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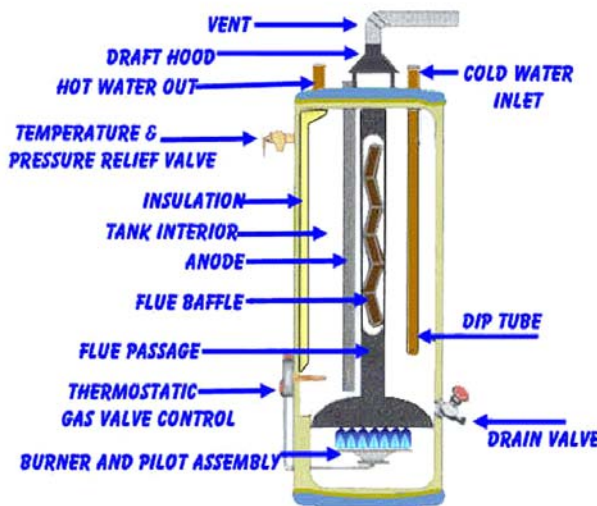
Water Heaters - Overview

Conventional gas-fired residential water heaters consist of a steel storage tank with a cold water inlet and a hot water supply outlet. They have an atmospherically fired burner at the bottom and are sometimes referred to as "under fired" water heaters. They usually have a continuous pilot.



Figure 9-1
Water Heater

- The flue passes vertically through the centre of the tank.



Breakdown of Water Heater Components

A baffle is used in the flue passage to improve heat transfer to the water. There are one or two inches of insulation between the tank and the outer jacket.

- Water heaters are equipped with a Temperature Pressure Relief Valve, known as a TPR or T&P valve. The T&P valve is a safety device



T&P Valve

activated by excess temperature or pressure conditions within the tank. It will release and spill if the pressure or water temperature reaches unsafe levels.

- An anode is a metal rod usually made of magnesium or aluminum which helps prevent corrosion of the tank. Electrolysis eats away the anode instead of the steel of the tank. Once the anode is gone however, then the tank itself will start to corrode. The anode is screwed into the top of the water heater and can be replaced if necessary.



Anode

- ◆ The dip tube directs incoming cold water down to the bottom of the tank, preventing the mixing of incoming cold water with the out- going hot water.



Dip Tube

- ◆ A combined thermostat and gas valve unit, known as a thermostatic control, controls both the temperature of the water in the tank and the gas flow. It senses when the water temperature drops below a certain point and causes the burner to come on and heat the water. When the water reaches the desired temperature it shuts off the burner. It utilizes the rod and tube method of temperature sensing, where the expansion and contraction of dissimilar metals in the sensor operate the gas valve in response to water temperature changes.



Thermostatic Control



SIT Control



Drain Valve

- ◆ The drain valve allows the water heater to be drained for various reasons including periodic removal of sediment or for replacement.

Power-Vented Gas Water Heaters



Power Vented Water Heater

- ◆ To make water heaters compatible with mid and high efficiency furnaces, gas-fired water heaters were developed with induced draft fans. They force exhaust gases either up vertically or through a sidewall plastic ABS, CPVC or PVC vent. These units retain the draft hood with its dilution air requirement and have either a hot surface ignition system or a continuous pilot.



