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RVIA STANDARDS AND EDUCATION DEPARTMENT

RV Water Heaters

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RV Water Heaters - 3rd edition

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The objectives covered are listed at the beginning of each chapter.

The following symbols are used in this textbook to help you find information quickly and easily.

 Valuable Information

 Chapter Review

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1

Introduction To Water Heaters

- Identify different water heater types (engine-assist, electric, propane, instantaneous).
- Obtain model specifications.
- Identify special tools and their use.
- Identify related terminology.
- Identify components and their function.
- Diagnose common operational problems and determine possible causes.
- Determine AC and DC electrical requirements and connect.
- Determine propane requirements and connect.
- Verify proper operation.

1-1 Water Heater Sizes and Energy Sources

Recreational vehicles have included the water heater as a standard component for many years. Just as houses have several sizes, RV water heaters come in several sizes and with various options. Water heaters traditionally have used propane as a source of fuel for many years. Propane water heaters will utilize a flame and heat the water as the flame passes through a flue tube inside the tank. There are two different types of propane water heaters, one that uses a standing pilot flame for a source of ignition for the burner and another type that uses a spark to ignite the main burner, eliminating the pilot flame. Examples of direct spark ignition models are shown in Figure 1-1 and Figure 1-2. Some water heaters use 120 VAC to heat the water with an optional heating element inside the water tank. Many water heaters have both sources of heat available; propane and 120 VAC. Some motorized RVs have an additional water heating source referred to as motor-aid. Another type of water heater is the "instantaneous" type (see Chapter 5) which will provide hot water on demand without the use of a storage tank. It heats the water as it passes through a coil with heat being applied over it.

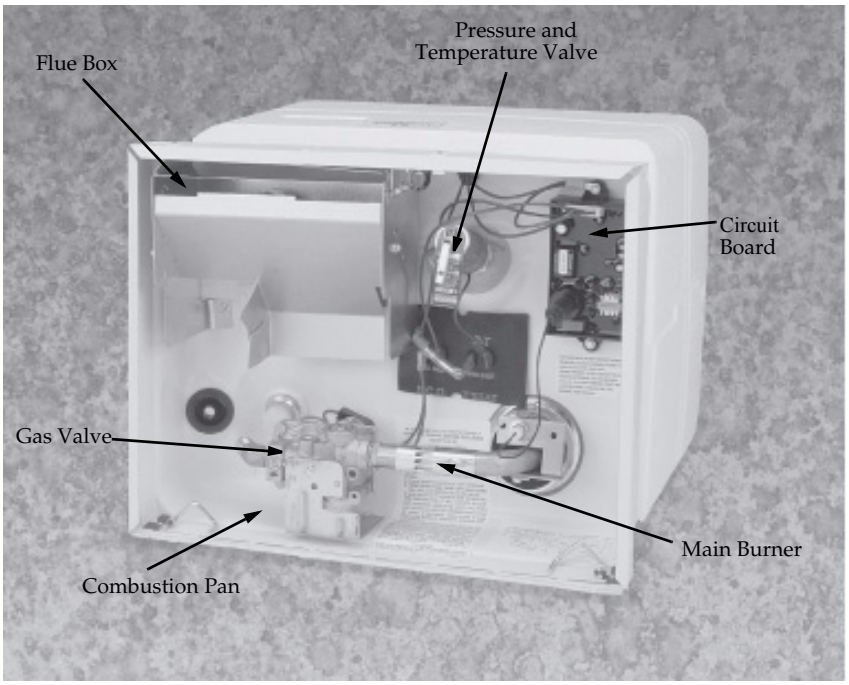


Figure 1-1 *Atwood Direct Spark Ignition Model Water Heater*

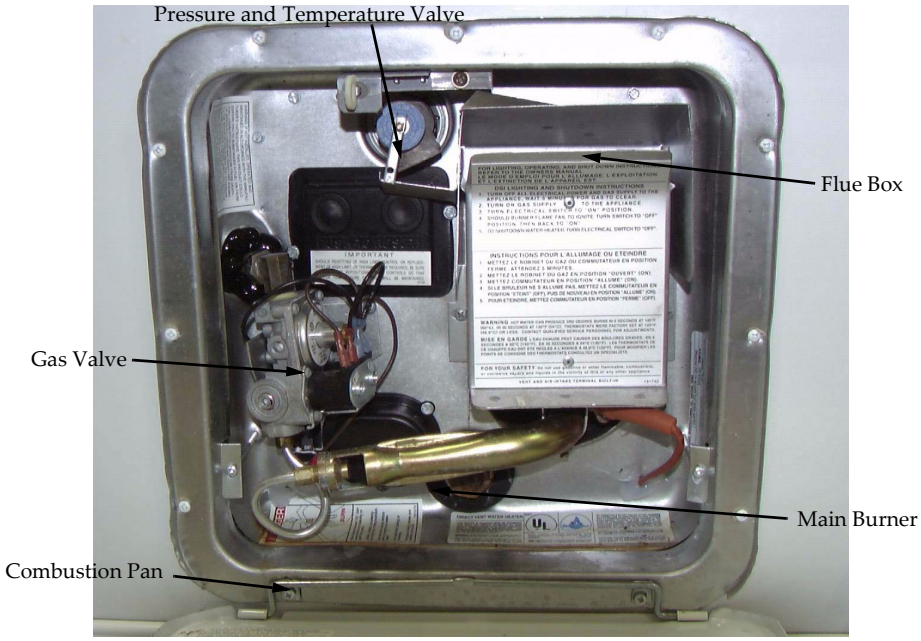


Figure 1-2 *Suburban Direct Spark Ignition Model Water Heater*

The majority of RV's use either a six or ten US gallon water heater. The six or ten-gallon designation refers to the capacity of the hot water storage tank. The most common is the six-gallon while the ten-gallon is usually seen on high-line coaches with more accessories such as clothes washers, dishwashers, etc. Three-gallon and twelve-gallon water heaters are also available. The three-gallon variation is only available as a pilot model. Six-, ten-, and twelve-gallon water heaters are available from most manufacturers in different configurations. Most manufacturers offer the same options.

The different heat sources offer the RV consumer a variety of options to operate their water heater, including using more than one source at a time. The six-gallon and ten-gallon models will have propane as their prime source of heat. They can be ordered with propane and 120 VAC, propane and engine-assist, or all three sources together. The pilot model has been the staple water heater for the industry for decades and is still in use.

1-1.1 Water Heater Data Plates and Information

1-1.1.1 *Model, Serial, Specification Numbers*

As with all appliances, water heaters will have data plates on them that will reflect important information needed to service the appliance. Information such as model number, serial number, specification number, gallon capacity, Btu/hr input, types of heat sources, voltages, amperages, and approval stamps from appropriate organizations such as the American Gas Association and Underwriter Laboratories. This plate will be on the side or bottom of the main housing when the outside access door is opened. The model number will reflect important information about the water heater. Figures 1-3 and 1-4 show both manufacturers' breakdown of what each digit or number represents about the water heater. As shown, it shows heat sources, type of ignition for the propane, a version or series, gallons, etc. The serial number is also on the data plate and it is the number for that water heater. The specification number is also important as it will reflect component changes and date of manufacture. The specification number is only used by Atwood, however.

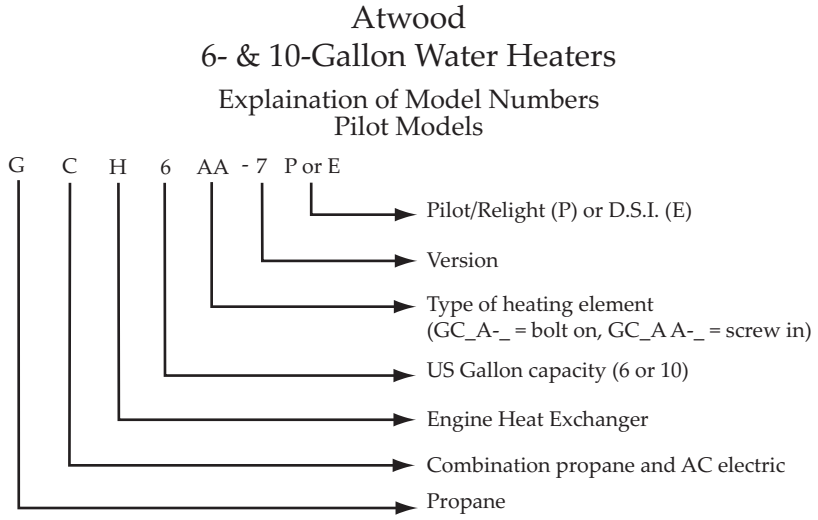


Figure 1-3 *Atwood Model Number*

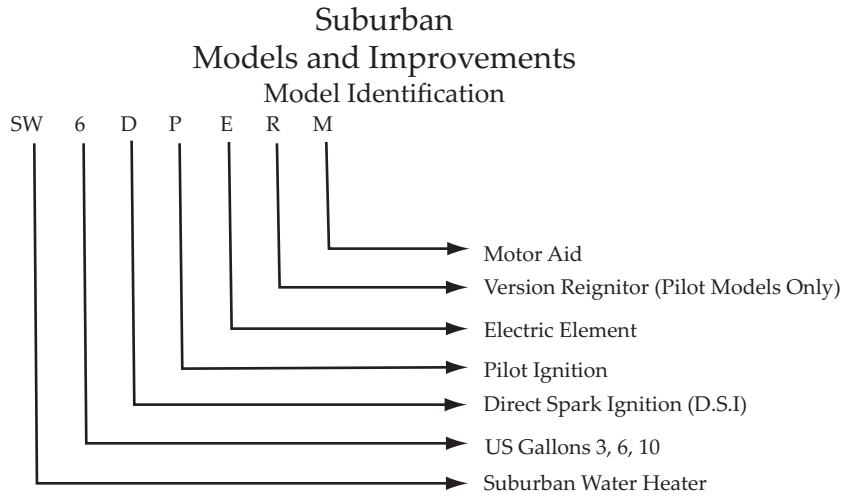


Figure 1-4 *Suburban Model Number*

1-1.1.2 *Btu/hr Input*

The Btu/hr input will give information about the heating rate on the propane mode. Some manufacturers offer a "high performance" model and will have a higher Btu/hr input. This input difference is important as it may designate different burners, orifices or components on the water heater.

1-1.1.3 *12 VDC Requirements*

If the water heater has a optional reignitor or is a direct spark ignition (D.S.I.) type, then 12 VDC from the battery is needed to power it. Sometimes the requirements, amperages or other information may be found on the data plate. If not, the information can be found in the owner's manual.

1-1.1.4 *120 VAC Requirements*

When 120 VAC heating elements are used on the water heater, the data plate will reflect the requirements or data needed for the unit such as voltages, amperages, or wattages of the 120 VAC system.

1-2 Water Heater Overview and Principles

1-2.1 Source of Heat

As discussed previously, most RV water heaters use one of three sources of heat; propane, 120 VAC heating element, and engine-assist or motor-aid.

1-2.1.1 *Propane*

The primary source of heating is propane. The propane is burned at the end of a burner tube as shown in Figure 1-5. The flame enters the flue tube where the heat and exhaust gases are carried through to an exhaust vent at the top of the water heater.

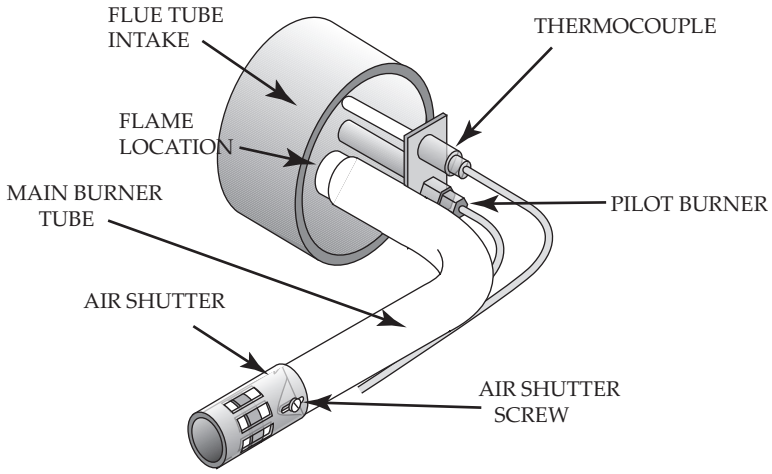


Figure 1-5 *Burner Tube and Pilot Assembly*

One manufacturer uses an aluminum tank with a flue tube that curves around inside the tank as shown in Figure 1-6. Another manufacturer uses a glass-lined steel tank that has a large tube installed in it divided in half through its length. The plate in the middle is open at the back of the tube and it allows the flame and heat to pass into the bottom half of the tube and be pushed up to the upper half at the back and return back out to the exhaust vent as shown in Figure 1-7. These units must have the burner/exhaust area sealed off to the inside of the coach and vented to the outside. They do not use any inside air from the RV for combustion. All intake and exhaust air is exterior air.

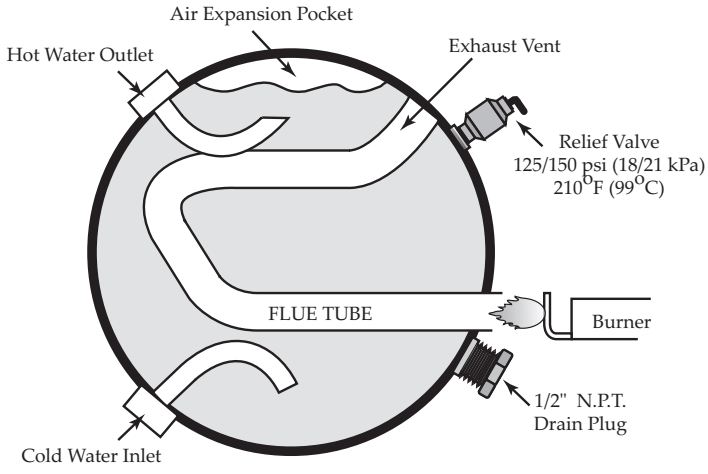
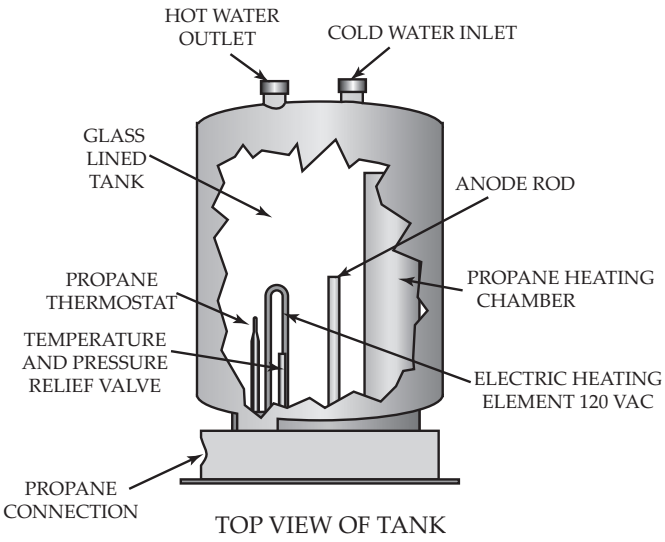


Figure 1-6 *Aluminum Tank with Flue Tube*



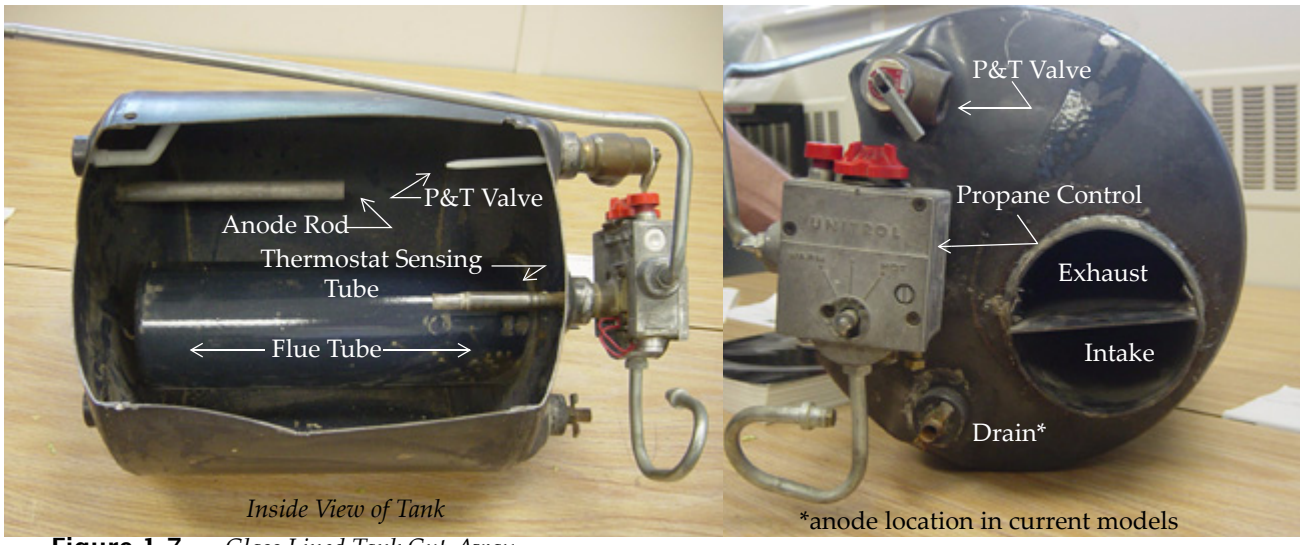
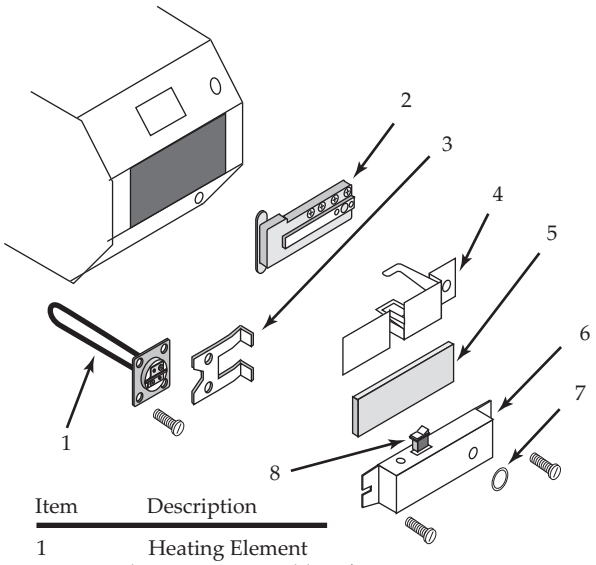


Figure 1-7 *Glass Lined Tank Cut-Away*

1-2.1.2 *120 VAC*

A popular option for a heat source is the 120 VAC heating element system. These are usually installed at the factory as a option on the water heater. There are aftermarket versions available; however, water heater manufacturers have issued service bulletins recommending that aftermarket heating elements not be used in their products.

The 120 VAC system utilizes a 1,000 to 1,500 watt heating element that is submerged inside the tank. Two types are commonly used, a screw-in type and a bolt-in type. Both have the element making contact with the water inside. On the outside surface of the water heater tank, there is a control called a thermostat that regulates temperature and an energy cut-off (E.C.O.) switch, that has a higher temperature rating, in case the thermostat fails. An on/off switch is also included to operate the 120 VAC system. An example of components of the 120 VAC water heater is shown in Figure 1-8.



Item	Description
1	Heating Element
2	Thermostat Assembly w/E.C.O.
3	Thermostat Clip
4	Retainer
5	Insulation
6	Cover
7	Grommet (E.C.O. button access)
8	On - Off Switch

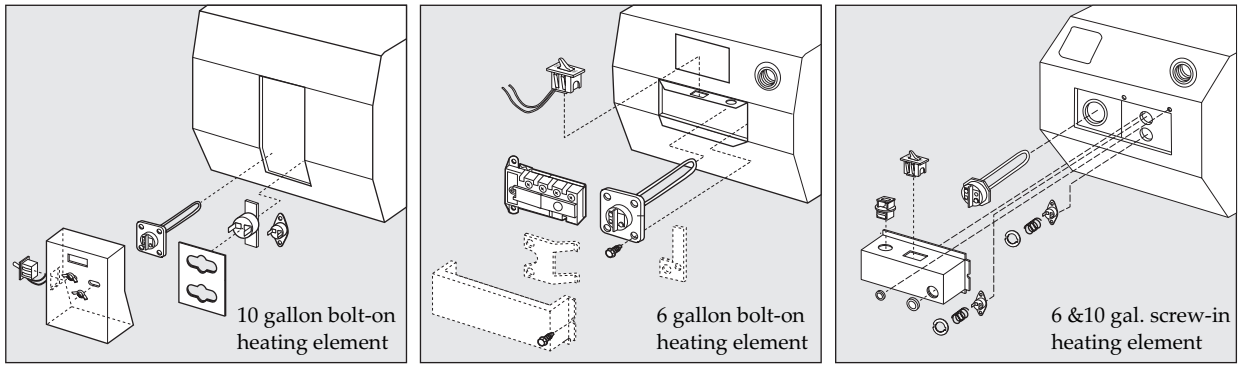


Figure 1-8 *Typical 120 VAC System*

1-2.1.3 *Engine-assist or Motor-aid*

The last heat source option available on water heaters is engine-assist or motor-aid. Different manufacturers use different names. This system will have a tube attached to the hot water tank that allows hot engine coolant to flow through it and heat the hot water tank. Figure 1-9 shows a typical motor-aid system and its connecting hoses to the engine of the RV. The fluids do not mix. Engine coolant flows through a tube attached to the water heater tank, transferring its heat to the cooler water inside the hot water tank. This feature is beneficial in a couple of ways. One, the engine coolant flowing by the hot water tank gives up heat and returns to the engine much cooler, allowing the engine to run cooler. Secondly, the RV always has hot water. The propane mode is not needed nor required while driving down the road.

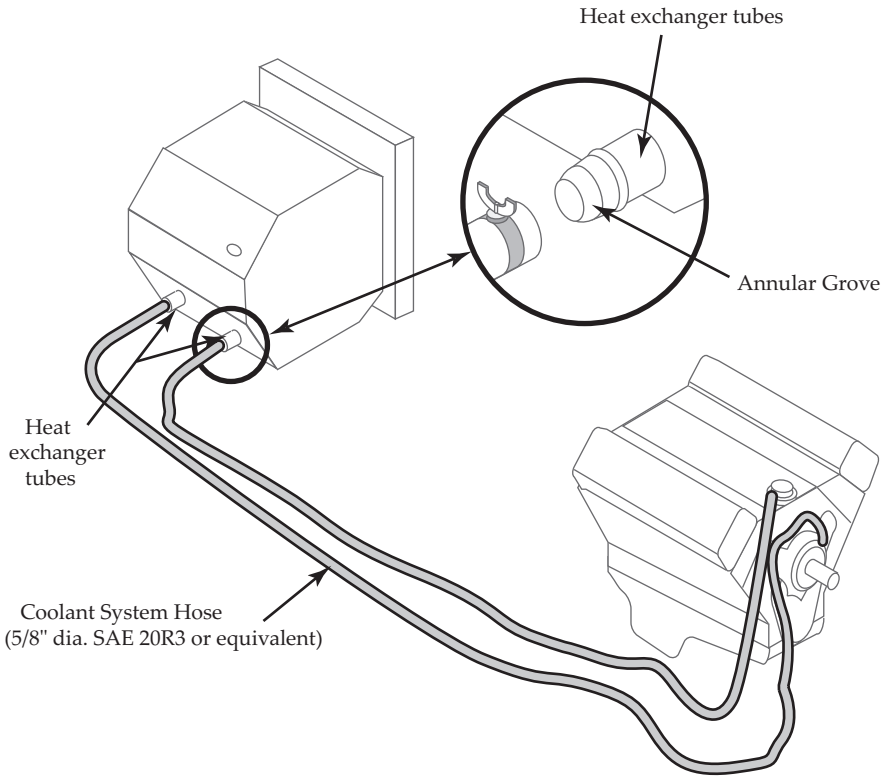


Figure 1-9 *Typical Motor-aid System*

Note: Excessive engine coolant, above 180°F (82.2°C), can trip the E.C.O. switch.

1-2.2 Regulation of Heat

1-2.2.1 *Thermostats*

The regulation of heat is important for a water heater. Propane and 120 VAC modes utilize thermostats. These thermostats will allow the water to heat to a preset temperature and shut off the source of heat.

1-2.2.2 *Energy Cut-Off Switch (E.C.O.)*

The energy cut-off switch is a high-temperature shut-off device. This is a safety device that shuts off the flow of propane in an overheat situtation (180°F (82.2°C)). On D.S.I models the E.C.O switch is resettable. On pilot models it is a one-time switch resulting in complete control replacement.

1-2.3 Pressure and Temperature (P&T) Relief Valves

A pressure and temperature safety device, as shown in Figure 1-10, is used on water-heating vessels. These safety devices utilize preset springs to release excess pressure build-up in the water tank when temperatures increase (125/150 psi (18/21 kPa) and 210°F (99°C)). If a thermostat were to fail, the P&T valve would protect the water tank from rupturing due to overpressurization.

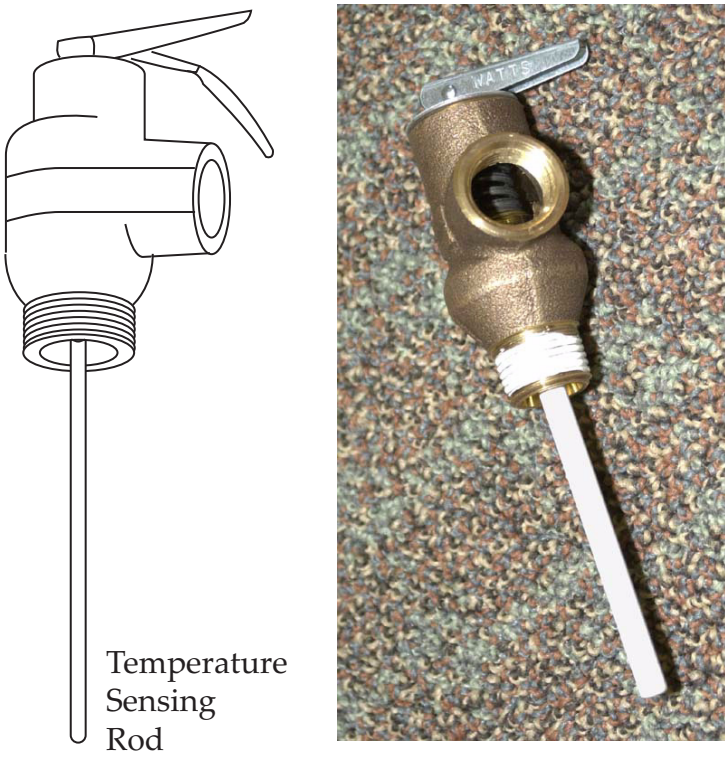


Figure 1-10 *P&T Relief Valve*

1-2.3.1 *Water Flow*

Water connections on water heater tanks are all in the same relative location among the different manufacturers. The tanks will typically have 1/2" female pipe thread connections at the rear of the water heater. The cold water input connection is located at the bottom of the tank while the hot water discharge connection is located at the top of the tank. This takes advantage of the principal that heat rises while cold will remain at the bottom. Figure 1-11 shows the fittings located on a side view of a cutaway water heater tank. This figure also shows an air expansion pocket. This is necessary because another physical principle comes into play with the heating process; as a solid or liquid is heated, it will expand. All solids and liquids will expand or contract at different rates, and water is unique because it can change to all three states of matter. At normal temperatures, above 32°F (0°C) and below 212°F (100°C), it is a liquid. Below 32°F (0°C), it changes state to a solid and will expand in volume. If it is heated above 212°F (100°C), the water will convert to a vapor and escape to the atmosphere, unless it is contained within a vessel such as a water heater tank. In this case the boiling point will rise accompanied by increased pressure, because the liquid is expanding in volume, compressing the air pocket inside the tank. The P&T relief valve will open with this pressure and/or temperature to avoid damage to the tank. Freezing the water with a full tank will, however, rupture the tank. The freezing water has tre-

mendous pressure and will easily open up the weakest part of the tank, such as around welds or weak portions of the tank caused by the forming process. Because of the freezing damage, winterization of RVs is extremely important in cold climates.

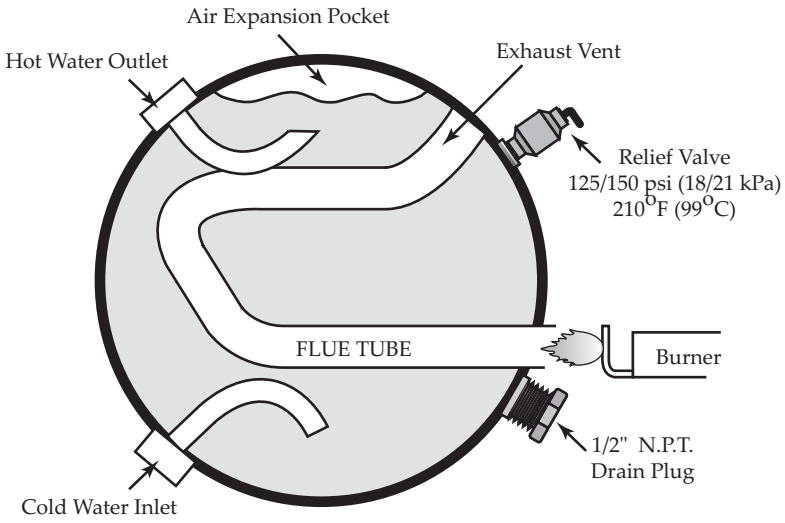


Figure 1-11 *Water Fittings*

1-2.4 Electrolysis

Water heater tank corrosion, or galvanic corrosion, is a common reaction with all water heaters. This is a process where microscopic particles of metals (like iron and copper) suspended in water, set up a reaction inside the water heater that is not unlike the principle on which an automotive battery operates. Water heater manufacturers use two different types of tanks, one is aluminum and the other a glass lined steel tank. With the steel tank, an anode rod is installed into the tank (with pipe threads) and the anode rod will sacrifice itself, that is, decompose until the aluminum or magnesium has completely gone from the base. Figure 1-12 illustrates the decomposing of the anode rod. It is recommended by the manufacturer that the anode rod be inspected annually (or more often depending on usage) or replaced when it is 75% of its original size. It is not recommended to operate the water heater without the anode rod and it also voids the warranty. Do not replace the anode rod with an after-market electric heater as this will also void the warranty and accelerate the destruction of the tank and other components.

