSFER is the movement of heat from one body to another. In many plumbing applications, it means the transfer of heat from one fluid to another, such as steam (a **GASEOUS STATE**) or water. In water heating, it means the movement of heat (gas or electric) through metal in order to heat water.

Types of Residential Water Heaters

Water heaters are the largest energy users in the home, after heating and/or cooling. Water heaters use more than 15 percent of the total energy of a home. The two basic types of water heaters are storage type and tankless type or demand-type water heaters. We will also briefly cover other types of water heaters, such as heat pump and solar water heaters.

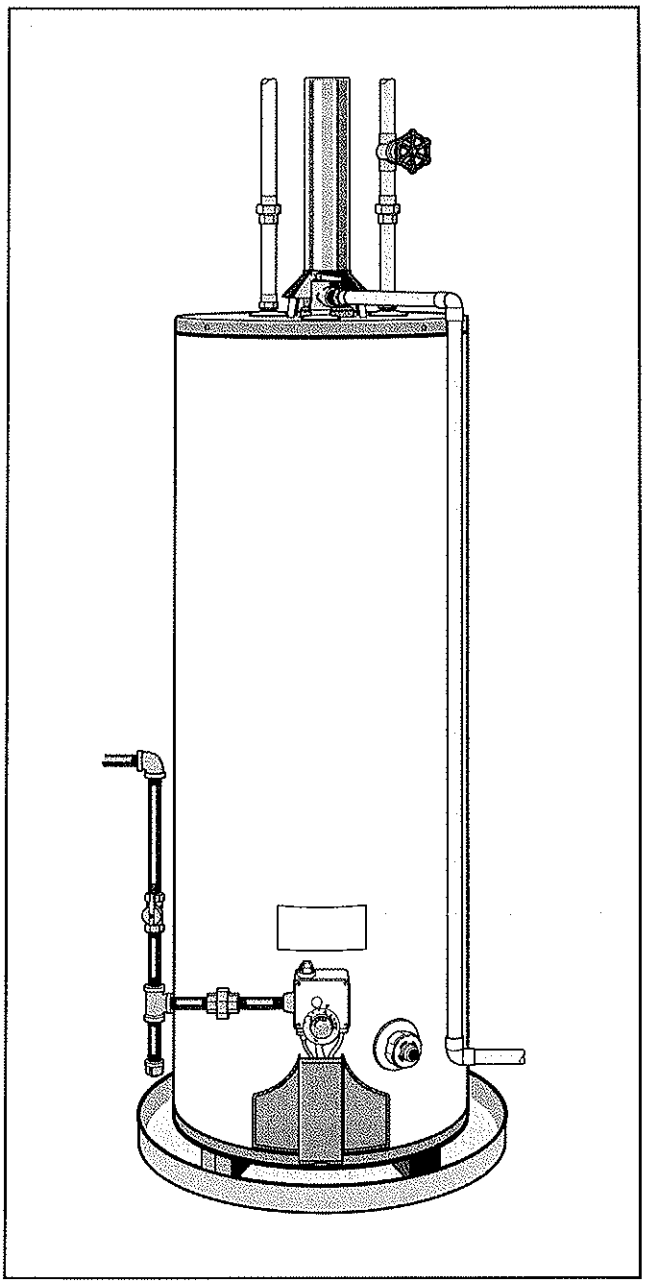
Storage Type

Conventional storage water heaters are by far the most common type of water heater in the U.S. today. Typical residential units range in size from 30 to 80 gallons, but smaller and larger tanks are available. Most are fueled by electricity, natural gas, propane, or oil. Some alternative **ENERGY SOURCES** such as solar, heat recovery units, and dedicated heat **PUMPS** are also available.

Storage water heaters heat the water in the tank to the set temperature, turn off, and then turn on and off as needed to keep the water hot and ready for use. As hot water is used, the unit comes on to heat the incoming cold water that replaces what has been used. When someone turns on the hot water tap, hot water is pulled out of the top of the water heater and cold water flows through a **DIP TUBE** from the top into the bottom to replace it. An example of this a storage water heater is shown on page 9. Some units may use a bottom inlet for cold water.

The major drawback for storage water heaters is heat loss. Heat is lost through the **FLUE** and the walls of the **STORAGE TANK**. Energy is consumed even when no hot water is being used. The industry term to describe heat energy lost from a water heater tank is **STANDBY HEAT LOSS**. New energy-efficient storage water heaters contain higher levels of **INSULATION** around the tank and one-way valves where pipes connect to the tank, substantially reducing standby heat loss.

STORAGE WATER HEATER



SP 5.1.05

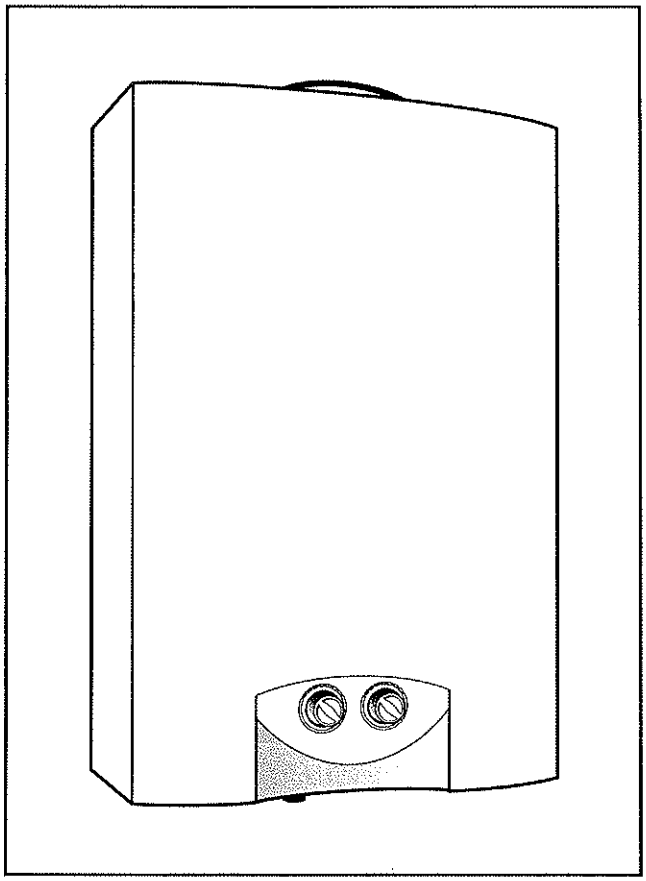
The electric-powered tank type water heaters also have a stored volume of water that is heated. However, the electric units heat the water through electricity. They use a resistance heating element that is immersed directly in the water in the tank. Normally there are two elements: one near the top and one near the bottom of the tank. When electrical current is applied to the heating elements, the built-in "resistance" to electricity flow gives off heat. In the case of these elements, the heat is transferred to the stored water.

Because there is no combustion happening, there is no need for a flue nor are there any exhaust gases that need to be vented. Thermostats are used to monitor the water temperature in the tank and to initiate the heating process.

Tankless Type

TANKLESS WATER HEATERS, also called **INSTANTANEOUS**, **DEMAND-TYPE**, or **ON-DEMAND WATER HEATERS**, are growing in popularity in the U.S. The storage tank is eliminated and hot water is generated as needed. A desired outlet water temperature is set. A gas **BURNER** or an electric **HEATING ELEMENT** heat the water when there is a demand or a need for hot water. When hot water is needed at a fixture, the tankless water heater will modulate the burner input to raise incoming water temperature to the desired outlet water temperature on a single pass of the water through the heater. Demand water heaters with enough capacity to meet household needs are gas-fired or propane-fired.

TANKLESS WATER HEATER



SP 1.1.06

Hot water never runs out, as long the designated flow rate is not exceeded. The temperature for demand water types may be relatively low (around 105° F). As a result energy is not wasted because there are almost no standby losses.

Demand-type water heaters three significant drawbacks for some applications:

1. Large simultaneous uses (two showers and the clothes washer, for example) may challenge their capacity, particularly in winter, when the inlet water is coldest.
2. They will not turn on unless the hot water flow is 1/2 - 3/4 gallons per minute. Retrofit installation can be very expensive.
3. Finally, because the efficiency tests were not developed with these designs being considered, it is not known if the **ENERGY FACTOR** accurately estimates energy consumption.

Other Types of Residential Water Heaters

According to the **U.S. DEPARTMENT OF ENERGY (DOE)**, in addition to storage and demand-type water heaters, there are three other types of residential water heaters:

1. Heat pump water heaters
2. Solar water heaters
3. Tankless coil and indirect water heaters

Because electricity is used for moving, rather than generating heat directly, **HEAT PUMP WATER HEATERS** are more efficient than electric resistance models. The heat source is the outside air or air in the basement where the unit is located. Refrigerant fluid and compressors are used to transfer heat into an insulated storage tank. Heat pump water heaters are available with built-in water tanks called integral units, or as add-ons to existing hot water tanks. A heat pump water heater uses one-third to one-half as much electricity as a conventional electric resistance water heater. In warm climates they may do even better, but there are few sources for these products.

TANKLESS COIL AND INDIRECT WATER HEATERS typically use a home's space heating system to heat water. They're part of what's called integrated or combination water and space heating systems. They use the home's boiler or furnace as the heat source. In boiler systems, hot water from the boiler is circulated through a **HEAT EXCHANGER** in a separate insulated tank by means of circulation pump.

In the less common boiler-based systems, water in a heat exchanger coil circulates through the boiler to be heated, then through the water storage tank. Since hot water is stored in an insulated storage tank, the boiler does not have to turn on and off as frequently, improving its fuel economy. Indirect water heaters, when used in combination with new, high-efficiency boilers are usually the least expensive way to provide hot water. These systems can be purchased in an integrated form, incorporating the boiler and water heater with controls, or as separate compo-nents. Gas, oil, and propane-fired systems are available.

SOLAR WATER HEATERS use energy from the sun to heat water. While the initial cost of a solar water heater is high, it can save money over the long term. Solar water heaters were more popular in the 1970s and early 1980s when they were supported by tax credits, but the units available today tend to be considerably less expensive and more reliable. At today's prices, solar water heaters compete very well with electric and propane water heaters on a life-cycle cost basis.

Although each of these types will be covered in more detail later, the primary focus in this course will be on conventional storage water heaters and demand water heaters.

Appliance Efficiency Standards

In the early 1970s, state and federal government policymakers began to consider minimum efficiency standards on new residential appliances. These standards removed inefficient products from the marketplace and assured that consumers would benefit by obtaining less energy-intensive products. The standards lead to appliances often cost a little more initially, but provided energy cost savings over the life of the appliance.

National Energy Policies

In 1978, the **NATIONAL ENERGY POLICY AND CONSERVATION ACT (NEPCA)** directed the U.S. Department of Energy (DOE) to develop mandatory efficiency standards for 13 products. DOE proposed regulations for eight products in 1980, but these standards were never finalized. Little progress was made towards enacting meaningful national standards during 1980-86.

In 1992, Congress adopted the **NATIONAL APPLIANCE ENERGY CONSERVATION ACT (NAECA)**, a federal law that established nationwide minimum efficiency levels for a variety of residential and commercial appliances that use energy and water. The DOE has responsibility for implementing NAECA, including updating minimum required efficiency levels periodically. As new technologies and manufacturing techniques make higher levels of energy efficiency more affordable, DOE increases the NAECA minimums to reflect these improvements that are "technically feasible and economically justified." NAECA minimums generally preempt (nullify) state and local regulations, including building/energy code provisions that are inconsistent.

New ANSI Standard

The U.S. water heater industry implemented a significant product design change that incorporates a new technology—**FLAMMABLE VAPOR IGNITION RESISTANCE (FVIR)**—that will help prevent problems caused by improper storage or use of gasoline and other flammable liquids near residential gas-fired water heaters.

Effective July 1, 2003, residential gas-fired water heaters with storage capacities of 30, 40, or 50 gallons had to meet a new **AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)** standard: ANSI Z21.10.1-2001. The standard applied to both natural gas and liquid propane units.

Any new conventional, atmospheric-type water heater with a storage capacity of 50 gallons or less that is produced on or after the effective date had to be designed so it could not ignite flammable vapors caused by spilled gasoline outside the unit. The ANSI FVIR standard did not affect the current installed base of residential gas-fired water heaters. Effective July 1, 2007, any gas-fired water heaters with an input of 75,000 BTU/hr or less must meet the ANSI standard as an FVIR appliance. This includes conventional vent (atmospherically-fired, natural draft vented), power vented, direct vent, and power direct vented units.

Department of Energy Program

The DOE energy program carries out activities in three areas: (1) labeling, (2) test procedures, and (3) mandatory energy conservation standards.

1. The Federal Trade Commission (FTC) is required to prescribe labeling rules for residential appliances. DOE and FTC share responsibility for labeling commercial equipment.
2. DOE outlines the test procedures that manufacturers must use to certify that their appliances meet the standards. The test procedures measure the energy efficiency and energy use and provide an estimate of the annual operating cost of each appliance. Test procedures are typically maintained by industry associations and incorporated by reference into the rules set by DOE.

3. DOE establishes Mandatory Energy Conservation Standards to keep consistent, national energy efficiency requirements for selected appliances and equipment. By law, DOE must upgrade standards to the maximum level of energy efficiency that is technically feasible and economically justified.

On July 11, 2014, the DOE released a schedule for setting new appliance efficiency standards designed to save consumers nearly $93 billion in energy costs by 2020.

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Selecting a Water Heater

There are many things to consider when selecting a new water heater for a home. When comparing the cost of various water heating options, there are two types of costs: purchase cost and operating cost.

Life-cycle costs, which take into account both the initial costs and operating costs of different water heaters, provide a much more accurate representation of the true costs of the water heater than the purchase price alone. When both purchase and operating costs are taken into account, one of the least expensive systems to buy (conventional electric storage) is one of the most costly to operate over a 13-year period. An electric heat pump water heater, though expensive to purchase, has a much lower cost over the long term. A solar water heating system, which costs the most to buy, has the lowest yearly operating cost among electric systems.

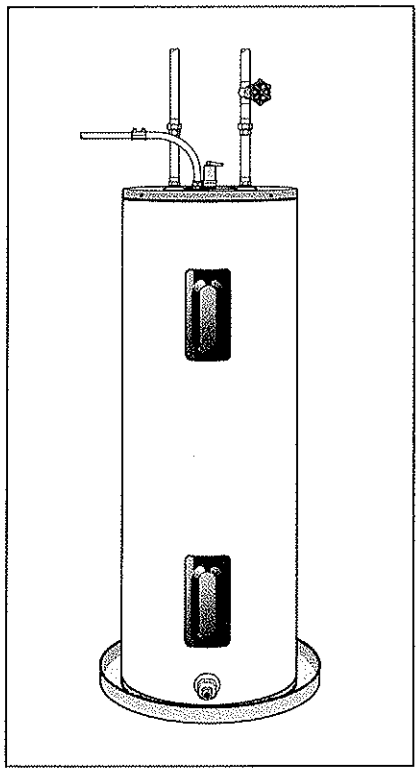
Your customer should choose a water heating system that will not only provide enough hot water but also that will do so energy efficiently and save them money. This includes considering the fuel source, determining the proper size for their needs, and the different types of water heaters available for the home.

Determine Available Fuel Source

Regardless of type, all water heaters have a fuel source. What type of fuel makes the most sense for your customer? The most common source of heat today is gas, with both natural and propane types being used. The second most common source of heat used is electricity. In many cases, utility companies offer special rates to make electricity an attractive option.

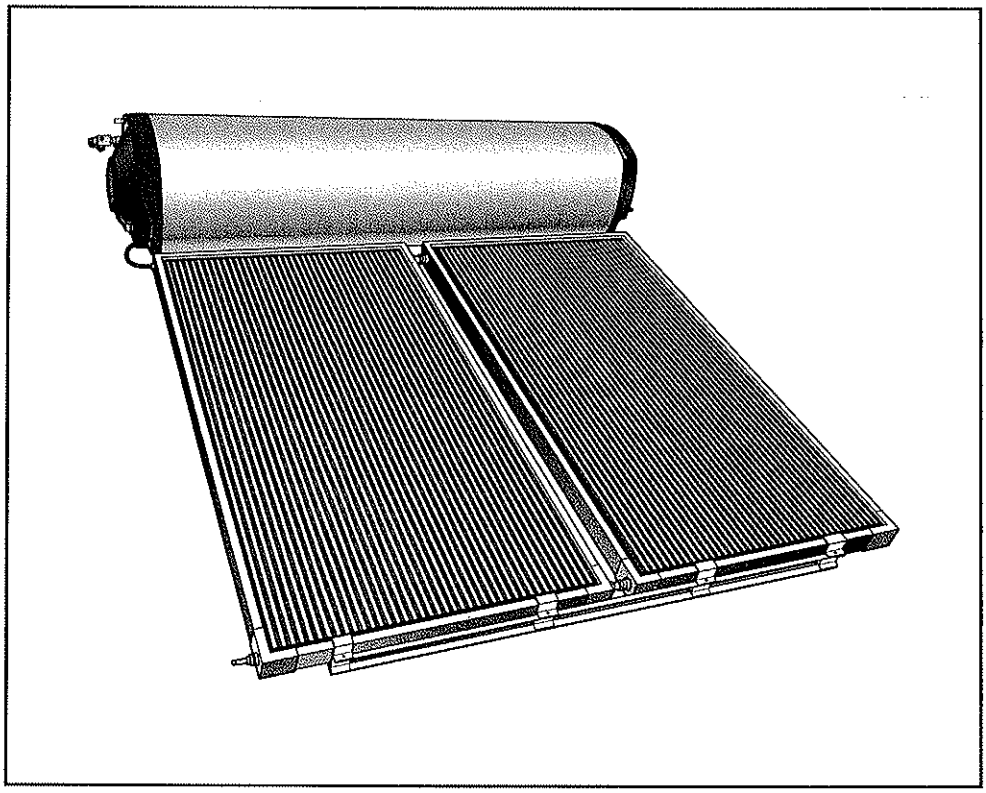
The model to the right uses electricity for its heat source.

STORAGE WATER HEATER



SP 1.1.07

SOLAR WATER HEATER



SP 1.1.08

Water heaters are also available in oil burning and solar models. **SOLAR HEATERS** gather radiant heat from sunlight and transfer the heat to the water. We'll discuss solar heaters in more detail later in this course.

Determine Recovery Rate

In addition to the kind of fuel used, it is also important to know the heater's recovery rate. The **RECOVERY RATE** is the rate at which a water heater can heat water a specified temperature difference. It indicates the number of gallons per hour (GPH) a water heater can raise the temperature of the cool water, usually by 90° F.

Manufacturers state recovery rate on the basis of degrees of **RISE**. This is also called Delta "T" or ΔT. For example, if the water entering the heater is 40°, a recovery rate based on a 90° rise will tell you the number of gallons of water the heater can provide at 130° in one hour.

Determine the Energy Factor For Residential Water Heaters

The energy efficiency of a storage water heater is indicated by its **ENERGY FACTOR (EF)**, an overall efficiency based on the use of 64 gallons of hot water per day. The first national appliance efficiency standards for water heaters took effect in 1990. New standards, which took effect in July 2004, increased the minimum efficiency levels of water heaters.

The United States Department of Energy (US DOE) developed a test using data taken for a specific pattern of hot water use during a 24-hour period. The test used a variety of drain patterns at nominal temperatures of 135° F for hot water, 58° F incoming cold water, and 67.5° F air temperature.

The test also considers the following measurements:

- Recovery efficiency—how efficiently the heat from the energy source is transferred to the water;
- Standby losses—the percentage of heat loss per hour from the stored water compared to the heat content of the water (water heaters with storage tanks);
- Cycling losses—the loss of heat as the water circulates through a water heater tank, and/or inlet and outlet pipes.

The higher the energy factor, the lower the energy consumption. Energy factor is not the same as water heating efficiency; it is defined only for the specific set of conditions in the test procedure.

The actual efficiency of a water heater varies with the amount of hot water used, the inlet water temperature, the hot water delivery temperature, and other operating conditions.

In addition to the energy factor, you must also consider the size, the fuel type, the over-all cost, and the first hour rating of the water heater. **Note:** Commercial water heaters use recovery efficiency to determine energy efficiency.

Determine Heat Measurement

The heat input is used to determine the recovery rate of a water heater. The **HEAT INPUT RATE** is the amount of fuel used to heat the water.

Each fuel source has its own heat measurement. Gas models are rated in British Thermal Units (BTUs); oil-fired models are rated in BTUs or gallons of fuel oil burned per hour; and electric models use kilowatts (kW), a unit of power equal to 1,000 watts. Determining the heat input rate for solar systems is very complex and will not be covered in this course.

Review your manufacturer's literature for more information on determining the heat input and recovery rates for the water heaters you sell.

Conventional Storage Tank—Determine Size

When selecting a conventional water heater, the size of the storage tank can be a determining factor. To properly size a storage water heater for your home (including a heat pump water heater with a tank), use the water heater's first hour rating. The **FIRST HOUR RATING (FHR)** is the amount of hot water in gallons the heater can supply per hour (starting with a tank full of hot water). It depends on the tank capacity, source of heat (burner or element), and the size of the burner or element.

The Federal Trade Commission requires an *Energy Guide label*, which lists the first hour rating in the top left corner as "Capacity (first hour rating)" on all new conventional storage water heaters. Product literature from a manufacturer may also provide the first hour rating.

Commercial models are available in a wide range of tank sizes. These tanks may hold a few or even hundreds of gallons of water. Manufacturers have sizing charts and instructions to determine the ideal tank for a commercial customer's use requirements.

Peak Period Requirement

The most common sizes for residential water heaters are 30-, 40-, or 50-gallon tanks. The ideal size water heater is one that is able to supply the peak period requirement through a combination of storage and recovery capacity. The **PEAK PERIOD** requirement is that time period when the greatest amount of hot water is needed by the user.

In residential installations, the peak period generally covers one hour. A typical peak period might be from 6:00 a.m. to 7:00 a.m. when the entire household is using hot water to prepare for the day, or from 7:00 p.m. to 8:00 p.m. when people are taking showers at night.

The worksheet example below shows a total peak hour demand. Based on this usage, a three-person household would need a water heater model with a first hour rating of 100 gallons (see page 20).

PEAK HOUR DEMAND ESTIMATE

Worksheet for Estimating Peak Hour Demand / First Hour Rating					
Use	Average Gallons of Hot Water per Usage		Times Used during 1 Hour		Gallons Used in 1 Hour
Shower	30	x		=	
Bath	30	x		=	
Shaving	2	x		=	
Hands & Face Washing	4	x		=	
Hair Shampoo	4	x		=	
Hand Dishwashing	4	x		=	
Automatic Dishwasher	15	x		=	
Food Preparation	5	x		=	
Wringer Clothes Washer	26	x		=	
Automatic Clothes Washer	20	x		=	
			Total Peak Hour Demand	=	

SP 1.1.02f

EXAMPLE

Use	Average Gallons of Hot Water per Usage		Times Used during 1 Hour		Gallons Used in 1 Hour
3 Showers	30	x	3	=	90
1 Shave	2	x	1	=	2
1 Shampoo	4	x	1	=	4
1 Hand Dishwashing	4	x	1	=	4
Total Peak Hour Demand				=	100

SP 1.1.02f

Water heaters with high recovery rates (higher BTU or KW input rates) may use smaller storage tanks than water heaters with lesser recovery rates. Because the recovery rate would be higher, the unit could meet the same peak period requirements.

Recovery capacity is affected by the design of the water heater and the fuel being used. For example, recovery rates for residential **ELECTRIC WATER HEATERS** are usually slower than for gas or **OIL-FIRED HEATERS**.

Demand-type Water Heater—Determine Size

Unlike conventional storage water heaters, demand-type water heaters heat water directly without the use of a storage tank. Therefore, they avoid the standby heat losses associated with storage water heaters. To size a demand water heater, first determine the flow rate and the temperature rise needed for its application (whole house or a remote application, such as just a bathroom) in the residence.

To determine the **FLOW RATE**, or amount of water flowing through the system at one time, needed for a demand water heater, begin by listing the number of hot water devices that will be in used at one time. Then add up their flow rates (gallons per minute).

For example, assume the customer wants to run a hot water faucet with a flow rate of 0.75 gallons (2.84 liters) per minute and a shower head with a flow rate of 2.5 gallons (9.46 liters) per minute. The flow rate through the demand water heater would need to be at least 3.25 gallons (12.3 liters) per minute.

To determine **TEMPERATURE RISE**, subtract the incoming water temperature from the desired output temperature. Assume that the incoming water temperature is 50°F (10°C) and the water will be heated to 120°F (49°C). In this example, you'd need a demand water heater that produces a temperature rise of 70°F (39°C) for most uses.

Common Water Heater Tank Components

While in some ways they may vary, all conventional storage water heaters have some common components. These components are:

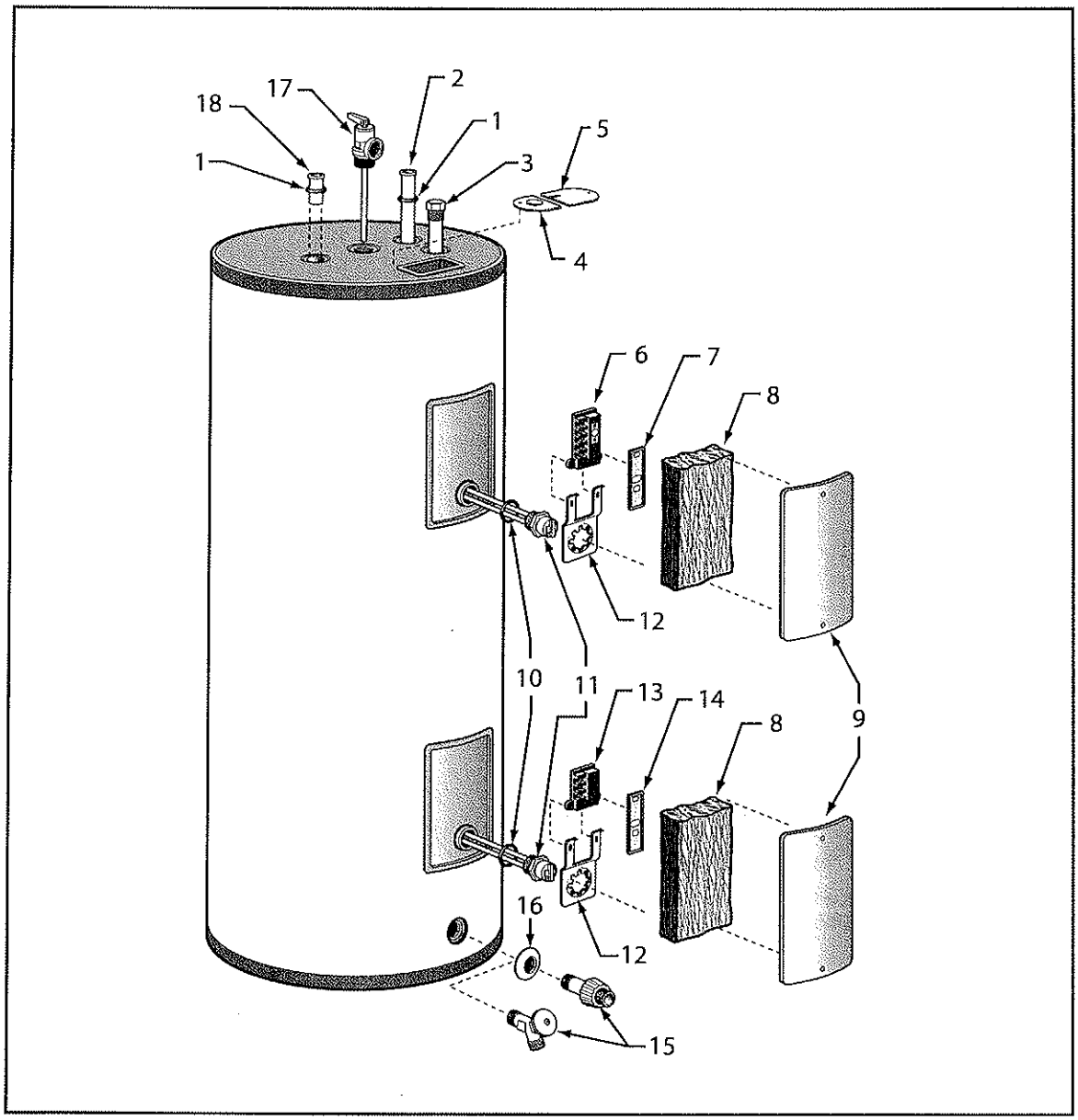
- tank
- tank insulation
- outer shell or jacket
- water inlet and outlet
- dip tube
- anode rod
- drain valve
- energy source (gas burner or heating elements)
- temperature controls
- temperature and pressure relief valve

The model on page 24 is a **GAS WATER HEATER**. However, all the parts labeled are common to gas, oil, and electric water heaters.

WATER HEATER PARTS

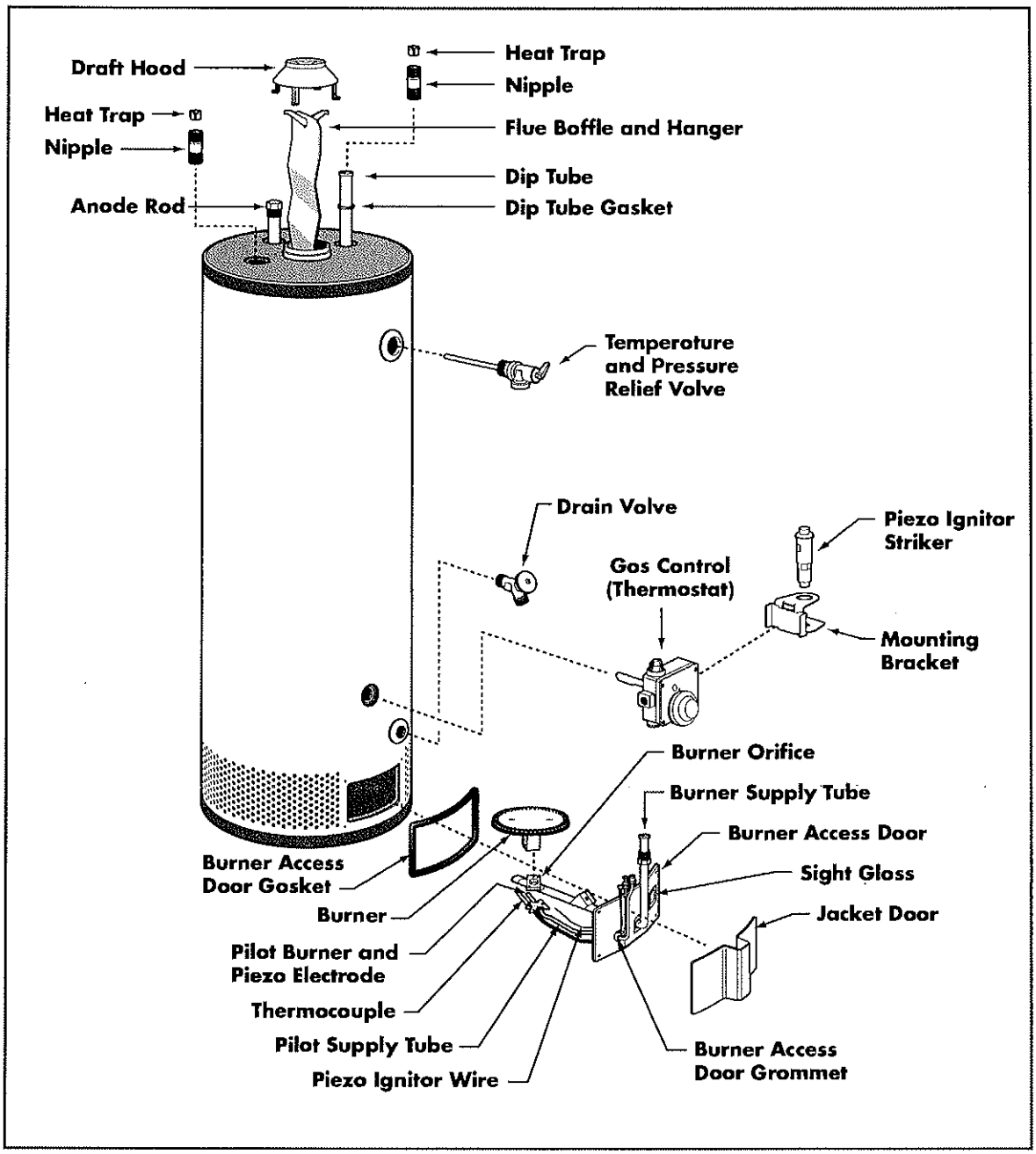
Reference No.	Part Description
1	Dip Tube Gasket
2	Dip Tube
3	Anode Rod
4	Plate Cover
5	Junction Box Cover
6	Upper Thermostat (on double element models only)
7	Upper Thermostat Protective Cover
8	Cavity Insulation
9	Jacket Access Panel
10	Heating Element Gasket
11	Heating Element
12	Thermostat Bracket
13	Lower Thermostat
14	Lower Thermostat Protective Cover
15	Drain Valve
16	Drain Valve Shroud
17	Relief Valve
18	Hot Water Outlet

WATER HEATER PARTS



SP 1.1.09

GAS WATER HEATER COMPONENTS



SP 1.1.09a

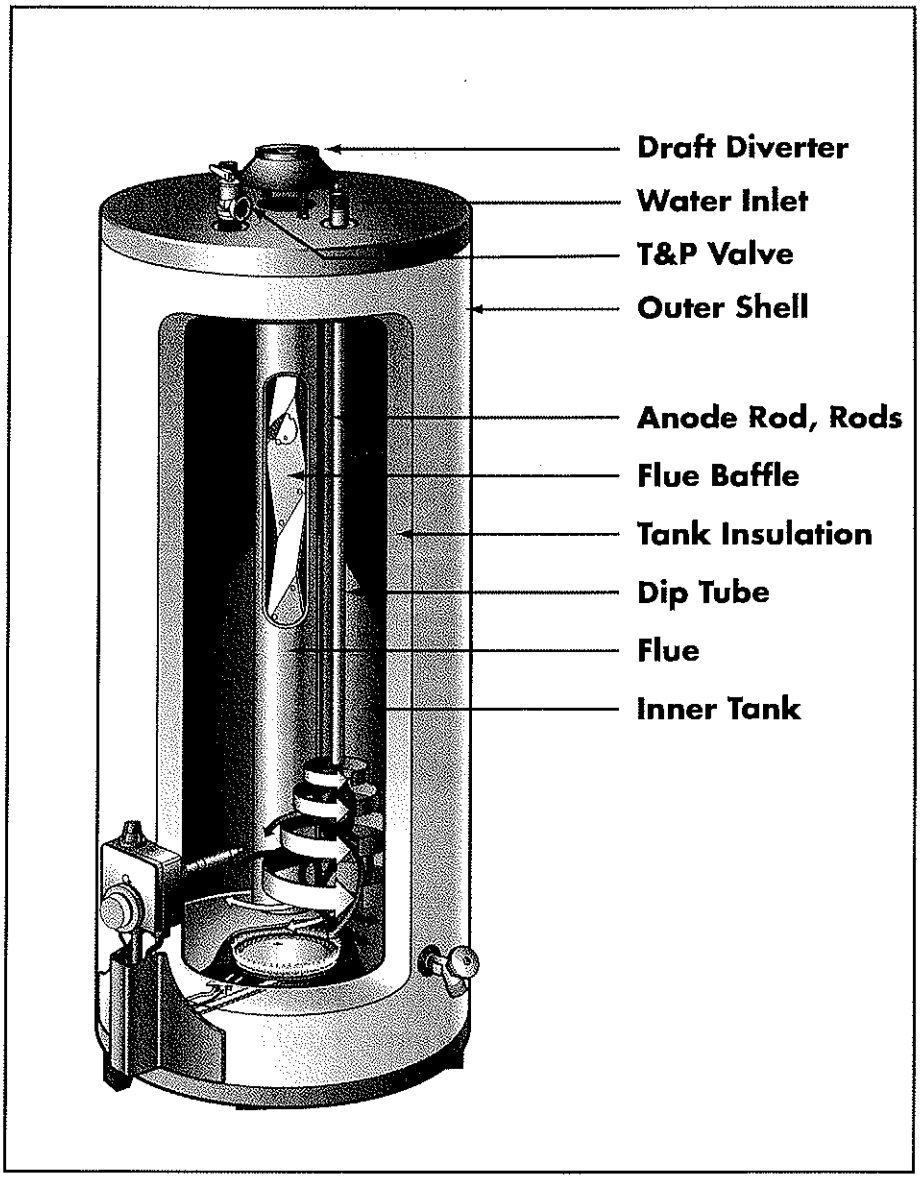
Tank Construction

All automatic storage water heaters have a tank. The storage is where the heating takes place and the water is stored. Typically the tank holds 30 to 100 gallons of water. Most tanks are constructed of steel and must be strong enough to withstand as much as 150 psi working pressure.

