$39.95

9

Recreation Vehicle Industry Association

Recreation Vehicle
Water Heaters

Recreation Vehicle Industry Association
1896 Preston White Drive
Reston, VA 20191
Phone 703/620-6003 • Fax 703/620-5071

RV Water Heaters - 4th edition

June 2012

THIS PAGE IS INTENTIONALLY BLANK

9 Table of Contents

9 List of Figures

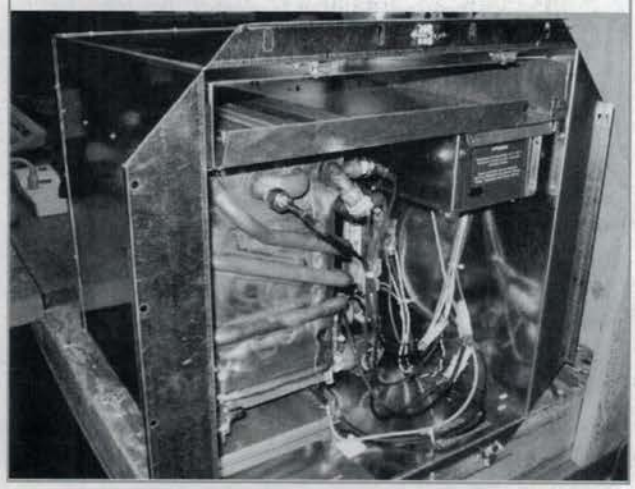
Chapter

9-1 Introduction to Water Heaters

- Identify different water heater types.
- Identify components and their function.
- Obtain model information.
- Determine AC and DC electrical requirements.
- Identify special tools and their use.
- Determine propane requirements.
- Identify related terminology.

9-1.1 Water Heater Sizes and Energy Sources

Figure 9-1 Instantaneous Water Heater



Recreation 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, with various options. Water heaters traditionally have used propane as a source of fuel for many years. Propane water heaters will utilize a flame to 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 9-2* and *Figure 9-3*. 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 9-5*), 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 9-2 Atwood Direct Spark Ignition Model Water Heater

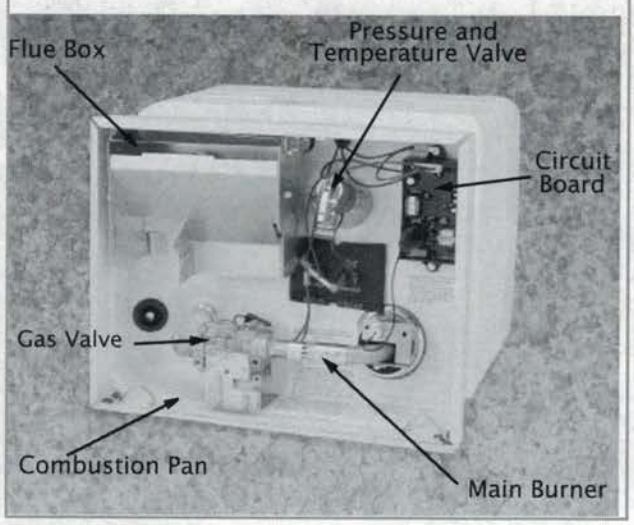
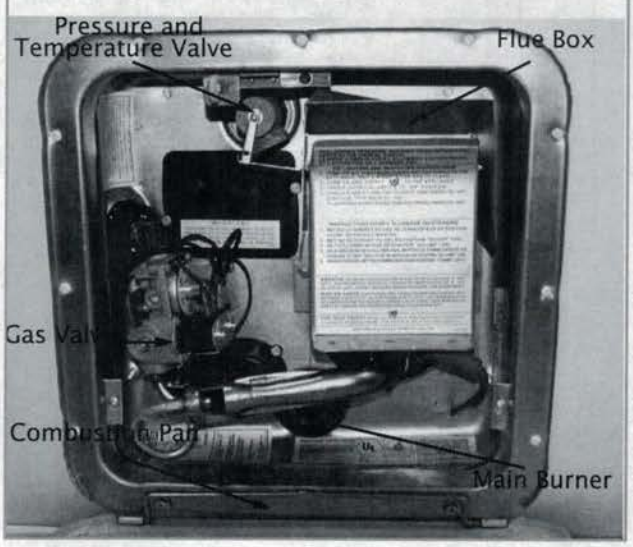


Figure 9-3 Suburban Direct Spark Ignition Model Water Heater



The majority of RVs use either a six- or ten-U.S.-gallon water heater. The six or ten gallon designation refers to the capacity of the hot water storage tank. The different heat sources offer the RV consumer a variety of options to operate the 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 motor-aid, or all three sources together.

9-1.1.1 Water Heater Data Plates and Information

9-1.1.1.1 Model and Serial Numbers

As with all appliances, water heaters have data plates on them that reflect important information needed to service the appliance. Information may include 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 Underwriters 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 9-5* and *9-6* show both manufacturers' breakdown of what each digit or number represents about the water heater. As shown, it displays heat sources, type of ignition for the propane, a version or series, gallons, and so on. The serial number is also on the data plate, and it is the number for that water heater. The version number is also important, as it will reflect component changes.

Figure 9-4 Data Plate

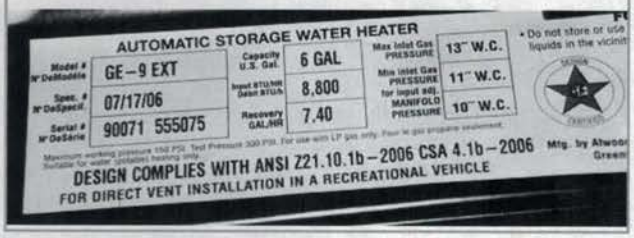


Figure 9-5 Atwood Model Number

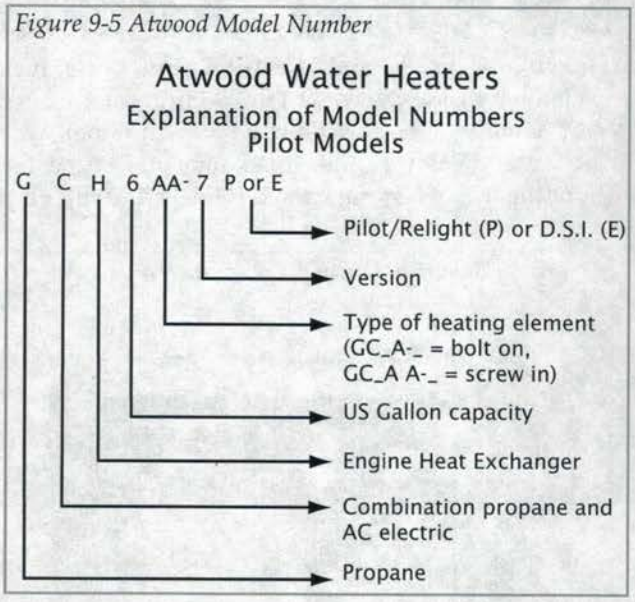


Figure 9-6 Suburban Model Number

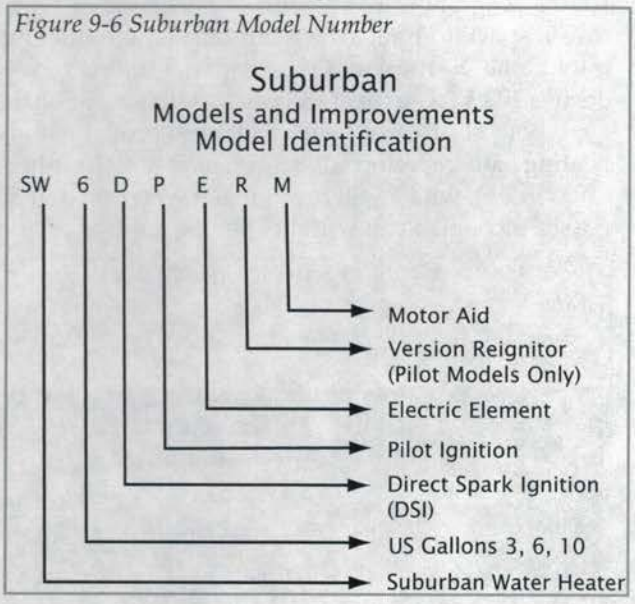


Figure 9-7 Suburban Data Plate

SUBURBAN MANUFACTURING CO. DAYTON, TENN.	
FOR USE WITH PROPANE GAS	EQUIPE POUR UTILISATION AU GAZ PROPANE
MODEL/MODELE **SW16DE**	STOCK. NO. **5073**
ORIFICE SIZE **61**	TAILLE DU ORIFICE **61**
TANK CAP. **16.0** U.S.GAL	CAPACITE DU RESERVOIR **16.0** U.S.GAL
TEST PRESS. 300 PSI	PRESSION D'EPREUVE 21.09 KG/CM
WORKING PRESS. 150 PSI	PRESSION DE FONCTIONNEMENT 10.55 KG/CM
GAS INPUT **12,000** BTU/HR	ENTREE DE GAZ **12,000** BTU/HEURE
RECOVERY **16.2** U.S.GAL/HR. AT 100F RISE	RECUPERATION **16.2** AVEC ELEVATION DE 37.8C
SERIAL NO. **072503340**	
MANUAL	MANUEL **192854**

Figure 9-8 Aqua-Hot Data Plate

Aqua-Hot®
HYDRONIC HEATING SYSTEM

For installation only in a compartment completely closed off from living quarters and accessible only from the outdoors.

Exhaust System MUST NOT terminate beneath the vehicle or under an openable window or vent.

Combustion Air MUST BE supplied from outside the vehicle.

⚠ CAUTION: This appliance operates on both AC and DC Electrical Power.

The AC-Powered Electrical Heating Element should be wired using an insulated conductor.

USE COPPER CONDUCTORS ONLY!

Use a 25-Amp fuse for over-current protection for the DC power supply.

Use a circuit breaker that cuts power at 25-Amps maximum for over-current protection for the 120-VAC power supply.

Mount Heater near a bay / storage door so the access cover can be easily removed.

Minimum Heater Clearances:
Front - Open Access
Back - 0 inches
Top - 6 inches
Sides - 0 inches

Install in strict compliance with local codes, NFPA 501c, and the manufacturer's instructions.

Made in the U.S.A.

120 VAC, 60 Hz / 1.65 kW	Testing Engineers International
Electric Heating Element / AC Power	Listing No. 02L01 Complies with the requirements of UL 307A
DIESEL / 56,000 BTU	
Fuel Type / Firing Rate	Manufactured Date
12 VDC / 174 Watts	
Diesel-Burner / DC Power	Diesel-Burner Serial Number
AHE-450	
Model Number	Serial Number

15549 East Highway 52 • Fort Lupton, CO 80621 • 1.800.685.4298 • www.aqua-hot.com

9-1.1.1.2 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 that 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.

9-1.1.1.3 12 VDC Requirements

If the water heater has a optional reignitor (pilot re-light) or is a direct spark ignition (DSI) 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.

9-1.1.1.4 120 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.

9-1.2 Water Heater Overview and Principles

9-1.2.1 Source of Heat

As discussed previously, most RV water heaters use various sources of heat: propane, 120 VAC heating element, diesel, and motor-aid (engine-assist using a heat exchanger).

9-1.2.1.1 Propane

The primary source of heating is propane. The propane is burned at the end of a burner tube as shown in *Figure 9-9*. 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.

One manufacturer uses an aluminum tank with a flue tube that curves around inside the tank as shown in *Figure 9-10*. 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 9-11*. 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 9-9 Burner Tube and Pilot Assembly

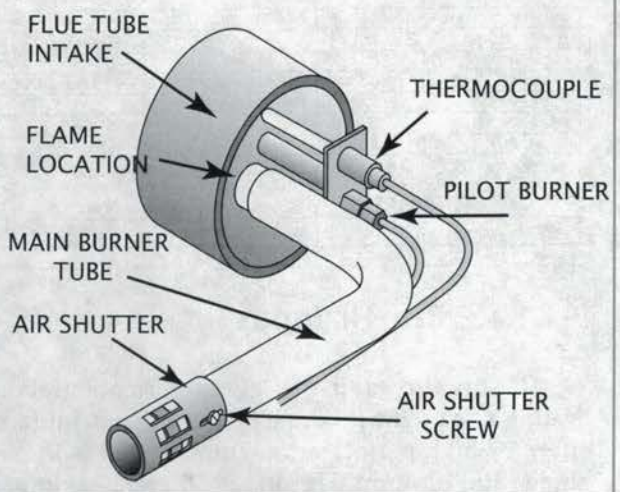


Figure 9-10 Aluminum Tank with Flue Tube

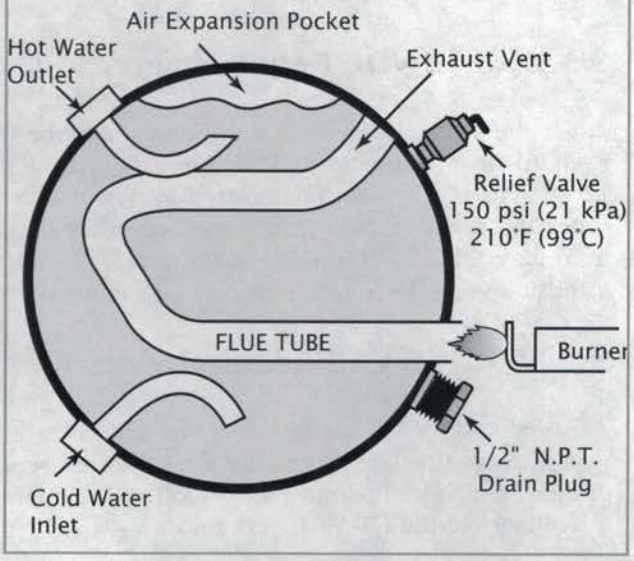
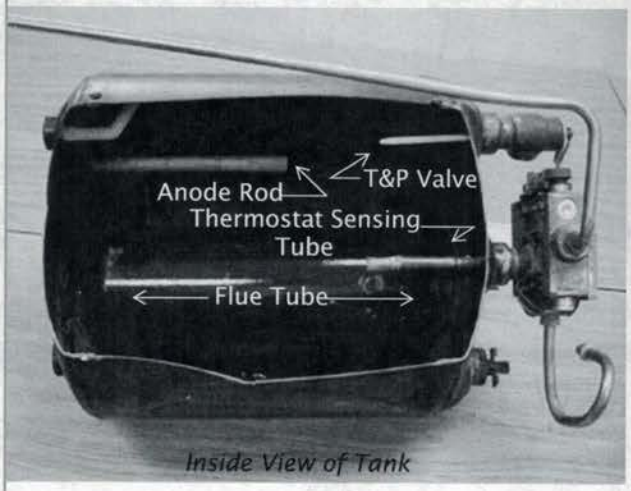
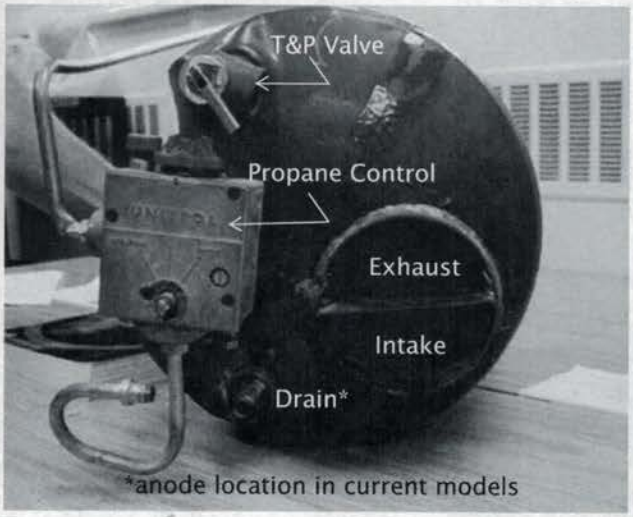
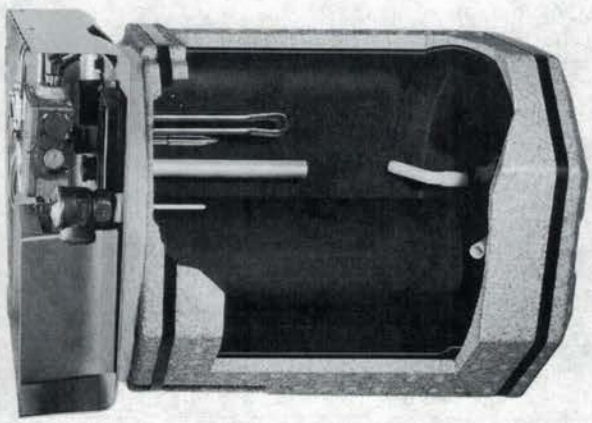
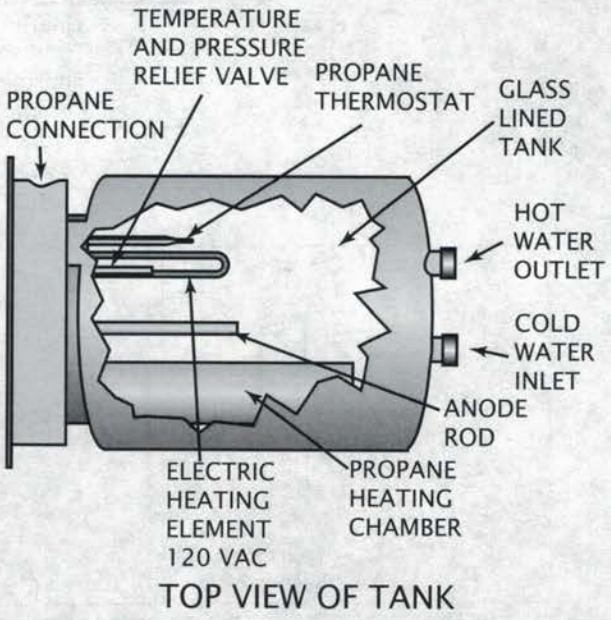


Figure 9-11 Glass Lined Tank Cutaway







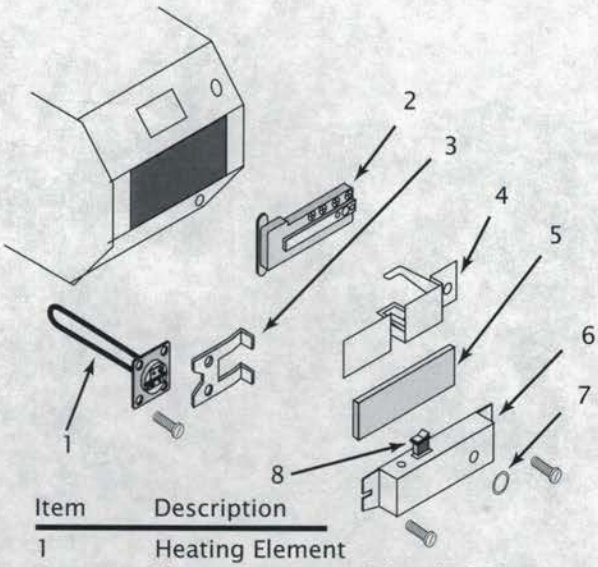


9-1.2.1.2 120 VAC

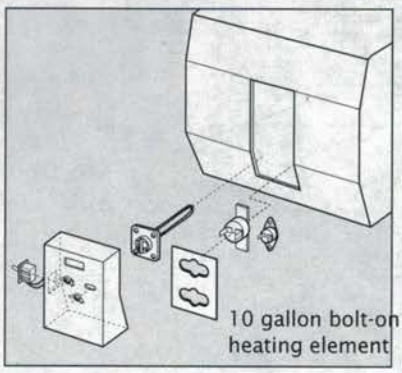
A popular option for a heat source is the 120 VAC heating element system. These are manufactured as part of the water heater. Aftermarket versions are available; however, water heater manufacturers have issued service bulletins recommending that aftermarket heating elements not be used in their products.

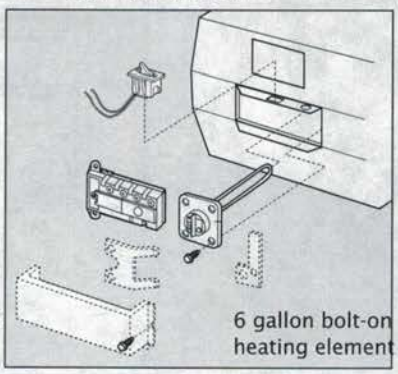
The 120 VAC system utilizes a heating element submerged inside the tank. Two types are commonly used, a screw-in type and a bolt-in type. Both have the element making contact with the water inside. On the outside surface of the water heater tank is a control that regulates temperature (the *thermostat)* and an energy cutoff (ECO) switch that has a higher temperature rating, installed 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 9-12*.

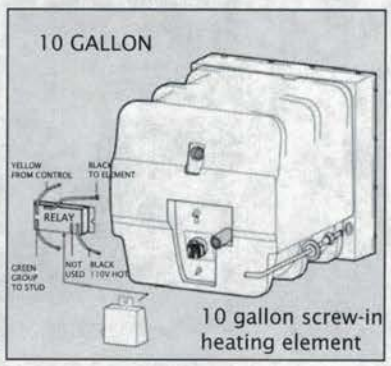
Figure 9-12 Typical 120 VAC System



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


10 gallon bolt-on heating element


6 gallon bolt-on heating element



10 gallon screw-in heating element

9-1.2.1.3 Motor-Aid

The last heat source option available on water heaters is known as *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 9-13* 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, allowing the water heater to use heat from the engine that would otherwise be lost. Second, the RV always has hot water available when the engine is running. Other heat sources are not needed when the motor-aid is being used.

NOTE: Engine coolant temperatures above 180°F (82.2°C) over an extended time can trip the ECO switch.

9-1.2.2 Regulation of Heat

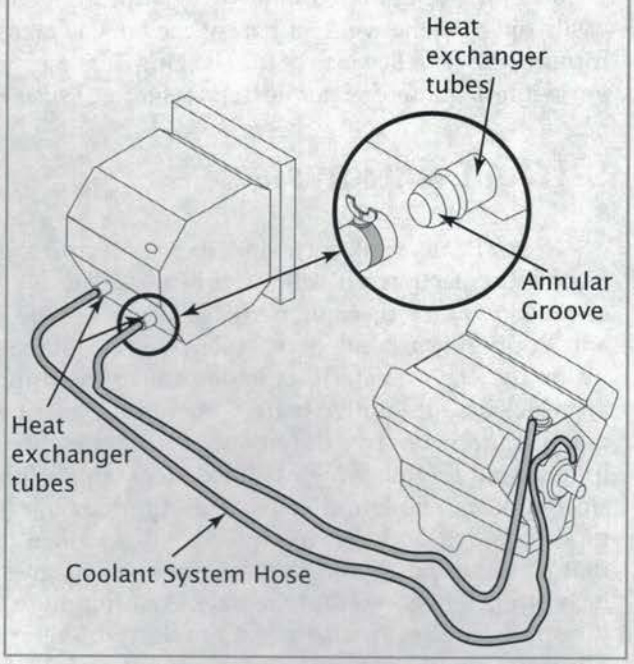
9-1.2.2.1 Thermostats

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.

9-1.2.2.2 Energy Cutoff Switch (ECO)

The energy cutoff switch is a high-temperature shutoff device. This is a safety device that shuts off the flow of propane in an overheat situation [180°F (82.2°C)]. On DSI models, the ECO switch is resettable. On pilot models, it is a non-resetting switch that, if activated, will result in a need for a complete control replacement.

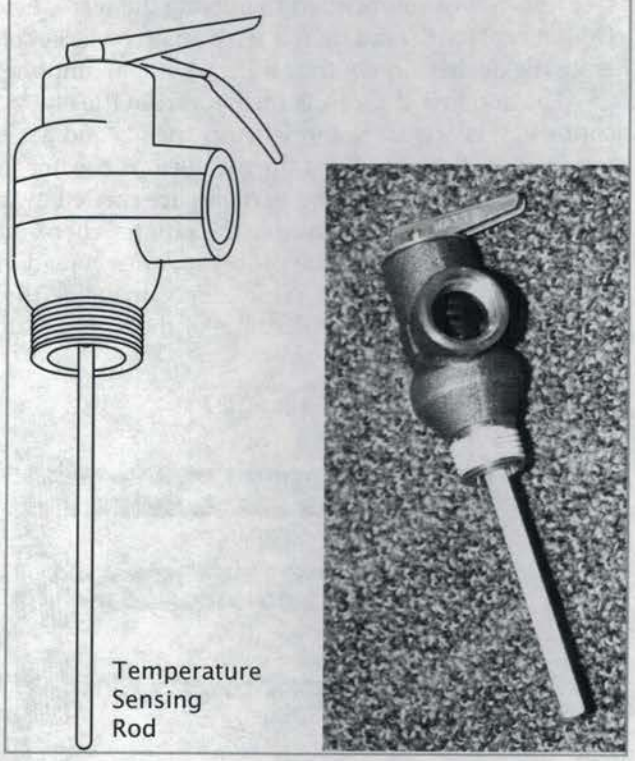
Figure 9-13 Typical Motor-aid System



9-1.2.3 Temperature and Pressure Relief Valve

A temperature and pressure (T&P) safety device, as shown in *Figure 9-14*, is used on water-heating vessels. This safety devices utilizes preset springs to release excess pressure buildup in the water tank when temperatures increase. If a thermostat were to fail, the T&P valve would protect the water tank from rupturing due to overpressurization.

Figure 9-14 T&P Relief Valve



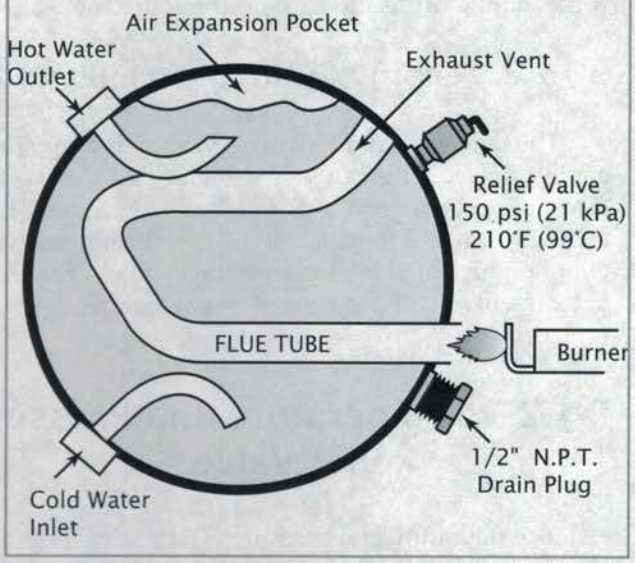
9-1.2.3.1 Water Flow

Water connections on water heater tanks are all in the same relative location among the different manufacturers. The tanks will typically have 1/2 in. 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 remains at the bottom. *Figure 9-15* 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 expands. 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 expands 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

T&P 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 tremendous 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. For winterization of water heaters, refer to *Chapter 6-4* of the *RV Plumbing Systems* textbook.

9-1.2.4 Electrolysis

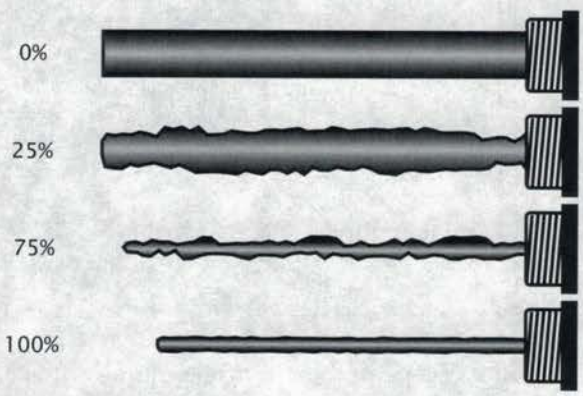
Figure 9-15 Water Fittings

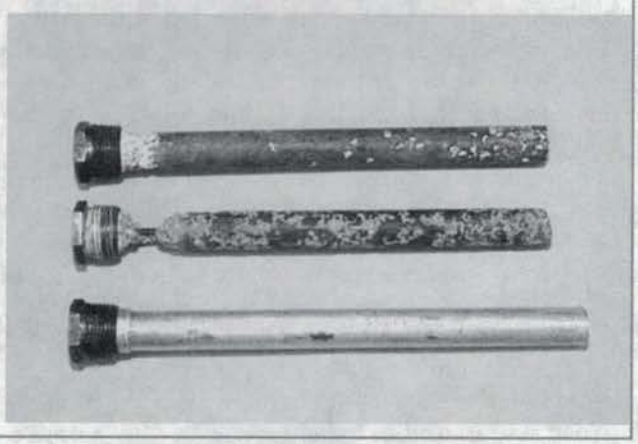


Water heater tank corrosion, or *galvanic corrosion,* is a common reaction with all water heaters. This is a process whereby microscopic particles of metals (like iron and copper), suspended in water, set up a reaction inside the water heater that is not unlike the principle on which an automotive battery operates. Water heater manufacturers use two different types of tanks, one 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. An aluminum tank does not require the use of an anode rod. *Figure 9-16* 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 percent of its original size. It is not recommended to operate the water heater without the anode rod, which also voids the warranty. Do not replace the anode rod with an aftermarket electric heater, as this will also void the warranty and accelerate the destruction of the tank and other components.

The anode rod 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 9-16 Deterioration of Anode Rod





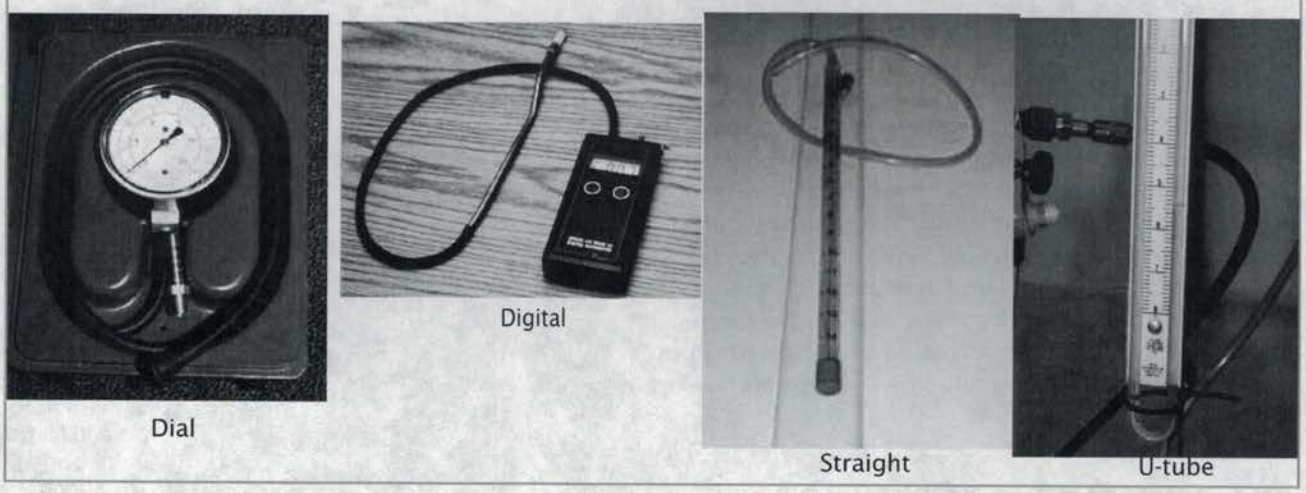
9-1.3 Tools and Equipment

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, and so on 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.

9-1.3.1 Manometer

The manometer is used to measure pressure in inches of water column (WC). This device is available in either dial (gauge), digital or 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 going 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 9-17*. For proper use of the manometer, refer to the *RV Propane Systems* textbook on system testing.