Power Vented Water Heater

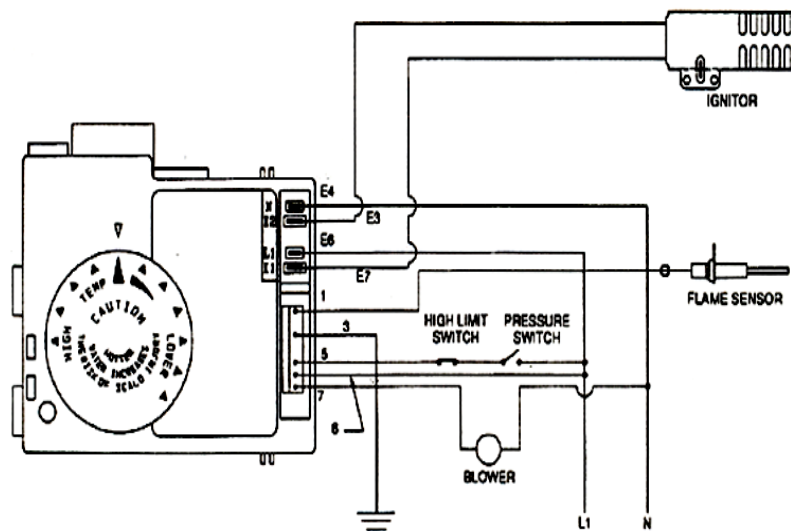
Power Vented Water Heaters

ROBERTSHAW 7222WDER SEQUENCE OF OPERATION

- When initially energized, the 7222WDER control will perform a self-diagnostic check and the red LED will momentarily flash 3-4 times.
- On a call for heat, a check is made by the control to ensure that the air pressure switch on the blower is in the open position (if closed the sequence pauses and the blower is not energized). With the air pressure switch proven open, the control energizes the blower (Terminal 7).
- With the blower energized the control checks to ensure that the air pressure switch closes. At this point the air pressure switch must close or the blower will run continuously. As the high limit switch on the blower is wired in series with the air pressure switch, both switches must be closed (energizing Terminal 5) or the blower will run continuously.
- With proven airflow and the high limit switch closed, a flame safety check is undertaken to ensure that a flame is not present prior to ignition. Providing a flame signal is not detected, the hot surface igniter is energized and a warm up period of approximately 17 seconds is initiated.
- Following the igniter warm up period, the control allows gas flow to the burner initiating a 4-second trial for ignition period. The control will normally establish a flame and maintain the flame until the call for heat is satisfied.

- If a flame cannot be established, is extinguished, or the flame signal drops below 0.7 microamps, the control will stop the flow of gas to the burner. The blower continues to be energized and a 30-second interpurge is undertaken.
- The control will attempt for ignition again. If the control cannot establish ignition after three attempts, it will lock-out. The red LED will flash continuously indicating a lock-out condition occurred. Unplugging the 120VAC-power supply to the water heater then restoring power will reset the control.

WIRING DIAGRAM



Power Vented - Troubleshooting Guide

Symptom	Possible Cause(s)	Corrective Action
Blower will not start	1. No Power to unit 2. Thermostat setting too low 3. Defective air pressure switch (must be open at start-up before blower is energized) 4. Defective blower 5. Disconnected or loose wire 6. Control locked-out	1. Plug in power cord, check fuses/supply voltage 2. Increase thermostat temperature setting 3. Replace air pressure switch 4. Replace blower 5. Repair/reconnect wires 6. Reset – determine cause of lock-out
Blower runs continuously	1. Air pressure switch not closing due to insufficient draft - check for: a) vent piping blocked b) piping length too long c) frozen vent termination d) clogged/dirty blower 2. Disconnected, torn or blocked pressure sensing tubing from air pressure switch to blower housing 3. Air pressure switch not closing due to defective switch 4. High limit switch open due to excessive vent temperature or defective switch.	1. Determine cause of insufficient draft. Check draft with manometer at pressure switch a) remove blockage b) reduce vent length/increase vent size c) clear termination of snow/ice d) clean blower wheel 2. Reconnect or replace pressure sensing tubing 3. Replace defective pressure switch 4. Determine cause of overheating check for: overfiring, insufficient air supply, high ambient air temperature, correct baffle (once activated high limit must be replaced)