To prevent corrosion, tanks are lined; the most common lining is **PORCELAIN GLASS**. A few tanks may be lined with stone (cement) or copper. A layer of insulation is placed between the tank and outer shell to reduce heat loss.

Tanks have a **COLD WATER INLET** and a hot water outlet. The water inlet is the opening where the cold water enters the tank to be heated. The **HOT WATER OUTLET** is the opening where the heated water leaves the tank when needed.

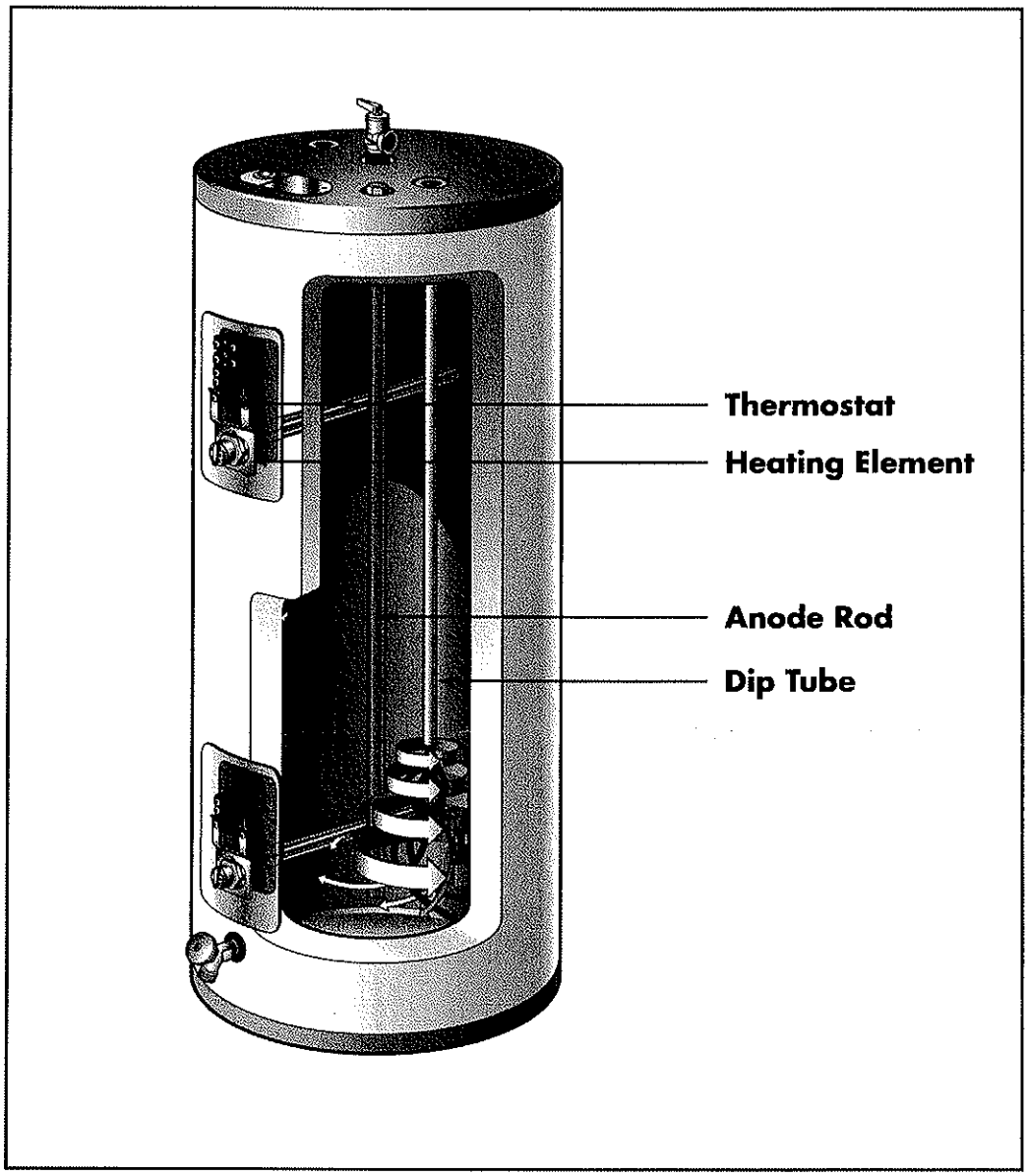
GAS WATER HEATER TANK CONSTRUCTION



SP 1.1.10

The cold water inlet fitting may be located on the top or on the side of the tank. When the cold water enters from the top, the water heater will have an internal channel called a dip tube.

DIP TUBE



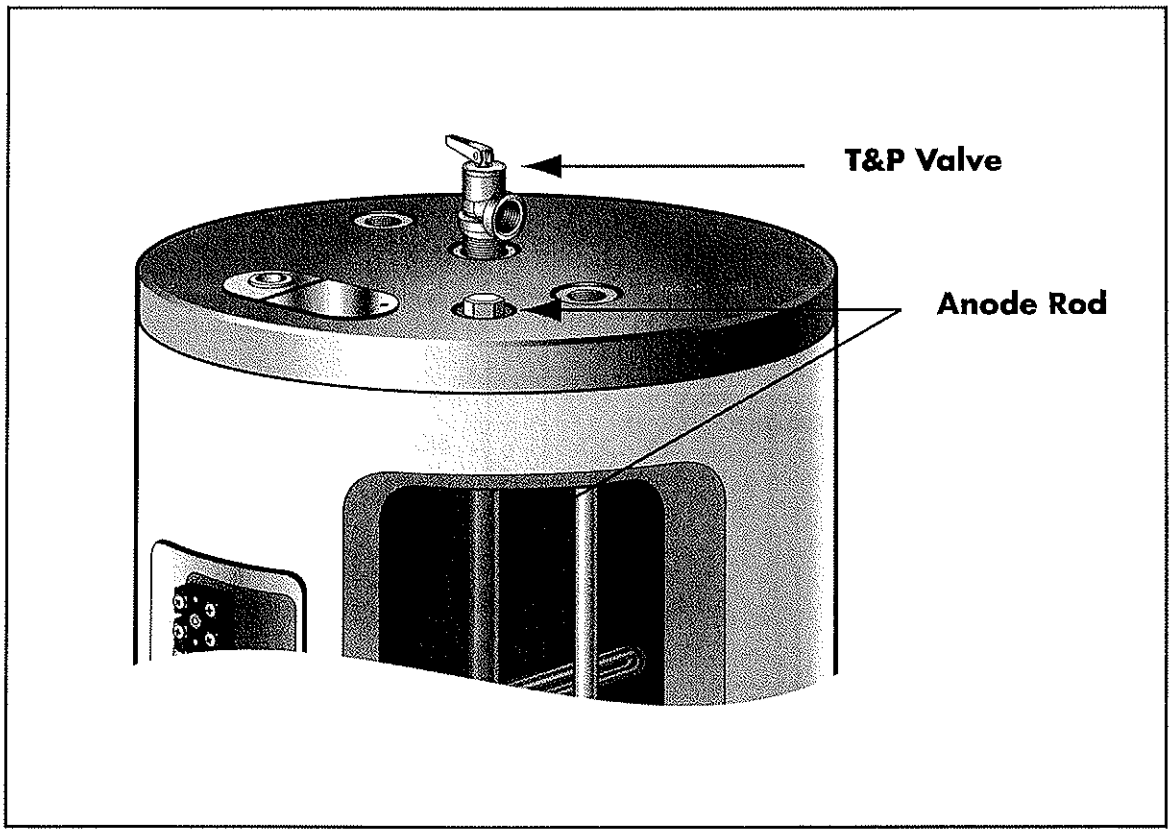
SP 1.1.11

The **DIP TUBE** delivers cold water into the bottom area of the tank so it doesn't mix with the hot water at the top of the tank. Today most dip tubes are made of plastic since plastic is not prone to corrosion.

The next common component in water heaters is the **SACRIFICIAL ANODE ROD**. (This rod "sacrifices" itself to protect the tank.) The anode rod is the primary source of protection against corrosion of the steel tank. It works by attracting corrosion to itself, preventing the corrosion from attacking the tank. Modern anode rods are made of magnesium, a material that is more prone to corrosion than steel. Water heaters connected to well systems may also use aluminum rods for smelly water.

Although the anode rod can be difficult to remove, the effort is worthwhile, because the anode rod provides the best clue to conditions inside the tank. The sacrificial metal is formed around a steel core wire. Normally, the anode slowly corrodes away to protect the heater from rust. When enough metal has corroded away to expose 6 inches of the core wire, it's time to replace the anode. So if you pull out an anode and find little or no sacrificial metal left, some damage will have occurred in the tank. Most gas and oil fired heaters have center flues and have two or more anode rods.

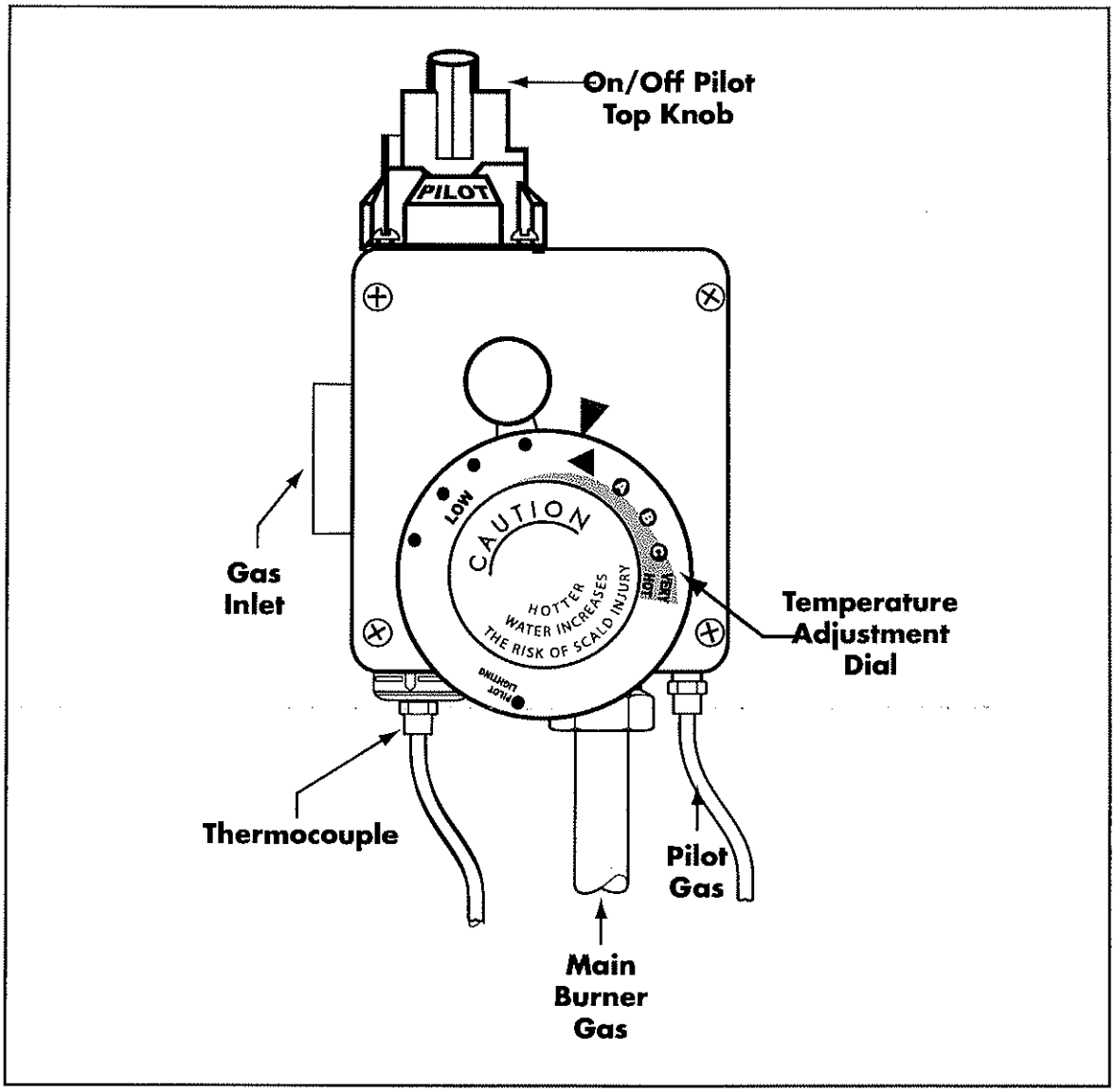
SACRIFICIAL ANODE ROD



SP 1.1.12

Another feature common to all storage water heaters is the **DRAIN VALVE** (also called a *drain cock or draw cock*). The drain valve is located at the bottom of the heater and is used to drain water from the unit.

CONTROL FOR GAS BURNER



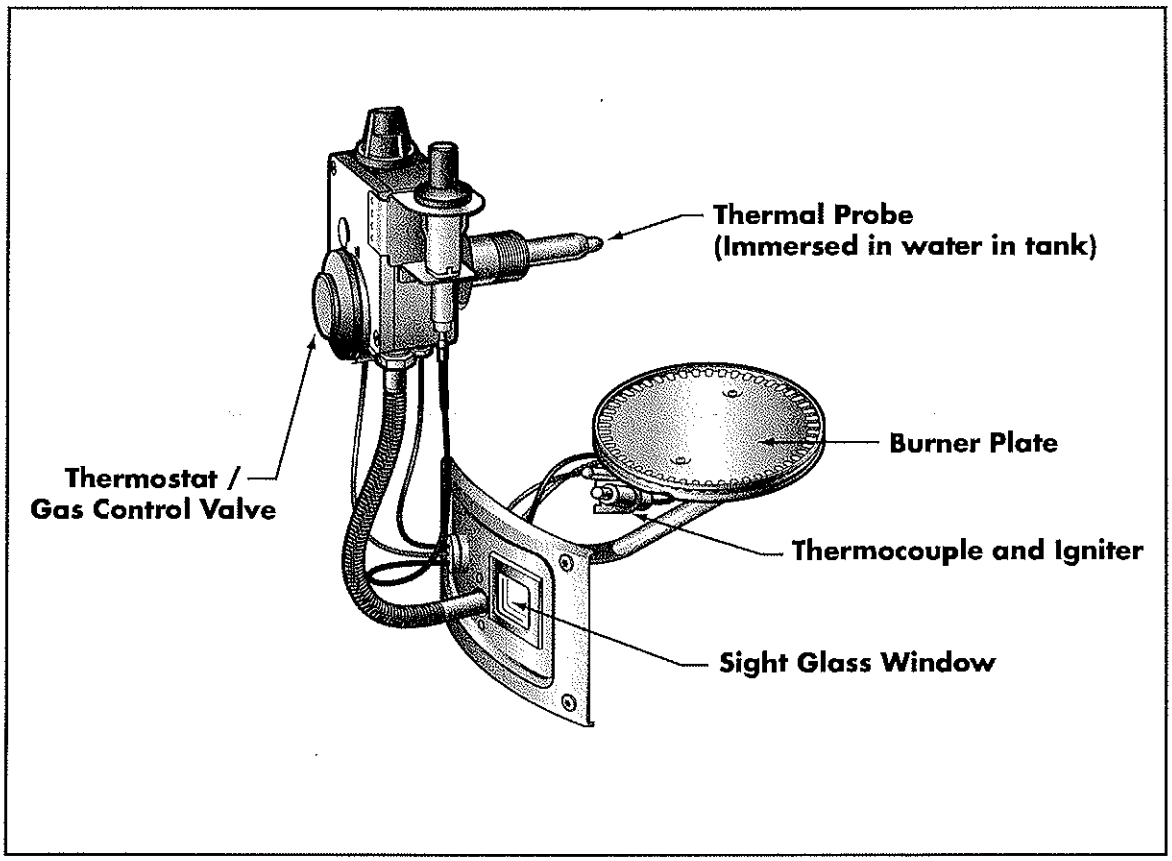
SP 1.2.13

Components Related to the Fuel Source

The other common components in water heaters relate to the fuel source. All automatic storage water heaters have an energy source that heats the water. The most common **ENERGY SOURCE** is gas.

In order to control the amount of energy flowing into the heater, **TEMPERATURE CONTROLS** (also called **THERMOSTATS**) are used to regulate the water temperature automatically. Basically, the component senses the temperature of the water and responds by turning the energy source on or off. We will look again at this device when we discuss gas water heaters in the next chapter.

TEMPERATURE CONTROLS



SP 1.1.14

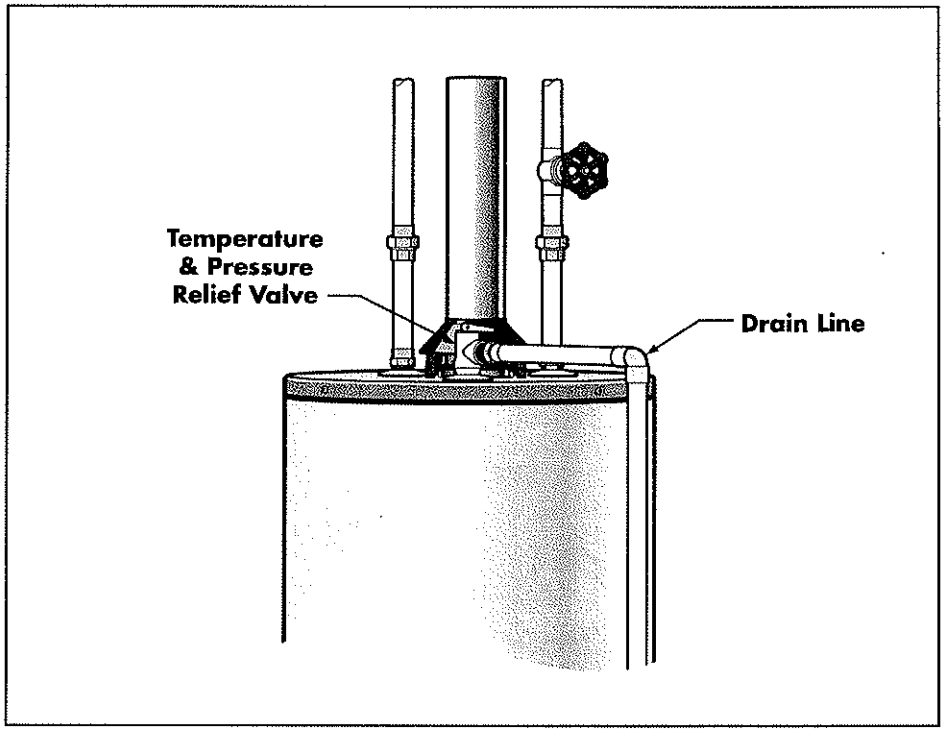
Safety devices are very important components of water heaters. **SAFETY DEVICES** are used to protect against excess heat or pressure in the tank. One such device is the **TEMPERATURE AND PRESSURE VALVE (T&P VALVE)**. If either the temperature or pressure gets too high, the valve opens, discharging hot water.

According to InterNACHI (International Association of Certified Home Inspectors) the discharge pipe should:

> "be constructed of an approved material, such as CPVC, copper, polyethylene, galvanized steel, polypropylene, or stainless steel. PVC and other non-approved plastics should not be used since they can easitly melt.
>
> http://www.nachi.org/tpr-valves-discharge-piping.htm

A piece of pipe attached to the T&P valve directs the discharging hot water down to the floor and to a safe place for disposal.

TEMPERATURE & PRESSURE (T&P) VALVE



SP 1.1.15

Thermal Expansion

When water is heated it expands. For example, water heated from 90° F to a thermostat setting of 140° F in a 40 gallon hot water heater will expand by almost one-half gallon. This is because when water is heated, its density decreases and its volume expands. Because water is not compressible, the extra volume created by expansion must go somewhere. During no-flow periods in a system, pressure reducing valves, backflow preventors, and other one-way valves are closed, thus eliminating a path for expanded water to flow back to the system supply. Therefore, system pressure increases.

The setting on the safety relief is quickly reached and the relief valve opens, losing heater water down the drain or, more often than not, all over the floor. The practice of operating the safety valve, once or twice a day, is not only wasteful, it is also dangerous.

In a closed plumbing system, **THERMAL EXPANSION** of water can create problems. These problems include the build up of unusually high pressure in a system (even when a pressure reducing valve is installed), pressure surges, and the chronic or continuous dripping of a T&P relief valve.

More serious problems can also occur due to thermal expansion. When dangerous pressures are built up in a water heater, internal parts such as the internal flues, fittings, or water connections may fail. If a flue way collapses it can lead to the potential release of toxic gases, such as carbon monoxide into living spaces. Thermal expansion can also lead to a ruptured or distorted water heating tank and will void the manufacturer's warranty.

A temperature and pressure relief valve is not considered a thermal expansion device. This is because when water is allowed to continuously drip from the T&P relief valve, minerals from the water can build up on the valve, eventually blocking it. This blockage can render the T&P valve useless and potentially lead to water heater explosions. The T&P relief valve serves as an emergency control only. It never was designed as an operating control. When used on a daily basis, deposits on the seat, deteriorating springs, and wear and tear erosion can quickly wear out a relief valve.

Expansion Tanks Solve Problem

The International Plumbing Code (IPC), Uniform Plumbing Code (UPC), and Standard Plumbing Code all require thermal expansion control to be addressed in plumbing systems.

The best solution to thermal expansion is to control the pressure it generates within a normal, safe operating range, well below the emergency setting of a relief valve. This will allow thermal expansion to occur, but without causing a dangerous increase in pressure.

This can easily be accomplished by adding a small **EXPANSION TANK** with a sealed-in air cushion which will compress as thermal expansion occurs and provides a space to hold and store the additional expanded water volume.

Circulating pumps have a variety of different uses when dealing with potable water. The most common use is with the installation of storage tank connected to the water heater. Remember that when dealing with potable water an iron body must not be used. Indirect water heaters when connected to a boiler will also require a circulator, and in this case a properly sized (for flow rate and head loss) iron body circulator can be used.

Recirculating pumps are commonly used in commercial applications where large demands are made on the water heater or heaters. The advantage is a reduction in standby loss and larger amounts of hot water are provided in a shorter period of time. There are two methods to control the operation of the recirculating pump. The first is using a thermostatic control on the return line generally as far away from the heaters as possible. The second is using a timer which can be mounted directly on the circulator. They can also be found in residential installations when large whirlpools or hot tubs are installed which require large amounts of hot water in a short period of time. Another practical use for a recirculating pump in residential applications is to reduce the amount of water drawn from a fixture furthest from the water heater to obtain hot water. This will reduce energy consumption as well as standby loss.

By sizing the air cushion according to **BOYLE'S LAW** (which states that at constant temperature, the volume of a gas varies inversely with the pressure exerted on it), the maximum pressure on the system can be selected when the total amount of expanded water has been generated. When hot water is used in the system, the pressurized air cushion forces hot water back into the system for use and the water is not wasted.

The thermal expansion tank for domestic water heaters, sized properly, is a logical answer to the problem of thermal expansion in water heaters. A simple installation to the supply side on the water heater and the small tank will eliminate the dangerous condition so that the relief valve will never open during normal operation.

NOTE: Sizing expansion tank - 10 gallons of stored water requires 1 gallon expansion.

REVIEW QUIZ – OVERVIEW OF WATER HEATERS

Answers appear on page 40

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 water heater is any appliance designed to supply _____ for domestic or commercial purposes.
   a. gas
   b. electricity
   c. energy
   d. hot water

2. The four segments of the water heater market are residential, commercial, replacement for residential and
   a. direct-fired.
   b. replacement for commercial.
   c. mechanical.
   d. demand.

3. What factor determines whether a water heater is classified as residential or commercial?
   a. British Thermal Unit (BTU)
   b. Recovery rate
   c. Tank capacity
   d. Dip tube

4. What is the safest water temperature that should be used in a residence?
   a. 120° F
   b. 180° F
   c. 160° F
   d. 190° F

REVIEW QUIZ – OVERVIEW OF WATER HEATERS

Answers appear on page 40

5. All of the following are types of residential water heaters EXCEPT
   a. Heat pump
   b. Commercial
   c. Solar
   d. Tankless

6. Demand-type water heaters are also commonly called
   a. solar water heaters.
   b. storage water heaters.
   c. tanked water heaters.
   d. tankless water heaters.

7. Movement of heat from one body to another is called
   a. heat transfer.
   b. heat storage.
   c. heat input.
   d. recovery rate.

8. What is the most common type of water heater used in homes and businesses?
   a. Indirect-fired water heater
   b. Solar water heater
   c. Automatic storage water heater
   d. Demand-type water heater

9. When cold water enters the water heater from the tap, it will have an internal channel called a/an
   a. dip tube.
   b. anode rod.
   c. safety device.
   d. energy source.

REVIEW QUIZ – OVERVIEW OF WATER HEATERS

Answers appear on page 40

10. The number of gallons per hour a water heater can raise the temperature of the cool water is called the
    a. rise.
    b. BTU.
    c. recovery rate.
    d. type of fuel.

11. What is the amount of fuel used to heat the water called?
    a. BTU
    b. Heat input rate
    c. Heat output rate
    d. Recovery rate

12. What are the most common sizes for residential water heaters?
    a. 30-, 40- or 50-gallon
    b. 50-, 60- or 70-gallon
    c. 100-, 150- or 200-gallon
    d. 10- or 20-gallon

13. How would a water heater be able to supply the peak period requirement?
    a. Heat input rate
    b. Recovery rate
    c. Combination of design and fuel being used
    d. Combination of storage and recovery capacity

14. Recovery capacity is affected by which two factors?
    a. Design of the water heater and the fuel being used
    b. Fuel being used and recovery rate
    c. Storage and recovery capacity
    d. Peak period requirement and the fuel being used

REVIEW QUIZ – OVERVIEW OF WATER HEATERS

Answers appear on page 40

15. In a conventional automatic water heater, the water is most commonly heated and stored in the
    a. cold water inlet.
    b. hot water inlet.
    c. tank.
    d. anode rod.

16. Where does cold water enter the tank to be heated?
    a. Hot water inlet
    b. Cold water inlet
    c. Hot water outlet
    d. Cold water outlet

17. The component in a water heater that allows itself to be attacked by corrosion to protect the steel tank is called the
    a. dip tube.
    b. outlet.
    c. sacrificial anode rod.
    d. safety device.

18. The drain valve is used for
    a. regulating temperature.
    b. protecting against excess pressure.
    c. draining water from the heater.
    d. turning the energy source on or off.

19. Which of the following is a safety device used to protect against excess heat or pressure in the water heater tank?
    a. Anode rod
    b. Dip tube
    c. Cold water inlet
    d. Temperature and pressure valve

REVIEW QUIZ – OVERVIEW OF WATER HEATERS

Answers appear on page 40

20. In a closed plumbing system, thermal expansion can cause all of the following problems EXCEPT
    a. Unusually high pressure in a system
    b. Pressure surges
    c. T&P relief valve drips
    d. Heat transfer

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. Where can you find the most up-to-date information about water heaters?

_____

_____

_____

B. What method does your company use to help customers select the appropriate water heater capacity?

_____

_____

_____

ANSWERS TO REVIEW QUIZ

CHAPTER 1

OVERVIEW OF WATER HEATERS

Answers to REVIEW OF OVERVIEW OF WATER HEATERS (pages 33 – 37)

1. d. hot water
2. b. replacement for commercial
3. a. British Thermal Unit (BTU)
4. a. 120° F
5. b. Commercial
6. d. tankless water heaters.
7. a. heat transfer.
8. c. Direct or automatic storage water heater
9. a. dip tube.
10. c. recovery rate.
11. b. Heat input rate
12. a. 30-, 40-, or 50-gallon
13. d. Combination of storage and recovery capacity
14. a. Design of the water heater and the fuel being used
15. c. tank.
16. b. Cold water inlet
17. c. sacrificial anode rod.
18. c. draining the water from the heater.
19. d. Temperature and pressure valve
20. d. Heat transfer

Applying what you have learned:

A. Depends on the company, but typically includes product catalogs and/or the Web where information can be quickly downloaded.

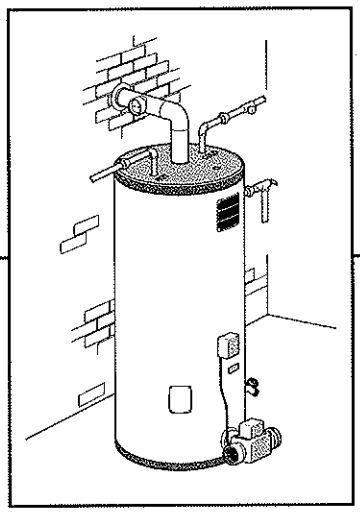
B. Depends on the company, but capacities are based on the needs of the residents. High demand capacities include the needs of large families, teenagers, whirlpool tubs, spas, and oversized baths.

2 RESIDENTIAL GAS WATER HEATERS

LEARNING OBJECTIVES

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

1. Differentiate between the components of residential oil-fired, gas-fired, and electric water heaters.
2. Discuss the basic functions of residential oil-fired and gas-fired water heaters.
3. Explain how gas water heaters are ignited and how gas is regulated.
4. Identify safety devices unique to gas water heaters.
5. Propose a plan to prevent tank corrosion.