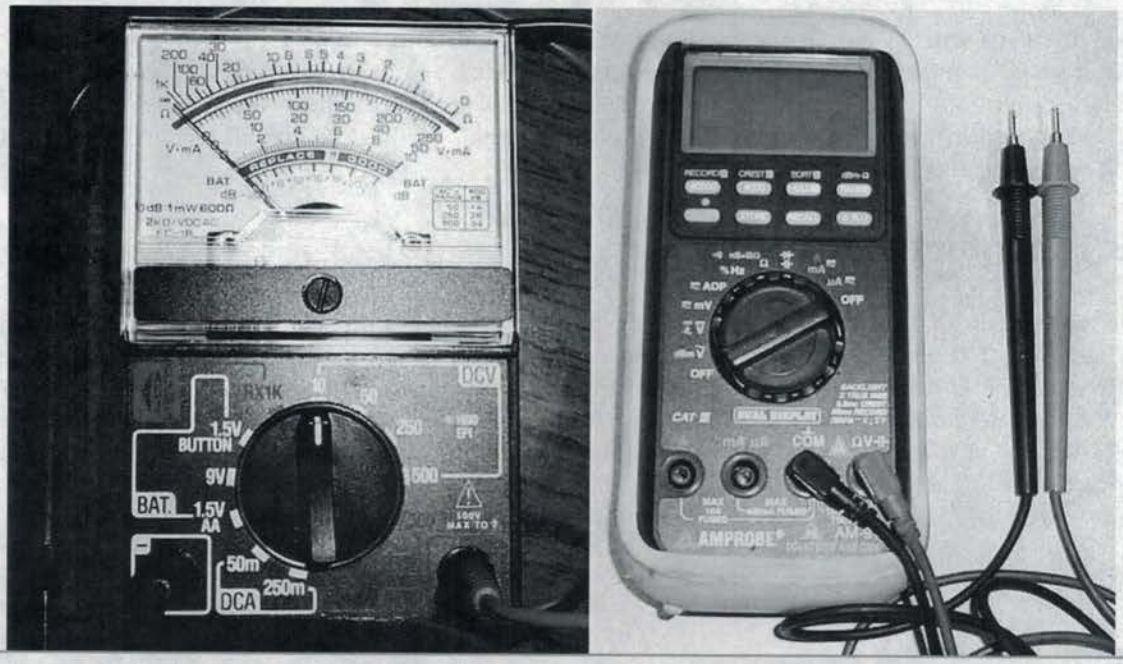
Figure 9-17 Manometer Examples



9-1.3.2 VOM

A quality VOM (volt-ohmmeter), as shown in *Figure 9-18*, is necessary and must have a DC voltage range capable of measuring a minimum of 0 to 50 mV. It must also be able to read AC and DC volts, ohms resistance, and DC current to about 10 A. Refer to the *RV Electrical Systems* textbook for information on how to use this device and its importance in performing testing.

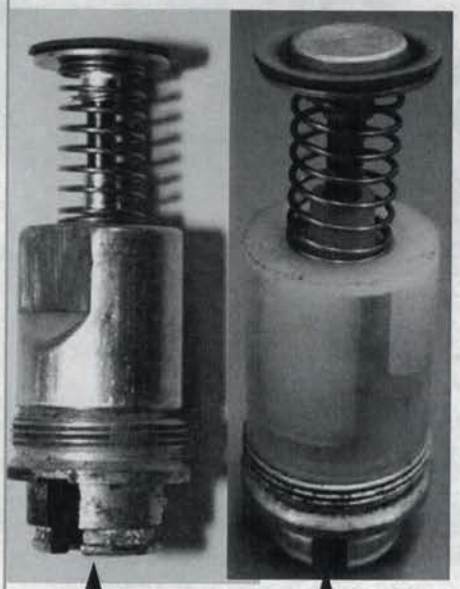
Figure 9-18 VOMs



9-1.3.3 Thermocouple Tester

A thermocouple tester, as shown in *Figure 9-19*, would be useful but not totally necessary. The thermocouple tester tests the operable range of the output of the standard thermocouple used in water heaters, old-style space heaters, and refrigerators. It simulates the magnet that is in the water heater gas thermostat control. The actual measurement of the thermocouple output, with a millivolt meter, is another valid test of a thermocouple's strength.

Figure 9-19 Thermocouple Tester



Depress spring and hold down when heating up the end of the thermocouple for around 30 seconds. After 30 seconds, remove flame from end of thermocouple and let go of the spring. The spring should stay depressed. If not, the thermocouple is defective.

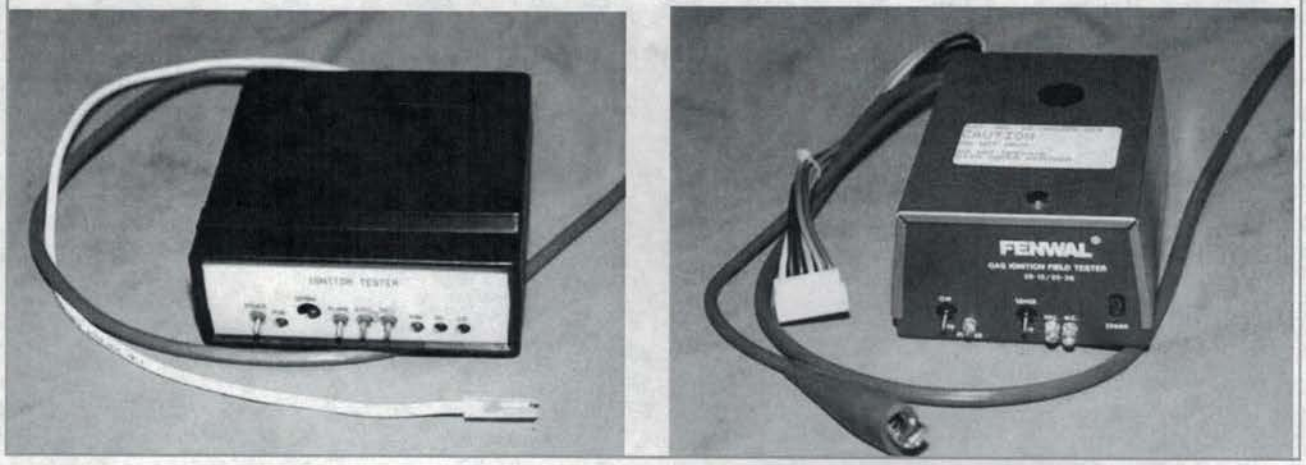
Screw the thermocouple into the tester here.

9-1.3.4 DSI Circuit Board Tester

Another specialty tool is the DSI circuit board tester, of which one type is shown in *Figure 9-20*. It is a simple tabletop device that will diagnose the following items on a circuit board: power circuit, sense circuit, spark generation, and lockout mode.

These board testers do not always simulate true working conditions.

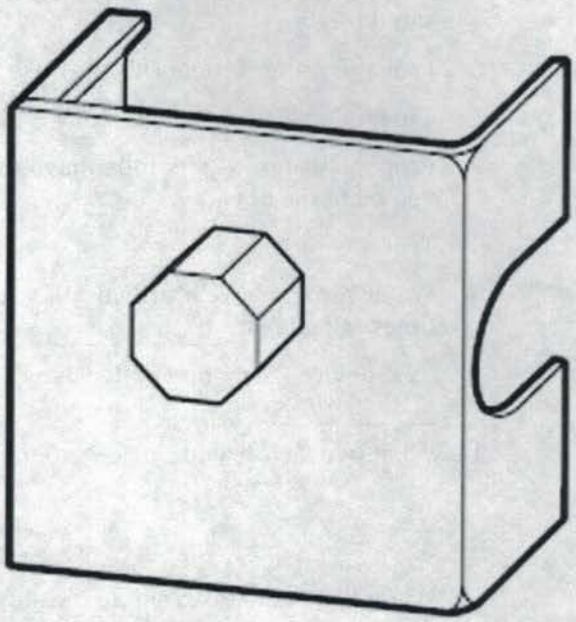
Figure 9-20 DSI Circuit Board Testing



9-1.3.5 Specialty 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.

Figure 9-21 Thermostat Wrench



9-1.3.6 Burner Brush/Flue Brush

Other convenient tools to have are a flue tube brush and a 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 9-23 Flue Tube and Burner Brushes

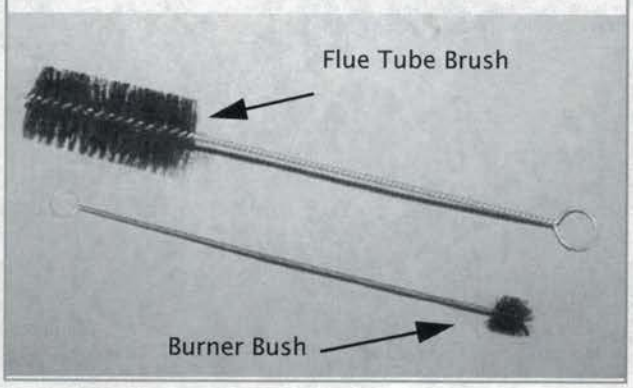
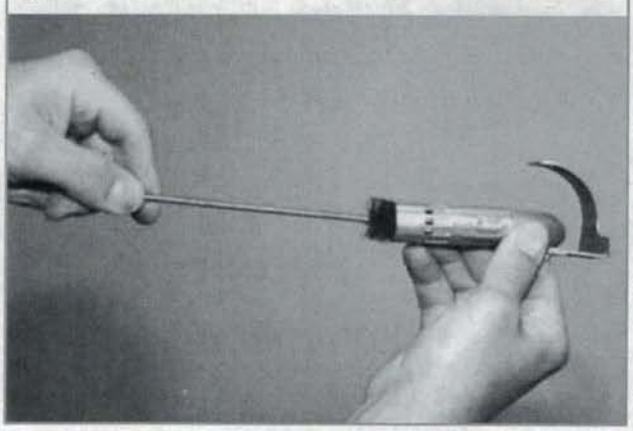


Figure 9-22 Clean Burner Tube



9-1 Review

1. The electric water heater is the primary type of water heater for all sizes and models of RVs.

   True False

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

   A.

   B.

3. 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

4. The following is the model number from an Atwood water heater: GC6AA-7P. What does the 6 stand for?

5. The following is the model number from a Suburban water heater: SW6DPERM. What does the D stand for?

6. Propane water heaters DO NOT use any inside air from the RV for combustion.

   True False

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

   True False

8. Water heaters have a primary thermostat and high limit switches. The high limit switches are sometimes called a/an _____.

9. A device that opens to avoid a possible rupture of the water heater tank is called a _____.

10. What two factors will cause water to change its state and therefore increase its volume by expansion?

    A.

    B.

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

    A. Monthly

    B. Quarterly

    C. Semiannually

    D. Annually

Chapter

9-2 Electric Water Heaters

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

9-2.1 History and Overview

9-2.1.1 Applications

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 electric water heaters in many types of recreation vehicles. Some manufacturers use stand-alone electric water heaters, but most use combination propane/electric water heaters.

9-2.1.2 Advantages and Disadvantages

Some motorhomes use a 120 VAC water heater alone, while others include the motor-aid feature for a little more versatility. In this section, only the 120 VAC portion of a water heater will be addressed.

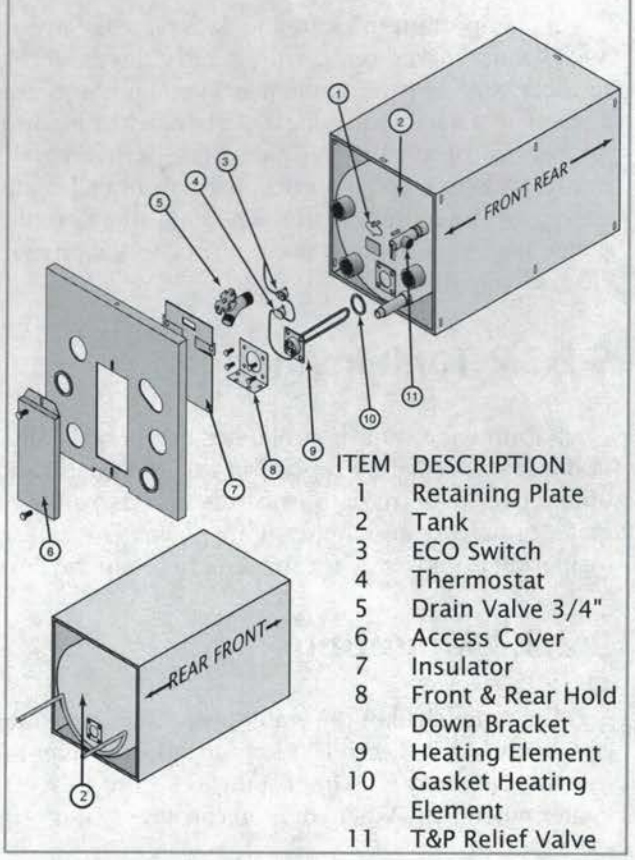
Advantages

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

Disadvantage

- Requires a 120 VAC power source

Figure 9-24 Typical Electric-Only Water Heater



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	T&P Relief Valve

9-2.2 Sequence of Operation

1. Turn on electric switch and/or circuit breaker.
2. 120 VAC goes through the thermostat (normally closed switch).
3. Normally, the thermostat demands heat, and contacts close.
4. 120 VAC goes through ECO switch (normally closed).

5. 120 VAC goes to heating element and heats water.
6. When the selected temperature is attained, the thermostat electrical contacts open.

NOTE: Steps 2 and 4 may be reversed, depending on the water heater manufacturer.

9-2.3 Components: Locations, Functions, Testing, and Interactions

9-2.3.1 Data Plate

Figure 9-25 Data Plate for Marine Application

It is important to locate the data plate on any appliance being worked on. It will identify the model, serial number, size of heating element, voltages, and amperages or wattages required. If parts need to be ordered 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.

9-2.3.2 Tank Insulation

Around the tank is a blanket of fiberglass insulation. Most tanks are wrapped in this fiberglass, and an outer cover of styrofoam 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.

9-2.3.3 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 the weight of the full water heater when the RV is in motion can stress water connections.

9-2.3.4 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 concealed behind an access cover that protects and covers all connections in one housing and that 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.

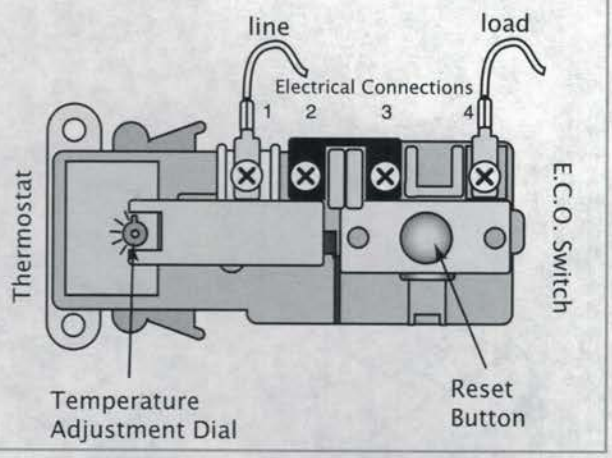
9-2.3.5 On/Off Switch

Care must be taken when selecting or replacing an on/off switch. The switch must be rated high enough to match or preferably exceed the rating for the heating element wattage or amperage. An underrated 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 separate 120 VAC 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 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 intended to be used as an on/off switch. Turning the water heater on and off with the circuit breaker will weaken the breaker and eventually destroy it.

9-2.3.6 Thermostat Assembly

Figure 9-26 Thermostat and ECO



The thermostat assembly controls the water temperature and usually includes the ECO switch. A typical thermostat assembly is shown in *Figure 9-26*. 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 9-27*, 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 ECO switch. Terminal 4 is the output from the ECO, and from here a wire connects to the heating element. In case the thermostat fails and does not open the circuit, the ECO portion of the assembly is preset to 180°F (82°C) and will open at that temperature. It is a backup for the thermostat to ensure safety, because if the water were allowed to heat with no control, the tank could rupture. The ECO 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 ECO 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 ECO switch has the button pushed out, check the terminals with a voltmeter. There should be voltage at terminals 1, 2, and 3, but not at 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 reengaged 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 ECO. 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.

Newer models may have the thermostat and ECO as separate components. *Figure 9-28* shows newer examples, but other types are similar. The thermostat is a preset normally closed (NC) switch, usually at 120 or 140°F (49 or 60°C). The ECO is also an NC switch with has a reset button and is set to open at 180°F (82°C). Whether in a combined thermostat/ECO unit or as a separate component, if an electric water heater fails to cycle, it is usually an indication of a failed ECO.

Figure 9-27 Adjusting the Temperature

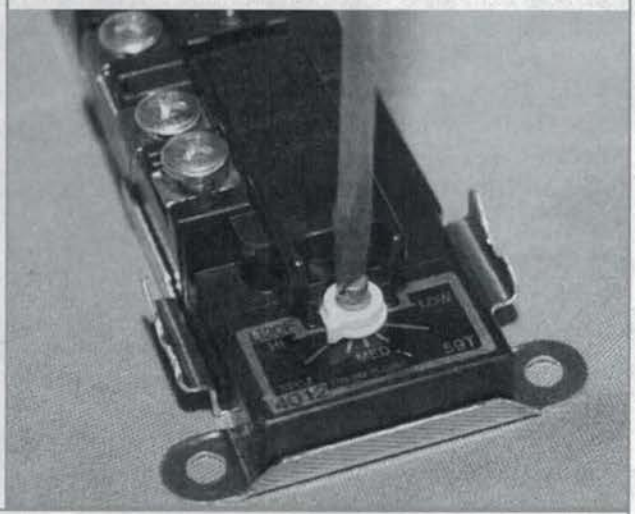
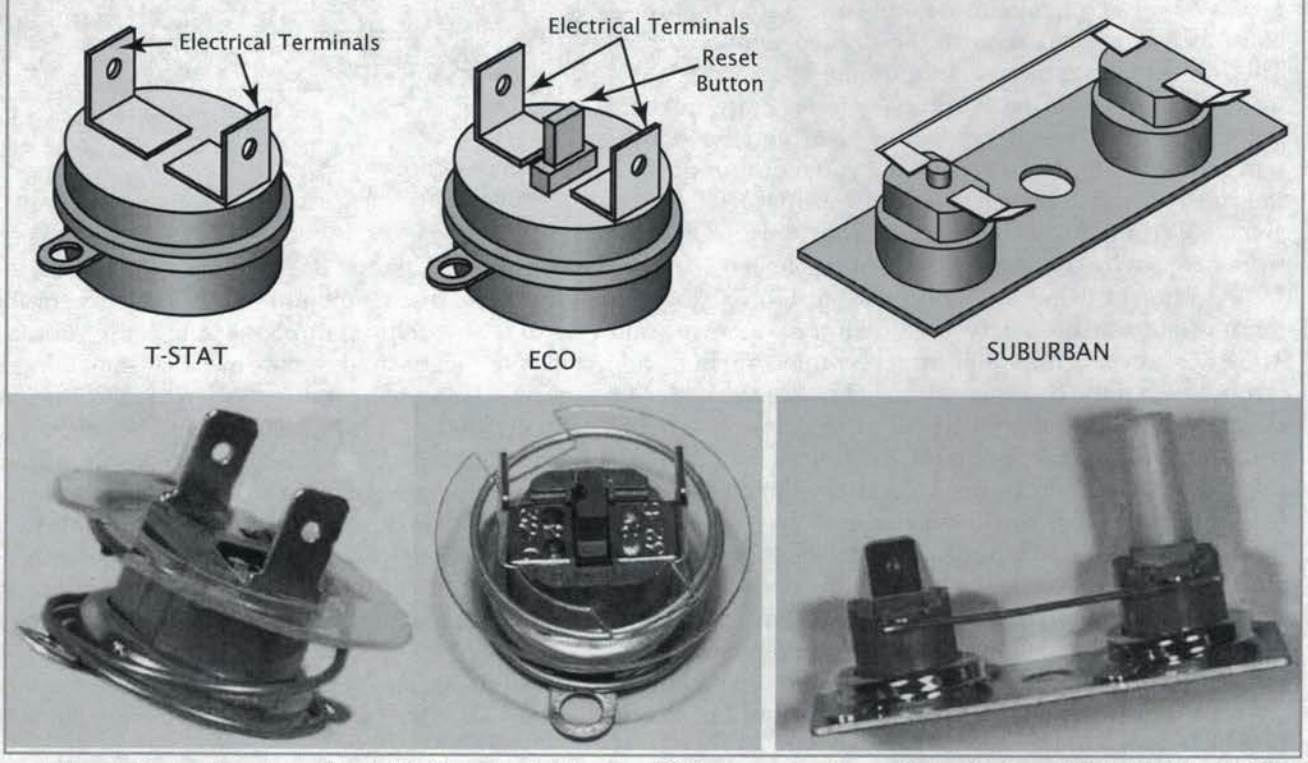


Figure 9-28 Newer T-Stat and ECO



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

9-2.3.7 Heating Element

An important component in a 120 VAC water heater is the heating element. There are two types of heating elements. *Figure 9-30* 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 W ranges. Newer elements have been reduced to 1,400 W to lower the amperage, which slightly prolongs the heating time. The 1,400 W heating element is considered the most common in six-gallon water heaters. As shown in *Figure 9-29*, 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. Take care to ensure that 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 two to three hours before adding water. Adding water before the tank cools sufficiently could damage the water heater.

The overcurrent protection device that is used to protect an electric water heater rated 13.3 A or higher and supplied by an individual branch circuit must not exceed 150 percent of the appliance ampere rating.

Some common electric water heaters are rated at approximately 1500 W (12.5 A). Even though a 15 A overcurrent device with AWG 14 wire would appear acceptable, NEC 422.13 specifically requires the rating of an electric storage-type water heater branch circuit to be not less than 125 percent of the nameplate rating on the water heater. Since 125 percent of 12. 5A = 15.63, which exceeds 15 A, a 20 A circuit breaker would be required. Since a 20 A overcurrent device is now required, 12 AWG wire would be required as well.

Usually, the appliance installation instructions or rating plate will include the fuse or breaker size required to protect the appliance.

To test the heating element, verify that there is voltage to the heating element first. If there is voltage, use an inductive amp clamp meter 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 useful 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 determines 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: 120 VAC/1400 W. It is possible to determine the resistance for this heating element as shown in *Figure 9-30*.

Figure 9-29 Heating Elements

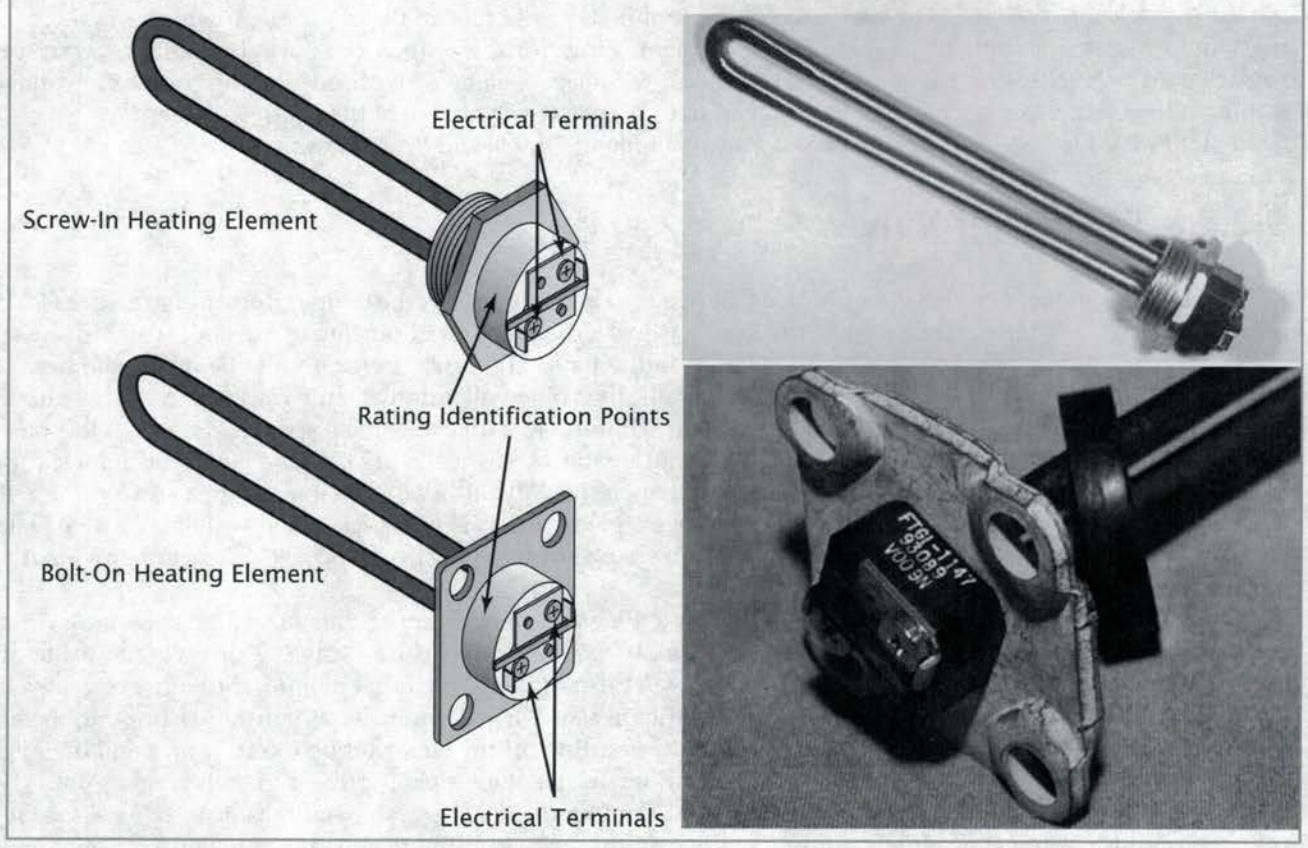
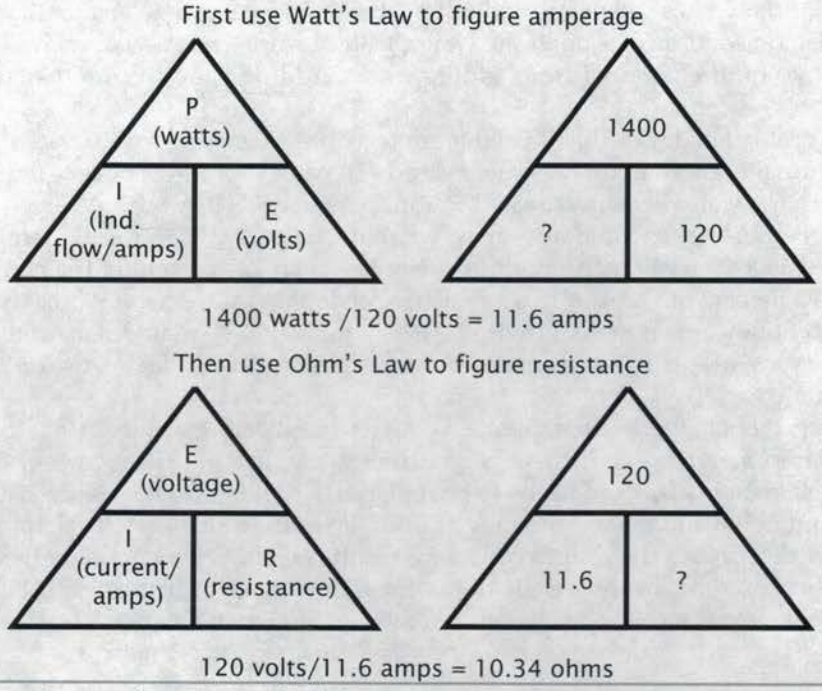


Figure 9-30 Calculating Resistance



Also check the resistance between each of the terminals to the case of the element. Any measurable reading would indicate a short to the case of the element. Either of these open or shorted conditions warrants replacement of the heating element. Always replace the heating element with one having the same wattage rating, as the other components may be matched to the capacity or wattage of the heating element.

Refer to *RV Electrical Systems* textbook for explanation of Ohm's and Watt's laws.

9-2.3.8 T&P Relief Valve

Another component on this water heater that needs to be addressed is the temperature and pressure (T&P) relief valve (*Figure 9-31*). As shown in *Figure 9-24*, it is located on the upper portion of the tank. This valve uses either 1/2 or 3/4 in. male pipe threads to install it in the tank. The probe portion must be inside the tank to monitor the temperature. If the thermostat or ECO fails, the valve will automatically open if the water temperature reach 210°F (99°C). The valve has a spring that will release with excessive pressure. As preset, the valve will open at a tank pressure exceeding 125 psi and automatically close at <125 psi. The outlet has female pipe threads. A lever located on the end of the valve will open the valve if lifted. The internal pressure spring will close the valve when the lever is released. Sometimes a piece of 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. One of two conditions usually exists if this valve weeps. One is if the air pocket in the tank has been depleted such that the water expands so much that the pressure must be relieved. At this point, the T&P relief valve opens to relieve the pressure. If this condition is constantly present, 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 T&P 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 rated operating temperature, the thermostat

may be at fault instead of the T&P relief valve. If the valve weeps and the water temperature is less than the T&P 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 the pressure temperature relief valve discharges again, repeat the above procedure.

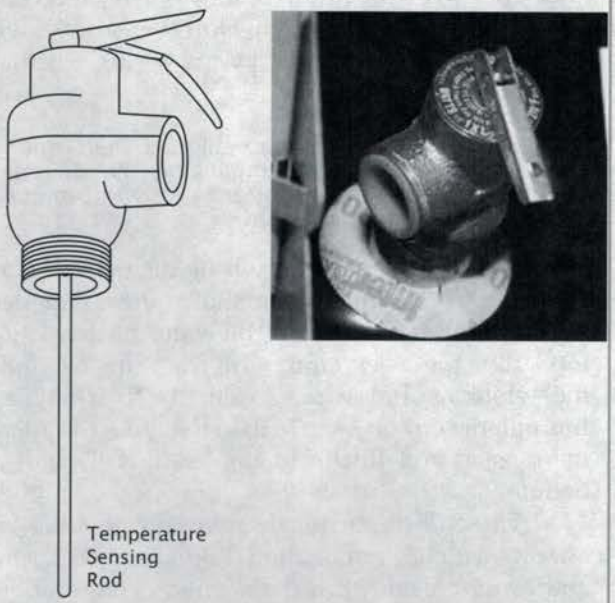
These devices can be obtained from a plumbing contractor or service center.

The replacement T&P 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, especially to replace it 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. Tighten and position the outlet of the valve to where it was previously. If replacement of the T&P valve does not correct the weeping condition, consult the *RV Plumbing Systems* textbook or the water heater manufacturer for additional information.

The T&P relief valve is typical of all water heaters and will not be readdressed in this manual.

Figure 9-31 T&P Relief Valve



9-2.4 Electrical Schematic Diagrams

The 120 VAC electrical system of the water heater is a basic wiring circuit. Since four components are 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 9-32* shows a basic wiring schematic. As the top line indicates, the dotted lines are wired by the installer. This diagram is typical of high-voltage water heater systems. The neutral wires connect 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 (ECO), and finally to the other terminal of the heating element.

Figure 9-32 Basic Wiring Schematic

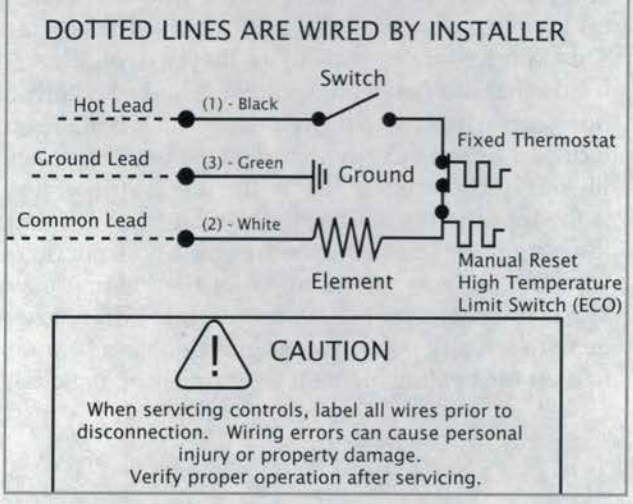
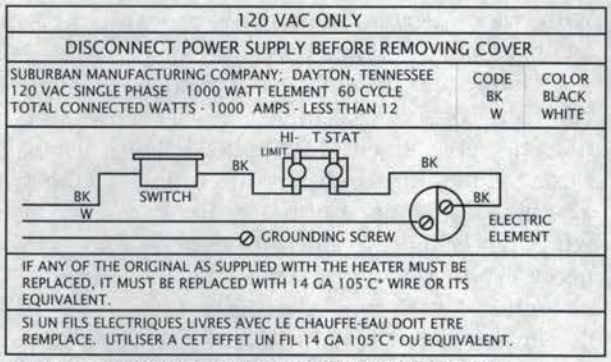


Figure 9-33 shows another system wired in a different configuration. The only difference between these two illustrations is that the thermostat and ECO are wired in reverse. The on/off switch is still at the beginning of the circuit, and the heating element is still at the end. The two temperature controls 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.