This material protects the tank from the effects of heavy metals and salts found in waters throughout the country. It is anodic to these heavy metals and acts much like an anode in a steel glass lined tank. The aluminum tank is the anode and the metals in the water serve as the cathode. Consequently, the aluminum or anode rod sacrifices itself and the particles are carried away with the water flow. A white scaly material (aluminum oxide) often is formed around the points where the heaviest action is taking place and heat accelerates the process. The severity of the problem varies considerably in different locales, depending on the metal and mineral content of the water. White deposits inside the water heater tank are usually from water impurities that have settled out. Periodic flushing of the water heater tank under pressure is recommended to slow down this process.

Figure 1-12 *Deterioration of Anode Rod*

1-3 Tools and Equipment

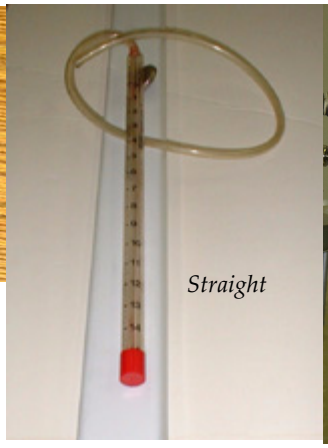
As is the case with all appliances and equipment, regular and special tools will be needed to perform repair and service on the RV water heaters. Regular tools such as nut drivers, screwdrivers, pliers, approved leak detector solution or electronic leak detectors, wrenches, etc. are needed. Special application tools are needed to perform tests on some of the components. Some of these tools will be needed to work on any propane appliance and/or electrical system.

1-3.1 Manometer

The manometer is used to measure pressure in inches of water column (W.C.). This device is available in either dial, digitial and water tube. There are two types of water tube manometers, a U-tube type and a straight tube. The U-tube type is recommended by all manufacturers of propane appliances because it is extremely accurate, however most technicians prefer the dial type. The gauge type does not function as accurately, especially at low pressures, and is susceptible to getting out of calibration if handled roughly. A dial manometer should be calibrated often against a U-tube manometer. The different types of manometers are shown in Figure 1-13. For proper use of the manometer, refer to the *RV Propane Systems textbook* on system testing.

Dial

Digital



Straight

U-tube

Figure 1-13 *Manometer Examples*

1-3.2 VOM

A quality VOM (volt, ohm meter), as shown in Figure 1-14, is necessary and must have a DC volt range capable of measuring a minimum of zero to 50 millivolts. It must also be able to read AC and DC volts, Ohms resistance and DC current to about 10 amps. Refer to the electrical systems textbook on how to use this device and its importance in preforming testing.

Figure 1-14 *VOMs*

1-3.3 Thermocouple Tester

A thermocouple tester, as shown in Figure 1-15, would be useful but not totally necessary. The thermocouple tester tests the operable range of the output of the standard thermo-

couple used in water heaters, old type space heaters and refrigerators. It simulates the magnet that is in the water heater gas thermostat control. The actual measuring of the thermocouple output, with a millivolt meter, is another valid test of a thermocouple's strength.

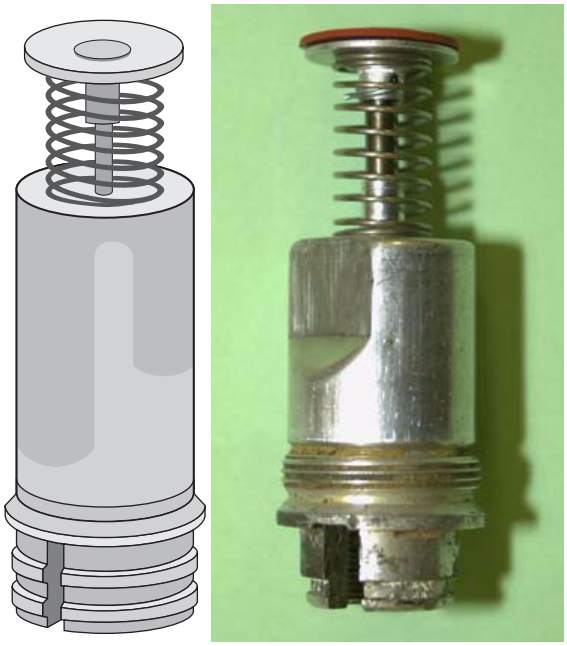


Figure 1-15 *Thermocouple Tester*

1-3.4 D.S.I. Circuit Board Tester

Another specialty tool is the D.S.I. circuit board tester of which one type is shown on Figure 1-16. It is a simple table top device that will diagnose the following items on a circuit board: power circuit, sense circuit, spark generation and the lock-out mode.

These board testers do not always simulate true working conditions. Boards can be intermittent due to ambient conditions.

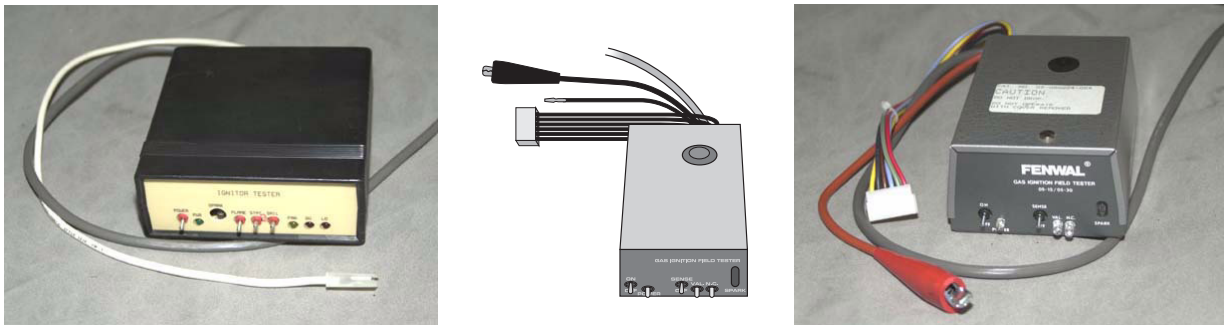


Figure 1-16 *D.S.I.Circuit Board Testing*

1-3.5 Speciality Tools

Specialty tools to remove components are also necessary. A gas thermostat removal tool to remove pilot control valves becomes very useful. It allows the removal and replacement of a control valve without damaging it. The control is large enough that wrenches cannot fit

around it, and it is installed tightly enough that even if a wrench could be applied, it would probably destroy or damage the control. A universal wrench can be built along with a different valve to remove and replace the P&T relief valve. A socket wrench opening or adaptor is welded to the wrench to allow a 1/2" breaker bar to be applied for maximum torque in removing and replacing the controls.

1-3.6 Burner Brush - Flue Brush

Another tool to have for convenience is a flue tube and burner brush. These brushes will clean the walls of the flue tube and the smaller burner brush will clean debris from the burner tube.

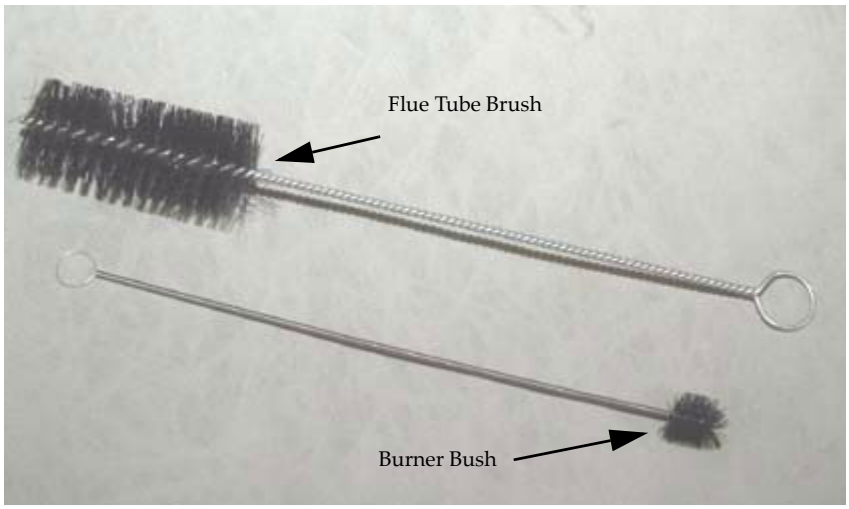


Figure 1-17 *Flue Tube and Burner Brushes*

Figure 1-18 *Clean Burner Tube*

Chapter 1 Review

1. The majority of RV's use _____ US gallon water heaters.

   A. 2 or 4

   B. 4 or 6

   C. 6 or 10

   D. 8 or 10

2. Electric water heaters are popular in all sizes and models of RV's.

   True False

3. List the two methods of ignition for propane water heaters

   A.

   B.

4. The type of water heater that heats water as it passes through a heated coil is called a _____ water heater.

   A. tankless

   B. flameless

   C. instantaneous

   D. spontaneous

5. The following is the model number from an Atwood water heater: GC6AA-7P. What does the 6 stand for?
6. The following is the model number from a Suburban water heater: SW6DPERM. What does the D stand for?
7. Propane water heaters DO NOT use any inside air from the RV for combustion.

   True False

8. Propane water heaters must have the burner/exhaust area sealed off to the inside of the coach and vented to the outside.

   True False

9. Water heaters have a primary thermostat and high limit switches. The high limit switches are sometimes called a/an _____.
10. A device which opens to avoid a possible rupture of the water heater tank is called a _____.
11. What two phenomena will cause water to change its state, and therefore, increase its volume by expansion?

A.

B.

12. Water heaters with an anode rod should have the rod inspected at least _____.

    A. monthly

    B. quarterly

    C. semi-annually

    D. annually

Chapter

2

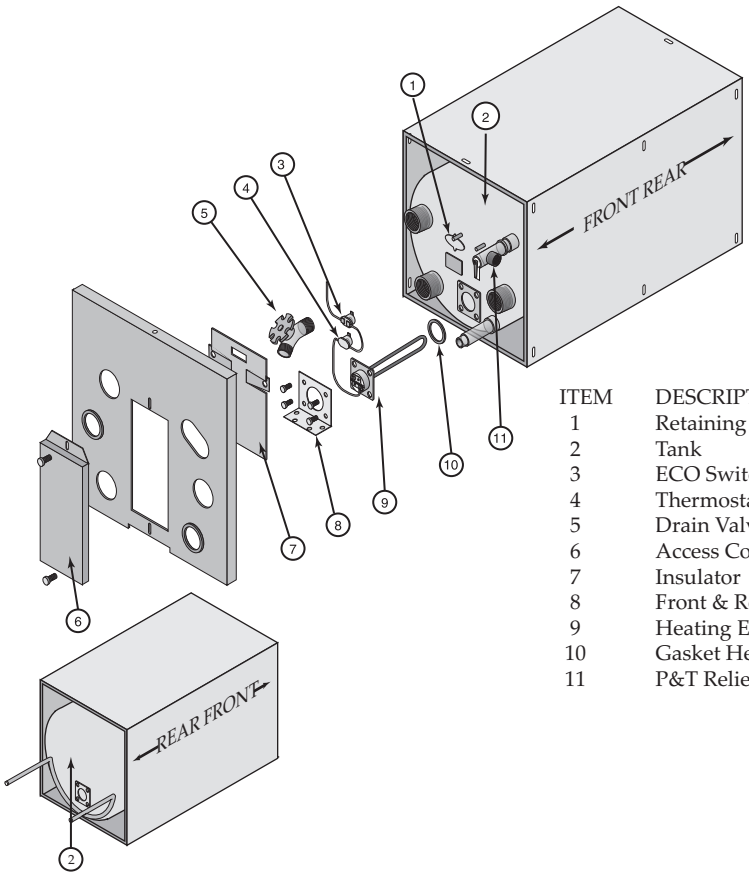
Electric Water Heaters

- Identify related terminology.
- Identify components and their function.
- Diagnose common operational problems and determine possible causes.
- Repair and/or replace faulty components.
- Verify the proper operation of the electrical water heater system.
- Determine AC and DC electrical requirements and connect.

2-1 History And Overview

2-1.1 Applications

A popular water heater in residential homes and apartments where electricity is cheaper than propane is the 120 VAC electric water heater. Many areas of the country use these electric water heaters as opposed to a propane water heater because of convenience, cost, and cleanliness. The marine industry typically uses electric water heaters as do small shops and offices. The RV industry has used this electric water heater in many applications. Some manufactures use stand-alone electric water heaters but most use combination propane/electric water heaters.



ITEM	DESCRIPTION
1	Retaining Plate
2	Tank
3	ECO Switch
4	Thermostat
5	Drain Valve 3/4"
6	Access Cover
7	Insulator
8	Front & Rear Hold Down Bracket
9	Heating Element
10	Gasket Heating Element
11	P&T Relief Valve

Figure 2-1 *Typical Electric Water Heater*

2-1.2 Advantages and Disadvantages

Some motorhomes use a 120 VAC water heater, some use a 120 VAC water heater coupled with engine assist for a little more versatility. In this section we will only address the 120 VAC portion of a water heater.

Advantages

- Does not require outside venting.
- Can be installed in a cabinet.

Disadvantage

- Requires a 120 VAC power source.

2-1.3 Power Consumption

Typically, the power draw on this system is quite high. The heating elements come in 1,000- to 1,400-watt. Some pre-1996 RVs had 1500-watt heating elements.

2-2 Sequence of Operation

1. Turn on electric switch.
2. 120 VAC goes through the thermostat (normally closed switch).
3. Normally thermostat demands heat and contacts close.
4. 120 VAC goes through E.C.O. switch which is normally closed.
5. 120 VAC goes to heating element and heats water.
6. When selected temperature is attained thermostat electrical contacts open.

2-3 Components: Locations, Functions, Testing and Interactions

2-3.1 Data Plate

The data plate is an important item to locate on any appliance you are working on. It will identify the model, serial number, size of heating element, voltages, and amperages or wattages required. If parts are necessary to order for service or repair, the data plate will give all the information to refer to service manuals or call customer service at the manufacturer. The data plate on electric water heaters is usually located in the vicinity of the electrical connections.

2-3.2 Tank Insulation

Around the tank is a blanket of fiberglass insulation. Most tanks are wrapped in this fiberglass and then an outer cover of metal or cardboard keeps the fiberglass contained and holds it in place. The fiberglass insulation is necessary for the tank to retain the heat longer, cutting down on the number of heating cycles. Some newer models use a foam insulation cover that form fits the tank and improves the insulation factor.

2-3.3 Mounting

The outer shell of the water heater will have tabs or holes predrilled for installation. Different manufacturers use different methods, therefore always refer to the owner's or installation manual for proper fastening of the water heater. It is important to secure this water heater properly because when it is full, it can weigh about 60 pounds (27 kg). This amount of weight will let it move with the motion of the RV, stressing water connections.

2-3.4 Junction Box

As with all high-voltage appliances or devices, the wire connections must, by code, be made inside an approved box. With the 120 VAC water heater, these connections are usually covered by an access cover that will protect and cover all connections in one housing and has been approved by an inspection organization such as Underwriters Laboratories for complying with all applicable codes and standards. This cover can be removed for service or replacement of parts, but it must be refitted anytime the unit is in operation, except when a qualified service technician is diagnosing the system. Periodic checks of the tightness of connections is good preventative maintenance.

2-3.5 On/Off Switch

The on/off switch on this type of water heater will usually be mounted on a cabinet surface as it is the only source of heat. Care must be taken when selecting or replacing this switch. The switch must be rated high enough to match or preferably exceed the rating for the heating element wattage or amperage. An under-rated switch will cause overheating and possible arcing, resulting in failure, or possibly a fire. Some units may have their own switch, in which case a manufacturer's replacement would be necessary for the same reason. If a wall switch is added to the system, even though the water heater has its own switch, then the switch must be rated heavy enough for the demand of the water heater. Again, that information can be found on the data plate. The wall switch must also be installed in an approved electrical junction box to satisfy code requirements. **The electric water heater must have its own dedicated circuit breaker**, its size will be specified in the installation manual. The circuit breaker is not an on/off switch. Turning the water heater on and off with the circuit breaker will weaken the breaker and eventually destroy it. The on/off switch turns the water heater on and off. Testing the switch can be accomplished easily by disconnecting the wires from it and checking for continuity through it when turned on and lack of continuity when it is in the off position. It can also be checked with a voltmeter if a neutral is available by checking both sides of the connectors with the lead (the other lead to neutral) and making sure the voltage is the same on both terminals.

2-3.6 Thermostat Assembly

The thermostat assembly controls the water temperature and usually includes the E.C.O. switch. A typical thermostat assembly is shown in Figure 2-2. This assembly will make direct contact with the water heater tank surface to sense the temperature of the water. It is secured with clips and/or screws to keep pressure against the tank. The thermostat portion, as shown Figure 2-3, has a temperature adjustment dial that the consumer can set to achieve the desired temperature. The hot lead is connected to terminal 1 which is the input to the thermostat. Terminals 2 and 3 are linked together with a metal connector plate and have no wires attached to them. Terminal 2 is the output of the thermostat and terminal 3 is the input to the E.C.O. switch. Terminal 4 is the output from the E.C.O. and from here a wire connects to the heating element. In case the thermostat fails and it does not open the circuit, the E.C.O. portion of the assembly is preset at 180^{o}F (82^{o}C) and will open at that temperature. It is a backup for the thermostat to insure safety, because if the water were allowed to heat with no control, the tank could rupture. The E.C.O. prevents the water from becoming too hot and it will give a signal to the consumer that something is wrong, even if the consumer does not notice the hotter than normal water temperature. When the E.C.O.

switch does open at 180°F (82°C), it will push out a reset button (usually red). If this button needs to be pushed to restart the heating process, it usually means the thermostat portion has failed. If the E.C.O. switch has the button pushed out, check the terminals with a voltmeter, there should be voltage at terminals 1, 2, and 3, but not 4 (use the neutral connection at the heating element for the other lead from the VOM). When the button is pushed, there should be voltage at 4. The button, however, cannot be re-engaged if the water temperature is still at 180°F (82°C) or better. To test the thermostat, run the hot water out of the tank until it is cool and push the reset button on the E.C.O. This will restart the heating process. Periodically check the voltage at terminal 4 or at the heating element. When there is no more voltage, check the reset switch to see if it has again popped out. To confirm the thermostat's failure, place an accurate thermometer under the faucet and run hot water over the thermometer. The temperature should be about 180°F (82°C). This confirms that the thermostat portion has failed and replacement is necessary.

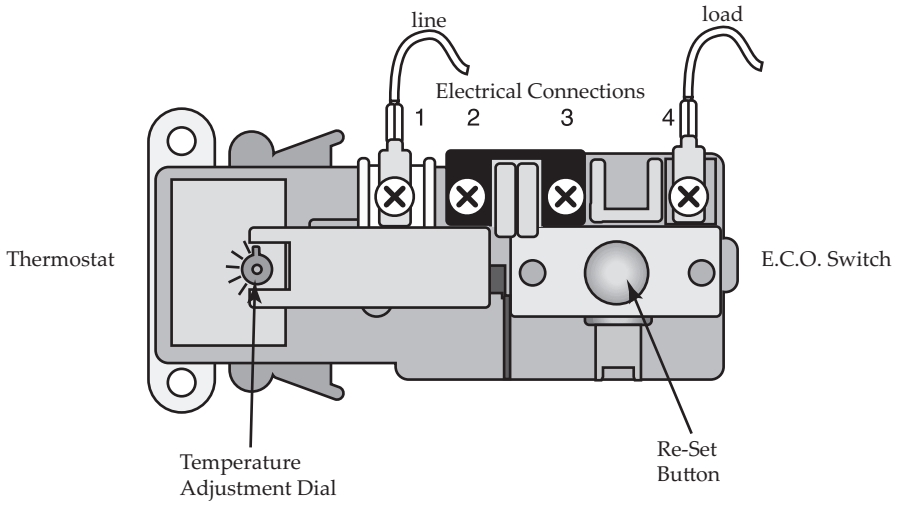


Figure 2-2 *Thermostat and E.C.O.*

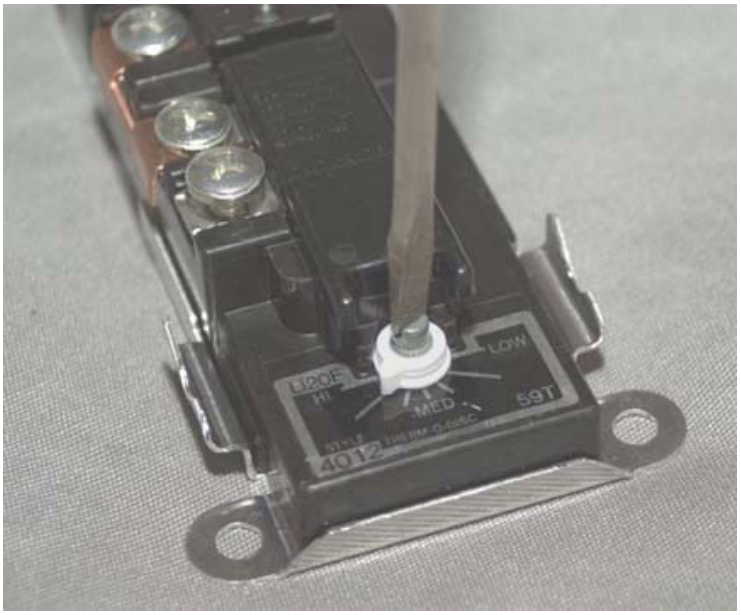


Figure 2-3 *Adjusting the Temperature*

Newer models may have the thermostat and E.C.O. as separate components. Figure 2-4 shows newer examples, but other types are similar. The thermostat is a preset normally closed (N.C.) switch, usually at 120°F (49°C) or 140°F (60°C). The E.C.O. is also an N.C. switch and has a reset button and set to open at 180°F (82°C).

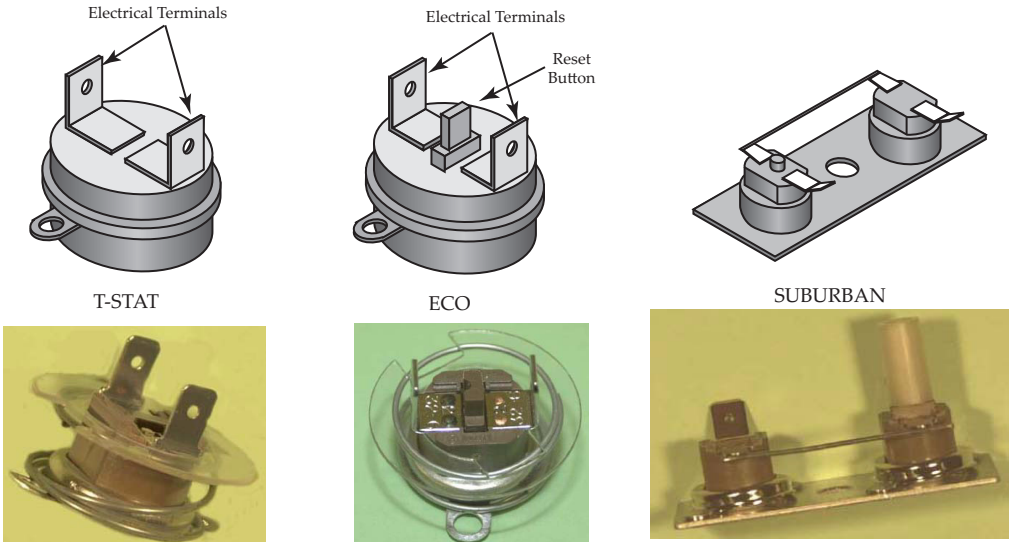


Figure 2-4 *Newer T-Stat and E.C.O*

Atwood now has an adjustable thermostat for the DSI propane side, adjustable for 110°F (43°C) to 150°F (66°C).

2-3.7 Heating Element

A very important component in a 120 VAC water heater is the heating element. There are two types of heating elements. Figure 2-6 shows the two types, screw-in and bolt-in. These are common in all 120 VAC water heaters. Typically, these will be in the 1,000- and 1,500-watt ranges. Newer elements have dropped to 1,400 watts to slightly lower the amperage and prolonging slightly the heating time. The higher the wattage, the more heat produced. As shown in Figure 2-5, the ratings are printed on the outside of the element housing. The loop portion of the element will be immersed inside the tank to make contact with the water. The screw-in and bolt-in elements will have a gasket to seal them. Never reuse a gasket when replacing a heating element. Normally, these elements will last a long time. Care should be taken to insure water is in the tank before turning the electric water heater on. If the water heater is turned on accidentally without water, let the tank cool down for 2-3 hours before adding water. Adding water before the tank cools sufficiently could collapse the tank. To test the heating element, verify there is voltage to the heating element first. If there is voltage, use a amprobe to see if there is a current draw. If there is no current draw and voltage is present, the heating element is open and needs to be replaced. Checking for resistance is also a test but the circuit must be shut down and the wires removed from the heating element. Check for resistance across the terminals. Ohm's law will tell you the proper resistance for the heating element using the data on the heating element's housing. The base on a heating element has the following information on it; 120V/1400W. Determine the resistance for this heating element as shown in Figure 2-6.

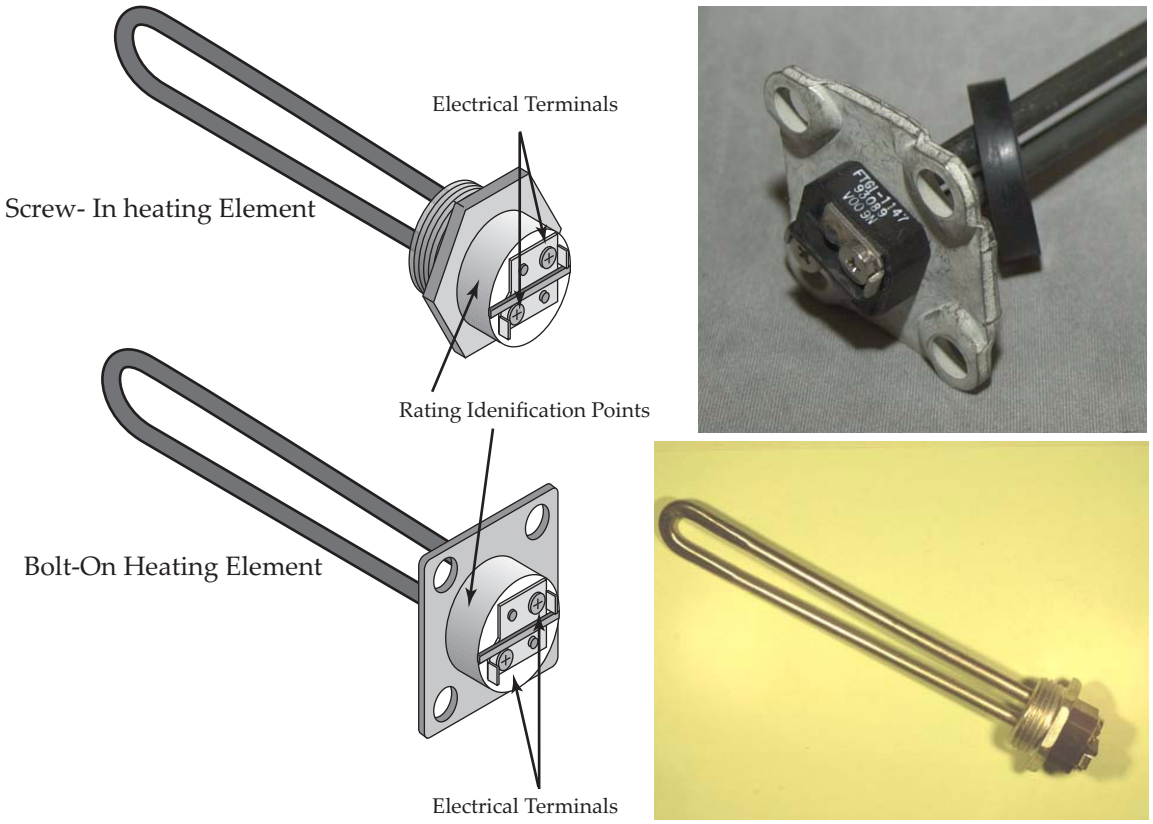


Figure 2-5 *Heating Elements*

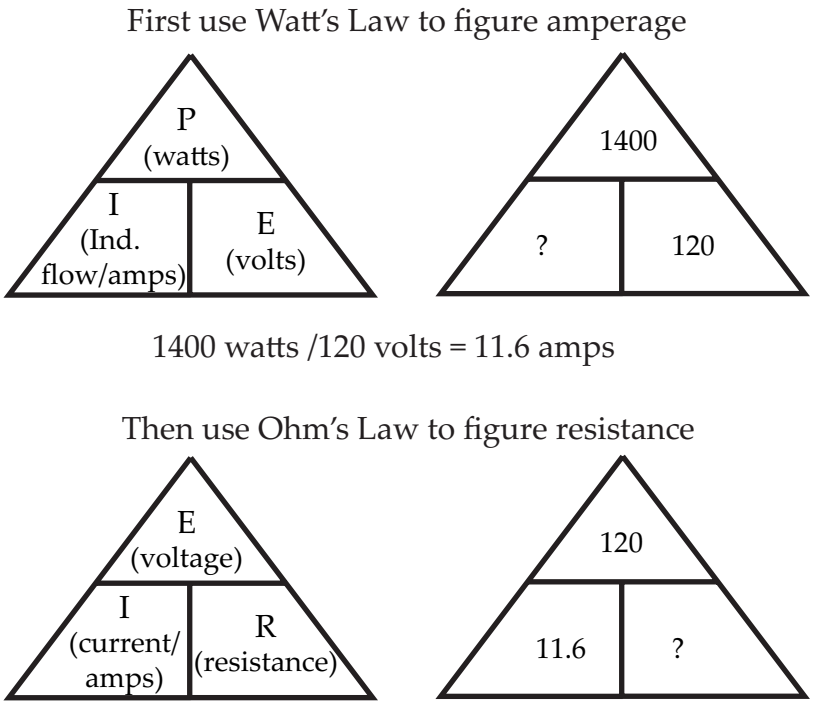


Figure 2-6 *Calculating Resistance*

Also check each of the terminals to the case of the element. Any reading would indicate a short to the case of the element. Either open or shorted condition warrants replacement of the heating element. Always replace the heating element with the same wattage ratings as the other components may be matched to the capacity or wattage of the heating element.

Refer to *RV Electrical Systems textbook* for explanation on Ohm's and Watt's Law.

2-3.8 P&T Relief Valve

Another component on this water heater that needs to be addressed is the pressure and temperature (P&T) relief valve (Figure 2-7). As shown in Figure 2-1, it is located on the upper portion of the tank. This valve has either 1/2"or 3/4" male pipe threads to install it in the tank. The probe portion must be inside the tank to monitor temperature and the valve has a spring that will release with excessive pressure. The outlet has female pipe threads. A lever is on the end of the valve that will open the valve if lifted. The internal pressure spring will close the valve when the lever is released. Sometimes a piece of aluminum oxide or debris will stick in the seal. If the valve leaks when closed, opening the valve quickly and letting it snap shut will usually dislodge the debris, allowing it to seal again.