FUEL-FIRED WATER HEATERS

Fuel-fired Water Heaters

Fuel-fired water heaters burn natural gas, propane, or oil producing heat that warms water in a storage tank. The heating surfaces for gas- and oil-fired water heaters (fuel-fired water heaters) are typically at the bottom of the tank. Air enters the combustion chamber, combines with the fuel, and the mixture is ignited. Heat is then transferred to the water through metal surfaces at the bottom of the tank.

The **VENT PIPE** is an exhaust pipe that carries the by-products of combustion to the outside and also serves as a heat exchanger. This pipe is usually surrounded by the water containment tank and often contains **BAFFLES** to slow the escape of these gases through the vent, thus allowing more time for heat to be transferred to the water around the pipe. Thermostatic controls regulating the temperature of the water are usually located near the mid-section of gas- and oil-fired water heaters.

The proper mixture of additional air with combustion or exhaust gasses is important in fuel-fired water heaters to assist in the safe passage of combustion products up the vent pipe to the outdoors. If their escape is impeded or blocked, serious problems can develop. To assure this proper mixture, gas-fired water heaters are equipped with a "cone-shaped" draft hood on the vent pipe, as it emerges from the tank.

In this chapter, we'll look briefly at residential oil-fired water heaters and then, in more detail, we'll discuss gas-fired water heaters.

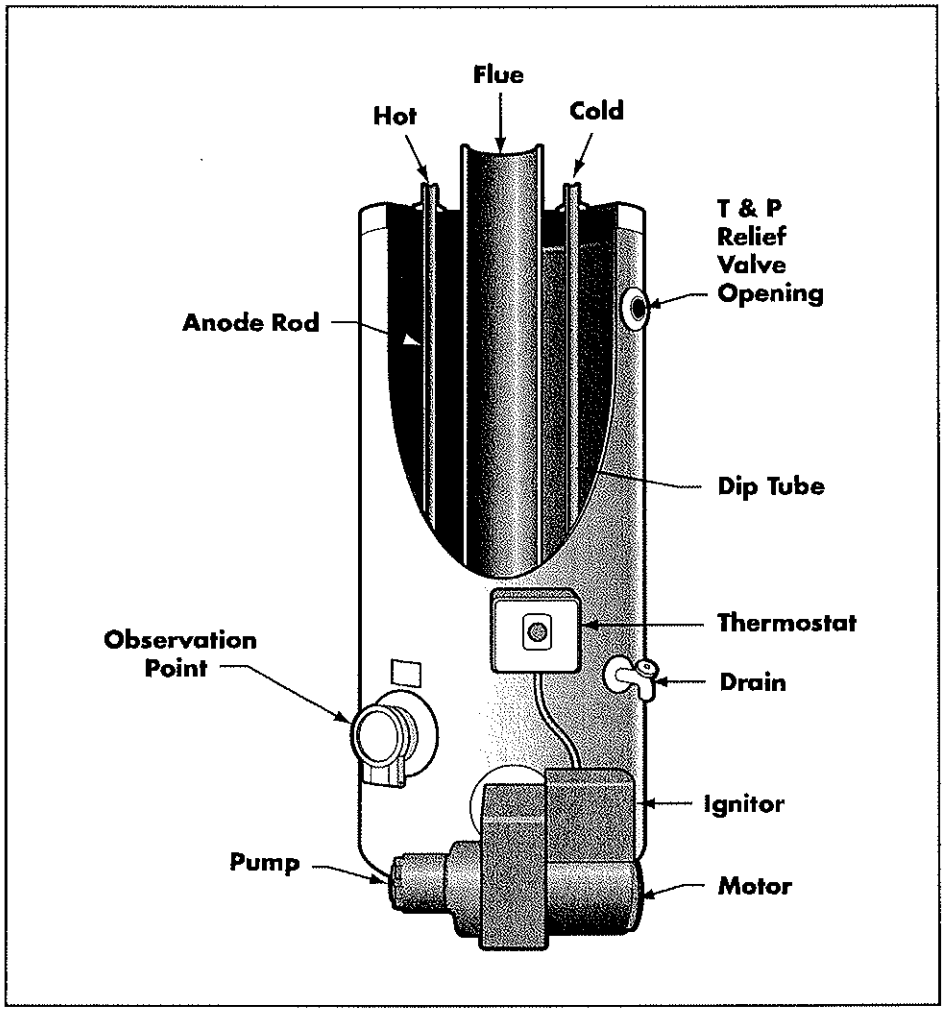
Venting the Water Heaters

One of the most important factors in the installation of a fuel-fired water heater is the venting. Improper or incorrect venting of the appliance is not only a safety factor but can reduce both the efficiency and create false warranty claims. Choosing the correct method of venting is critical in choosing the correct appliance for the application. It is important to understand that the appliance dictates the method of venting. An atmospheric water heater can only be vented one way, by means of natural draft. Similar to power vented, direct vented, and seal combustion, they can only be vented as per the manufacturer's instructions which conform to their UL or CSA Listing. They also conform to NFPA31 for oil-fired appliances and NFPA54 (National Fuel Gas Code). When venting an appliance, it is important to rad the manufacturer's instruction (Venting Requirements) with regard to vent sizing as well as the maximum venting lengths. This is extremely important when installing 90% plus condensating appliances. Proper ventilation air is also a critical factor in the venting process with all types of venting with the exception of appliances using direct venting/seal combustion.

Residential Oil-fired Water Heaters

Oil-fired water heaters use oil as their energy source. In the illustration below, you can see that the **OIL-FIRED WATER HEATER** parts are similar to automatic storage water heaters.

OIL-FIRED HEATER



SP 1.2.1

Notice that the greatest difference in the parts between a gas model and oil model heater is the burner assembly. The most common type of burner used for oil-fired models is called the gun-type burner.

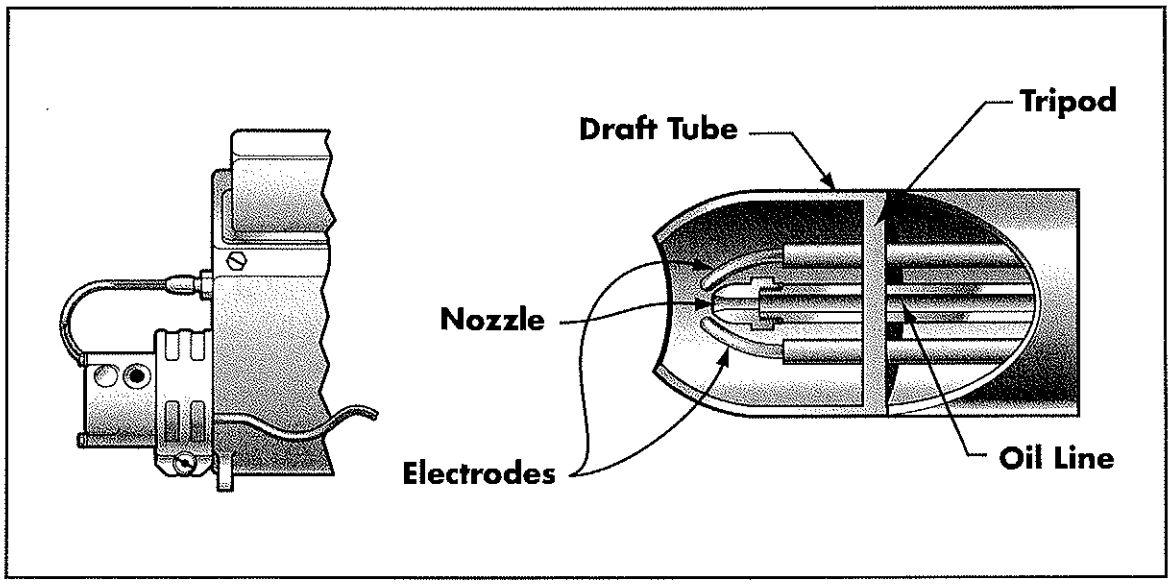
POWER BURNERS have a motor, pump, fan, and ignitor. These parts work together to produce the burner flame. Power gas burners are also available and are similar to oil burners except for the fuel pump.

When the thermostat calls for heat, the motor operates the pump and the fan. The pump sprays oil and the fan blows air into the burner. At the same time, the transformer creates a spark to ignite the oil and gas mixture so combustion can take place.

When the thermostat senses that the water in the tank is heated to the desired temperature, the motor stops.

Below is an inside view of the gun-type burner where combustion occurs. The high pressure pump sprays oil in a mist out of the **NOZZLE** opening. (The nozzle is similar to the **ORIFICE** on a gas burner.) The oil mist is mixed with air blown in under pressure, and sparks from the **ELECTRODES** ignite the mixture. The resulting flame is blown into the combustion chamber to heat water at the bottom of the tank.

GUN-TYPE BURNER



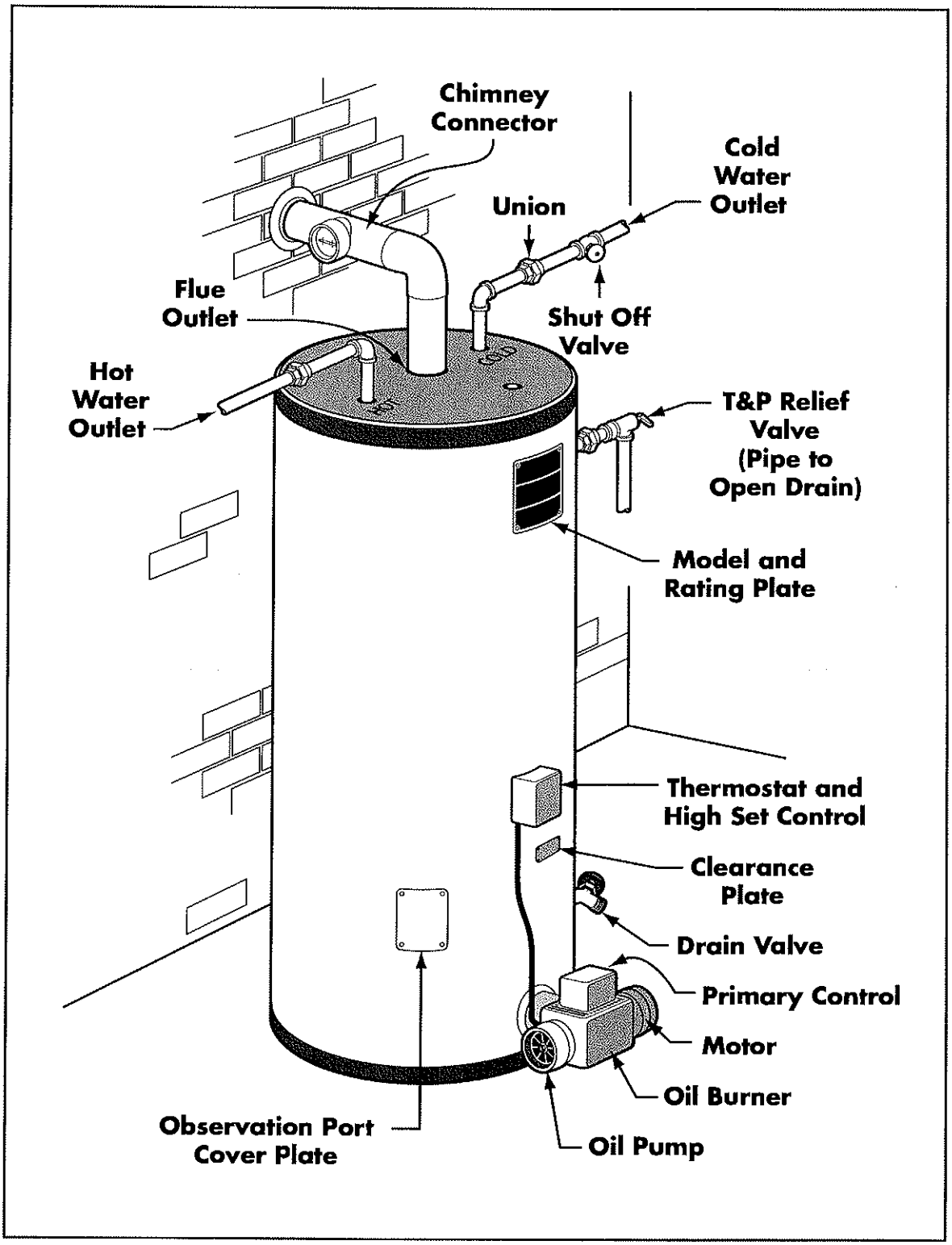
SP 1.2.2

As with gas models, the proper mixture of air and oil is required for combustion to take place. It takes a qualified technician to adjust the amount of air mixing with the oil. Per NFPA - 31, adjustments must only be made using combustion testing instruments.

The amount of oil going into the fire pot is regulated by the size of the nozzle opening and the oil pressure. Different input rates and combustion chamber designs determine the type of nozzle used.

Like the gas models, an oil-fired water heater needs a flue to vent the combustion fumes. Although some oil-fired water heaters may have different flue designs, most residential models use an internal flue.

SAFETY DEVICES



SP 1.2.3

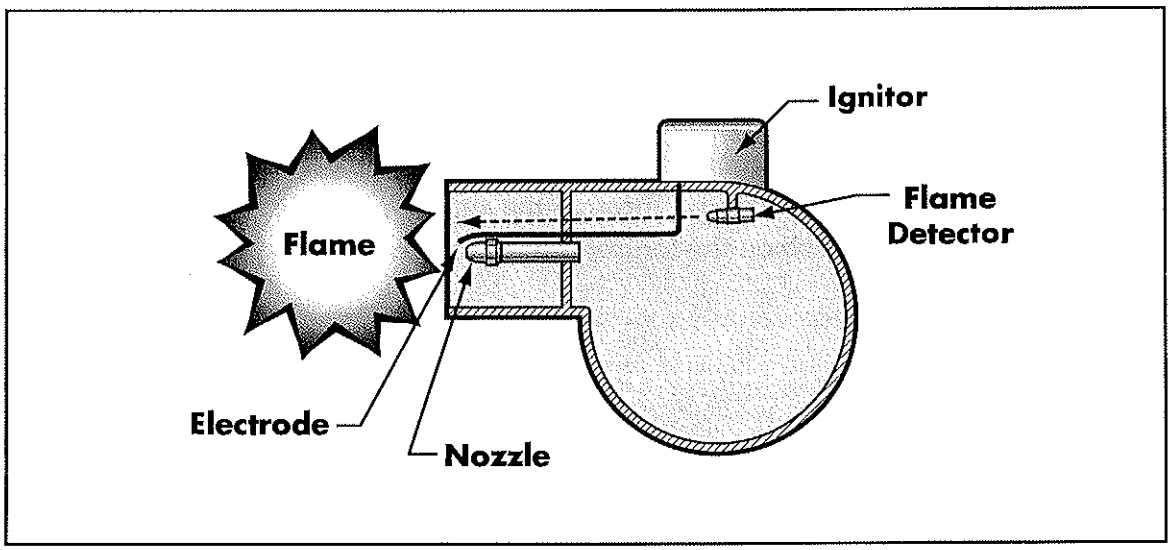
As with gas and electric water heaters, oil-fired heaters have a thermostat and a high-limit control. These two safety devices provide the same function on all automatic storage water heaters.

The oil model has a third safety device not found on the other types of water heaters, the **PRIMARY CONTROL**. It controls the operation of the burner by turning the motor on and off as needed. If combustion should fail to take place for any reason, the primary control will shut the burner off and place it into safety or lockout.

Construction of the primary control varies by manufacturer. However, each has some type of device to sense whether a burner flame is present. Some manufacturers use a **FLAME DETECTOR** inside the burner assembly to detect the burner flame.

Others may use a device inside the flue to sense rising combustion temperature. Below is an example of how one type of flame detector works.

FLAME DETECTOR



SP 1.2.04

The flame detector reacts to light from the burner flame. As long as the detector can see the burner flame, the burner will continue to operate until the water in the tank is heated to the set temperature.

If the flame detector is not in the proper position to see the burner flame, or if no burner flame is present, the primary control will shut the burner off.

All primary controls must be reset manually in order for the heater to operate again.

Residential Gas-fired Water Heaters

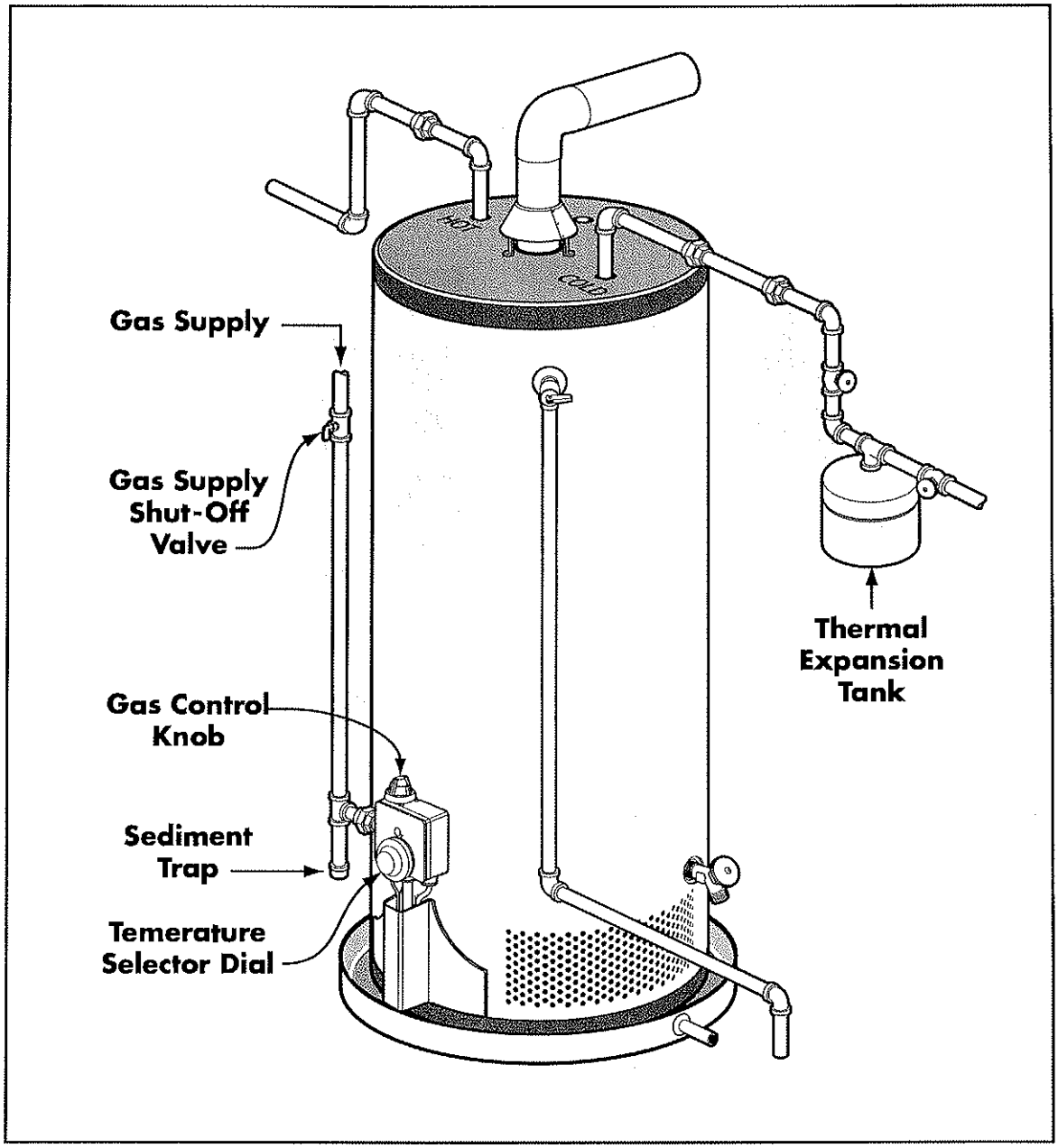
In this chapter we will look more closely at the components and functions of the gas water heater. A gas water heater is nearly identical to an electric water heater, except that it does not contain the two heating elements. Instead, it has a gas burner at the bottom, with a flue running up through the middle of the tank.

Gas water heaters are the most common type of heater used in residential applications. One reason for this is the gas water heater's ability to heat water more quickly than an electric or solar heater. Gas water heaters also use less energy than the other types of heaters. Natural gas is available in many areas of the United States to fuel conventional storage and demand-type (tankless or instantaneous) water heaters, as well as combination water and space heating systems, which include tankless coil and indirect water heaters.

Outside a Gas Water Heater

Illustrated on page 49 is the outside of an automatic storage gas burning water heater. Gas enters the thermostatic control through the supply pipe line connected to the gas supply. The indicator knob on the control is used to select the temperature for the water in the tank.

GAS WATER HEATER EXTERIOR

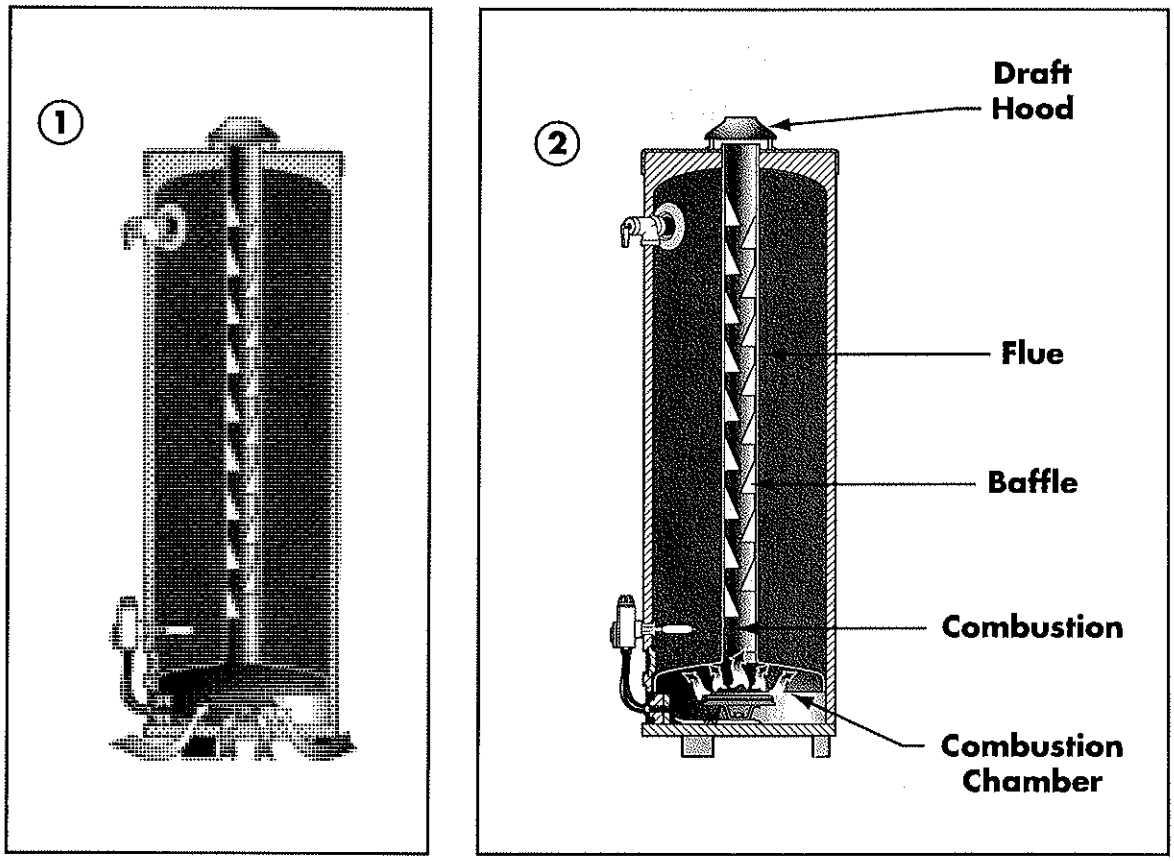


SP 1.2.01

THERMOSTATIC CONTROLS turn the gas to the burner on and off as necessary to regulate the water temperature. In a gas or electric water heater, the thermostat constantly monitors water temperature in the bottom of the tank. When water temperature drops beneath the desired setting, the thermostat signals gas flow or electric heating element operation to begin, starting a new water heating cycle. When water temperature in the bottom of the tank is increased to the desired setting, the thermostat shuts off gas flow or electric heating element operation.

COMBUSTION, or burning of the fuel, takes place inside the **COMBUSTION CHAMBER**. Gas water heaters must be connected to a vent to allow for combustion exhaust (commonly called fumes) to flow to the outside.

COMBUSTION CHAMBER

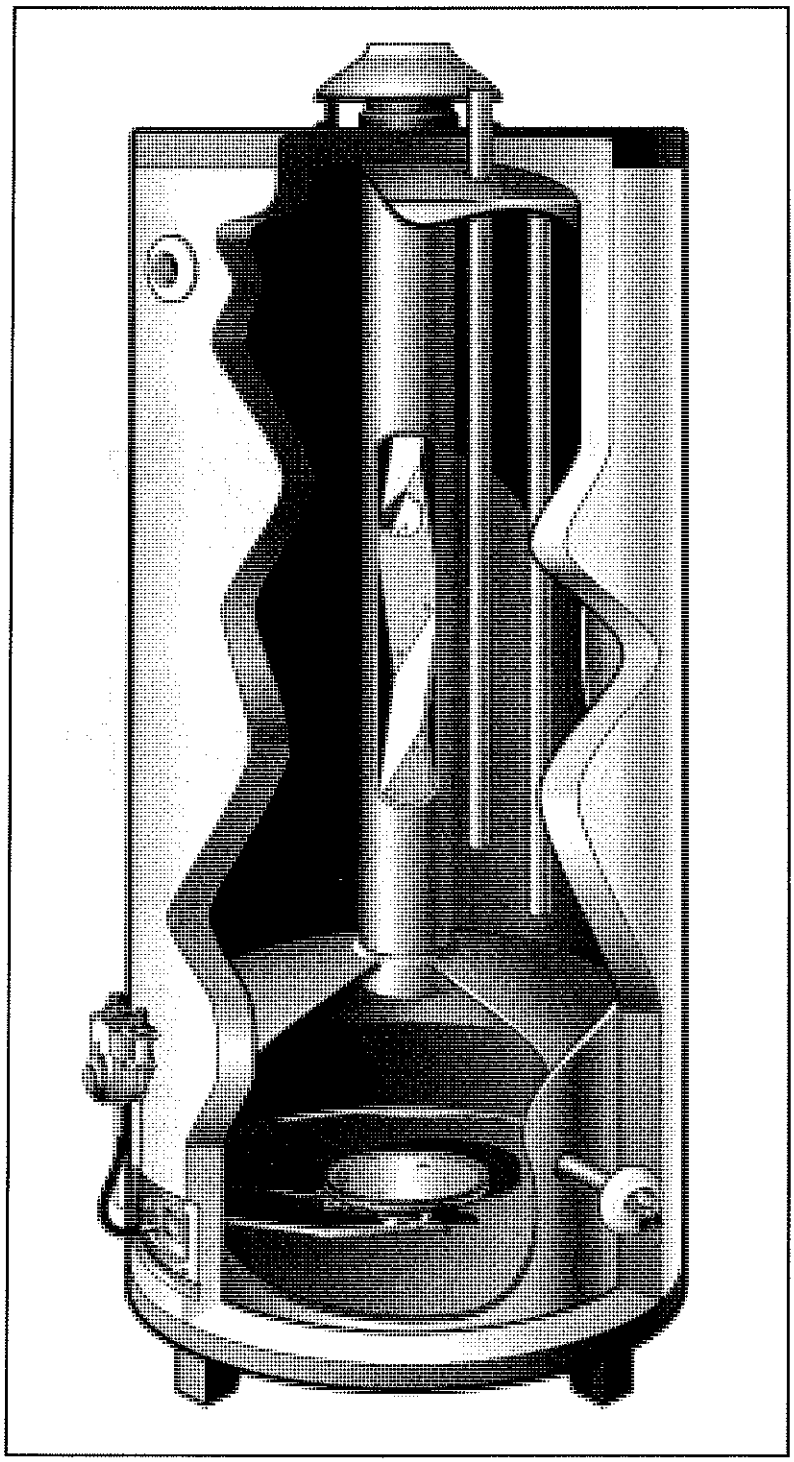


SP 1.2.02

Purpose of the Flue Tube

In a gas water heater, the **FLUE TUBE** is a cylindrical chimney that runs through the center of the tank. Products of com-bustion from the gas burner rise through the flue tube and leave the water heater, where they are safely discharged to the outdoors through the water heater's vent piping. The flue tube does two things: (1) it carries the exhaust gases to the vent and (2) it transfers heat to the water. These combustion gasses contain toxic carbon monoxide.

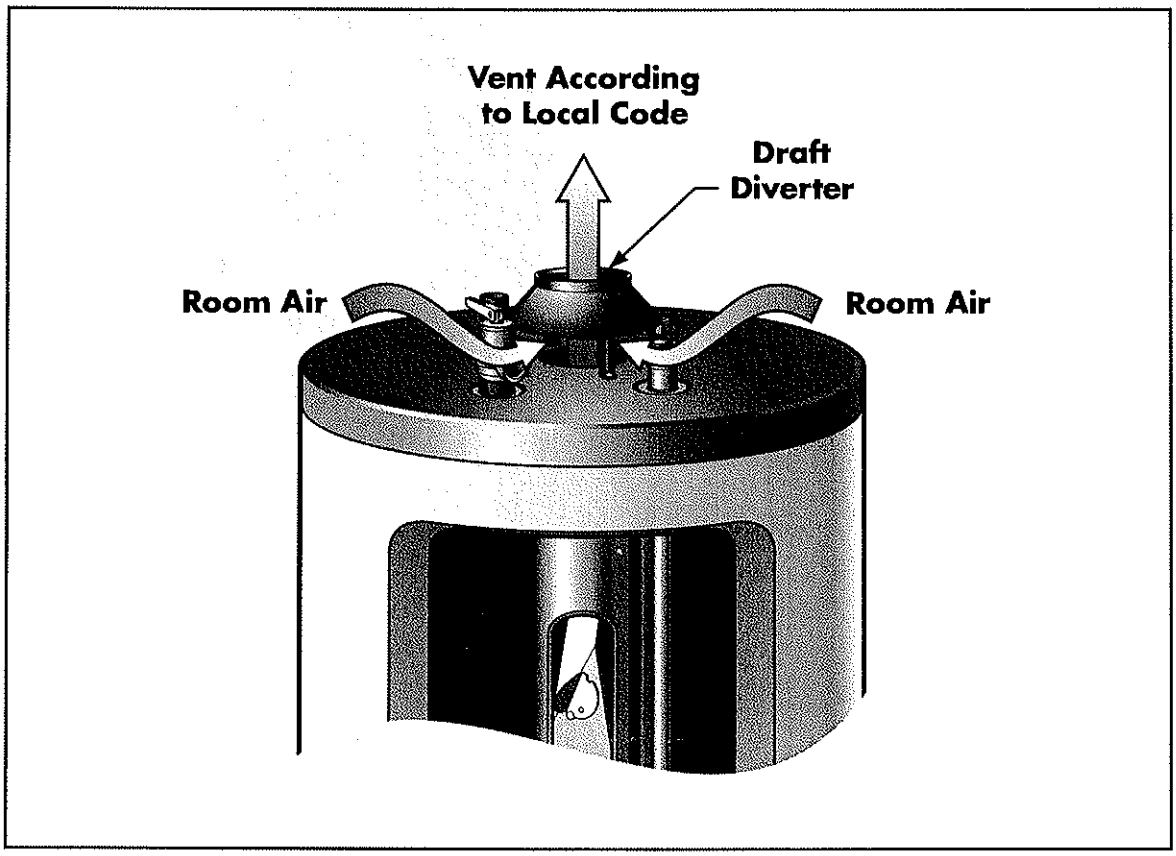
FLUE TUBE



SP 1.2.03

In order to vent the combustion fumes to the outside, the flue uses a **DRAFT DIVERTER** or hood. Flue gases rise to the top of the flue because heated air is lighter than normal room air.