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

Figure 9-33 Wiring Schematic



Another version of the wiring diagram is shown in *Figure 9-34*. 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 ECO, the adjustable thermostat, and finally to the heating element at the bottom.

Figure 9-35 is an illustration showing the wiring, on/off switch, combination thermostat/ECO switch, and 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 ECO switch. A connector strip connects the ECO 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 ECO 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 a heating element 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 9-34 Wiring Schematic

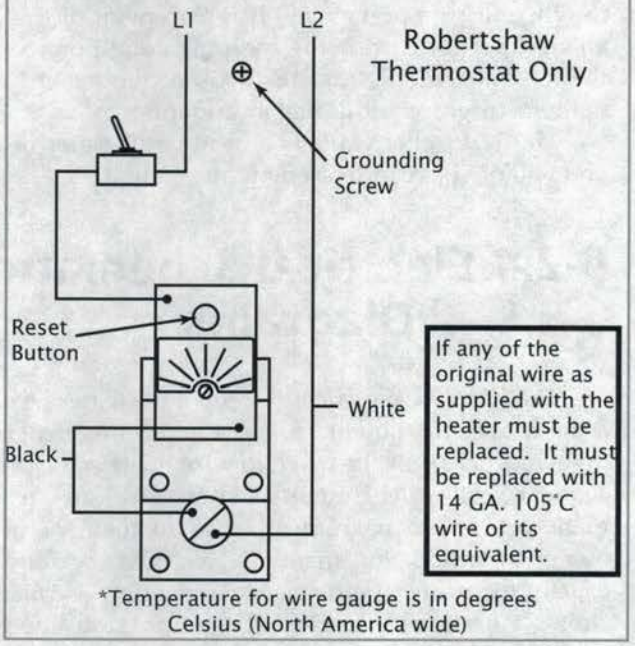
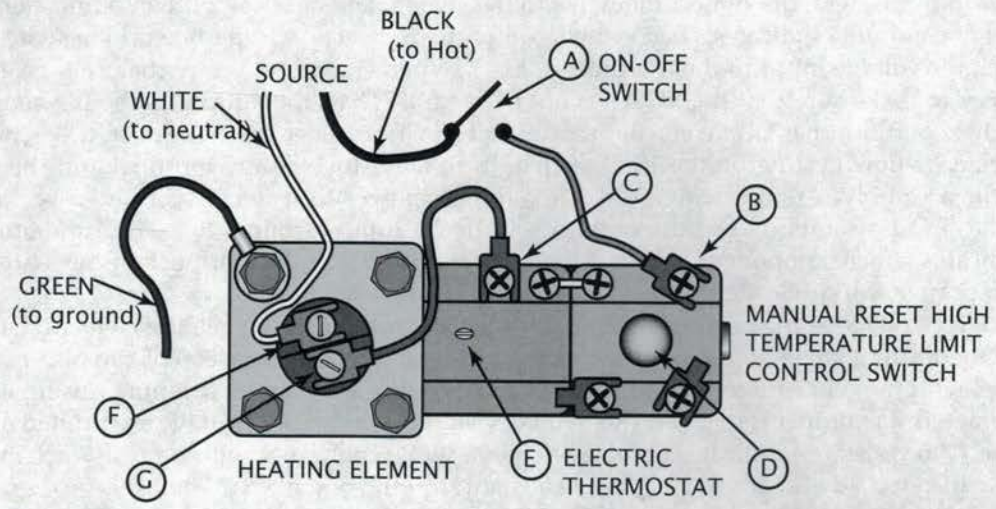


Figure 9-35 Wiring Pictorial



9-2.5 Installation

The installation requirements of the electric water heater in an RV are in the installation manual of the water heater. 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 is required. The water heater must be properly supported to avoid any movement that could rupture water lines or fatigue wires by constant motion. The installation instructions will designate minimum required distances from surrounding cabinets or walls. 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 draws considerable power (almost as much as an air conditioner), and a 20 to 30 A power supply 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.

9-2.6 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.

9-2.6.1 No Hot Water

NOTE: Check system with power on unless checking individual components with an ohmmeter.

Ensure that the bypass kit valves are set properly (if installed).

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

Check for voltage at the on/off switch, and make sure 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 the wires to the switch, and check it with an ohmmeter. With the switch on, a lack of continuity indicates a bad switch; continuity indicates a properly working switch.

Check for voltage input to the thermostat/ECO switch assembly. Verify that voltage exists at all terminals. Check to make sure that the ECO has not tripped; if it has, 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 ECO 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/ECO 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 Ohm's and Watt's laws will determine proper resistance. (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 a constant tripping of the circuit breaker.

9-2.6.2 Water Too Hot

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

9-2.6.3 Water Insufficiently Heated

A 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 bypass kit installed, and the valving is not configured properly, leaving a bypass avenue for water to flow. Check that all valves on the bypass 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 three valves are open, cold water will mix readily with the hot water, causing cool water at the hot water faucet.

Verify that the outside faucet valves are turned off. If an outside valve is on, it will allow the hot and cold water to flow together, preventing sufficiently heated water at any other faucet.

Ensure that the cold water inlet and the hot water outlet are properly connected.

Figure 9-36 Suburban Troubleshooting Guide: Electric Element Section

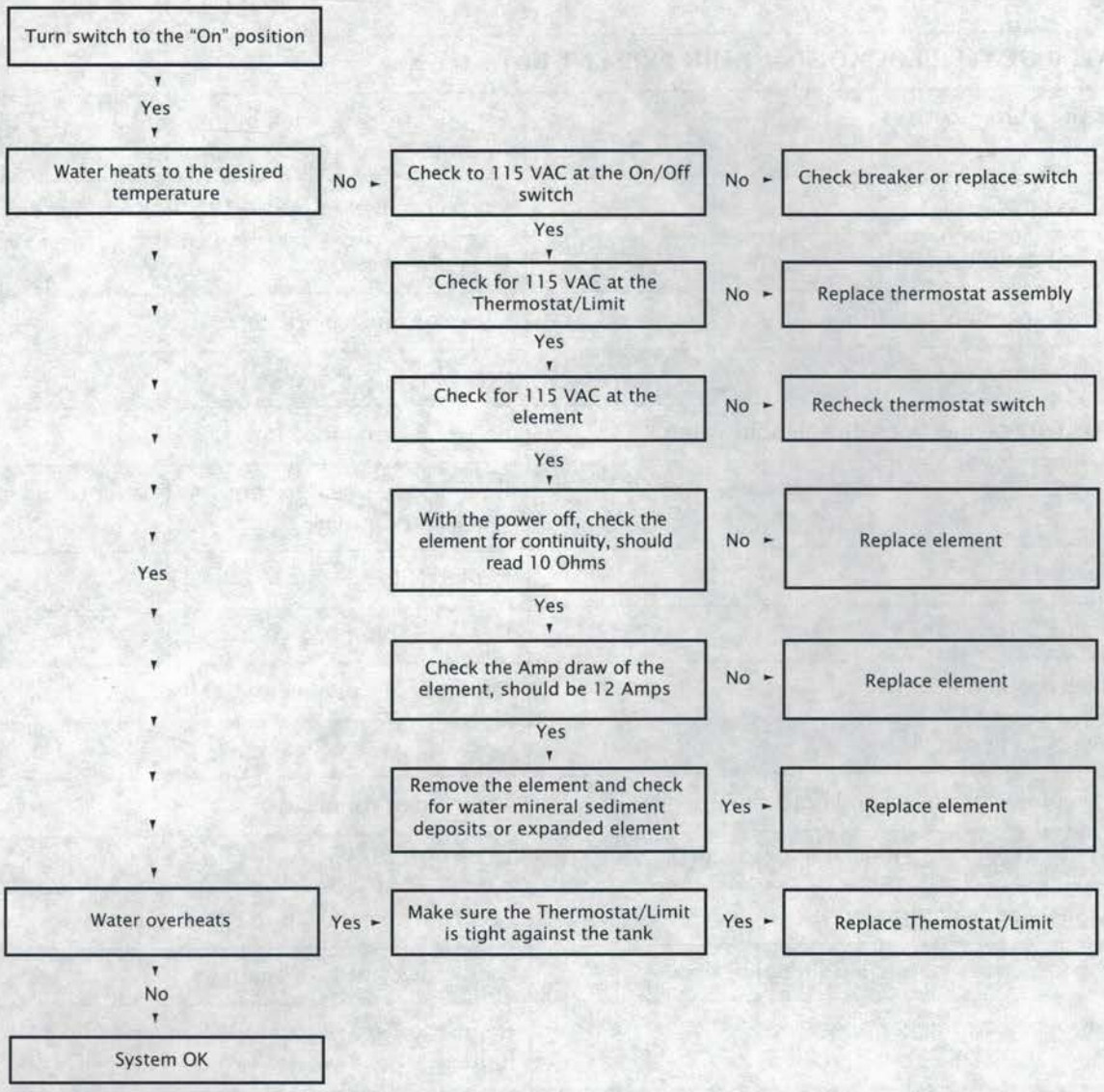


Table 9-1 Atwood Troubleshooting Guide for Electronic Ignition Water Heaters

CAUSE	SOLUTION
WATER HEATER LOCKOUT—SPARK PRESENT BUT NO GAS	
Gas pressure incorrect	Set inlet pressure at a minimum 11 in. WC with two or more gas 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 ECO	Secure wire connections.
Loose wire connections on solenoid valve	Secure wire connections.
Loose valve wire on wiring harness	Repair wire on edge connector or replace wiring circuit board harness.
Defective ECO	Replace ECO.
Defective circuit board	Replace circuit board.
Defective solenoid valve	Replace coils or solenoid valve.
No gas to solenoid valve	Correct gas supply.
Dirty connector on circuit board	Clean edge connector.
WATER HEATER LOCKOUT—GAS 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	Reposition spark gap to 1/8 in. and into path of flame.
Dirty electrodes	Clean electrodes.
Wires loose in electrode porcelain	Replace electrodes.
Cracked porcelain on electrode	Replace electrodes.
Defective circuit board	Replace circuit board.
WATER HEATER LOCKOUT— GAS AND SPARK PRESENT	
Gas pressure incorrect	Set inlet pressure at a minimum 11 in. WC with two or more gas appliances running.
Low voltage	Correct power supply—10.5 VDC minimum.

Table 9-1 Atwood Troubleshooting Guide for Electronic Ignition Water Heaters (Continued)

CAUSE	SOLUTION
Poor electrical ground	Secure electrical ground.
Electrodes out of flame pattern	Readjust electrodes.
Electrodes sparking to screw fastening burner to flue tube	Adjust electrodes away from screw.
Dirty electrodes	Clean electrodes.
Partial obstruction in main burner	Clean main burner.
Partially obstructed main burner orifice	Clean main burner orifice or replace.
Improper air adjustment	Adjust main burner air shutter approximately 1/4 open.
Flame spreader on main burner out of adjustment	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	Realign solenoid valve with main burner.
Partially opening solenoid valve	Replace solenoid valve.
Defective circuit board	Replace circuit board.
EXCESSIVE OR INSUFFICIENT WATER TEMPERATURES	
Bypass kit valves not set properly	Place valves in proper position.
Thermostat not seated against tank	Reseat thermostat.
Defective thermostat	Replace thermostat.
ERRATIC BURNER FLAME OR SOOTING	
Low gas pressure	Set inlet pressure at a minimum 11 in. WC with two or more gas appliances running.
Poor gas supply	Replace gas supply
Improper air adjustment	Adjust main burner air shutter approximately 1/4 way open. Flame should be mainly blue and quiet.
Poor main burner alignment	Adjust valve and main burner alignment.
Misaligned burner flame spreader	Align 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.

Table 9-1 Atwood Troubleshooting Guide for Electronic Ignition Water Heaters (Continued)

CAUSE	SOLUTION
Obstructed "U" tube	Clean "U" tube.
Obstructed exhaust grille	Remove obstruction.
NO SPARK AND NO GAS	
No voltage	Correct power supply – minimum 10.5 VDC.
Dirty edge connector on circuit board	Clean edge connector.
Defective thermal cutoff	Replace thermal cutoff.
Defective ON/ OFF switch	Replace switch.
Defective circuit board	Replace circuit board.
Defective thermostat	Replace thermostat.

9-2 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 cutoff 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. Make pipe connections using proper pipe sealant.

   True False

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

5. To find the amperage of a customer's water heater without using an ammeter, a technician can _____.

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 underrated switch can cause _____.

   A.

   B.

   C.

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

   A.

   B.

   C.

   D.

10. The heating element is being checked. 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, the resistance can be checked. The water heater is a 120 VAC, 1000 W heater. What is the correct resistance?

    A. 16.8 ¾

    B. 8.3 ¾

    C. 14.4 ¾

    D. 9 ¾

12. Replace a heating element 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 to 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 (multiple answers)?

    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

9-3 Manual Pilot Ignition Water Heaters

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

9-3.1 History and Overview

9-3.1.1 Application

A common water heater used on RVs is the pilot model. By heating water with propane 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 fits 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 T&P 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 (*NFPA 1192 5.4.1- CSA Z240 5.1.1*).

9-3.1.2 Advantages and Disadvantages

The advantages of 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.

9-3.1.3 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.

9-3.2 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 in. WC (nominal) 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.

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 9-37* (Robertshaw), *Figure 9-38* (SIT), and *Figure 9-39* (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 is 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 9-37 Robertshaw Control Valve

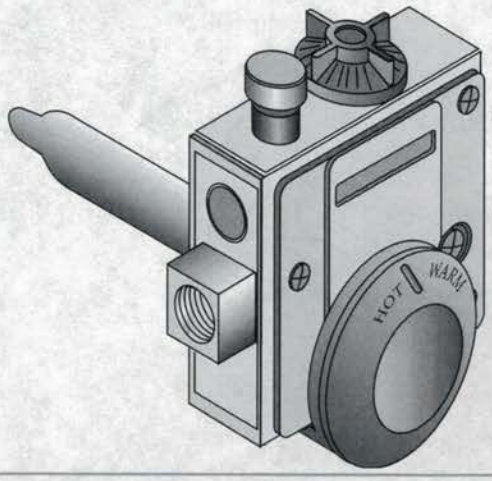


Figure 9-38 SIT Control Valve

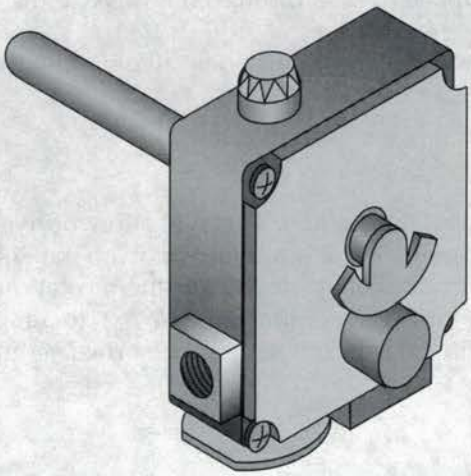


Figure 9-39 Jade Control Valve

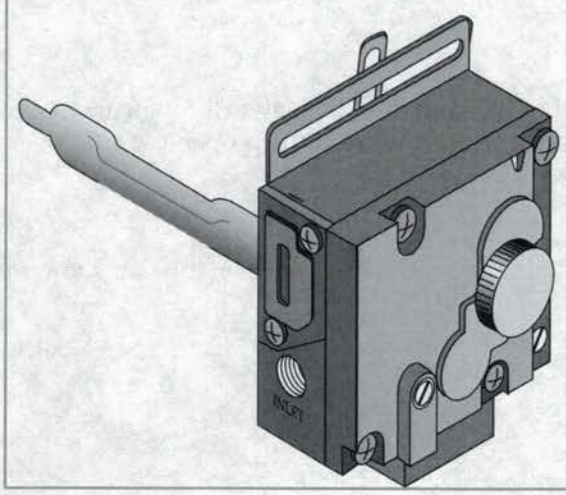
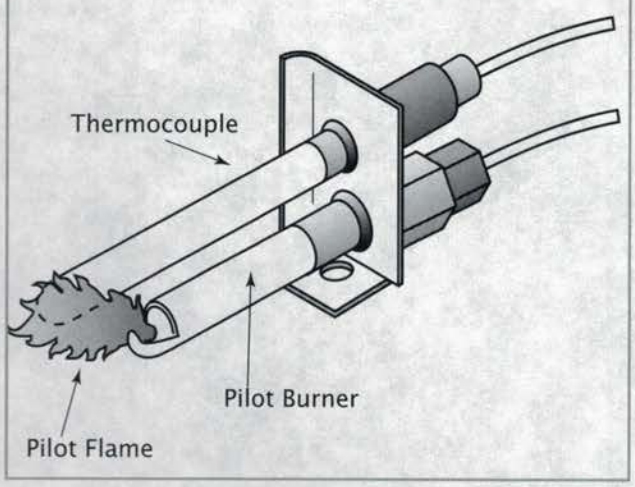


Figure 9-40 shows a pilot burner assembly with a flame engulfing the thermocouple. There are many variations of this pilot assembly, but all work on the same principle. The pilot flame must engulf the thermocouple. When heat is applied to the thermocouple, it generates a millivolt output. Dissimilar metals inside the thermocouple will generate electricity (in millivolts, mV) by reacting with each other during the application of heat. About 12 mV is the minimum output allowed. When the 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 mV is applied. This allows propane to pass through the valve to the pilot assembly for a continuous flow of propane to the pilot.

Figure 9-40 Pilot Burner Assembly



If a pilot cannot be established after several attempts, a likely cause would be a defective thermocouple. Check the thermocouple for proper output.

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 use the normal setting as the starting point for the desired temperature setting.

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.

Thermostat Opens Gas Valve

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

Main Burner Lights

The main burner will be ignited by the pilot flame at the end of the main burner tube as shown in *Figures 9-41* and *9-42*.

Figure 9-41 Pilot Sequence of Operation

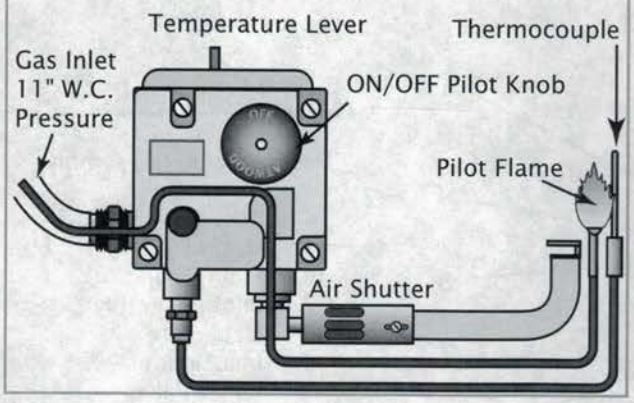
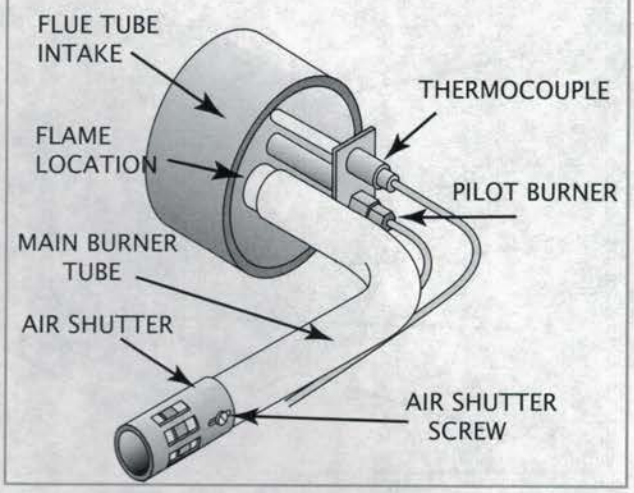


Figure 9-42 Main Burner and Pilot Assemblies



Water Heats

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

Thermostat Satisfied

Water reaches desired temperature.

Thermostat Closes Gas Valve

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

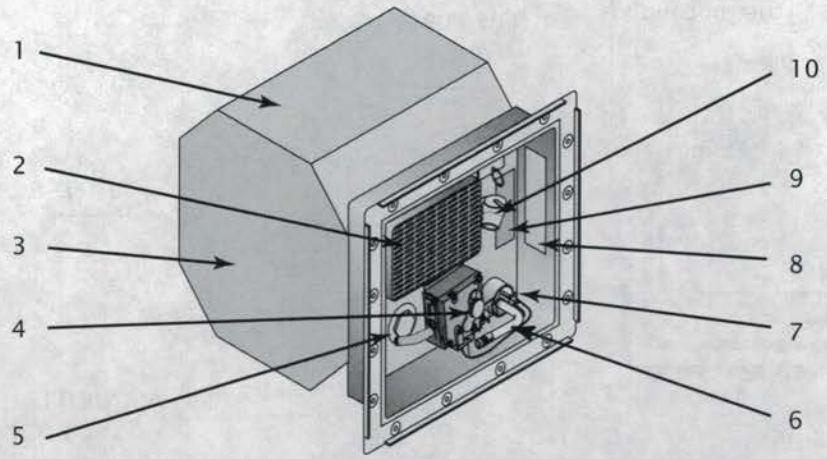
Main Burner Shuts Off and Standing Pilot Continues to Burn

9-3.3 Components—Functions, Locations, Testing, and Interaction

9-3.3.1 Data Plate

The data plate on pilot models will be inside the exterior cover on the housing of the water heater. This data plate displays 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 illustrated on *Figure 9-43* along with other components of the water heater.

Figure 9-43 Data Plate and Component Locations



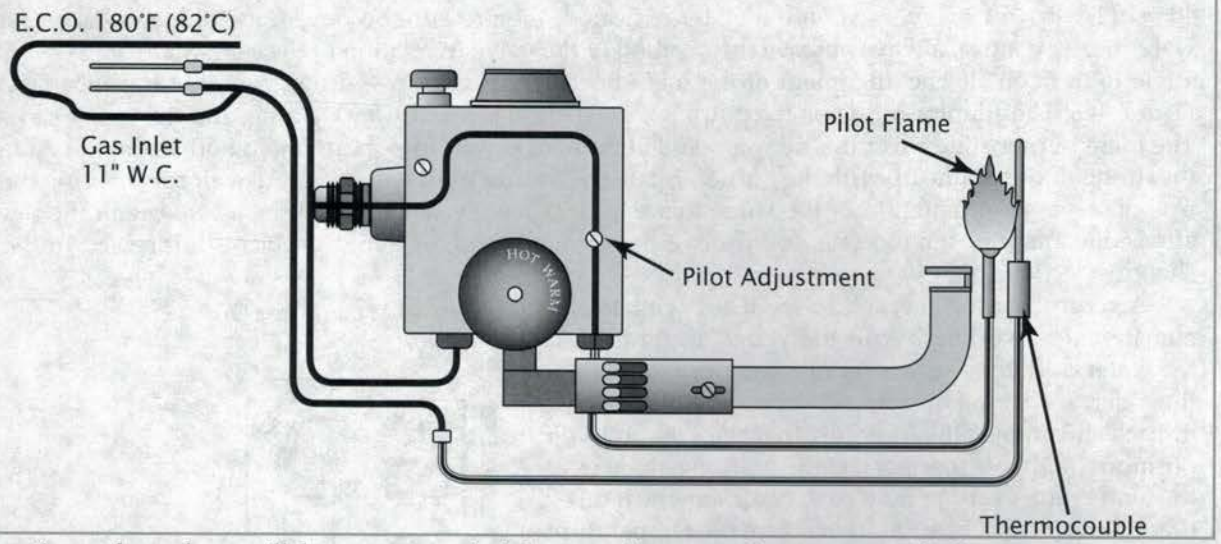
ITEM	DESCRIPTION
1	Jacket
2	Flue Box Assembly
3	Inner Tank
4	Thermostat
5	Drain Plug
6	Main Burner
7	Pilot Assembly
8	Data Plate
9	Instructions
10	Relief Valve
N/S	Exterior Access Door

9-3.3.2 Propane Thermostat Control

The propane thermostat control is a self-contained unit that has multiple functions. 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 it has an ECO 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 somehow extinguishes, 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 ECO switch built into the control. This ECO 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 ECO switch will open permanently. When the ECO 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 ECO 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.

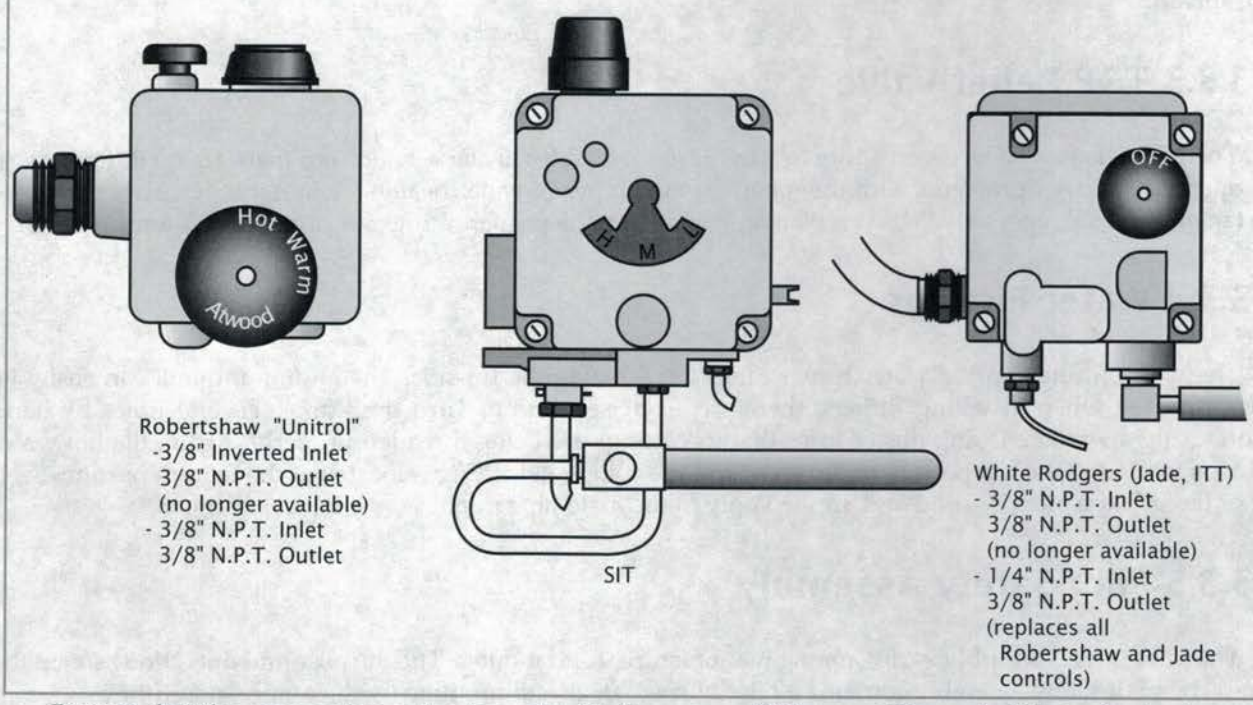
There is an adjustment on some water heater controls to adjust the pilot flame. It is a minimal adjustment and must be used with caution, as the adjustment screw could accidentally come out or leak. *Figure 9-44* shows the pilot adjustment location on the Unitrol or Robertshaw control. There is a cap 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 9-44* 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 ECO 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 in. ID) to measure output pressures from the valve while the valve is in operation.

Figure 9-44 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 9-44* also shows the ECO loop from the thermocouple to the control. The actual ECO 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.

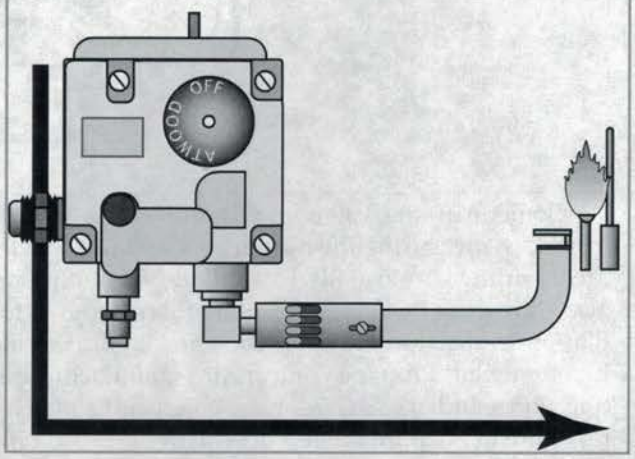
Figure 9-45 Input/Output Fitting Differences



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 corro-

sion tightens the seal at the pipe fitting in the back. This pipe fitting is male and is secured very tightly to ensure 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 9-46*. The adaptor fitting on the output of the control is usually a 90° 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 located with the new one, or after adjustment of the old one, to improve performance and/or avoid problems addressed in the troubleshooting section.

Figure 9-46 Main Burner Orifice Line up



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 that 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 when 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.

9-3.3.3 T&P Relief Valve

The T&P 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 T&P relief valve when replacing it to ensure the proper ratings for pressure and temperature.

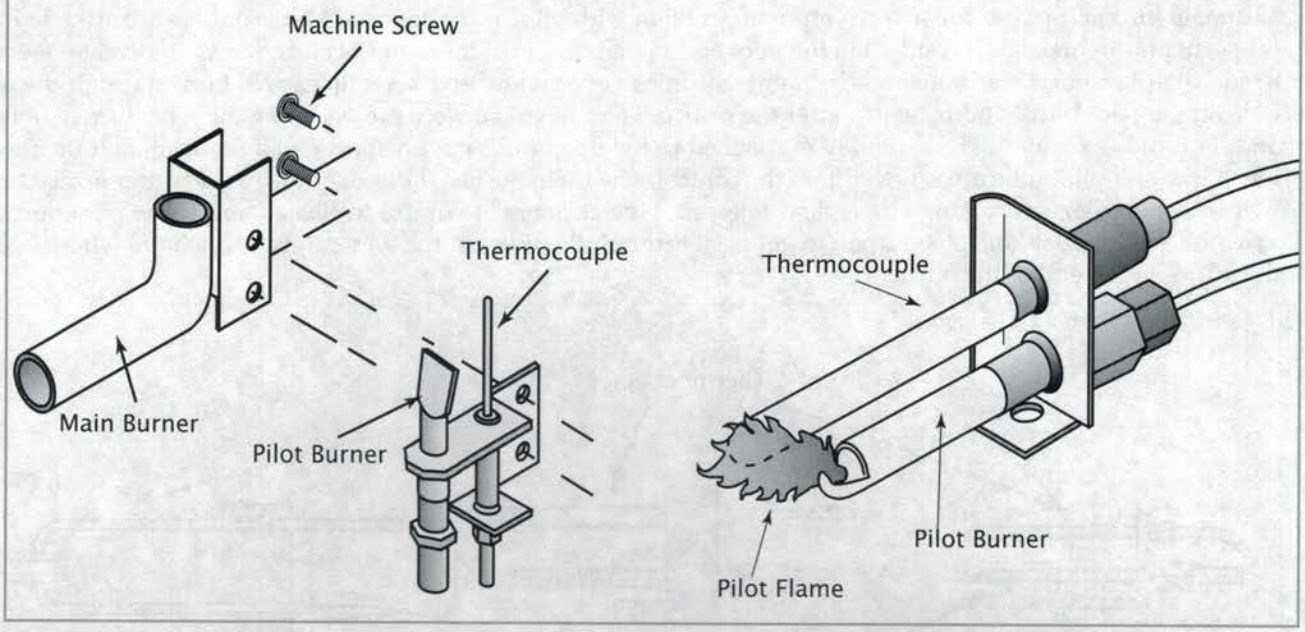
9-3.3.4 Water Fittings

The water fittings on the water heater tanks are female pipe threads. The aluminum tank can easily be cross-threaded when installing fittings; therefore, exercise caution. Turn the fittings several times by hand before using a wrench. Doing this ensures 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 applied only to the male pipe threads of fitting connections.

9-3.3.5 Pilot Safety Assembly

The pilot safety assembly varies among 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 into which it all fits. The bracket will attach to the main burner assembly. Typical assemblies are shown in *Figure 9-47*.

