



COMMERCIAL ELECTRIC ENERGY SAVER WATER HEATER MII SERIES

IMMERSION AND SURFACE MOUNTED
THERMOSTAT MODELS



SERVICE MANUAL

Troubleshooting Guide
and Instructions for Service

(To be performed ONLY by
qualified service providers)

Models Covered by This Manual:

MII50(A)-*-**-(SF,CF,SCF)-***
MII80(A)-*-**-(SF,CF,SCF)-***
MII120(A)-*-**-(SF,CF,SCF)-***

*Denotes kW Rating

**Denotes Warranty Years

***Denotes Wiring Code

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Introduction

This service manual is designed to aid service and maintenance professionals on the function, proper diagnosis and repair of Bradford White Commercial Electric Water Heaters.

The text and illustrations in this manual provide step by step instructions to facilitate proper operation and troubleshooting procedures. Contact the Bradford White Technical Support Group immediately if diagnosis can not be made using the methods described in this service manual.

Tools

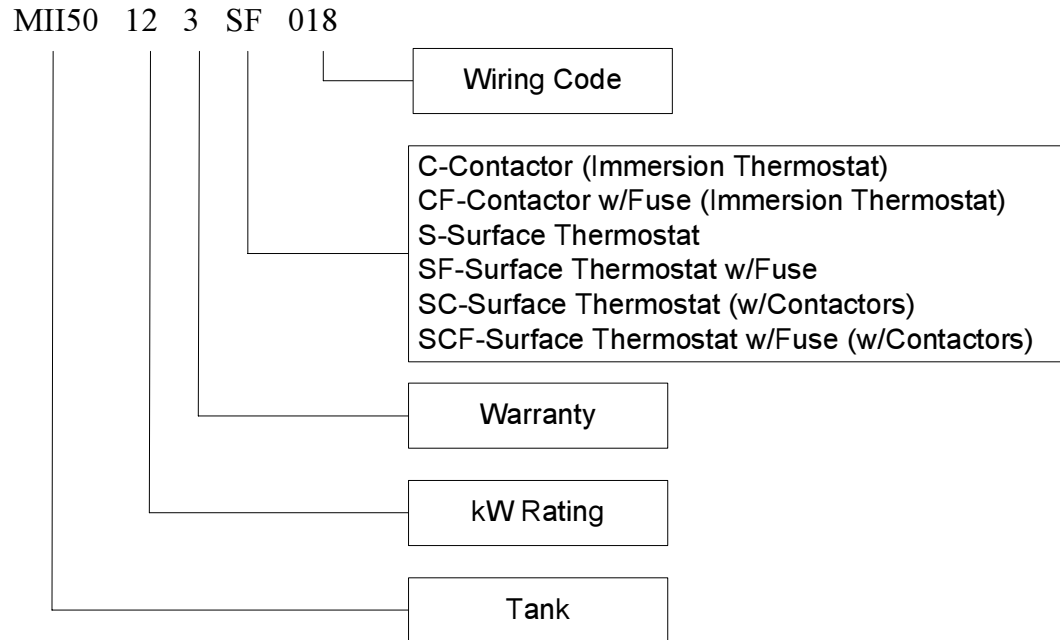
- Multi Meter.
- 1-½" Deep Well Socket.
- 1-1/16" Deep Well Socket.
- ¼" Nut Driver.
- Phillips Head Screw Driver.
- Common Screw driver.
- Thermometer.
- Drain Hose.

- Other Hand Tools: Pipe Wrench, Channel Locks, Pliers (common & needle nose), Wire cutters, Wire Strippers, Allen Wrench Set, Flash Light.

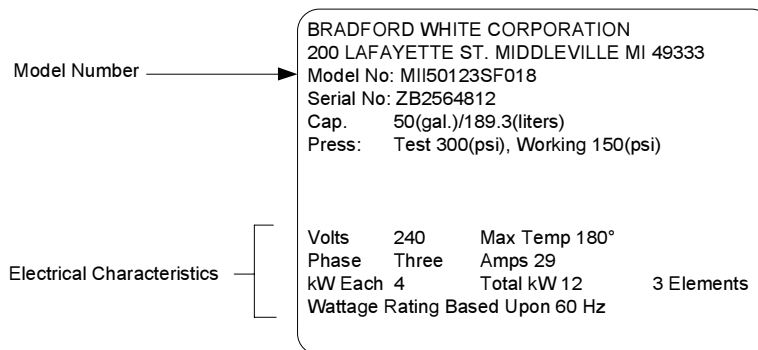
Bradford White MII Series Commercial Electric water heaters can be manufactured with a choice between two different types of thermostat control options as follows:

Surface Mounted Thermostats.
Immersion Thermostat (contactor models).

The model number is coded to identify the specific thermostat control system used for a particular unit. Below is typical model number and coded definitions:

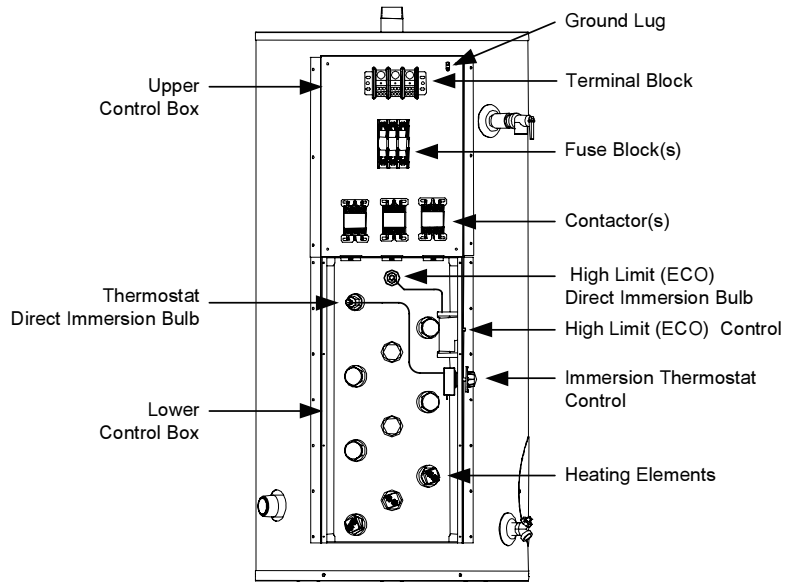


The wiring code at the end of the model number is used at the factory to facilitate proper construction based on the electrical characteristics such as voltage, phase, kW rating and amp draw. In the field this information is determined from the heaters rating plate located on the front of the water heater.