Symptom	Possible Cause(s)	Corrective Action
Hot surface igniter not glowing following warm-up period	1. 120VAC polarity reversed at 120VAC outlet receptacle 2. Defective hot surface igniter 3. Defective Control	1. Reverse polarity at 120VAC outlet receptacle 2. Replace igniter (Check for 120 VAC supply to igniter across I1 & I2) 3. Replace control
Control locked-out *Continuously flashing red LED (Resettable lock-out condition)	1. No gas supply 2. Gas control in off position 3. Insufficient gas supply 4. Incorrect manifold gas pressure 5. Incorrect gas type 6. Defective igniter/loose or disconnected wire 7. Improperly positioned, dirty, or defective flame rod/loose or disconnected wire 8. Main burner orifice clogged 9. Blocked water heater flue 10. Defective control	1. Check /turn on gas supply 2. Turn control to On position 3. Ensure correct supply pressure for gas type (Nat Gas 7.0 "w.c.) (Propane 11.0 w.c) 4. Check/adjust for correct manifold gas pressure (Nat Gas 3.5 "w.c.) (Propane 10.0 w.c) 5. Ensure correct gas type for water heater model 6. Replace defective igniter/reconnect wiring 7. Reposition, clean, or replace defective flame rod/reconnect wiring 8. Remove obstruction 9. Remove blockage/clean flue 10. Replace Control
Control locked-out *Solid red LED	1. Internal control fault 2. ECO failure – excessive water temperature 3. Excessive humidity/damp environment	1. Replace control 2. Replace control 3. Allow control to dry

Plumbing Crossover

- A plumbing crossover is a condition where cold water can flow into the hot water system. Plumbing crossovers can cause “not enough hot water” complaints. This can occur through a single handle type faucet or commonly through washing machine mixing valves should either become defective. A crossover of hot and cold water can occur even though there are no visible signs present.
- Testing the plumbing system for a cross over condition is quick and simple and may prevent unnecessary dip tube replacement.
- Shut off the cold water supply valve to the water heater.
- Open a hot water faucet of a fixture that has separate hot and cold spigots.
- With the cold water to the heater isolated, water should completely stop flowing from the hot water faucet.
- If the water continues to flow and turns cold, then cold water is crossing over to the hot water plumbing system.
- To locate the cross-over, first shut off the hot and cold valves to the washer. If the water stops flowing at your hot faucet, the washing machine mixing valve is causing the cross-over.

- If the flow does not stop, then you must check, by feel, each of the feed lines to each of the single handle faucets. If you find one faucet where both feed lines are equally cold, that faucet is allowing an internal cross-over to occur and should be rebuilt or replaced.
- If none of the above resolve the cross-over, a direct cross-over exists in the plumbing somewhere. This means the hot water subsystem and the cold water subsystem are directly tied together after the hot water heater.

Conducting a Draw Test

- A residential water heater should supply 70% of the tank's capacity without the water temperature dropping more than 20 °F. For example, if the thermostat is set to 140 °F. (60 C.) the water heater should supply 70% of the tanks volume at a temperature between 120 °F. (49 C.) and 140 °F. (60 C.)
- The draw test is used to determine if the water heater is functioning properly. If the water heater passes the draw test investigate other causes such as undersized water heater, wasteful showerheads or too much demand on the heater at one time.
- If the heater does not pass the draw test look for plumbing crossovers, deteriorated, broken, or missing dip tubes or dip tubes incorrectly located on hot side, improper cold or hot water piping connection at water heater.
- To conduct a draw test, be sure the water heater thermostat(s) are satisfied and the heater is fully recovered. Using a thermometer, draw about a cup full of water from the T&P discharge tube and measure the temperature.
- This water temperature should be within 10 degrees of the thermostat setting. Since hot water rises, it may be a little more than 10 degrees hotter, this is acceptable. If it is more than 10 degrees colder than the thermostat setting, something else is wrong and that should be investigated first.

- Next, using a five gallon bucket, draw hot water from the heater at a laundry tub or bathtub. After filling the 5 gallon bucket, immediately measure the water temperature.
- Record the water temperature and pour the hot water down the drain. Now fill the bucket again, measuring and recording the temperature of the water. Continue until you have drawn 70% of the tank capacity.
- Take accurate temperature and volume measurements. The water temperature on the last bucket should be within 20 degrees of the first temperature reading. If not investigate the cause.