Figure 9-47 Typical Pilot Safety Assemblies



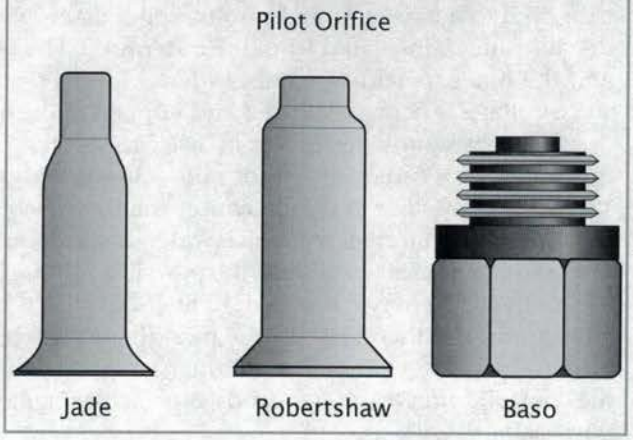
9-3.3.5.1 Pilot Burner

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 ECO.

Three different types of orifices are shown in *Figure 9-48*. 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, ensuring 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 an 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 become clean, replace it with a new one. Never insert a probe, drill, or anything similar into the orifices.

Figure 9-48 Orifice Types

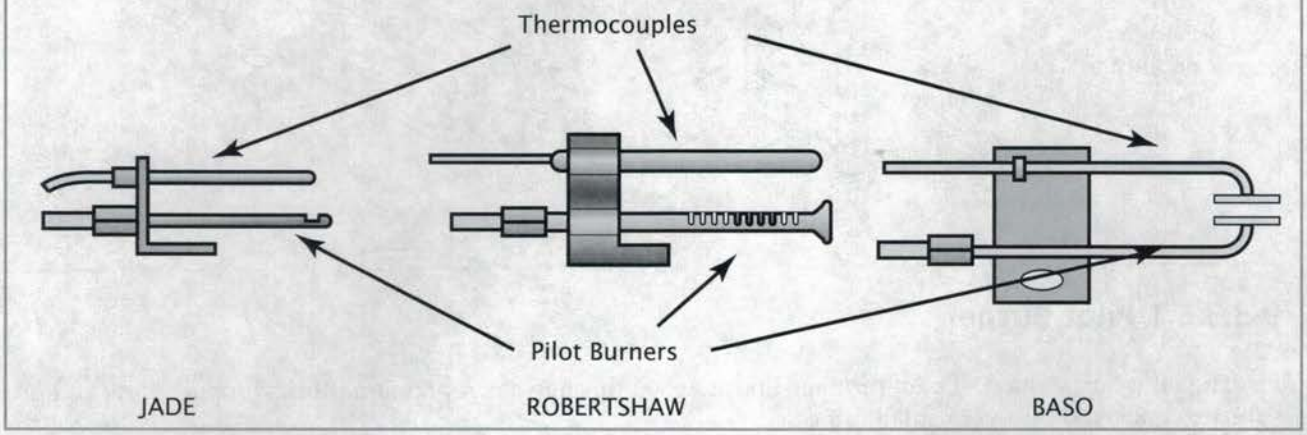


NOTE: Always check for propane leaks with an approved leak detector solution or electronic leak detector anytime the fittings have been opened or connected.

Older pilot assemblies used a 1/4 in. aluminum tubing for the pilot burner. Newer models have reduced this line to 1/8 in. Various pilot assemblies in use are shown in *Figure 9-49*. The pilot flame is usually blue and orange. The flame should completely engulf the tip of the thermocouple to ensure 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 ensure good main burner ignition. The pilot assemblies usually have a very solid mount and fit that ensures 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 9-49 Safety Pilot Assemblies

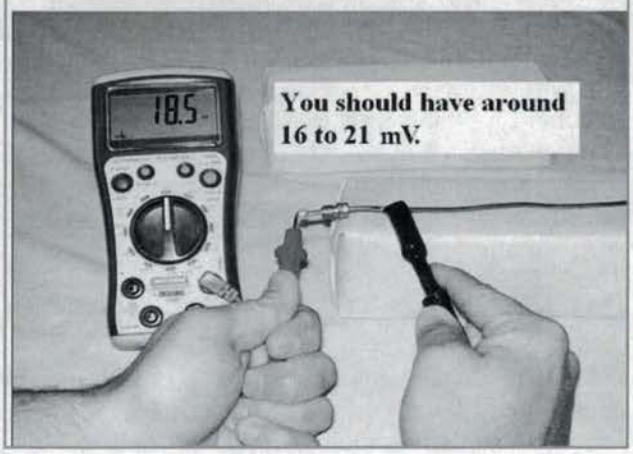


9-3.3.6 Thermocouple

The thermocouple is a very important component. It must create a minimum of 16 to 21 mV by having a flame applied to its tip. The thermocouple has a tip on it that is connected to a small housing that 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.

Figure 9-50 VOM Thermocouple Testing



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 nub end of the thermocouple that screws into the valve. Light the pilot flame and monitor the millivolts. If the meter starts to swing to a minus reading, reverse the leads of the meter on the thermocouple. As the tip gets hotter, the voltage should rise, possibly to 30 mV. 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 below 16 mV or a tester that pops in less than 30 seconds indicates a weak thermocouple and means that it needs to be replaced. Make sure it is completely engulfed in the pilot flame and that 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. Improper combustion of propane or improper positioning of the hot junction (tip) of the thermocouple will eventually result in a buildup of carbon residue on the tip of the thermocouple. This buildup will act as an insulator, thereby reducing the voltage output of the thermocouple and extinguishing the flame. Use steel wool to remove this, as it acts as an insulator, and the flame cannot heat the thermocouple enough.

9-3.3.7 Main Burner, Orifice, and Air Shutter

Figure 9-51 Main Burner

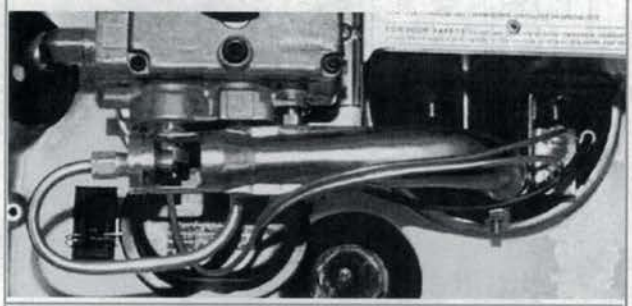
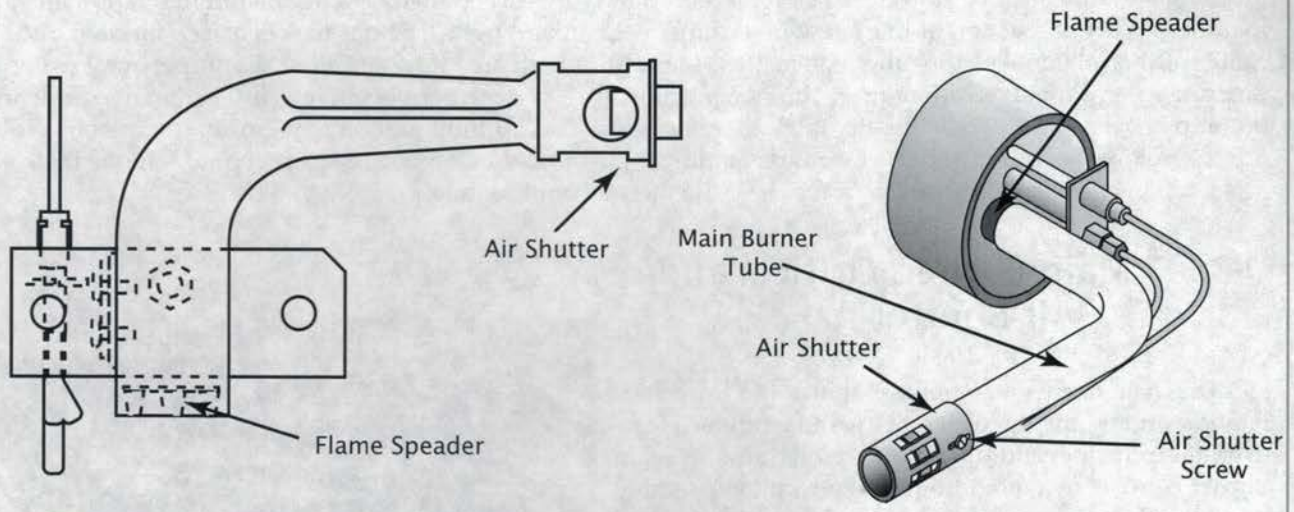


Figure 9-52 Orifice

The main burner assembly, as shown in *Figure 9-51*, has variations among different manufacturers. However, the principle and operation are the same. A main burner consists of a mounting bracket, a 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. Adjust the flame 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 9-52* and *Figure 9-53*. One manufacturer (Atwood) recommends a 1/4 in. (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 ensure cleanliness, run a burner brush 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. This is a flame spreader that is designed to make the flame spread to the sidewalls of the flue tube to increase the application of heat to the flue tube and hence to the water. Set the flame spreader parallel to the end of the opening of the burner tube. If the flame spreader deteriorates or breaks 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 or interchanging parts.

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

Figure 9-53 Air Shutter and Flame Spreader



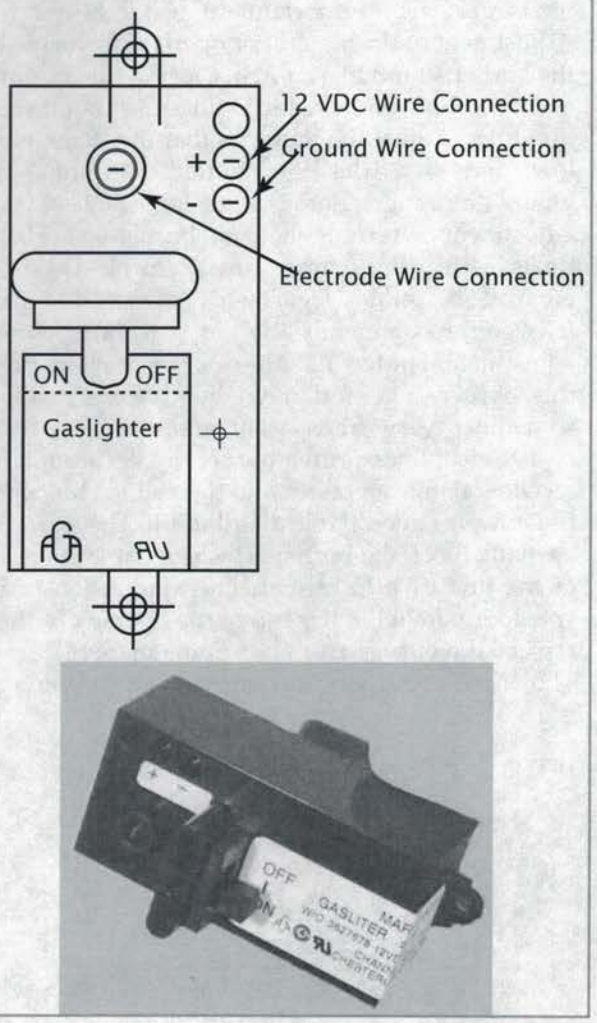
9-3.3.8 Reignitor

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 9-54*, 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.

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 bypass 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

Figure 9-54 Reignitor



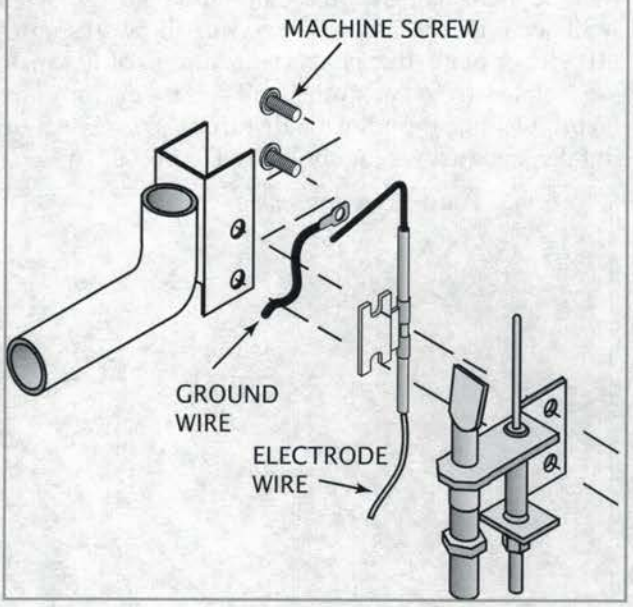
the loss and tries to re-establish the flame by sparking and beeping. In other words, the reignitor not only provides a source of ignition for the pilot flame, eliminating the need for matches or flame ignitors, it also monitors the pilot flame to try to keep it from blowing out. The propane will continue 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 collect 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 in. (0.3 cm) from the tip of the pilot burner as shown in *Figure 9-55*. It is recommended that the spark be in the same plane as the propane flow to ensure better ignition. The electrode and wire connection must be more than 1/4 in. (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 in. (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.

9-3.3.9 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 the installation of aftermarket electric heating elements. Some warranties could be voided by installing these elements in the appliance. The drain fitting on the tank contains female pipe threads, so care must be taken 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 also serves as the drain plug. Do not remove the drain plug and install a petcock. While this may make draining the tank easier, the petcock will not allow all the sediment in the tank to escape. The drain opening needs to be as large as possible to remove sediment and other contaminants in the tank. If it is necessary to replace a damaged drain plug on an Atwood water heater, use only a plastic plug, since the plug also serves as a high-pressure safety device.

Figure 9-55 Electrode Mounting

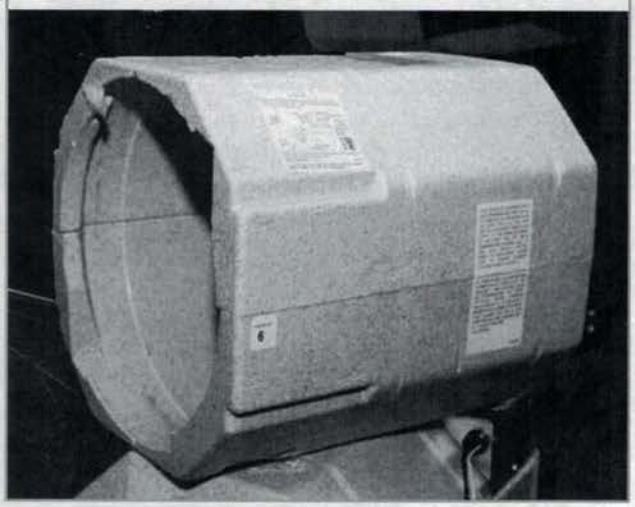


9-3.3.10 Combustion Pan

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.

9-3.3.11 Tank Insulation

Figure 9-56 Tank Insulation

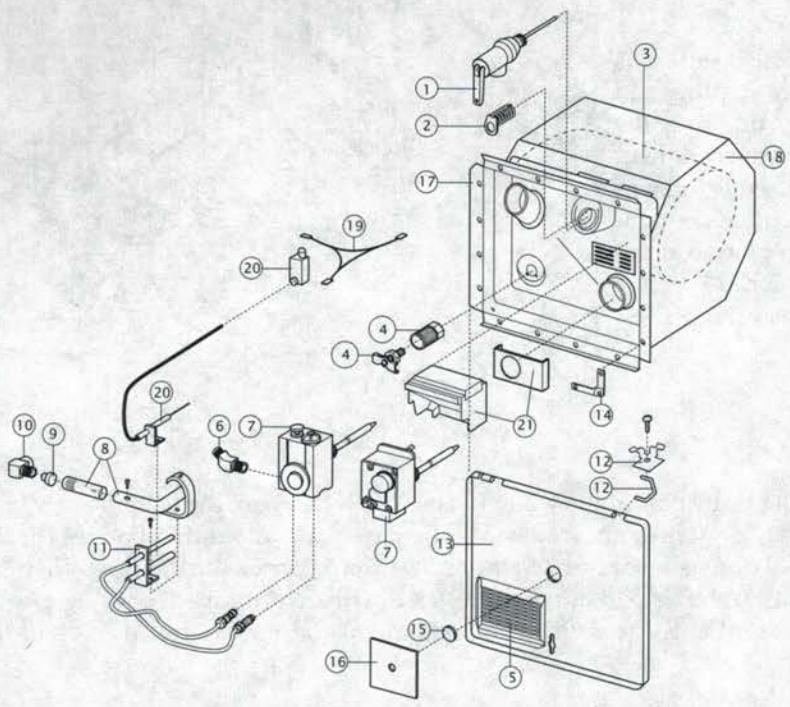


The tank insulation has changed through the years. Older water heaters used to have a fiberglass insulation wrapped around them, covered by either a cardboard cover or a galvanized sheet metal cover. Newer water heaters utilize a styrofoam-type insulation jacket that form fits around the tank, is thicker 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.

9-3.3.12 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 allows 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, ensure that the divider or plate (flue box) is a maximum of 1/4 in. (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 9-57* in parts 5 and 21.

Figure 9-57 Water Heater Assembly



1. T&P 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

9-3.3.13 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 9-57* shows the components for the door assembly.

9-3.4 Wiring Schematics

The 120 VAC system of a pilot water heater is the same as a 120 VAC electric water heater. Refer to *Chapter 9-2*, 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.

9-3.5 Installation

The sizes of water heaters will vary among manufacturers. One may not fit into another's cut-out hole if water heaters are to be interchanged. Modifications would have to be made to the hole, and possibly in the cabinet. The manufacturers will, however, make all of their similar capacity models the same size, whether they are pilot model or direct spark ignition, or whether 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 manufacturer'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 is 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.

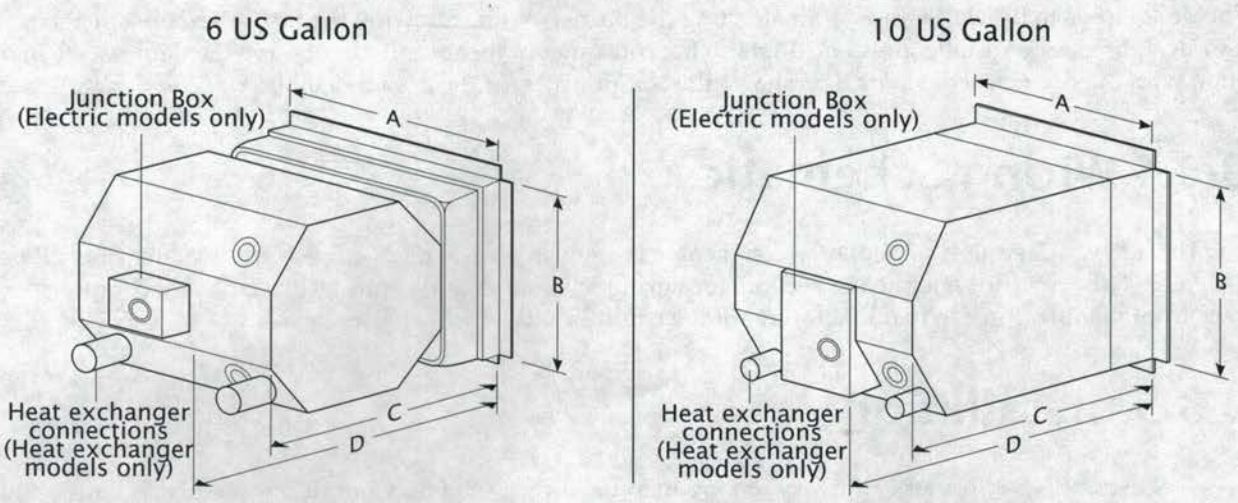
9-3.5.1 Cut-Out Sizes

The cut-out sizes are included in the installation manual of each water heater. One manufacturer's installation dimensions are shown in *Figure 9-58*, but not all are 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, there must be 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 in 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 a 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. Do not use the cabinet in which the water heater is installed for storage purposes.

Figure 9-58 Installation Dimensions



9-3.5.2 Electrical Requirements

Electrical requirements are found in the installation manuals, along with *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 that all connections are 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 appropriately sized wires to a battery source for positive and negative. The installation manual will list the required size and type of wire needed.

9-3.5.3 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. The clip is rotated 90° 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.

9-3.6 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 9-2* shows Atwood's troubleshooting guide.Most troubleshooting methods follow the same criteria for most water heaters, even older models. *Table 9-2* does not address possible propane system problems; refer to the *RV Propane Systems* textbook and/or service manuals for this information.

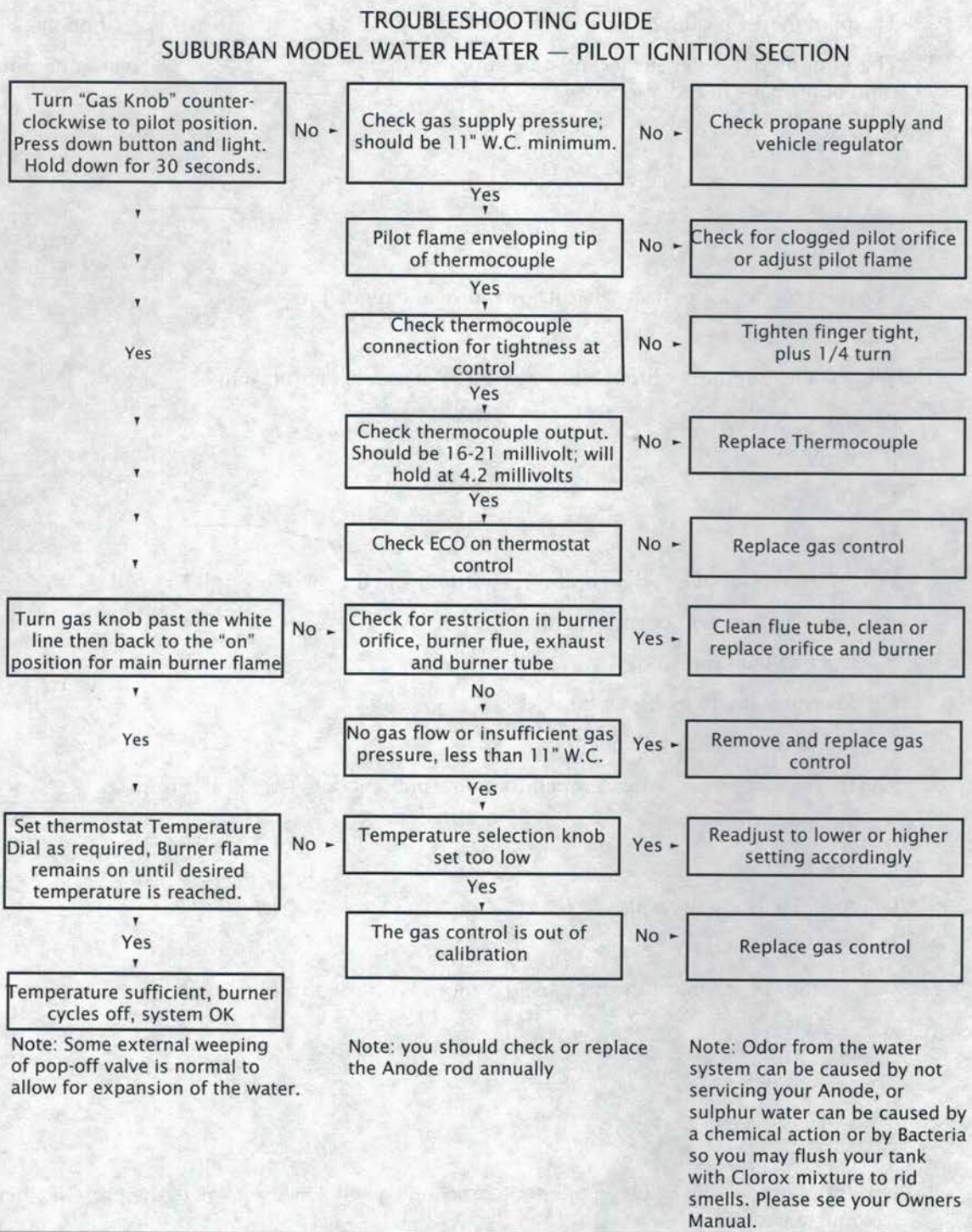
Table 9-2 Atwood's Troubleshooting Guide for Pilot Water Heaters

CAUSE	SOLUTION
PILOT OUTAGE	
Propane pressure incorrect	Set inlet pressure to 11 in. nominal WC with two or more appliances running.
Blocked U-tube	Remove obstruction.
Improper main burner alignment	Realign main burner and main burner orifice holder.
Improper air adjustment	Adjust main burner air shutter approximately 1/4 in. open.
Weak thermocouple	Replace thermocouple.
Poor pilot flame	Clean or replace pilot orifice.
Weak propane control magnet	Replace propane control.
Defective ECO 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.
Weak propane control magnet	Replace propane control.
Defective ECO 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 in. 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 in. nominal WC with two or more appliances running.

Table 9-2 Atwood's Troubleshooting Guide for Pilot Water Heaters (Contin-

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

Figure 9-59 Suburban Troubleshooting Guide: Pilot Ignition Section



9-3 Review

1. A common water heater used in RVs is the _____.
2. The pilot model is offered with an 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. ECO 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 ECO 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. On a pilot model, the ECO is a one-time function switch. Once activated, the propane thermostat control must be replaced.

   True False

10. Explain what happens when the ECO on a pilot model water heater is activated.
11. Only use listed sealant with an inverted flare fitting.

    True False

12. Which of the following is not 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. ECO

    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. The 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 fireproof 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.

THIS PAGE IS INTENTIONALLY BLANK

Chapter

9-4 Direct Spark Ignition Water Heaters

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

9-4.1 History and Overview

9-4.1.1 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, but the controls remained identical. Today, RV owners demand appliances that are more efficient and convenient to maintain and operate.

9-4.1.2 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, and having to turn it off at night, as they feared the water heater's propane. They would complain that the water heater kept them awake at night. The new direct spark ignition (DSI) 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. 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 thermostat, an ECO switch (one use), a 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 five different parts, each with its own function in the system.

9-4.1.3 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 less than one 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 DSI 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. Advise consumers to inspect the flame on the water heater each time the unit is turned on after taking it from storage.

9-4.2 Sequence of Operation

To understand and diagnose a DSI 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, or 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 six to eight seconds. If the burner fails to light, the circuit board will sense the absence of the flame and will go into a "lockout" 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.

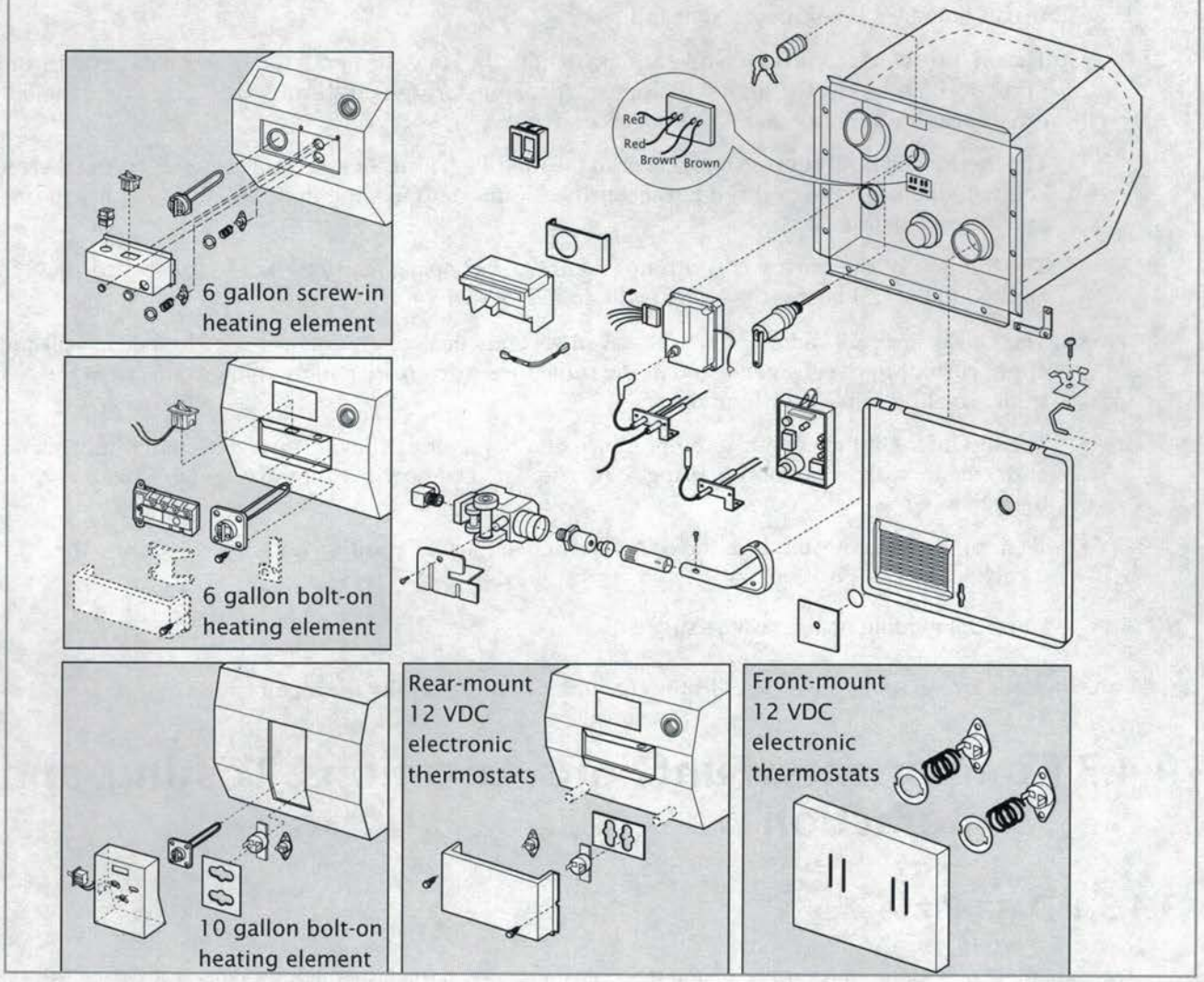
9-4.2.1 Atwood Sequence

Atwood water heaters usually follow a sequence of operation that is different from Suburban's. *Figure 9-60* shows a typical Atwood DSI 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 (NC) 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 lower 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 a thermal cutoff is opened, it must be replaced, since the water heater will no longer ignite. The flames from a bad burner heat this component and open it permanently. If it is OK, power is routed to the circuit board, energizing it. Some have a slight delay, after which a spark is produced at the burner electrode assembly for ignition. At the same time the spark is implemented, power from the circuit board is sent through the ECO switch and onto the propane valve. The ECO switch is set at 180°F (82°C) and is located near the thermostat, but it is a separate component. It is also a normally closed switch. After power runs through the ECO switch, it continues onto the redundant valve. This ensures 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 15μA of current flows. This "tells" the circuit board that 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, preventing power from going to the circuit board and shutting down the propane valve. Should the thermostat fail, the ECO will open at 180°F (82°C). It will shut down only 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 lockout, and the flame failure light will illuminate. Some models have reset buttons installed in the ECO switch.

The power sequence is summarized as follows:

- 12 VDC to switch from power source
- 12 VDC from switch to thermal cutoff
- 12 VDC from thermal cut off to thermostat
- 12 VDC from thermostat to board
- 12 VDC from board to ECO switch, simultaneously sends 26,000 volts to the electrodes for ignition
- 12 VDC from ECO switch to gas valve

Figure 9-60 Atwood Water Heater)



9-4.2.2 Suburban Sequence

Figure 9-61 Suburban Water Heater

The Suburban water heater differs slightly from the Atwood sequence, but the same operation is established. *Figure 9-61* shows a typical Suburban DSI water heater and identifies its components. Power from the on/off switch flows to the ECO switch (rated the same as an 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 that the water has reached the set temperature, it opens, preventing power from going to the circuit board and the propane valve. In the event of thermostat failure, the ECO switch will open, preventing power from

going to the thermostat, circuit board, and propane valve. This configuration will have a manual reset button installed on the ECO.

The Suburban sequence is summarized as follows:

- The on/off 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 to 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 ECO switch will open 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:
- The DSI board will delay for five to seven 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.
- The module will then confirm the presence of a flame. If the flame is not detected within six seconds, the module will stop the firing sequence. The DSI board will try for ignition twice and will then go into the lockout mode.
- To reset the water heater, turn the on/off switch to the OFF position for about 10 sec and then turn it back to the ON position.

NOTE: Some DSI module boards will be single-try units.