Diagnosing the valve usually involves measuring the water temperature, if the valve starts weeping when the water heater is in operation. Two conditions usually exist if this valve weeps. One is that the air pocket in the tank has been depleted to the point that the water expands so much that the pressure must be relieved and the P&T relief valve opens to relieve the pressure. If this condition is constantly happening, the air pocket must be restored. This can be accomplished by shutting off the water pump or city water and opening the hot water faucet inside the RV nearest to the water heater, then opening the P&T relief valve until the water stops flowing, and then closing the valve. Next, turn on the water pump or city water and leave the faucet open until the water flows freely without air. Be careful when purging the air, as the water will sometimes splash violently.

Another cause of weeping is excessive temperature. Use a thermometer and measure the temperature of the water coming out of the faucet. If the temperature exceeds the standard operating temperature, the thermostat may be at fault instead of the P&T relief valve. If the valve weeps and the water temperature is normal, less than the P&T relief valve rating, the air pocket may be gone. If the air pocket is restored and the valve still weeps, even with cold water, replacement is probably necessary. When pressure temperature relief valve discharges again, repeat above procedure.

- Install a pressure relief valve in cold water inlet line to water heater and attach a drain line from valve to outside of coach. Set the relieve at 100-125 PSI.
- Install a diaphragm typed expansion tank in cold water inlet line. Tank should be sized to allow for expansion for approximately 15 oz. of water and pre-charged to a pressure equal to water supply pressure.

These devices can be obtained from plumbing contractor or service center.

Replacement of the P&T relief valve must have the same temperature and pressure ratings as the original. The housing is made of brass and care must be taken when replacing it. A special wrench or socket may be necessary to remove it, and especially to replace with a new one, so as to avoid damage.

Proper listed sealant must be applied to the pipe threads for a watertight seal. Avoid cross-threading by starting the valve in by hand and threading it for several turns to insure that the valve is not cross-threaded. Tighten and position the outlet of the valve to where it

was previously. The P&T relief valve is typical of all water heaters and will not be re-addressed in this manual.

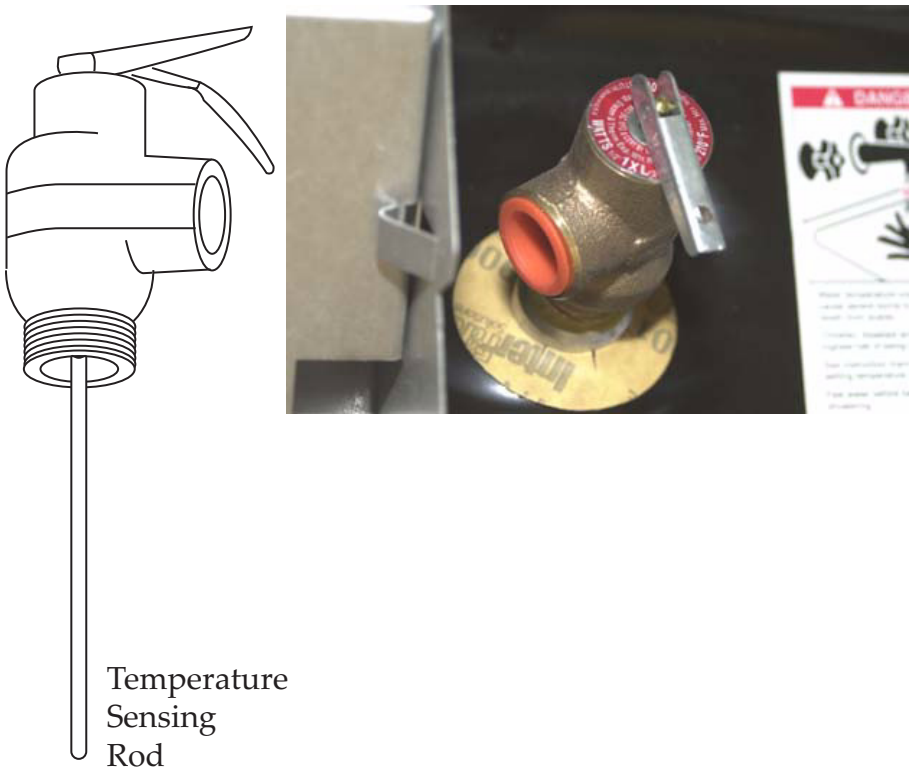


Figure 2-7 *P&T Relief Valve*

2-4 Electrical Schematic Diagrams

The 120 VAC electrical system of the water heater is a basic wiring circuit. Since there are 4 components involved, care must be taken to wire them in the proper sequence. All water heaters will have an electrical schematic or wiring diagram attached to them or in the owner or installation manual. This must be followed exactly for proper performance and safety. Figure 2-8 shows a basic wiring schematic. As the top line indicates, the dotted lines are wired by the installer which could be the RV manufacturer, a service technician, or the customer. This diagram is typical of high-voltage water heater systems. The neutral wires directly to the heating element, the ground wire grounds the whole system, and the hot wire is connected first to the on/off switch, then to the fixed (sometimes adjustable) thermostat, then the high limit switch (E.C.O.), and finally to the other terminal of the heating element.

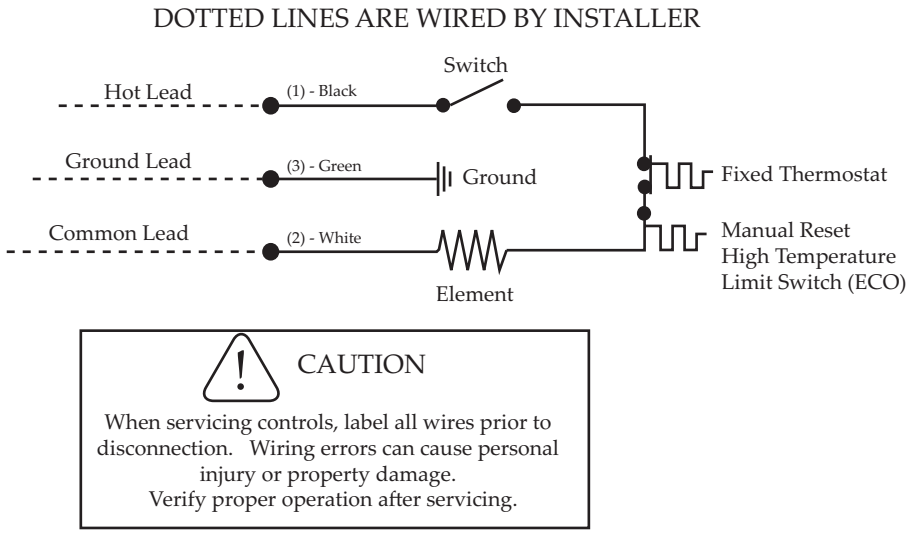
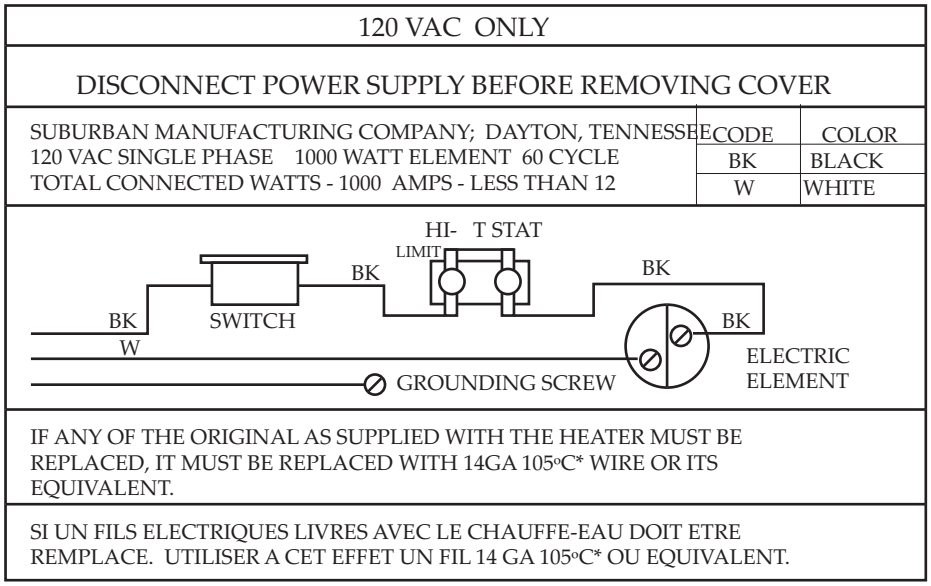


Figure 2-8 *Basic Wiring Schematic*

Note: Be sure to read all CAUTION and safety notations accompanying the diagrams, as they offer important safety information that must be followed.

Figure 2-9, shows another system wired in a different configuration. The only difference between these two illustrations is that the thermostat and E.C.O. are wired in reverse. The on/off switch is still at the beginning of the circuit and the heating element is still at the end. The two temperature controls can be reversed in this design and still function. However, always wire the water heater as designated by the wiring schematic on the water heater.

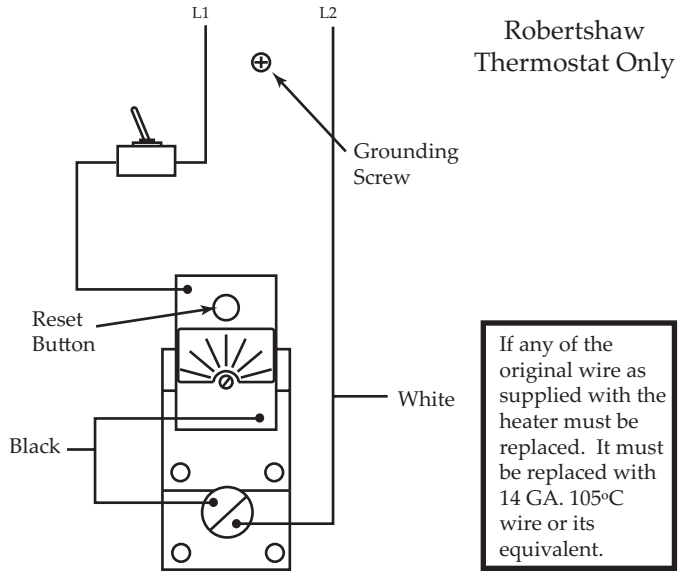


*Temperature for wire gauge is in degrees Celsius (North America wide)

Figure 2-9 *Wiring Schematic*

Another version of the wiring diagram is shown in Figure 2-10. This illustration shows the components in their actual orientation on the water heater. L1 at the top left is the black

input wire from the RV and L2 is the white neutral wire. Again, the black wire runs through the on/off switch, then the E.C.O., the adjustable thermostat, and finally to the heating element at the bottom.



*Temperature for wire gauge is in degrees Celsius (North America wide)

Figure 2-10 *Wiring Schematic*

Figure 2-11 is pictorial showing the wiring, on/off switch, combination thermostat/ E.C.O. switch and the heating element in their wired configuration. The hot wire from the RV is wired to an on/off switch (A) and continues to terminal B at the E.C.O. switch. A connector strip connects the E.C.O. to the thermostat (E). This connection is shown as the two phillips screw heads that are between terminal B and C. The connection screw directly to the left of terminal B is the output terminal of the E.C.O. switch. The connection directly to the left of that, connected by the metal strip connector, is the input to the electric thermostat (E). Terminal C is the output of the electric thermostat and from there it is wired directly to one terminal of the heating element. The connections on the heating element do not need to be wired in any polarity configuration, as heating elements can be wired either way unless it is clearly identified on the heating element of wiring schematic with a reference marker on the element or diagram.

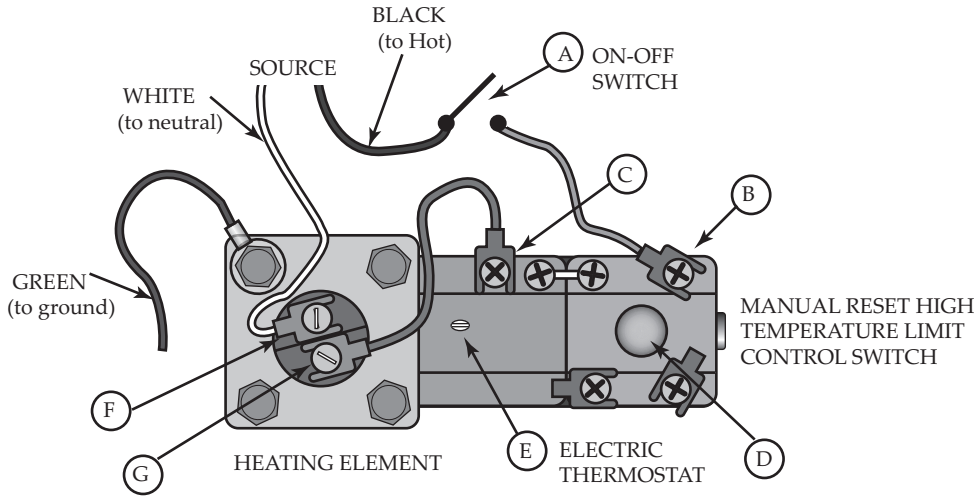


Figure 2-11 *Wiring Pictorial*

2-5 Installation

The installation requirements of the electric water heater in an RV are in the installation manual of the water heater. Usually, the water heater is installed inside a cabinet at floor level. The hot and cold water lines are run to the proper connections on the water heater. Water lines need to be secured according to all applicable codes and standards. The electrical wiring must also be performed according to codes and standards. All connections are to be made inside an approved connector box, usually supplied with the water heater. If an external on/off switch is to be used, one with the proper amperage rating called for in the installation manual is required. The water heater must be supported on the floor of the RV to avoid any movement that could rupture water lines or fatigue wires by constant motion. The installation instructions will designate minimum distances from surrounding cabinets or walls that will be required. When wiring in a new installation or replacing an existing unit, always check the power requirements for the new water heater to make sure the old circuit is wired with the proper size circuit breaker and wire. If the new water heater exceeds the capacity of the old wiring system, it must be upgraded for increased capacity. Be aware and advise the customer that the 120 VAC electric water heater system draws considerable power, almost as much as an air conditioner, and power supply at many campgrounds will not support running the water heater and air conditioner at the same time. Always consult the installation and owner's manuals for proper installation methods and materials.

2-6 Troubleshooting

Troubleshooting an electric water heater requires knowledge of the sequence of operation of the water heater. Consulting the wiring schematic will indicate the components in the circuit applicable for troubleshooting

2-6.1 No Hot Water

Note: Check System with Power on Unless Checking Individual Components with an Ohmmeter

Check the circuit breaker to make sure it is not tripped. If tripped (possibly by low-voltage condition or overloading), reset breaker and test.

Check for voltage at the on/off switch, and that the switch is functional. If voltage is present at the input of the switch but not at the output when turned on, replace the switch. An alternative test is to shut off power to the system, disconnect wires to the switch and check with an ohmmeter. With the switch on, lack of continuity indicates a bad switch; continuity indicates a properly working switch.

Check for voltage input to the thermostat/E.C.O. switch assembly. Verify voltage is at all terminals. Check to make sure that the E.C.O. has not tripped, in which case the button can be pushed to reset it. However, if this condition has occurred, the thermostat must be tested to make sure it has not failed and the water heater is now cycling on the E.C.O. switch. If voltage stops at any terminal and the water is not hot, replace the assembly. An alternative test is to shut off power to water heater and disconnect wires to the thermostat/E.C.O. assembly. Test for continuity from the input terminal to each of the other terminals.

An open indicates which component is bad. If there is continuity, and the thermostat is not satisfied the component is in proper working order.

Check for voltage at the heating element. If voltage is present at the heating element, but there is no amp draw on the heating element, replace the heating element. The heating element can also be checked with an ohmmeter with the wires disconnected. A resistance reading that can be computed using Ohms and Watts law will determine proper resistance. The heating element should read approximately 14 - 17 Ohms (remember that the voltage and wattage are printed on the heating element case). No resistance indicates an open element, while continuity with no resistance indicates a shorted element which would also be indicated by constant tripping of the circuit breaker.

2-6.2 Water Too Hot

Excessively hot water usually indicates that either the adjustable thermostat is set too high and just needs to be turned down, or that it has failed completely. The non-adjustable thermostat is usually set for 120°F (49°C) to 140°F (60°C). A good thermometer should be used to test the water temperature as it comes out of the P&T relief valve at the end of a heating cycle, or when no more amperage is flowing through the electrical circuit. If water temperature reaches 180°F (82°C), the adjustable or fixed thermostat has failed and the E.C.O. switch has shut off the system and the thermostat must be replaced.

Note: Overheating can occur if the thermostat is not mounted properly (i.e., insulation under the sensing disc surface).

2-6.3 Water Too Cold

Lack of hot water could be caused by a water heater with an adjustable thermostat, that is set too cold. Adjust the thermostat and retest. If the thermostat constantly shuts down colder than its rating, it is defective and must be replaced. Another possible cause of cool water is that the system may have a by-pass kit installed and the valving is not configured properly, leaving a by-pass avenue for water to flow. Check that all valves on the by-pass valving system are in proper configuration, in other words, the hot and cold valves are open and the valve in between the hot and cold water is closed. If all 3 valves are open, cold water will mix readily with the hot water, causing cool water at the hot water faucet.

Chapter 2 Review

1. Heating elements for electric water heaters come in _____ watt sizes.

   A. 800 and 1,000

   B. 1,000 and 1,200

   C. 1,000 and 1,400

   D. 1,200 and 1,400

2. The energy cut-off switch is usually preset at _____.

   A. 110°F (43°C)

   B. 150°F (66°C)

   C. 175°F (79°C)

   D. 180°F (82°C)

3. Pipe connections should only be made using proper pipe sealant.

   True False

4. The thermostat on some electric water heaters sense water temperature by _____.

5. You need to find out the amperage of a customer's water heater. You can determine the amperage without using a ammeter by _____.

6. Most water heaters are insulated to hold water temperature longer. List the two insulation materials most often used.

   A.

   B.

7. When replacing a water heater on/off switch, the switch must be rated high enough to match, or preferably, exceed the amperage rating of the _____.

8. An under-rated switch can cause _____.

   A.

   B.

   C.

9. List the electrical components of 120 VAC water heater.

   A.

   B.

   C.

   D.

10. You are checking the heating element. There is voltage to the heating element but there is no current draw. This means _____.

    A. the heating element is closed

    B. the heating element is open

    C. the thermostat needs replacement

    D. the heating element needs replacement

11. Another way to check the heating element is to check resistance. After the power has been turned off and the wires disconnected from the heating element, you can check the resistance. The water heater is a 120 VAC, 1000-watt heater. What is the correct resistance?

    A. 16.8 ohms

    B. 8.33 ohms

    C. 14.46 ohms

    D. 9 ohms

12. A heating element should be replaced if it has an open or shorted condition.

    True False

13. Always replace a heating element with one of the same or higher wattage rating.

    True False

14. List three possible locations that you can find the electrical wiring diagram for a water heater.

    A.

    B.

    C.

15. When installing a new electric water heater, which of the following are concerns to consider?

    A. Is the existing venting adequate?

    B. Is the heat generated adequately dissipated?

    C. Is the existing wiring adequate for the new water heater?

    D. Is the existing circuit breaker adequate for the new water heater?

16. List two possible causes of the water being too hot.

    A.

    B.

17. What is the easiest way to confirm the temperature of the water?

Chapter

3

Manual Pilot Ignition Water Heaters

- Identify related terminology.
- Identify components and their function.
- Diagnose common operational problems and determine possible causes.
- Repair and/or replace faulty components.
- Verify the proper operation of the manual pilot and heat ignition system.
- Determine interchangeability of models.
- Determine AC and DC electrical requirements and connect.
- Determine propane requirements and connect.

3-1 History and Overview

3-1.1 Application

A common water heater used on RVs is the pilot model. By heating water with propane that is supplied from the RV's propane tank, the true concept of mobility with hot water for the RV consumer is realized. The propane water heater originally was designed as a miniature residential water heater. When propane is burned, exhaust gases and heat must be vented outside which made this design very awkward and inconvenient in an RV. The water heater manufacturers designed a special water heater that better fit the installation requirements in the RV. It has an exterior that mounts to a sidewall of an RV and sits on the floor or other support plate. It is sealed off from the inside of the coach, but completely vents to the outside, including combustion and exhaust air. Even if the water heater has a problem and the P&T relief valve opens, it is also on the outside, minimizing any damage the water could do to the RV. The controls on this water heater are basically the same as used in residential homes. Any fuel-burning appliance installed in an RV should be listed for RV use (ANSI/NFPA 1192 5.4.1- CSA Z240 5.1.1).

3-1.2 Advantages and Disadvantages

The advantages to this water heater are that it uses relatively little propane to operate, uses no electricity from the RV, unless a reignitor is used, and is compact. Disadvantages are that the consumer must turn the water heater on and off from the exterior of the vehicle. The pilot flame must be lit while the safety button is pushed to establish millivolts at the

thermocouple for the valve to work. High winds can sometimes extinguish the pilot flame, causing nuisance outages.

3-1.3 Energy Sources and Power Consumption

The Btu/hr consumption is indicated on the data plate of each water heater along with the recovery rate, so that propane consumption can be computed on the basis of average usage. The pilot model is offered with 120 VAC and engine assist heat exchanger options.

3-2 Sequence Of Operation

The pilot model water heater is the same for all models and manufacturers. The lighting procedure and sequence of operation are also the same. The water heater must be supplied with 11" (nominal) water column of propane pressure in order to work. This appliance with pilot ignition must depend on the RV's main propane regulator to provide a constant supply and pressure. The first step in lighting the water heater is to place the control knob in the pilot position. Different valves have different positions but all do the same thing. The reset button or dial is used to manually allow propane through to the pilot burner. The probes out of the back of the valve are inside the water tank to sense water temperature and are installed with pipe threads on the water heater control back. Both valves have propane inlet fittings on the left side and the outlet to the burner orifice is at the bottom.

The sequence of operation of a pilot ignition water heater:

1. Pilot flame established.
2. Set thermostat to desired temperature.
3. Thermostat senses low water temperature.
4. Thermostat opens gas valve.
5. Main burner lights.
6. Water heats.
7. Thermostat sensing tube senses desired water temperature (thermostat satisfied).
8. Thermostat closes gas valve.
9. Main burner shuts off and standing pilot continues to burn.

The cycle is repeated whenever the thermostat senses an inadequate water temperature.

10. Turn on valve.

11. Set temperature.

3-2.1 Pilot Flame Established

To light the pilot, the control knob must be turned to the pilot position. There are three common control valves as shown in Figure 3-1 (Robertshaw), Figure 3-2 (SIT) and Figure 3-3 (Jade.) In the case of the Robertshaw control valve, the reset button must be pushed. The other control valves have the "button" built into the control knob. The consumer must turn the Jade control knob to pilot and hold it a little beyond the pilot marking on the knob. They are spring-loaded, so it must be held there. It must be held in this position until the pilot flame has been lit and established (air purged and the flame is steady). After approximately 30 to 45 seconds, the button or knob can be released, leaving the knob in the pilot position or the button will pop back up. If the pilot flame goes out, the procedure must be repeated until the pilot stays on without holding the button or knob. The reason the button or knob must be held is that when the pilot flame is established, the flame engulfs the thermocouple in the pilot burner assembly.

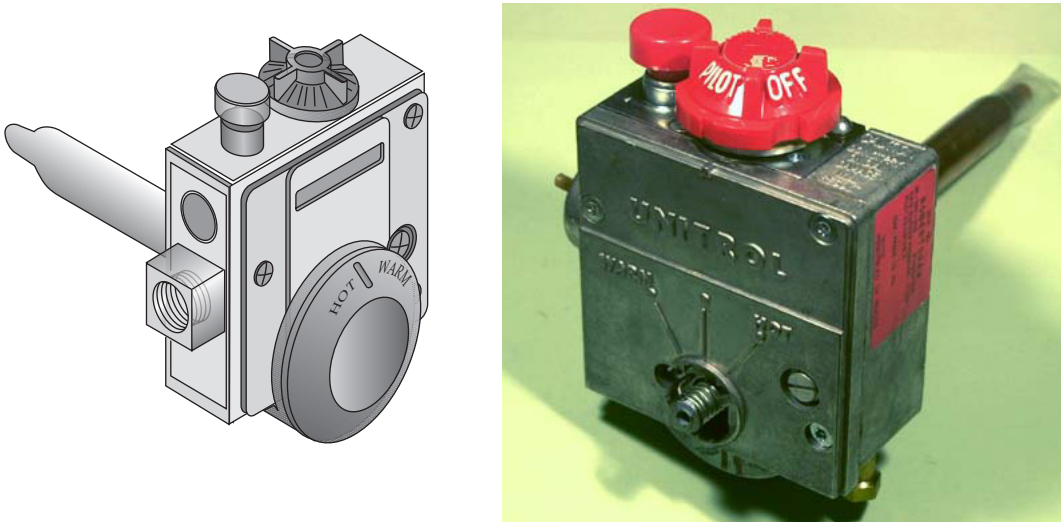


Figure 3-1 *Robertshaw Control Valve*

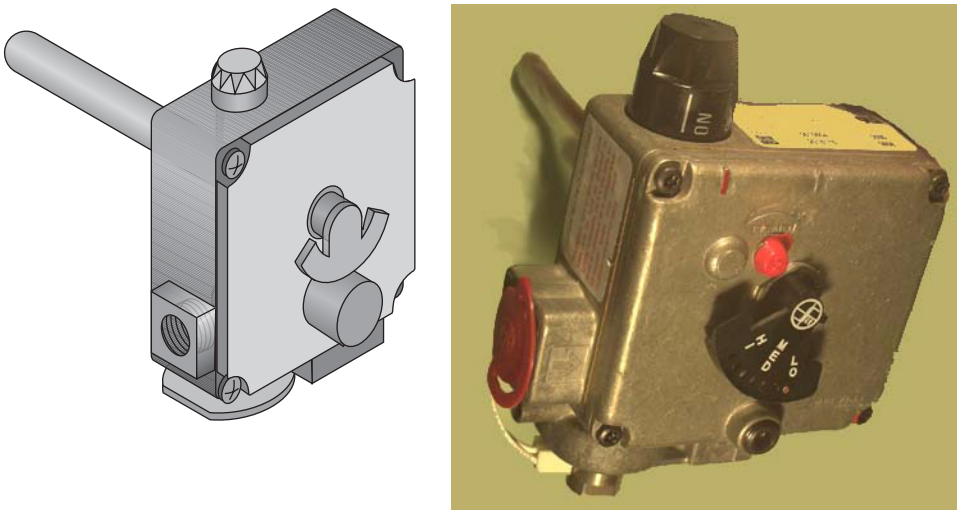


Figure 3-2 *SIT Control Valve*

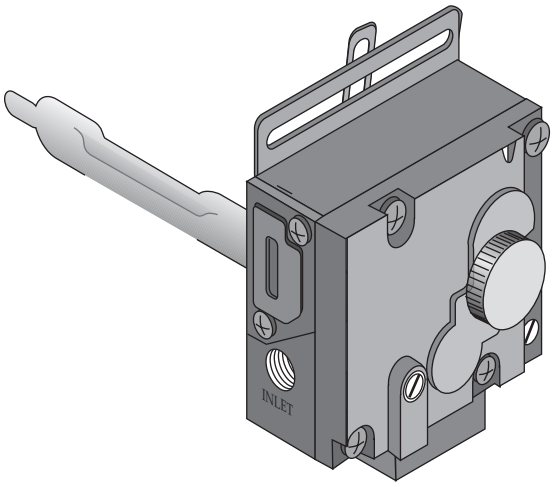


Figure 3-3 *Jade Control Valve*

Figure 3-4 shows a pilot burner assembly with a flame engulfing the thermocouple. There are many variations of this pilot assembly, but all work on the same principle. The pilot flame must engulf the thermocouple. When heat is applied to the thermocouple, it generates a millivolt output. Dissimilar metals inside the thermocouple will generate electricity (millivolts) by reacting with each other with the application of heat. About 12 millivolts (12mv) is the minimum output that should be allowed. When the millivolt output from the thermocouple exceeds 12 mv, a coil of wire inside the water heater control creates a magnetic field that is strong enough to hold a plunger open against a spring. This plunger is what the button or knob is opening when initially lighting the pilot flame. It is important that the consumer or technician push the button all the way down or hold the knob all the way over so that the magnet can make contact with the plunger. The magnet will not open the valve, it will simply hold it open when 12 millivolts are applied. This allows propane to pass through the valve to the pilot assembly for a continuous flow of propane to the pilot.

If a pilot cannot be established after several attempts, a likely cause would be a defective thermocouple. The thermocouple should be checked for proper output.

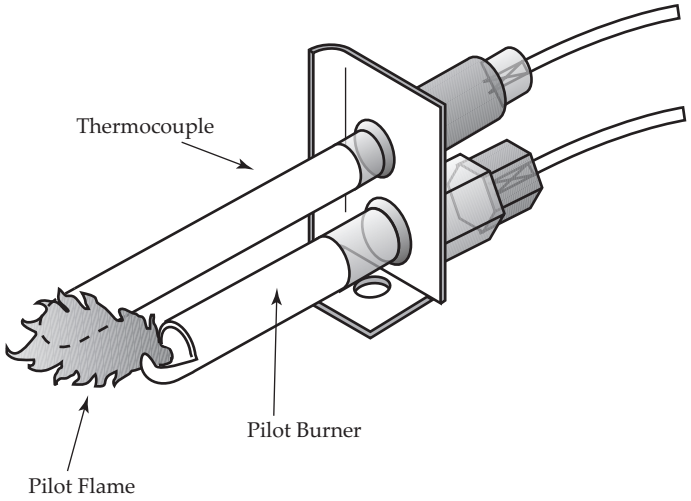


Figure 3-4 *Pilot Burner Assembly*

3-2.2 Set Temperature

After the pilot is established, the control knob can be set to the ON position. This will allow propane to flow through the thermostat valve to the main burner. The thermostat control is a round knob on the Robertshaw and Jade control valves and a triangular knob on the SIT control valve. By moving the thermostat control in either direction, the consumer can select from a warm temperature, a minimum 120°F (49°C), to a high of 150°F (66°C). Temperature settings of the thermostat will vary with consumers, so the normal setting should be the starting point for the desired temperature setting.

3-2.3 Thermostat Senses Low Water Temperature

The thermostat control will turn the main burner on or off depending on what temperature it senses from the probe inside the tank.

3-2.4 Thermostat opens gas valve

When the thermostat calls for heat, propane will flow out of the bottom of the valve, through an adaptor fitting, the main burner orifice, to the burner tube where air is mixed with the propane.