Tank Capacity	70% of Tank Capacity	Number of 5 gallon buckets
30	21	4 (+ 1 gallon)
40	28	5 (+ 3 gallons)
50	35	7
65	45.5	9 (+ .5 gallons)
75	52.5	10 (+ 2.5 gallons)
80	56	11 (+ 1 gallon)
100	70	14

Standard Gas Water Heater Troubleshooting Guide

Symptom	Possible Cause(s)	Corrective Action
No Hot Water	1.Pilot light out 2.Pilot light does not stay lit 3.Repeated pilot outages thermocouple gas valve ok 4.Temperature control turned off	1.Re-light pilot 2.Check/replace thermocouple gas valve 3.Check for floor drafts, check and clean flue and vent 4.Reset temperature control
Not enough hot water or water not hot enough	1.Heavy household demand for hot water 2.Temperature control set too low 3.Poor burner flame slows recovery time 3.Sediment in tank slows heater recovery time 4.Hot water faucet leaks 5.Incoming water too cold 6.Dip tube broken	2.Stagger use of hot water or have a larger water heater installed 2.Raise temperature control setting 3.Check and clean flue and vent 3.Drain and refill tank. If rate of sedimentation is high, have a water softener installed 4.Repair faucet 5.Raise temperature control setting 6.Replace
Water too hot	1.Temperature control set too high or frequent short draws of hot water cause buildup of very hot water in top of tank (stacking) 2.Temperature control faulty	1.Lower temperature control setting. Change usage pattern 2.Change Control
Relief valve leaks continuously	1.Relief valve faulty 2. Excessive pressure in supply water 3.Water at top of tank too hot	1.Replace 2.Install expansion tank 3.Stacking - change pattern use Defective control - overheating
Drain valve leaks	1.Valve loose or faulty	1.Tighten valve handle, threading, replace valve.

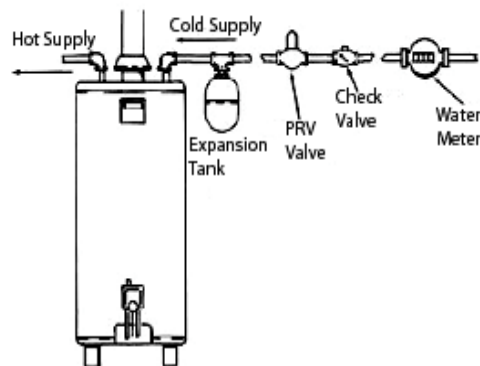
Symptom	Possible Cause(s)	Corrective Action
Rusty Hot water	1. Anode rod depleted exposing iron core 2. Water heater tank corroded 3. Galvanized steel water pipes corroded	1. Check and replace anode rod, drain and refill tank 2. Have water heater replaced 3. Have pipes replaced
Hot water smells bad	1. Magnesium anode rod reacting with sulfurous hot water	1. Replace with aluminum anode rod. Chlorinate and flush tank.
Water heater rumbling	1. Sediment in tank trapping and releasing air.	1. Drain and refill tank regularly Have water softener installed if sedimentation rate is high De-lime using vinegar
Water heater sizzles	1. Water leaks into burner chamber from leaking tank 2. Condensation through under sizing	1. Replace Tank 2. Have water heater replaced with proper size

Thermal Expansion

- The effects of thermal expansion are often noticed after hot water use followed by periods of no water use. The relief valve drips during any recovery cycle when no hot or cold water is used.
- The water in a water heating system expands when it is heated and has a greater volume. Water in a closed tank at 50 psi, when heated just 10 degrees, may reach a pressure of 250 psi.
- Many water supply systems have check valves at the water meter to prevent any possible contamination of the public water supply by the accidental back-flow of contaminated water into the supply mains. Many PRVs also act as very effective check valves. Water softeners in the system may also act as back-flow preventers.
- Follow these easy steps to diagnose thermal expansion:
- Turn the heater thermostat all the way down, and install a water pressure gauge with dead hand on the drain valve. Open the drain valve, so the gauge reads system pressure. Open a hot water tap and allow 15% to 20% of the tanks volume to run out. Shut off the drain valve and make sure that no other fixture in the system, hot or cold, is open. Make sure that outside fixtures, if they are on the same system, are turned off too. Any water leaks or use will make the test meaningless.
- Check the water pressure gauge, and turn the pointer so it lines up with the pressure-indicating needle.