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

9-4.3 Components: Functions, Locations, Testing, and Interaction

9-4.3.1 Data Plate

The data plate on DSI models will be inside the exterior cover on the housing of the water heater. This data plate furnishes 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 on the pilot model (refer to *Figure 9-43*).

9-4.3.2 Power Source

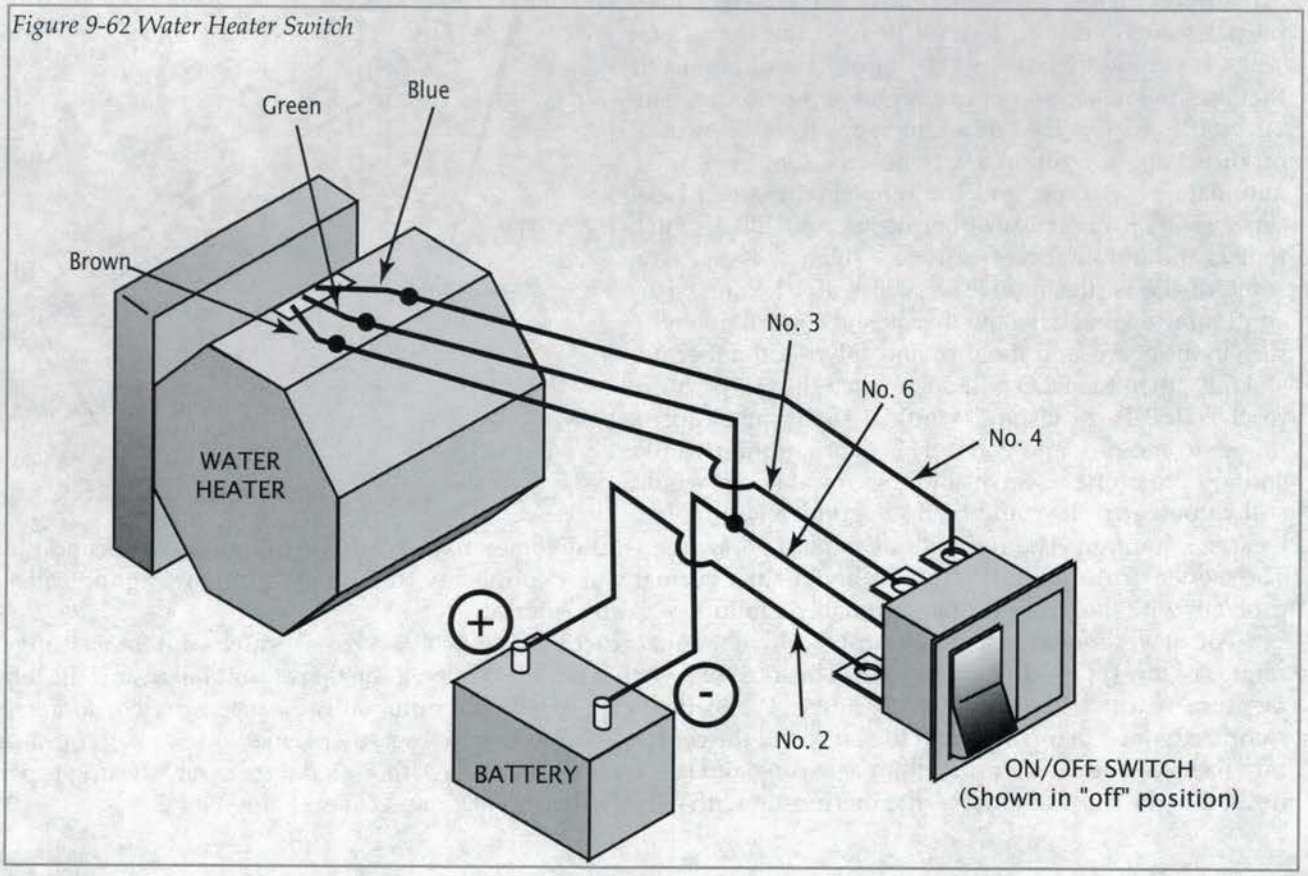
The normal power source for the DSI water heater is a fuse terminal on the converter. While "dry camping," the water heater will be powered by the RV's house battery. While camping with 120 VAC hookups, the converter will supply power to the water heater. It is recommended that, along with a positive wire from the converter, a ground wire should also run to the battery or converter to ensure 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.

NOTE: Most DSI appliances are designed to operate above 10.5 VDC.

9-4.3.3 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 9-62* shows a typical water heater switch and its relationship to the water heater and battery connections. The switch will usually have four terminals on it. Two terminals are for the on/off switch and the other two 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 two 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, use a VOM set on DC volts to make sure positive 12 VDC is present 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 no voltage to the light, the wiring from the water heater must be tested for continuity. Also test the circuit board 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 9-62 Water Heater Switch



9-4.3.4 Thermostat

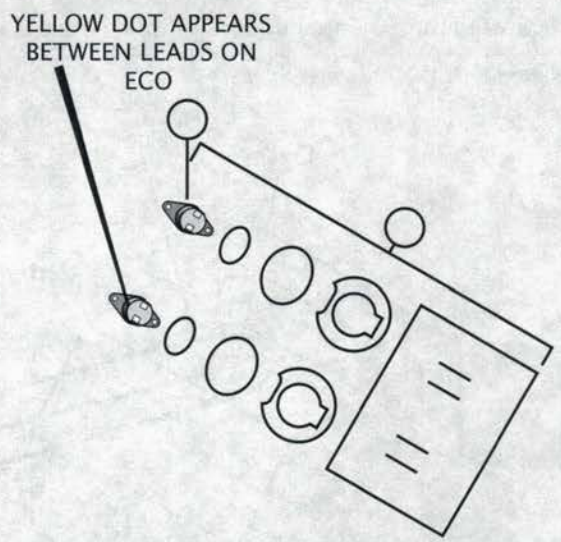
The thermostat for this model water heater is an electrical heat sensor that is located on the surface of the water heater tank. The thermostat is a heat-sensing switch that is normally closed and is usually clipped in a

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 to 140°F (49 to 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 to 140°F (49 to 60°C) is reached again. To test temperature range, use a good thermometer and hold it under the T&P relief valve after the water heater has cycled off. It should read about 120 to 140°F (49 to 60°C). The thermostat can also be tested by removing it and checking it with an ohmmeter. It should have continuity when at ambient temperature. This tests for operation, but 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 to 150°F (43 to 66°C). It is the same size as the original thermostat and is easily replaced.

NOTE: Operating temperatures may vary among manufacturers and models. Check service manuals.

9-4.3.5 ECO

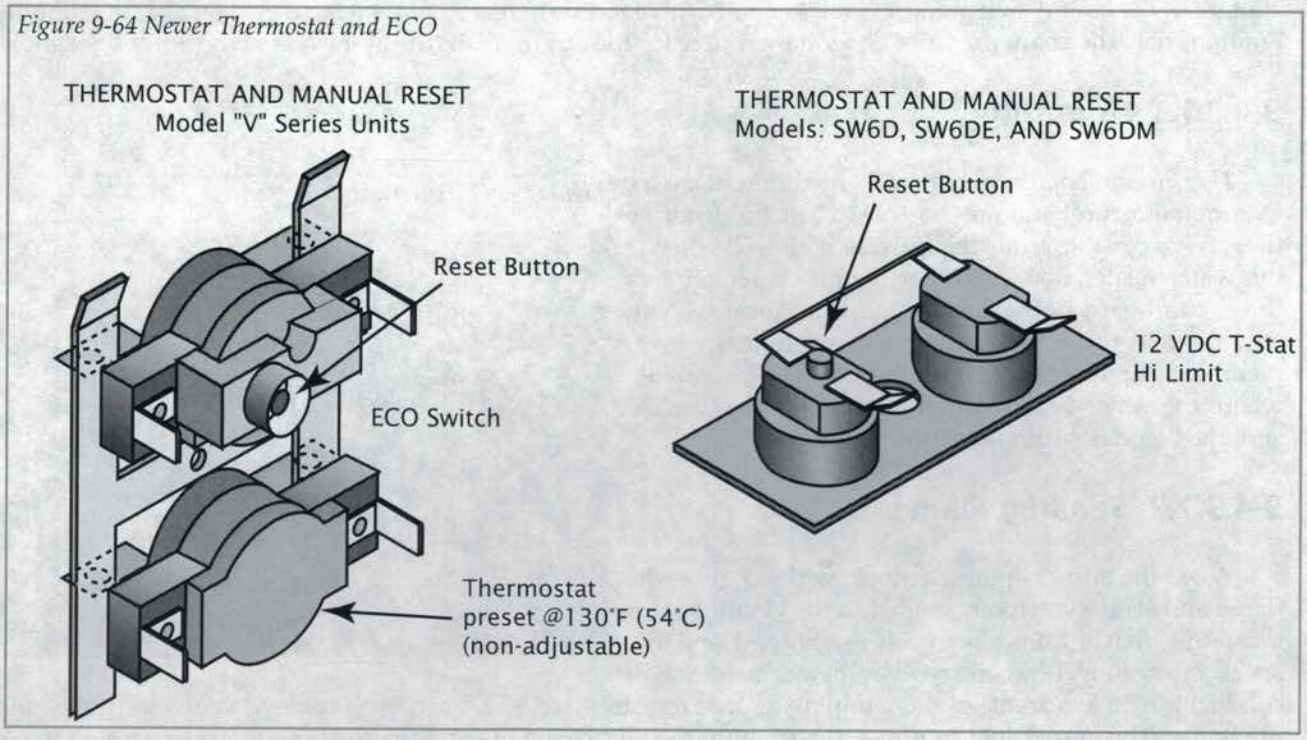
Figure 9-63 Older Thermostat and ECO



The energy cutoff switch (ECO) 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 9-63* shows a thermostat and ECO switch that is the automatic reset type, which was used on some of the earlier models of DSI water heaters. This configuration will have the thermostat control power to the circuit board and the propane valve. If the thermostat fails, then the ECO 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 lockout 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 glowing indicates a problem with the water heater—probably a failure of the thermostat.

The newer models use a thermostat with a manual reset ECO switch. *Figure 9-64* shows different configurations of this type with a thermostat. This type of switch would trip open if the thermostat failed and the temperature reached the ECO 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 9-64 Newer Thermostat and ECO



9-4.3.6 Thermal Cutoff

Some later-model Atwood DSI 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 cutoff is designed to permanently break the 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 cutoff switch opens at about 190°F (88°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 cutoff, the circuit will open. When testing the thermal cutoff with a VOM meter, it should have continuity.

9-4.3.7 Circuit Board

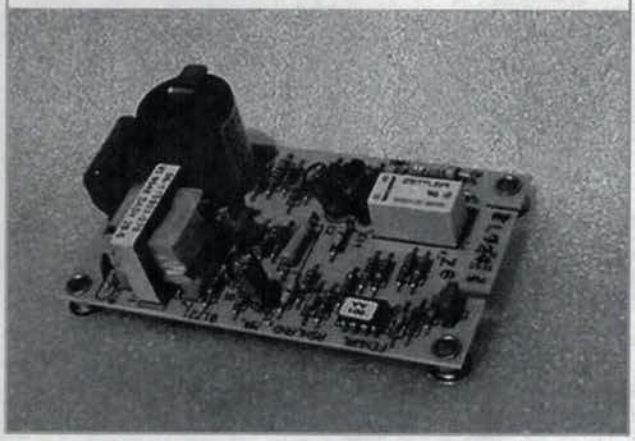
The circuit board is the key feature of the DSI water heater. There have been several models of this component as newer designs and requirements have been developed. Some manufacturers now include a 2 A fuse to protect the board; therefore, verify that the fuse has not opened. Boards are designed for each manufacturer's appliance to meet specifications and tolerances; therefore, be sure to use an approved replacement board that meets the manufacturer's specifications. 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 but also prevents them from being rebuilt. Covers for the circuit boards are necessary to protect the boards from moisture and from 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 six to eight 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.

9-4.3.7.1 Mounting

The circuit boards are located in different areas. One manufacturer mounts the boards in the front so they are 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 9-65 Circuit Board



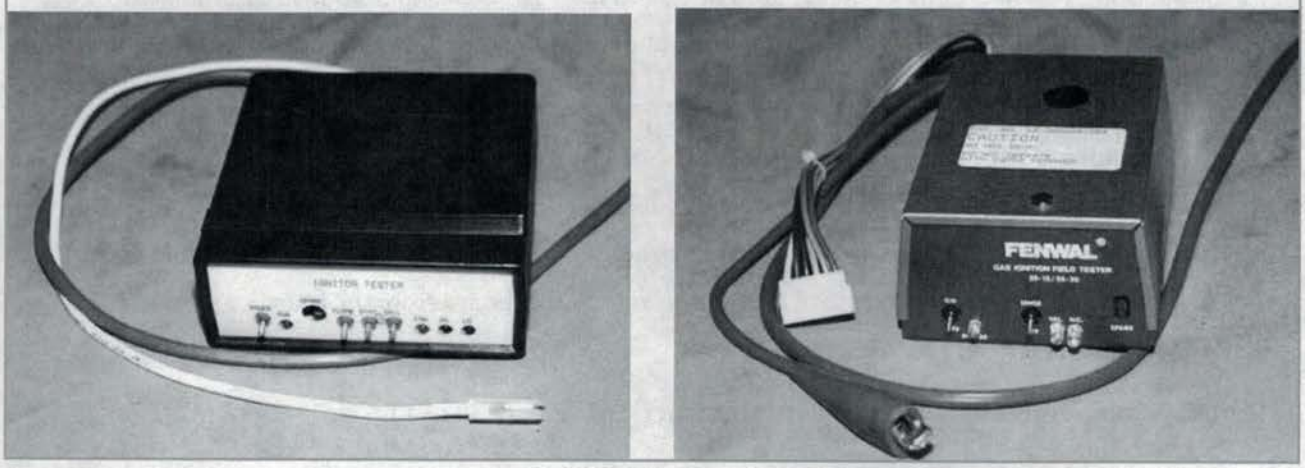
9-4.3.7.2 Sensing Flame

When the burner ignites, a sensor will recognize the flame and send a microamp signal to the circuit board, indicating that a flame has been established and the spark is no longer necessary. The newer sensor will conduct a 1. 5μA current. A microamp meter that registers 0 to 10 μA 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 that it needs to start sparking again to try and relight. The valve is still open during this trial period but 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 lockout condition until reset. Newer models have a built-in three-try feature that allows for three ignition cycles to occur before the board goes into a lockout 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 units) 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 test the circuit board with a board tester.

9-4.3.7.3 Circuit Board Tester

Testing of circuit boards is accomplished with a circuit board tester. Test circuit boards with a circuit board tester that is recommended by the water heater's manufacturer, and follow the manufacturer's instructions.

Figure 9-66 DSI Circuit Board Testing



NOTE: DO NOT INTERCHANGE CIRCUIT BOARDS. Liability is assumed for damage in the event of failure. 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 ensure that the board is good.

When using a circuit board tester, make sure that the board is tested several times if found suspect. Often, the electronics of the board will establish a pattern of failure. That is, it may repeat a failure of operation every two, three, four, or more times but work 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 they are cycled several times to see if there is a failure pattern. Sometimes the tester must operate the board continuously to warm up the board up, after which it could fail in a pattern. Extreme caution must be taken to avoid using the wrong circuit board for the application. Dangerous conditions could occur if the wrong board is used in a particular application. If everything tests OK, and the flame will not stay on, test the ignitor and wires to the circuit board. The following are instructions for testing blower and non-blower controls.

12 VDC DSI Module Board Field Tester Instructions, Part #641511

Blower Control Version Module Board, Part # 52082

1. Make sure the A/B SWITCH is in the B position, the ON/OFF SWITCH is in the OFF position, and the SENSE/OFF SWITCH is in the OFF position. **The control win run in the A position but will not test the blower function.**
2. Plug the power cord into a 120 VAC outlet.
3. Connect the control to be tested to the tester wiring harness and high-voltage wire. Connect the RED power wire to the PWR terminal on the fan control module board and the ORANGE blower wire to the BLO terminal on the fan control module board.
4. Place the ON/OFF SWITCH to the ON position. The POWER LED, NC LED, and BLOWER LED should illuminate on the test box. This will simulate the thermostat points closing and the blower operating.
5. After the pre-purge time, the VAL LED should illuminate, and the control should begin to spark, illuminating the neon spark bulb. The NC LED should turn off.

6. During the spark sequence, place the SENSE SWITCH to the SENSE position. The control should stop sparking before the end of the ignition time, and the VAL LED should remain illuminated.
7. Turn the SENSE SWITCH off. The fan control module board will perform three more trial-for-ignition sequences before proceeding to lockout. After lockout occurs, the NC light will be illuminated.
8. After approximately three minutes of being in the lockout condition, the blower LED should turn off, simulating the furnace blower shutting off.
9. The control **PASSES** test if the module board does not function as stated in items 4 through 7 listed above.
10. The control **FAILS** test if module board does not function as stated in items 4 through 7 listed above.
11. Turn off all switches and remove the fan control module board from the tester.
12. Unplug tester from 120 VAC.

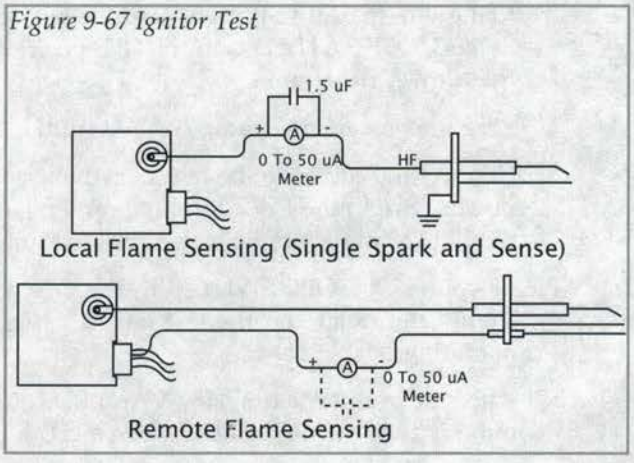
12 VDC DSI Module Board Field Tester Instructions, Part #641511

Non-blower Control Version Module Boards, Part #520741

1. Before plugging the tester into 120 VAC or connecting the module board to the tester, make sure that the A/B SWITCH is in the A position, the ON/OFF SWITCH is in the OFF position, and the SENSE/OFF SWITCH is in the OFF position.
2. Plug the power cord into a 120 VAC outlet.
3. Connect the module board to be tested to the tester wiring harness and the high-voltage wire.
4. Place the ON/OFF SWITCH to the ON position. The POWER LED and the marked NC LED should illuminate on the test box. This will simulate the thermostat points closing, thus calling for ignition.
5. After the pre-plug time, the LED marked VAL should illuminate, and the control should begin to spark, illuminating the neon spark bulb. This will indicate that 12 VDC power is being applied to the valve and the electrode is sparking. The NC LED should turn off.
6. During the spark sequence, place the SENSE/OFF switch TO THE sense POSITION. This will simulate the burner igniting. The module board should stop sparking when the switch is placed in the sense position. The VAL LED should remain illuminated, simulating that there is a flame present and keeping 12 VDC power to the valve. The NC LED should remain off.
7. Turn the SENSE SWITCH off. One-trial-for-ignition models will perform one more trial-for-ignition sequence then fall into lockout. Three-trial-for-ignition module boards will perform three more trial-for-ignition sequences then proceed to lockout. After lockout occurs, the NC LED light will be illuminated.
8. The control **PASSES** test if the module board functions as stated in items 4 through 7 listed above.
9. The control **FAILS** test if the module board does not function as stated in items 4 through 7 listed above.
10. Turn off all switches and remove the control from the tester.
11. Unplug tester from 120 VAC.

Figure 9-67 shows a test for both old and new style ignitors with a microamp meter and a 1.5 µF 200 capacitor. This test would indicate whether there is sufficient

Figure 9-67 Ignitor Test



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 that the water heater is connected to a linear converter that has too much AC ripple in its output. Also, some consumers living full time in their RVs 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.

9-4.3.8 Solenoid Propane Valve

The propane valve for DSI 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 that 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 ensures 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 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 check the valve coils for resistance. Disconnect the leads from the coil terminals and check the resistance reading. It should read between 30 to 50-3/4. 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 the adaptor (1/8 in. or 3.2 mm) to the 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 the manufacturer's 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 these brackets must be reused when installing the new valve. These valves cannot be repaired; if defective, they must be replaced.

9-4.3.9 Spark Probes

Spark and sensor probes are an important part of the DSI water heater. The older models use three 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 ensures a strong spark for burner ignition. *Figure 9-68* shows a typical three-probe ignitor assembly. This type has the spark wire and sense wire attached and weatherproofed to the probes.

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 in. 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 two pliers are used 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. If this occurs, the assembly must be replaced. If the tips of the electrodes begin to crack, swell, or distort, replacement is also necessary. If carbon buildup exists on the probes, simply clean them with steel wool, then find the cause of sooting and correct it. It could be as simple as spider webs in the burner! *Figure 9-69* shows the newer two-probe style ignitor assembly with a 1/8 in. 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 DSI water heater.

Figure 9-68 Three Probe Ignitor

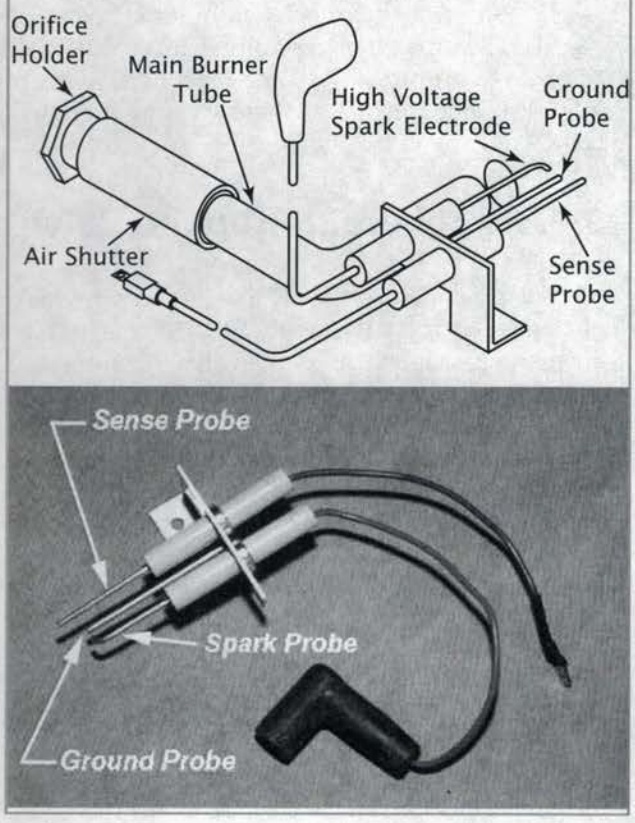
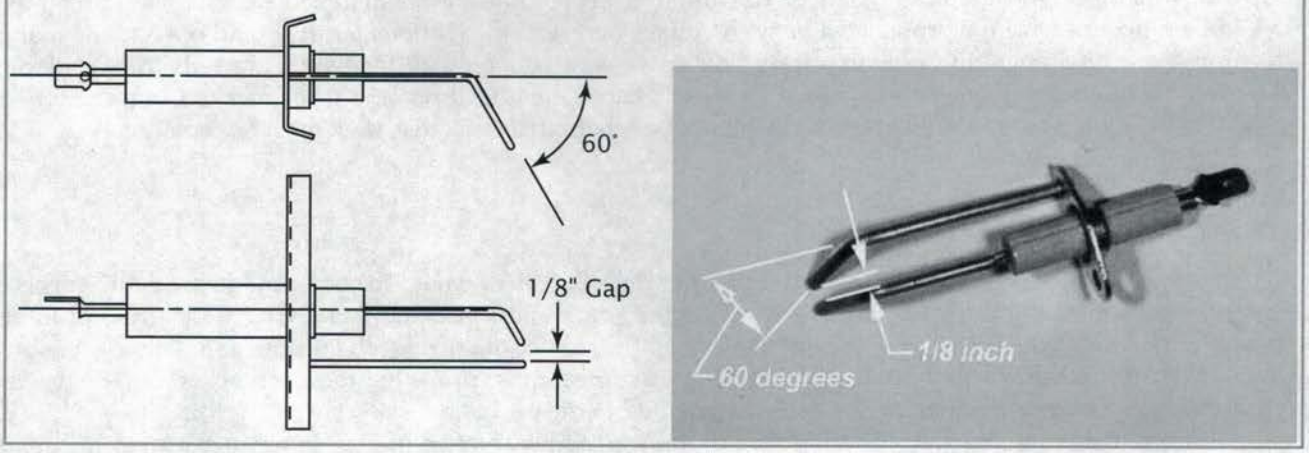


Figure 9-69 Two-Probe Ignitor



9-4.3.10 T&P Relief Valve

The T&P relief valve, water fittings, burners, junction boxes and other components, as well as heating systems and engine-assist systems have already been covered in previous sections. These are the same on DSI sys-

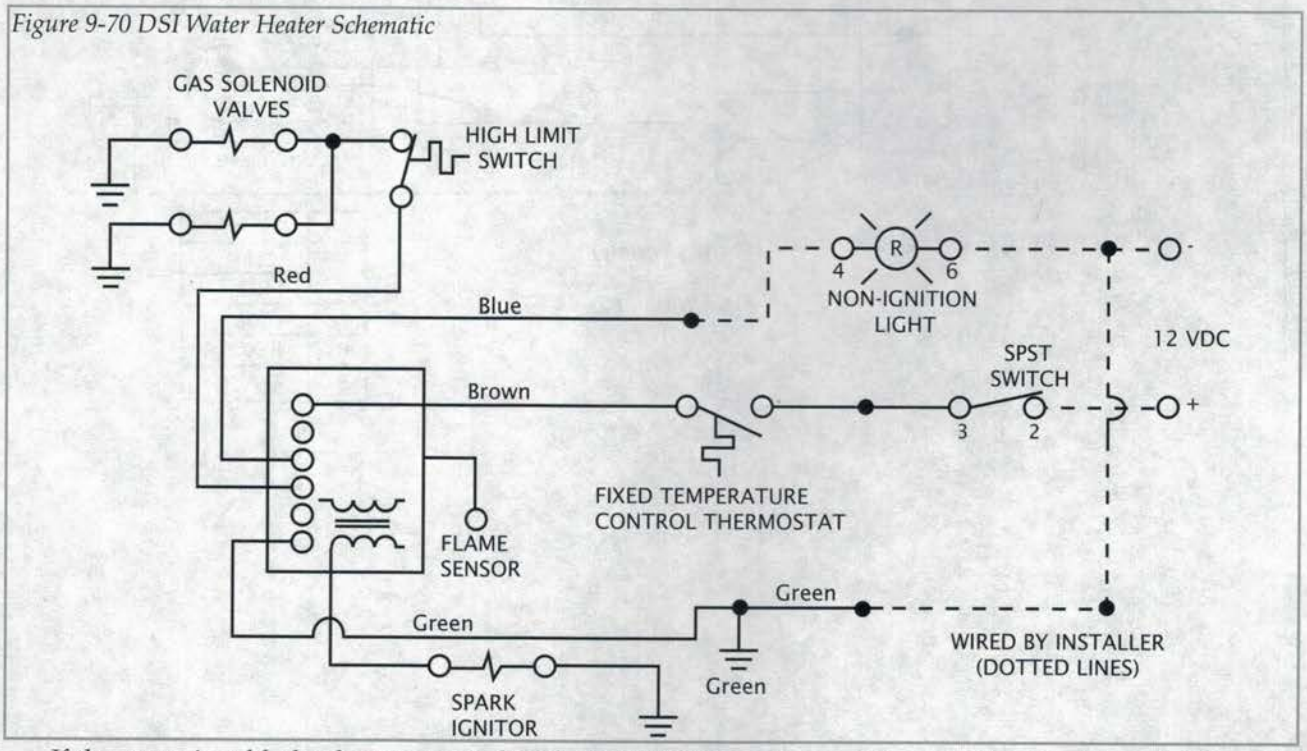
tems. All three sources of heat can be used at the same time to heat water for faster recovery. Each, except the engine-assist, has controls to regulate the heat sources, propane and electric.