3-2.5 Main burner lights

It will be ignited by the pilot flame at the end of the main burner tube as shown in Figures 3-5 and 3-6.

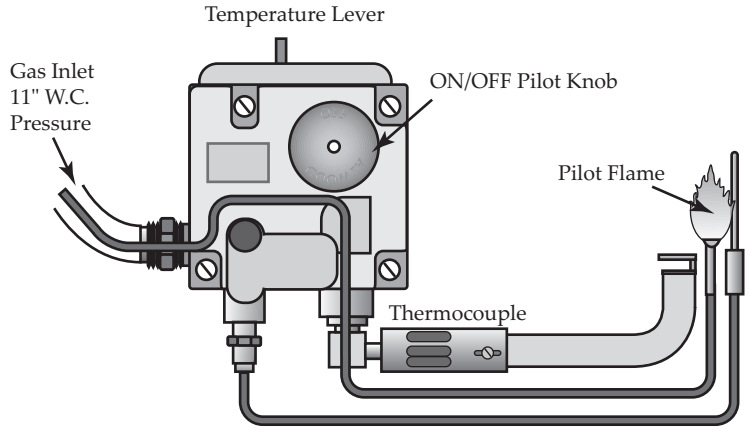


Figure 3-5 *Pilot Sequence of Operation*

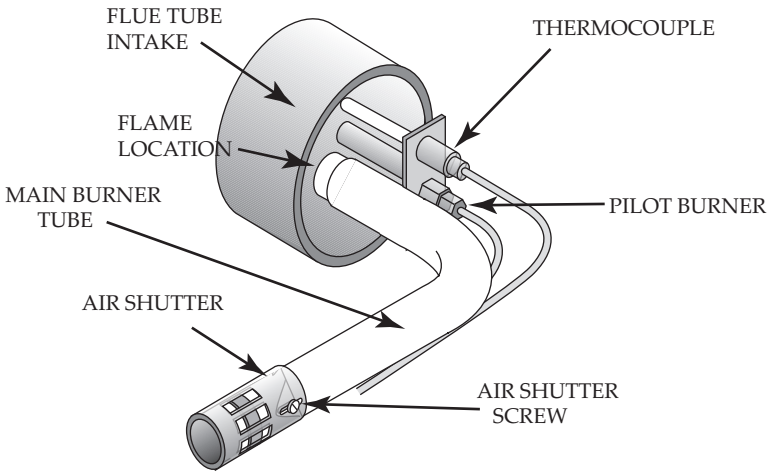


Figure 3-6 *Main Burner and Pilot Assemblies*

3-2.6 Water Heats

The flue acts as a heat exchanger between the main burner flame and the water in the tank.

3-2.7 Thermostat satisfied

Water reaches desired temperature.

3-2.8 Thermostat closes gas valve

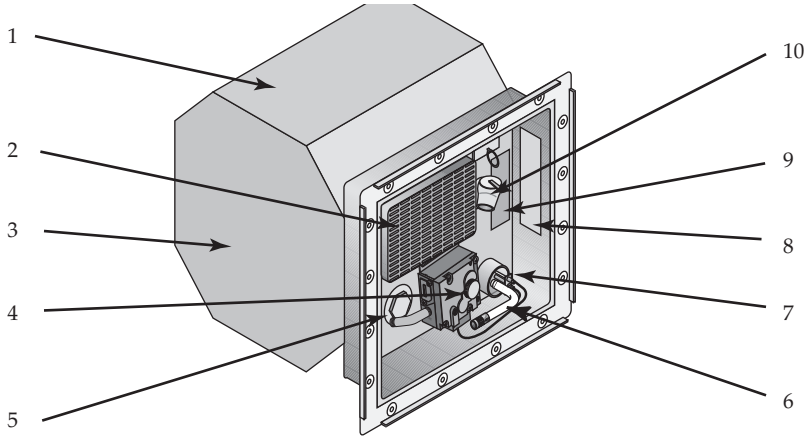
After the water reaches the desired temperature, the gas valve shuts off the flow of propane to the main burner.

3-2.9 Main burner shuts off and the Standing pilot continues to burn.

3-3 Components - Functions, Locations, Testing and Interaction

3-3.1 Data Plate

The data plate on pilot models will be inside the exterior cover on the housing of the water heater. This data plate will give you model number, specification numbers (if applicable), serial numbers, Btu/hr input and/or output, size, recovery rate, and miscellaneous information. Again, this data-plate will be the key to ordering parts, interacting with the manufacturer's representative and servicing the appliance. This plate's typical location is illustrated on Figure 3-7 along with other components of the water heater.



ITEM	DESCRIPTION
1	Jacket
2	Flue Box Assembly
3	Inner Tank
4	Thermostat
5	Drain Plug
6	Main Burner
7	Pilot Assembly
8	Data Plate
9	Instructions
10	Relief Valve
N/S	Exterior Access Door

Figure 3-7 *Data Plate Location*

3-3.2 Propane Thermostat Control

The propane thermostat control is a self-contained unit that has multifunctions. It allows propane to enter and divides it to flow to the pilot burner and to the main burner. It senses water temperature and responds to it, and has a E.C.O. that will not allow the water temperature to exceed 180°F (82°C) in the event of the thermostat failing. This protects the appliance and the consumer. As explained in the sequence of operation section, the valve monitors the pilot flame and operates the main burner flame. The thermocouple must provide voltage to the safety valve built into the control to keep the propane flowing to the pilot burner. If the pilot flame should somehow extinguish, voltage will diminish and the spring-loaded safety valve will close, shutting off the propane to the pilot and main burner. The thermocouple is screwed into this safety valve on the control. When screwing in the thermocouple to the control, do not tighten too much. When the nut reaches bottom, tighten 1/4 turn further and stop. This is an electrical connection, not a propane connection. Included in the fitting in the valve is a piece of plastic. On each side of the plastic is a metal

strip or wire. This wire is connected to the E.C.O. switch built into the control. This E.C.O. is a one-time switch or connection. If the control ever fails to shut off the main burner, or any other source of heat allows the water temperature to rise to 180°F (82°C), the E.C.O. switch will open permanently. When the E.C.O. opens, it opens the millivolt circuit and the safety valve inside no longer has power to operate the magnet and shuts off the propane to the pilot and main burner immediately. Verify E.C.O. operation by performing a continuity test, see service manual for proper procedures. Obviously, this mandates the replacement of the control assembly. This control cannot be taken apart and repaired, especially since there are no gaskets or replacement parts available.

There is an adjustment on some water heater controls to adjust the pilot flame. It is a minimal adjustment and must be used with caution, as the adjustment screw could accidentally come out or leak. Figure 3-8 shows the pilot adjustment location on the Unitrol or Robertshaw control. There is a cap with an O-ring on it to remove before access to the screw is obtained. Be sure to replace the cap, as this seals the valve for leaks in case the adjustment screw leaks. Figure 3-8 also shows that the Robertshaw and Jade adjust in the opposite direction to raise the pilot flame. Again, this adjustment is minimal and rarely has to be used. Newer controls have eliminated the pilot adjustment feature. Be aware that if the pilot flame is adjusted too high, it can blow the one-time E.C.O. in the valve. If planning to adjust the pilot flame, first check the pilot orifice for cleanliness and for proper propane pressure input. All these valves will also have a propane access port fitting (1/8" ID) to measure output pressures from the valve while the valve is in operation.

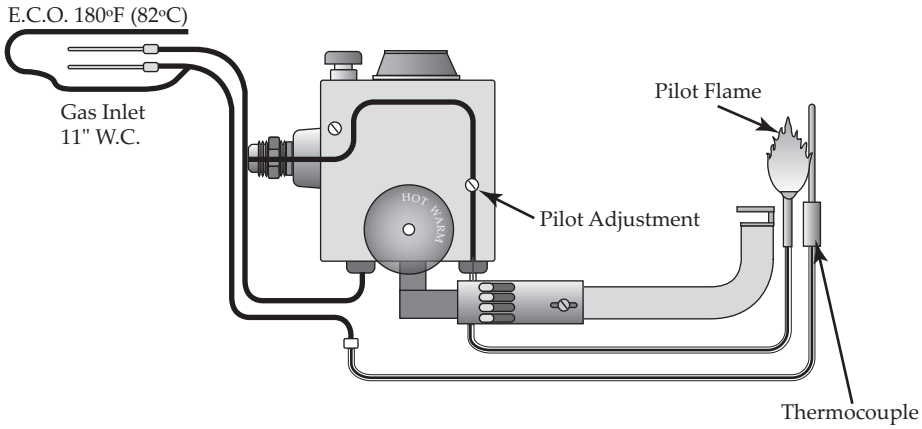


Figure 3-8 *Sample Pilot Adjustment*

Sometimes the valves will become corroded from moisture and passages will clog or close. In these instances, measuring the output pressure tells the technician that there is no restriction through the valve. The access fittings are usually located at the bottom portion of the valve near the main burner fitting. Figure 3-8 also shows the E.C.O. loop from the thermocouple to the control. The actual E.C.O. sensor is built into the probe that protrudes into the tank. The wires to the thermocouple fitting can be seen at the back of the control when it is removed. Propane controls are manufactured in various configurations. The primary differences are fitting types and sizes. Care must be taken to match fittings and provide leak-free propane connections. Only pipe threads require the use of sealant or thread tape.

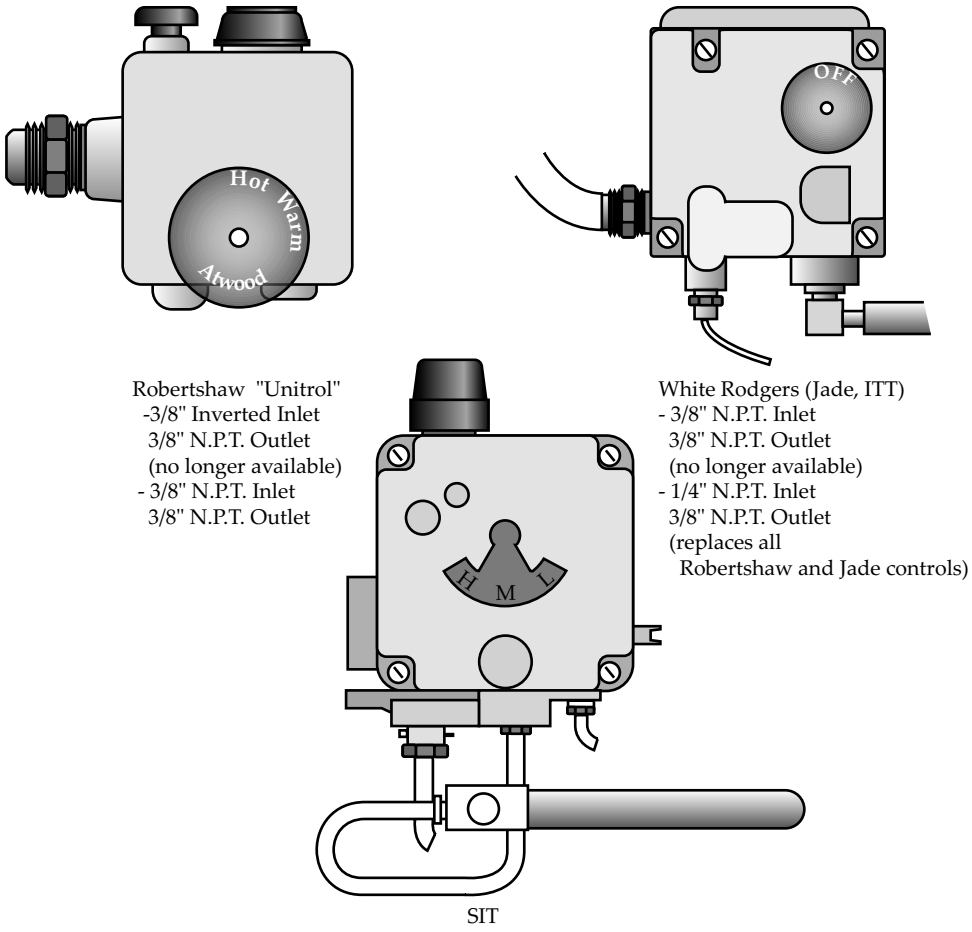


Figure 3-9 *Input/Output Fitting Differences*

Be sure that the appropriate valve is used with the proper fittings and the rest of the valve looks exactly the same. The propane thermostat control wrench is a necessity when removing or replacing this control. It becomes very difficult to remove, especially after it has been in the water heater for a period of time, as corrosion tightens the seal at the pipe fitting in the back. This pipe fitting is male and is secured very tightly to insure that there are no water leaks. When water pressure is applied from the pump, the pressure is about 40 psi (276 kPa). However, when the water is heated, the pressure becomes much higher. When replacing a water heater control, always observe the position of the valve in relation to the case. Many valves will be at an angle to horizontal. The alignment of the main burner orifice to the burner assembly is critical as shown in Figure 3-10. The adaptor fitting on the output of the control is usually a 90 degree fitting and the orifice screws into it. The main burner slides over this adaptor and alignment is very important for smooth burning and ignition. If the fitting does not line up with the burner, rotate the control until it does. Again, before removing the old control, observe the orientation of the valve to see approximately where it will be reset with the new one, or adjustment of the old one to improve performance and/or problems addressed in the troubleshooting section.

A control can be checked to see if the temperature adjustment is working. With the water heater off and the water cold, move the lever or knob from one side to the other. A clicking or snapping noise should be heard in each direction. This indicates the ON and OFF positions and the thermostat are working. However, the temperature setting may be way off, in which case a thermometer must be used to measure the temperature. Another problem that may occur is where a large temperature spread exists between ON and OFF. If

a complaint is made that the temperature heats up properly, but the water gets almost cold before it comes back on again, the control may have a large temperature spread between ON and OFF and the control needs to be tested with a thermometer to test the ON and OFF settings. If this temperature spread is noted between the ON and OFF settings, replacement of the control will be necessary as there are no adjustments for temperature spread.

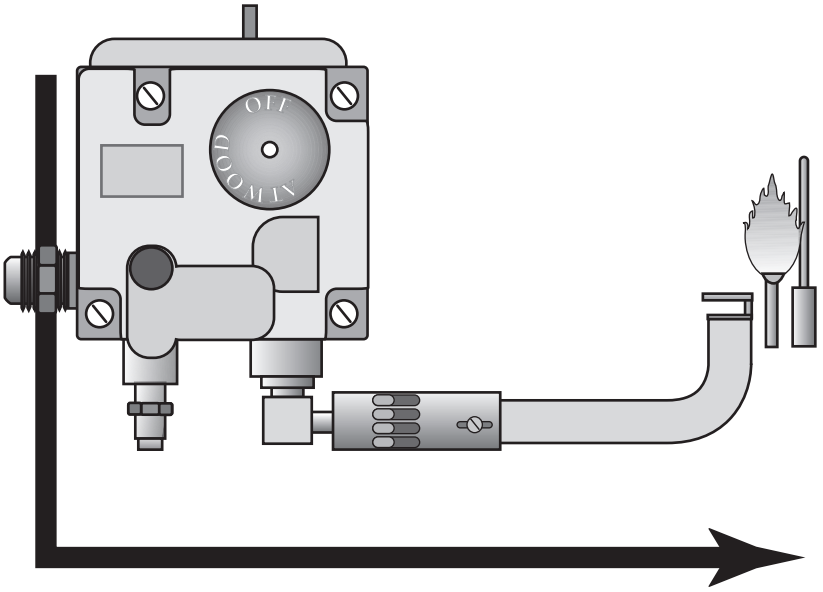


Figure 3-10 *Main Burner Orifice Line up*

3-3.3 P&T Relief Valve

The P&T relief valve has been addressed in the electric water heater section and there are no differences in the operation and/or problems with them between the types of water heaters. As a reminder, always refer to the tag on the P&T relief valve when replacing them to insure the proper ratings for pressure and temperature.

3-3.4 Water Fittings

The water fittings on the water heater tanks are female pipe threads. The aluminum tank can easily be cross-threaded when installing fittings therefore caution should be exercised. Turn the fittings several times by hand before using a wrench. By doing this, you insure that the fittings are being threaded properly. Again, the hot water fitting is located at the top portion of the tank and the cold water fitting is located at the bottom portion. Sealant or thread tape must be used, and only applied to on the male pipe threads of fitting connections.

3-3.5 Pilot Safety Assembly

The pilot safety assembly varies by manufacturers and models. The purpose and operation remain the same. The pilot safety assembly contains a pilot burner, an aluminum tube

(with compression fittings) to connect to the control and the pilot burner, a pilot orifice, a thermocouple, and a bracket it all fits into. The bracket will attach to the main burner assembly. Typical assemblies are shown in Figure 3-11.

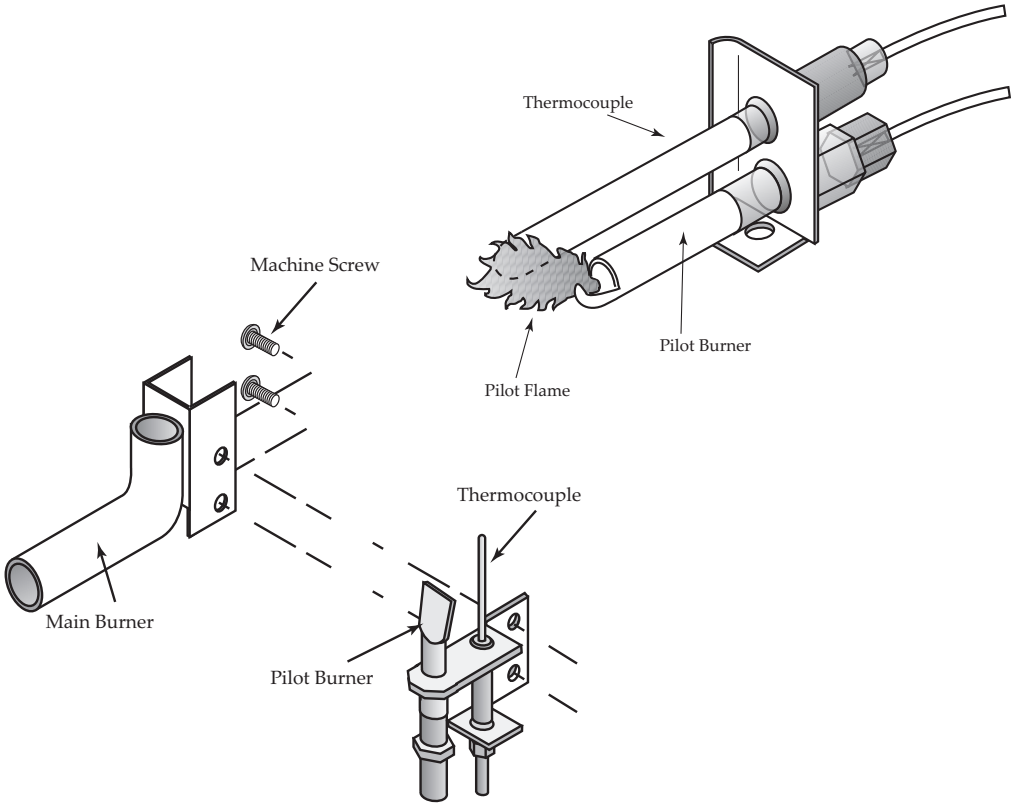


Figure 3-11 *Typical Pilot Safety Assemblies*

3-3.5.1 *Pilot Burner*

The pilot burner has the pilot propane line attached through a compression fitting. Propane flow and pressure are controlled by a very small orifice.

Note: Never insert a probe, drill, or anything similar into orifice openings as they could easily be damaged and allow too much propane to come through, melting down the thermocouple or blowing the E.C.O.

Three different types of orifices are shown in Figure 3-12. The Jade, Robertshaw and Baso are stainless steel sleeves that have a small orifice hole at the top in the center. At the base, the fittings are flared. This allows the compression nut to seal against one side of the orifice and the other side against the nut, insuring a vaportight seal. The Baso fitting has a male thread that fits into the pilot burner and the female compression portion is at the bottom of the hexagon fitting into which the tubing, compression ring, and male flare fitting are screwed. When cleaning these orifices, use a alcohol-type solvent or cleaner with a brush or low pressure compressed air. Compressed air used for computer cleaning is desirable. If it will not clean, replace it with a new one, never insert a probe, drill, or anything similar into the orifices.

Note: Always check for propane leaks with an approved leak detector solution or electronic leak detector anytime the fittings have been opened or connected.

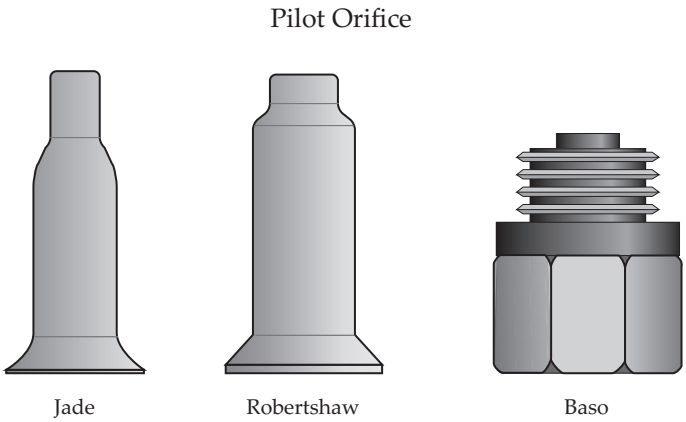


Figure 3-12 *Orifice Types*

Older pilot assemblies used a 1/4" aluminum tubing for the pilot burner. Newer models have reduced this line to 1/8". Various pilot assemblies in use are shown in Figure 3-13. The pilot flame is usually blue and orange. The flame should completely engulf the tip of the thermocouple to insure the proper millivolt output. It should also be large enough and close enough to the main burner flame to ignite the main burner without needing to "jump". Adjustment may be necessary to insure good main burner ignition. The pilot assemblies usually have a very solid mount and fit that insures proper orientation of the pilot assembly, thermocouple, and main burner. Spiders are a very common problem with pilot water heaters. Many spiders are attracted to the scent of propane that is residual in the pilot and main burners of the water heaters. If a spider creates a web inside the pilot burner or housing, the flame becomes very yellow and sometimes will burn through the air hole on the pilot burner housing just after the orifice. To remove the web, the assembly must be disassembled and thoroughly cleaned. The assembly is attached to the flue housing with sheet metal screw(s) and the thermocouple and pilot tube are screwed into the control. The main burner slides over the main burner orifice and will slide off when everything else is disconnected. Pipe cleaners are useful to clean some of the pilot burner assemblies. The pilot hole is too small to get back through the tube so the web can be located anywhere from the orifice to the end of the burner.

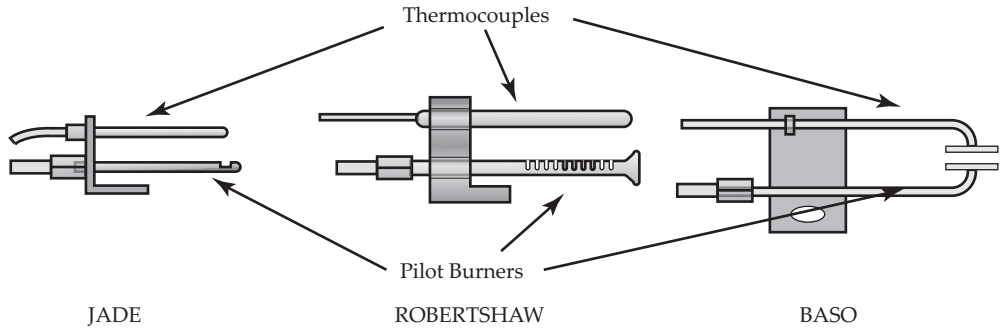


Figure 3-13 *Safety Pilot Assemblies*

3-3.6 Thermocouple

The thermocouple is a very important component. It must create a minimum of 12 millivolts by having a flame applied to its tip. The thermocouple has a tip on it that is connected to a small housing which will allow it to snap into a clip mounted into the pilot assembly. The housing has a tube coming out of it that contains a metal inside it, insulated from the outer tube. The other end has a screw fitting or nut that slips over the tube, and the inner metal has a nub soldered to it. The inner metal and outer tube are insulated from each other, since voltage is being produced and applied at the other end to the safety valve.

A thermocouple tester can be used to test the thermocouple or it can be tested for millivolt output with a VOM. To test either way, the end of the thermocouple must be disconnected from the water heater control. The tester can be attached and the pilot lit until the button on the tester stays down. Hold the flame for at least 30 seconds and then turn off the pilot flame. The tester button should stay down (simulating the safety valve in the control) for at least 30 seconds, after which it should pop back up.

To test with the VOM, disconnect the thermocouple from the water heater control and place one lead on the outer tube and the other lead on the tip of the thermocouple. Light the pilot flame and monitor the millivolts. If the meter starts to swing to minus reading, reverse the leads of the meter on the thermocouple. As the tip gets hotter, the voltage should rise, possibly to 30 millivolts. Keep the pilot flame on until the voltage stops increasing. After the pilot flame is shut off, continue to read the voltage. The voltage will gradually decrease as the tip of the thermocouple gets cooler. Low voltage readings around 12 millivolts or a tester that pops in less than 30 seconds indicate a weak thermocouple and it should be replaced. Make sure it is completely engulfed in the pilot flame and the contact on the end of the screw in terminal is clean and tight. The nut makes one connection and the center of the tube makes the other connection. Make sure both are clean and tight. Sometimes, if a dirty pilot flame (yellow) has been on, the thermocouple may have a coating of black soot or carbon on its surface. Use steel wool to remove this, as it acts as an insulator and the flame cannot heat the thermocouple enough.

3-3.7 Main Burner, Orifice and Air Shutter

The main burner assembly, as shown in Figure 3-14, has variations from different manufacturers. However, the principle and operation are the same. A main burner consists of a mounting bracket, pilot assembly mounting bracket, a flame spreader, an air shutter, and the burner tube itself. Alignment of the burner tube with the flow of propane out of the main burner orifice is very important and often overlooked. The air/fuel mixture is very important on water heater burners. Adjustment of the air shutter open (more air) will make the burner sound like a torch. Closing the air down will cause a yellow flame which will cause soot through the flue tube. The flame should be adjusted so that the flame turns yellow and then back the shutter off until a blue or blue with orange flame is established. Check the adjustment by turning the main burner on and off a few times with the temperature control as shown in Figure 3-15 and Figure 3-16. One manufacturer (Atwood) recommends a 1/4" (0.6 cm) opening as an adjustment. Spiders like the odor of propane present in this burner tube and often build webs inside them, sometimes very transparent and difficult to see. To insure cleanliness, a burner brush should be run through it when a yellow flame is present and then adjust the air shutter. The burner should also point down the middle of the flue tube for good flame distribution. The end of the burner has a little plate or washer-like piece, appearing to partially block the burner. It is a flame spreader that is designed to make the flame spread to the side walls of the flue tube to increase the application of heat to the flue tube and hence to the water. It should be set parallel to the end of the opening of the

burner tube. If the flame spreader should deteriorate or break off, replace the burner assembly. Some manufacturers offer standard and high output burners for their products. The different burners are matched to a specific size orifice so care must be taken when ordering parts or interchanging parts.

Note: Always refer to the model number of water heater and to the parts breakdown to match parts.

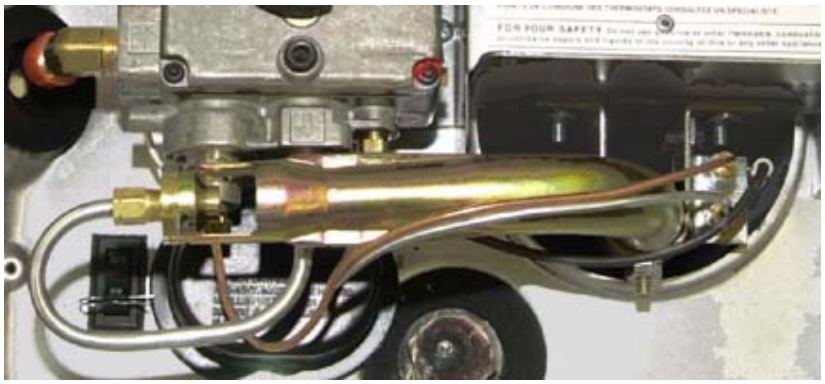


Figure 3-14 *Main Burner*

Figure 3-15 *Orifice*

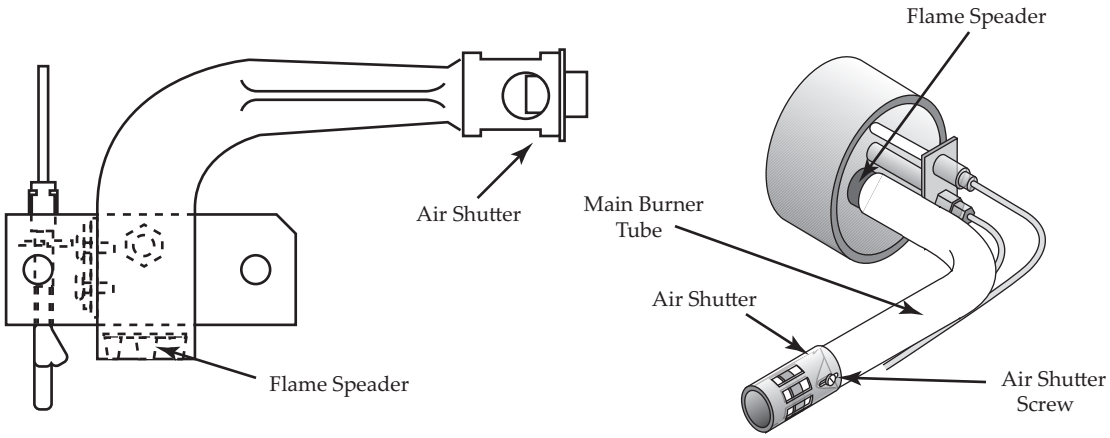


Figure 3-16 *Air Shutter and Flame Spreader*

3-3.8 Reignitor

A reignitor assembly is offered with later model water heaters and as an add-on unit for older models. It is a solid state device that is powered by the RV's 12 VDC system or a 9 VDC battery and is used to light and monitor the pilot flame on the water heater. A typical reignitor control is shown in Figure 3-17 depicting a connection for positive and negative, an on/off switch midway on the left and the electrode wire connection. This is a very high voltage that gives the spark at the electrode. Wire provided with the kit must be used because of the high voltage.

