Troubleshooting and Repair of Your Propane Equipment Furnace

INTRODUCTION

One of the key secrets to troubleshooting a piece of equipment is to have some idea about how it works. We usually know what the input and output are supposed to be but have no idea how we get from here to there. A water heater takes cold water and delivers hot water using propane; a furnace provides hot air using propane; an air conditioner provides cool air using 120 VAC; a refrigerator provides cool and frozen food using propane or 120 VAC or sometimes 12 VDC; a generator provides 120 VAC from either gas, diesel or propane; a charger keeps our batteries working properly using 120 VAC or an alternator; an inverter changes our 12 VDC into 120 VAC; a solar panel helps keep our batteries charged using sunlight; etc., etc.

We take all of this equipment, stick it into a box, leave it outside all year long and subject it to extremely hot and cold temperatures. We dump water and dirt all over it and then periodically shake the heck out of it. No wonder our RV appliances and equipment constantly need care and feeding. Lots of little critters like the smell of propane so they build nests in the equipment that can block the flow of air or gas. Exposure to the weather and dirt can cause short circuits on printed circuit boards. Occasionally, manufacturers may have done a poor design or used an unreliable component which will eventually cause a failure. I know it's hard to believe but some of us might actually not take care of our expensive RV systems (sometimes referred to as MAINTENANCE) resulting in failures at the most inopportune times.

Home appliances usually last for many years without continuous maintenance but they live in a benign environment and with millions of each item sold receive the ultimate in design for reliability and cost. Most of our RV equipment is designed to survive in the environment in which it has to live, but periodic maintenance is a requirement not an option. The, don't touch it

until it goes bad, philosophy just does not work on RV's. Most of the equipment has specified periodic maintenance schedules, just like your Tow Vehicle or Motor Home. It may be as simple as cleaning the area around the equipment, changing a filter or tightening an electrical connection. Read your individual instruction manuals, check the RV manufacturer's service and maintenance manuals and down load any available appliance service information. Reference (1), http://bryantrv.com/owners.html provides an excellent collection of RV Manuals and Service Documents. This includes various brands of water heaters, refrigerators and furnaces that have been used by Airstream over the years. You can also obtain free manuals directly from many of the manufacturers by going to their Support section on the Internet. For Dometic equipment

Reference (2), http://dometic.com/enus/Americas/USA/Customer-Support/Operation--Installation-Manuals/ .

In this Seminar we are going to cover Water Heaters, Furnaces and Refrigerators. This is not intended to be a detailed step by step troubleshooting manual for a technician. We will provide a basic outline of how the equipment works, maintenance you should be doing on a routine basis and an outline of what usually goes bad. Many of you should be able to do the simpler repairs yourselves and gain some knowledge in order to make the decision when you need to visit a professional repair shop.

PROPANE APPLIANCES

Fundamental to any propane or natural gas operated equipment is the following items:

1. Uses the heat from burning gas
2. An electrically operated valve which turns on the gas
3. A method of automatically lighting the gas jet
4. The ability to turn off the gas valve if the flame goes out
5. A means of setting and/or changing the operating temperature
6. A turn off protective device if it gets too hot
7. Several protective circuits involving timing of turn on and turn off cycles
8. A good source of 12 volt DC power to run the circuitry
9. A source of propane that provides the correct gas pressure (11" of water).

Let's define a few terms:

Thermometer	Sensor that measures temperature and usually provides a visual reading
Thermocouple	Generates a voltage as a function of temperature (millivolt levels)
Thermostat	Opens or closes a switch as a function of temperature
Thermistor	Changes resistance as a function of temperature

eco or E.C.O. Temperature activated electrical cut-off switch.

I have two gas furnaces in my house that operate from natural gas. They are used in a zoned two area system. One is an original unit over 50 years old and the other, a much larger furnace that was replaced about 8 years ago. The older unit has a pilot which burns all of the time. The gas line goes into a valve which controls the main gas input for the furnace. A separate smaller gas line feeds around the gas valve through a small manual cutoff switch to provide the pilot flame. You open the small cutoff, light the pilot flame and then hold a spring loaded switch till the flame stays on. A wall mounted thermostat can now close a switch when the ambient temperature reaches the level you have set. This provides the final voltage to the relay controlled gas valve that turns on the furnace. If the flame goes out the gas valve turns off and you must go thru a re-light cycle by resetting the spring loaded switch.