DRAFT DIVERTER



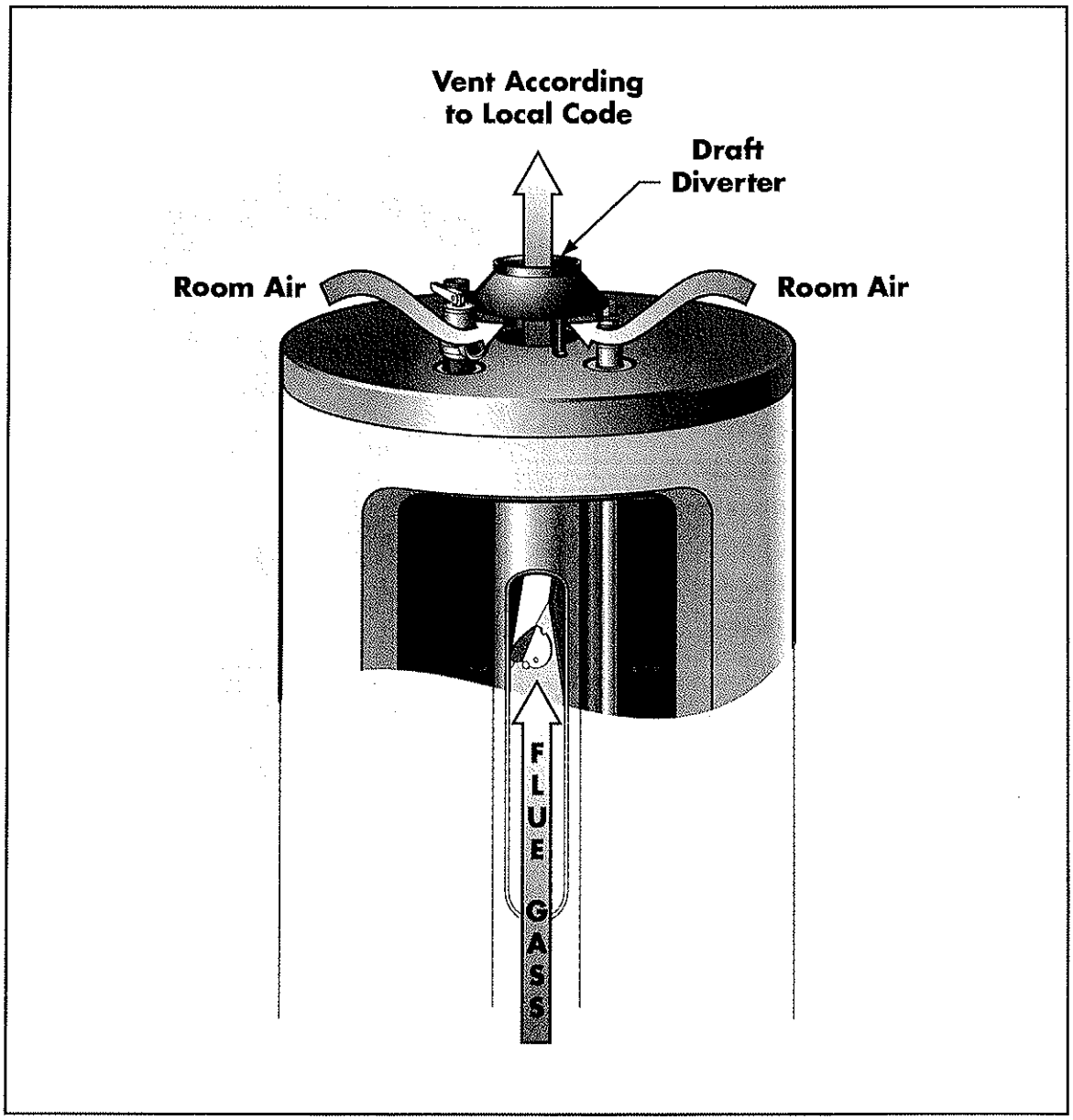
SP 1.2.04a

Because these gases tend to condense and become heavier when condensing, heated room air is drawn in at the base of the hood. Without the addition of this room air, heavier condensed gases would stop rising and would then back up into the house.

As mentioned previously, the flue provides a passageway for combustion exhaust to reach the vent. The flue provides another important function. As the heat produced travels upward, the flue transfers the rising heat to the water.

In order to allow more time for the water in the tank to absorb the heat, a **BAFFLE** is usually placed inside the flue to cause turbulence and retard the air flow. This also increases the fuel efficiency of gas water heaters. A baffle is illustrated below.

BAFFLE AND FLUE GASES



SP 1.2.05

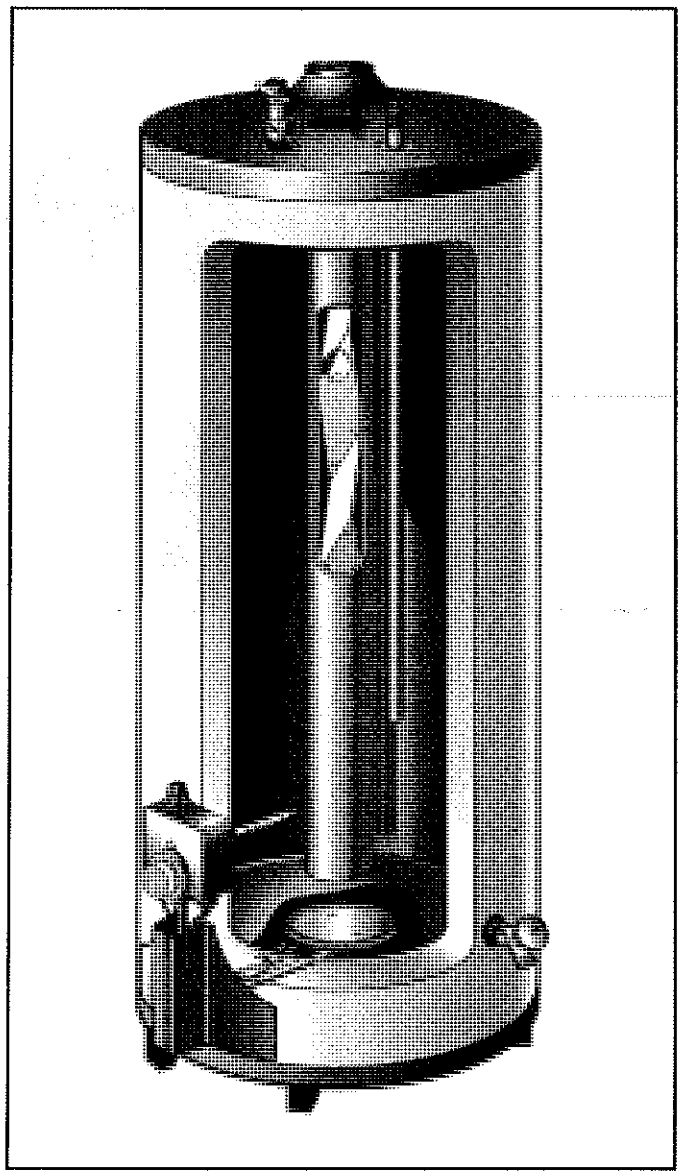
Inside a Gas Water Heater

A glass lining coating is applied to the inside of a water heater tank to shield the steel from water and help prevent corrosion. The glass lining is actually a porcelain compound, typically sprayed onto all inner tank surfaces and then fired at very high temperatures, leaving a hard, protective surface.

Here is another view of the entire gas-fired water heater. Recall that cold inlet water is directed to the bottom of the tank by the dip tube. As the water is heated, the warm water begins to rise. Hot water rises because it is lighter (less dense) than cold water.

If you were to measure the warmth of the water in the tank, you would find different layers of water temperatures. Each layer would be hotter than the one below it, with the hottest layer being at the very top because of convection, a physical process in nature. Heated fluids, due to their lower density, rise and cooled fluids fall. A heated fluid will rise to the top of a column, radiate heat away and then fall to be reheated, rise and so on. The closer the water is to the top of the tank, the hotter the water.

INSIDE WATER HEATER



SP 1.2.06

When hot water is drawn off, more cold water comes in and the water temperature at the tank bottom drops. This causes the thermostat to go on, generating the gas flow into the main burner assembly, which begins the heating cycle again.

Per the Department of Energy ruling for efficiency, tank type water heaters above 55 gallons of storage will be required to be condensing water heaters. The major benefit is efficiency (90% plus), but there will be a price to pay for it. The physical dimensions will be larger and considerably heavier and require a 120 VAC power supply. Additionally, since the high efficiency water heaters produce condensation, a suitable drain will be required for disposal of the condensate in accordance will local code requirements.

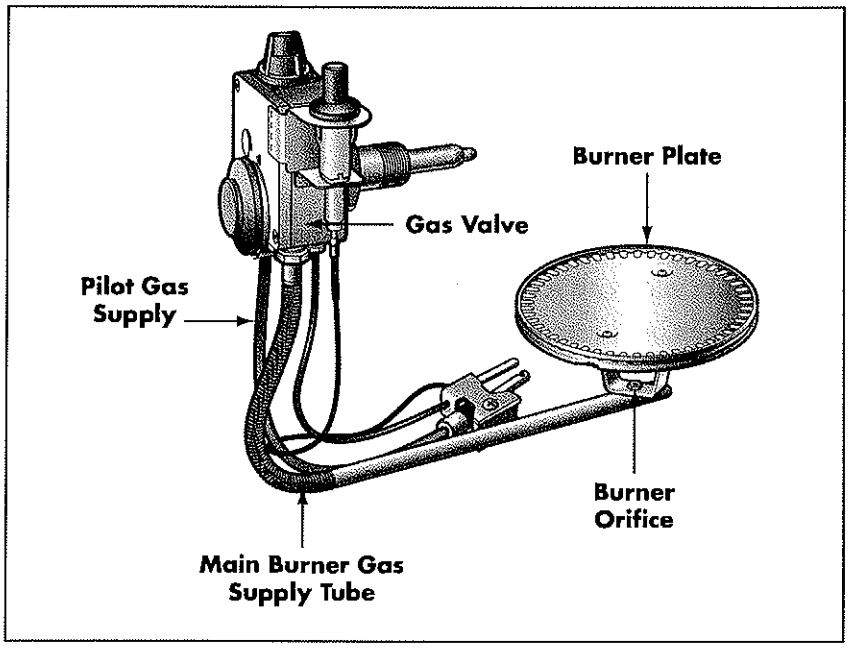
Another consideration is venting of the appliance. Materials such as PVC, CPVC, or ABS are the preferred method for venting with some models requiring a fresh air intake of the same size as the vent. Following the manufacturer's installation instructions is extremely important as an incorrectly installed vent will prevent the water heater from operating safely and efficiently.

Characteristics of Burners

When the thermostat calls for heat, the main burner is ignited to heat water in the tank. The gas burner is a round disk, placed immediately under the tank containing water. At the beginning of a heating cycle, gas flows through the burner through multiple ports. The gas is then ignited by the pilot flame or electronic ignition, creating a round pattern or burner flame for even distribution and transfer of heat to the water.

Illustrated below is one type of control and burner assembly from a gas water heater.

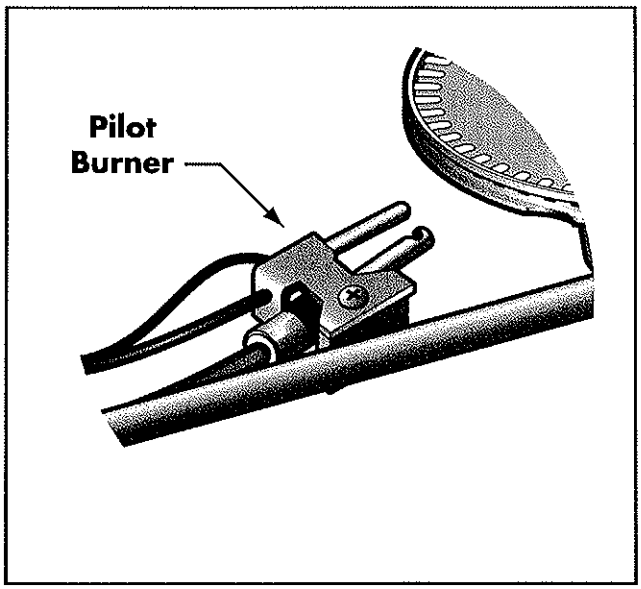
CONTROL AND BURNER ASSEMBLY



SP 1.2.07

In older cast iron burners, there was an inlet jet called the **ORIFICE**, beginning at the gas entry portion of the device, which allowed the gas to enter the burner unit. Adjacent to the gas orifice, the **AIR INTAKE** opening sometimes takes the form of a specific "shutter" opening. On other designs, this is simply a general air opening in the immediate area of the burner.

PILOT BURNER



SP 1.2.08

The gas and air enter a channel or chamber where the two are mixed before exiting the port or ports where they are ignited. The **PORT** of a burner was designed as a series of slots or holes or as a single port which flares out into a funnel shape.

Residential gas models typically use a **PILOT FLAME**, a small flame that burns constantly next to the gas burner. When the thermostat calls for water heating and gas begins to flow through the burner, the pilot flame ignites the main gas supply and cause full burner operation.

Today, however, because of concern over the amount of energy consumed by **PILOT BURNERS**, we are seeing some alternate ignition systems, such as the **ELECTRONIC IGNITION SYSTEM**.

Electronic ignition gas water heaters may be one of two types:

1. Intermittent ignition device (IID): A spark lights the pilot on each call for heat. The pilot flame is confirmed through an electronic flame sensor. The pilot then lights the main burner.
2. Hot surface ignition (HSI): On each call for heat, a probe is heated electronically until it is red-hot. The main gas opens and is ignited; there is no pilot burner. The presence of the main burner flame is confirmed electronically.

Efficient Combustion

Efficient combustion requires the proper mixture of air and gas in the burner. The amount of gas that enters the burner is regulated by the gas pressure in the supply pipe and the size of the orifice.

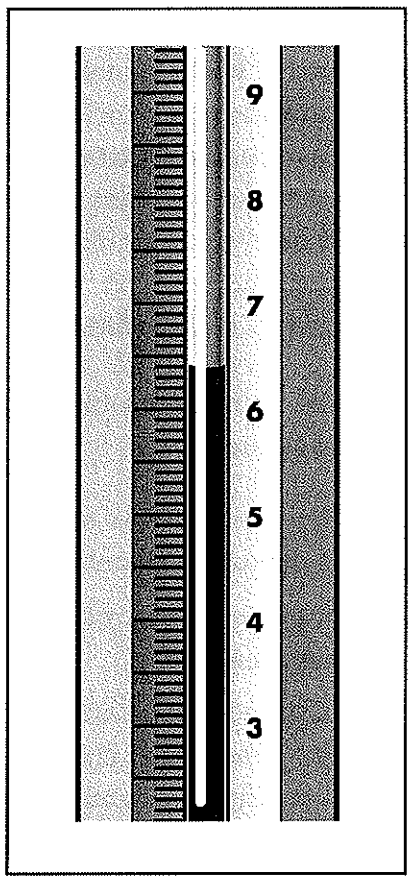
In newer water heater models made for residential use, the gas pressure on the gas control (thermostat) is preset at the factory and cannot be adjusted.

It is important to have the proper orifice and gas pressure. You will find different size orifices for different gas pressures and altitudes.

Gas water heaters for homes may use natural or Liquefied Petroleum (LP) gas. Natural gas requires a larger orifice than LP gas to provide the same amount of heat. Manufacturers make water heaters with the correct size orifice for the type of fuel used. A cubic foot of natural gas contains about 1000 BTU of heat; a cubic foot of propane contains about 2500 BTU of heat.

Using an incorrect orifice for the fuel type is very dangerous and should not be attempted. We mentioned that the gas valve is preset at the factory for pressure control and cannot be adjusted. Nonetheless, because gas pressure is important to proper combustion, we will discuss how gas pressure is measured.

MANOMETER



SP 1.2.09

Measure Gas Pressure

Most modern gas appliances use controls which measure gas pressure in inches of water. Manufacturers may dictate minimum and maximum inlet gas pressures to ensure safe operation. On the right you can see a **MANOMETER** with water columns. The manometer is one of the simplest tools for measuring gas pressure differences. The manometer is a u-shaped tube.

One side of the "U" is a vacuum and the other side is connected to a closed container.

The "U" is filled with a fluid (usually mercury). If both sides of the "U" have the same liquid levels then the pressure inside and the pressure outside are the same. The difference between the liquid levels equals the pressure difference between inside and outside. The mercury level will be lower on the side with greater pressure. The higher pressure "pushes" the mercury down.

Controls and Safety Devices

Besides the manometer, there are a variety of controls and safety devices used on a water heater. These are important because of the potential danger in heating water in a closed container. Most of these controls operate automatically to assure a high degree of safety.

However, to guarantee almost total safety, manufacturers' instructions must always be read before servicing or installing a water heater.

As explained previously, beginning in 2003 the American National Standards Institute (ANSI), the agency that sets safety standards for gas water heaters, required all residential water heaters to be flammable vapor ignition resistant (FVIR). In the event of a flammable vapor incident, the water heater must not ignite vapors in the room. This standard requires that all new residential gas water heaters incorporate design features to make them resistant to igniting flammable vapors outside of the water heater. If a flammable vapor ignition occurs in the combustion chamber, the flame must be contained and the heater shut off. Water heaters incorporating these design features are commonly referred to as **FLAMMABLE VAPOR IGNITION RESISTANT (FVIR)** water heaters.

The following technologies are included in every new FVIR water heater, regardless of manufacturer:

1. a one-way intake system to control the movement of makeup air into the combustion chamber;
2. a flame arrestor plate, the single biggest component change in the new FVIR designs; and
3. a sealed burner access door and burner assembly, to create a sealed junction with the combustion chamber, preventing combustion air and flammable vapors from entering the chamber through the front of the water heater.

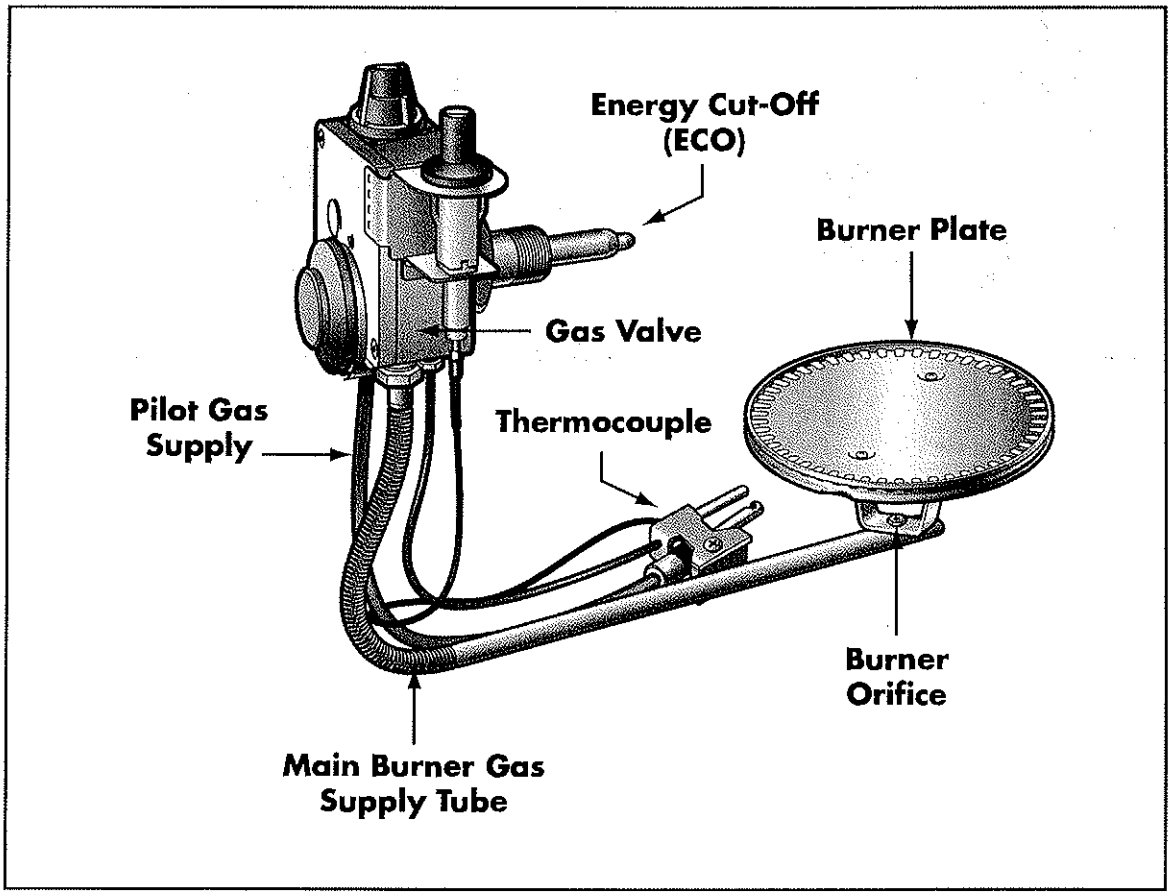
Burner Control and Safety Devices

The control and safety devices related to water heaters can be divided into two groups: those that relate to the burner and those that relate to the tank. The first group we will look at are those associated with the burner assembly.

The burner control and safety devices consist of the:

- Pilot burner
- Thermocouple/Thermopile
- Thermostat
- Energy cut-off device

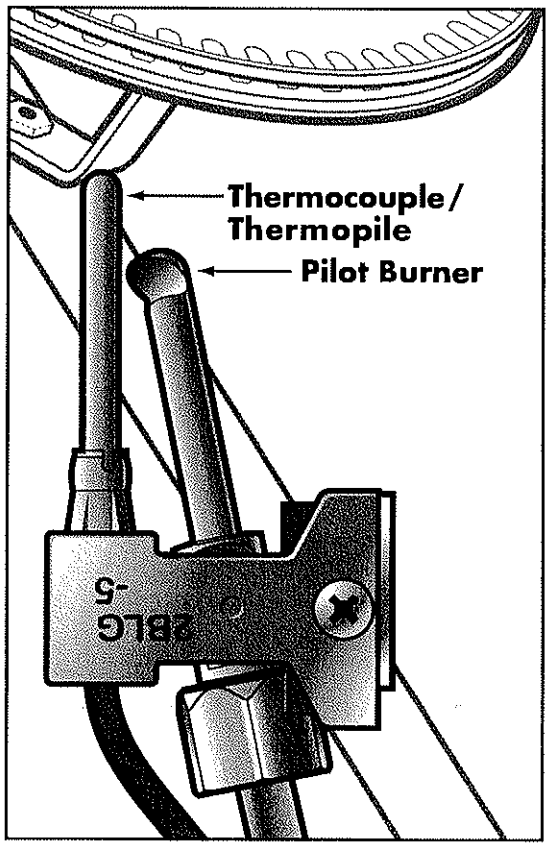
BURNER CONTROL AND SAFETY DEVICES



SP 1.2.10

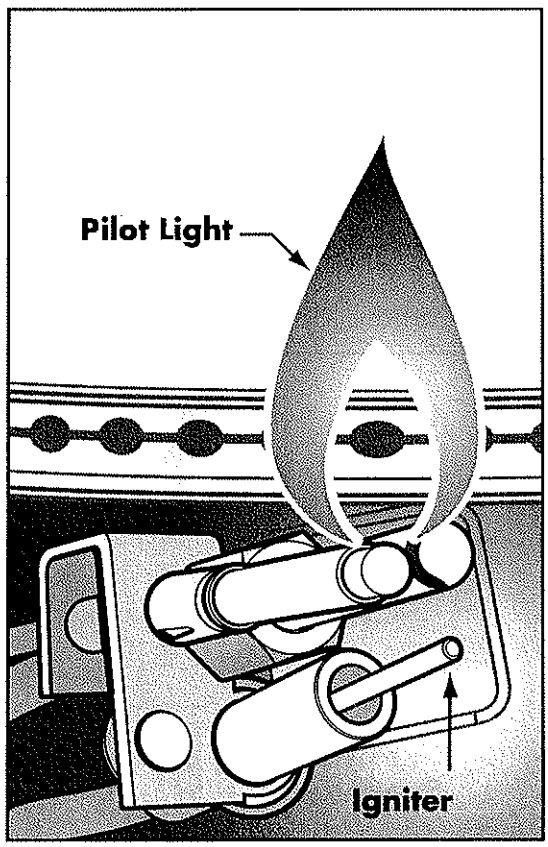
The **PILOT BURNER** flame ignites the fuel and oxygen mixture at the main burner ports when the main gas control is turned on. To light the pilot flame, a spring loaded button is depressed. Gas can only flow to the pilot burner while the button is in the depressed position.

PILOT BURNER



SP 1.2.11

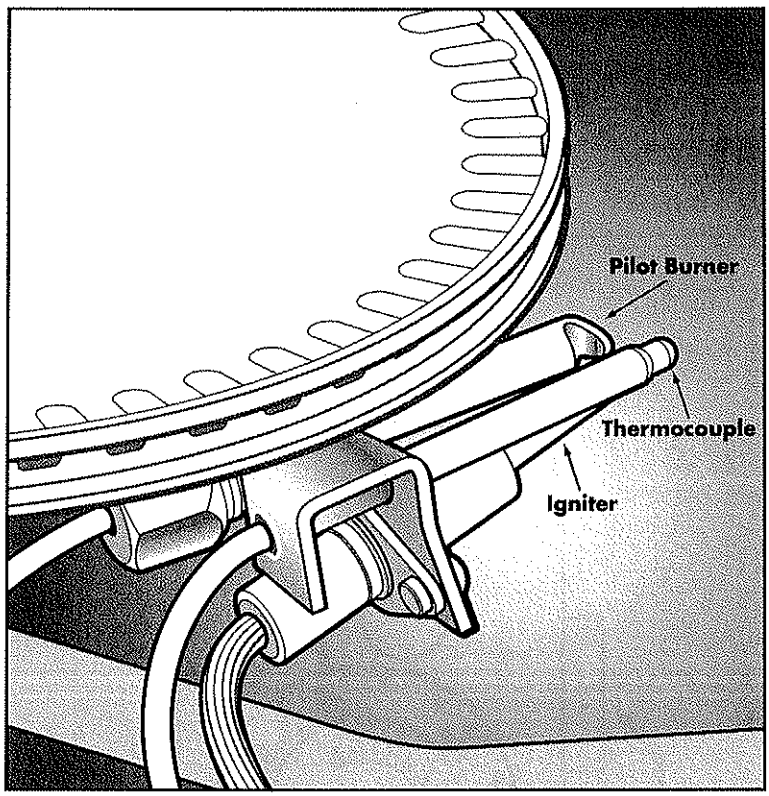
IGNITOR



SP 1.2.11a

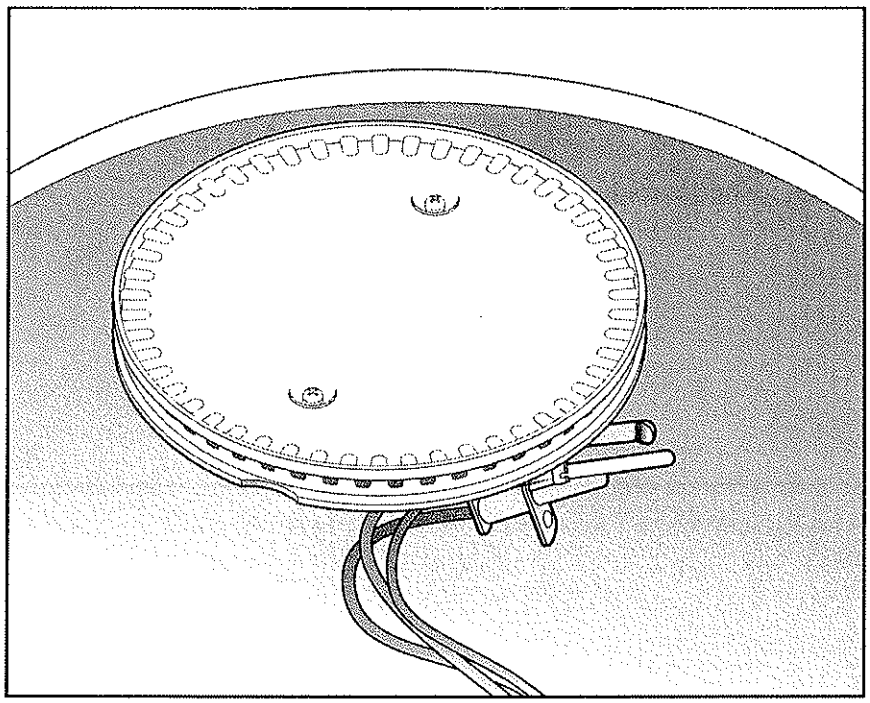
The second control, the **THERMOCOUPLE/THERMOPILE**, is a sensing device used to assure the pilot flame is burning and to shut off gas if the pilot flame goes out. The pilot flame heats the tip of the thermocouple/thermopile which keeps the gas valve open and in some cases actually powers the gas valve through a millivolt technology. In the drawing on page 61, you can see that the thermocouple/thermopile is located next to the pilot flow.

THERMOCOUPLE/THERMOPILE



SP 1.2.12

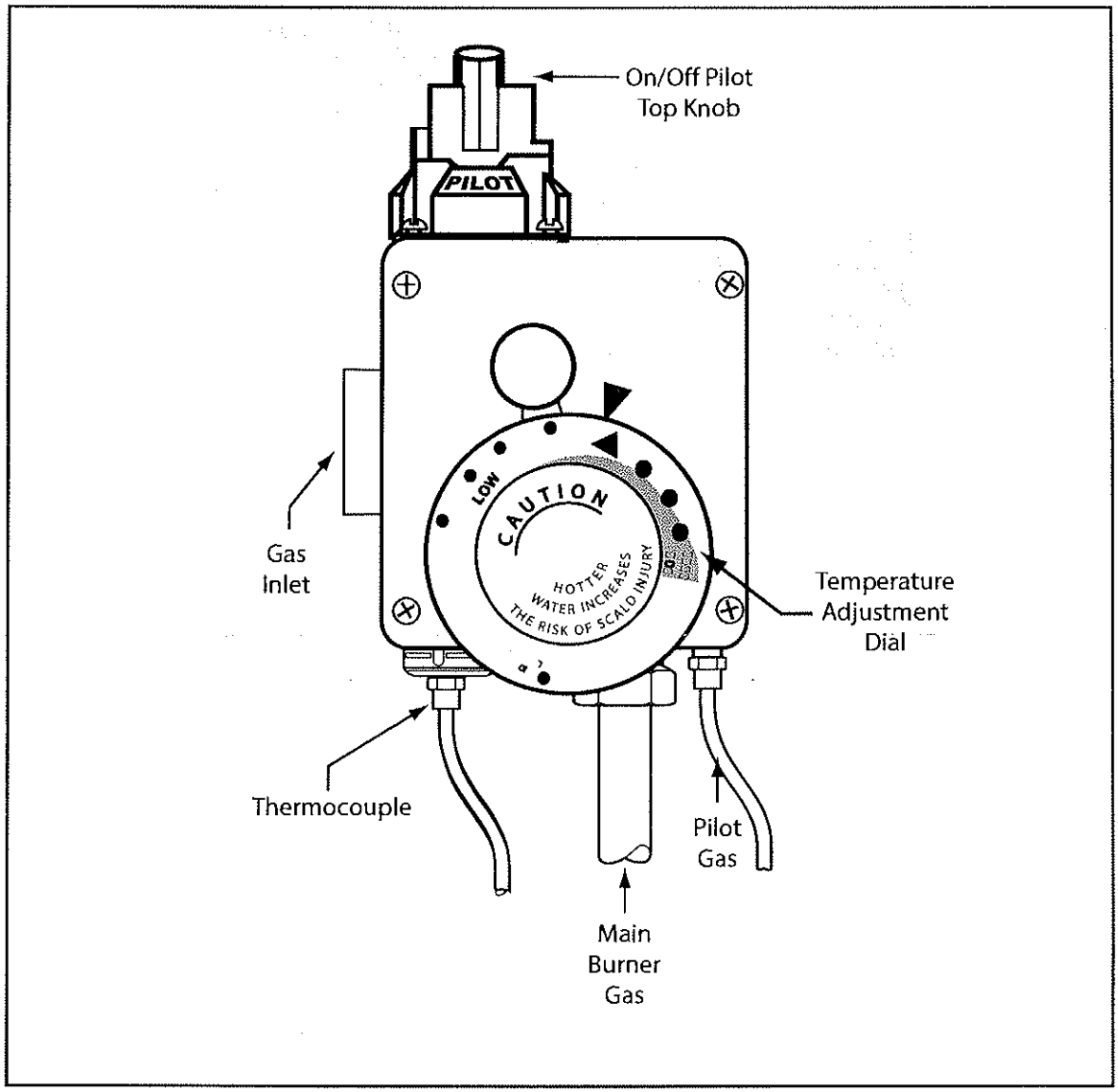
MAIN BURNER



SP 1.2.12a

A magnetic coil inside the controls is energized when current flows from the thermocouple/thermopile wires. The current keeps the valve open and allows gas to flow to the burner. If the pilot flame is out or not adjusted to properly heat the end of the thermocouple/thermopile, no current is made to run to the controls and the magnetic valve closes, preventing gas from entering the burner or pilot assembly.

CONTROL FOR GAS BURNER



SP 1.2.13

The third control and safety device related to the burner is the thermostat. The **THERMOSTAT** regulates the water temperature in the tank by controlling the main burner.

Below is a view of a control for a gas water heater. The temperature of the water in the tank is regulated by the setting on the temperature adjusting knob.