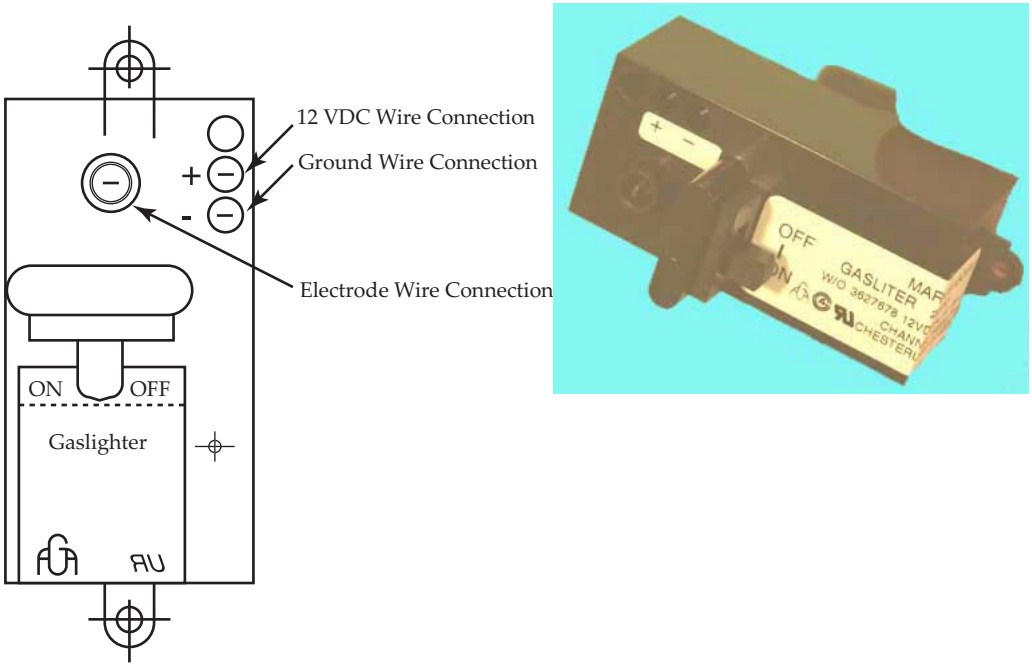


Figure 3-17 *Reignitor*

Note: Never touch the connection or electrode when the reignitor is on, as it will provide several thousand volts.

The spark produced is not continuous so the duration of the spark and the time in between sparks will vary. Each time a spark occurs, an audible tone will sound. This is a warning that the pilot has been extinguished and the reignitor is trying to re-establish the flame. The reignitor will spark and beep indefinitely until it senses the flame, the battery goes dead, or the unit is shut off. When the reignitor is turned on initially, there is no flame and the unit sparks at the electrode and beeps. The water heater control is turned to pilot and the pilot by-pass is engaged, allowing propane to the pilot burner. When propane gets to the pilot burner, the spark ignites the flame. The reignitor reads the millivolts and shuts off the spark and the beeper. Anytime the circuit is interrupted, such as when the pilot goes out or the wind distorts the flame, the reignitor senses the loss and tries to re-establish the flame by sparking and beeping. In other words, the reignitor not only provides a source of ignition for the pilot flame, eliminating the need for matches or flame ignitors, but also monitors the pilot flame to try to keep it from blowing out. The propane will continue to flow as long as the thermocouple is hot enough and this time lag for the thermocouple to cool is usually enough time for the wind to dissipate and the spark to relight the pilot flame. The reignitor assembly is usually mounted inside the water heater pan assembly, preferably not on the bottom, as water could form there and short out the module. The electrode is mounted on the pilot assembly so that after it is installed, the tip of the electrode is 1/8" (0.3 cm) from the tip of the pilot burner as shown in Figure 3-18. It is recommended that the spark is in the same plane as the propane flow to insure better ignition. The electrode and wire connection must be more than 1/4" (0.6 cm) from any metal surface so that the spark will not be produced there instead of at the tip of the electrode. Make sure the electrode is more than 1/4" (0.6 cm) away from the thermocouple since it is also made of metal. If the reignitor continues to spark and beep after the flame is established, adjustment may be necessary until the spark and beep stop. The electrode is partially enclosed in a porcelain jacket. This porcelain is very fragile, so caution must be exercised to avoid breakage. If the porcelain cracks, the spark could go through the crack to the mounting bracket instead of the tip of the electrode. Moisture will cause the reignitor to become nonfunctional.

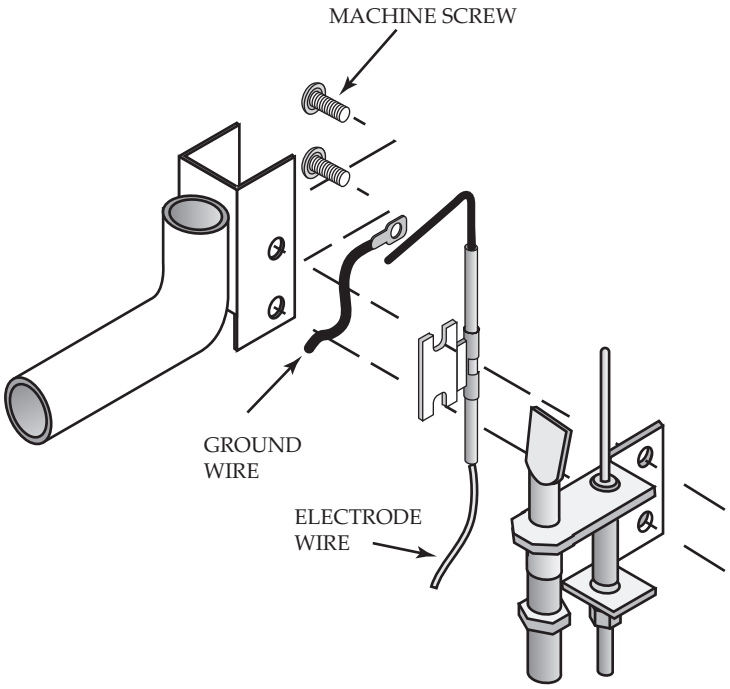


Figure 3-18 *Electrode Mounting*

3-3.9 Drain Fitting

The water heater has a drain fitting on the exterior portion at the bottom of the tank. This is for flushing and draining purposes and not for placement of aftermarket electric heating elements. Some warranties could be voided by placing these elements in the appliance. The drain fitting may be a steel plug or a plastic plug. Older units came with a drain cock installed. The drain fitting is a female pipe thread fitting so care must be taken, especially with the plastic plug, not to cross thread the fitting when reinstalling the plug. Also, be sure to use the proper pipe sealants. On Suburban models the anode rod is the drain plug. Do not remove the drain plug and reinstall a petcock. While this may make draining the tank easier, the petcock will not allow all the sediment in the tank to escape. The drainage needs as large a hole as possible to remove sediment and other contaminants that may be in the tank. On Atwood models the plastic plug acts as a final pressure safety device.

3-3.10 Combustion Pan

The combustion pan or control housing is the part of the water heater that is between the water heater tank and the controls and seals the controls to the RV interior. It may also be part of the mounting flanges for the water heater. Basically, it is a metal pan acting as a vapor barrier and fireproof barrier for the RV. When fittings, propane lines, or anything passes through this pan, it must be sealed with an approved seal ring or gasket to make sure no vapor or flame can enter the RV from the combustion area on the exterior portion of the water heater.

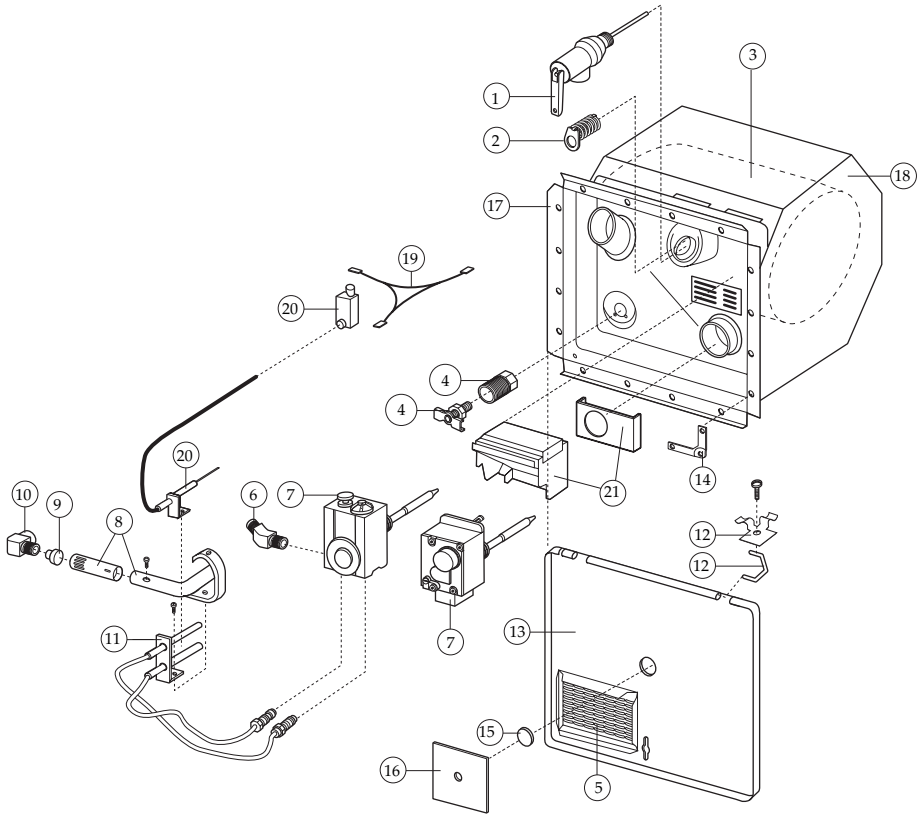
3-3.11 Tank Insulation

The tank insulation has changed through the years. Older water heaters used to have a fiberglass insulation wrapped around them covered by either a cardboard cover or a galvanized sheet metal cover. Newer water heaters utilize a styrofoam-type insulation jacket that form fits around the tank, is thicker than the fiberglass blanket, and provides better insulation for the tank, resulting in fewer cycles. The foam covers are secured by straps around them to hold them in place.

Figure 3-19 *Tank Insulation*

3-3.12 Intake/Exhaust Vent

The intake and exhaust vent is similar on the different models. They are both usually a portion of the exterior door that has a screen-type opening on them. The screen prohibits birds and some insects from entering, but allowing air to pass readily through it. The top portion will be the exhaust from the flue tube portion that allows the hot gas to escape out and up. A divider or plate will separate the intake portion to allow fresh air in for combustion. On Suburban models, insure the divider or plate (flue box) is a maximum of 1/4" (0.6 cm) from the installed door. These two air systems must be isolated from each other to keep them from mixing. The ducting of the vent also discourages winds from extinguishing the pilot or distorting the main burner by using indirect baffles to redirect the airflow. The intake/exhaust vent is shown in Figure 3-20 in part #5 and #21.



1. P&T relief valve
2. Clip and spring to hold exterior door shut
3. Water heater tank
4. Drain plug or drain cock
5. Intake/exhaust screen
6. Propane fitting - 3/8″ mail pipe thread (typical but may be different) - 45° bend
7. Propane control
8. Main burner and air shutter
9. Main burner orifice
10. Main burner orifice housing adaptor
11. Pilot safety assembly with thermocouple
12. Clips and hinge to mount exterior door
13. Exterior doors
14. Corner brackets
15. Sight window
16. Sight sealer
17. Combustion pan
18. Fiberboard jacket - Foam jacket
19. Reignitor wire harness
20. Pilot reignitor
21. Intake/Exhaust Vent/Flue box

Figure 3-20 *Water Heater Assembly*

3-3.13 Access Door

The exterior access door is a decorative cover that also serves an important function. It is usually painted to match the exterior of the RV. The door hinges at the bottom and is held closed with a clip at the top center. The door closes to prevent winds from affecting the burners while allowing the intake/exhaust vents to function. A sight glass is installed in some doors so the consumer or technician can observe the flame while in operation with the door closed. Figure 3-20 shows the components for the door assembly.

3-4 Wiring Schematics

The 120 VAC system of a pilot water heater is the same as a 120 VAC electric water heater. Refer to Chapter 2, the electric water heater section, for wiring schematics and controls. Placement of components will vary from manufacturer to manufacturer, but the controls and wiring are similar.

3-5 Installation

The sizes of water heaters will vary among manufacturers. One may not fit the other's cut-out hole if water heaters are to be interchanged. Modifications would have to be made to the hole and possibly the cabinet. The manufacturers will, however, make all of their similar capacity models the same size, whether or not they are pilot model or direct spark ignition, or whether or not they have engine assist, 120 VAC electric heating or both. Usually, labor costs will be a factor for consumers to replace their water heaters with the same manufacturer's current model, as the cabinet/wall openings will probably be the same size. Installation procedures follow the same standards regardless of the water heater's manufacturer. Always follow the manufacture's installation instructions when installing a water heater.

The pilot water heater will be installed through a hole cut through the side of the RV. It is required to be installed with a support for the water storage tank portion of the water heater inside the RV. Typically, the water heater is installed at the floor line of the RV, allowing the tank to be set on the floor so no other support is required. Care must be taken when installing a water heater over carpet or other materials. Generally, a sheet metal pan should be installed underneath and several inches around the tank inside the RV. The outside of the water heater is fastened to framing. The framing will secure the water heater pan to help seal it from the inside and allow waterproofing. Some manufacturers' instructions require additional anchoring of the water heater body inside the coach. Appropriate sealants must be used to waterproof the water heater flange, frame or casing to the RV's frame and exterior surface.

3-5.1 Cut-out Sizes

The cut-out sizes are included in the installation manual of each water heater. One manufacturer's installation dimensions are shown in Figure 3-21, but all may not be the same. In

some instances, an adaptor kit may be available for easier installations where cut-out sizes vary.

Several things must be considered when installing a water heater, especially a new one where there was none before. First, is there physical room for the water heater, both through the exterior wall of the RV and where it will be inside the RV, particularly since it needs to be inside of a cabinet. Also, thought must be given to the fact that the cold and hot water lines, must be run to the back of the water heater along with the propane line. If all conditions can be met with an appropriate location, then the water heater can be installed. The hole in the exterior of the RV is the first thing to inspect for either new installation or replacement of a water heater. Water heaters are typically installed at the floor line. This means the bottom side of the cut-out will be located so the water heater can rest directly on the floor. Additionally, there must be room inside the RV, usually in a cabinet where the tank of the water heater will be installed. The cabinet hides the water tank, the water lines, the propane line, electrical wires, and engine water lines, if those accessories were included on the water heater. All lines for connecting the water heater must be installed and run according to current codes and standards. The cabinet in which the water heater is installed should not be used for storage purposes.

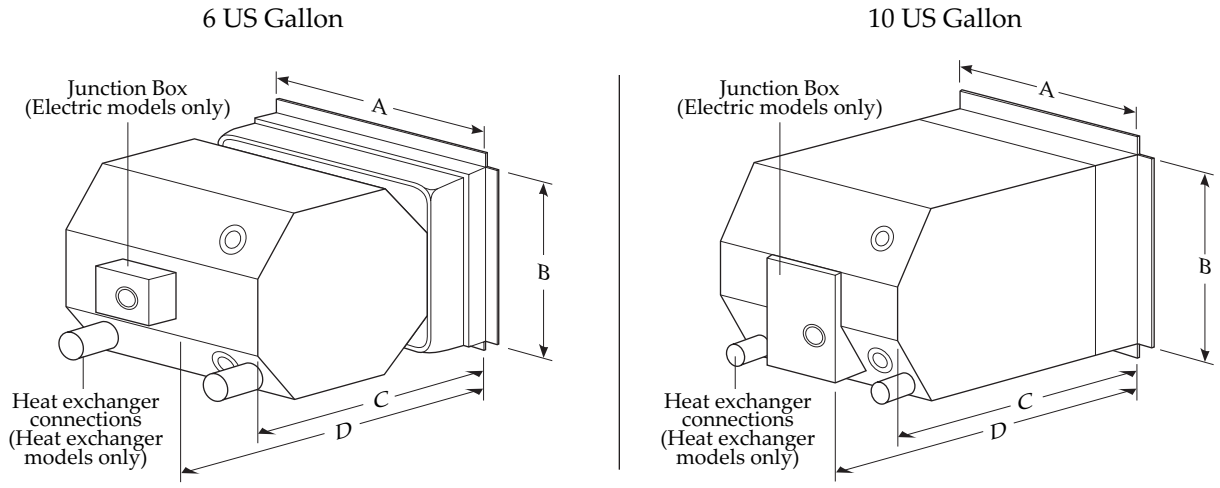


Figure 3-21 *Installation Dimensions*

3-5.2 Electrical Requirements

Electrical requirements are found in the installation manuals, along with ANSI/NFPA 1192, NFPA 70 NEC, and CSA Z240. The 120 VAC heater option makes high-voltage connections a part of installation. Since the water heater draws a considerable amount of current, a dedicated circuit breaker is usually required. Make sure the right size of wire is run, compensating for length, and all connections must be made inside an approved junction box. Low-voltage connections are made if the pilot model water heater has a optional ignitor. This would require running appropriate size wires to a battery source for positive and negative. The installation manual will list the required size and type of wire needed.

3-5.3 Access Door Installation

The outside access door is the last thing to be installed. It simply fastens to the bottom of the outside frame of the water heater with clips. These clips will act as a hinge for the

door. The door will hinge from the bottom and a rotating clip at the top of the frame will fit through a hole in the door and the clip is rotated 90 degrees to secure the door closed. The clips at the bottom will either fasten with screws, or they will clip into small brackets already on the water heater's pan.

3-6 Troubleshooting

Troubleshooting a water heater requires knowledge of the sequence of operation of the water heater. Consulting the wiring schematic will indicate the components in the circuit applicable for troubleshooting. Troubleshooting a pilot model water heater is fairly generic. All models work with the same controls, and problems will be similar. Table 3-1 shows Atwood's troubleshooting guide.Most troubleshooting methods follow the same criteria for most water heaters, even older models. Table 3-1 does not address possible propane systems problems, refer to the RV Propane Systems textbook and/or service manuals.

Table 3-1 Atwood's Trouble Shooting Guide for Pilot Water Heaters

CAUSE	SOLUTION
PILOT OUTAGE	
Propane pressure incorrect	Set inlet pressure to 11" nominal water column with two or more appliances running
Blocked U-tube	Remove obstruction
Improper main burner alignment	Re-align main burner and main burner orifice holder
Improper air adjustment	Adjust main burner air shutter approximately 1⁄4 open
Weak thermocouple	Replace thermocouple
Poor pilot flame	Clean or replace pilot orifice
Weak propane control magnet	Replace propane control
Defective E.C.O. in control	Replace propane control and check the flame, it should be high enough to engulf the thermocouple at all times
PILOT OUTAGE WHEN BUTTON OR KNOB IS RELEASED	
Thermocouple is not hot	Hold button or knob for at least 30 seconds
Thermocouple loose	Tighten connection at propane control
Weak thermocouple	Replace thermocouple

Table 3-1 Atwood's Trouble Shooting Guide for Pilot Water Heaters

CAUSE	SOLUTION
Weak propane control magnet	Replace propane control
Defective E.C.O. in control	Replace propane control
MAIN BURNER WILL NOT IGNITE	
Blocked main burner orifice	Clean or replace orifice
Main burner flame spreader out of alignment	Square flame spreader to end of main burner
Blocked main burner	Remove blockage
Improper air adjustment	Adjust main burner air shutter approximately 1⁄4 open
Blocked U-tube	Remove obstruction
Propane control out of calibration	Replace propane control
ERRATIC MAIN BURNER FLAME	
Improper propane pressure	Set inlet pressure to 11" nominal water column with two or more appliances running
Improper air adjustment	Adjust main burner air shutter approximately 1⁄4 open
Partial blockage of main burner	Remove blockage
Partial blockage of main burner orifice	Clean or replace orifice
Flame spreader misalignment	Re-align or replace main burner
Blockage in U-tube	Remove blockage
Poor propane supply	Replace propane supply
Exhaust grill blocked	Remove blockage
SMOKING AND SOOTING	
Propane pressure incorrect	Set inlet pressure to 11" nominal water column with two or more appliances running
Poor propane supply	Replace propane supply
Improper pilot flame	Replace or clean pilot orifice
Improper air adjustment	Adjust main burner air shutter approximately 1⁄4 open

Table 3-1 Atwood's Trouble Shooting Guide for Pilot Water Heaters

CAUSE	SOLUTION
Flame spreader misalignment	Re-align or replace main burner
Blocked main burner	Remove blockage
Improper main burner alignment	Re-align main burner and main burner orifice holder
Blocked U-tube	Remove blockage
INSUFFICIENT WATER TEMPERATURE	
Temperature selector out of place	Reset to desired position
By-pass levers improperly positioned	Reposition levers
Improper air adjustment	Adjust main burner air shutter approximately 1/4 open
Partial main burner blockage	Remove blockage
Improper main burner alignment	Re-align main burner and main burner orifice holder
Flame spreader misalignment	Re-align or replace main burner
Blocked U-tube	Remove blockage

Chapter 3 Review

1. A common water heater used in RV's is the _____.
2. The pilot model is offered with a optional 120 VAC, and _____ options.
3. The pilot model water heater must be supplied with _____ inches nominal water column of propane in order to work.

   A. 7

   B. 9

   C. 11

   D. 13

4. The pilot model water heater has its own propane regulator.

   True False

5. What is the minimum output allowed for a pilot model thermocouple?

   A. 6 mv

   B. 8 mv

   C. 10 mv

   D. 12 mv

6. What is the result of less than optimum output from the thermocouple?

   A. Propane flow will be prevented.

   B. E.C.O. will not function.

   C. Thermostat will malfunction.

   D. propane regulator will not open.

7. The thermostat senses water temperature on a pilot model water heater from _____.

   A. the thermocouple

   B. the E.C.O. switch

   C. a probe inside the tank

   D. the sail switch

8. List the four functions of the propane thermostat control on a pilot model water heater.

   A.

   B.

   C.

   D.

9. One a pilot model the E.C.O. is a one time function switch. Once activated the propane thermostat control must be replaced.

   True False

10. Explain what happens when the E.C.O. on a pilot model water heater is activated.

11. Only listed sealant should be used with an inverted flare fitting.

    True False

12. Which of the following is <u>not</u> an approved or safe way to clean the pilot burner orifice?

    A. alcohol-type solvent

    B. probe

    C. compressed air

    D. All of the above are safe and approved.

13. Always check for propane leaks with an approved leak detector solution or an electronic leak detector anytime the fittings have been opened or connected.

    True False

14. The 12 VDC solid state device that is powered by the RV's 12 VDC system and is used to light and monitor the pilot flame is called a _____.

    A. heat exchanger

    B. E.C.O.

    C. thermocouple

    D. reignitor

15. Water is cold and there is a beeping coming from the water heater. What is the probable cause of the beeping?

    A. Water heater access door is ajar.

    B. The propane detector is activated.

    C. The reignitor is activated.

    D. The carbon monoxide detector is activated.

16. Burner and orifice sizes are the same for all current pilot model RV water heaters.

    True False

17. The part of the water heater that acts as a vapor barrier and fire proof barrier for the RV is called the _____.

18. The flame at the main burner is yellow. What are the two most probable measures that will correct the problem?

    A.

    B.

Chapter

4

Direct Spark Ignition Water Heaters

- Identify related terminology.
- Identify components and their function.
- Diagnose common operational problems and determine possible causes.
- Repair and/or replace faulty components.
- Verify the proper operation of the automatic electronic ignition systems.
- Determine DC electrical requirements and connect.
- Determine propane requirements and connect.

4-1 History and Overview

4-1.1 Applications

The evolution of the modern RV has made the industry think of new and innovative ideas to improve products and provide more convenience for the consumer. The water heater is part of that evolution. The original water heaters were an adaptation from the residential home. They were reconfigured and made much smaller, however the controls remained identical. Today, RV owners demand appliances that are more efficient and convenient to maintain and operate.

4-1.2 Advantages and Disadvantages

In the past, consumers were required to go outside the coach, light a pilot light and set the control to operate the old pilot model water heaters. Many consumers also complained of having to light the water heater in the morning, of having to turn it off at night, as they feared the water heater's propane. They would complain the water heater kept them awake at night. The new direct spark ignition (D.S.I.) models eliminate the need to go outside the coach to start the water heater. A switch inside the RV now allows the consumer to turn the water heater on or off from inside the RV. This innovation made the water heater an easier appliance to operate for the consumer. The technician's life, however, became a little more complicated by the controls and requirements of circuit board technology. Special test equipment is now needed, such as a circuit board tester and possibly a microamp meter. The technician must now know the sequence of operation of this appliance in order to diagnose and repair it. The old pilot models had only one control which incorporated a thermo-

stat, E.C.O. switch (one use), thermocouple magnet, and an on/off propane valve all in one. If any part of that failed, the whole component had to be replaced. New water heater models incorporate up to 5 different parts, each with its own function in the system.

4-1.3 Energy Sources and Power Consumption

The new models include 12 VDC to power the water heater. The amperage to power this appliance is very small, usually about an amp, so the consumption of power is very small. However, with a dead battery, the water heater will not function. A disadvantage to the new D.S.I. water heater is that the consumer rarely inspects the main burner flame. As mentioned earlier, spiders are attracted to propane vapors. A burner could have spider webs on it and still function, causing black soot to streak up the side of the motorhome and make the water heater less efficient. Consumers should be advised to inspect the flame on the water heater each time the water heater is turned on after taking it from storage.

4-2 Sequence of Operation

To understand and diagnose a D.S.I. water heater, a technician must know the sequence of operation. 12 VDC is used at the on/off switch in the interior of the RV. This switch may be installed in a cabinet, it may be incorporated into the range hood panel, of the RV. The on/off switch will be accompanied by a red indicator light. The light is a "failure to ignite" indicator. The light may turn on when the switch is turned on, but will go out during the ignition time, typically 6 to 8 seconds. If the burner fails to light, the circuit board will sense the absence of the flame and will go into a "lock-out" mode. When it locks out, the "failure to ignite" light will once again illuminate. The light will stay on until the consumer turns the switch off and tries the ignition again. The light is designed to tell the consumer that the water heater is not functioning. Both manufacturers use this indicator method.

4-2.1 Atwood Sequence

Atwood water heaters usually follow a sequence of operation that is different from Suburban's. Figure 4-1 shows a typical Atwood D.S.I. water heater with component identification. On Atwood models, the power is routed from the on/off switch to the thermostat on the water heater. This is a normally closed (N.C.) switch that is set at a specific temperature. Older models were set at 120°F (49°C), but later models increased to 140°F (60°C). An optional variable temperature thermostat is offered as a replacement from Atwood. As long as the water temperature is less than the set temperature of the thermostat, power will continue through the thermostat to the water heater's circuit board. Newer models incorporate a fixed-temperature thermal cutoff that is designed and positioned to monitor the burner flame in case of a spider web or incorrect burner flame. If thermal cutoff is opened, it must be replaced, since the water heater will no longer ignite. The flames from a bad burner heats this component and opens it permanently. If it is OK, power is routed to the circuit board, energizing it. Some have a slight delay, then a spark is produced at the burner electrode assembly for ignition, while at the same time as the spark it implemented, power from the circuit board is sent through the E.C.O. switch and onto the propane valve. The E.C.O. switch is set at 180°F (82°C) and is located near the thermostat, but it is a separate compo-

nent. It is also a normally closed switch. After power runs through the E.C.O. switch, it continues onto the redundant valve. This insures that if the valve does not close on one valve, the other valve will close, making it a very safe component. The valve opens, and the propane flows to the main burner where the spark will ignite it. Upon ignition, the flame will engulf the tip of the electrode, especially the sensor electrode. The flame excites the electrons and about 15 microamps flow and "tells" the circuit board there is a flame and it is OK to shut off the spark and keep powering the propane valve. When the water reaches temperature, the thermostat opens, stopping the power from going to the circuit board, and shutting down the propane valve. Should the thermostat fail, the E.C.O. will open at 180°F (82°C). It will only shut down the propane valve, making the circuit board see the flame failure and it will try to reignite. Of course, it cannot because power cannot reach the propane valve. After trying to light for its ignition cycle, it will go to lock-out and the flame failure light will illuminate. Some models have reset buttons installed in the E.C.O. switch.

- 12 VDC to switch from power source
- 12 VDC from switch to thermal cut off
- 12 VDC from thermal cut off to thermostat
- 12 VDC from thermostat to board
- 12 VDC from board to E.C.O. switch and simultaneously sends 26,000 volts to the electrodes for ignition
- 12 VDC from E.C.O. switch to gas valve

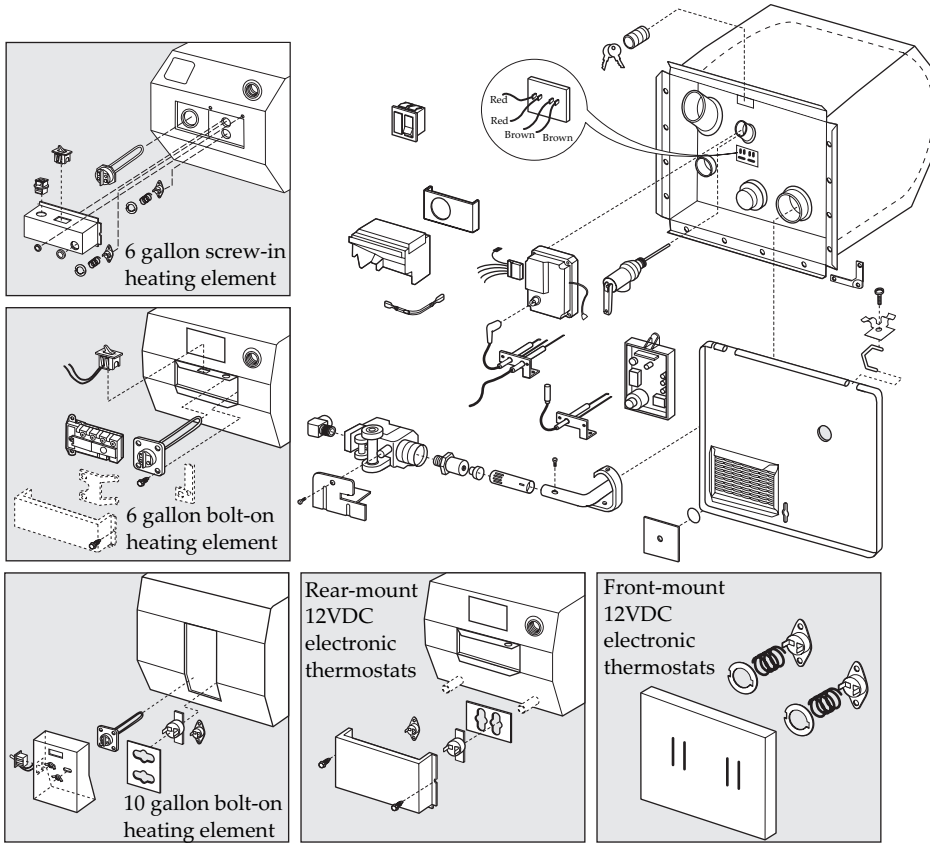


Figure 4-1 *Atwood Water Heater*

4-2.2 Suburban Sequence

The Suburban water heater differs slightly from the Atwood sequence, but the same operation is established. Figure 4-2 shows a typical Suburban D.S.I. water heater and identifies its components. Power from the on/off switch flows to the E.C.O. switch (rated the same as a Atwood, 180°F (82°C), and continues on to the thermostat. From the thermostat, power continues onto the circuit board and from the circuit board, to the propane valve. When the thermostat recognizes the water has reached the set temperature, it opens, stopping power from going to the circuit board, and the propane valve. In the event of thermostat failure, the E.C.O. switch will open, stopping power from going to the thermostat, circuit board and propane valve. This configuration will have a manual reset button installed on the E.C.O.