The newer furnace does not have a pilot flame but uses a direct-spark ignition that effectively turns on the main gas valve and lights it using an electrical spark. Once the preset temperature has been reached the thermostat (inside the wall thermometer) opens and shuts off the gas supply. It has several electric circuit boards that control the turn-on and turn-off cycles. Home furnaces usually use 24 VAC which is supplied by a transformer connected to the 110 VAC. Our RV furnaces operate in a similar manner except for using 12 VDC to operate the gas valve and electronic circuits.

GENERAL

The following sections will consider the propane operated Water Heater, Furnace and Refrigerator. All of these are fundamentally the same in terms of how they operate in generating heat, controlling it and providing suitable protection systems. They all have similar gas systems and use a high voltage to create a spark that will automatically light the gas jet. If the flame goes out they will wait till any gas fumes clear and then automatically re-light the appliance.

Good trouble shooters are worth their weight in gold to any service shop. You usually find two basic types; (1) Those who learn how a system works and understand the different functions which must occur and (2) those who have fixed so many systems over the years and learned what usually goes wrong. The technician who has fixed a hundred refrigerators can look at a problem, check the Model number and go right to the defective component. He may not know how the fridge actually works or the operating principles behind it but who cares. He quickly finds the bad component, has it in stock (because he knows what usually fails) and makes the repair. Actually fixing the problem (replacing a bad component, tightening a wire, fixing a ground lead, etc.) takes a minimal amount of time and effort. Determining the problem (troubleshooting) is what is most difficult and takes the longest.

Since it is not likely that we will be spending enough time to gain years of experience in fixing our RV appliances our best approach is (1) learn how it works, (2) learn how to isolate the

problem, (3) learn how to make some simple safe tests and (4) learn when to stop and get an expert.

The first step is to clearly define what the problem is. This is not always as easy as it sounds. My refrigerator does not work?? On gas? On electric? The freezer is not cold enough? Food in the main box is too cold? Ice cubes are not freezing? Etc, etc.

Check carefully and determine what is working correctly. If the food is spoiling put a thermometer in the Fridge freezer or the main food box and determine the actual temperature. Check the ambient temperature when you measure the box. Make sure your refrigerator is set on high if it is a hot day.

Being able to succinctly state the problem as well as any applicable environmental factors is needed regardless of whether you tackle the problem yourself or take it to a repair shop. The better you define the problem the less trouble shooting time that will be required. If you can you should also try to isolate the problem to a subsystem. For propane appliances the subsystems could include:

(a) Gas components (Valve, sparker, gas connectors, combustion chamber, jet)
(b) Electronic section (Circuit Boards, fuses, High voltage source, switches)
(c) Electrical parts (heating element, thermostats, motors, connectors, wiring)
(d) Mechanical components (motors, fans, ducts, covers)

Instead of just wading in and testing components one after the other get the instruction manual out and read how the sequence of operation is supposed to occur. Observe each step and try to verify that each operation is correct.

FURNACE

Operation

Figure (7) illustrates the typical furnace configuration that we use in our RV's.