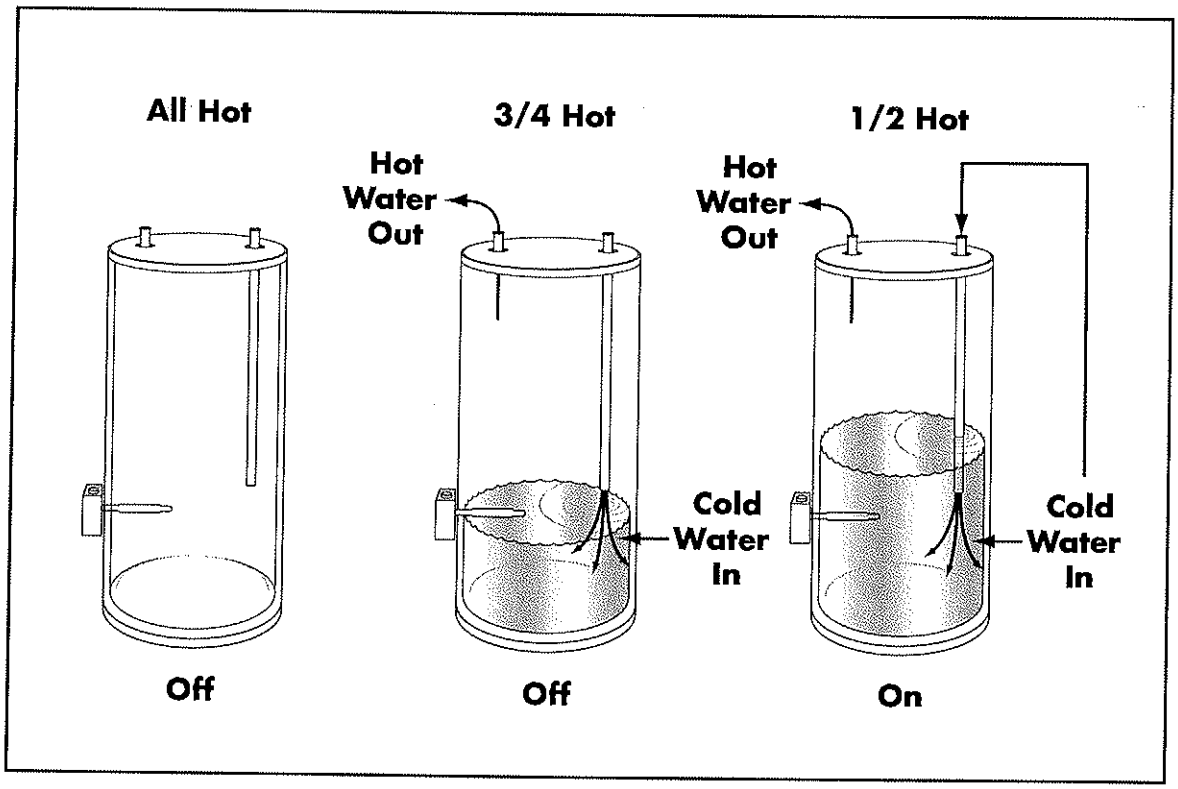
The thermostat will call for heat whenever the water temperature in the tank falls below the desired setting.

It is important to note that the gas valve and the orifice control the rate at which gas passes into the burner assembly. In addition to this type of control, electronic ignition type controls (24V or 120V) may use thermistors to monitor water temperature and cycle gas on or off.

The thermostat is activated by a sensor probe, or thermistors within a probe, which extend into the tank.

When the cold water entering the bottom of the tank rises above the level of the probe, the temperature at the probe drops. The thermostat reacts to the cold water, turns the gas on, and the water is heated to the desired temperature.

MAINTAINING SELECTED WATER TEMPERATURE



SP 1.2.14

The thermostat turns the main burner on and off as needed to maintain the selected water temperature.

The fourth control in this group is the **ENERGY CUT-OFF DEVICE**. The energy cut-off device, also called the **ECO DEVICE**, is a heat-sensitive device with its own thermostat that monitors the temperature of the water in the tank to prevent the water from getting too hot.

The ECO is designed to shut off *all* gas flow to the pilot and main burner if the thermostat which normally regulates the water temperature should fail and the burner remains on. The ECO does this by a switch connection to the thermocouple wiring or by sending an ohm resistance signal to the gas control circuit board.

Heater Tank Control and Safety Devices

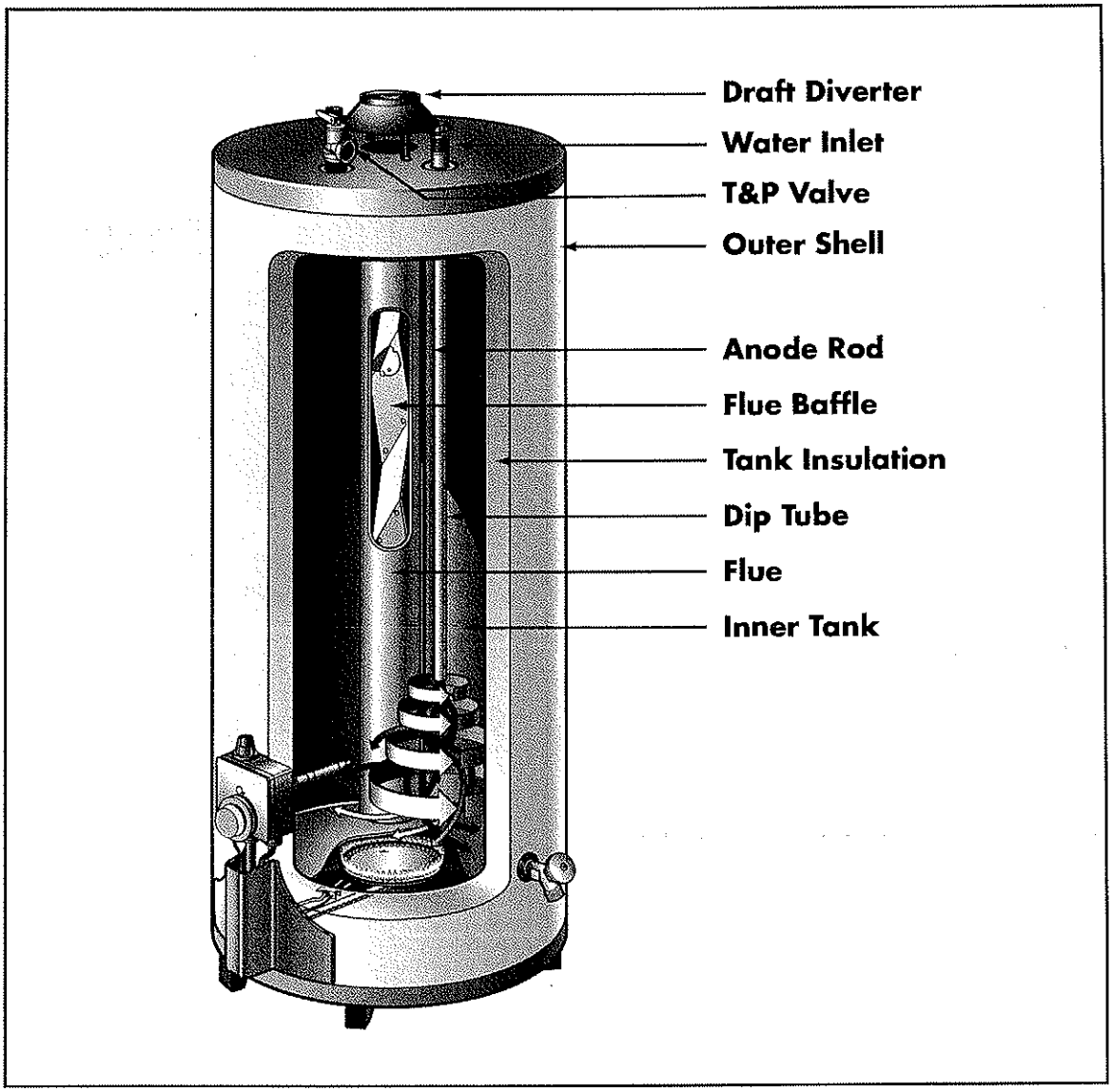
As mentioned previously, controls and safety devices can be related to either the burner or to the tank of a water heater. The following discussion will focus on those devices and controls which protect the water heater tank.

These control and safety devices consist of the:

- Temperature and pressure (T&P) relief valve
- Anode rod
- Tank lining
- Drain valve

These controls are found on both gas and electric water heaters.

CONTROL AND SAFETY DEVICES



SP 1.2.15

The **TEMPERATURE AND PRESSURE RELIEF VALVE (T&P)** automatically opens up when there is excess temperature (>210° F) or pressure (150 psi) in the water heater tank. It prevents damage to the tank by reducing the pressure and heat. (Pressure is the force exerted per square unit of area, for example, pounds per square inch or psi.)

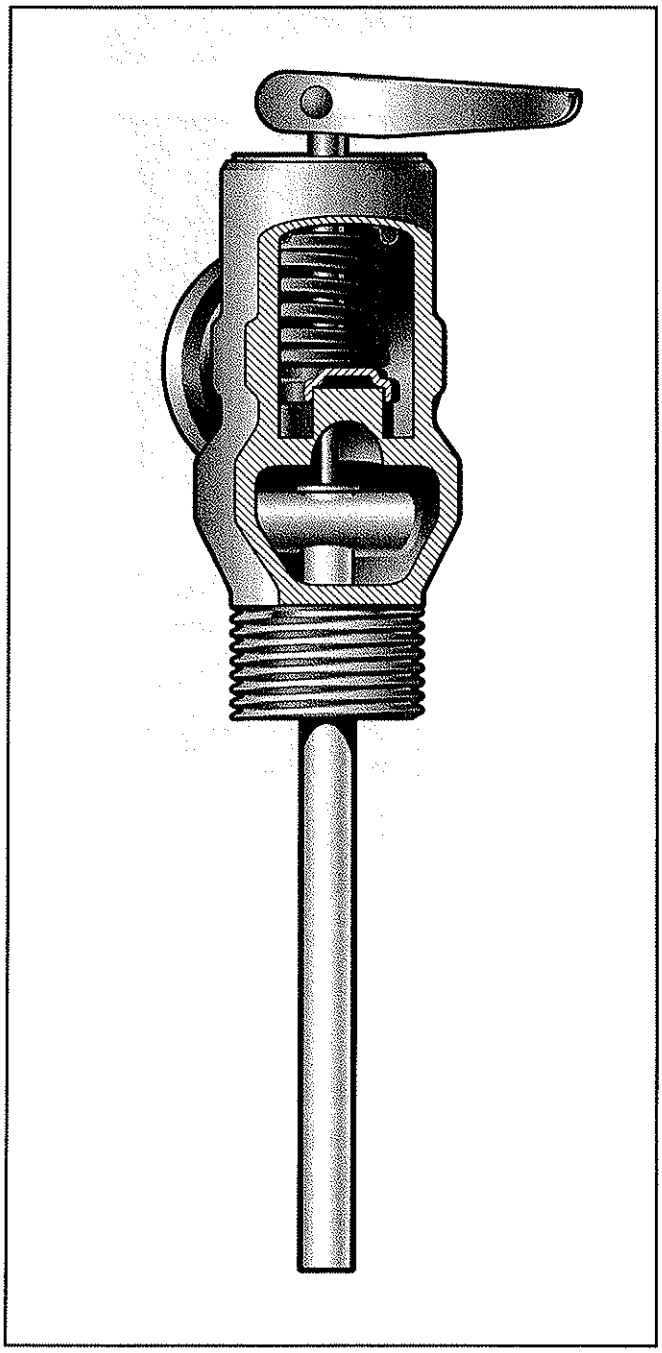
When the T&P valve opens, hot water is allowed to escape, controlling the amount of pressure and temperature in the tank. The pressure should never be allowed to exceed the maximum working pressure of the water heater or 210° F water temperature.

The T&P valve opening can be found on the top or side of the water heater tank.

To understand exactly how the T&P valve works, let's first look at the heating process of the water in the tank. As cold water is heated, water temperature increases. As the temperature increases, the pressure inside the tank also rises in a closed system.

If either the temperature or pressure becomes too high (>210° F or 150 psi) in the tank, the T&P valve opens, discharging hot water. A length of pipe attached to the valve outlet directs the discharge down to the floor and to a safe place of disposal. This discharge pipe is a safety precaution to prevent injury to anyone nearby, since the water temperatures will be extremely hot.

T&P VALVE



SP 1.2.16

A T&P relief valve is always required on all residential water heater installations.

The second device associated with the water heater tank is the **ANODE ROD** (also called the **SACRIFICIAL ANODE ROD**). The anode rod is a rod that extends from the top 30 to 54 inches down into the tank. The anode rod helps protect the tank from rust and corrosion through a chemical process called *cathodic protection*. It can be fitted from its own opening, or attached with the hot water outlet fitting.

Corrosion and rust may occur from the reaction of steel and water, and flaws in the **TANK LINING** that expose the steel. The anode rod is designed simply to be eaten away by corrosion that otherwise would attack exposed metal of the tank.

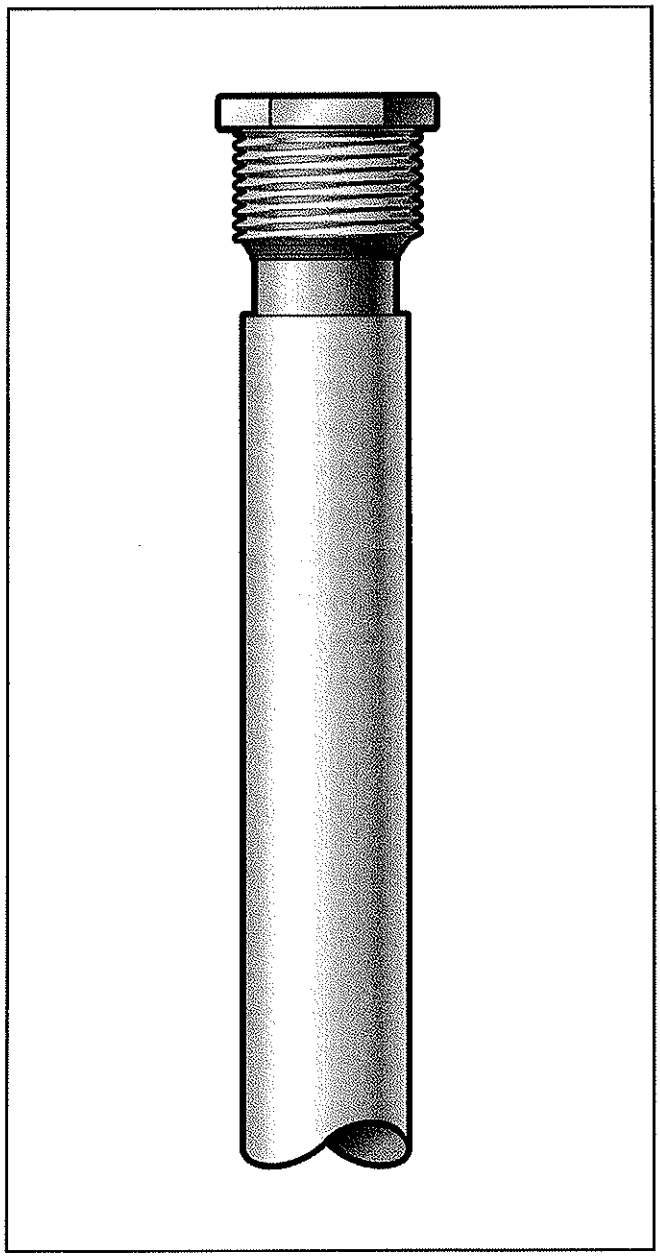
To understand how the anode rod protects against corrosion, we need to know more about the corrosion of metal. All metal will eventually corrode, but deterioration is more rapid when metal is exposed to oxygen and water. Heating water often accelerates this corrosion process, which is what we commonly call *rust*.

The Corrosion Process

CORROSION, whether in the atmosphere, underwater, or underground, is caused by the flow of electricity from one metal to another metal, or from one part of the surface of a piece of metal to another part of the same metal where conditions permit the flow of electricity. For this to occur there must be a moist conductor or electrolyte present for the flow of energy to take place.

When two different metals are immersed in water, an electrical current will flow between them. This process occurs because water is an electrolyte. An **ELECTROLYTE** is a substance which, due to its makeup, can conduct an electric current. This current causes corrosion or decomposition of one of the metals.

SACRIFICIAL ANODE ROD

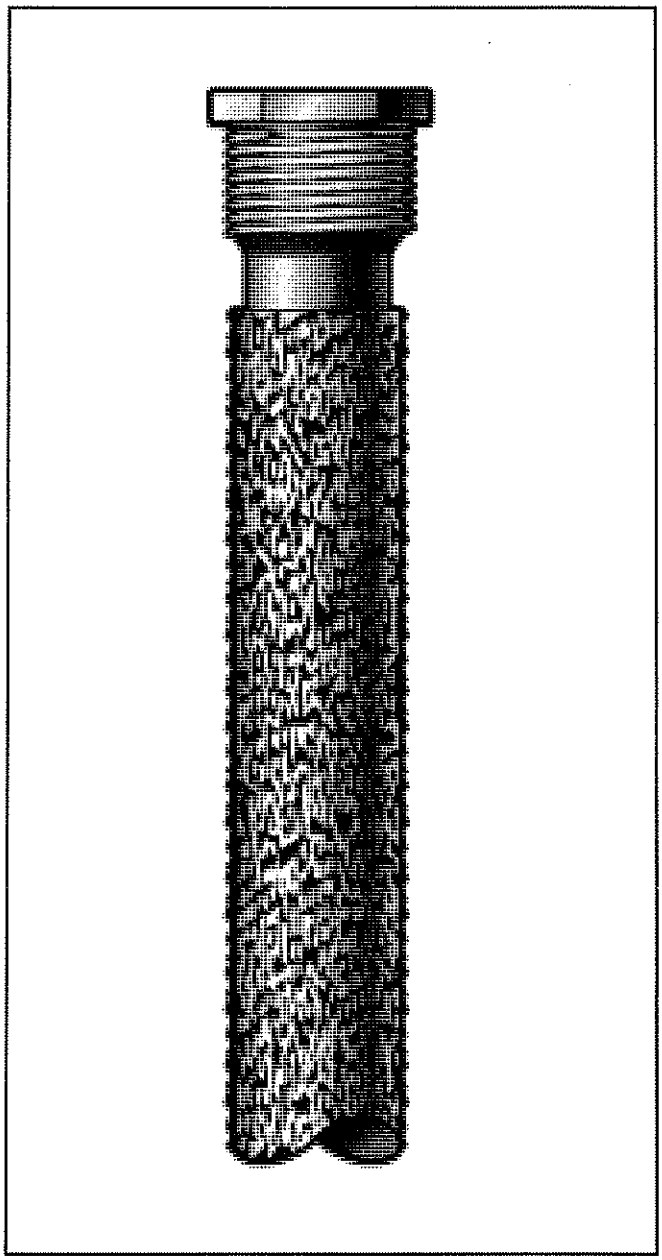


SP 1.2.17

To produce electric current, you need an anode (negative electrode), a cathode (positive electrode), and a conductor (electrolyte). In a water heater, the sacrificial rod is the anode, the steel tank becomes the cathode, and the water becomes the conductor. The electric current conducted through the water causes the anodic metal to gradually corrode instead of any exposed steel in the tank.

In chemistry, the term *base metal* is used informally to refer to a metal that oxidizes or corrodes relatively easily. *Noble metals* are metals that are resistant to corrosion or oxidation and tend to be precious metals, often due to perceived rarity. Examples include gold, silver, tantalum, platinum, and rhodium. Unlike most base metals, noble metals are chemically inert or in-active especially toward oxygen.

ANODE ROD PROTECTS AGAINST CORROSION



SP 1.2.18

On the next page is a list of various metals and alloys. This list shows whether a metal has the tendency to become anodic or cathodic. The higher a metal or alloy is on the list, the greater its tendency to corrode.

Most anode rods are made from magnesium or aluminum because they are the most anodic or likely to corrode. Zinc/aluminum anode rods are also available for specific water conditions.

The third method used to protect the water heater tank is the **TANK LINING**. The purpose of the tank lining is to reduce corrosion by providing a protective barrier for the steel structure of the tank. The tank lining may be made of glass, copper, cement, or an epoxy material.

The most common material used for the tank lining is glass. In water heaters, this is basically a coating of vitreous enamel bonded to an iron or steel surface by firing at red-hot temperatures (approxi-mately 1600° F).

The enamel is a special formulation resistant to hot water. Glass lined heaters may be referred to as "glass enamel lined," "glass enameled," "vitreous enamel lined," or "bonded vitreous lined."

The **DRAIN VALVE** is the fourth device used to protect the water heater tank. The drain valve is located at the bottom of the heater and is used to drain the heater or, in regular maintenance, to prevent sediment build-up.

Galvanic Series of Metals and Alloys
Anodic End (Most Like to Corrode)
Magnesium Magnesium Alloys Zinc
Aluminum 1100 Cadmium Aluminum 2024-T4 Steel or Iron Cast Iron Chromium-Iron (active) Ni-Resist Cast Iron
Type 304 Stainless (active) Type 316 Stainless (active)
Lead-Tin Solders Lead Tin
Nickel (active) Inconel Nickel-Chromium Alloy (active) Hastelloy Alloy C (active)
Brasses Copper Bronzes Copper-Nickel Alloy Monel Nickel-Copper Alloy
Silver Solder Nickel (passive) Inconel Nickel-Chromium Alloy (passive)
Chromium-Iron (passive) Type 304 Stainless Steel (passive) Type 316 Stainless Steel (passive) Hastelloy Alloy C (passive)
Silver Titanium Graphite Gold Platinum
Cathodic (Least Likely to Corrode)

Water commonly contains minerals which tend to settle at the bottom of the heater as the water is heated. If the heater is not drained regularly, these minerals will eventually form a solid deposit of residue at the bottom of the heater.

Benefits of Residential Gas Water Heaters

Most homes use a storage type water heater; an insulated tank with an electric or gas heating unit. A conventional hot water heater typically will heat 40 to 80 gallons of water, and keeps it hot both day and night. Gas heaters generally heat water faster and cost much less to operate.

Today's natural gas water heaters are the most efficient models on the market. Compared to electric water heaters, they're less expensive to operate, they heat water faster, and they provide hot water even when the electricity goes out. They're more durable, since the flame does all the work and there are fewer parts to fail or wear out. And, they come in a variety of sizes so you can select one to best meet your needs.

A gas-fired water heater may also be tankless and provide hot water at a preset temperature when needed without storage, thereby reducing or eliminating standby losses. Tankless water heaters can be used for supplementary heat, such as a booster to a solar hot water system, or to meet all hot water needs.

For those customers who wish to purchase an on-demand heater, there are additional benefits. Demand heaters save energy, never run out of hot water (within flow limits), usually last longer than storage heaters, free up floor space, and have easily replaceable components.

REVIEW QUIZ – RESIDENTIAL GAS WATER HEATERS

Answers appear on page 76

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. Another way to describe of the term *combustion* is the
   a. heating of water.
   b. production of fumes.
   c. burning of fuel.
   d. cooling of air.

2. The gas supply to the burner turned on and off by the
   a. temperature control.
   b. thermostatic control.
   c. indicator knob.
   d. combustion chamber.

3. The size orifice needed for a water heater is determined by the
   a. type of gas used.
   b. type of pilot burner.
   c. type of thermostat.
   d. manometer.

4. What provides the passageway for combustion exhaust to move from the combustion chamber to the vent?
   a. Dip tube
   b. Baffle
   c. Chimney
   d. Flue

5. A manometer is an instrument which is used to measure
   a. water temperature.
   b. water pressure.
   c. gas pressure.
   d. heat.

REVIEW QUIZ – RESIDENTIAL GAS WATER HEATERS

Answers appear on page 76

6. Where is the hottest layer of water located in a gas-fired tank?
   a. At the top of the tank
   b. In the center of the tank
   c. At the bottom of the tank
   d. All layers are the same temperature

7. What do residential gas models typically use to ignite the main burner when the thermostat calls for heat?
   a. Thermostat
   b. ECO
   c. Pilot burner flame
   d. Thermocouple

8. What regulates the amount of gas that enters the burner?
   a. Thermostat
   b. Pilot burner
   c. Gas pressure in the supply pipe and the size of the orifice
   d. ECO

9. What controls the water temperature in the tank?
   a. Thermostat
   b. Thermocouple
   c. Pilot burner
   d. ECO

10. The purpose of the ECO is to
    a. regulate the water pressure in the tank.
    b. ignite the fuel and oxygen source at the main burner.
    c. regulate the water level in the tank.
    d. prevent the water from getting too hot.

11. Gas pressure is measured in
    a. inches of water column.
    b. BTUs.
    c. degrees Fahrenheit.
    d. cubic feet.

REVIEW QUIZ – RESIDENTIAL GAS WATER HEATERS

Answers appear on page 76

12. Four control and safety devices related to the burner are the pilot burner, thermocouple, energy cut-off (ECO) device, and
    a. T&P valve.
    b. anode rod.
    c. tank lining.
    d. thermostat.

13. The purpose of the pilot burner is to
    a. ignite the main burner.
    b. protect the water heater tank.
    c. relieve excess pressure.
    d. control water temperature.

14. Which of the following assures that the pilot flame is burning and shuts off the gas if the pilot flame goes out?
    a. Thermostat
    b. Thermocouple/Thermopile
    c. T&P valve
    d. Anode rod

15. Four control and safety devices that protect the water heater tank are the anode rod, tank lining, drain valve, and
    a. pilot burner.
    b. thermocouple/thermopile
    c. T&P relief valve.
    d. thermostat.

16. The T&P valve protects the water heater tank because it
    a. relieves excess temperature and pressure in the tank
    b. protects the tank from corrosion.
    c. allows the water to drain.
    d. ignites the main burner.

17. Which metals are used to make most sacrificial anode rods?
    a. Magnesium or aluminum
    b. Silver or graphite
    c. Gold or platinum
    d. Copper or bronze

REVIEW QUIZ – RESIDENTIAL GAS WATER HEATERS

Answers appear on page 76

18. What is the most common material used to line water heater tanks?
    a. Magnesium
    b. Aluminum
    c. Silver
    d. Glass

19. Most anode rods are made from magnesium or aluminum because they are the most
    a. cathodic.
    b. negative.
    c. noble.
    d. anodic.

20. The drain valve allows water to drain from the heater and
    a. causes mineral build-up.
    b. prevents mineral build-up.
    c. accelerates corrosion.
    d. relieves pressure.

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. Where can you find the most up-to-date information about gas water heaters?

_____

_____

_____

B. What method does your company use to help customers select the appropriate gas water heater capacity?

_____

_____

_____

ANSWERS TO REVIEW QUIZ

CHAPTER 2

RESIDENTIAL GAS WATER HEATERS

Answers to REVIEW OF RESIDENTIAL GAS WATER HEATERS (pages 71 – 74)

1. c. the burning of fuel.
2. b. thermostatic control.
3. a. the type of gas used.
4. d. Flue.
5. c. gas pressure.
6. a. At the top of the tank
7. c. Pilot burner flame
8. c. Gas pressure in the supply pipe and the size of the orifice
9. a. Thermostat
10. d. to prevent the water from getting too hot.
11. a. in inches of water column.
12. d. thermostat.
13. a. ignite the main burner.
14. b Thermocouple
15. c. T&P relief valve.
16. a. relieves excess temperature and pressure in the tank.
17. a. Magnesium or aluminum
18. d. Glass
19. d. anodic.
20. b. prevents mineral buildup.

Applying what you have learned:

A. Depends on the company, but typically includes product catalogs and/or the Web where information can be quickly downloaded.

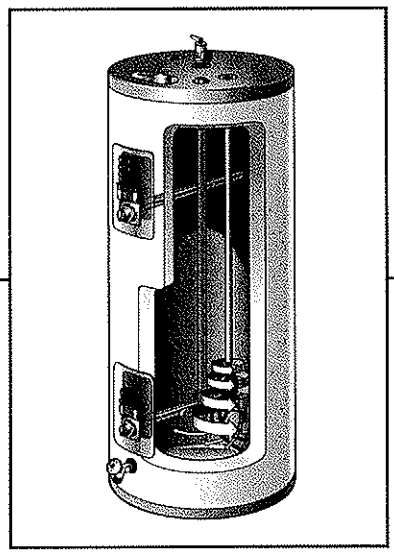
B. Depends on the company, but capacities are based on the needs of the residents. High demand capacities include the needs of large families, teenagers, whirlpool tubs, spas, and oversized baths.

3 RESIDENTIAL ELECTRIC WATER HEATERS

LEARNING OBJECTIVES

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

1. Diagram the components of residential electric water heaters.
2. Explain the basic functions of residential electric water heaters.
3. Generalize about how heating elements work.
4. Describe and assess the types of thermostats found in electric water heaters.

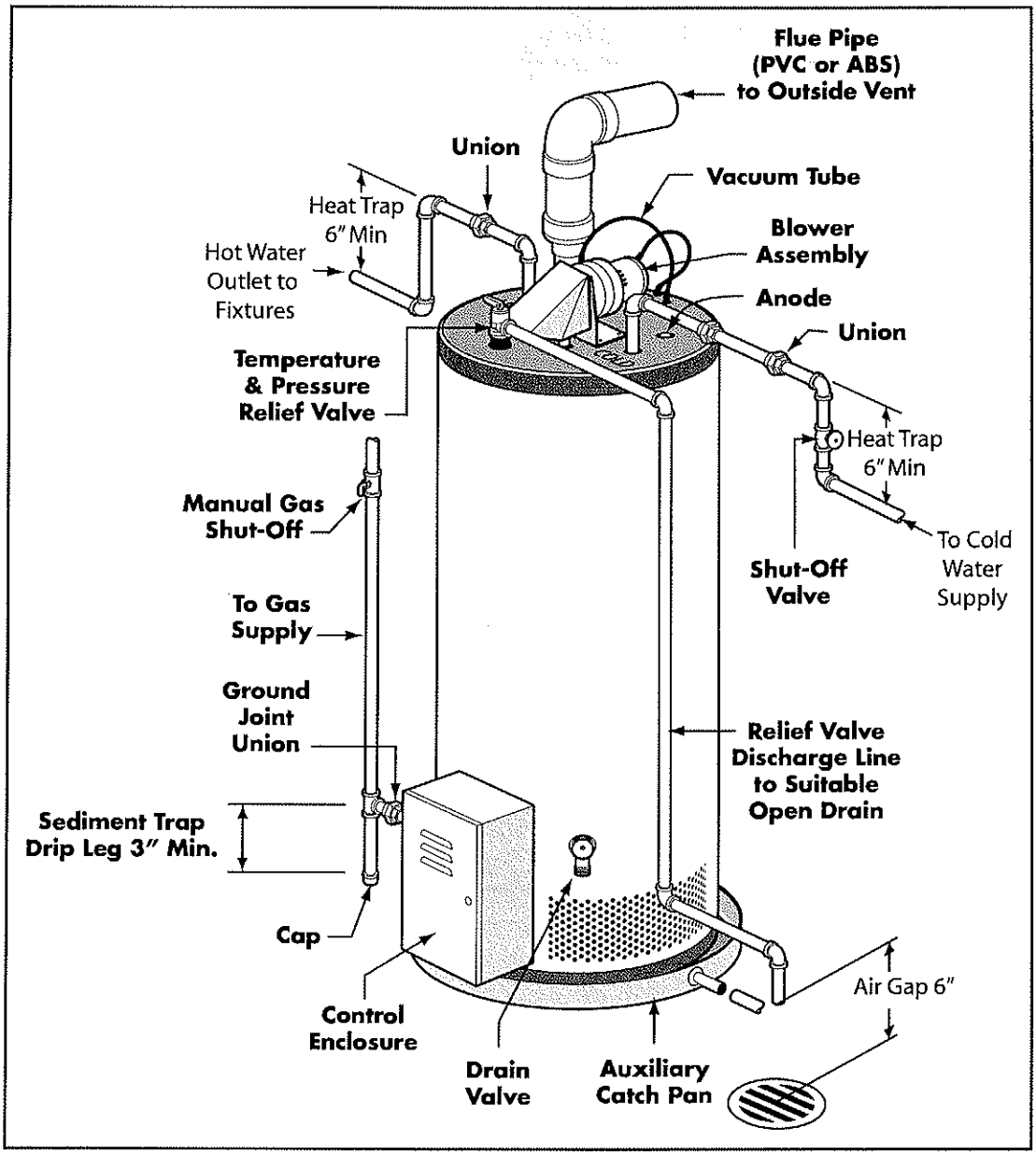


ELECTRIC WATER HEATERS

Gas and Electric Water Heaters Compared

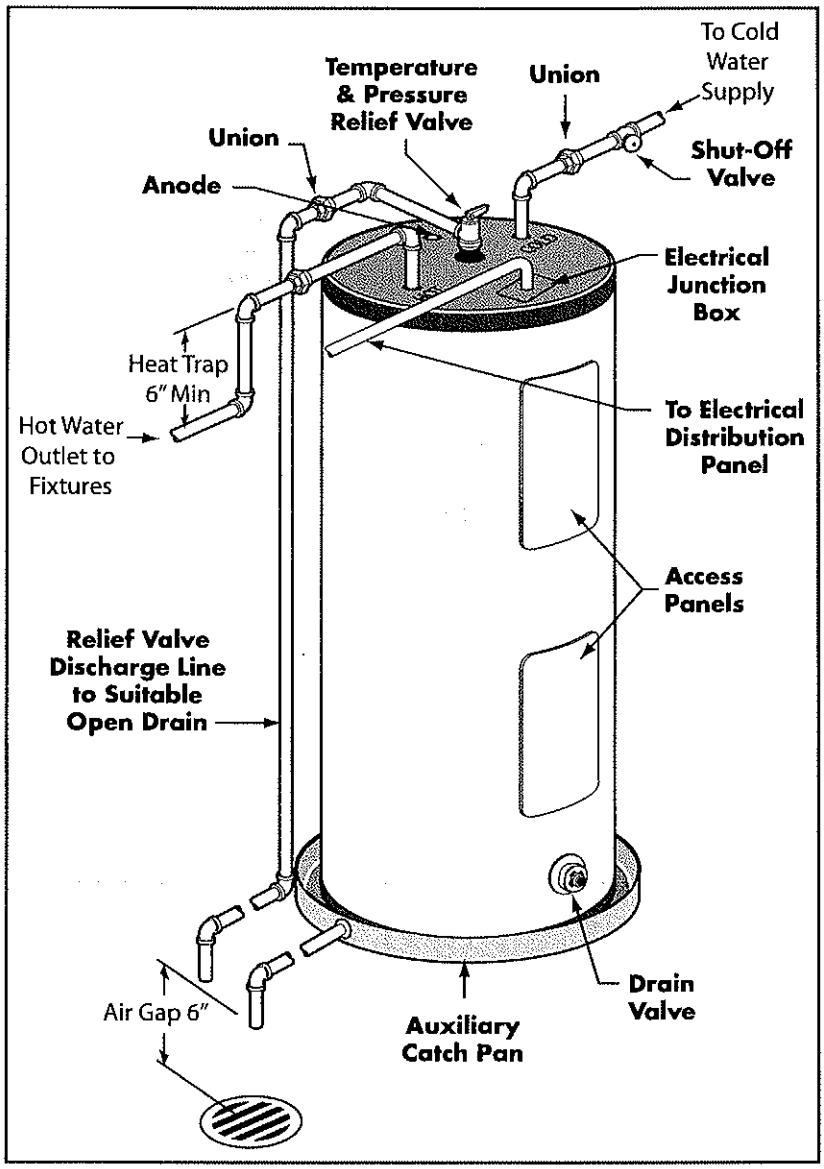
In this chapter, we will focus on residential electric water heaters. As we mentioned in the overview of this course, many parts of the electric water heater are the same as those on gas models.