- The on/of switch controls the operating circuit to the water heater. If the heater fails to ignite or is in the lockout mode, the light will appear. Also, on startup and during the purge cycle, the light can appear for approximately 15-18 seconds.
- The thermostat-limit controls the power to the module board. At a preset temperature the thermostat, will open shutting off the burner. If the thermostat fails, the limit or E.C.O. switch will pen and must be manually reset.
- The ignition of the burner is controlled by the direct spark ignition. As module board power is applied to the DSI board, the system will do the following:

  1. The DSI board will delay for 5-7 seconds before ignition occurs. The board will then apply current to the gas valve and at the same time also create a high voltage current to the electrode, creating a spark for ignition.
  2. The module will then confirm the presence of a flame. If the flame is not detected within 6 seconds the module will stop the firing sequence. The DSI board will try for ignition two times, and will then go into the lockout mode.
  3. To reset the water heater turn the on/off switch to the off position for about 10 seconds and then turn back to the on position.

Note: Some DSI module boards will be single try.

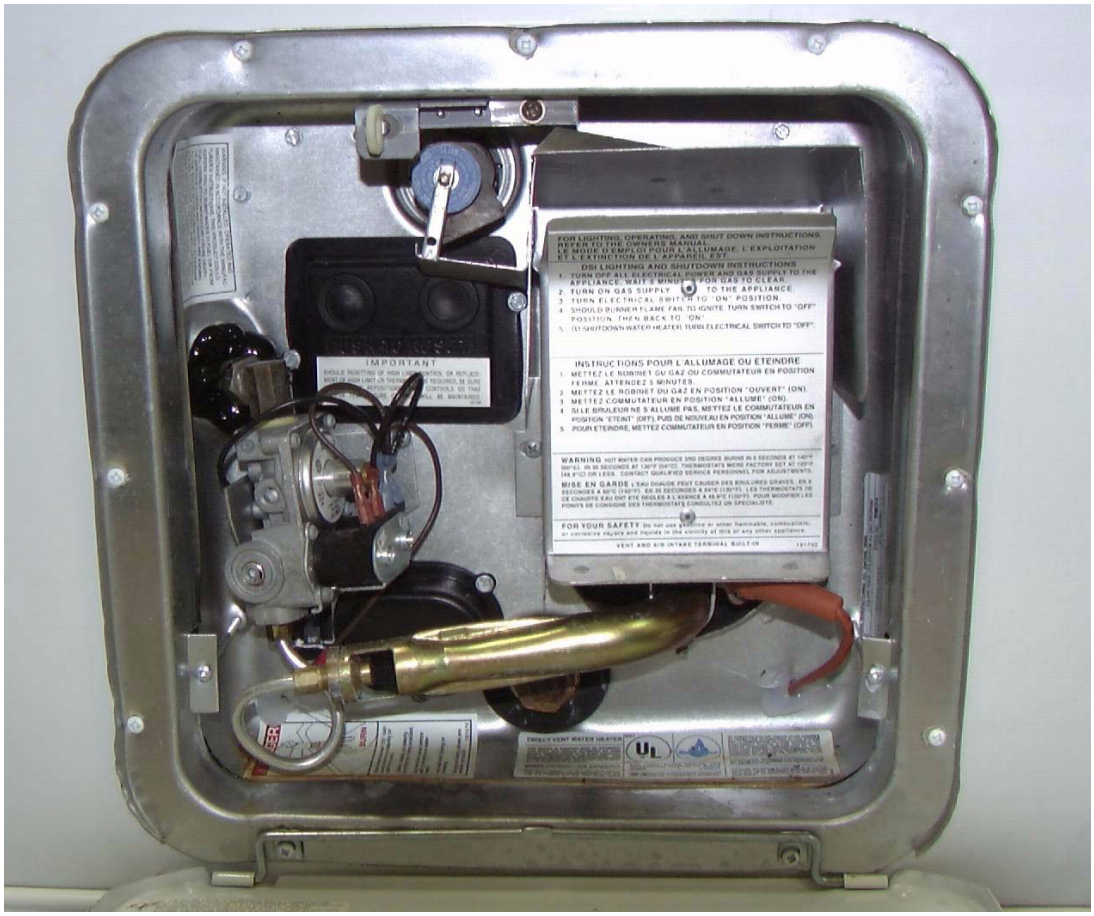


Figure 4-2 *Suburban Water Heater*

Either system incorporates a way to alert the consumer of the necessity for repairs.

4-3 Components: Functions, Locations, Testing and Interaction

4-3.1 Data Plate

The data plate on D.S.I. models will be inside the exterior cover on the housing of the water heater. This data plate will give you the model number, specification numbers (if applicable), serial numbers, Btu/hr input and/or output, size, recovery rate, and miscellaneous information. Again, this data plate will be the key to ordering parts, interacting with the manufacturer's representative and servicing the appliance. This plate's typical location is the same as the pilot model (refer to Chapter 3 Figure 3-7).

4-3.2 Power Source

The normal power source for the D.S.I. water heater is a fuse terminal on the converter. While “dry camping,” the water heater will be powered by the RV's house battery. While camping with 120 VAC hookups, the converter will supply power to the water heater. It is recommended that along with a positive wire from the converter, a ground wire is also run to the battery or converter to insure a good circuit, especially since there is an electronic circuit board in the system using a very small current, with specific voltage requirements. Additional resistance from bad or loose connections can cause damage to the water heater components.

4-3.3 On/Off Switch

The on/off switch is the control device the consumer uses to operate this appliance. As stated earlier, it is usually a rocker switch with a indicator light next to it. Figure 4-3 shows a typical water heater switch and its relationship to the water heater and battery connections. The switch will usually have 4 terminals on it, 2 terminals are for the on/off switch and the other 2 are for the indicator light. The first terminal will be for 12 VDC positive power input. On the other side of the switch, the 12 VDC power will go to the water heater. The other 2 terminals will power the indicator light. One side of this must go to ground the light. The other terminal, which will supply 12 VDC positive to the light, must come from the circuit board on the water heater. To test the switch, a VOM, on DC volts should be used to make sure 12 VDC positive are at the input to the switch, using a good ground for the other lead. When the switch is turned on, power will flow through the switch to the water heater. Removing the leads from the switch will enable the technician to use an ohmmeter to ensure continuity through the switch as an alternative test. If 12 VDC positive is at the switch, use the VOM on DC volts to test for ground at the light ground terminal. If the light is suspected of not functioning, test it by not allowing the propane to ignite, such as by disconnecting the propane valve wires. If, however, there is not voltage to the light, the wiring from the water heater must be tested for continuity and the circuit board should be tested for voltage output on the indicator light wire. If the wiring is OK and the circuit board does not provide voltage to the wire on the plug for the light, the circuit board is defective and must be replaced. The water heater must be fused somewhere in the coach before it gets to the on/off switch. Refer to the installation manual to make sure the fuse is of the right amperage rating.

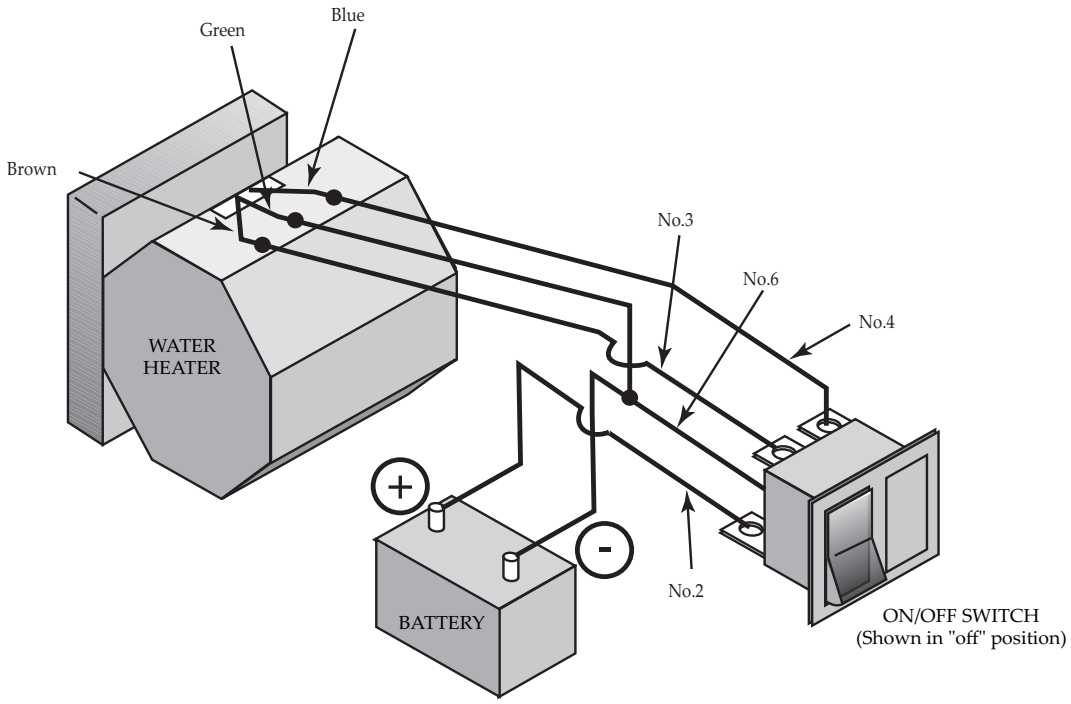


Figure 4-3 *Water Heater Switch*

4-3.4 Thermostat

The thermostat for this model water heater is an electrical heat sensor that is located on the surface of the water heater tank. The thermostat is a heat sensing switch that is normally closed and is usually clipped in a position to sense the outside surface temperature of the water heater tank. Some water heaters have them mounted on the front of the tank, while other models may have them mounted in the rear of the tank, accessible from a cabinet door or opening. These switches are relatively small and automatically reset when the temperature sensed drops to a preset range. In other words, the switch is normally closed until it reaches approximately 120°F (49°C) to 140°F (60°C). At this temperature it will open, interrupting the electrical circuit to the circuit board. When the temperature drops to about 100°F, the contacts close again, re-energizing the circuit board and engaging the heating cycle once again until 120°F (49°C) to 140°F (60°C) is reached again. To test temperature range, use a good thermometer and hold it under the P&T relief valve after the water heater has cycled off. You should see about 120°F (49°C) to 140°F (60°C). You can also test the thermostat by removing it and checking it with an ohmmeter. It should have continuity when at ambient temperature. This tests for operation, it does not test for proper operating temperature range. One manufacturer, Atwood, offers an adjustable thermostat for their models that the consumer can use to set the temperature from 110°F (43°C) to 150°F (66°C). It is the same size as the original thermostat and is easily replaced.

Note: Operating temperatures may vary between manufactures and models. Check service manuals.

4-3.5 E.C.O.

The E.C.O. or energy cutoff switch is a high temperature limit switch. These switches are similar to the thermostat switch and are located next to the thermostat when it is mounted against the tank. The difference is that these switches are set to a higher temperature, usually 180°F (82°C). Two different types have been used on direct spark ignition water heaters. One type is an automatic reset type, and the other is a manual reset type. Figure 4-4 shows a thermostat and E.C.O. switch that is the automatic reset type which was used on some of the earlier models of D.S.I. water heaters. This configuration will have the thermostat control power to the circuit board and the propane valve. If the thermostat fails, then the E.C.O. will open when the temperature reaches 180°F (82°C) and would usually just control power to the propane valve. This configuration would shut off the propane valve, and the circuit board would still be powered. It would try to reignite, resulting in a lock out condition. The red light at the on/off switch would come on, indicating a failure to light condition. The owner's manual indicates that hotter than normal water coupled with the red light on indicates a problem with the water heater, probably a failure of the thermostat.

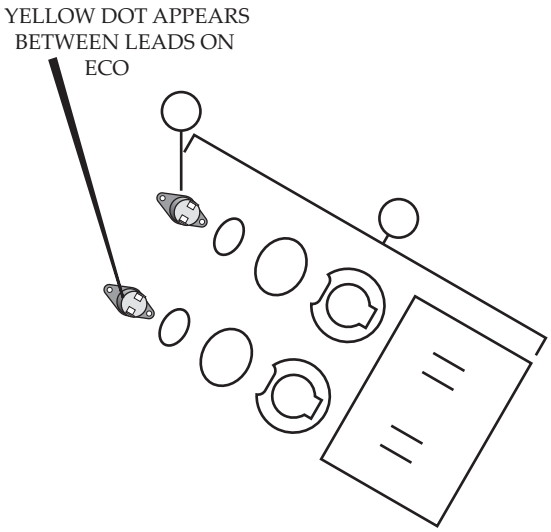


Figure 4-4 *Older Thermostat and E.C.O.*

The newer models use a thermostat with a manual reset E.C.O. switch. Figure 4-5 shows different configurations of this type with a thermostat. This type switch would trip open if the thermostat failed and the temperature reached the E.C.O. switch range. When it opens, it will not automatically reset, the consumer or technician must manually push the button at the center of the switch to reset it. This method is a better indicator for the consumer that something is wrong and service is necessary. Although failure is rare, testing is performed in the same manner as the thermostat with either a thermometer and/or an ohmmeter.

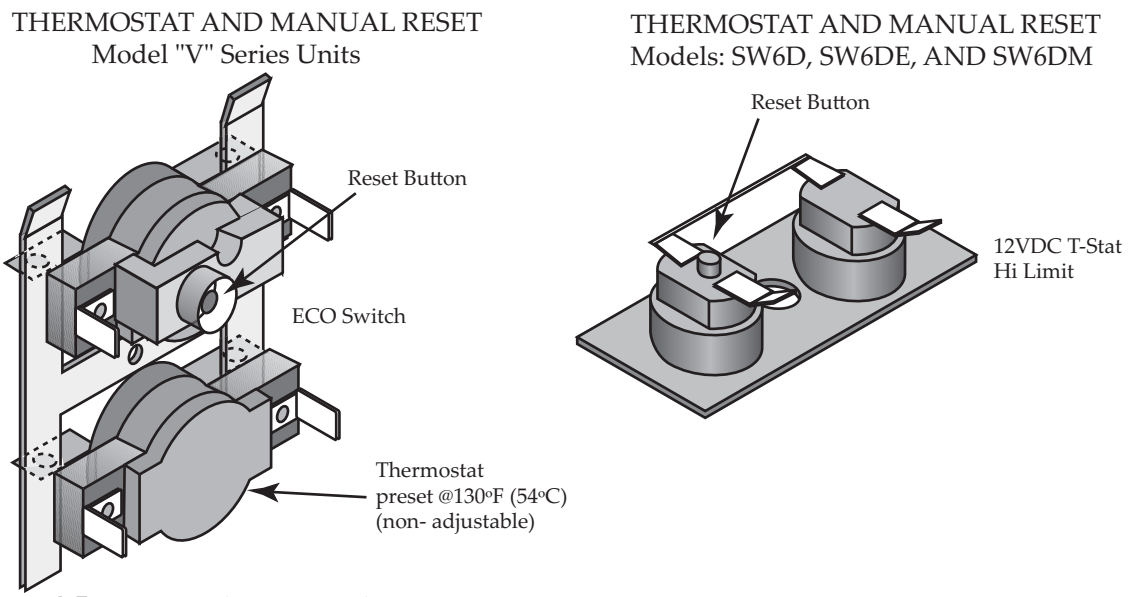


Figure 4-5 *Newer Thermostat and E.C.O.*

4-3.6 Thermal Cut-Off

Some later model Atwood D.S.I. water heaters include another safety device. This device was installed to sense excessive heat outside the burner area. This device is located on the incoming power wire and is connected to the thermostat. The thermal cut-off is designed to permanently break circuit and shut down the water heater. Excessive heat can cause damage due to obstructions in the main burner tube or flue tube caused by spiders or mud wasps. The thermal cut-off switch opens at about 190^{o}F (88^{o}C). Obstructions can cause the main burner flame to burn outside the main burner tube. When the flame or the heat from the flame contacts the thermal cut-off, the circuit will open. Test the thermal cut-off with a VOM meter, it should have continuity.

4-3.7 Circuit Board

The circuit board is the key feature of the D.S.I. water heater. There have been several models of this component as newer designs and requirements have been developed. The older versions were Fenwall boards used in many appliances in the industry such as refrigerators, water heaters, and furnaces. The boards are designed for each manufacturer's appliance to meet specifications and tolerances. Figure 4-6 shows a couple of different types. One type has a removable cover and another is a potted type where the components are not visible. The potted type avoids corrosion and/or damage from outside influences and prevents them from being rebuilt. Covers for the circuit boards are necessary to protect the boards from moisture, and other objects. Circuit boards have several functions for the operation of the water heater. When the circuit board is energized from the on/off switch and through the thermostat, it may or may not have a delay before it works. Newer models will have a slight delay and then will start sparking at the electrode while simultaneously powering the propane valve. The circuit board is designed to attempt ignition for a relatively short period, typically 6 to 8 seconds. If the flame does not ignite at the end of this period, the board will shut down the spark and power to the propane valve. The board will continue to

power the failure to ignite light at the on/off switch, telling the consumer to try again. In order to try again, the board must be shut off at the on/off switch for several seconds to give it time to reset and then be turned on again for another ignition trial. The spark provides an ignition source for the air/fuel mixture at the end of the burner assembly.

4-3.7.1 *Mounting*

The circuit boards are located in different areas. One manufacturer mounts the boards in the front, accessible from the outside of the RV, inside the water heater door. Another manufacturer mounts the circuit board in the back of the water heater. With new models, the board is mounted where it is convenient for replacement or testing inside the cabinet where the water heater is mounted. In all cases, make sure the board is securely mounted.

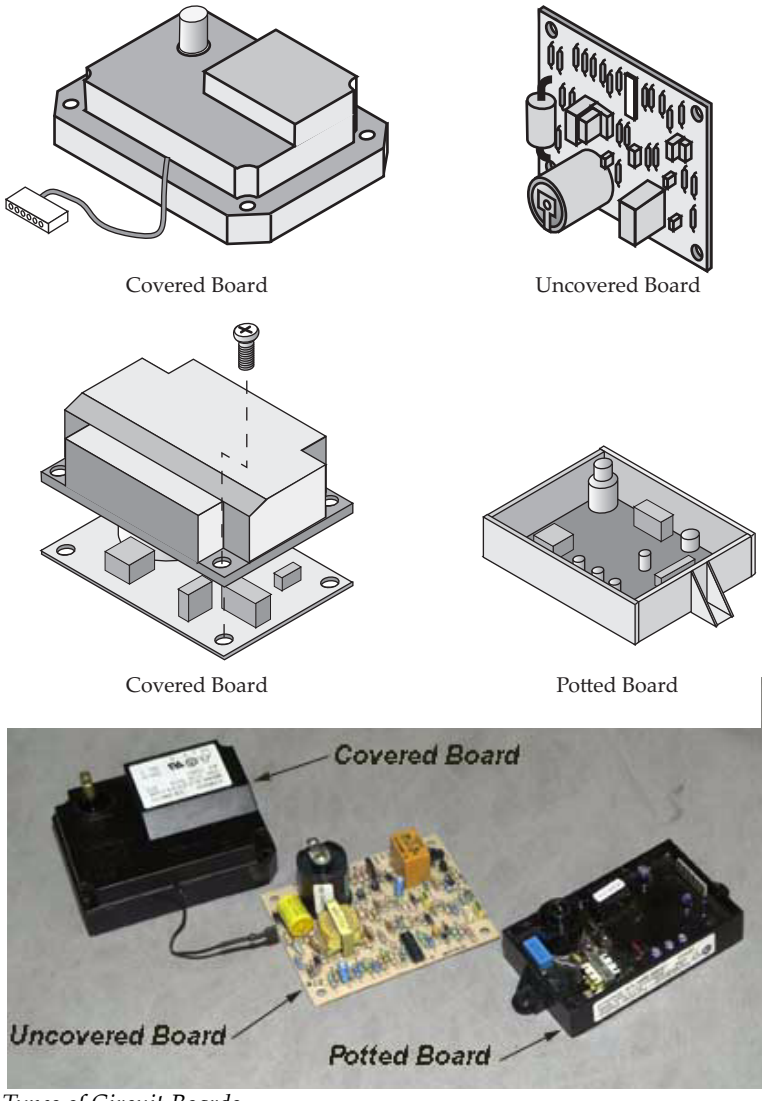


Figure 4-6 *Types of Circuit Boards*

4-3.7.2 *Senses Flame*

When the burner ignites, a sensor will recognize the flame and send a microamp signal to the circuit board that a flame has been established and the spark is no longer necessary. The newer sensor will conduct a 1.5-microamp current. A microamp meter that registers 0 to 10 microamps can be purchased at an electronics supply house. The burner will continue to burn until the thermostat opens at its set temperature, stopping power to the circuit board and shutting down all electrical functions. If, however, the burner is extinguished before the thermostat opens, the "open circuit" at the sensor signals the board that there is no flame and it needs to start sparking again to try and relight. The valve is still open during this trial period and will shut down if the flame does not reignite. In this case, the consumer must manually shut off the on/off switch and try again until ignition is successful. Older circuit boards would try to light only once and then go into a lock out condition until reset. Newer models have a built-in 3-try feature that allows for 3 ignition cycles to occur before the board goes into a lock out mode. Nuisance outages from winds make this multiple ignition board an improvement in operation and performance. To begin testing the circuit board, first make sure there is 12 VDC present at the plug for the circuit board. One pin is 12 VDC positive, one is ground, one is the failure to light power line, one is propane valve power, and on some there is a sensor wire on the plug. Later model circuit boards had a "flying lead" that came directly out of the circuit board to the sensor on the ignitor assembly, giving a more positive connection. If there is 12 VDC present at the circuit board plug, check the back of the circuit board for oxidation or corrosion. Since the board is exposed to the outside atmosphere, it sometimes will oxidize, making a good connection difficult. If it looks oxidized or corroded where the plugs connect, simply remove the plug and run a pencil eraser across all the connection terminals on the circuit board until they are clean. Reinstall the boards and reconnect the plug and try again. If it fails to light or spark again, then the circuit board should be tested with a board tester.

4-3.7.3 *Circuit Board Tester*

Testing of circuit boards is accomplished with a circuit board tester. Circuit boards should be tested with a circuit board tester recommended by the water heater's manufacturer and used according to instructions.

Figure 4-7 *Circuit Board Testing*

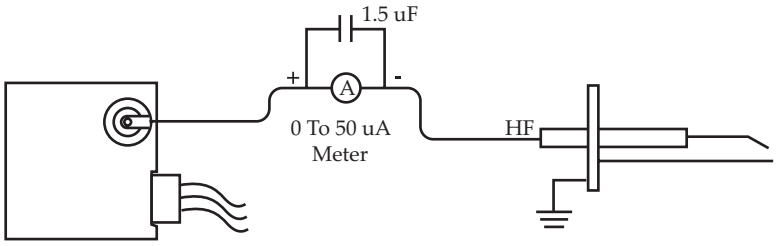
Note: DO NOT INTERCHANGE CIRCUIT BOARDS. You assume liability for damage in the event of failure or disaster. Use caution to identify the circuit boards. Call the manufacturer, if in doubt.

Note: Never operate the tester for only one cycle, test multiple cycles to insure the board is good.

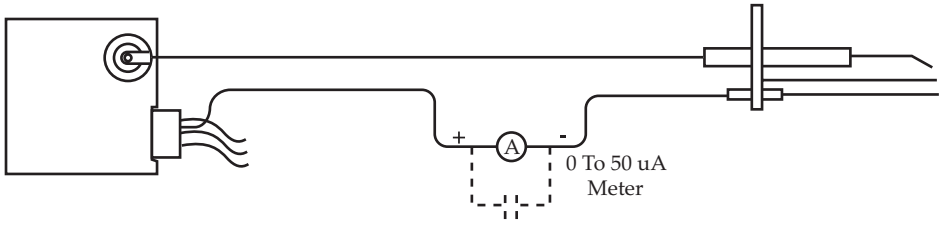
When using a circuit board tester, make sure that a board is tested several times if found suspect. Many times the electronics of the board will establish a pattern of failure. That is, it may repeat a failure of operation every 2, 3, 4, or more times while working fine in the cycles in between. Remember that the circuit board has controls that work the board with established parameters, it does not duplicate field conditions such as battery voltage, AC ripple from converters, and high resistance from bad connectors on the water heater controls. If the board performs perfectly on the tester, but not on the water heater, the problems may be in the supply power or connections or other "feeder" components. Circuit boards have been known to fail with patterns that would be seen on the board tester only if it is cycled several times to see if it has a failure pattern. Sometimes the tester must operate the board continuously to warm up the board up, then it could fail in a pattern. Extreme caution must be taken to avoid using the wrong circuit board for the wrong application. Dangerous conditions could occur if the wrong board is used in the wrong application. If everything tests OK, and the flame will not stay on, test the ignitor and wires to the circuit board.

Figure 4-8 shows a test for both old and new style ignitors with a microamp meter and a 1.5-microfarad 200 capacitor. This test would indicate whether there is sufficient current present for the circuit board to sense the flame. If the amperage is adequate and the flame goes out after an ignition trial period, the circuit board is defective, since it does not respond to the amperage. If, however, the amperage is too low, there is probably too much resistance in the sensor, wires, or connections and those must be repaired, instead of replacing the circuit board.

If a consumer complains of multiple board failures, there is probably an outside influence destroying the boards. The problem is typically the water heater is connected to a linear converter which has too much AC ripple in its output. Also, some consumers living in their RV's full-time in a park will remove their coach batteries. With some converters these act as an AC filter and must be installed with the converter to power all circuit boards in the RV.



Local Flame Sensing (Single Spark and Sense)



Remote Flame Sensing

Figure 4-8 *Ignitor Test*

4-3.8 Solenoid Propane Valve

The propane valve for D.S.I. water heaters was originally a single coil propane valve. The circuit board simply powered the valve with 12 VDC and the coil would create an electromagnet, pulling a plunger which opened a passage through the valve. A pressure tap fitting was installed on the outboard side of the valve to test pressure after the propane valve, allowing for testing of full opening of the valve for enough propane flow to the burner. Safety mandated an improved valve, however, and all the newer valves have a built in propane regulator with redundant valves. Redundant valves mean that there are at least two valve coils and valves, making sure that in case one valve fails, mechanically, the other will back up the system and close it down. A pressure tap will also be included on the valve, allowing the technician to access the valve to test pressure after it goes through the valve. The propane valve coils must have a minimum of 10.5 VDC to open. Voltage any lower than this would not guarantee the opening of the valve ports. This insures that the power for the water heater is adequate to operate within safe parameters. The valves have female pipe threads on the input and output ports. Sealants compatible with propane must be used to seal the fittings installed in the propane valve. A male pipe to male flare fitting is usually installed to the input side of the valve, while a male pipe thread to an adaptor fitting for the burner orifice is installed in the output port. The main burner slides over this output fitting. Testing the propane valve includes using a VOM meter and a manometer with a test port fitting. If 12 VDC is at the valve coils, or, at least 10.5 VDC, and the valve does not open, or no propane is at the burner, then the valve coils should be checked for resistance. Disconnect the leads from the coil terminals and check the resistance reading. It should read between 30 to 50 ohms. If either coil does not read within these numbers, replace the propane valve**.** If the input voltage is adequate and the coils check out, reconnect the leads to the coils. Remove the pressure tap plug and install your adaptor, 1/8" or 3.2 mm to barb connector, and attach a manometer, preferably a U-tube type. Energize the propane valve with voltage and read the manometer. It should open to manufacturers specified operating pressure. If not, the valve is not opening all the way and needs to be replaced. The valve is mounted to brackets designed by the appliance manufacturer and the brackets must be reused when installing the new valve. These valves cannot be repaired, and if defective must be replaced.

4-3.9 Spark Probes

Spark and sensor probes are an important part of the D.S.I. water heater. The older models use 3 probes: spark, sense, and ground. Newer models combine the spark and sense and usually have the ground. Either type has the same requirements for operation. Consult the service manual for the proper gap. This gap insures a strong spark for burner ignition. Figure 4-9 shows a typical three-probe ignitor assembly. This type has the spark wire and sense wire attached and weatherproofed to the probes.

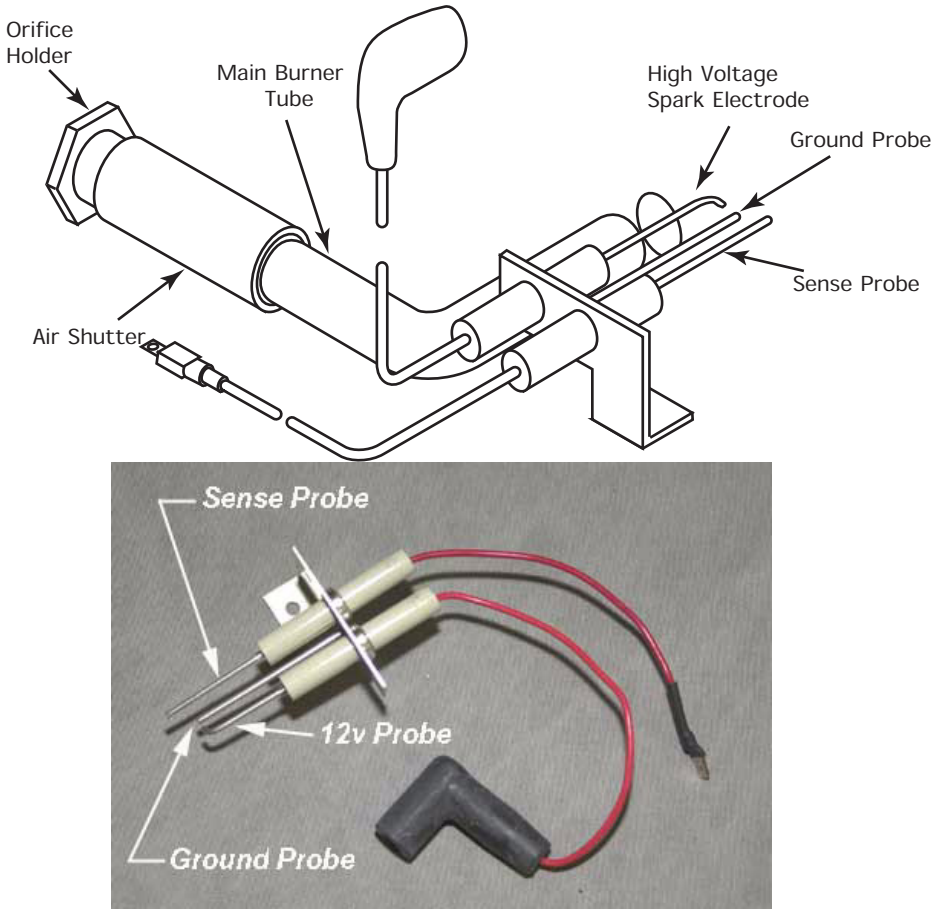


Figure 4-9 *Three Probe Ignitor*

Older models plugged the wires onto the ignitor assembly. Notice the relationship between the spark probe and the end of the burner. As propane flows through the burner, the flat, round plate at the end of the burner, called a flame deflector, spreads the air/fuel mixture and directs it toward the ignitor/ground probes. As the propane passes, the spark ignites it and then the sensor comes into operation. The flame will engulf the sensor probe, along with the ground probe. The flame will create a small amperage that completes a circuit for the circuit board to sense milliamps, indicating the presence of a flame. The typical gap for the sense to ground probe is about 1/4". Notice that the sense probe is on the opposite side from the spark probe. If the sense probe were to receive the very high voltage from the spark probe, damage to the circuit board would result.