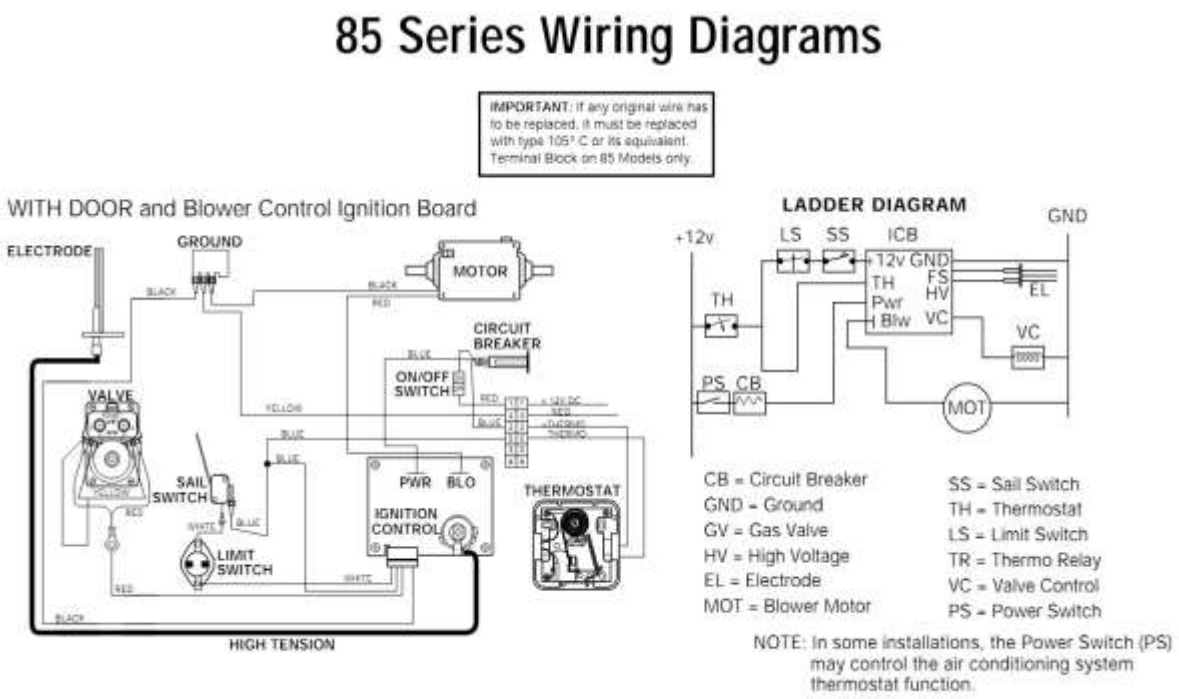

Figure (7) Typical Furnace

The previous discussions about propane appliances are directly applicable to an RV Furnace. With a furnace we are heating the air which must be circulated throughout the RV, usually by providing a duct type distribution system. This means we need a blower to distribute the heated air inside the RV and also a separate blower for the combustion system. The combustion blower draws outside air into the burner and exhausts burned gases from the chamber.

Figure (8) Blower Motor

This is accomplished by using one motor with a double shaft, Figure (8) and two different type squirrel cage blower blades, Figures (9) and (10), both having their own separate housings.

Figure (9) Combustion Blower

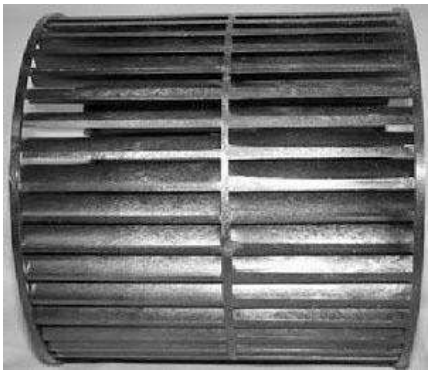

Figure (10) Circulation Blower

The combustion chamber is isolated from the RV interior and uses the smaller blower to draw air in and exhaust the burned gases. This chamber provides the heat for the air flow going through the interior duct system. A much larger squirrel cage blower is needed for the large volume of interior air flow required. Since hot air rises most furnace installations use ducting on the floor level for maximum heating efficiency. Conversely, cold air drops so for maximum efficiency air conditioners should be located on the ceiling and use ceiling duct systems. Since our RV's are poorly insulated compared to our homes maximizing efficiency should be a major concern for designers.

The 12 VDC enters the furnace through a circuit breaker which limits the maximum current draw. This can also serve as combination on/off switch. The power then goes to the wall mounted Thermostat which allows you to set the desired RV ambient temperature. This can be a simple analog device which uses a mercury switch. In newer RV's, the thermostat is usually a digital unit which can be used to control all of the temperature appliances in the RV. This could include multiple air conditioners, heat pumps, furnaces, heat strips and fans.

When the temperature gets below the set point the contacts close and apply 12 volt power to both the circuit board and a heavy duty relay. The relay starts the air flow by applying power to the motor. Power is also applied to the circuit board, Figure (11), which controls timing, motor functions and gas ignition. A furnace requires some special timing since we are circulating air throughout the RV and coordinating the flow with the heat source.