9-4.4 Wiring Schematics

9-4.4.1 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 DSI water heater with several different configurations. *Figure 9-70* shows a typical schematic for a DSI water heater. The solid lines indicate the wiring on the water heater, whereas 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 9-70 DSI 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, a spark occurs, and the propane valve is energized through the ECO 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 opens the circuit to the propane valve only, making the circuit board try to reignite as a result of the open circuit at the sensor probe. Since the ECO switch is open, the board would go into lockout 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 9-70* depicts the switch, power source, and water heater connected together electrically. *Figure 9-71* shows another manufacturer's schematic. In this case, 12 VDC positive flows through both the thermostat and the ECO switches to the circuit board. These models have a manual reset ECO switch, so a problem would be indicated to the consumer in the event of a thermostat failure. *Figures 9-72* and *9-73* show several schematics for several different models, each with its 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 9-71 Schematic

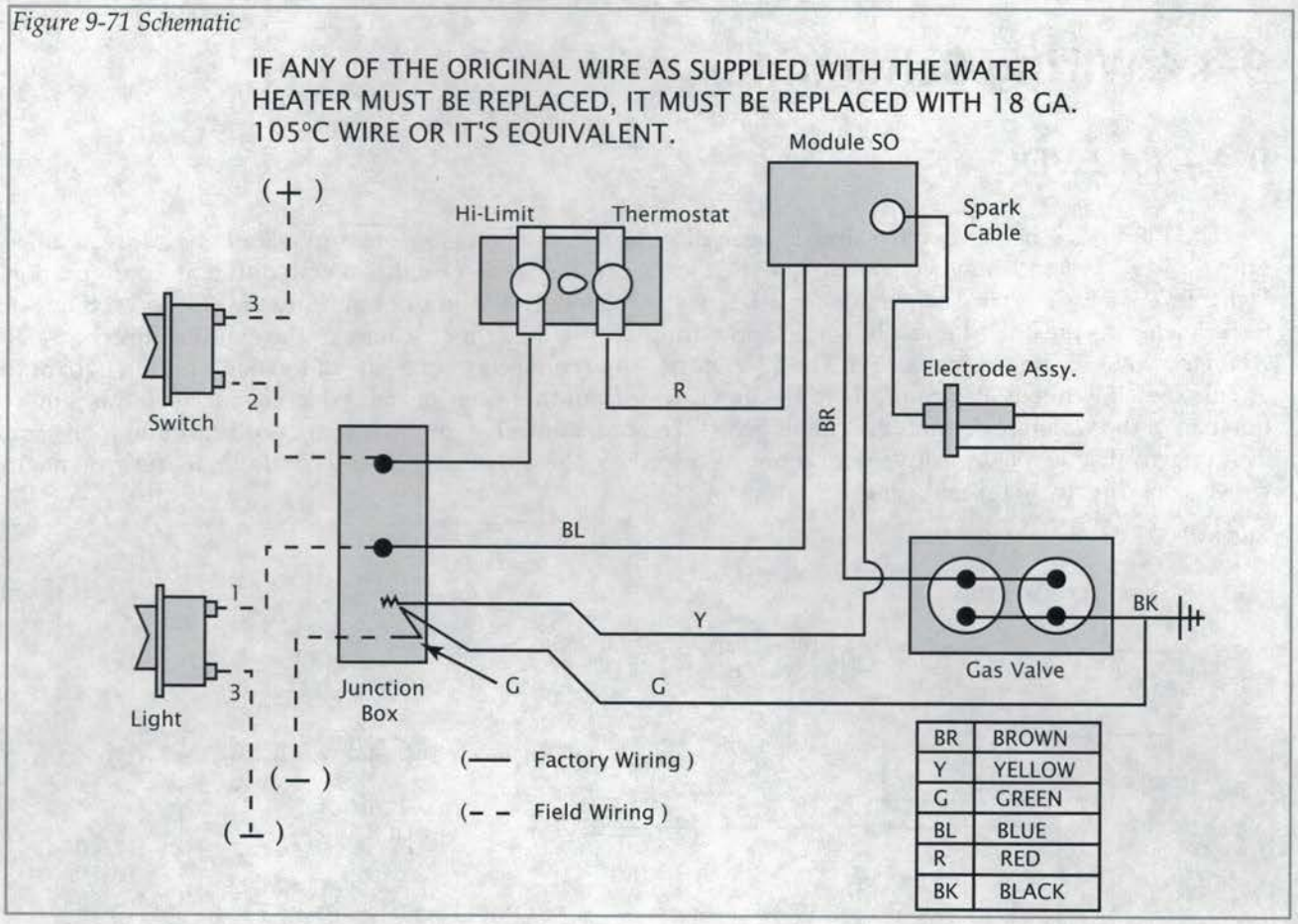


Figure 9-72 Schematic

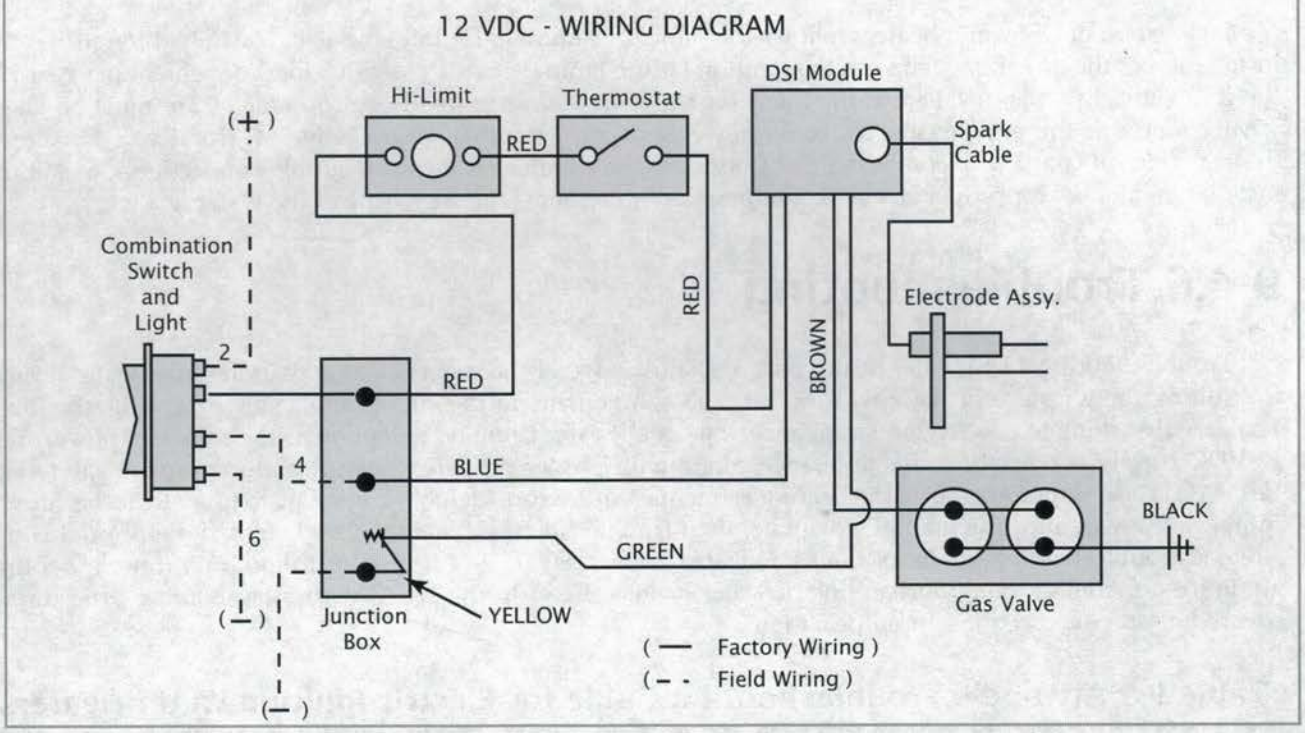
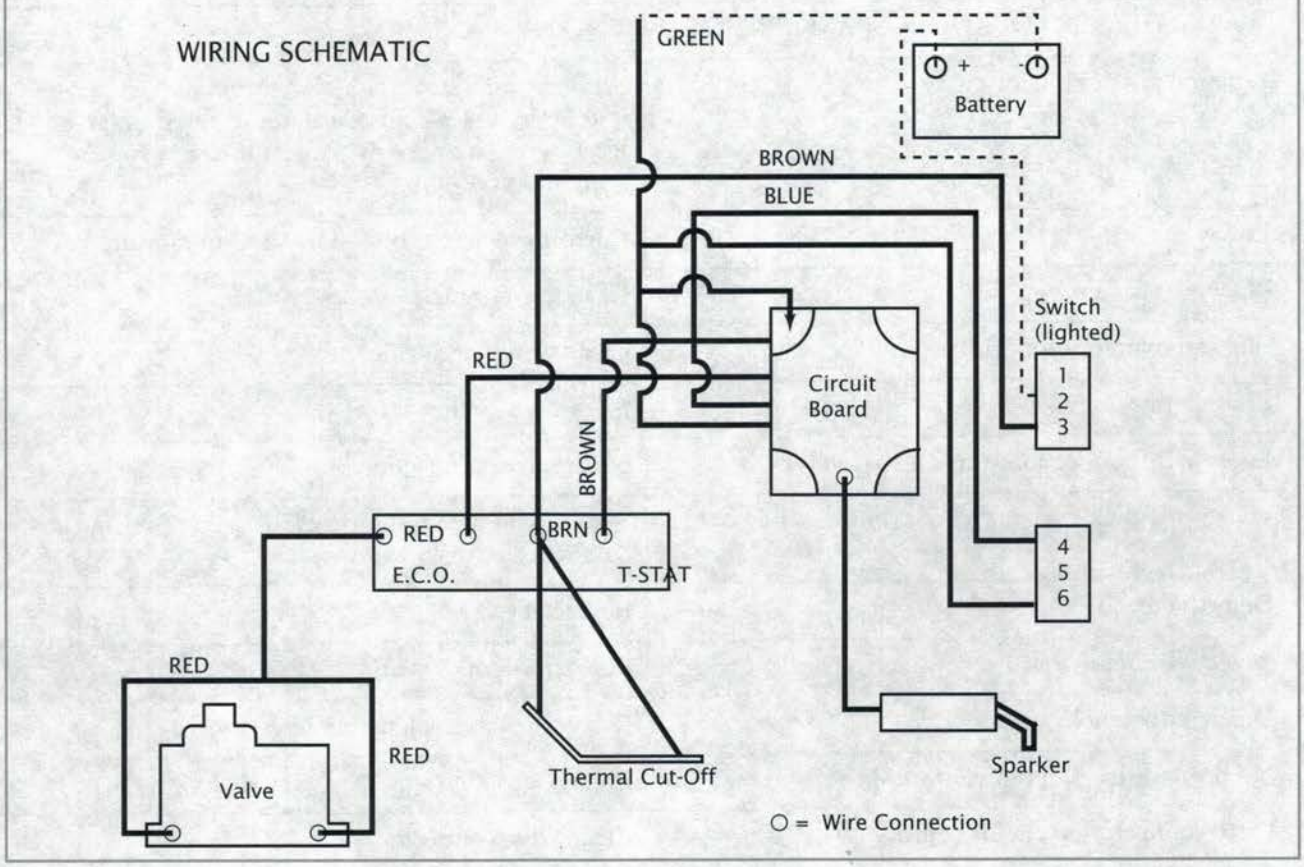


Figure 9-73 Schematic



9-4.5 Installation

Installation of DSI water heaters follows the same procedure as for pilot models. The only difference is the installation of the on/off switch with the ignition failure lamp. Locate this switch 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.

9-4.6 Troubleshooting

Troubleshooting a DSI 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 source 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 9-3* is the Atwood troubleshooting guide for their DSI water heaters. *Figure 9-74* is an illustration for a troubleshooting guide for a model of the Suburban line of water heaters. Refer to the 120 VAC troubleshooting procedures, covered in previous sections, for information.

Table 9-3 Atwood's Troubleshooting Guide for Electric Ignition Water Heaters

CAUSE	SOLUTION
WATER HEATER LOCKOUT—SPARK PRESENT BUT NO PROPANE	
Propane pressure incorrect	Set inlet pressure at 11 in. WC (nominal) with the system under at least 50 percent 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 ECO	Secure wire connections.
Loose wire connections on solenoid valves	Secure wire connections.
Loose valve wire on wiring harness	Repair wire on edge connector or repair wiring circuit board harness.
Defective ECO	Replace ECO.
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.

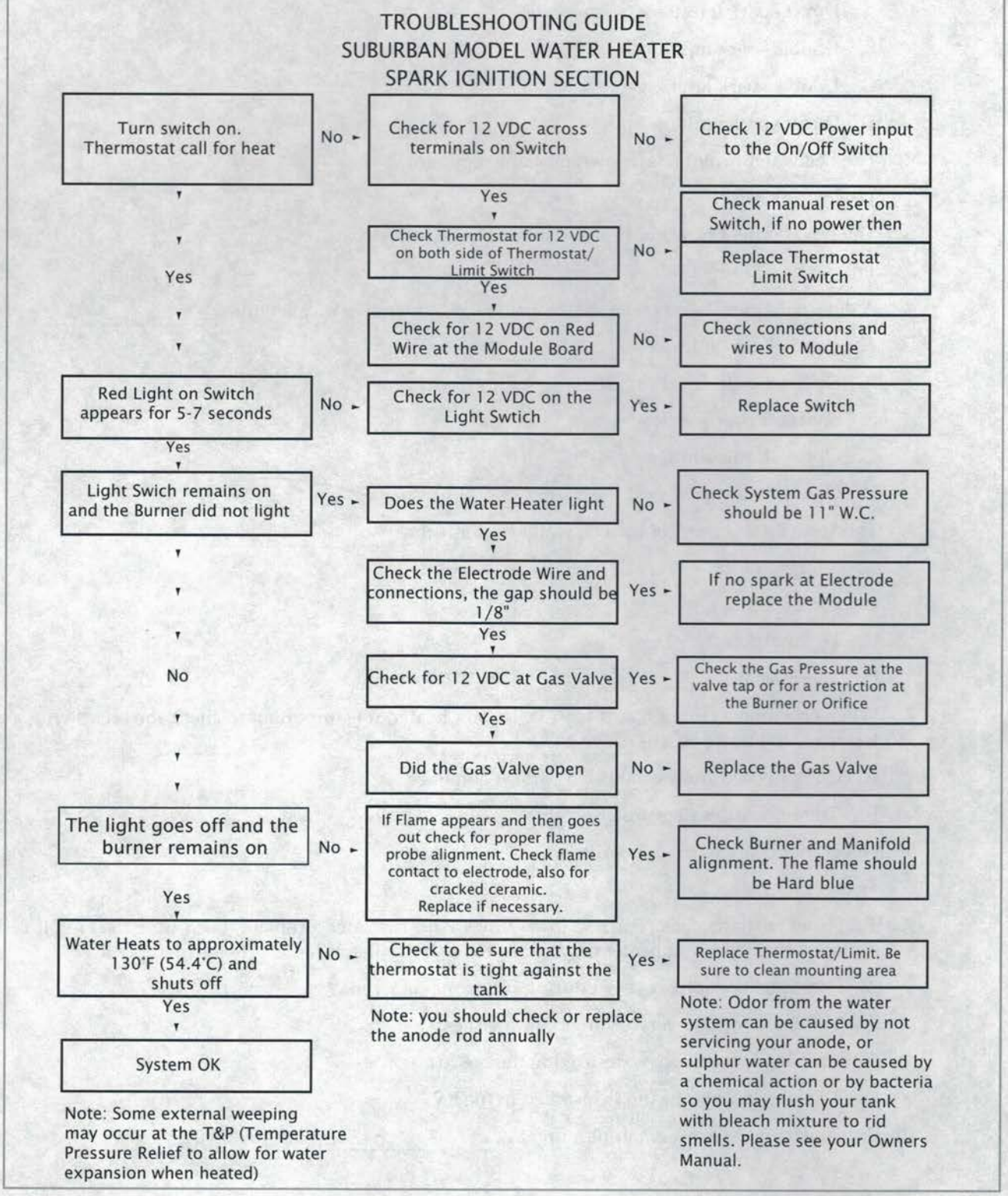
Table 9-3 Atwood's Troubleshooting Guide for Electric Ignition Water Heaters

CAUSE	SOLUTION
WATER HEATER LOCKOUT – 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	Reposition spark gap to 1/8 in. (3.2 mm)
Dirty electrodes	Clean electrodes.
Wires loose in electrode porcelain	Replace electrodes.
Cracked porcelain on electrode	Replace electrodes.
Defective circuit board	Replace circuit board.
WATER HEATER LOCKOUT – PROPANE AND SPARK PRESENT	
Propane pressure incorrect	Set inlet pressure at 11 in. WC (nominal) with the system under at least 50 percent 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	Readjust electrodes.
Electrodes sparking to screw fastening burner to flue tube	Adjust electrodes.
Dirty electrodes	Clean electrodes.
Partial obstruction in main burner	Clean main burner.
Partially obstructed main burner orifice	Clean main burner orifice or replace.
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	Realign solenoid valve with main burner.
Partially opening solenoid valve	Replace solenoid valve.
Defective circuit board	Replace circuit board.
EXCESSIVE OR INSUFFICIENT WATER TEMPERATURES	
Bypass kit valves not set properly	Place valves in proper position.
Thermostat not seated against tank	Reset thermostat.

Table 9-3 Atwood's Troubleshooting Guide for Electric Ignition Water Heaters

CAUSE	SOLUTION
Defective thermostat	Replace thermostat.
ERRATIC BURNER FLAME OR SOOTING	
Low propane pressure	Set inlet pressure at 11 in. WC (nominal) with the system under at least 50 percent 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 way 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	
No voltage	Correct power supply—minimum 10.5 VDC.
Dirty edge connector or circuit board	Clean edge connector.
Defective thermal cutoff	Replace thermal cutoff.
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.

Figure 9-74 Suburban Troubleshooting Guide: Spark Ignition Section



9-4 Review

1. DSI stands for:
   A. Direct spark injection
   B. Double spark injection
   C. Double spark ignition
   D. Direct spark ignition
2. The DSI water heater has its own propane regulator.
   True False
3. The ECO on the DSI water heater is a one-time use device.
   True False
4. A device that senses excessive heat outside the burner area is called the _____.
5. The thermal cutoff 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 DSI water heater is the _____.
   A. Energy cutoff
   B. Circuit board
   C. Thermal cutoff
   D. Thermostat
7. When checking a circuit board for a DSI water heater, it is important to 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 the circuit board is replaced, the DSI water heater only works for a short time. What is probably happening?
   A. Poor quality control existed 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 will have a resistance of _____ ohms.

    A. 1 to 5

    B. 5 to 10

    C. 10 to 30

    D. 30 to 50

12. Defective DSI water heater propane valves must always be replaced and never repaired.

    True False

13. Care must be taken when connecting a DSI 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

THIS PAGE IS INTENTIONALLY BLANK

Chapter

9-5 Instantaneous Water Heaters

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

9-5.1 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 that 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 DSI 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 it. 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 to keep the stored water hot. This type activates only 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 ECO switches that monitor the heat as the water progresses through the heat exchanger. *Table 9-4* shows a comparison chart for an instantaneous water heater versus a typical tank-type water heater.

Table 9-4 Instantaneous Water Heater vs. 10-U.S. Gallon Propane Water Heater

Standard Features	Instantaneous	10-U.S. Gallon Tank
Maximum shower time*	Virtually unlimited	5 minutes
Recovery Time	Immediate	30 minutes
Gallons of water/20-lb propane tank*	904 U.S. gallons	740 U.S. gallons
Case material	Galvanized steel	Cardboard with neoprene foam
Door material	Painted aluminum—flush mounted	Painted steel—surface mounted
Water fittings	Solid brass	Aluminum

*@ Normal shower temperature

Table 9-4 Instantaneous Water Heater vs. 10-U.S. Gallon Propane Water Heater

Standard Features	Instantaneous	10-U.S. Gallon Tank
Weight full	27.5 lb (12.47 kg)	110 lb (45.36 kg)
Space requirements	1.52 ft^3 (43 dm^3)	3.1 ft^3 (87.78 dm^3)
Temperature setting	Adjustable	Adjustable (some are fixed and nonadjustable)
Flue propane temperature	Under 300°F (150°C)	Over 500°F (260°C)
High-temperature cutoff switches	Three	One

*@ Normal shower temperature

9-5.2 Components, Function, Location, Testing, and Interactions

Since there are not many manufacturers of 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.

9-5.2.1 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.

9-5.2.2 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 ensures 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 ensures 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 (gpm) [1.5 liters per minute (L/m)]. Anything less than 0.4 gpm (1.5 L/m) will not activate the switch, and the burner will not ignite. Testing this valve involves ensuring that there is hot water flow and testing for continuity through the switch.

9-5.2.3 Ignition Source

In older models, the ignition source was a standing pilot flame. However, there are currently no models using standing pilot flames, as all have gone to a DSI-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 ensure that there is no AC ripple from the power source.

9-5.2.4 Propane Valve

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

9-5.2.5 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.

9-5.2.6 Burner

The burner is not the same as in 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 produce 50,000 Btu/hr input or more because of the substantial area they must cover.

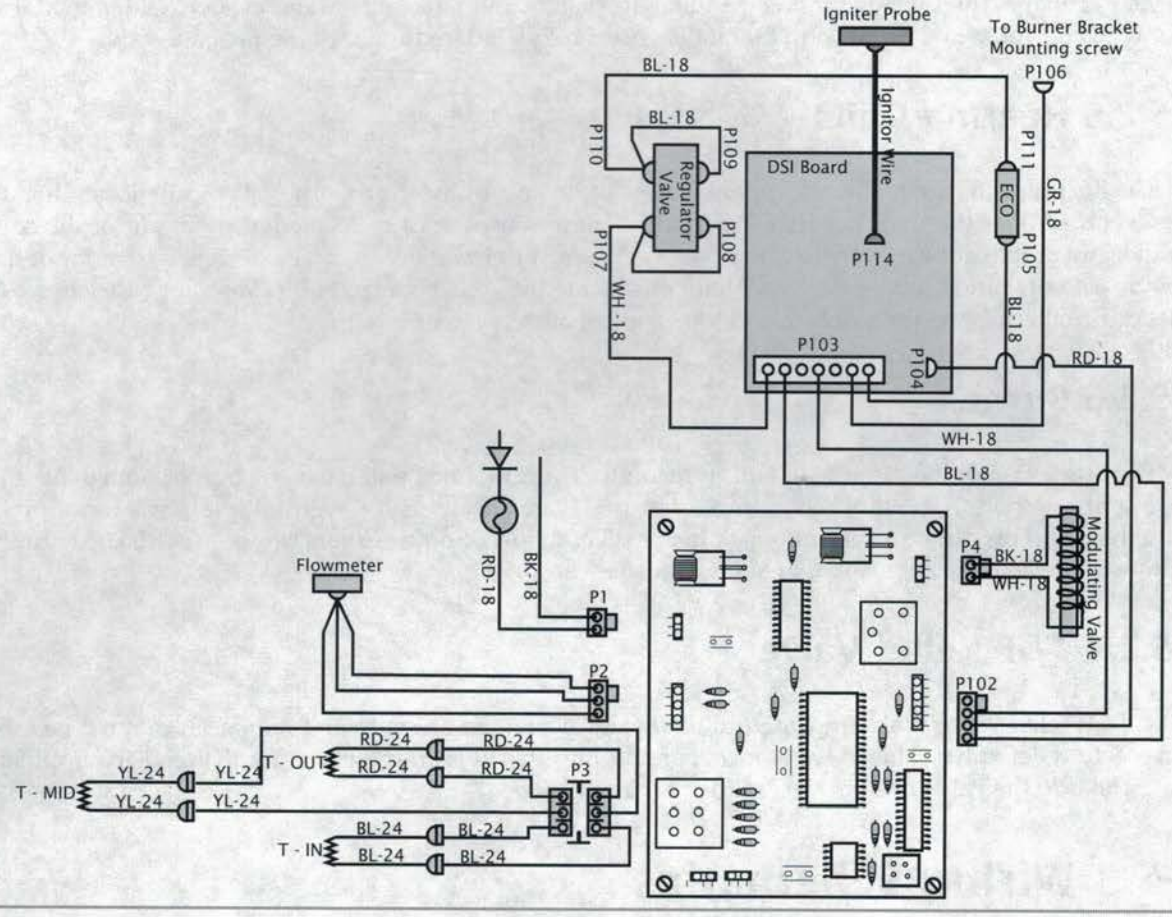
9-5.2.7 T&P Relief Valve

A T&P 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.

9-5.3 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 9-75* illustrates an instantaneous water heater system. As shown, there is the power input (with a fuse), a flowmeter that monitors the water flow, three thermisters for sensing temperature on the heating coil, a regulated propane valve with an ECO switch in line with it, a modulating valve, an 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 9-75 Water Heater System



9-5.4 Installation

Installation of this water heater is similar to that of 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 a minimum 3/8 in. because of its high Btu/hr demand. It uses 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 in. 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 *NFPA 1192*. The water lines utilize the typical 1/2 in. 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. Refer to the installation instructions before connecting these lines, as improper operation will occur if these lines are reversed, mainly affecting 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. *NFPA 1192* will indicate a proper location in an RV.

9-5.5 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.

9-5.5.1 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.

9-5.5.1.1 Water Flow Trigger Device

The sensors can be tested with a VOM meter. Refer to the service manual for the water heater for proper resistance values and to determine whether continuity is required.

9-5.5.1.2 Propane Valve

The propane valve can be tested in the same manner as in tank-type water heaters. Again, 11 in. (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 and requires immediate service.

9-5.5.2 Electrical Circuit

Test the water temperature at the faucet 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 ECO switch could be controlling the temperature.

9-5 Review

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

   True False

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

3. The water tanks for DSI 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 ECO switches.

   True False

Chapter

9-6 Maintenance and General Repairs

· Perform preventive maintenance procedures.

9-6.1 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 different geographic locations, sediment will accumulate from the chemical reaction of the water, minerals, and 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. Additionally, these contaminants may cause the water to become fouled. It may taste different or emit a "rotten egg" odor. On Suburban water heaters, a "rotten egg" odor may also be caused by a deteriorated anode rod. Periodic flushings, perhaps once a year or more often, 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. This 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 T&P valve. After the water has stopped flowing, observe that, due to the location of the drain valve on the tank, there will still be approximately two quarts left inside the tank. This water contains most of the harmful corrosive particles. If, while draining the unit, it is noticed that the water is flowing sporadically or trickling instead of flowing steadily, it is recommended to make sure that a hot water faucet or the T&P relief valve be opened. Then use 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, flush it with fresh water. Pump fresh water 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 T&P valve.

9-6.2 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 tank.

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

1. Turn off the main water supply.

2. Drain the water heater. After doing so, because of 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, a two-step solution is recommended. First, open the valve to allow air into the tank. Second, 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, flush it with fresh water. Pump fresh water into the tank, either with the assistance of the onboard pump or with the use 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, thus forcing the deposits through the drain opening.
4. Upon completion of the above steps, close off the drain valve and the relief valve.
5. After this procedure, there will be approximately two quarts of water left at the bottom of the inner tank. If this water freezes, 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 bypass 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 bypass systems disconnect the water heater from the rest of the water system and allow antifreeze (which needs to be identified for RV use) to be introduced to the RV water lines.

NOTE: Never introduce antifreeze in a water tank that has an anode rod, as it destroys anode rods.

9-6.3 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 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 come with the tank, gaskets, and instructions to follow for that particular model. Be sure to use the appropriate gaskets when the combustion pan is put back on and the components are being replaced. The combustion pan must be sealed to the inside of the RV by these gaskets to ensure that 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 the wire connections, and conduct an operational test.

9-6.4 T&P Relief Valve Weeping

A common complaint from RV users is that, after some time, the water heater starts dripping or weeping from the T&P 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 T&P relief valve while the water heater is operating very seldom means that the T&P 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 T&P relief valve straight out, and allow the water to flow out until it stops.
5. Allow the T&P relief valve to snap shut, close the hot water faucet, and turn on the water supply. Heat the water to ensure proper operation of the T&P relief valve. If it continues to leak, the T&P relief valve is defective.

See *"T&P Relief Valve" on page 9-18*

9-6.5 Maintain Burner Flame and Flue

Inspect the main burner and pilot burner, if applicable, 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 DSI-type water heater is the one that causes more problems. This is because 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. Encourage any consumer with a DSI water heater 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.

9-6 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 the drain plug is removed and the T&P relief valve is opened, the water tank will be completely drained.

   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 T&P relief valve while the water heater is operating usually means:

   A. The T&P 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 T&P 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

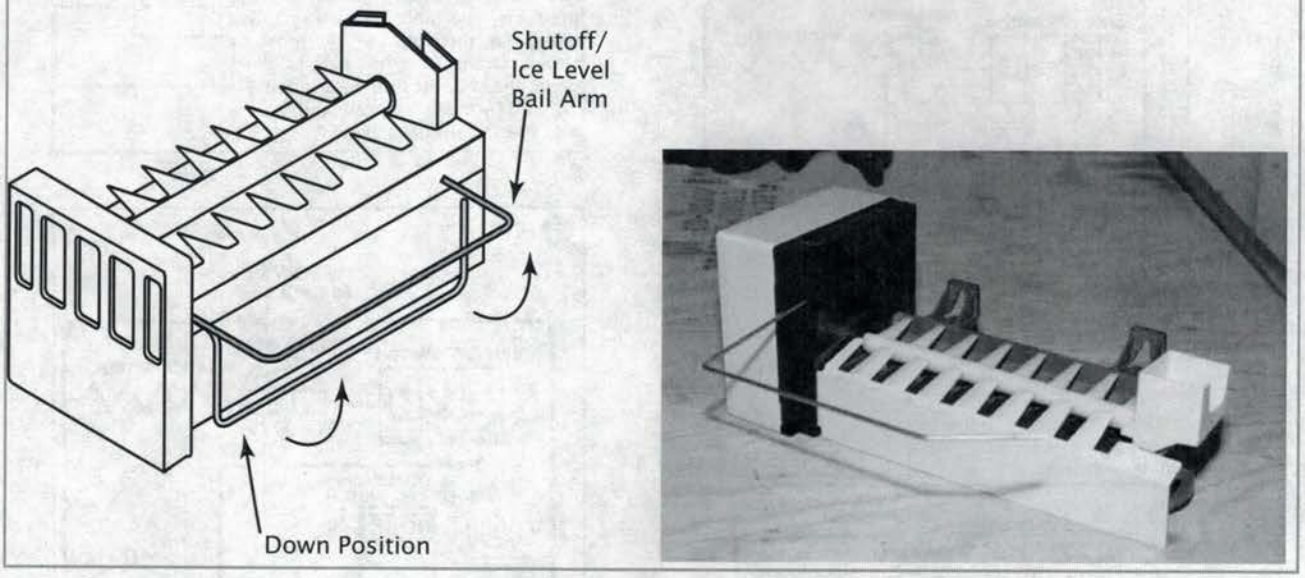
8-6 Ice Makers

- Explain operation and components of a Dometic ice maker.
- Explain the operation and components of a Norcold Ice maker.
- Troubleshoot Ice Makers.

8-6.1 Dometic Ice Makers

The refrigerator has to be connected to 120 VAC and must be allowed to precool properly before the ice maker can operate. The water valve supplying the refrigerator must be turned on, and the ice shutoff/level bail arm must be in the fully down position. When the ice maker thermostat senses the preset temperature for ejection of the ice cubes, the fingers will start to rotate, dumping any ice cubes and filling the mold with water. When the storage container is full of ice, the ice level bail arm cannot return to the down position. This will stop further production of ice until the container is emptied and the bail arm is returned to the down position.

Figure 8-84 Ice Maker



NOTE: If the ice maker was cleaned and drained, no ice cubes will be dumped into the storage container during the first cycle. The first few cycles may have small cubes due to air trapped in the water lines. The first container of ice cubes should be dumped if the water system has been winterized or not used for several weeks.

8-6.1.1 Sequence of Operations

While the operation of the ice maker is fairly simple, an understanding of its cycle is necessary for the service technician to diagnose specific problems. The following electrical schematics will show a typical cycle and the positions of various components during the cycle. These are the mold and its contents, the ejector, the shutoff arm, and the storage bin.