Proper adjustment for the assembly to the burner is important for smooth ignition. Adjust the bracket by carefully bending it until a smooth ignition and proper operation is achieved. If the probes themselves must be adjusted, make sure you use two pliers to bend the end of the electrode. Keep one pair of pliers at the base by the porcelain insulator while the other pair can bend the electrode. Do not try to bend the ends of the probes without supporting the part coming out of the porcelain, as the porcelain will crack very easily, causing a path for high voltage leakage to the mounting bracket. In this case the assembly must be replaced. If the tips of the electrodes begin to crack, swell, or distort, replacement is also necessary. If carbon buildup is on the probes, simply clean with steel wool, then find the cause of sooting and correct it. It could be as simple as spider webs in the burner! Figure 4-10 shows the newer 2-probe style ignitor assembly with a 1/8" gap requirement. This shows a two view perspective for a particular model water heater. In this application, the spark probe is the same as the sensor probe with the other probe being the ground. The

adjustment of these probes and the location in the burner are very important when analyzing a D.S.I. water heater.

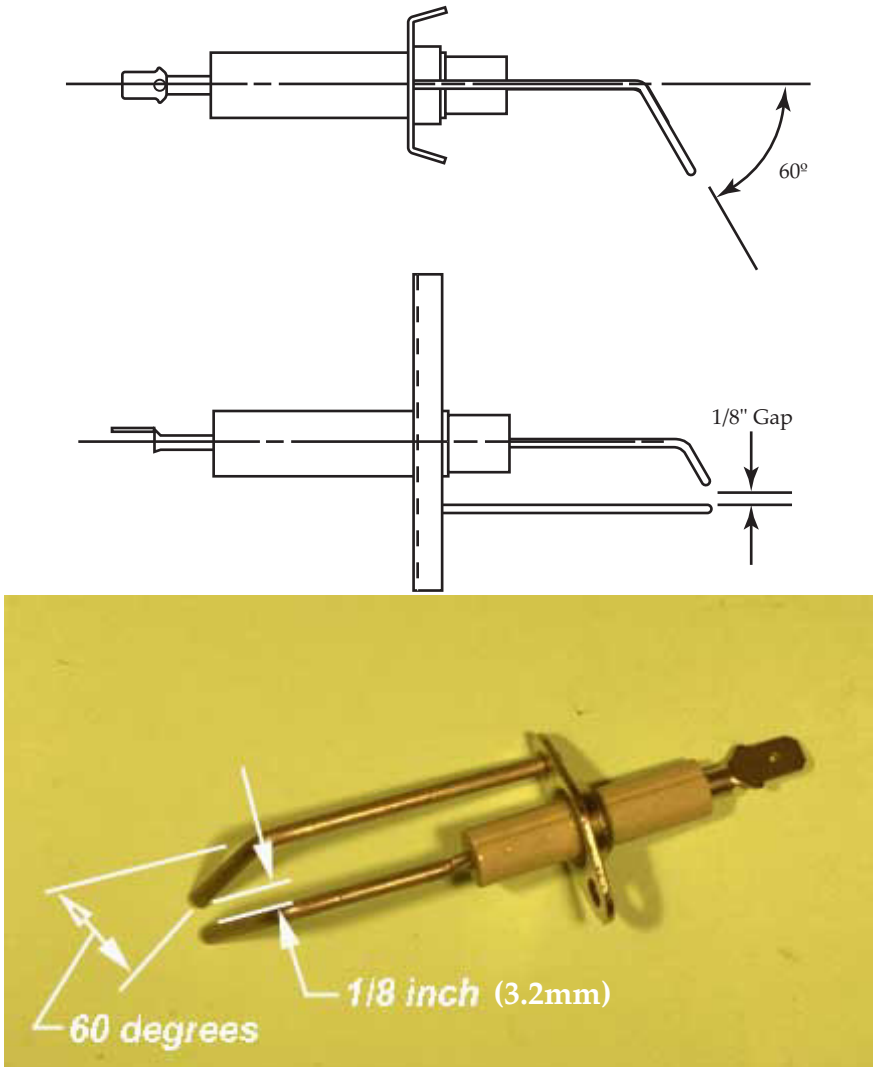


Figure 4-10 *Two- probe Ignitor*

4-3.10 P&T Relief Valve

The P&T relief valve, water fittings, burners, junctions boxes, other components, heating systems and engine assist systems have already been covered in previous sections and are the same on D.S.I. systems. All three sources of heat can be used at the same time to heat water for faster recovery. Each, except the engine assist, has controls to regulate the heat sources, propane and electric.

4-4 Wiring Schematics

4-4.1 12 VDC

The 120 VAC schematics have already been discussed in previous sections and will not be addressed here. The 12 VDC system, however, is unique to the D.S.I. water heater with several different configurations. Figure 4-11 shows a typical schematic for a D.S.I. water heater. The solid lines indicate the wiring on the water heater while the dotted lines show the field wiring supplied by the customer or the manufacturer of the RV when the water heater was installed. The 12 VDC negative connects to one side of the non-ignition light at the on/off switch, while it also connects to the green wire from the water heater which connects to the combustion pan of the water heater and the circuit board. The propane valves and the spark probe ground to the combustion pan. The 12 VDC positive wire connects directly to the on/off switch and continues to the brown wire which goes directly to one side of the thermostat.

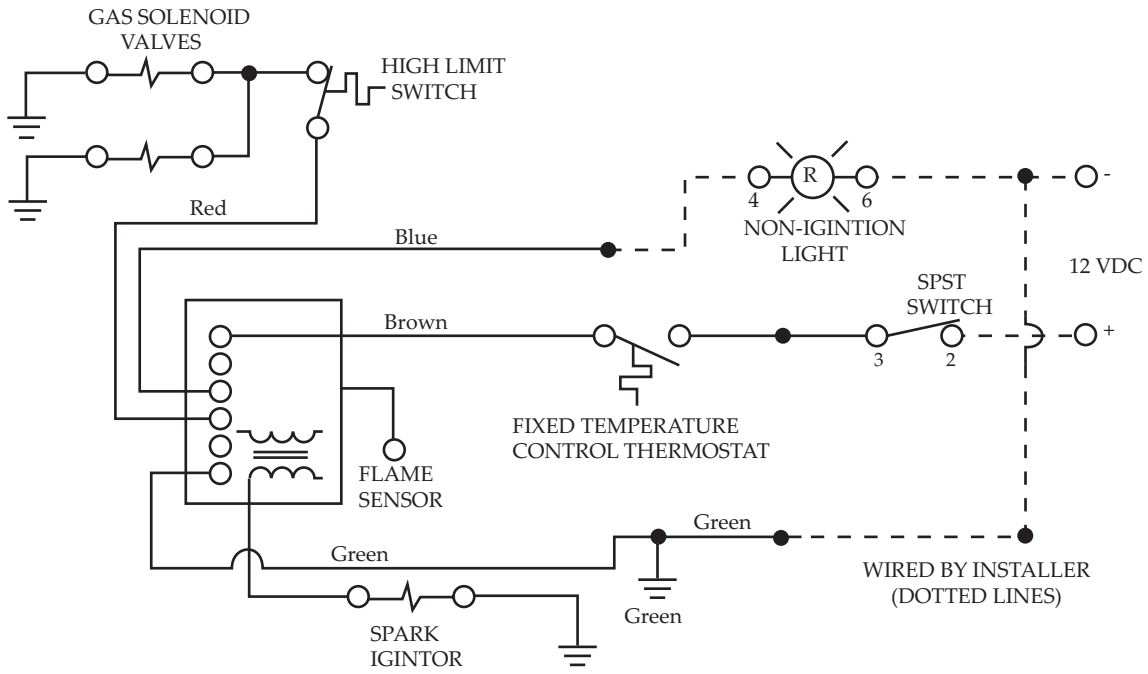


Figure 4-11 *D.S.I. Water Heater Schematic*

If the water is cold, the thermostat is closed and 12 VDC positive continues to the circuit board. When the circuit board is energized, then a spark occurs and the propane valve is energized through the E.C.O. or high-limit switch. When the water becomes hot enough for the thermostat to trip open, power to the board and everything downstream shuts down. If, however, the thermostat fails, then the high-limit switch would open the circuit to the propane valve only, making the circuit board try to reignite because of the open circuit at the sensor probe. Since the E.C.O. switch is open, the board would go into lock-out mode, activating the non-ignition light at the on/off switch (the blue wire from the circuit board to the field connection). The drawing at the upper right of Figure 4-11 depicts the switch, power source, and water heater, connected together electrically. Figure 4-12 shows another manufacturers schematic. In this case, 12 VDC positive flows through both the thermostat and the E.C.O. switches to the circuit board. These models have a manual reset E.C.O. switch, so a

problem would be indicated to the consumer in the event of a thermostat failure. Figures 4-13 and 4-14 show several schematics for several different models, each with their own unique wiring configuration and controls. These schematics offer the technician a "road map" to the electrical circuit for the evaluation of current flow and failure or components. Manufacturers will supply these schematics through tech services, if called.

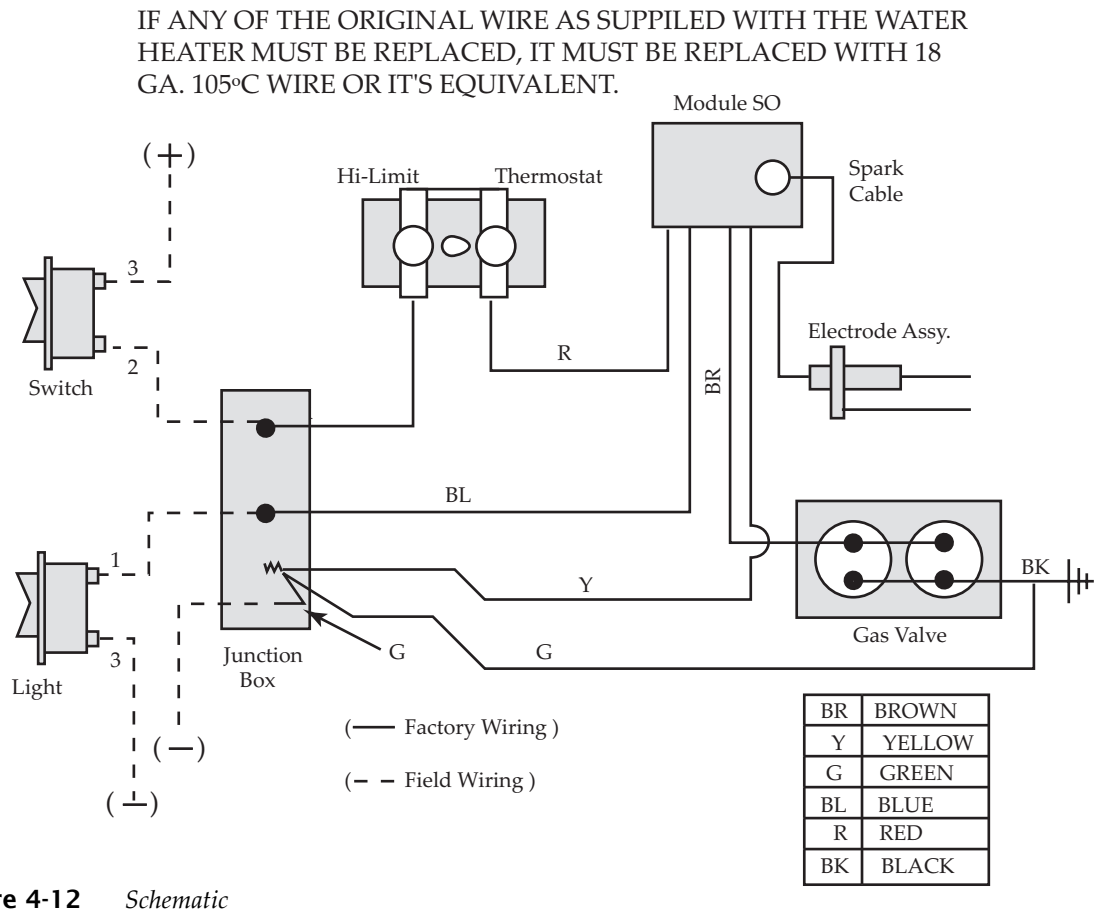


Figure 4-12 *Schematic*

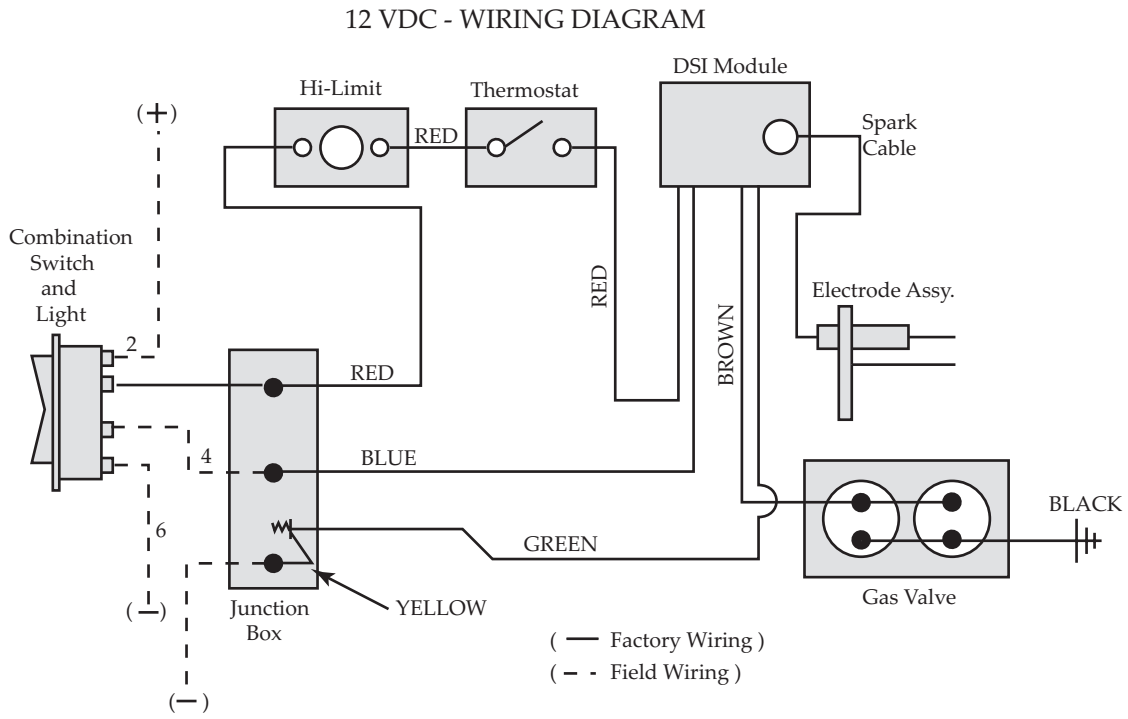


Figure 4-13 *Schematic*

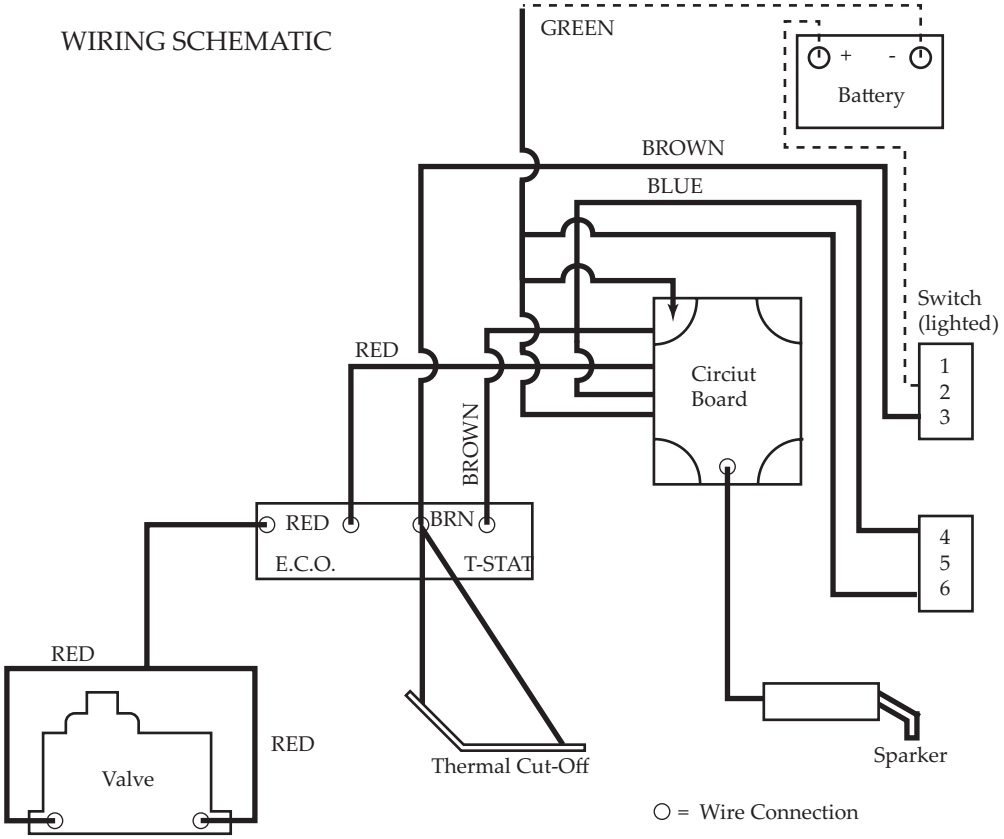


Figure 4-14 *Schematic*

4-5 Installation

Installation of D.S.I. water heaters follow the same procedure as the pilot models. The only difference is the installation of the on/off switch with the ignition failure lamp. This switch should be located in a convenient place inside the RV. Typically, it is installed in the kitchen area or in the range hood control panel. Care must be taken when connecting this appliance to converter power, as a converter that has excessive AC ripple will damage or destroy a circuit board with continued use. Connection to a battery is the ideal supply connection. Consult the installation manual for proper size wire and power requirements for the wiring of the water heater.

4-6 Troubleshooting

Troubleshooting a D.S.I. water heater requires knowledge of the sequence of operation of the water heater. Consulting the wiring schematic will indicate the components in the circuit applicable for troubleshooting. The very first thing to check in any appliance, the water heater being no exception, is the sources of power. The 12 VDC supply is crucial for this appliance along with proper propane pressure to the propane valve. The 120 VAC is also important, since the heating elements require considerable amperage to operate. If the supply sources of power and propane are adequate, then troubleshooting the appliance is in order. Table 4-1 is the Atwood troubleshooting guide for their D.S.I. water heaters. Figure 4-15 is for a trouble shooting guide for a model of the Suburban line of water heaters. The 120 VAC troubleshooting procedures have been covered in previous sections and should be referred to for information.

Table 4-1Atwood's Trouble Shooting Guide for Electric Ignition Water Heaters

CAUSE	SOLUTION
WATER HEATER LOCK OUT - SPARK PRESENT BUT NO PROPANE	
Propane pressure incorrect	Set inlet pressure at 11" water column (nominal) with the system under at least 50% of its operating load (at least two or more of the largest Btu/hr propane appliances) running
Low voltage	Correct power supply - 10.5 VDC minimum
Blocked main burner tube	Clean burner tube
Blocked main burner orifice	Clean or replace orifice
Loose wires on E.C.O.	Secure wire connections
Loose wire connections on solenoid valves	Secure wire connections

Table 4-1Atwood's Trouble Shooting Guide for Electric Ignition Water Heaters

CAUSE	SOLUTION
Loose valve wire on wiring harness	Repair wire on edge connector or repair wiring circuit board harness
Defective E.C.O.	Replace E.C.O
Defective circuit board	Replace circuit board
Defective solenoid valve	Replace coils or solenoid valve
No propane to solenoid valve	Correct propane supply
Dirty connector on circuit board	Clean edge connector
WATER HEATER LOCK OUT - PROPANE PRESENT BUT NO SPARK	
High tension lead wire loose	Secure wire connection on circuit board
Electrodes loosely attached to main burner	Secure electrodes to main burner
Improper electrode gapping	Re-position spark gap to 1⁄8" (3.2 mm)
Dirty electrodes	Clean electrode
Wires loose in electrode porcelain	Replace electrode
Cracked porcelain on electrode	Replace electrodes
Defective circuit board	Replace circuit board
WATER HEATER LOCK OUT - PROPANE AND SPARK PRESENT	
Propane pressure incorrect	Set inlet pressure at 11" water column (nominal) with the system under at least 50% of its operating load (at least two or more of the largest Btu/hr propane appliances) running
Low voltage	Correct power supply - 10.5 VDC minimum
Poor electrical ground	Secure electrical ground
Electrodes out of flame pattern	Re-adjust electrodes
Electrodes sparking to screw fastening burner to flue tube	Adjust electrodes
Dirty electrodes	Clean electrode
Partial obstruction in main burner	Clean main burner

Table 4-1Atwood's Trouble Shooting Guide for Electric Ignition Water Heaters

CAUSE	SOLUTION
Partially obstructed main burner orifice	Clean main burner orifice
Improper air adjustment	Adjust main burner shutter approximately 1⁄4 open or greater
Flame spreader on main burner	Adjust flame spreader so that it is square to the end burner tube out of alignment of the main burner
Manifold not aligned with main burner	Re-align solenoid valve with main burner
Partially opening solenoid valve	Replace solenoid valve
Defective circuit board	Replace circuit board
EXCESSIVE OR INSUFFICIENT WATER TEMPERATURES	
By-pass kit valves not set properly	Place valves in proper position
Thermostat not seated against tank	Reset thermostat
Defective thermostat	Replace thermostat
ERRATIC BURNER FLAME OR SOOTING	
Low propane pressure	Set inlet pressure at 11" water column (nominal) with the system under at least 50% of its operating load (at least two or more of the largest Btu/hr propane appliances) running
Poor propane supply	Replace propane supply
Improper air adjustment	Adjust main burner shutter approximately 1⁄4 open (Flame should be mainly blue and quiet)
Poor main burner alignment	Adjust valve and main burner alignment
Misaligned burner flame spreader	Adjust flame spreader so it is square with end of burner tube
Blocked burner orifice	Clean orifice-DO NOT enlarge orifice
Obstructed main burner	Clean main burner
Obstructed U-tube	Clean U-tube
Obstructed exhaust grille	Remove obstruction
NO SPARK AND NO PROPANE	

Table 4-1Atwood's Trouble Shooting Guide for Electric Ignition Water Heaters

CAUSE	SOLUTION
No voltage	Correct power supply - minimum 10.5 VDC
Dirty edge connector or circuit board	Clean edge connector
Defective thermal cut-off	Replace thermal cut-off
Defective ON/OFF switch	Replace switch
Defective circuit board	Replace circuit board
Defective thermostat	Replace thermostat
INTERMITTENT IGNITION - FAILS TO IGNITE	
Cracked electrode ceramic	Replace spark electrode
Chattering or fluctuating thermostat	Replace thermostat
Insulation on electrode wire cut or damaged	Replace electrode
Ground screw at top of circuit board not tight	Tighten ground screw, if stripped, replace with larger screw
Loose ground wire on valve	Tighten ground wire screw
Poor ground at electrodes	Loosen electrode attachment screw and retighten

TROUBLE SHOOTING GUIDE
SUBURBAN MODEL SW6 WATER HEATER
SPARK IGNITION SECTION

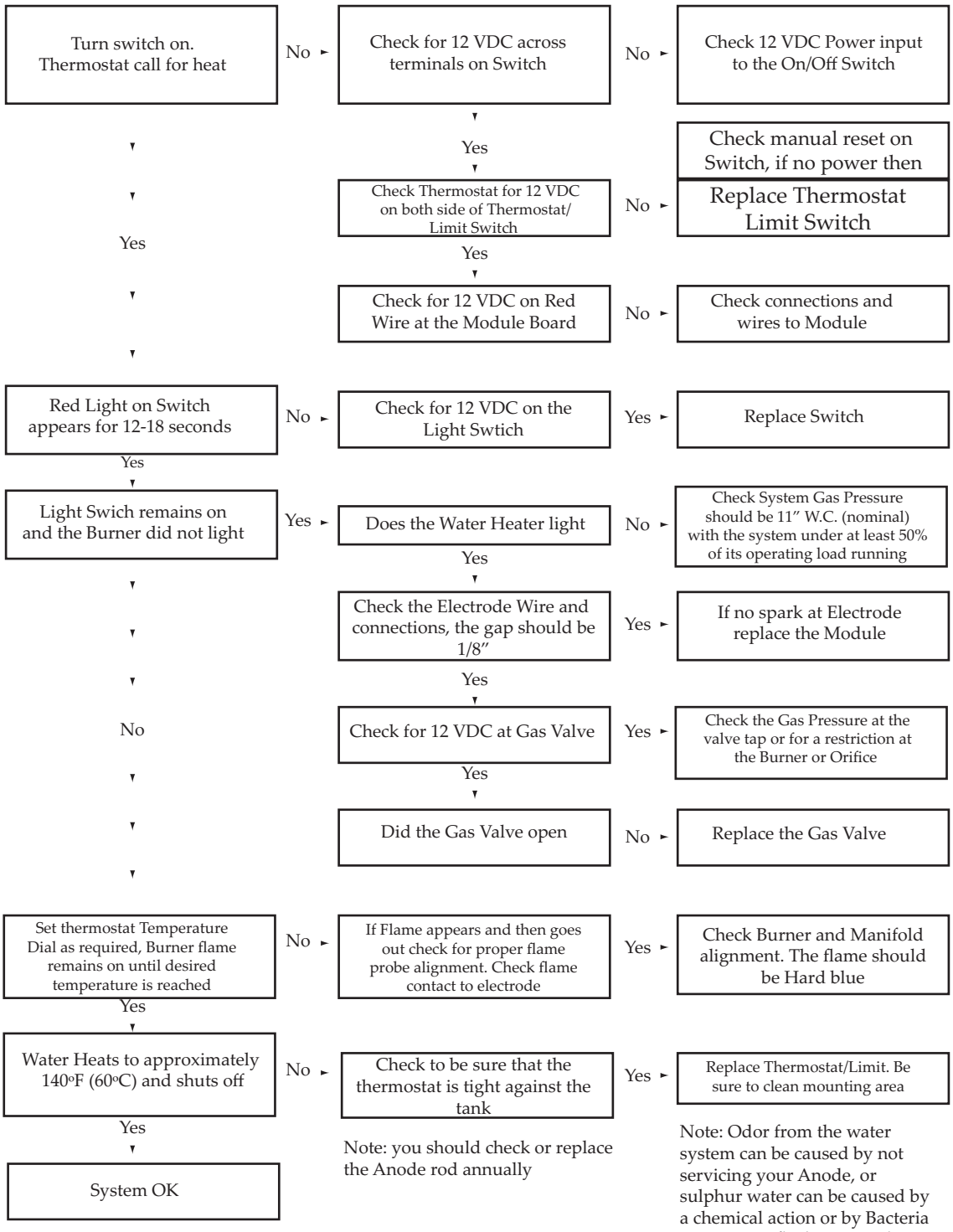


Figure 4-15 *Suburban Troubleshooting Guide*

Chapter 4 Review

1. D.S.I. stands for:

   A. Direct Spark Injection

   B. Double Spark Injection

   C. Double Spark Ignition

   D. Direct Spark Ignition

2. The D.S.I. water heater has its own propane regulator.

   True False

3. The E.C.O. on the D.S.I. water heater is a one time use device.

   True False

4. A device which senses excessive heat outside the burner area is called the _____.

5. The thermal cut-off device _____.

   A. opens the electrical circuit

   B. shuts off propane flow

   C. opens the air shutter

   D. opens the exhaust vent

6. The "heart" or "brain" of the D.S.I. water heater is the _____.

   A. energy cut-off

   B. circuit board

   C. thermal cut-off

   D. thermostat

7. When checking a circuit board for a D.S.I. water heater, you should check the board with a board tester several times because _____.

   A. circuit boards may establish a pattern of failure.

   B. circuit board testers are unreliable.

8. Never interchange circuit boards.

   True False

9. The same customer has returned three times with the same problem. Each time you replaced the circuit board and the D.S.I. water heater works for a short time. What is probably happening?

   A. Poor quality control during board manufacture.

   B. The consumer is overworking the water heater.

   C. An outside influence is destroying the boards.

   D. The wrong water heater is installed in the RV.

10. Propane valve coils need a minimum of _____ volts to open.

    A. 8

    B. 9.5

    C. 10.5

    D. 12

11. When checking propane valve coils for resistance, a good coil should have a resistance of _____ ohms.

    A. 1 - 5

    B. 5 - 10

    C. 10 - 30

    D. 30 - 50

12. Defective D.S.I. water heater propane valves must always be replaced and never repaired.

    True False

13. Care must be taken when connecting a D.S.I. water heater to converter power because a converter that has excessive AC ripple will damage or destroy a circuit board with continued use.

    True False

Chapter

5

Instantaneous Water Heaters

- Identify related terminology.
- Identify components and their function.
- Diagnose common operational problems and determine possible causes.
- Repair and/or replace faulty components.
- Determine interchangeability of models.
- Identify the advantage of a heat exchange and verify flow.
- Determine AC electrical requirements and connect.
- Determine propane requirements and connect.