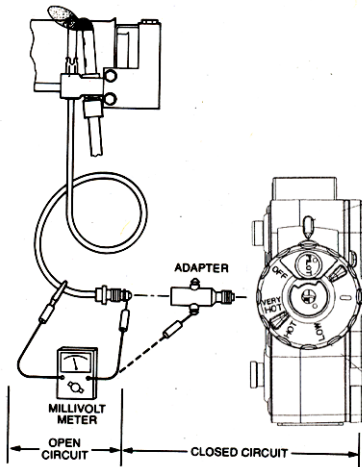
- Turn the thermostat back up to its normal position, so the heater cycles on. Watch the pressure gauge.
- If the system is closed, the pressure will start to climb steadily and rapidly. A small amount of thermal expansion control may be built into the system because of trapped air pockets or a water hammer arrestor. In that case the pressure will increase slightly, hold steady for a short time and then rapidly increase. The temperature and pressure relief valve (T&P) should open and release water once the pressure reaches the maximum setting on the valve. The valve will close once the pressure falls below the pressure setting of the valve.
- The ideal fix involves the use of a pressure-reducing valve if supply pressures are above 60 to 70 psi, and a properly sized expansion tank. The PRV reduces supply pressures to 40 to 60 psi allowing an economically priced and sized expansion tank to be used.
- The PRV is installed between the check valve and the water heating system.
- The expansion tank is installed between the PRV and the water heating system. Follow the manufacturers instructions for installing the expansion tank.



Testing Thermocouples and Gas Control Valves

- **Open Circuit Test:** An open circuit test determines the full voltage output from a thermocouple. The range for a single thermocouple should be approximately 20-30 millivolts. The millivolt meter should be set for the lower scale (e.g. 0-50 M.V.) One lead is attached to the thermocouple's lead, the other to the thermocouple's terminal adaptor.

- **Closed Circuit Test:** The closed circuit test determines the voltage drop across the gas control's coil and indicates if the coil is adequately energized to hold the gas control valve in the open position. For a single thermocouple the voltage drop across the coil should be approximately 10-15 millivolts, one half of the open circuit test.



- In a closed circuit test, the thermocouple is under a load condition since power is being supplied to the gas control coil. A reading substantially below the normal expected value would indicate that the thermocouple has a high internal resistance and should be replaced. A reading substantially above the normal expected value would indicate that the coil has a high operating resistance and may need to be replaced.
- **Drop Out and Response Test:** The drop out test determines the minimum voltage drop across the coil that will just hold it in. It is conducted the same way as a close circuit test having the same millivolt meter application. However, in this test the pilot flame is turned off and the thermocouple is allowed to slowly de-energize the gas control valve coil allowing it to drop out. For a normal coil and single thermocouple, this is approximately 2-4 millivolts.

Pictures



Ensuring draft hood air inlets are free of debris and obstructions



Measuring draft at blower with electronic manometer



Ensuring blower is free of dirt and dust build up



Anode rod at new, partially depleted, and completely depleted stage.



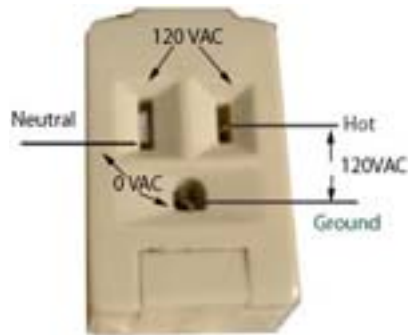
Checking for correct manifold
gas pressure



Cold and hot water inlets. Double
lining on cold indicating presence of
dip tub



Sliding cover up to obtain voltage readings



Ensuring correct polarity at outlet



Robertshaw WDER Gas Control



Baffle out of correct positioning



Correct Baffle positioning



Checking air switch operation with Ohmmeter



Measuring draft at blower with electronic manometer



Deteriorated dip tub



Measuring flame signal



Burner assembly showing correct flame rod positioning