Figure 8-85 Electrical Schematics 1–5

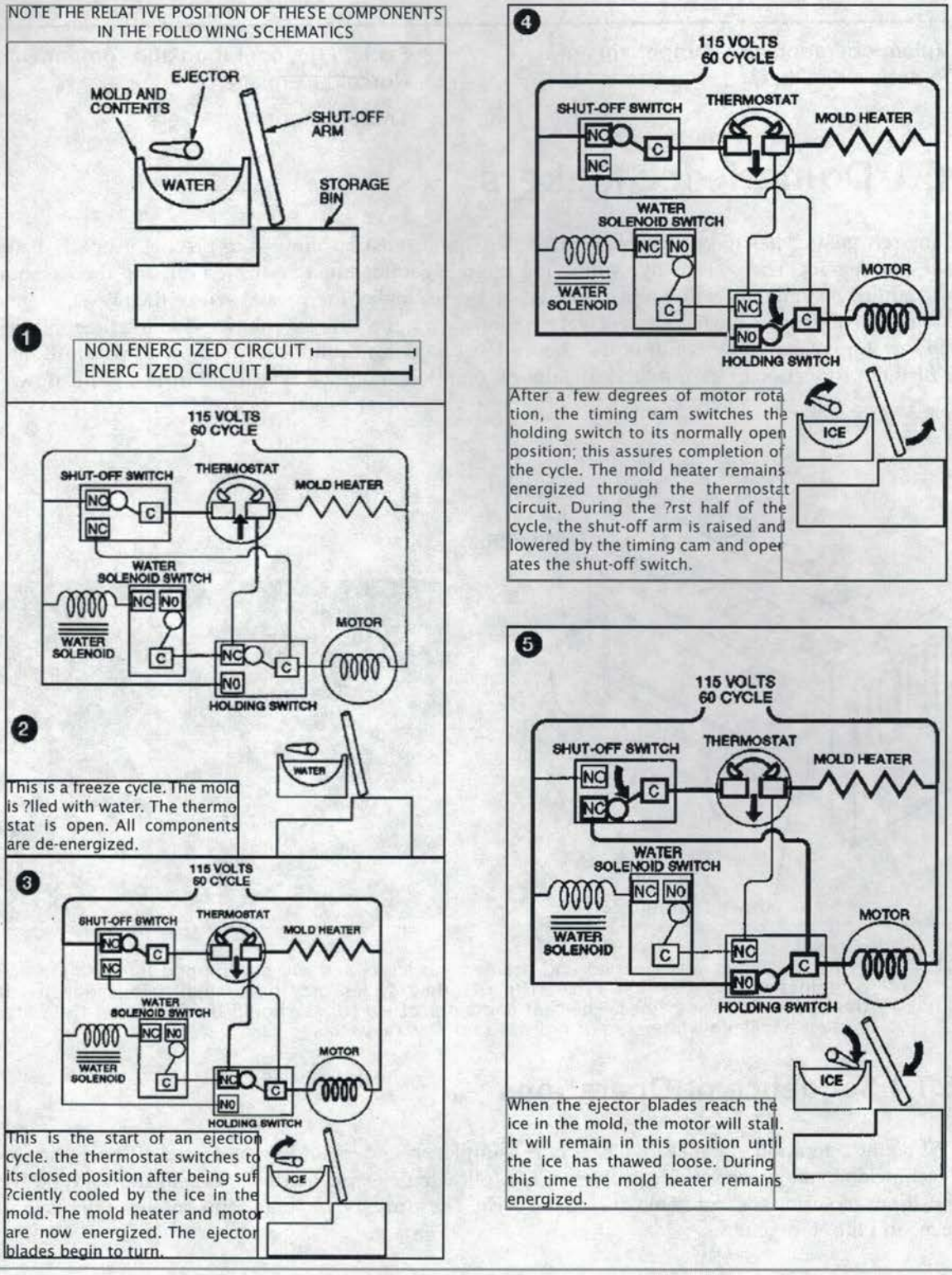
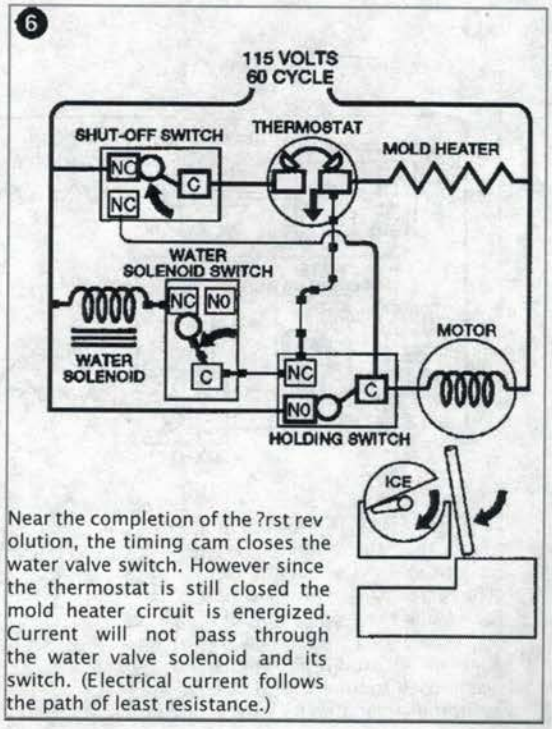
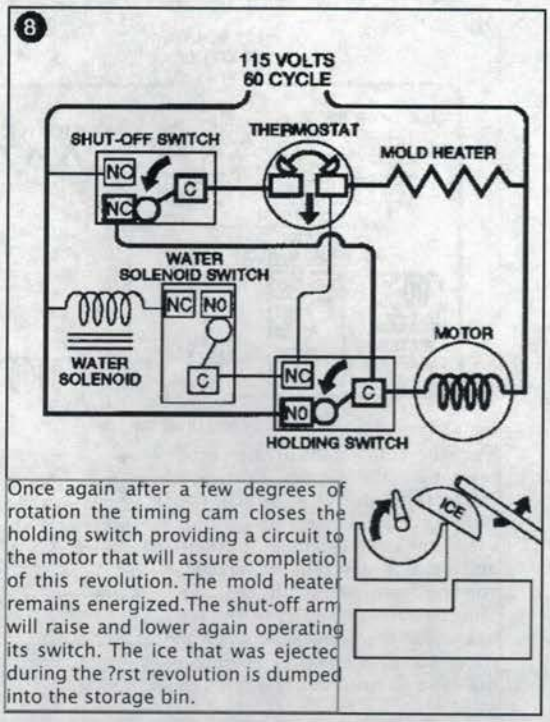


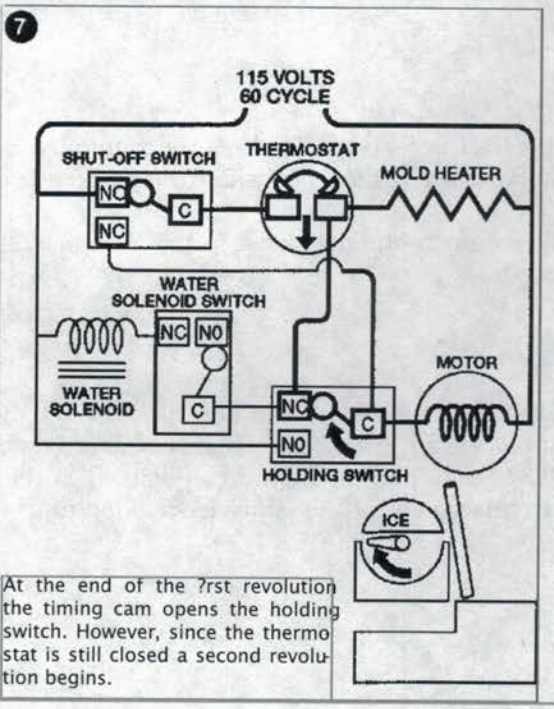
Figure 8-86 Electrical Schematics 6–9



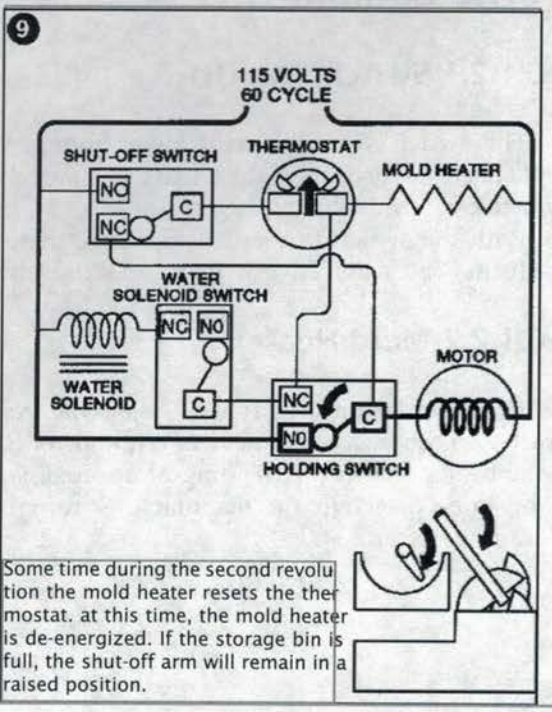
Near the completion of the ?rst rev olution, the timing cam closes the water valve switch. However since the thermostat is still closed the mold heater circuit is energized. Current will not pass through the water valve solenoid and its switch. (Electrical current follows the path of least resistance.)



Once again after a few degrees of rotation the timing cam closes the holding switch providing a circuit to the motor that will assure completion of this revolution. The mold heater remains energized. The shut-off arm will raise and lower again operating its switch. The ice that was ejected during the ?rst revolution is dumped into the storage bin.

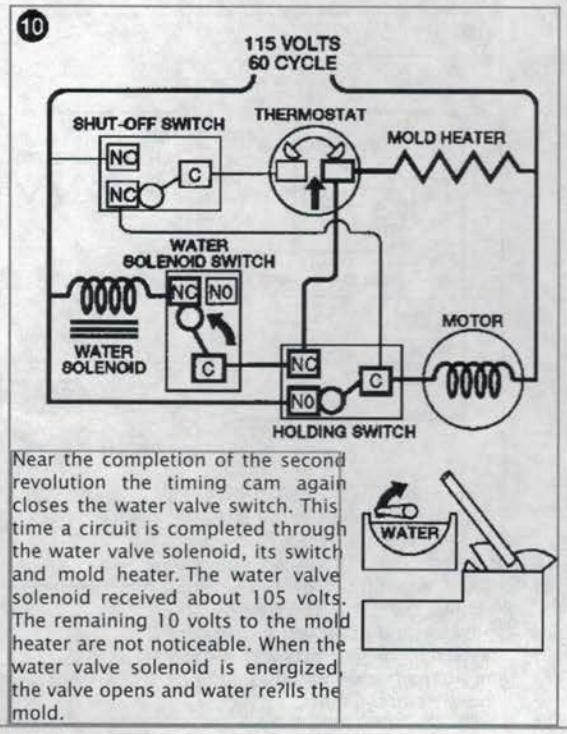


At the end of the ?rst revolution the timing cam opens the holding switch. However, since the thermo stat is still closed a second revolu tion begins.



Some time during the second revolu tion the mold heater resets the ther mostat. at this time, the mold heater is de-energized. If the storage bin is full, the shut-off arm will remain in a raised position.

Figure 8-87 Electrical Schematics 10–11



8-6.1.2 Components

8-6.1.2.1 Switch, On/Off

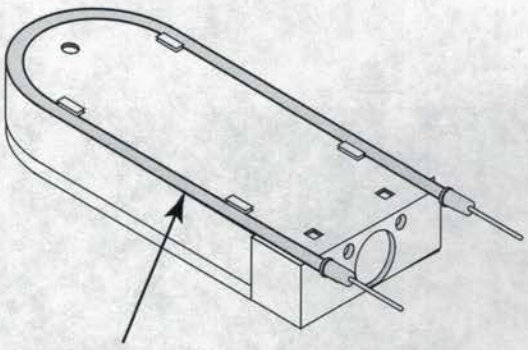
This switch is located on the lower front panel inside the freezer door. To check for continuity, unplug the appliance, and disconnect the wires to the switch. With the switch in the ON position, there should be continuity between terminals 1 and 2.

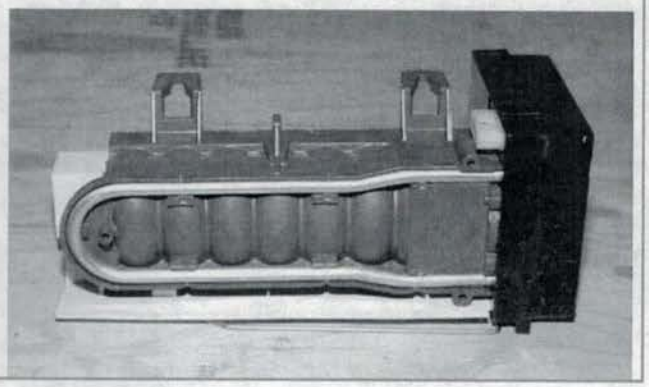
With the switch in the OFF position, there should be no continuity between the terminals. Any other results indicate a defective switch, and it must be replaced.

8-6.1.2.2 Mold Heater

The mold heater uses 165W to thaw the ice free from the mold. It is wired in series with the thermostat, which also acts as a safety device. With power to the appliance off, check for resistance between the two leads to the heater element. A reading of approximately 80-3/4 ± 10 percent should be obtained. If the heater is found to be defective, the manufacturer recommends replacement of the entire ice-making unit for proper operation.

Figure 8-88 Mold Heater



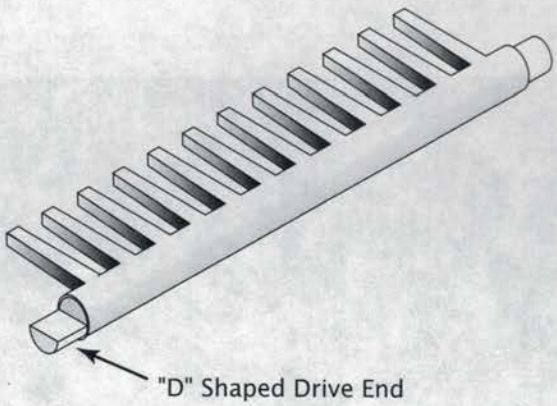


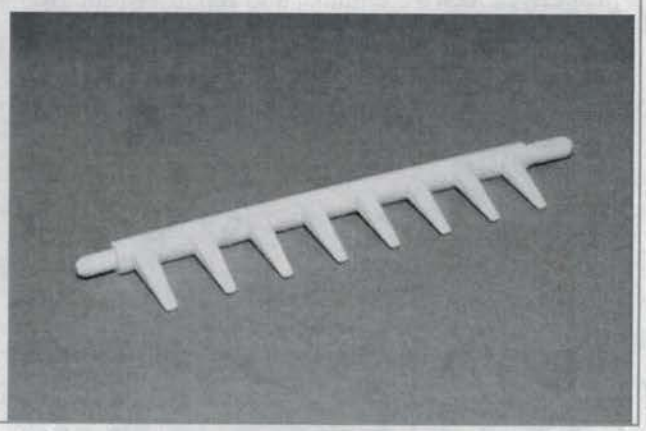
8-6.1.2.3 Ice Ejector

The ice ejector blades sweep the ice from the mold cavities during the ejection cycle.

The drive end of the ejector is D-shaped for positive coupling. The bearings at both ends are lubricated with silicone grease. If the ejector blades are frozen into the ice, defrost the ice maker and manually cycle the ice-making unit, making sure the ejector stops at the right location.

Figure 8-89 Ice Ejector

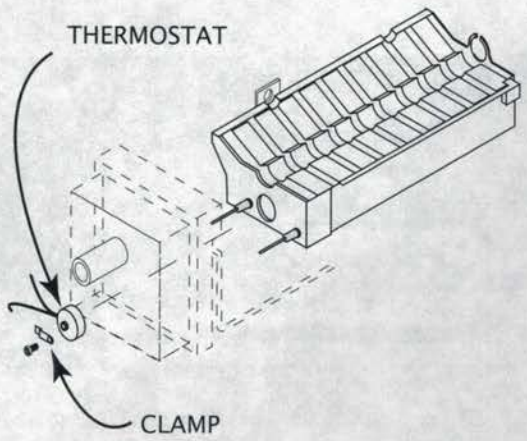


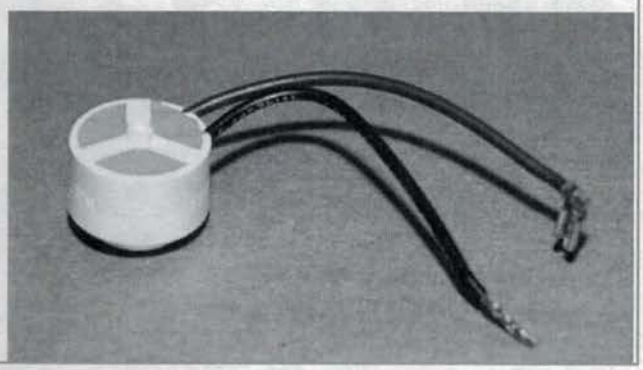


8-6.1.2.4 Mold Thermostat

This is a single-pole, single-throw, bimetal switch. It starts an ejection cycle by closing at 15 ± 5°F (-10 ± 3°C). The reset temperature is 50 ± 5°F (10 ± 3°C). The thermostat is in series with the mold heater and acts as a safety against overheating in case of a mechanical failure. To check the thermostat, disconnect one wire and conduct a continuity check. The temperature surrounding the ice maker must be at 20°F (-7°C) or lower. A continuity reading should be obtained. If the thermostat is defective, replace it. The mold thermostat starts the ice ejection cycle. A cycle can be started by turning the large gear clockwise 1/8th to 1/4th of a turn.

Figure 8-90 Mold Thermostat

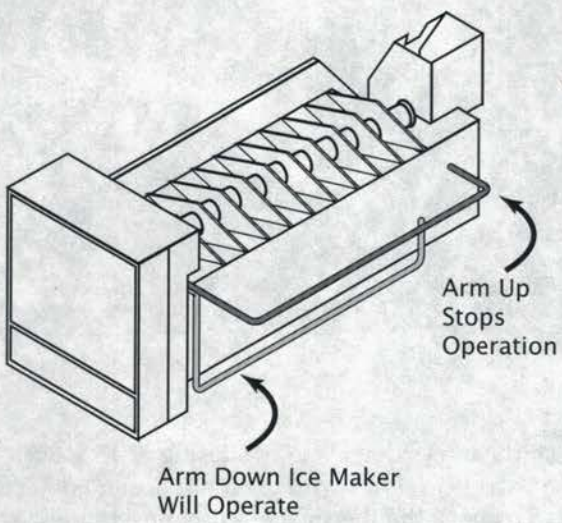


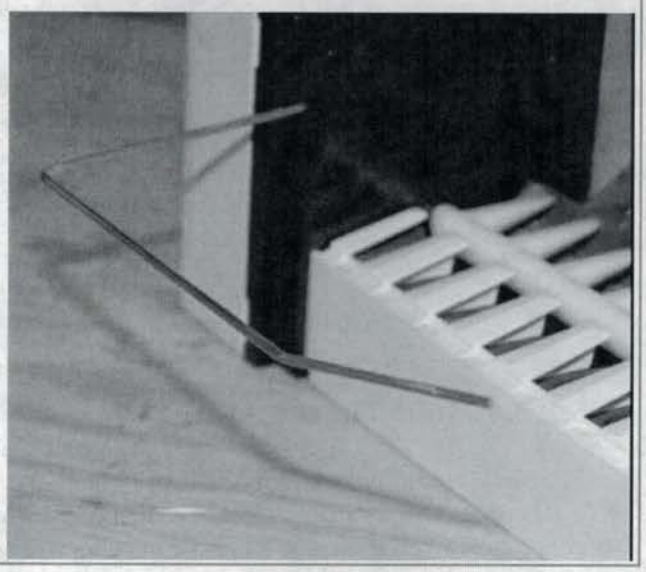


8-6.1.2.5 Shutoff/Ice Level Bail Arm

The shutoff arm is cam driven. It operates a switch to control the quantity of ice produced. During the ejection cycle, the arm is raised and lowered during each of the two revolutions of the timing cam. If the shutoff arm comes to rest on top of the ice in the storage bin during either revolution, the switch will remain open and stop the ice maker at the end of that revolution. The arm has a manual shutoff built into the linkage; by raising the arm as high as possible, it will lock in that position until forced down. If the arm and switch do not operate properly, check for damage and repair or replace parts as necessary.

Figure 8-91 Shutoff/Ice Level Bail Arm





8-6.1.2.6 Mold Switches

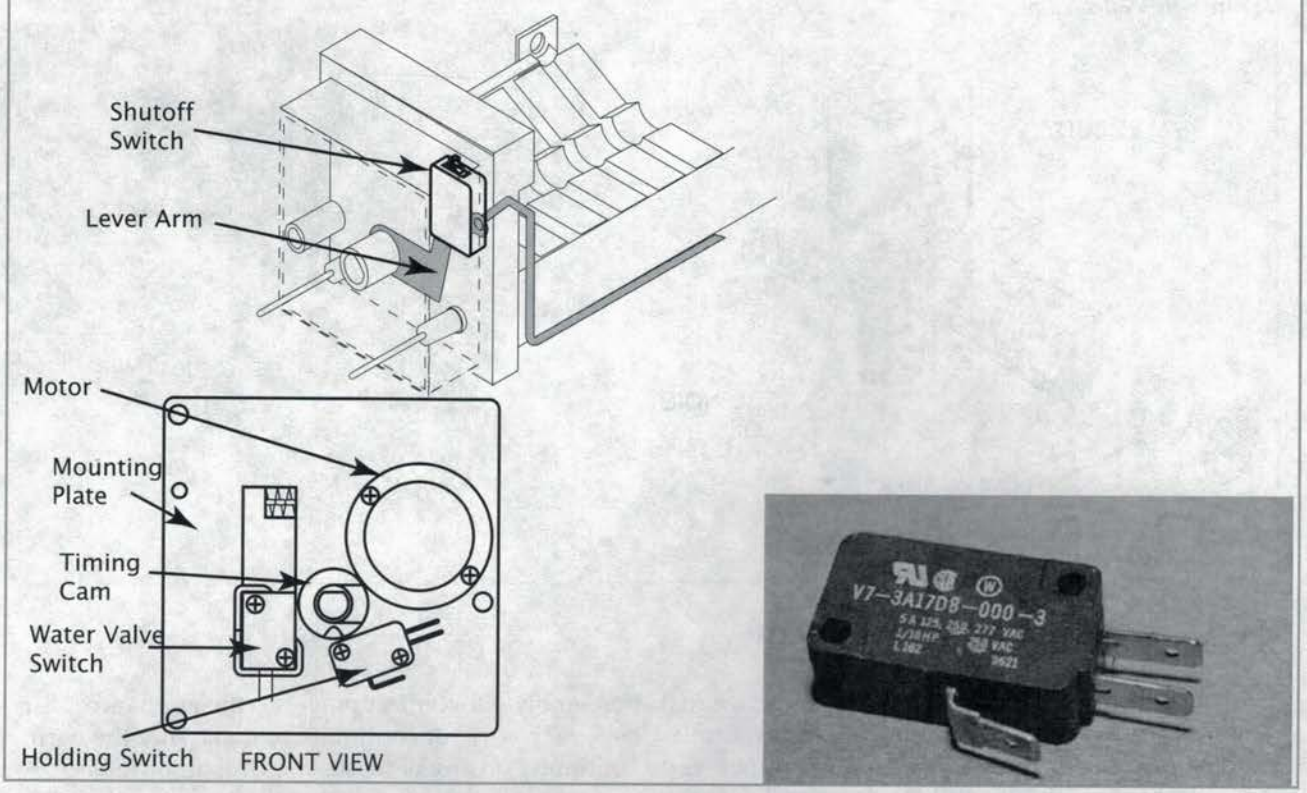
These three switches are single-pole, double-throw (SPDT) style. They are identical and interchangeable.

The holding switch ensures completion of a revolution once a cycle has started.

The water valve switch opens the water valve during the fill stage of the cycle. NOTE: this is the only adjustable component of the ice maker. If a double-throw switch is used, DO NOT use the normally open (NO) terminal.

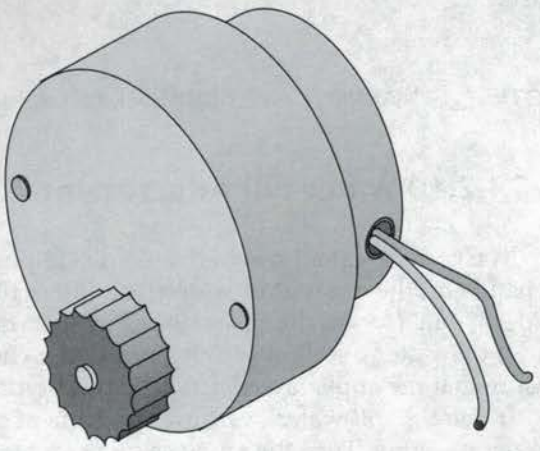
The shutoff switch stops the ice maker's operation when the storage bin is full.

Figure 8-92 Mold Switches



8-6.1.2.7 Timing Motor

Figure 8-93 Timing Motor



This is a low-wattage, stall-type motor, which is geared to the timing cam and ice ejector. It is a 1 rpm motor.

To check the motor, disconnect power to the appliance and test for continuity between the two leads. If continuity DOES NOT exist, replace the motor. If continuity exists and the motor runs, DO NOT replace.

8-6.1.2.8 Water Valve

This valve is solenoid operated. When it is open, it releases water from the source to the mold. The amount of water is proportional to the length of time the water valve switch is held closed by its timing cam.

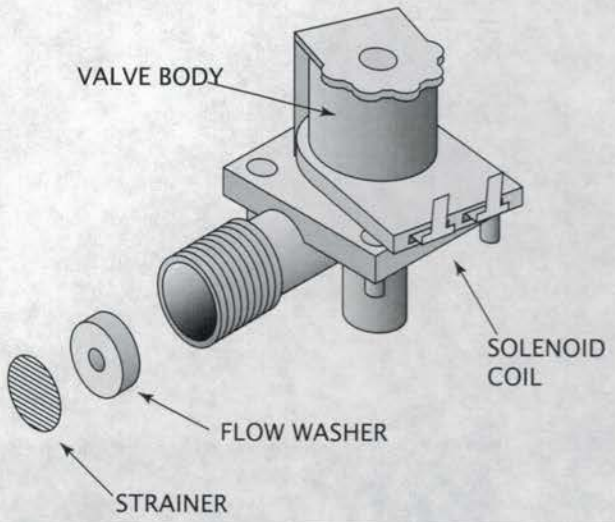
Disconnect power to the appliance, remove the wires to the valve solenoid coil, and check for continuity between the two terminals. An ohmmeter should read between 200 and 500-3/4. If there is continuity, the solenoid is good. It takes 10 to 15 W to energize the solenoid coil.

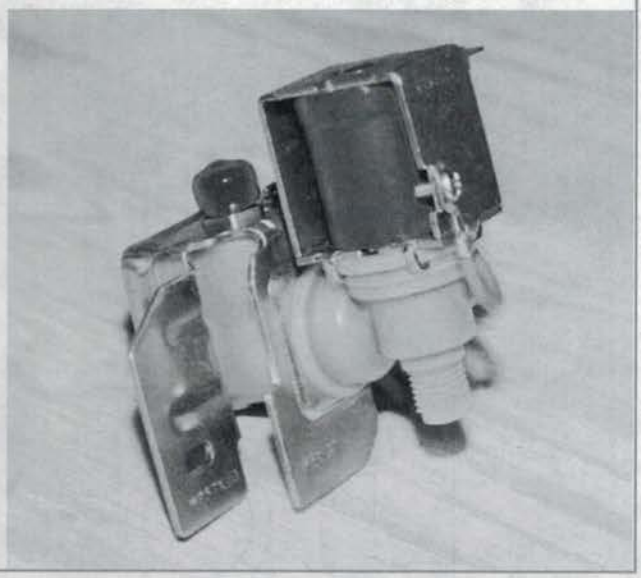
The mold heater and coil are in series. When the mold heater is activated, this causes the voltage to drop to about 105 VAC at the coil.

The valve has a flow washer inside that acts as a pressure regulator. A strainer is installed to prevent dirt, rust, and so forth from entering the valve. Check for any debris that might obstruct the flow of water or pre-

vent the valve from closing completely when the circuit is not energized. Remove any obstructions. If the valve still fails to operate properly, replace it.

Figure 8-94 Water Valve





8-6.1.2.9 Ice Maker Replacement

It may be necessary to replace the entire ice maker assembly. Disconnect power to the appliance. Disconnect the four-pin connector from the ice maker unit. Check each wire for continuity to make sure the wiring is good before replacing the ice maker unit. If there is no continuity on any of these wires, repair or replace them, then retest for continuity and check ice maker functions. Once it is determined that the ice maker is not functional, remove the three screws holding the unit to the plate. Before replacing the ice maker assembly, check the temperature of the freezer. For the unit to cycle, it should be 12°F or colder as the mold thermostat starts the cycle.

NOTE: WARNING: electrical shock can occur.

8-6.1.2.10 Water Fill Adjustment

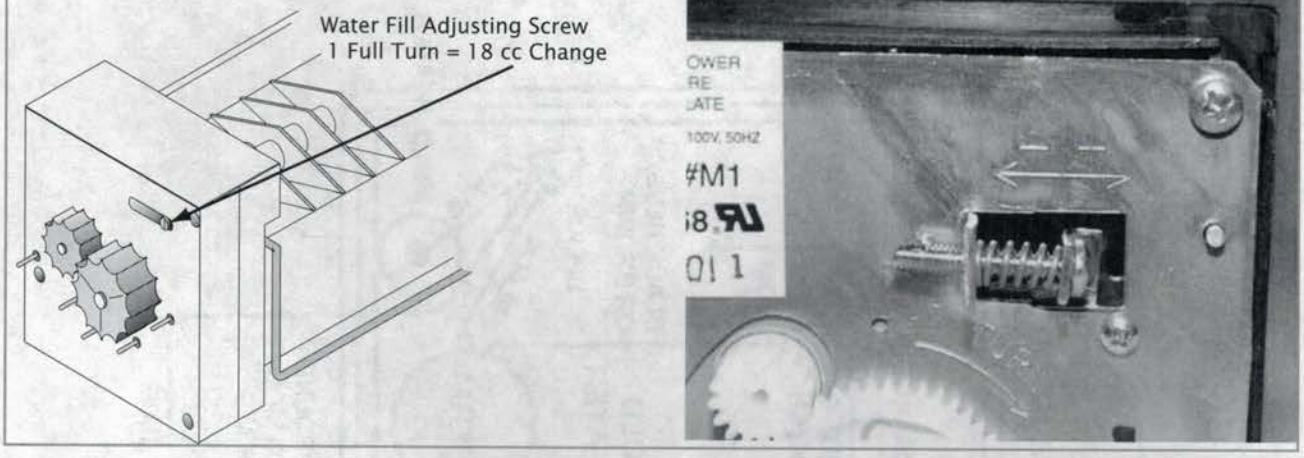
The correct water level in the mold is important for the proper production of ice. The size of the ice cubes depends on the amount of water that enters the mold. The cubes should be approximately 1/2 in. (1.2 cm) wide, 3/4 in. (1.9 cm) high, and 2-1/2 in. (6.35 cm) long.

If the water overflows in the mold, first check to see if the ice maker unit is level in the appliance. Next ensure that the appliance is installed level in the RV.

If there is still water overflow, adjustment of the water fill screw is necessary. Locate the screw on the ice maker assembly. Turn the screw as necessary toward the "+" or "–" side. One full turn of the screw will make an 18 cc (0.6 oz) change in the amount of water. DO NOT turn the screw more than one full turn at a time. If the water level is not set properly, ice production can be affected.

If the water level is too high, it can also cause the ejector blades to become frozen in the ice and stop producing ice cubes. Follow the procedures above to correct the problem.

Figure 8-95 Water Fill Adjustment



8-6.1.3 Water Supply

To operate properly, the water pressure in the water supply line must be between 15 and 125 lb psi. Lower water pressure, water turned off, or obstructions or air in the water line can cause low or no ice production. First check that the water supply is fully turned on. Visually check the line for kinks that might obstruct the flow of water. To remove trapped air, loosen the connection at the water solenoid valve of the appliance. Ensure that pressurized water is reaching this point and bleed off any air in the line. Retighten the connection making sure there are no leaks.

8-6.1.4 Wiring

Refer to the wiring diagram supplied with the unit being worked on, and make sure all wiring connections are correct and tight.

Figure 8-96 Wiring Diagram

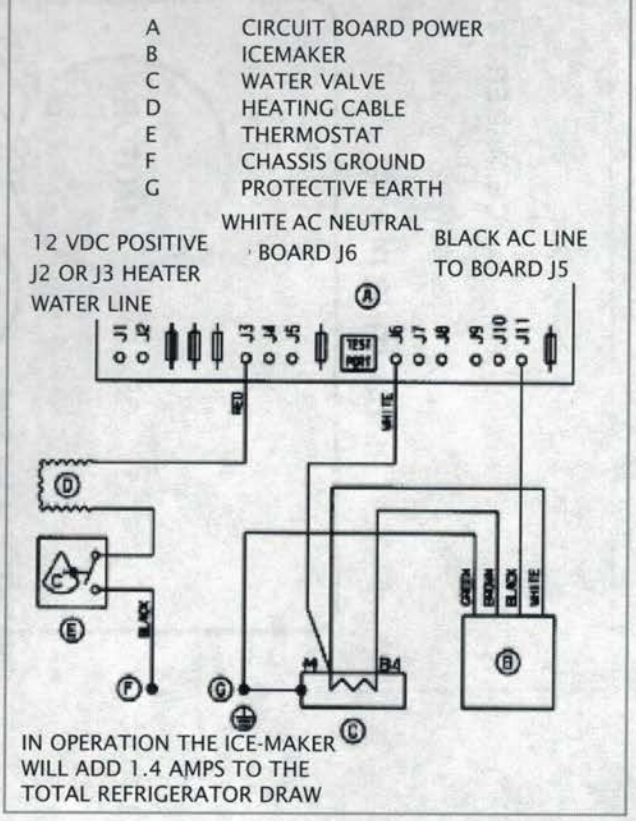
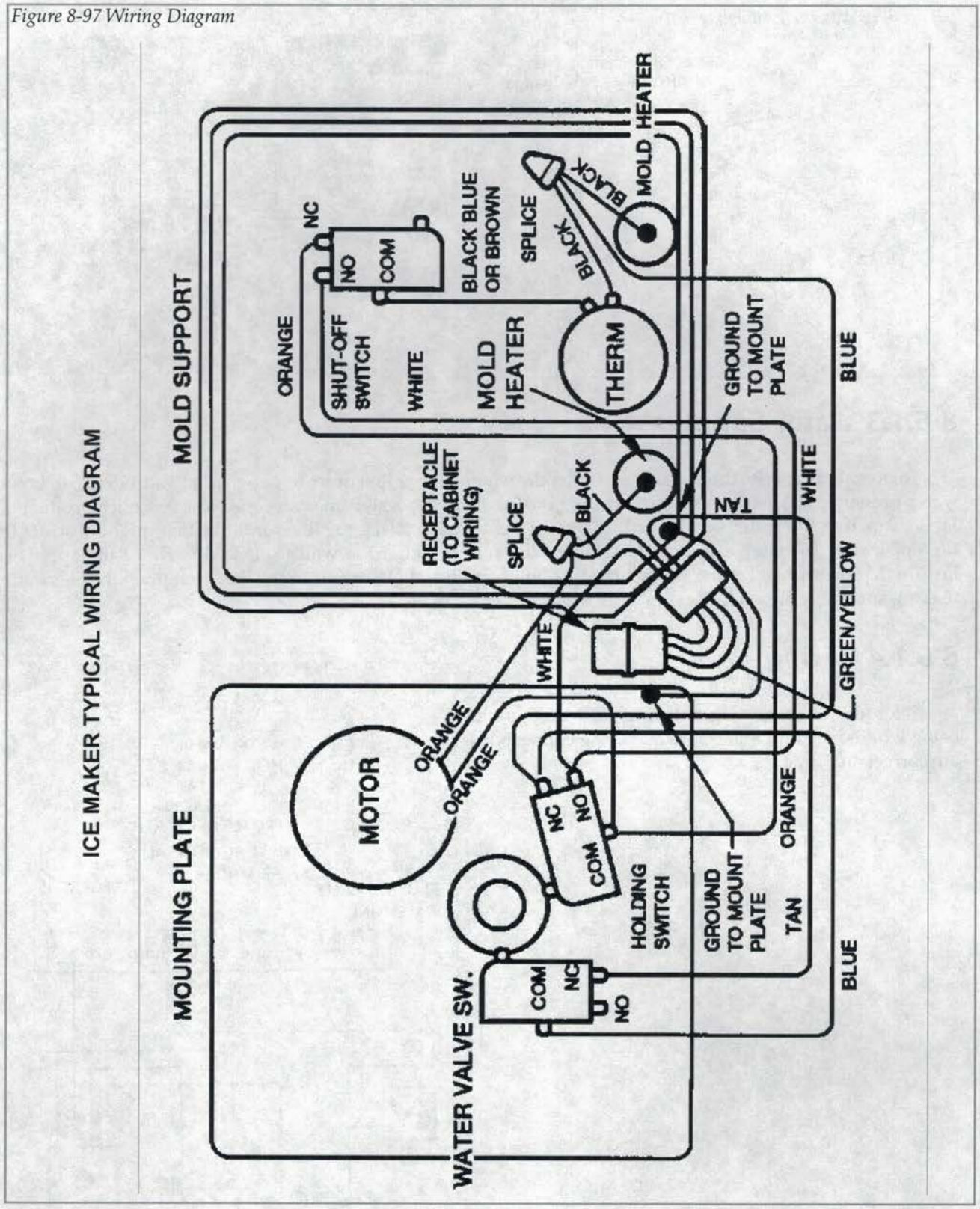


Figure 8-97 Wiring Diagram



8-6.1.5 Water Supply

To remove trapped air, loosen the connection at the solenoid water valve of the appliance. Ensure that pressurized water is reaching this point, and bleed off any air in the line. Retighten the connection, making sure there are no leaks.