5-1 General Information and Sequence of Operation

Instantaneous water heaters have been around for a while. With this type of water heater, there is no storage tank for hot water. Instead, a coil for water to flow through is heated by a propane flame when water flows through it. Heat is only applied when water flows because the consumer opens a hot water faucet somewhere in the RV. A valve activates with water flow closing a circuit which opens the propane valve. This ignites a burner and heats the water only while the water flows. This type of water heater mounts on the exterior of the RV because of the air/propane requirements, similar to a tank-type water heater. Earlier models had a standing pilot flame and would ignite a burner that heated the heat exchanger or coil. Newer models work with D.S.I. ignition activated by water flow. Typically, a copper coil is used as it has the maximum heat transfer properties to heat the water efficiently. Several burners apply heat along the coil while the water flows through the coil. When the faucet is closed, the water valve stops rotating and shuts off the power to the control module and to the burners. Efficiency is higher with this type of water heater since there is no heating of water in a tank, and there is a limitless supply of hot water. There is no recovery time, since there is no storage tank. Another benefit of this type of water heater is that, since there is no tank, the water heater does not cycle on and off during the night, keeping the stored water hot. This type only activates when a hot water faucet is turned on, supplying a demand only when it is needed. There is no thermostat for this type of unit since there is no tank. There are, however, redundant E.C.O. switches that monitor

the heat as the water progresses through the heat exchanger. Table 5-1 shows a comparison chart for an instantaneous water heater against a typical tank-type water heater.

Table 5-1 Instantaneous Water Heater vs. 10-US Gallon Propane Water Heater

Standard Features	Instantaneous	10-US Gallon Tank
Maximum Shower Time*	Virtually Unlimited	Five Minutes
Recovery Time	Immediate	30 Minutes
Gallons of Water/20 lbs. Propane Tank*	904 US Gallons	740 US Gallons
Case Material	Galvanized Steel	Cardboard with neoprene foam
Door Material	Painted Aluminum - Flush Mounted	Painted Steel - Surface Mounted
Water Fittings	Solid Brass	Aluminum
Weight Full	27.5 pounds (12.47 kg)	110 Pounds (45.36 kg)
Space Requirements	1.52 Cubic Feet (43 dm^3)	3.1 Cubic Feet (87.78 dm^3)
Temperature Setting	Adjustable	Adjustable (some are fixed and non-adjustable)
Flue Propane Temperature	Under 300°F (150°C)	Over 500°F (260°C)
High Temperature Cutoff Switches	Three	One

*@ Normal Shower Temperature

5-2 Components, Function, Location, Testing and Interactions

Since there are not a lot of manufacturers for this type of water heater, only general information will be supplied here. The components are similar to other types of water heaters and will be addressed here as such.

5-2.1 On/Off Switch

Obviously, an on/off switch in a part of the water heater. This will enable the consumer to turn the system on or off, depending on requirements.

5-2.2 Impeller-Type Valve/Switch

The device that activates the heating process is an impeller-type valve/switch. This type of switch is also used on pool water heaters. On a pool heater, this device insures that there is water flow through the heating coils before the heater will turn on. The RV version utilizes this valve/switch to turn the system on and off automatically. When water flows because a hot water valve is opened, it trips a switch by means of an impeller and closes an electrical circuit, allowing power to go to the circuit board or valve. When the water stops flowing, the switch opens, interrupting the power to the circuit board or valve. This device insures that water is flowing in the unit before a flame is introduced. Typically, a minimum water flow must be maintained to activate the switch. This flow is about 0.4 gallons per minute (g.p.m.) (1.5 liters per minute). Anything less than 0.4 g.p.m. (1.5 liters per minute) will not activate the switch and the burner will not ignite. Testing this valve involves insuring that there is hot water flow and testing for continuity through the switch.

5-2.3 Ignition Source

In older models, the ignition source was a standing pilot flame. However, there are currently no models using standing pilot flames and all have gone to a D.S.I.-type system. This system is very similar to the tank-type water heater as it controls the flame and is interrupted by heat sensors on the coils. This control also requires pure 12 VDC input and care must be taken to insure that there is no AC ripple from the power source.

5-2.4 Propane Valve

The propane valve is, again, very similar to the tank-type water heater. Older models used a pilot-type control, while the newer D.S.I. models use a regulated, redundant-type propane valve.

5-2.5 Heating Coils

The heating coils are made of copper because of its heat transfer properties. Typically located on the coils are several sensors that monitor its temperature. These sensors can be located at the input of the coil, in the middle, and at the output. By including several sensors, the circuit board can be designed to monitor them and provide safe operation, no matter what happens inside the coils because of blockages or restrictions. Modern units utilize thermisters for accurate and total control of the system.

5-2.6 Burner

The burner is not the same as the tank-type units. The tank units will have one burner with a lot of flame at the end at one point. The tankless or instantaneous water heater can have multiple ports for applying heat along the coil. This can be a continuous flame or several ports. Some burners can add up to as much as over 50,000 Btu/hr input because of the amount of area they must cover.

5-2.7 P&T Relief Valve

A P&T relief valve is also included in this water heater, as pressure and temperature must be monitored by a safety relief valve. This valve is incorporated into this system to protect the RV and the appliance. It is very similar to the valve used in the tank-type water heater.

5-3 Wiring Schematics

As with any other electrical appliance, the electrical schematic is very important to use as a troubleshooting aid. Following the schematic enables the technician to see what components are involved in the systems and how they are connected to each other. Figure 5-1 illustrates an instantaneous water heater system. As shown, there is the power input, with a fuse, a flowmeter which monitors the water flow, three thermisters for sensing temperature on the heating coil, a regulated propane valve with an E.C.O. switch in line with it, a modulating valve, ignitor probe, and a circuit board. The schematic illustrates very clearly where each circuit connects, with connections on both sides of the circuit board. This schematic could easily be used to connect the various circuits of the water heater.

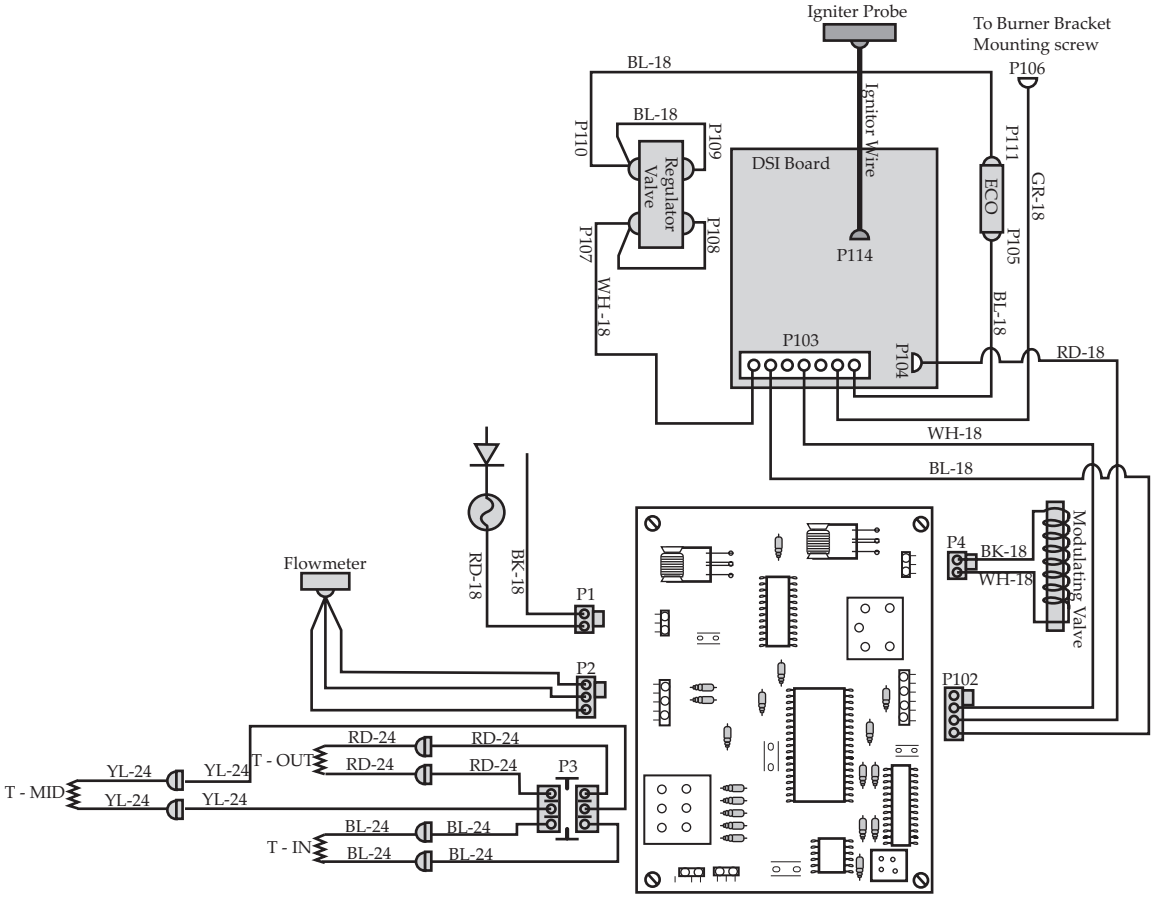


Figure 5-1 *Water Heater System*

5-4 Installation

Installation of this water heater is similar to the tank-type water heater because it involves installation through the exterior wall of the RV. A propane line must be supplied to it, typically minimum 3/8" because of its high Btu/hr demand and a 12 VDC power source for energizing the system. There are no 120 VAC instantaneous water heaters used in the RV industry at this time. The propane connection uses the typical 3/8" male flare fitting and is located at the back of the unit on most types. In some applications, a manual on/off propane valve must be installed. Consult codes in your area for requirements or the ANSI/NFPA 1192 codes. The water lines utilize the typical 1/2" female pipe thread fittings. However, one difference from the tank-type water heaters is evident. On the tank-type water heaters, the cold water input is at the bottom, while the hot is at the top. The instantaneous water heaters may have these fittings reversed. Make sure you refer to the installation instructions before connecting these lines as improper operation will occur if these lines are reversed, mainly the impeller valve/switch. The water heater must be mounted securely to the RV's body or the framing around the water heater. It must be located in an area that is appropriate for all water heaters. ANSI/NFPA 1192 codes will indicate a proper location in an RV.

5-5 Troubleshooting

As with the tank-type water heater, troubleshooting follows a logical pattern to determine where the problem may be. In this system, there is only a water flow or an electrical circuit to investigate.

5-5.1 Water Flow

Water flow is important as the water impeller/switch is the activation device. Testing has already been discussed. Contaminants in the water systems can also be suspect if water flow in the hot water system is restricted. A water pump that is not pumping properly can also be a source of problems, since the water heater requires a minimum water flow for operation. A clogged water filter from the water tank to the water pump may cause such a restriction. Another problem may be the screen on the faucets being used. A restriction from calcium deposits may restrict the amount of water flowing through the system.

5-5.1.1 *Water Flow Trigger Device*

The sensors can be tested with a VOM meter. Refer to the service manual for the water heater for proper resistances or whether continuity is required.

5-5.1.2 *Propane Valve*

The propane valve can be tested in the same manner as the tank-type water heaters. Again, 11" (nominal) water column pressure is required for proper performance. Check the unit for clean burning flames with no soot accumulation. Soot indicates either bad propane pressure or dirty burners or orifices. They should be serviced immediately.

5-5.2 Electrical Circuit

Water temperature at the faucet should be tested for an indication of proper operation of the system. As with the tank-type water heater, excessive heat could be an indication of sensor failure and the E.C.O. switch could be controlling the temperature.

Chapter 5 Review

1. The instantaneous water heater only heats water while the water flows.

   True False

2. The switch that activates the heating process during water flow is called the _____.

3. The water tanks for D.S.I. water heaters are interchangeable with the tanks of the instantaneous water heaters.

   True False

4. Instantaneous water heaters do not have thermostats.

   True False

5. Instantaneous water heaters do not have E.C.O. switches.

   True False

Chapter

6

Maintenance And General Repairs

- Perform preventative maintenance procedures.

6-1 Tank Flushing

A good practice for consumers to implement is a periodic flushing of the water heater tank. Over a period of time, using water from many areas, sediment will accumulate from the chemical reaction of the water, minerals, and the tank metals. Living in an RV or using the coach a great deal will increase the rate of accumulation of sediment inside the water heater tank. Since the hot water is drawn off the top of the tank, this sediment will keep accumulating at the bottom. Periodic flushings, perhaps once a year or more, will add to the life of a water heater tank. The following is a step by step procedure for flushing the water heater tank.

1. Turn off the main water supply.
2. Drain the water heater. There is a drain plug on the bottom of most water heaters on the outside of the RV. Water heaters that have an anode rod may require the removal of the anode rod as it may be the drain plug. It is also an excellent time to inspect the anode rod for integrity. All of the drain plugs are on the bottom of the water heater on the outside portion of the RV. After the plug is removed, open one or two hot water faucets inside the RV to allow air to displace the water and make it flow faster. Another method is to open the P&T valve. After the water has stopped flowing, you will see that, due to the location of the drain valve on the tank, there will still be approximately 2 quarts left inside the tank. This water contains most of the harmful corrosive particles. If, while draining the unit, you note that the water is flowing sporadically or trickling, instead of flowing steadily, it is recommended that you first make sure that a hot water faucet or the P&T relief valve is open, then use a small-gauge wire or coat hangar device and prod through the drain opening to eliminate any obstructions. Make certain not to damage the threads.
3. After thoroughly draining the tank, you should then flush it with fresh water. Fresh water should be pumped into the tank either with the assistance of the onboard pump or with the assistance of external water pressure. Once again, external pressure may be hosed into the unit either through the inlet or outlet water fittings found on the rear of the unit. Continue this flushing process for approximately five minutes, allowing ample time for the fresh water to agitate the stagnant water on the bottom of the tank, thus forcing the deposits through the drain opening.
4. Upon completion of the above steps, close or replace the drain fitting, or anode rod and replace or close the P&T valve.

6-2 Winterizing Water Heater

The water heater and the water system of the RV must be attended to in order to prevent major freeze damage of water lines, water tanks, pumps, and of course, the water heater tank. If a full tank or even a partial tank of water is left in the water heater tank, the expansion of the water when it freezes could split the water heater tank.

Following is a description and procedure for winterizing the water heater tank:

1. Turn off the main water supply.
2. Drain the water heater. Upon doing so, due to the location of the drain plug, approximately two quarts of water will remain in the bottom of the tank. This water contains most of the harmful corrosive particles. If, while draining the unit, water is flowing sporadically or trickling, instead of flowing steadily, we recommend one of two things. You should first open the valve to allow air into the tank and secondly, take a small-gauge wire or coat hanger device and prod through the drain opening to eliminate any obstructions. Make certain not to damage the threads.
3. After thoroughly draining the tank, you should flush it with fresh water. Fresh water should be pumped into the tank either with the assistance of the on board pump or with the assistance of external water pressure. Once again, external pressure may be hosed into the unit either through the inlet or outlet water fittings found on the rear or through the valve located on the front of the unit. Continue this flushing process for approximately five minutes, allowing ample time for the fresh water to agitate the stagnant water on the bottom of the tank and thus forcing the deposits through the drain opening.
4. Upon completion of the steps above, close off the drain valve as well as the relief valve.
5. After this procedure, there will be approximately two quarts of water left at the bottom of the inner tank. Should this water freeze, it will not cause any splitting of the tank. If antifreeze (identified for potable water) is used in the RV water system, it is advisable to install a water heater by-pass kit so that the water heater can be disconnected from the rest of the water system by use of the valves installed on the back of the water heater. These by-pass systems disconnect the water heater from the rest of the water system and allow antifreeze (needs to be identified for RV use) to be introduced to the RV water lines. Antifreeze should never be introduced in a water tank that has an anode rod. Antifreeze will destroy anode rods.

6-3 Tank Replacement

In the rare event of tank failure, the Atwood water heater tank can be replaced. Suburban water heaters do not offer the tank as a replacement component.

To replace the tank, the water heater must be removed from the RV. Shut off the propane. Disconnect all propane lines, water lines, and electrical wires, if applicable. Once out, the components on the front of the water heater must be removed in order to make it possible to remove the combustion pan. This will also allow for removal of the insulation around the water heater tank. The replacement water heater tank will have the tank, gaskets, and instructions to follow for that particular model. Make sure to use the appropriate gaskets when the combustion pan is put back on and the components are being replaced. The com-

bustion pan must be sealed to the inside of the RV by these gaskets to insure no propane can enter the RV. When all components are installed, reinstall the water heater in the RV and reconnect all lines and wires. Check the propane system for leaks, secure wire connections and conduct operational test.

6-4 P&T Relief Valve Weeping

A common complaint from RV users is that after some time the water heater starts dripping or weeping from the P&T relief valve. This is a natural event, since the air pocket designed to be in the top of the tank will, over time, be diminished. This is due to the fact that as the water is heated and cooled, the air pocket becomes smaller because the water flow pulls a very small amount of air out of the tank. The water will absorb the air as a natural reaction of heating of water. Weeping or dripping of the P&T relief valve while the water heater is operating very seldom means the P&T relief valve is defective. To replace the air pocket in the tank, follow the procedure described below.

1. Turn off the water heater, electric or propane.
2. Turn off the water sources, i.e. water pump or city water faucet.
3. Open a hot water faucet in the RV.
4. Pull or open the handle on the P&T relief valve straight out and allow the water to flow out until it stops.
5. Allow the P&T relief valve to snap shut, close the hot water faucet, and turn on the water supply. Heat the water to insure proper operation of the P&T relief valve. If it continues to leak, the P&T relief valve is defective.

See Paragraph 2-3.8 of Chapter 2

6-5 Maintain Burner Flame and Flue

The main burner and pilot burner, if applicable, should be inspected anytime the RV is brought out of storage and put into service. With a pilot model, lighting the pilot flame and turning on the main burner to heat requires the operator to be at the outside of the water heater while these burners are fired off. This is a good opportunity to look at the flame and see its characteristics. The pilot flame may be blue and orange in some cases, it will be a small yellow flame. The main burner should be a crisp, blue flame with an inner blue cone configuration. There could be traces of orange in the tips of the flame, but a yellow flame causes sooting. This usually means that there is a good probability of a clogged orifice, bad propane pressure or valve, bad air/fuel mixture, or a spider in the burner assembly. The automatic or D.S.I-type water heater is the one that causes more problems. This is due to the fact that the water heater is lit from inside the RV, and the flame characteristics are seldom observed unless soot is seen on the outside of the RV or there is a failure to light. A consumer with a D.S.I. water heater should be encouraged to observe the flame every time the RV is brought out of storage. Once the flame is observed and seen to be in order, it will probably function properly for the trip.

Chapter 6 Review

1. The process of removing sediment from the bottom of a water tank is called _____.

   A. purging

   B. flushing

   C. sanitizing

   D. recycling

2. When you remove the drain plug and open the P&T relief valve you will completely drain the water tank.

   True False

3. Never add antifreeze, even antifreeze identified for RV use, to a water heater that has an anode rod.

   True False

4. In the event of damage all water tanks can be replaced.

   True False

5. Weeping or dripping of the P&T relief valve while the water heater is operating usually means:

   A. The P&T relief valve needs replacement.

   B. The air pocket in the water tank needs to be restored.

   C. The pipe fittings need new sealant or Teflon tape®.

   D. The P&T relief valve needs flushing.

6. A customer complains of the presence of a yellow flame at the main burner. Which of the following could be the cause?

   A. A clogged orifice.

   B. Insufficient propane pressure.

   C. Defective propane valve.

   D. Incorrect air/fuel mixture.

   E. Insects or webs in the burner assembly.

Chapter

7

Water Heater Codes and Standards

- Identify and apply codes and standards.

7-1 Codes and Standards

Codes and Standards for Recreational Vehicles are contained in the document ANSI/ NFPA 1192 Standard on Recreational Vehicles. This document contains chapters on Fuel Systems, Fire and Life Safety and Plumbing, references the National Electrical Code Section 551 for 120 VAC electrical requirements and ANSI RVIA/12V, Standard for Low Voltage Systems in Conversion and Recreational Vehicles. All the requirements relating to propane systems are contained in the Fuel Systems chapter. The technician is encouraged to have access to these documents and to become familiar with standards applicable to the work he performs. Many of these standards have been mentioned in this document, where applicable. The following table summarizes applicable standards and is organized according to the task the technician is performing.

Table 7-1 Appliances - CSA Z240,1192 and NFPA 58 Requirements Applicable to RV Service Technician

Service Technicians Task	Z240	2005 Code Reference	Summary of Requirement
Inspect/Repair/ Replace Water Heater	5.1.1/5.2/ 5.4.1/5.5	5.4.5.1	Any appliance must be listed for RV use and installed according to the installation instructions. The installation of some water heaters on combustible materials is not acceptable.
	5.8.1	7.3.12.1	Relief valves for water heaters shall terminate to the outside of unit.
	N/A	7.3.12.1	Relief valve pipe away shall not diminish in size or be threaded so that it could be capped.

Table 7-1 Appliances - CSA Z240,1192 and NFPA 58 Requirements Applicable to RV Service Technician

Service Technicians Task	Z240	2005 Code Reference	Summary of Requirement
	4.7.1.1/ 4.7.1.2	551.43(A)(1)	Check rating of water heater vs. size and load of overcurrent protection.
	5.7.2	N/A	Inlet separation from gasoline filler spout.

Note: There are no summary questions for Chapter 7.

Answer Keys

Chapter 1

1. C (page 1-2)
2. False - Most water heaters have propane as the primary source of heat. There are a few propane/electric and even fewer all electric. (page 1-1)
3. A. Standing Pilot Flame (page 1-1)

   B. Spark Ignition
4. C (page 1-1)
5. Number of gallons (page 1-3)
6. Direct spark ignition (page 1-4)
7. True (page 1-5)
8. True (page 1-5)
9. Energy cut-off switch (E.C.O.) (page 1-8)
10. Pressure and temperature (P&T) relief valve (page 1-9)
11. A. Freezing (page 1-9)

    B. Vaporization

    Both frozen water and vapor from boiling water cause the volume of water to expand.
12. D (page 1-10)

Chapter 2

1. C (page 2-2)
2. D (page 2-4)
3. True (page 2-8)
4. direct contact with the water heater tank surface (page 2-4)
5. checking the data plate (page 2-3)
6. A. Fiberglass (page 2-3)

   B. foam
7. heating element (page 2-4)
8. A. Overheating (page 2-4)

   B. arcing

   C. fire

9. A. On/off switch (page 2-3)

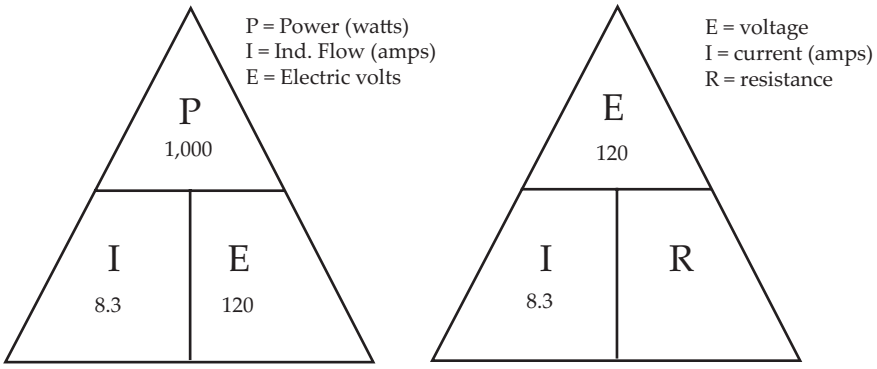
   B. Thermostat assembly

   C. Heating element

   D. P&T relief valve

10. Both B and D are correct (page 2-6)
11. C

    120 volts divided by 8.3 amps = 14.46 ohms



12. True (page 2-8)
13. False - Always use the same wattage rating. (page 2-8)
14. A. attached on the water heater (page 2-9)

    B. in the owner's manual

    C. in the installation instructions

15. All are major concerns and must be checked using applicable standards, codes and listing requirements. C & D. (page 2-12)
16. Any two of the following: (page 2-13)

    A. The thermostat needs adjustment.

    B. The thermostat has failed.

    C. Improper thermostat positioning.

17. Check water temperature coming out of the faucet with a good mercury-type bulb thermostat at the P&T valve. (page 2-13)

Chapter 3

1. pilot model (page 3-1)
2. engine assist heat exchanger (page 3-2)
3. C (page 3-2)
4. False - The main propane regulator controls the supply and pressure to the water heater. (page 3-2)

5. D (page 3-4)
6. A - 12mV or more is required for the coil inside the water heater to create a magnetic field that is strong enough to hold a plunger open against a spring. This allows propane to pass through the valve to the pilot assembly. (page 3-4)
7. C (page 3-5)
8. A. allows propane to enter (page 3-7)

   B. sense water temperature

   C. has E.C.O.

   D. divides propane between pilot and main burner
9. True (page 3-7)
10. The minimum 12mV circuit is opened, the magnetic field is eliminated or reduced allowing the spring to push back the plunger and shut off the flow of propane. (page 3-7)
11. False - No sealant. (page 3-11)
12. B (page 3-11)
13. True (page 3-12)
14. D (page 3-15)
15. C (page 3-16)
16. False - Different burners are matched to a specific size orifice so care must be taken when ordering or interchanging parts. (page 3-13)
17. combustion pan (page 3-17)
18. A. Clean or replace burner and orifice. (page 3-21)

    B. Adjust air shutter.

Chapter 4

1. D (page 4-1)
2. True (page 4-1)
3. False - The D.S.I. E.C.O. can be reset for continuous usage. There are two types of E.C.O.s, automatic- and manual-reset types (page 4-8)
4. thermal cut-off (page 4-9)
5. A (page 4-9)
6. B (page 4-9)
7. A (page 4-12)
8. True (page 4-11)
9. A
10. C (page 4-12)
11. C (page 4-13)
12. D (page 4-13)

13. True (page 4-13)
14. True (page 4-12)

Chapter 5

1. True (page 5-1)
2. water impeller type valve/switch (page 5-3)
3. False - Instantaneous water heaters do not have water tanks. (page 5-1)
4. True (page 5-1)
5. False - Instantaneous water heaters have redundant E.C.O. switches. (page 5-1)

Chapter 6

1. B (page 6-1)
2. False - There will be approximately 2 quarts of water left in the tank. This is also where most of the sediment is. (page 6-1)
3. True (page 6-2)
4. False - Replaceability of water tanks varies from manufacturer to manufacturer. You may have to replace the entire water heater. (page 6-2)
5. B (page 6-3)
6. A, B, C, D & E (page 6-3)

Glossary of Water Heater Terms

AGA	American Gas Association.
Access Door	Hinged cover on outside of water heater.
Anode Rod	An aluminum or magnesium rod that sacrifices itself to prolong the life of the water heater tank.
By-Pass Kit	A combination of hoses and valves that can aid in the winterization of the water heater.
Calibration	To set or adjust an indicator of capacity or graduations of a measuring instrument and can be used to determine whether the thermostat is responding to temperatures properly.
Cam-Loc Fastener	A door securing item.
Combustion Pan	Metal pan attached to tank and in turn fastened to coach sidewall to isolate combustion to outside of coach.
D.S.I.	Direct spark ignition.
Circuit Board	An electronic panel that controls the spark, solenoid valve and senses the main burner flame.
ECO	(Energy cut-off) a high-temperature limit switch.
Electrolysis	Electro-chemical corrosive process that can cause pinholes in tanks.
Fenwal Tester	A diagnostic circuit board analyzer.
Flame Out Indicator Light	A light that illuminates when the burner fails to ignite (D.S.I. models)
Flame Spreader	A round deflective piece found at the combustion end of main burner to spread.
Flue Box	A chamber that separates air intake and exhaust.
Flue Tube	Combustion and water heating surface area on inside of tank.
Flying Lead	Flame sensing wire that is sometimes found hardwired to circuit board.
Front of Water Heater	Access door side of water heater.
Heat Exchanger	A tube directly connected to the water heater tank that has engine coolant flowing through it while an the RV engine is running heating the water.
Immersion Element	Electrical heating coil that is immersed directly into water.
Insulation	Fiberglass or foam that covers the water heater tank to allow it to retain heat longer.
Inverted Flare	Type of connection using double-flare fitting and tube nut.
Inner Tank	Patented, designed vessel for heating water.
Jade Knob Clip	A horse-shoe retainer clip on main shaft of Jade Propane thermostat that allows for proper moving of on/off knob and shaft.
Junction Box	An approved box designed for making electrical connections.
Main Burner	A propane and air mixing tube.
Main Burner Air Shutter	The slotted sleeve or holes on burner tube that allows for propane and air mixing adjustment.

Glossary of Water Heater Terms

Main Burner Orifice A precision-drilled fitting that regulates the Btu/hrs of combustion.

Motor Aid See HEAT EXCHANGER.

NPT (National Pipe Thread) a plumbing measurement standard. A slightly tapered thread designed for plumbing connections.

P&T Valve Pressure and temperature valve known as a relief valve.

Pilot Burner A burner designed to produce a flame that is a source of ignition for the main burner and heats the thermocouple at the same time.

Pilot Orifice A precision-drilled, thimble-shaped component that meters propane flow to pilot burner.

Pilot Relight Igniter Module An add-on 12 VDC electronic panel that provides spark ignition and flame sense to maintain pilot flame.

Propane Solenoid Valve A 12 VDC device that turns the flow of propane on or off. Sometimes there is a pressure regulator built-in.

Relief Valve See P&T valve.

Ring and Gasket Retaining fiber and metal rings that secure and seal combustion pan to tank.

Pilot Assembly Consists of propane tubing, orifice, pilot burner, and thermo-couple.

Sight Glass Burner flame viewing port on access door.

Spark Probe Assembly A spark electrode, flame sensing electrode with a ground electrode. Different models will vary.

Tank Drain A fitting on the front of the tank that will allow the water to be drained from the tank.

T-Stat Industry terminology for thermostat.

Thermal Cut-Off A heat-sensor that opens when tripped by excessive heat. Some are one time use and some can be reset either automatically or manually.

Thermostat (propane) A temperature-sensitive device for turning the flow of propane to the main burner on and off (T-Stat).

Thermostat (12 VDC) A surface-mount, temperature-sensitive device that turns on/off power to the circuit board.

Thermostat (120 VAC) A surface-mount, temperature-sensitive device that turns on/off the voltage to the heating element.

Thermocouple A device, when heated, generates millivolts of electricity to hold the propane valve open.

UL Underwriters Laboratories.

Winterization Process of preparing a water heater for cold winter storage.

Index

V

W

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