ELECTRIC WATER HEATER / GAS HEATER



SP 1.3.01

ELECTRIC WATER HEATER

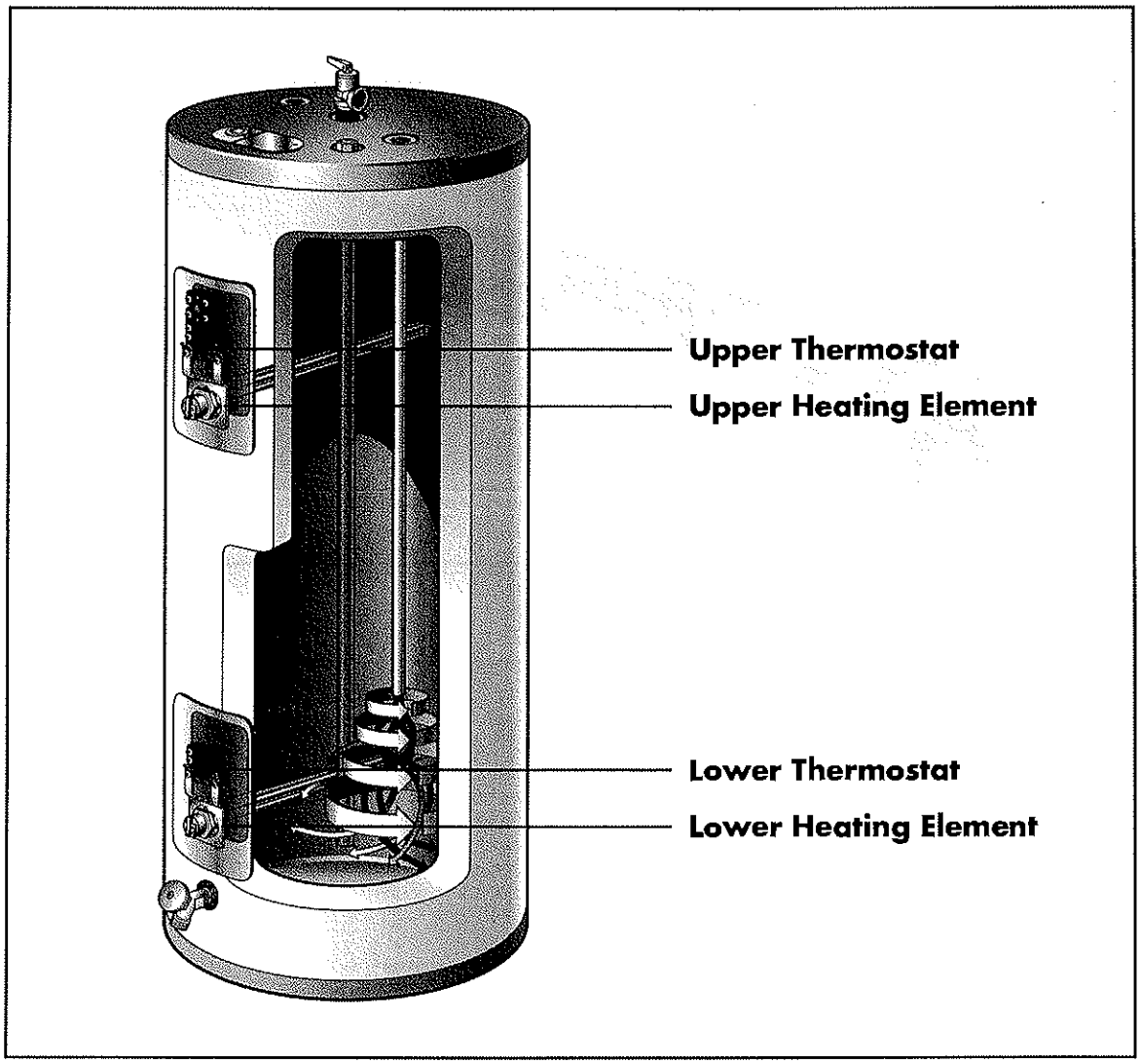


SP 1.3.01

Notice that, unlike the gas water heater, electric water heaters have no draft diverter or vent connection. Electric heaters do not heat by combustion products, so there are no combustion wastes that need to be vented.

Electric models heat the water in the tank by using **HEATING ELEMENTS**. The heating elements in an electric water heater look like elongated coils. Most heaters contain two elements; however, some smaller, compact models may only have one.

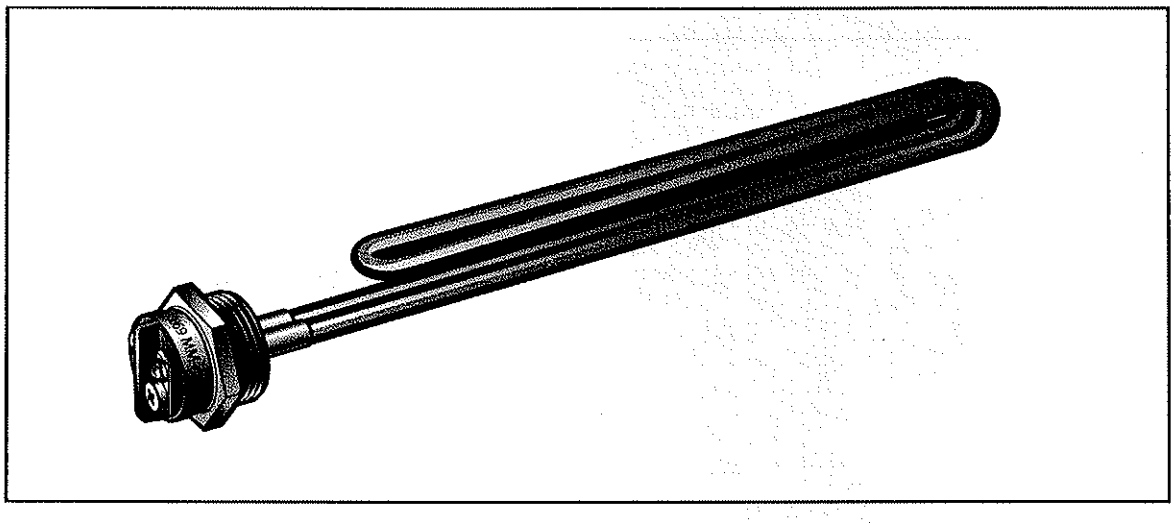
HEATING ELEMENTS



SP 1.3.02

The most common type of heating element used in residential electric water heaters is the **IMMERSION ELEMENT**. This type of device is actually inmersed in the water, thus providing contact between the water and the hot element. Immersion elements are attached to the interior of the tank by using a threaded flange, making replacement of the element easy. However, some older models may use a bolt for attachment.

IMMERSION ELEMENT



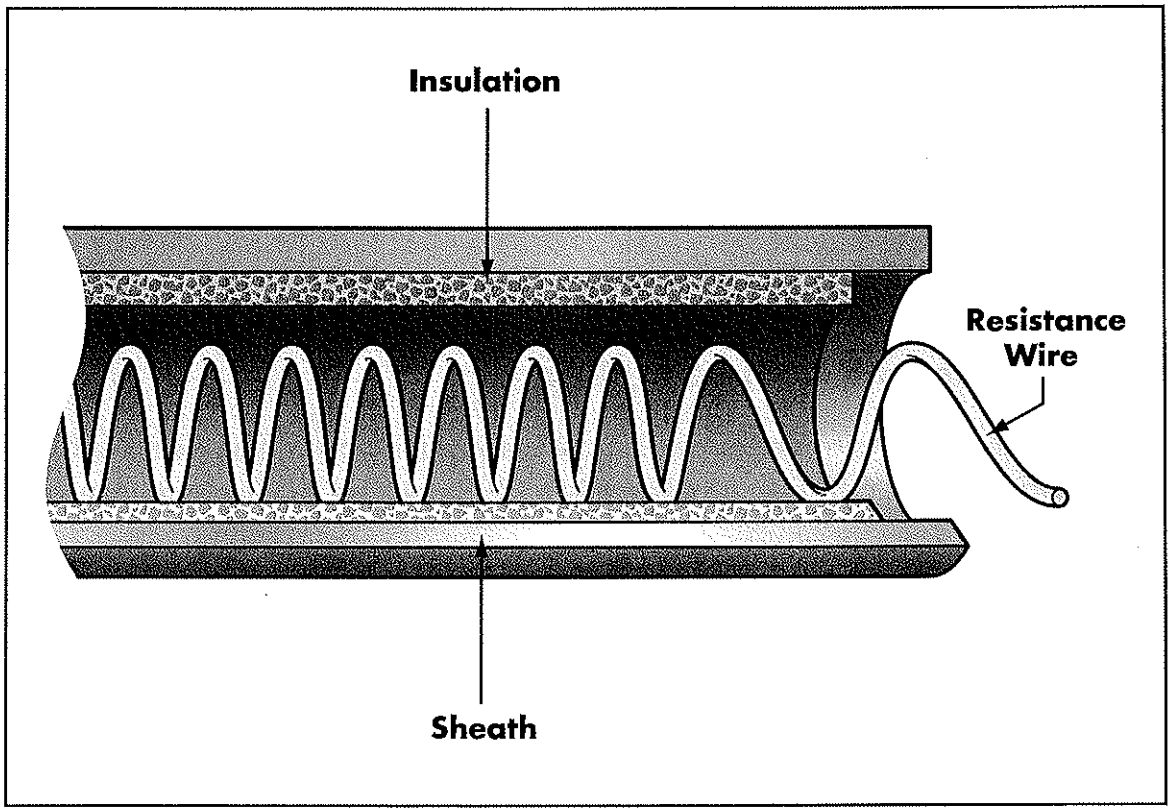
SP 1.3.03

Heating Element Makeup

The heating element is made simply of three parts; the sheath, coiled wire and electrical insulation.

The outer casing of the heating element is called the sheath. The **SHEATH** contains the coiled wire. **ELECTRIC INSULATION** surrounds the coiled wire to prevent the current from passing through the metal sheath into the water in the storage tank, and causing injury by electrical shock.

PARTS OF THE HEATING ELEMENT



SP 1.3.04

Electric current flows through the coiled wire when the thermostat is on. The **COILED WIRE** is called the **RESISTANCE WIRE** because it resists the flow of current. When the resistance wire reduces the current flow, heat is produced. Heat is passed on through the electrical insulation and outer sheath into the water in the storage tank.

All metals repel electricity, but some resist the electrical current flow better than other metals. On page 84 is a chart which shows the amount of resistance some metals have to current flow.

Most heating elements use a **NICHROME** wire filament for the wire coil (resistance wire) because it offers a high resistance to current flow. Nichrome is an alloy of nickel, chromium, and iron.

To control the heating elements, the electric water heater requires thermostats. The thermostats on an electric heater serve the same purpose as those on the gas water heater—to regulate the temperature of the water.

RESISTANCE OF METAL

METAL	RESISTANCE
Copper	1
Aluminum	1-1/2
Tungsten	3+
Nickel	5
Steel	7 to 13
Stainless Steel	53
Nichrome	65

SP 1.3.1f

The most common type of thermostats are surface mounted. Surface mounted thermostats sense water temperature through the steel tank.

Thermostats for Each Heating Element

Most electric water heaters have two thermostats; one for each heating element. These two thermostats typically operate differently once the tank is filled (non-simultaneous operation).

The illustration on page 85 shows the initial heating of a tank of cold water and the operation of the electric heater. Follow the illustrations as the process is explained. The thermostats are set for 120° F.

(1) When the tank is filled with cold water, the top thermostat turns on the upper heating element.

(2) The water begins to heat in the upper third of the tank.

(3) In most cases, when the water reaches the preset temperature, the top thermostat shuts off the upper heating element and transfers electricity to the bottom thermostat.

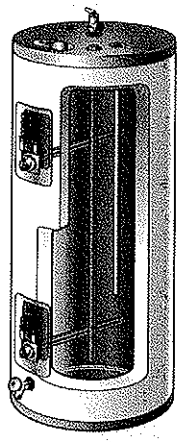
(4) The lower heating element stays on until the water in the bottom of the tank reaches thermostat setting.

(5) Then the lower thermostat shuts off the bottom heating element.

(6) The lower heating element remains off until hot water is drawn off the top of the tank and cold water enters the bottom. The lower heating element does the most work.

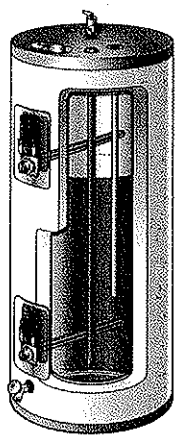
OPERATION OF ELECTRIC HEATER

1.



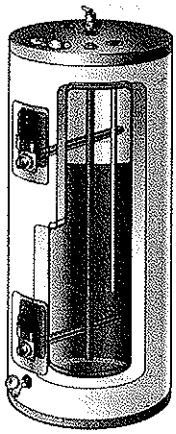
Upper thermostat is the controlling thermostat. When tank is filled with cold water, or tank runs out of hot water, the upper thermostat will demand heat and turn on the upper heating element. Cold water enters the bottom of the tank through the drip tube.

2.



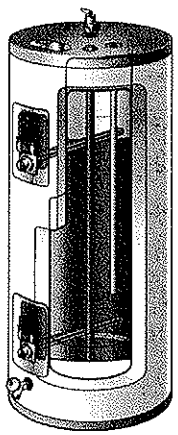
The water in the top of the tank is heated. Since heat rises, only the water at or above the heoting element gets hot. When you run out of hot water, the upper thermostat and element attempt to keep up with the demand.

3.



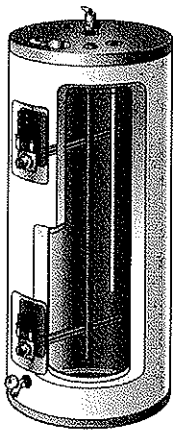
When the water in the top of the tank reaches thermostat setting, it will automatically turn off and transfer power to the lower thermostat. The lower thermostat, demanding heat from the cold water, turn the lower heating element on. Only one thermostat has power and only one heating element can heat at one time.

4.



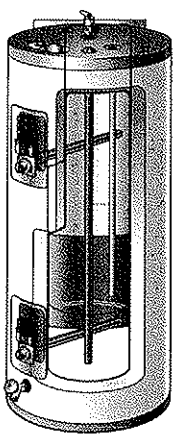
The water in the bottom area (roughly the bottom 2/3 of the tank) is heated as the lower heating element and thermostat operate.

5.



When all the water in the bottom of the tank is heated to the thermostat settings, the bottom heating element is turned off. All thermostats are satisfied and the tank is in 'stand-by' mode.

6.



As hot water is drawn from the tonk, it is replaced by cold water from the drip tube. The cold water enters the bottom of the tank and the lower thermostat senses a heat change. The lower heating element will heot the incoming cold water. If you use all the hot water in the tank, the upper thermostat will demand heat and withdraw power from the bottom of the tank.

SP 1.3.06

When cold water enters the bottom of the tank, the lower thermostat and heating element go on. The upper thermostat will not come on again unless there is excessive use of hot water causing the water in the upper third of the tank to be cooler than the thermostat setting. When the top heating element comes on, the lower element will shut down. The heating cycle will repeat itself.

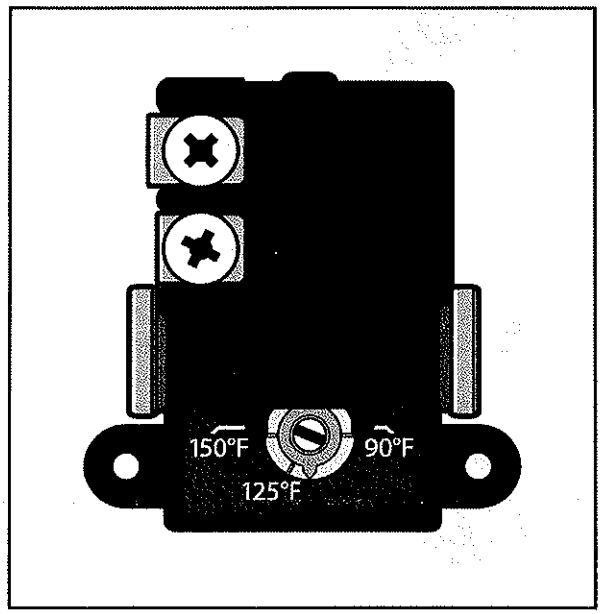
Electric Water Heater Thermostats

Electric water heaters use two basic types of thermostats:

1. Single throw thermostat
2. Double throw thermostat

A **SINGLE THROW THERMOSTAT** can only control the current going to one heating element. It controls only the current to the element to which it is wired. Electric water heaters with only one element will have a single throw thermostat. A single throw thermostat is shown below.

SINGLE THROW THERMOSTAT



SP 1.3.07

A **DOUBLE THROW THERMOSTAT** is generally located by the upper element with the single throw thermostat by the lower heating element. Element operation in these water heaters is called **NON-SIMULTANEOUS** or **INTERLOCKED** because only one element can operate at a time.

You will also find some electric water heaters which have two single throw thermostats instead of the combination.

Element operation of two single throw thermostats is called **SIMULTANEOUS** because both heating elements can operate at the same time.

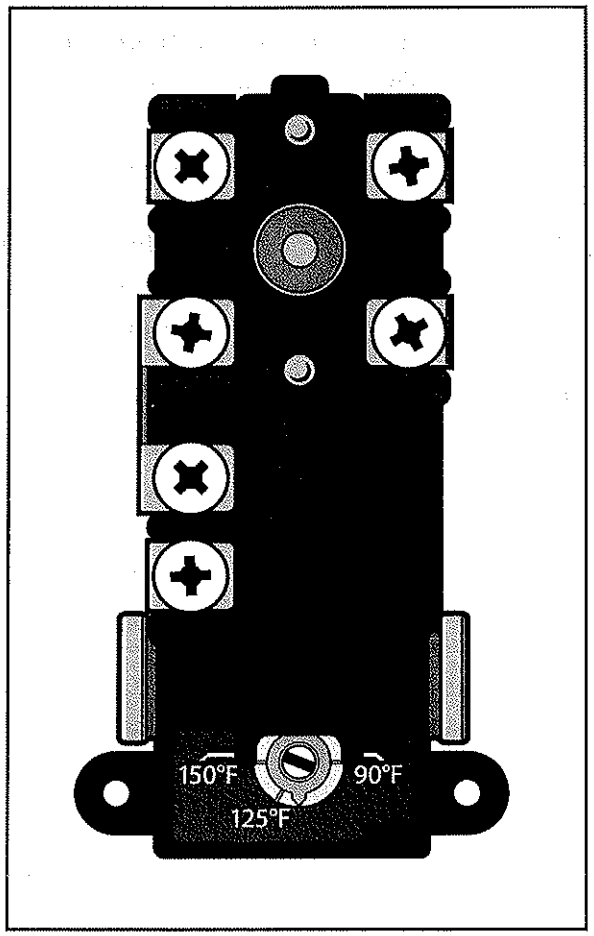
The type of thermostat used in a water heater will depend on the zoning and utility requirements in your area. Always check the code requirements for your area.

Like gas model water heaters, electric water heaters have an **ENERGY CUT-OFF (ECO) DEVICE**. This device on electric heaters is called the **HIGH LIMIT CONTROL**.

The high limit control will turn off all electric current if the water in the tank becomes too hot (at 170° F) and the thermostat has failed to shut off the current to the heating elements.

Repeated high limit operation should be investigated.

DOUBLE THROW THERMOSTAT



SP 1.3.08

Benefits of Electric Water Heaters

With an electric water heater, there is no need for a chimney, flue or venting since it's all-electric. There is no danger of gas leaks, fires, or explosions. In fact, the National Fire Protection Association states a gas water heater is seven times more likely to cause a fire than an electric water heater.

Without the need for a vent or flue, an electric water heater can be located at various points around the home. That means it can be placed closer to the point where hot water is used, instead of waiting several minutes for the hot water to arrive.

The typical gas water heater is 80% thermal efficient and a typical electric water heater is 98% thermal efficient. Some experts would argue that electric water heaters should be rated 100% thermal efficient, since the elements are fully submersed in the water and all heating energy is being transferred directly to the water. In regards to gas water heaters, heat can be lost through the combustion process or flues. Thermal efficiency is the ability to transfer and absorb heat from the fuel source into the water.

And finally, because electricity is generated by many means, is very stable, clean, safe, reliable, and efficient and is not as vulnerable to price fluctuations as individual fuel sources.

REVIEW QUIZ – RESIDENTIAL ELECTRIC WATER HEATERS

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. Which of the following is the device used to heat the water in an electric water heater?
   a. Draft diverter
   b. Pilot burner
   c. Immersion element
   d. Thermostat

2. The outer casing of the heating element is called the
   a. sheath.
   b. coil.
   c. resistance wire.
   d. insulation.

3. The coiled wire that carries the flow of electric current and produces heat is called the
   a. sheath.
   b. insulation.
   c. coil.
   d. resistance wire.

4. Which of the following is an alloy of nickel, chromium, and iron?
   a. Aluminum
   b. Tungsten
   c. Copper
   d. Nichrome

REVIEW QUIZ – RESIDENTIAL ELECTRIC WATER HEATERS

Answers appear on page 94

5. What controls the current going to one heating element, the one to which it is wired?
   a. Resistance wire
   b. High limit control
   c. Single throw thermostat
   d. ECO device

6. The element operation of double throw thermostats in which only one element can operate at a time is called
   a. simultaneous.
   b. non-simultaneous.
   c. continuous.
   d. non-continuous.

7. The element operation of two single throw thermostats is
   a. simultaneous.
   b. non-simultaneous.
   c. continuous.
   d. non-continuous.

8. What is the energy cut-off (ECO) device on an electric water heater called?
   a. High limit control
   b. Single throw thermostat
   c. Double throw thermostat
   d. Element

9. What is the purpose of the resistance wire?
   a. to hold the coiled wire
   b. to reduce electric current flow and produce heat
   c. to prevent the current from passing through the sheath
   d. to sense water temperature

REVIEW QUIZ –
RESIDENTIAL ELECTRIC WATER HEATERS

Answers appear on page 94

10. Why is nichrome used for the resistance wire in an electric heating element?
    a. It is inexpensive.
    b. It has a low resistance to current flow.
    c. It has a high resistance to current flow.
    d. It does not repel electricity.

11. How many thermostats and heating elements does an electric water heater generally have?
    a. One
    b. Two
    c. Three
    d. Four

12. In an electric water heater, which heating element does the most work?
    a. Upper heating element
    b. Electrical heating element
    c. Higher heating element
    d. Lower heating element

13. The two basic types of thermostats used on electric water heaters are single throw and
    a. double throw.
    b. surface mounted.
    c. non-simultaneous.
    d. simultaneous.

REVIEW QUIZ – RESIDENTIAL ELECTRIC WATER HEATERS

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. Where can you find the most up-to-date information about electric water heaters?

_____

_____

_____

B. What method does your company use to help customers select the appropriate electric water heater capacity?

_____

_____

_____

ANSWERS TO REVIEW QUIZ

CHAPTER 3

RESIDENTIAL ELECTRIC WATER HEATERS

Answers to REVIEW OF RESIDENTIAL ELECTRIC WATER HEATERS (pages 89 – 92)

1. c. Immersion element
2. a. sheath.
3. d. resistance wire.
4. d. Nichrome
5. c. Single throw thermostat
6. b. non-simultaneous.
7. a. simultaneous.
8. a. High limit control
9. b. to reduce electric current flow and produce heat
10. c. It has a high resistance to current flow.
11. b. Two
12. d. Lower heating element
13. a. double throw.

Applying what you have learned:

A. Depends on the company, but typically includes product catalogs and/or the Web where information can be quickly downloaded.

B. Depends on the company, but capacities are based on the needs of the residents. High demand capacities include the needs of large families, teenagers, whirlpool tubs, spas, and oversized baths.

4 OTHER TYPES OF WATER HEATERS

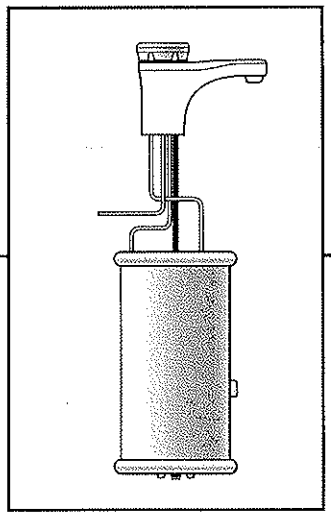
LEARNING OBJECTIVES

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

1. Analyze the basic functionality of several water heaters: heat pump, solar, tankless coil and indirect, and other types of water heaters.

2. Evaluate the basic components of several water heaters: heat pump, solar, tankless coil and indirect, and other types water heaters.

3. Compare and contrast the similarities and differences among the types of water heaters.



OTHER WATER HEATERS

Overview of Other Water Heaters

In the previous chapters, we looked at conventional storage water heaters that operate by pulling hot water out of the top of the water heater. Cold water flows into the bottom (through a dip tube from the top) to replace it.

We also looked at demand (or instantaneous) water heaters that eliminate the storage tank by heating water directly when there is a call for hot water.

These units are growing in popularity in the United States Demand water heaters with enough capacity to meet household needs are gas- or propane-fired.

In this chapter we will look at less commonly used water heaters: heat pump water heaters, solar water heaters, and indirect and tankless coil water heaters. We'll also briefly look at task heaters.

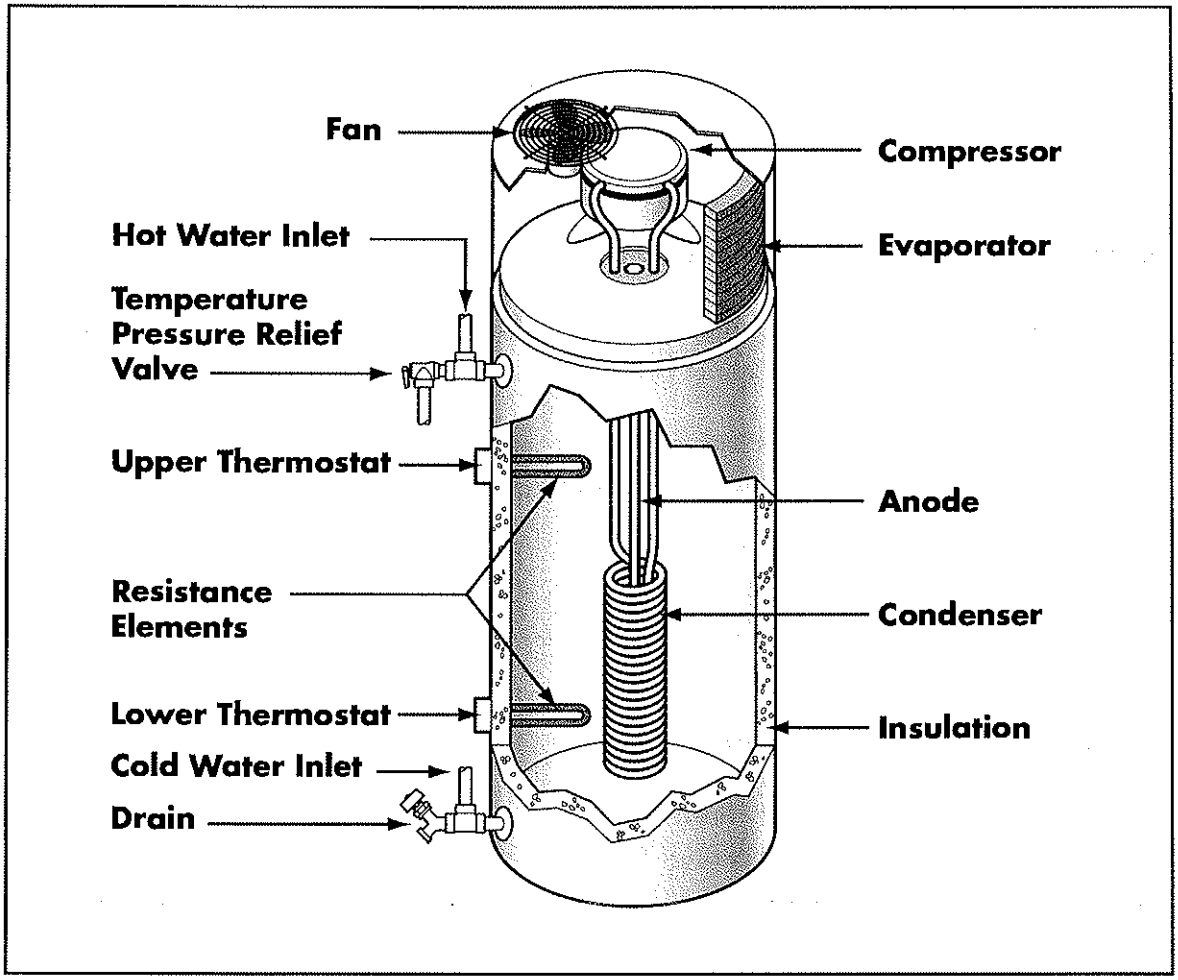
Heat Pump Water Heaters

Heat pumps have traditionally been used for space conditioning, but are now also being used for electric water heating. They are usually three times more efficient than electric resistance water heaters; they can produce the same amount of hot water for one-third the amount of electricity.

Heat pump water heaters (HPWHs) that draw room air must be located in a room large enough to prevent over-cooling of the space. Exhaust-air HPWH should not be used in residences that have gas stoves or fireplaces unless there is a separate make-up air supply to avoid backdrafting. HPWHs need to be installed by an experienced contractor.

In moderate climates, heat pumps are an energy-efficient alternative to air conditioners and furnaces. Heat pumps have traditionally been used for space conditioning, but are now also being used for electric water heating. The same principal of transferring heat is at work except that a HPWH extracts heat from air and delivers it to water. HPWH systems extract the energy content of air to produce hot water very efficiently.