8-6.2 Norcold Ice Makers

8-6.2.1 General Description

The ice maker is a factory-installed accessory located on the right side of the freezer compartment. The components that support the ice maker are the wire harness, water fill tube, water fill line, and water valve.

NOTE: An ice maker cannot be added to a refrigerator that was manufactured without an ice maker.

The ice maker is installed by Norcold as optional equipment. The refrigerator installer is required to connect a cold water supply to the water solenoid valve at the rear of the refrigerator. The ice maker requires 120 VAC to operate (even when the refrigerator is operating on propane) and is fully automatic. When the refrigerator's freezer reaches ice freezing temperatures, the ice maker will signal the water valve to fill up the mold cavity. When the ice bin is full, the shutoff arm will stop the ice-making process until the bin is emptied and the shutoff arm is returned to the down position.

8-6.2.2 Ice Maker Specifications

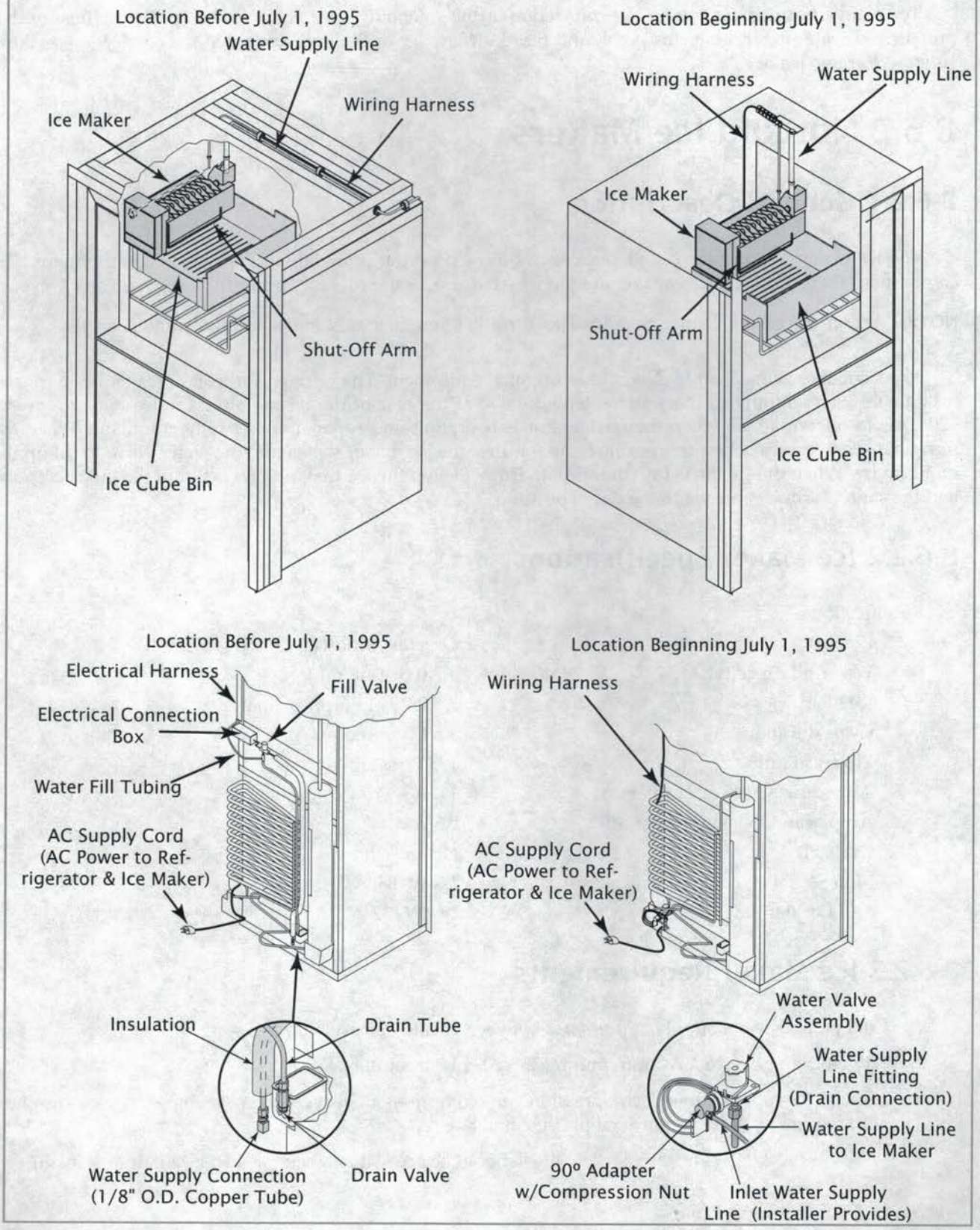
Specifications

Cycle	One revolution (eject and water fill)
Water fill capacity	4.7 fl oz (140 mL)
Ice yield	3.5 lb/24 hr (approximate)
Cycle duration	3.5 to 7 minutes
Electrical rating	185 W @ 115 VAC, 60 Hz
Amp draw Cycle on/heater on	1.6 A
Amp drawCycle on/heater off	0.3 A
Cycle off	No amp draw
Motor	1.5 W/8800 W
Mold heater	185 W/72 W

8-6.2.3 Ice Maker Requirements

1. Cold potable water supply at pressures between 15 and 125 psi.
2. 120 VAC supply (108 VAC minimum, 132 VAC maximum).
3. 1/4 in. OD copper tubing (compression nut, compression sleeve, and 90° tubing adapter supplied with refrigerator) or an approved plastic tubing.
4. 1/4 in. shutoff valve in water supply line (should be accessible when the lower vent door is open).

Figure 8-98 Location of Norcold Ice Maker's Related Components



8-6.2.4 Water Supply Connection

8-6.2.4.1 Connecting the Ice Maker

The ice maker is assembled to the refrigerators at the factory as optional equipment. If the refrigerator does not have a factory-installed ice maker, one cannot be added to the refrigerator at a later time.

The refrigerator installer must connect a cold water supply line to the solenoid valve at the rear of the refrigerator. The following are necessary to connect the icemaker:

- 1/4 in. OD copper tubing for the water supply line.

OR

- 1/4 in. OD plastic tubing for the water supply line.
- 1/4 in. shutoff valve in the water supply line. This should be easily accessible through the lower intake vent.

Connect the water supply line:

- Install a 1/4 in. OD water supply line from the water shutoff valve of the vehicle to the solenoid water valve at the rear of the refrigerator:

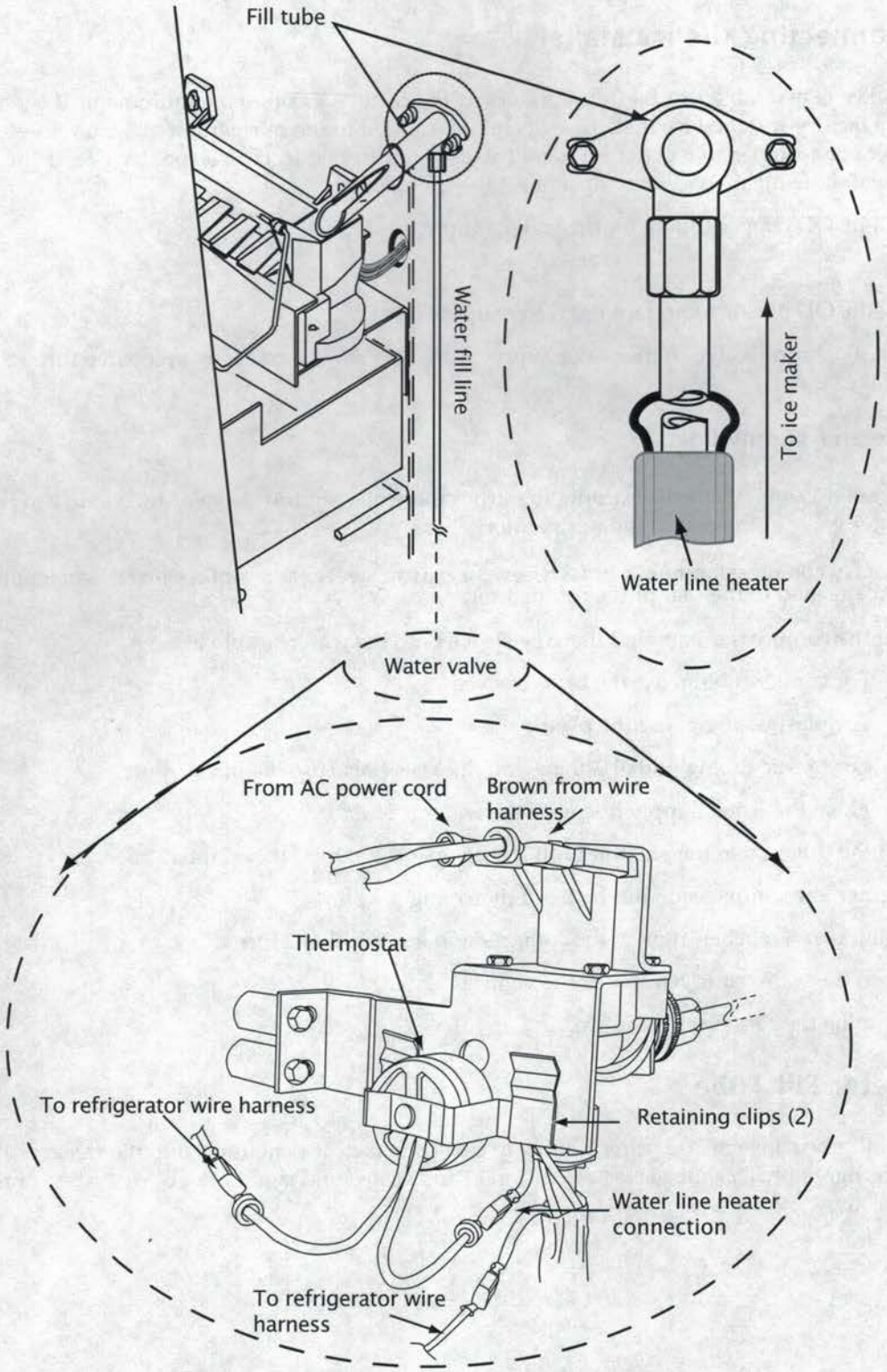
NOTE: A brass compression nut, a brass sleeve, a plastic sleeve, and a brass insert are supplied and attached to the rear of the refrigerator.

- Put the compression nut and then the sleeve onto the water supply line.
  - For copper tubing, use the brass sleeve.
  - For plastic tubing, use the plastic sleeve.
  - For plastic tubing with 0.040 in. wall thickness, also use the brass insert.
  - Flush the water supply line until the water is clear.
- Put the tubing into the adapter until it is against the stop of the adapter.
- Tighten the compression nut by hand (hard finger-tight).
- Using two wrenches, tighten the compression nut 1-1/2 to 2 turns.
- Open the water shutoff valve of the vehicle.
- Examine the connections for leaks.

8-6.2.4.2 Water Fill Tube

The water fill tube connects the water fill line to the ice maker. It penetrates into the freezer cabinet from the rear of the refrigerator. This tube is factory installed and sealed and should not be disturbed or removed; it cannot be replaced.

Figure 8-99 Water Fill Tube, Line, and Heater (Norcold)



8-6.2.4.3 Water Fill Line

The water fill line connects the water fill tube to the water valve at the bottom of the refrigerator. It is constructed of 1/4 in. plastic tubing. It connects to the water valve and water fill tube with 1/4 in. compression-style fittings. The water line is encased in a 12 VDC foil-style strip heater. To replace the water fill line, the refrigerator must be removed from the enclosure.

8-6.2.4.4 12 VDC Water Line Heater

The water line heater encases the entire length of the water fill line. This heater operates on 12 VDC.

Heater operation is automatically controlled by a small thermostat. The thermostat is "clipped" to the water valve bracket. It turns the heater on when the surrounding temperature is 38 ± 4° F (34 to 42° F). It turns the heater off when the temperature rises to 48°F.

8-6.2.5 Operating Instructions

1. Make sure 120 VAC is available to the refrigerator.
2. Turn the water supply on.
3. Move the shutoff arm down to the ON position. Do not allow food packages to interfere with the shutoff arm.

NOTE: If refrigerator is to be opened before the water connection is made or before the water is turned on, ensure that the ice maker's shutoff arm is in the up/OFF position.

4. Allow the freezer to reach ice freezing temperatures. This may take a minimum of 24 hours from initial refrigerator start-up. When the freezer temperature is satisfactory, the ice maker will start.
5. When the bin is filled with ice, the ice maker will stop ice production.
6. The first ice yield may be discolored or have an odd flavor because of the new plumbing connections or because of impurities remaining in the water lines after winterizing.
7. To stop the ice maker, raise the shutoff arm to the up/OFF position.
8. When operation of the refrigerator is to be discontinued for any length of time (e.g., storing the RV for the winter), empty and dry the ice maker.

NOTE: Operating the ice maker when ambient temperatures reach 32°F (0°C) or below can cause irreparable damage to the ice maker's water valve and inlet water line.

Winterize in accordance with the procedures below.

1. To drain the ice maker, move the ice maker's shutoff arm to the up/OFF position.
2. Turn off the water at the supply line shutoff valve.
3. Loosen and disconnect the inlet fitting from the water valve. Drain water from the supply line.
4. Loosen and disconnect the outlet fitting (line from the valve to the ice maker) from the water valve. Drain water from the line.
5. Reconnect the inlet and outlet fittings to the water valve.
6. Leave water supply off until the outside temperatures are above freezing (32°F/0°C). Dry the ice maker with a dry cloth.

8-6.2.6 Wire Harness Check

8-6.2.6.1 Wire Harness

The ice maker wire harness (*Figure 8-100*) connects the ice maker to the 120 VAC ice maker power cord. The assembly is bundled together with plastic ties. The wire harness runs through the surface of the cooling unit foam plug. On the upper ice maker end, the harness has a modular plug with a locking tab (*Figure 8-101*). Each wire on the harness has the appropriate connector to connect to the ice maker AC power cord (white AC cord). The four wires making up the wire harness are:

- Black: line voltage (L), black wire with female quick-connect terminal. This conductor is equipped with a thermal fuse. The thermal fuse is held onto the ice mold by a spring clip.
- White: neutral (N), white wire with male quick-connect terminal. It connects to the AC power cord neutral wire.
- Brown: water valve line voltage, brown wire with female quick-connect terminal. It connects to the water valve solenoid, terminal M.
- Green: ground wire, green wire with lug terminal. It connects to the refrigerator cabinet metal plate.

The refrigerator has to be removed from the enclosure to replace the ice maker wire harness. The ice maker connector is set up as follows: black connects to smooth AC wire, white connects to ribbed AC wire, brown connects to water valve, green connects to metal plate.

The ice maker wire harness is not the same as, nor is it connected to, the wire harness that serves the power board and the optical display assembly.

Figure 8-101 Wire Harness Connection to Ice Maker

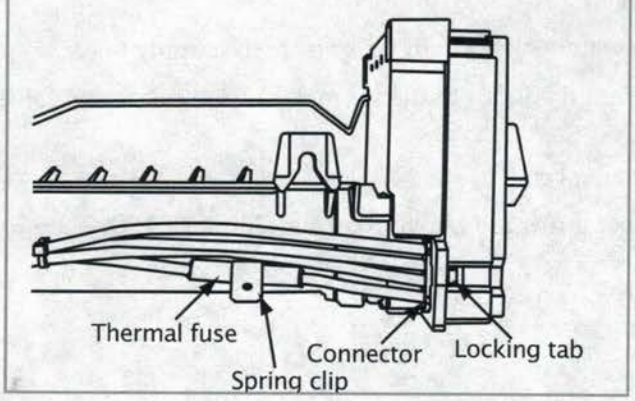
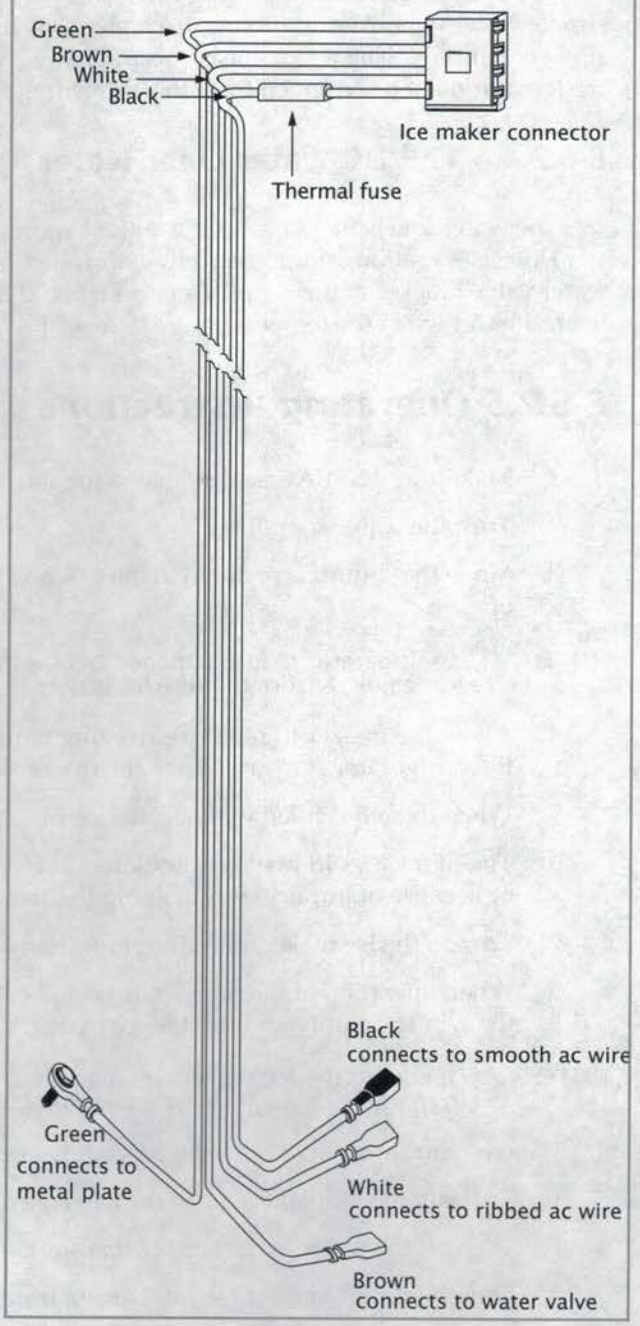


Figure 8-100 Ice Maker Wire Harness (Norcold)

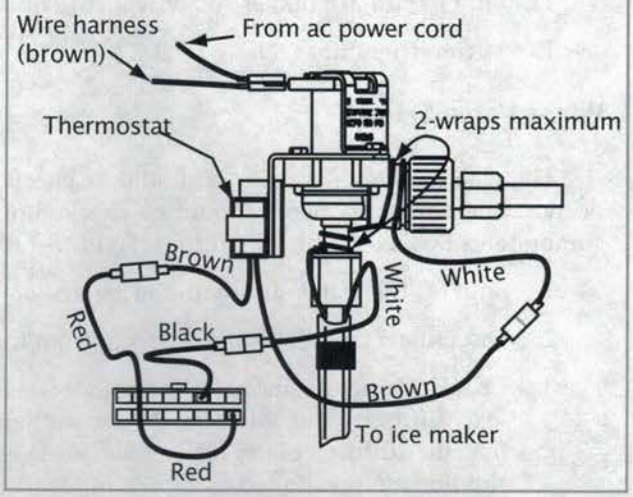


The wire harness is equipped with a thermal fuse. The fuse protects the ice maker mold from overheating. If the fuse is open, the wire harness requires replacement.

8-6.2.6.2 Water Valve

The water valve is solenoid operated. This valve is located on the back of the cabinet on the bottom of the refrigerator The solenoid is supplied 120 VAC through the ice maker wire harness. Spring pressure keeps the valve shut when the solenoid is not energized.

Figure 8-102 Solenoid Water Valve



Water Valve Replacement Procedure

1. Turn the refrigerator OFF.
2. Unplug both the ice maker AC power cord and the refrigerator AC power cord from the RV receptacle.
3. Shut off the water supply to the ice maker.
4. Disconnect the wires from the water valve solenoid terminals.
5. Disconnect the white heater wire from the thermostat wire (white from brown).
6. Disconnect the remaining white heater wire from wire harness lead (white from red).
7. Disconnect the brown thermostat wire from wire harness (brown from red).
8. Disconnect the water supply line from valve's inlet fitting.
9. Disconnect the ice maker water line.
10. Remove the thermostat clips (2) and thermostat. Retain thermostat and clips.
11. Unwrap the heater wire from water valve.
12. Remove the water valve retaining screws, then remove the water valve/bracket assembly. Retain screws and spacers.

To install a replacement solenoid water valve:

1. Install the replacement water valve/bracket assembly on the refrigerator. Use screws and spacers previously removed.
2. Clip the thermostat to water valve bracket. Use clips previously removed.
3. Carefully wrap one white heater wire around the valve as shown in *Figure 8-102*. Do not exceed two wraps at each point.
4. Tape the wire wraps to keep the wire turns in position and to keep wire turns from overlapping. Do not allow wires to overlap.
5. Connect the wrapped white heater wire to a thermostat wire (brown).
6. Connect the remaining white heater wire to the black wire connected to the refrigerator wire harness.
7. Connect the remaining thermostat brown wire to the red wire connected to the refrigerator wire harness.
8. Connect ice maker water line, then tighten fitting firmly. Do not overtighten.

Chapter

9-7 Water Heater Codes and Standards

- Identify and apply codes and standards.

9-7.1 Industry Codes and Standards

Industry codes and standards have been developed to ensure safety and to reduce liability. The major source of RV standards are the *NFPA 1192* and *CSA Z240*. These standards outline requirements for plumbing, heating (propane system), fire and life safety, and electrical.

The Recreation Vehicle Industry Association (RVIA) requires that member manufacturers agree to in-plant visits by the RVIA inspectors. If members refuse or fail to comply, they can be expelled and therefore lose the right to bear the association's seal of membership.

To help everyone better understand the requirements of the standard, an industry handbook is maintained by RVIA. Industry stakeholders work with RVIA to document the enforcement positions, which explains the standards in detail. Although standards are primarily designed for RV manufacturers, it is important from a liability standpoint that RV service technicians strive to follow these standards where possible when modifying, servicing, or installing RV systems or their components.

Agencies, state and private, involved with RV safety training use and follow the NFPA and CSA standards for recreational vehicles. This NFPA standard is revised every three years, with dates being 2002, 2005, 2008, 2011, and so on. Industry always begins using the new edition of the NFPA requirements on or near May 1 of the revision year, and manufacturers must comply with requirements by September 1 of the new code edition year.

9-7.2 Code Summary

Table 9-5 is a summary of the current RV standard that pertains to the normal duties of the RV service technician. This summary is provided as a quick reference, NOT AS A SUBSTITUTE FOR THE ACTUAL STANDARDS. Once the reference in these tables has been found, go to the referenced standard for the exact wording and use the handbook for the detailed explanation.

The *NFPA 1192 Standard for Recreational Vehicles*, RVIA's NFPA 1192 Handbook, *A Guide to NFPA 1192*, and *ANSI/RVIA 12V Standard for Low Voltage Systems in Conversion and Recreational Vehicles* are available at www.rvia.org. The *National Electrical Code* is available from NFPA at www.nfpa.org/catalog/ or by calling 1-800-334-3555.

Information on CSA standards can be obtained by going to their website at www.shopcsa.ca.

Table 9-5 Appliances—Applicable to RV Service Technicians

Service Technicians Task	2008 CSA Z240	2011 1192	Summary of Requirement
Inspect/repair/replace water heater	5.7.1.1(b) Electric	551.43(A)(1)	Check rating of water heater vs. size and load of overcurrent protection.
	5.1.3 Propane	5.4.5.1 5.4.5.2	Any propane water heater 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.

	6.3.3 Plumbing	7.3.12.1	Relief valves for water heaters shall terminate to the outside of unit.

NOTE: There is no chapter review for this chapter.

9 Answer Keys

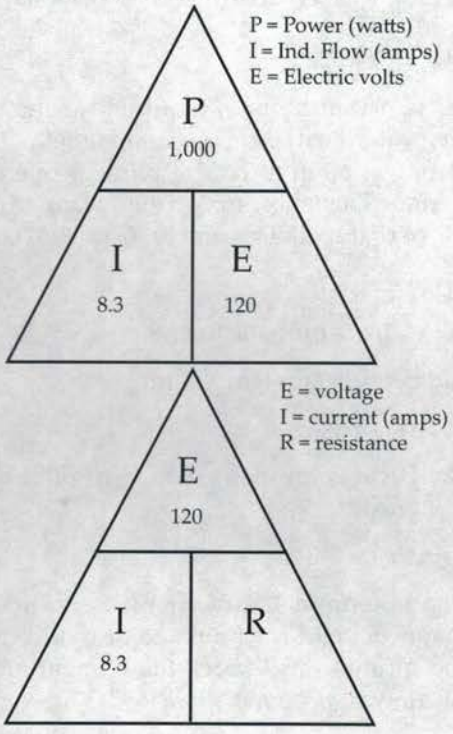
Chapter 9-1

1. False. Most water heaters have propane as the primary source of heat. There are a few propane/electric and even fewer all-electric ones. *(page 9-1)*

1. A. Standing pilot flame *(page 9-1)*
   B. Spark ignition
2. C *(page 9-1)*
3. Number of gallons *(page 9-2)*
4. Direct spark ignition *(page 9-2)*
5. True *(page 9-4)*
6. True *(page 9-4)*
7. Energy cutoff switch ECO *(page 9-7)*
8. Temperature and pressure T&P relief valve *(page 9-7)*
9. A. Freezing *(page 9-7)*
   B. Vaporization
   Both frozen water and vapor from boiling water cause the volume of water to expand.
10. D *(page 9-8)*

Chapter 9-2

1. C *(page 9-15)*
2. D *(page 9-15)*
3. True *(page 9-19)*
4. Direct contact with the water heater tank surface *(page 9-15)*
5. Checking the data plate *(page 9-14)*
6. A. Fiberglass *(page 9-14)*
   B. Foam
7. Heating element *(page 9-14)*
8. A. Overheating *(page 9-14)*
   B. Arcing
   C. Fire
9. A. On/off switch *(page 9-14)*
   B. Thermostat assembly
   C. Heating element
   D. T&P relief valve
10. Both B and D are correct *(page 9-16)*
11. C
    120 VAC divided by 8.3 A = 14.46-3/4



12. True *(page 9-18)*
13. False. Always use the same wattage rating. *(page 9-18)*
14. A. Attached on the water heater *(page 9-19)*
    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 9-21)*
16. Any two of the following *(page 9-22)*:
    D. The thermostat needs adjustment.
    E. The thermostat has failed.
    F. Improper thermostat positioning.
17. Check water temperature coming out of the faucet with a good mercury-type bulb thermostat at the T&P valve. *(page 9-22)*

Chapter 9-3

1. Pilot model *(page 9-29)*
2. Engine-assist heat exchanger *(page 9-29)*
3. C *(page 9-29)*

4. False. The main propane regulator controls the supply and pressure to the water heater. *(page 9-29)*
5. D *(page 9-32)*
6. A. 12 mV 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 9-32)*
7. C *(page 9-32)*
8. A. Allows propane to enter *(page 9-34)*
   B. Sense water temperature
   C. Has ECO
   D. Divides propane between pilot and main burner
9. True *(page 9-34)*
10. The minimum 12 mV circuit is opened, and the magnetic field is eliminated or reduced, allowing the spring to push back the plunger and shut off the flow of propane. *(page 9-34)*
11. False. No sealant *(page 9-37)*
12. B *(page 9-37)*
13. True *(page 9-37)*
14. D *(page 9-40)*
15. C *(page 9-40)*
16. False. Different burners are matched to a specific size orifice, so care must be taken when ordering or interchanging parts. *(page 9-39)*
17. Combustion pan *(page 9-41)*
18. A. Clean or replace burner and orifice. *(page 9-45)*
    B. Adjust air shutter.

Chapter 9-4

1. D *(page 9-51)*
2. True *(page 9-51)*
3. False. The DSI ECO can be reset for continuous usage. There are two types of ECOs: automatic- and manual-reset types. *(page 9-56)*
4. Thermal cutoff *(page 9-57)*
5. A *(page 9-57)*
6. B *(page 9-57)*
7. A *(page 9-59)*
8. True *(page 9-59)*
9. C *(page 9-61)*
10. C *(page 9-61)*
11. D *(page 9-61)*
12. True *(page 9-61)*
13. True *(page 9-61)*

Chapter 9-5

1. True *(page 9-73)*
2. Water impeller-type valve/switch *(page 9-74)*
3. False. Instantaneous water heaters do not have water tanks. *(page 9-73)*
4. True *(page 9-73)*
5. False. Instantaneous water heaters have redundant ECO switches. *(page 9-73)*

Chapter 9-6

1. B *(page 9-79)*
2. False. There will be approximately two quarts of water left in the tank. This is also where most of the sediment is. *(page 9-79)*
3. True *(page 9-80)*
4. False. Replaceability of water tanks varies from manufacturer to manufacturer. The entire water heater may have to be replaced. *(page 9-80)*
5. B *(page 9-80)*
6. A, B, C, D, and E *(page 9-81)*

Chapter 9-7

There is no review for this chapter.

9 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.
Bypass 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. 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.
DSI	Direct spark ignition.
Circuit Board	An electronic panel that controls the spark and solenoid valve, and senses the main burner flame.
ECO	Energy cutoff. A high-temperature limit switch.
Electrolysis	Electrochemical 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 (DSI 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 the inside of a tank.
Flying Lead	Flame-sensing wire that is sometimes found hardwired to the 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 vessel designed for heating water.
Jade Knob Clip	A horseshoe retainer clip on the main shaft of a Jade propane thermostat that allows for proper moving of the 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 allow for propane and air mixture adjustment.

Main Burner Orifice	A precision-drilled fitting that regulates the Btu/hr of combustion.
Motor Aid	See *Heat Exchanger*.
NPT	National Pipe Thread. A plumbing measurement standard. A slightly tapered thread designed for plumbing connections.
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 *T&P valve*.
Ring and Gasket	Retaining fiber and metal rings that secure and seal combustion pan to tank.
Pilot Assembly	Assembly consisting of propane tubing, orifice, pilot burner, and thermocouple.
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.
T&P Valve	Temperature and pressure valve known as a relief valve.
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 Cutoff	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 that, 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.

9 Index