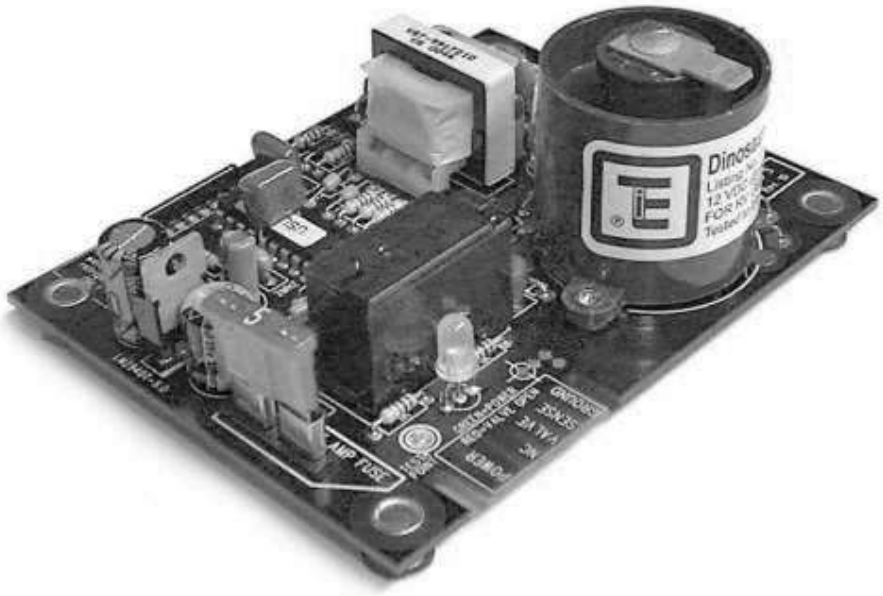

Figure (11) Furnace Circuit Board

The timing circuit keeps the blower running for about 15 seconds to purge the combustion and air chamber. A sail switch is included, Figure (12), which monitors the interior air flow to insure that the burner cannot be lit unless air is circulating through the heat ducts.

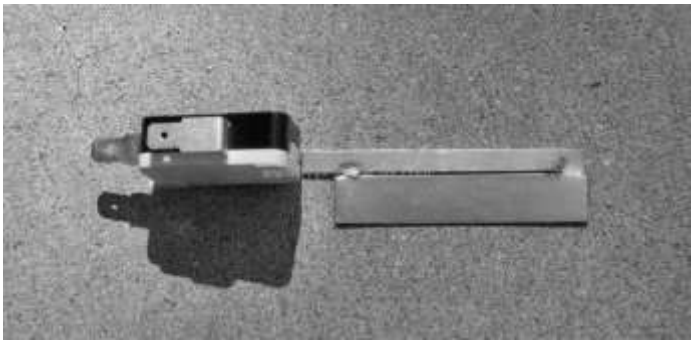

Figure (12) Furnace Sail Switch

With the sale switch closed power will be supplied to the gas valve, Figure (13). Similar to the water heater 'eco' a high temperature limit switch in series with the gas valve, Figure (14) and is normally in the closed position. If the furnace overheats this switch will open and cut off the propane supply be removing power from the gas valve solenoid.

Figure (13) Furnace Gas Valve

Figure (14) High Temperature Limit

Once the gas valve has opened the circuit board generates a high voltage which is used to automatically light the gas burner through a spark probe, Figure (15). There are two types of spark generators each with a thermocouple, much the same as the water heater. Again the thermocouple must be in the flame in order to generate the millivolt signal that tells the circuit board to keep the gas valve open and thus the burner operating.

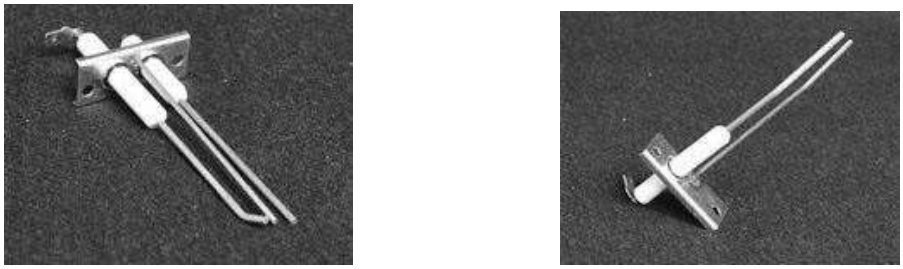

Figure (15) Furnace Spark Probes

If the thermocouple does not detect a burning flame within 6 or 7 seconds then the valve will automatically be turned off, effectively turning off the gas supply. After a 25 sec purge of gases and any leftover propane from the combustion chamber the system will try again to light the burner. The burner is similar to the water heaters and also uses a jet to shape the gas for optimum heating.