HEAT PUMP WATER HEATER



SP 1.4.01

Types of Heat Pumps

The **AIR-SOURCE HEAT PUMP**, the most common type of heat pump, transfers heat between a house and the outside air. Homeowners who heat with electricity can potentially save between 30% and 65% on their electricity costs by using a heat pump. However, the efficiency of most air-source heat pumps as a heat source drops dramatically at low temperatures, generally making them unsuitable for cold climates.

Geothermal heat pumps are more efficient than air-source heat pumps. They transfer heat between a house and the ground or a nearby water source. Although they more expensive to install, geothermal heat pumps have low operating costs because they take advantage of relatively constant ground or water temperatures.

However, the installation depends on the size of the lot, the subsoil, and landscape. Ground-source or water-source heat pumps can be used in more extreme climatic con-ditions than air-source heat pumps, and customer satisfaction with the systems is very high.

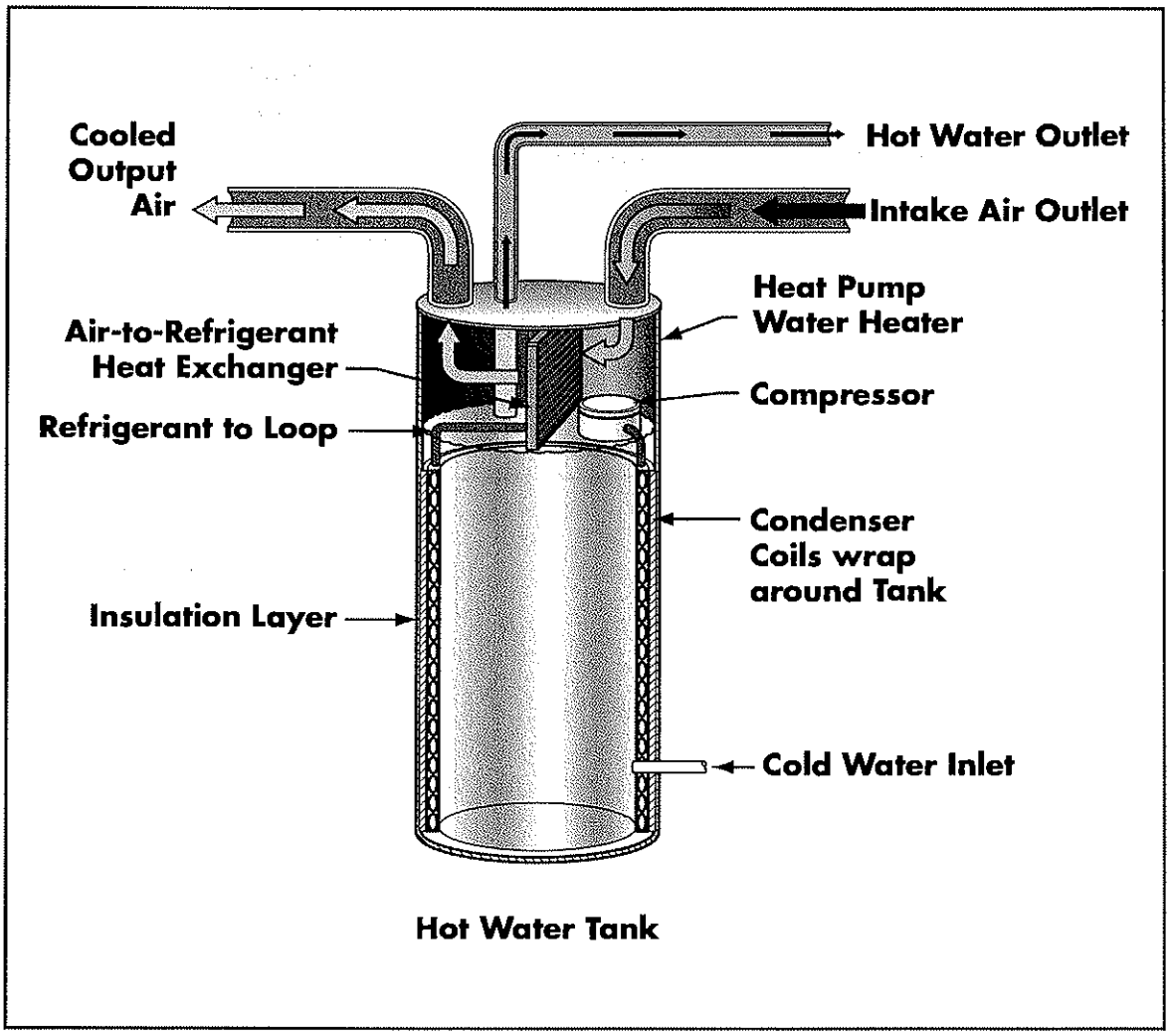
For water heating, homeowners may add a **DESUPERHEATER** to a geothermal heat pump system. A desuperheater is a small, auxiliary heat exchanger that uses superheated gases from the heat pump's compressor to heat water. This hot water then circulates through a pipe to the home's storage water heater tank.

Another type of heat pump for residential systems is the absorption heat pump. Because natural gas is the most common heat source for absorption heat pumps, they are also referred gas-fired heat pumps. Absorption heat pumps can be driven with a wide variety of heat sources. Residential absorption heat pumps use an ammonia-water (ammonium hydroxide) absorption cycle to provide heating and cooling. The ammonia is condensed in one coil to release its heat. Then its pressure is reduced and the ammonia is evaporated to absorb heat. If the system absorbs heat from the interior of the home, it provides cooling; if it releases heat to the interior of the home, it provides heating.

Integrated Versus Add-On Systems

Some heat pump water heaters come as a complete package including tank and backup heating elements while others work as an addition to a conventional water heater. Integrated systems incorporate both the heat pump apparatus and the hot water tank into a single unit, with the condenser typically wrapped around the tank, surrounded by insulation.

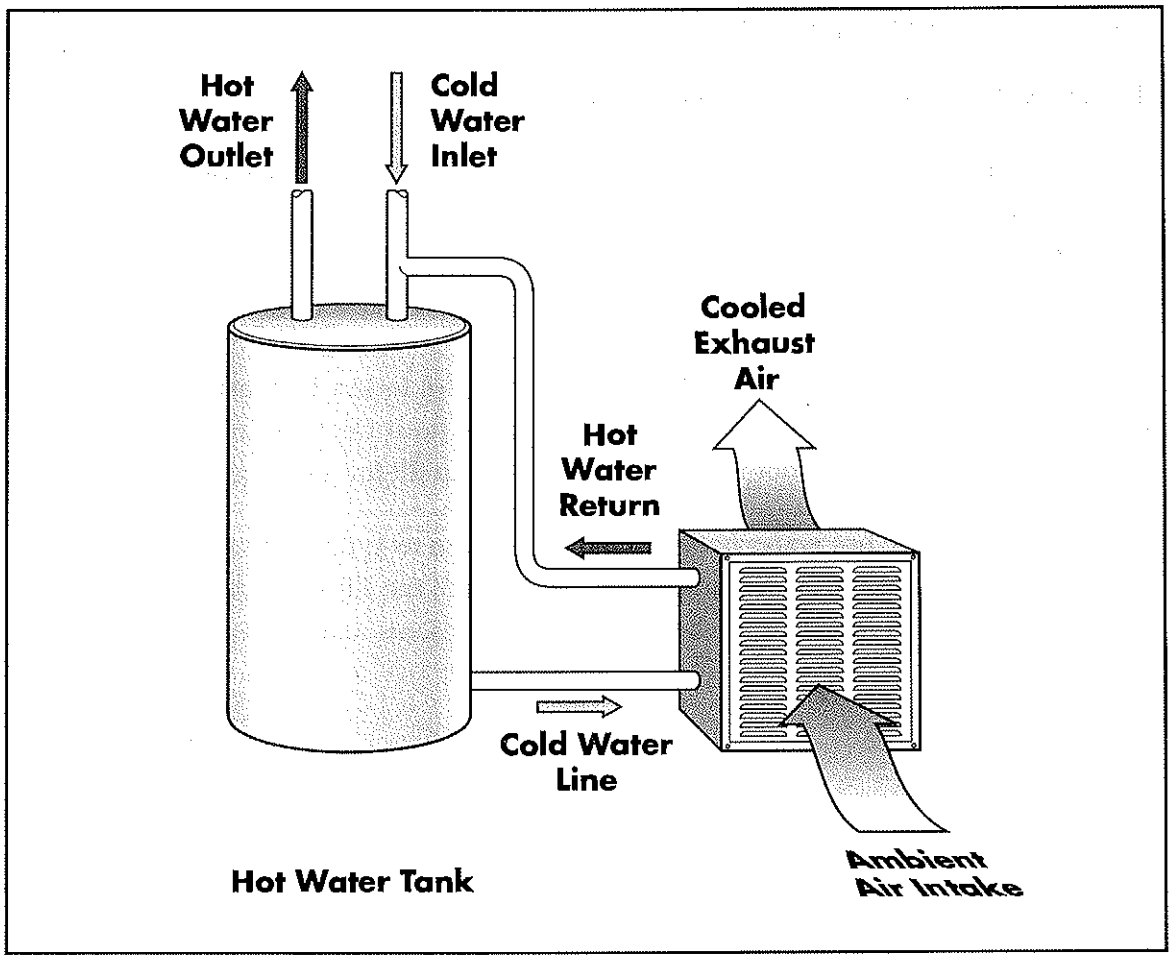
INTEGRATED SYSTEM



SP 1.4.02

In add-on systems, the heat pump apparatus stands alone. Heat is transferred from the condenser to the water tank via a heat exchanger and a small pump, using the tank's water as a heat exchange medium.

ADD-ON SYSTEM



SP 1.4.03

Combination systems are also available that combine heating, cooling, and water heating. These combination systems pull their heat indoors from the outdoor air in the winter and from the indoor air in the summer.

Stand-alone heat pump water heaters (HPWH) are different from heating and cooling heat pump systems that have integrated water-heating capability. To move the heat, heat pumps work like a refrigerator in reverse. Unlike a refrigerator that pulls heat from inside a box and unloads it into the surrounding room, a stand-alone heat pump water heater pulls heat from the surrounding air and unloads it into a tank to heat water.

Measuring Efficiency

There is no simple method to measure the hot water output and the cold air input of an HPWH. The energy efficiency depends on incoming water temperature, intake air temperature, the heat pump's heat transfer characteristics, and various conductive and convective losses through out the system.

The HPWH uses two indexes of energy efficiency:

1. Coefficient of performance (COP) which is a measure of the instantaneous energy output of a system in comparison to it instantaneous energy input, but does not reflect standby losses; and
2. Energy factor (EF) which reflects standby losses.

The energy factor (EF) for an HPWH is the more useful index. It measures the total amount of water pulled from the system every other hour for 12 hours. When measured by its EF, a typical electric hot water heater is 0.90; the EF for a typical HPWH is 2.2.

For a typical electric hot water heater, the COP is close to 1; the COP for a typical HPWH is 3 or 4. Even if the cooling benefit is ignored, the EF, when temperatures of incoming water and input air are held constant, represents an efficiency improvement of 200 percent.

Choosing a Location

Heat pump water heaters will not operate efficiently in a cold space. In addition, they must be located in a space that allows adequate air flow so they should not be placed in cramped areas. Because they produce dry, cool air and tend to cool the spaces they are in, HPWHs should be place in damp basements or spaces that need cooling. Like many refrigerators, the compressor motor on a HPWH system produces some noise. If noise is an issue, the HPWH should be located where the homeowner is not bothered by the noise.

Benefits of HPWHs

Before buying a heat pump water heating system, as with any water heater, the buyer should also to consider the size and first hour rating, fuel type and availability, energy efficiency, and overall costs.

Heat pump water heater systems typically have higher initial costs than conventional storage water heaters. However, they have lower operating costs, which can offset their higher purchase and installation prices.

Solar Water Heaters

Next we will discuss a type of residential water heater which uses solar energy. Solar relates to the sun, therefore, **SOLAR WATER HEATERS**, sometimes called *solar domestic hot water systems*, use the sun's rays to heat the water supply. Solar water heaters have been commercially available since the 1800s. But, unlike the early models, most modern solar water heaters mount flush with a home's roof and resemble skylights.

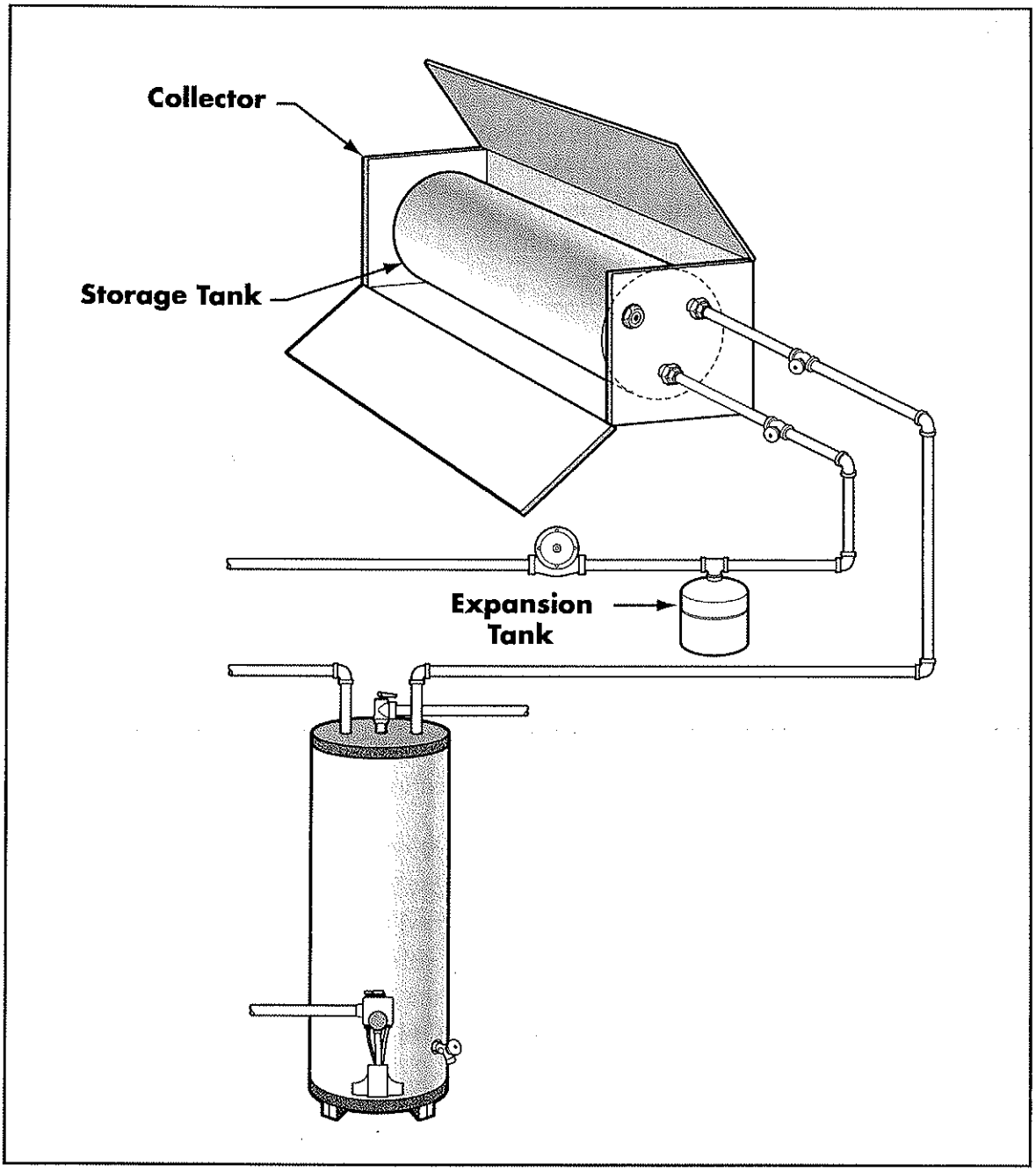
Solar water heaters are an environmentally sound way to reduce energy bills. Solar energy can meet part or all of a home's domestic hot water needs. Geographic location, system design, **COLLECTOR** orientation, and collector size will determine how much energy can be provided for domestic hot water heating.

Solar water heaters come in a variety of configurations. Each differs in design, cost, performance, and level of complexity. Most systems have back-up water heating such as electricity or gas. Solar water heaters are designed to serve as preheaters for conventional storage or demand water heaters. A solar water heating system usually consists of a hot water storage tank, a solar collector that absorbs solar energy, a back-up energy source, and (for **FORCED CIRCULATION** systems) a pump and controls.

While the initial cost of a solar water heater is high, it can save a lot of money over the long term. Solar water heaters are less common than they were during the 1970s and early 1980s when they were supported by tax credits, but the units available today tend to be considerably less expensive and more reliable. At today's prices, solar water heaters compete very well with electric and propane water heaters on a life-cycle cost basis, though they are still usually more expensive than natural gas.

Below is an illustration of a simple solar water heating system.

SIMPLE SOLAR WATER HEATER



SP 1.4.04

Solar Water System Design

Solar water system designs can be classified as active or passive. Active systems have circulating pumps and controls. A passive system does not. The type and size of the system, the amount of sun available, the insulation, and the tilt angle and orientation of the controls determine the amount of hot water a solar water heater can produce.

Active Systems

Active systems use electric pumps, valves, and controllers to circulate water or other heat-transfer fluids through the collectors. A simple collector could be made of glass-topped insulated box with a flat solar **ABSORBER PLATE** made of sheet metal attached to copper pipes and painted black. A **DIFFERENTIAL CONTROL** circulates the heated fluid between the collector and the storage tank.

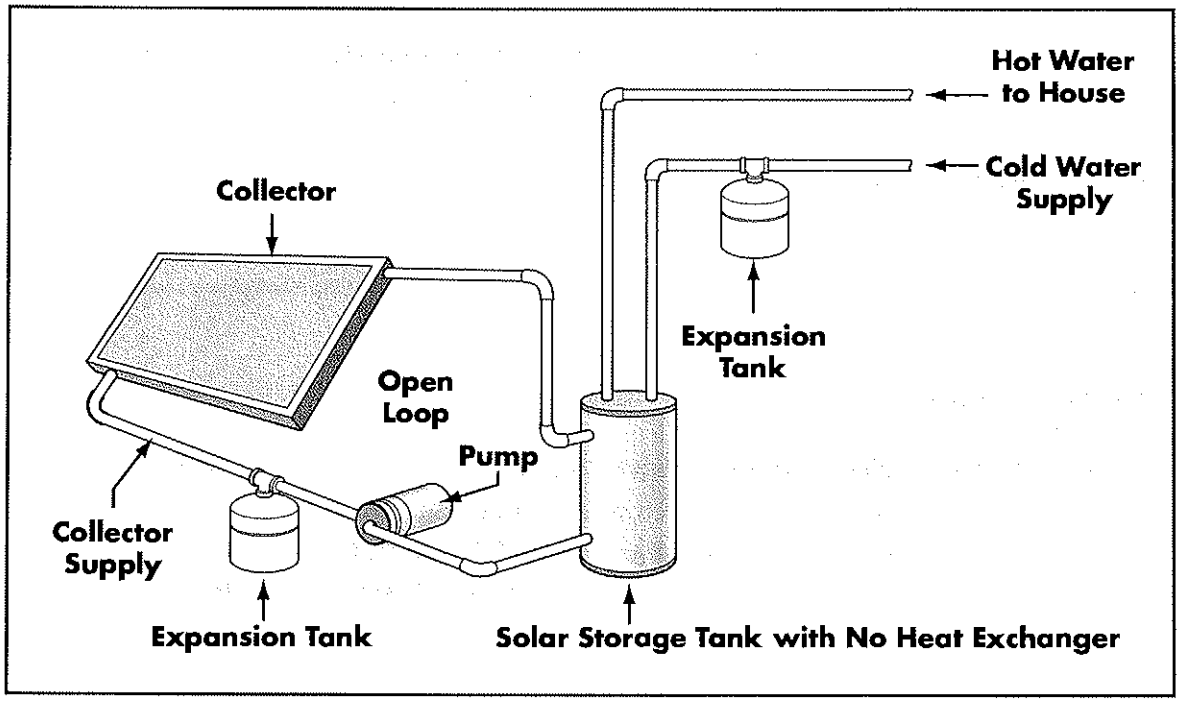
There are two types of active solar water heating systems: direct circulation systems and indirect circulation systems.

- **DIRECT CIRCULATION SYSTEMS**—Pumps circulate household water through the collectors and into the home. They work well in climates where it rarely freezes.
- **INDIRECT CIRCULATION SYSTEMS**—Pumps circulate a non-freezing, heat-trans-fer fluid through the collectors and a heat exchanger. This heats the water that then flows into the home. They are popular in climates prone to freezing temperatures.

The system shown on page 106 is using the direct method. With the **DIRECT METHOD**, water in the storage tank is heated at the collector directly by the sun's rays.

All direct heating methods use open-loop systems. It is called an **OPEN-LOOP SYSTEM** because water heated at the collector is the same hot water which flows out of the fixture faucet. These systems should be installed in mild climates. If there is a chance of an occasional freeze, freeze protection must be considered.

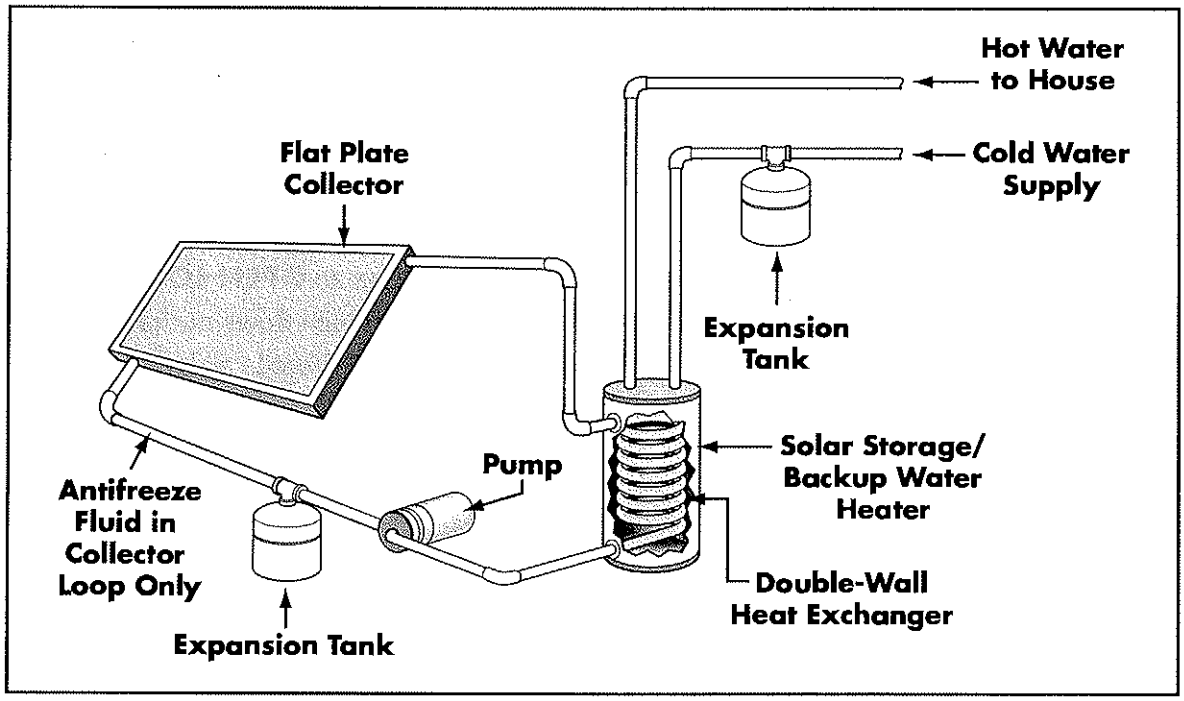
OPEN-LOOP SYSTEM



SP 1.4.05

The solar system shown below uses an indirect heating method. All indirect water heaters have the heat source at a different location from the heating process.

CLOSED-LOOP SYSTEM



SP 1.4.06

All indirect heating methods have closed-loop systems. It's called a **CLOSED-LOOP SYSTEM** because the flow between the storage tank and the collector does not open into the household water supply system. These systems pump heat-transfer fluids (such as a glycol-water antifreeze mixture) through collectors.

Since water from the household water supply does not circulate up to the collector, a heat exchanger is used to heat the water in the tank.

The **HEAT EXCHANGER** transfers heat from fluid heated at the collector to water in the storage tank. Generally, the heat exchanger will be located inside the storage tank, as shown in the system in this illustration.

Passive Systems

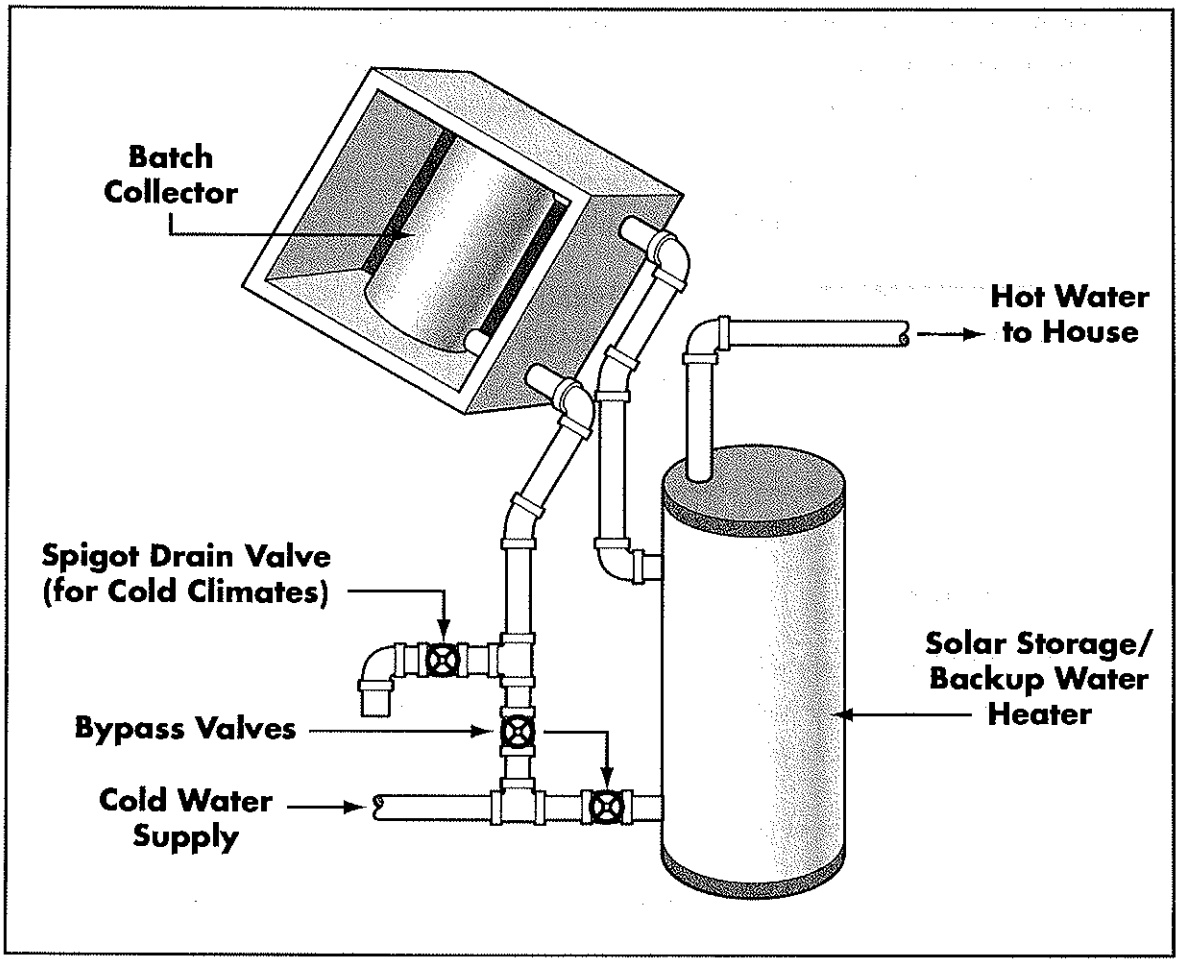
PASSIVE SYSTEMS move water or a heat-transfer fluid though the system without pumps and controls. They have no electrical components to break so they are generally more reliable, durable, less expensive, and easier to maintain than active systems.

There are two basic types of passive systems:

- Integral collector-storage passive systems—These simple passive systems have one or more storage tanks placed in an insulated box that has a glazed side facing the sun. A batch heater is mounted on the ground or on the roof to absorb sun well but inhibit radiative loss. They work best in areas where temperatures rarely fall below freezing. They also work well in households with significant daytime and evening hot-water needs.

- Thermosyphon systems—These systems rely on warm water rising, or natural convection, to circulate water through the collectors and to the tank. Water flows through the system when warm water rises as cooler water sinks. The collector must be installed below the storage tank so that warm water will rise into the tank. These systems are reliable, but contractors must pay careful attention to the roof design because of the heavy storage tank. They are usually more expensive than integral collector-storage passive systems.

BATCH SOLAR WATER HEATER



SP 1.4.07A

Types of Solar Collectors

Solar water heaters use a solar energy collector, or **COVER PLATE**, usually mounted on the roof of the house, to heat a fluid such as water, which is pumped through a **PIPING SYSTEM**. The hot fluid is stored in a tank, usually located in a basement or utility room, and the cool household water is piped through a heat exchanger in the tank to heat it. The hot household water can then be stored in another tank, or it may be piped into a standard water heater, which can serve as both a storage tank and a backup water heating system.

Three types of solar collectors are used for residential applications:

- Flat-plate collector—A large, flat box with a glass cover, insulation, and dark-colored metal plates inside that absorb and transfer solar energy to a heat transfer fluid. Flat-plate collectors are best suited for moderate temperature applications where the demand temperature is 30-70°C and/or for applications that require heat during the winter months.

  Glazed, liquid-based, flat-plate solar collectors are the most common type of solar collector for use in heating domestic and commercial hot water, buildings, and indoor swimming pools.

- Integral collector-storage systems—A simple solar collector consists of one or more storage tanks placed inside an insulated box that has a glazed side facing the sun. Because the storage tank and the solar absorber act as a single unit, there is no need for other components. A batch collector is mounted on the ground or on the roof (in which case, the roof structure must be strong enough to support it).

  Some batch heaters use "selective" surfaces on the tank(s). These surfaces are good absorbers of solar infrared radiation but inhibit radiative loss. On an area basis, batch collector systems are less costly than glazed flat-plate collectors but also deliver less energy per year. Also known as ICS, bread box system, or batch systems.

- Evacuated-tube solar collectors—A solar collector in which the absorber strip is located in an evacuated and pressure proof glass tube. The heat transfer fluid flows through the absorber directly in a U-tube or in countercurrent in a tube-in-tube system. Several single tubes, serially interconnected, or tubes connected to each other via a manifold, make up the solar collector.

A heat pipe collector incorporates a special fluid which begins to vaporize even at low temperatures. The steam rises in the individual heat pipes and warms up the carrier fluid in the main pipe by means of a heat exchanger. The condensed liquid then flows back into the base of the heat pipe. The pipes must be tilted at a specific angle above horizontal so that the process of vaporizing and condensing functions. **RETURN PIPING** carries heated fluid from the solar collector back to the storage tank.

Benefits of Solar Water Heaters

Although solar water heating systems almost always require a backup system for cloudy days and times of increased demand, there are many benefits to owning a solar water heater. The most obvious benefits are long-term protection from future fuel shortages and price increases, as well as the environmental benefits of using solar power.

When a solar heater replaces an electric water heater, the electricity displaced over 20 years represents more than 50 tons of avoided carbon dioxide emissions alone. Carbon dioxide traps heat in the upper atmosphere, thus contributing to the **GREENHOUSE EFFECT**.

Tankless and Indirect Coil Water Heaters

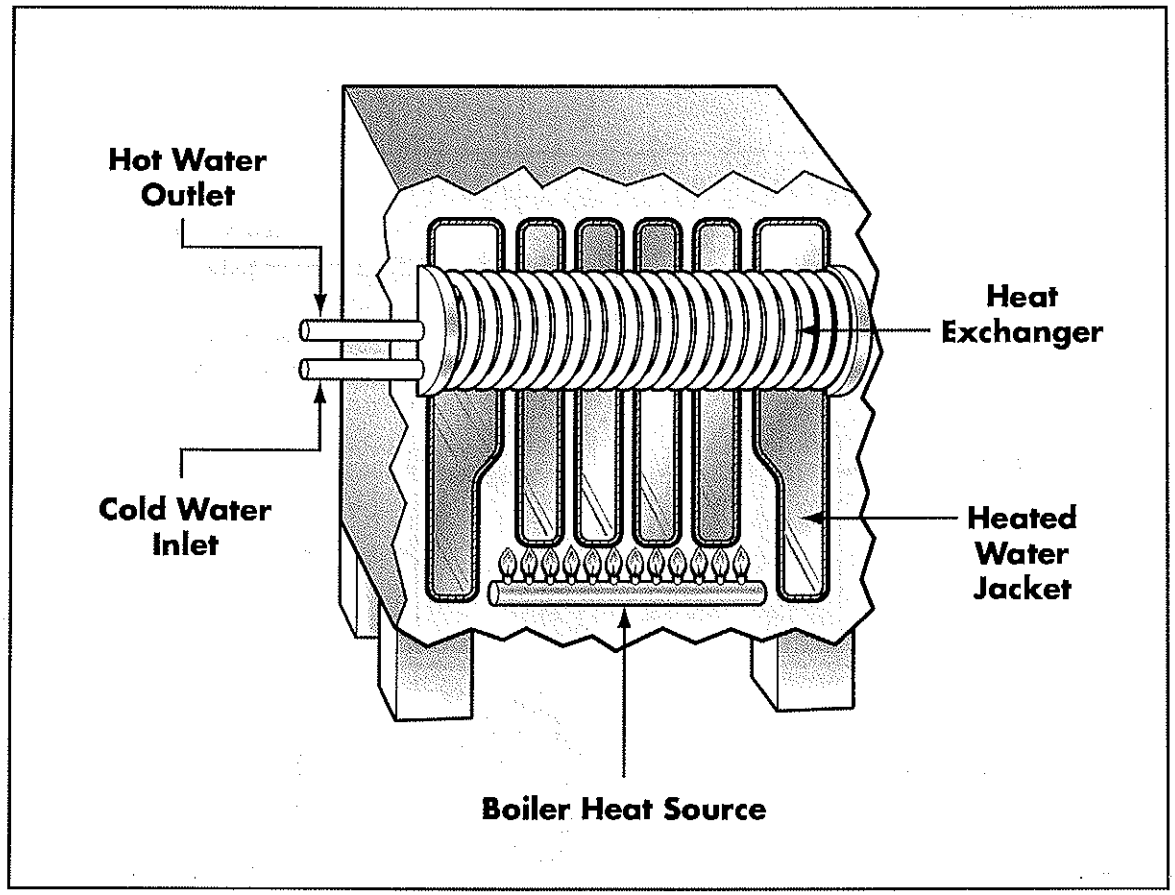
Some newer houses have integrated or combination water and space heating systems. The systems are designed to prove a single heat source. Indirect and tankless coil water heaters use the home's main heating system (either a boiler or furnace) as the heat source.

Tankless Coil Water Heater System

In the **TANKLESS COIL SYSTEM**, water is heated directly inside the boiler in a hydronic (i.e., hot water) heating system. Boilers, seen more often in colder climates, are heating systems that use water or steam to distribute heat throughout the home. Tankless coil water heaters use the heat from a home's boiler to heat water just when it is needed. The water flows through a heat exchanger in the boiler whenever a hot water faucet is turned on.

One advantage of tankless coil systems over storage units is they have no stand-by heat losses since water is heated only when needed. A disadvantage of these systems is that the home's heating system must be operating for them to work. Like a demand water heater, the system relies on the furnace or boiler to heat the water directly so it works most efficiently during the winter when the heating system is regularly used. Therefore, for many homeowners, especially those in warmer climates, a tankless coil system may not be an energy-efficient choice.

TANKLESS COIL WATER HEATER



SP 1.4.07B

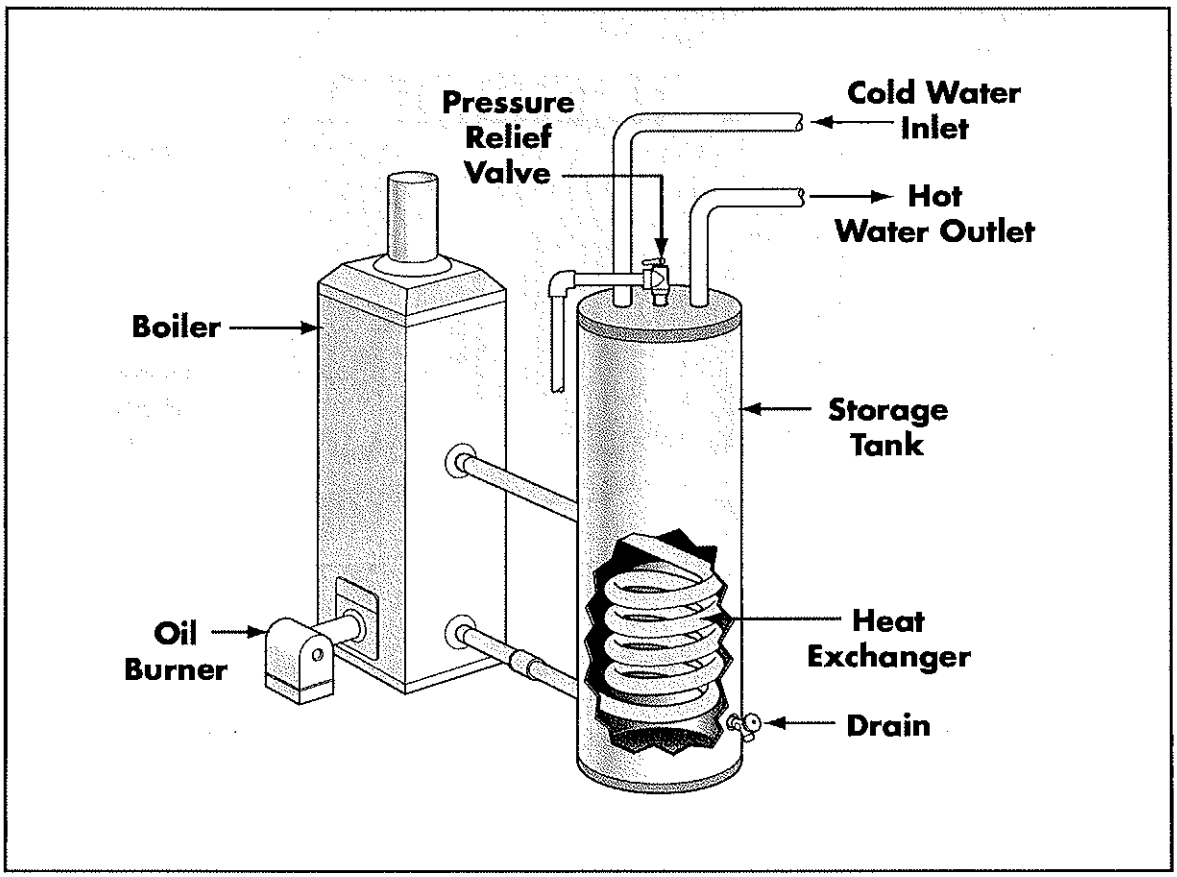
Indirect Water Heater System

Even though they require a storage tank, indirect water heaters offer a more efficient choice for most homes. In an **INDIRECT WATER HEATER SYSTEM**, water is circulated through a heat exchanger in the boiler. This heated water then flows to an insulated storage tank. Since hot water is stored in an insulated storage tank, the boiler does not have to turn on and off as frequently, improving its fuel economy.

Indirect water heaters, when used in combination with new, high-efficiency boilers, are an inexpensive way to provide hot water. The energy stored by the water tank allows the furnace to turn off and on less often, which saves energy.

Indirect water heater systems can be purchased in an integrated form, incorporating the boiler or furnace and water heater with controls, or as separate components. Gas, oil, and propane-fired systems are available.

INDIRECT WATER HEATER



SP 1.4.08 Indirect-Fired
SP 1.1.03 Direct-Fired

Benefits of Indirect and Tankless Coil Water Heaters

Combining the space heating and water heating functions in a single appliance can substantially reduce the energy used for water and space heating and reduce initial construction costs by eliminating the need for a separate furnace for space heating. Combination water and space heating systems use a high efficiency water heater or central boiler to supply heating energy to the space heating system while still meeting the needs for domestic hot water.

The space-heating component can be accomplished with either a forced air system or a radiant heat system. A forced air system can either use hot water piped to individual fan coil units in each unit or the hot water can be sent to a central heat exchanger and fan coil unit that then sends hot air to the individual units. When installing a combination system in conjunction with a cooling system, the same distribution system must be used to achieve any initial cost savings. Cooling systems can use either piped water or forced air but forced air is much more common and usually less expensive.

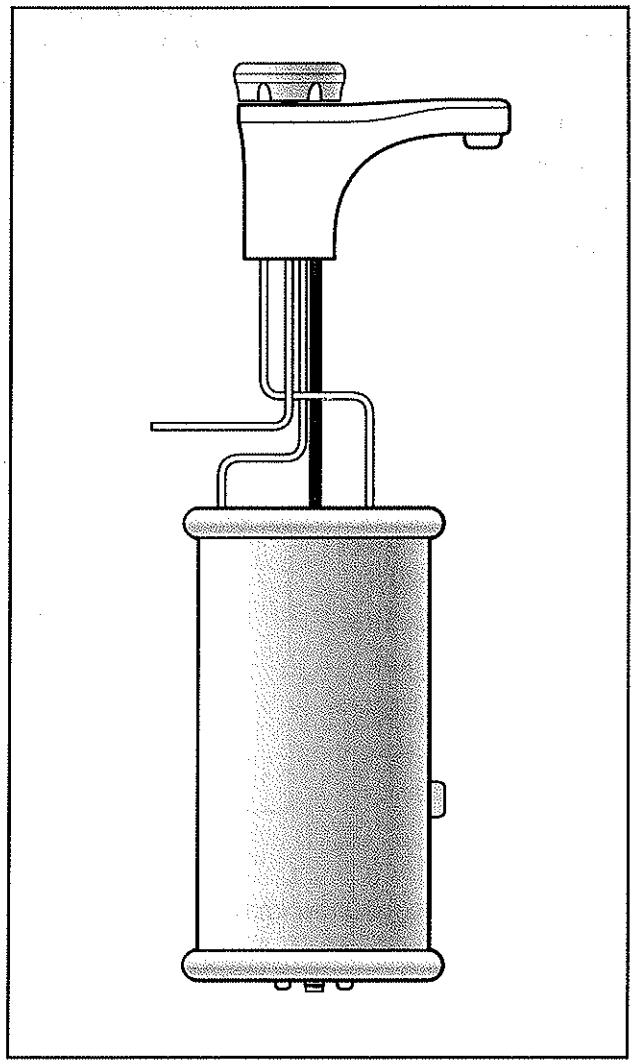
Point-of-Use Water Heater

There is one more type of water heater we will look at briefly. Earlier in this course we said that water heaters are available in a wide variety of tank sizes. The water heater shown below holds a half gallon of water.

It is one type of **TASK HEATER** which represents a way to get small amounts of very hot water for "special" tasks such as instant coffee or soup.

Today, this very small type of water heater is more commonly called a **POINT-OF-USE WATER HEATER**. Commonly they are sized to supply hot water to one specific application, such as a remote sink in an office building. This water heater is actually mounted through the sink ledge or countertop. The faucet is visible above the sink, while the tank is concealed below. Copper tubes connect the water supply line to the tank and faucet.

TASK WATER HEATER



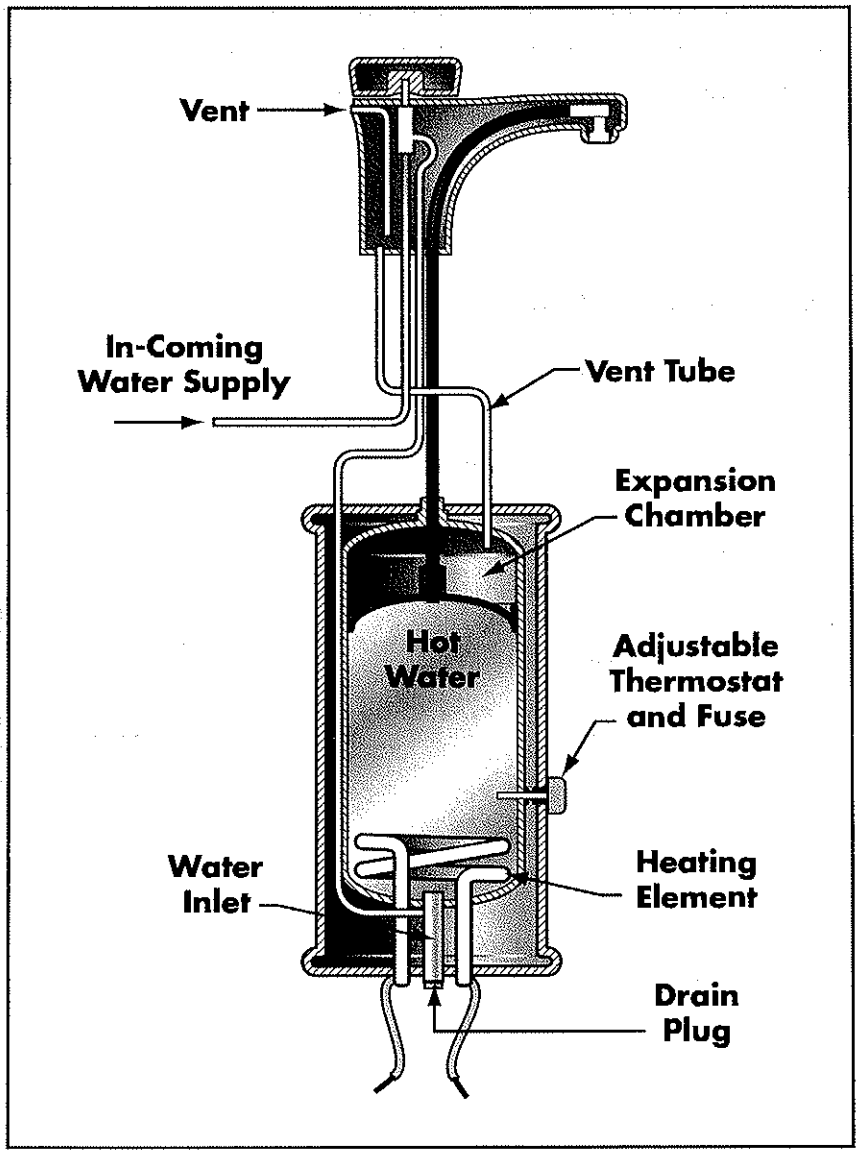
SP 1.4.09

Typically, point-of-use water heaters either (1) supply hot water to a remote location that is not served by a larger water heater; or (2) eliminate the wait time for hot water at a particular faucet. When the faucet is turned on, there is no wait for hot water. Hot water is instantly available which saves additional water from being wasted while waiting for hot water to arrive.

The illustration on the right shows an inside view of this special water heater. As you can see, many of the components are similar to those on the more common types of electric water heaters.

Water is heated by the heating element at the bottom of the tank. When the faucet is turned on, water from the supply line flows into the tank and forces the heated water upward and out of the faucet spout.

TASK WATER HEATER INTERIOR



SP 1.4.10

The vent and expansion chamber prevents excess pressure from building in the tank. The thermostat, usually set to provide almost boiling water, is adjustable. A thermal fuse cuts off the energy source if there is no water in the tank. Once this has happened, the fuse must be replaced in order to operate the water heater again.

REVIEW QUIZ – OTHER WATER HEATERS

Answers appear on page 122

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. Heat pump water heaters operate by
   a. moving water from one place to another.
   b. transferring steam to the hot water storage tank.
   c. moving heat from one place to another.
   d. transferring a cold substance to a hot substance.

2. How much can homeowners who heat with electricity and use a heat pump save on their electricity costs?
   a. Nothing
   b. 10% to 20%
   c. 20% to 30%
   d. 30% to 65%

3. A device for recovering superheat from the compressor discharge gas of a heat pump or central air conditioner for use in heating or preheating water is called a/an
   a. heat exchanger.
   b. air-source heat pump.
   c. desuperheater.
   d. geothermal heat pump.

4. A heat pump water heater's efficiency is measured by all of the following factors EXCEPT
   a. Operating cost
   b. Incoming water temperature
   c. Intake air temperature
   d. Heat transfer characteristics

REVIEW QUIZ – OTHER WATER HEATERS

Answers appear on page 122

5. What liquid is used in a residential absorption heat pump?
   a. Ammonia
   b. Water
   c. Ammonium-hydroxide
   d. Ammonium-chloride

6. When the heat exchanger is located inside a storage tank, where does the heat transfer agent (water or steam) circulate?
   a. Through the nozzle
   b. Around the pump
   c. Around the tubes
   d. Through a pipe

7. Active solar water systems use of all of the following devices to circulate water or heat-transfer fluids EXCEPT
   a. Collectors
   b. Pumps
   c. Valves
   d. Controllers

8. In a solar water heater, the heat exchanger transfers fluid heated at the collector to water in the
   a. storage tank.
   b. absorber plate.
   c. piping system.
   d. outlet.

9. What is the name of the system in which water heated at the collector is the same hot water which flows out of the fixture faucet?
   a. Closed-loop
   b. Open-loop
   c. Task heater
   d. On-demand

REVIEW QUIZ – OTHER WATER HEATERS

Answers appear on page 122

10. What is a device that is generally mounted on a building roof and used to absorb solar energy?
    a. Cover plate
    b. Tubing
    c. Collector
    d. Storage tank

11. A small water heater which may be mounted through the sink ledge or countertop is known as a
    a. ledge heater.
    b. solar heater.
    c. task heater.
    d. sink heater.

12. What provides the energy source for a solar water heater?
    a. Pilot burner
    b. Gas flame
    c. Electricity
    d. Sun

13. In which type of solar water heater system does the flow between the storage tank and the collector not open into the household water supply system?
    a. Open-loop system
    b. Closed-loop system
    c. Direct circulation system
    d. Indirect circulation system

14. What is the most common type of solar collector in moderate climates?
    a. Cover plate collector
    b. Absorber plate collector
    c. Flat-plate collector
    d. Storage plate collector

REVIEW QUIZ – OTHER WATER HEATERS

Answers appear on page 122

15. How is the water heated in the tank in a closed loop system?
    a. Heat exchanger
    b. Pump
    c. Collector
    d. Storage plate

16. What component circulates the heated fluid between the collector and the storage tank?
    a. Heat exchanger
    b. Pump
    c. Collector
    d. Differential control

17. In which solar collector does the heat transfer fluid flow through the absorber directly into a U-tube?
    a. Integral collector storage system
    b. Flat-plate collector
    c. Evacuated–tube solar collector
    d. Bread box system

18. What is another name for the task type water heater?
    a. Solar water heater
    b. Sink water heater
    c. Boiler heater
    d. Point-of-use water heater

19. What is the process called which causes dense fluid to rise and circulate through a solar heating system?
    a. Heat exchange
    b. Indirect circulation
    c. Natural convection
    d. Forced circulation

REVIEW QUIZ – OTHER WATER HEATERS

Answers appear on page 122

20. How does a stand-alone heat pump water heater move the heat through the system?
    a. It pulls heat from inside a box and unloads it into the surrounding room.
    b. It uses an ammonia-water absorption cycle to provide heating and cooling.
    c. It pulls heat from the system and circulates it into the tank to heat water.
    d. It pulls heat from the surrounding air and unloads it into a tank to heat water.

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. Where can you find the most up-to-date information about solar water heaters?

_____

_____

_____

B. What method does your company use to help customers select the appropriate water heater?

_____

_____

_____

ANSWERS TO REVIEW QUIZ

CHAPTER 4

OTHER WATER HEATERS

Answers to REVIEW OF OTHER WATER HEATERS (pages 115 – 119)

1. c. moving heat from one place to another.
2. d. 30% to 65%
3. c. desuperheater.
4. a. Operating cost
5. c. Ammonium-hydroxide
6. d. Through a pipe
7. a. Collectors
8. a. storage tank.
9. b. Open-loop
10. c. Collector
11. c. task heater.
12. d. Sun
13. b. Closed-loop system
14. c. Flat-plate collector
15. a. Heat exchanger
16. b. Pump
17. c. Evacuated-tube solar collector
18. d. Point-of-use heater water
19. c. Natural convection
20. d. It pulls heat from the surrounding air and unloads it into a tank to heat water.

Applying what you have learned:

A. Depends on the company, but typically includes product catalogs and/or the Web where information can be quickly downloaded.

B. Depends on the company.

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 Certificate of Completion, please contact ASA at info@asa.net. You will be contacted about how to register for the exam.

GLOSSARY OF TERMS

Absorber plate: A component in a solar collector panel that absorbs the sun's rays and produces heat.

Air intake: The opening adjacent to the gas orifice. Used to take in air needed to mix with gas in order for combustion to take place.

American National Standards Institute (ANSI): Organization that coordinates the development and use of voluntary consensus standards in the United States and represents the needs and views of U.S. stakeholders in standardization forums around the globe.

Anode rod: A rod made of magnesium used in water heater tanks to protect against rust corrosion by allowing itself to be attacked by the corrosion first. Also called sacrificial anode.

ASHRAE: American Society Heating, Refrigeration, Air Conditioning Engineers. Develops service water heating guides.

Automatic storage heater: The common name for a direct water heater.

Baffle: A device, usually placed inside the flue, to cause turbulence and retard flow, allowing more time for the water in the tank to absorb the heat.

Boiler: A heating device that heats water or makes steam; in water heaters it is used with a heat exchanger.

Boyle's law: In 1662 Robert Boyle made the first systematic study of the relationship between volume and pressure in gases. The law can be summed up in the statement: At constant temperature, the volume of a gas varies inversely with the pressure exerted on it. Boyle's law is commonly used to predict the result of introducing a standard, in volume and pressure only, to the initial state of a fixed quantity of gas.

British Thermal Unit: The basis for classifying water heaters as residential or commercial. It is the amount of heat required to raise the temperature of one pound of water by one degree Fahrenheit.

BTU: *SEE* British Thermal Unit.

Burner: The mechanism in a gas water heater that burns the fuel to heat water in the tank.

Closed-loop system: A system in a solar hot water heater where the flow between storage tank and the collector does not open into the household water supply.

Coil type: *SEE* Heat exchange water heater.

Coiled wire: Wire used in electric heating elements to resist the flow of current to produce heat. Also called resistance wire.

Cold water inlet: The place where cold water enters the water heater tank to be heated.

Collector: A component of a solar heating system generally mounted on a building roof and used to absorb solar energy.

Combustion: The burning of fuel.

Combustion chamber: The area where actual burning of the fuel takes place in a water heater.

Cover plate: A component of a solar collector that keeps the heat produced from the sun's rays inside the panels.

Demand-type water heater: A water heater without a storage tank where the water goes directly through the heat exchanger and then to the point of use. Also called instantaneous or tankless water heater.

Desuperheater: A device for recovering superheat from the compressor discharge gas of a heat pump or central air conditioner for use in heating or preheating water.

Differential control: A device with sensors used to control the pump that circulates the fluid between the solar collector and the storage tank.

Dip tube: A device that delivers cold water into the bottom area of the water heater tank so it doesn't mix with the hot water at the top of the tank.

Direct-fired water heater: A water heater in which the method of heating is located in the same basic structure where the actual heating takes place.

Direct method: The method in a solar heating system where water in the storage tank is heated at the solar collector directly by the sun.

Double throw thermostat: A device that sends or shuts off current to two heating elements, one at a time.

Draft diverter: A component that helps vent the combustion fumes to the outside by drawing heated room air in at the base of the hood. *Also called a hood.*

Drain cock: *SEE* Drain valve.

Drain valve: A valve located at the bottom of the water heater that is used to drain water from the water heating unit. *Also called drain cock.*

ECO: *SEE* Energy cut-off device.

Electric insulation: Material used to wrap around coiled wires to prevent electric current from passing through the metal sheath into the water.

Electrodes: Elements that produce sparks to ignite the oil and air mixture on a gun-type burner.

Electronic ignition system: This system is an alternative to a pilot light in a water heater. It may be an *intermittent ignition device* in which a spark lights the pilot on each call for heat or a *hot surface ignition device* in which a probe is heated electronically until it is red-hot on each call for heat.

Energy cut-off device: A heat sensitive device with its own thermostat that monitors the temperature of the water in the tank to prevent the water from getting too hot.

Energy source: The method or fuel source used to heat water.

Expansion Tank: Part of a hot water heating system that is filled with air. Its purpose is to provide a cushion for the expansion of the hot water in the heating system. (Many people confuse expansion tanks with hot water storage tanks.)

Fire pot: Another name for the combustion chamber in an oil-fired water heater.

Flame detector: A sensing device on the primary control to detect whether a burner flame is present.

Flammable vapor ignition resistant (FVIR): Describes a water heater that is designed so that it cannot ignite flammable vapors caused by spilled gasoline near the water heater.

Flue: A passageway in water heater tanks that allows fumes to rise up from the combustion chamber to the vent or chimney.

FVIR: *SEE* Flammable vapor ignition resistant.

Gaseous state: Water heated above 212° Fahrenheit at sea level; also called steam.

Greenhouse effect: Warming of the Earth's surface as a result of atmospheric pollution by gases. It is now feared that the warming effects are being undesirably increased, causing climate changes and melting polar icecaps.

Heat exchanger: A device used to transfer heat from a hot substance to a cold substance.

Heat exchange water heater: A water heater in which water is heated by passing through a heat exchanger immersed in static heated water. *Also called coil type.*

Heat input rate: The amount of fuel used to heat water within a certain amount of time. Determines the recovery rate of the water in the tank.

Heat transfer: The movement of heat from one body to another.

High limit control: The energy cut-off device on all types of storage water heaters.

Hot water outlet: The exit where the heated water leaves the tank to flow to the fixtures.

Immersion elements: Electric devices used to heat water on contact in electric water heaters.

Indirect heating system: A heating system in which the heat source is located apart from the heating process.

Indirect water heater: A water heater where the heat source is located apart from the heating process.

Instantaneous water heater: *SEE* On-demand water heater.

Insulation: Material used in a solar collector panel behind the absorber plate and tubing to prevent collected heat from escaping.

Interlocked: *SEE* Non-simultaneous.

Manometer: An instrument used to measure gas pressure.

NFPA 31: Installation code for oil fired appliances.

NFPA 59: Installation code for gas fired appliances.

National Appliance Energy Conservation Act (NAECA): Standards that established minimum energy efficiency requirements for 12 types of residential appliances sold in the United States.

National Energy Policy and Conservation Act (NEPCA): Directed the Department of Energy (DOE) to develop mandatory efficiency standards for 13 products.

Nichrome: An alloy of nickel, chromium and iron used to make wire filament; often used for wire coil because if offers a high resistance to current flow.

Non-simultaneous: Refers to element operation in electric water heaters where only one element can operate at one time. Also called *interlocked.*

Nozzle: An orifice-like device that delivers the oil mist so combustion can take place in an oil-fired water heater.

Oil-fired water heater: A water heater that uses oil as its energy source.

Open-loop system: A direct heating method used in solar water heater systems; water heated at the collector is the same hot water which flows out of the fixture faucet.

Orifice: An opening where gas enters in a gas burner assembly.

Peak period: The period of time when the greatest amount of hot water is needed by the user of a water heater.

Pilot burner: Device used to ignite the main burner when the thermostat controls calls for heat in a burner assembly.

Piping system: A system used in a solar water heater system that circulates the water in a loop between the storage tank and the collector.

Point-of-use water heater: *SEE* Task water heater.

Ports: A series of slots or holes in a burner assembly where the mixture of gas and air exits to be ignited.

Power Burner: A common type of burner used in both oil-fired and gas fired water heaters, consisting of a motor, pump, fan, and transformer.

Primary control: A safety device on an oil water heater that controls the operation of the burner by turning the motor on and off as needed.

Pump: A device used in a solar water heater system to force fluid in the supply piping up to the collector.

Recovery efficiency: Heat absorbed by the water divided by the heat input to the final temperature (includes heat losses from the water heater jacket or tank).

Recovery rate: The number of gallons per hour (gph) a water heater can raise the temperature of cool water.

Resistance wire: *SEE* Coiled wire.

Return piping: Piping that carries heated fluid from the solar collector back to the storage tank.

Rise: A term used by water heater manufacturers to state recovery rate on water heaters.

Sacrificial anode: *SEE* Anode rod.

Safety devices: Devices used to protect against excess heat or pressure in the water tank which can be found on burners in water heaters.

Sheath: The outer casing of the heating element in an electric water heater.

Simultaneous: Refers to element operation of two single throw thermostats that are able to operate at the same time.

Single throw thermostat: Type of thermostat that controls the current going to one heating element, to which it is wired.

Solar: Refers to gathering radiant heat from sunlight and producing heat.

Storage tank: The tank where water is heated and/or stored until needed.

T&P valve: *SEE* Temperature and pressure relief valve.

Tank lining: The lining in a storage tank, usually made of glass, that provides a protective barrier to the steel structure of the tank to reduce corrosion.

Task heater: A small water heater generally mounted through the sink ledge or countertop. Also called point of use water heater.

Temperature controls: Devices that control the water temperature automatically.

Temperature and pressure relief valve: A valve that automatically opens under excess temperature or pressure. *Also called T&P valve.*

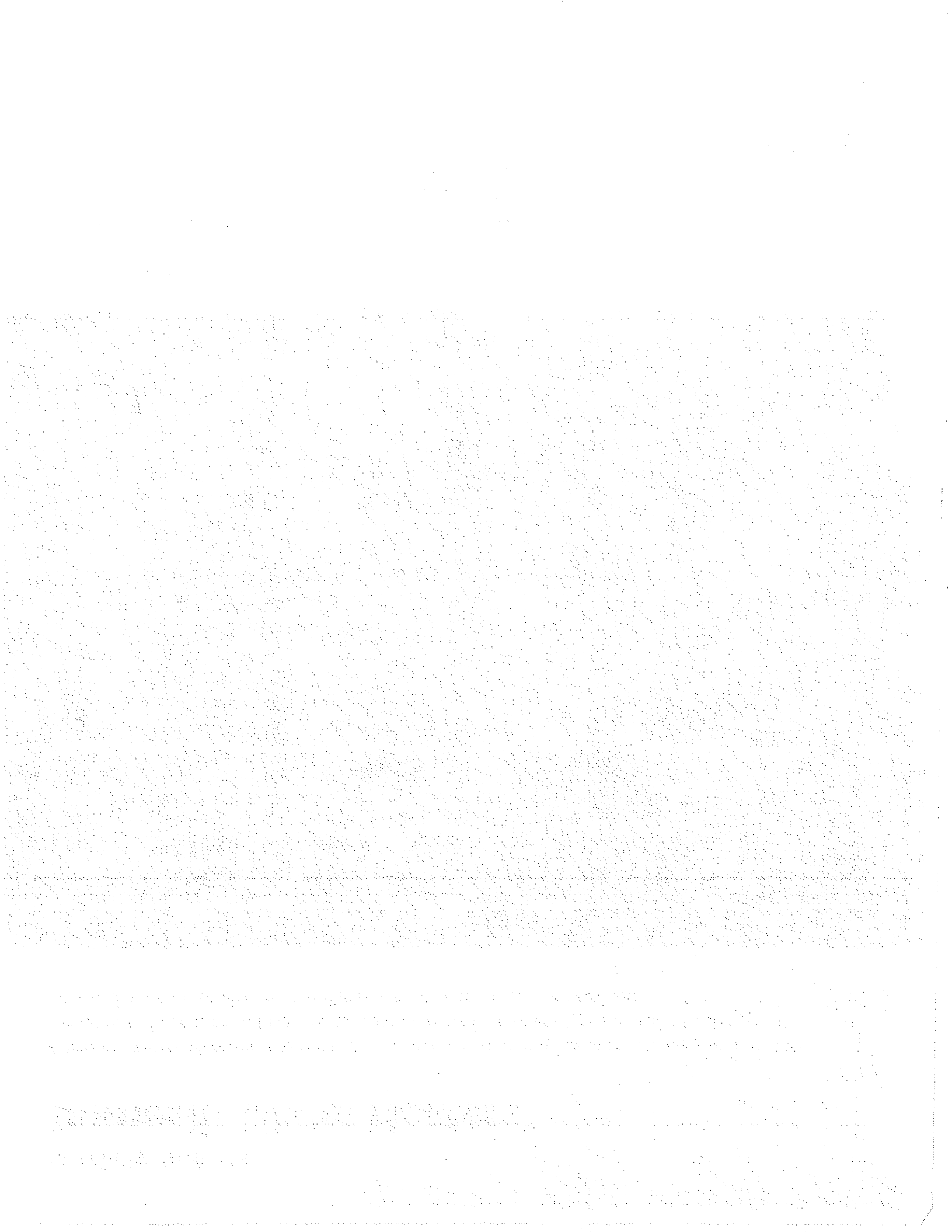
Thermal Efficiency: Heat in water flowing from the water heater outlet divided by the energy input to the heating unit over a specific period of steady-state condition (includes the losses from the water heater jacket and or tank).

Thermocouple: A sensing device used to assure the pilot flame is burning in a gas burner and shuts off the gas if the pilot flame goes out.

Thermostat: A device that regulates the water temperature in the tank by controlling the main gas flame.

Thermostatic control: Device that turns the energy source on and off as necessary to regulate the water temperature.

Water heater: An appliance for supplying hot water for domestic purposes or for commercial purposes other than for space heating. Its maximum outlet water temperature is 210° F.



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