As long as the Thermostat is below the set point the blower will continue to operate. So even if the burner has been turned off the blower will still be operating. To start the system again you must turn off the thermostat manually and then restart the furnace.

When the thermostat senses that the set point has reached the proper temperature it will open the switch removing power from the ignition system and turning off the gas valve. The blower will run for about 90 seconds clearing out the air and combustion chamber and then automatically shut down the system.

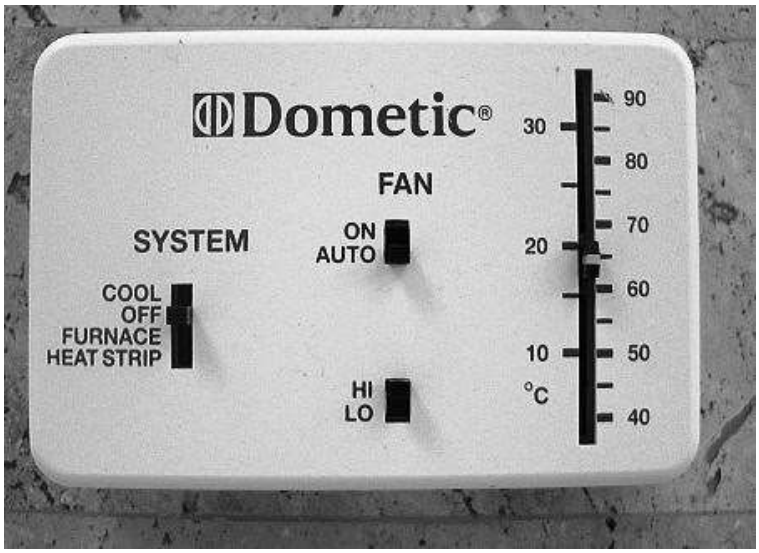

Figure (16) Analog Thermostat

Figure (16), illustrates a typical analog thermostat which is designed to control your furnace, air conditioner and if available a heat strip. These new combination thermostats are nice because they use one temperature monitoring system (with sensor and temperature setting) that serves the entire climate needs for the RV.

Older RV's have a simple thermostat which just handles only the furnace that is virtually identical to the older home units. These are inexpensive and available at any Hardware store. Older units have controls for the air conditioner and heat strip on the ceiling unit itself, with a manual temperature adjustment.

The most advance thermostats are the digital Climate Control Centers which provide control for all of the RV temperature related equipment. These can include multiple location sensors, air

conditioner, furnace, heat pump and heat strip. There can be four different zones with a different set of climate control equipment in each zone. This one CCC allows you to monitor and adjust different temperatures for each piece of equipment in the RV. Once it is set up correctly and you learn how to use it the CCC, illustrated in Figure (17) it provides the ultimate in RV comfort.

Figure (17) CCC Digital Thermostat

The wall unit is coupled to a control board installed in the front main air conditioner using a 4wire telephone plug type cable. The control board has a set of dip switches which allows you to set-up each zone with its individual sensor and climate control equipment. You can have air conditioning in the front and heat in the rear at the same time.

The CCC converts its sensor inputs and desired equipment settings into a computer signal and feeds it into the control board computer. The control board converts the computer signals into analog voltages and operates a set of relays which are used to operate the physical equipment through contact closures. Essentially instead of you turning off the furnace when it is getting too hot you tell the CCC what temperature you want it uses its computer to tell the control board computer to turn the furnace off or on for you. Fortunately this complex system is pretty reliable and trouble free.

Troubleshooting

When troubleshooting for an electric problem, make sure the tank gas supply valve is turned off. When you cycle the furnace for testing it has built in time delays which will make sure you wait until any released propane or exhaust gases have been dissipated.

The furnace is much more reliable than the water heater because its electronics and major components are located inside the RV and not exposed to moisture and dirt. However, it is also much harder to get to the components for testing or replacement. This means for many tests you will have to remove it from the RV. For older RV's you remove the furnace from the inside. For newer models you usually remove it from the outside. In either case you must disconnect the gas line, electrical connections, several round ducts and remove mounting plates and sealing material on the outside furnace flanges. Once you have decided which area might be causing the problem thoroughly check those accessible components before you remove the entire unit. .

Nothing Works

1. Check the 12 volt source, circuit breaker, main input wire plug and particularly the ground lugs.

2. Check the heater circuit breaker and on/off switch. You can use several terminal lugs (which are accessible without removing the furnace) to see if 12 VDC is getting into the unit.

3. The motor relay has burned contacts or is burned out and is not feeding 12 volts to the motor. This prevents the motor from starting and with no air flow the sail switch will not turn on. Older units have a separate relay while newer furnaces have the relay as part of the circuit board.

Air is on but burner is off

1. Similar to the water heater the 12 volts must get to the gas valve so listen for the valve click about 15 seconds after the blower has turned on. The 12 volts must go through the thermostat, sail switch, temperature limit switch and finally the circuit board to get to the gas valve.

2. The thermostat should be checked next by setting it so that it calls for heat. Using the six pin plug, figure (7), the wires on pins 2 and 5 are from the thermostat. If you short these together the gas valve should click and you should hear arcing from the spark probes. **Of course only do this with the gas turned off.** You can also use an ohmmeter (should measure about 45 ohms) to see if the solenoid has continuity.

3. Check for 12 volts on the gas valve solenoid. If it is not present the sail switch is the next best candidate. You can usually get to this component and remove it for an easy ohmmeter test. Be sure to operate the sail during the test by pushing and holding it so the switch is in the on position.

Air and Gas Valve are OK

1. Similar to the water heater the board may be defective and not generating the high voltage or the spark probe wires may not be close enough together (1/8 inch).

Burner will not stay lit

1. Again check the position of the thermocouple in the flame or it may be defective.

2. If the thermocouple is good then you may have a defective circuit board.

Burner making loud noises

1. Air-gas mixture incorrect or burner chamber has foreign material in it and needs to be cleaned.

Defective Thermostat

If you have either a four or five button digital CCC and you have determined it might not be working correctly you are faced with a dilemma. Since it is essentially a computer and it is connected to another computer (control board mounted in the air conditioner) how do you know which end is bad? Or could the 4-pin telephone type connection between the computers be bad?

The first step is to remove the thermostat from the wall and unplug the cable. This is a special cable and not a standard phone cable. Remove the air conditioner cover and unplug the CCC cable. Do an ohmmeter test to determine if any of the wires are broken or shorted. Especially check for shorts to ground. If you find a problem you can make a new cable, just make sure the wire color sequence is configured as shown in Figure (18). You can also build a test cable to make sure the built in wires are not shorted or broken. Home Depot has a phone cable kit for about $11 which has RJ11 plugs, the proper crimping tool and a good set of instructions.

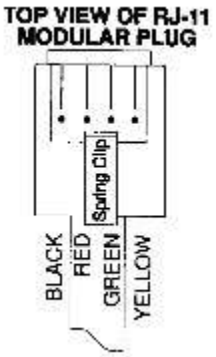

Figure (18) CCC Cable

If the cable is OK the best option you have is to connect a new CCC to the built in cable and if the problem is still there the control board is defective. Other than finding a dealer or repair shop with Dometic board testers (I have never found any repair shop with this equipment) I know of no other way to determine which component is bad.

If your furnace does not work and you or your service shop has determined that the problem is in the control board. It is most likely the control board furnace relay. This requires replacement of the complete board which is quite expensive. If everything else on your control board works than you can just purchase an inexpensive house thermostat (less than $20), install it somewhere near the CCC and run two new wires from the furnace.

Maintenance

The principle maintenance for the furnace is to keep the burner area and the jet clean and remove any nests. At least once a year check all of the wire connections and grounds. Also check the flange seals on the outside of the RV to make sure they are properly caulked. Periodically turn on the furnace during the summer months to make sure it is working. Most campers do not use the furnace very often but when it's really needed you don't want any surprises.