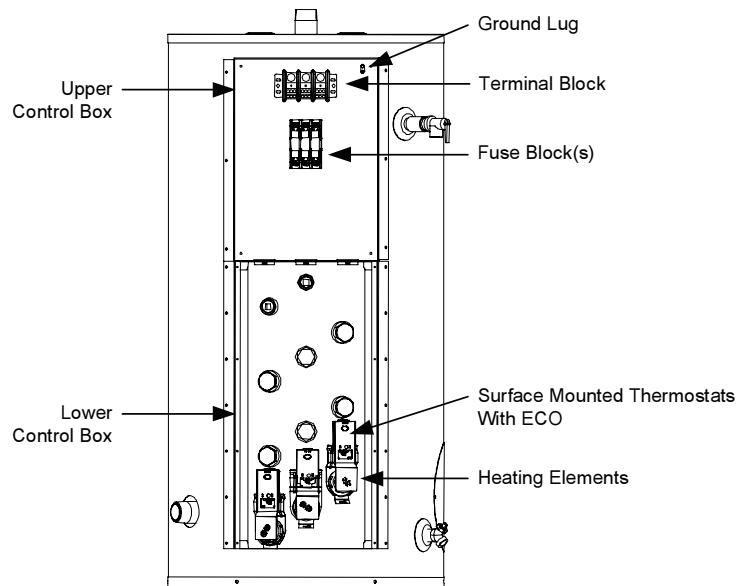


Typical Rating Plate
Located On Front Of Water Heater

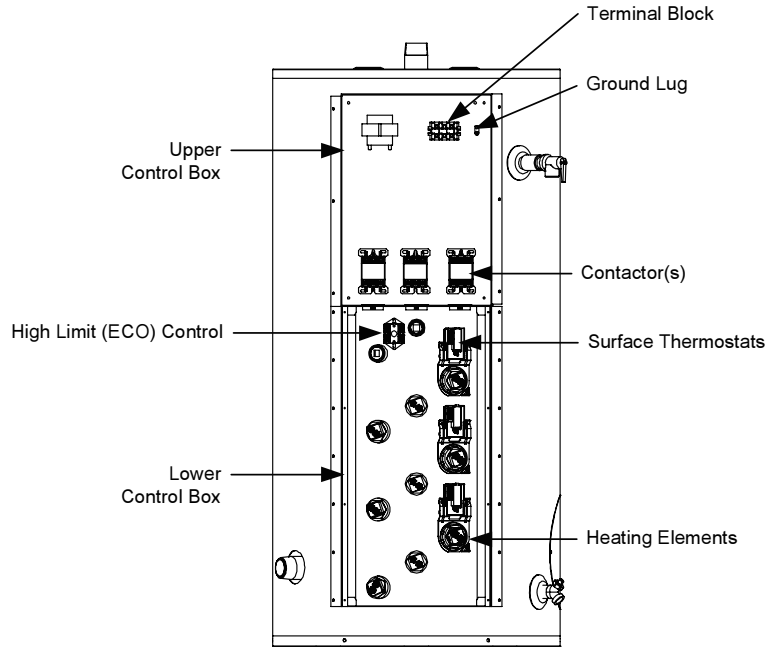
**Contactor Models
General Controls Layout**



**Surface Mounted Thermostat Models
General Controls Layout**

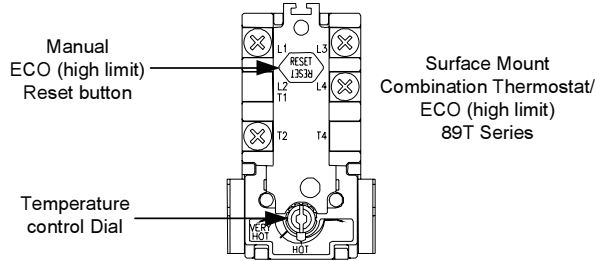


600V Surface Thermostat (w/Contactors) Models General Controls Layout



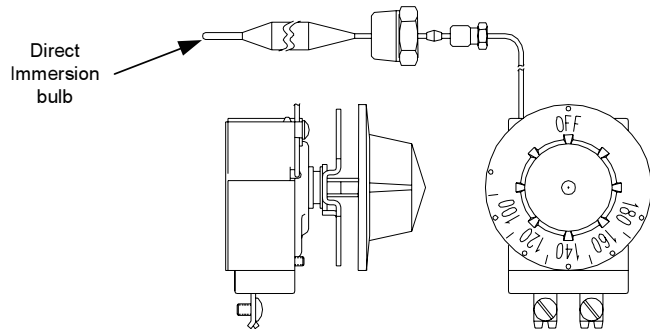
Surface Mounted Thermostats

Surface mounted thermostats are mounted into a bracket above each heating element. The bracket holds the thermostat against the side of the tank responding to tank surface temperatures to sense a call for heat, set point temperature and high limit (ECO) activation. As each element has a dedicated thermostat (for all models excluding 600V), it is possible to sequence the elements by varying the settings on the thermostats.



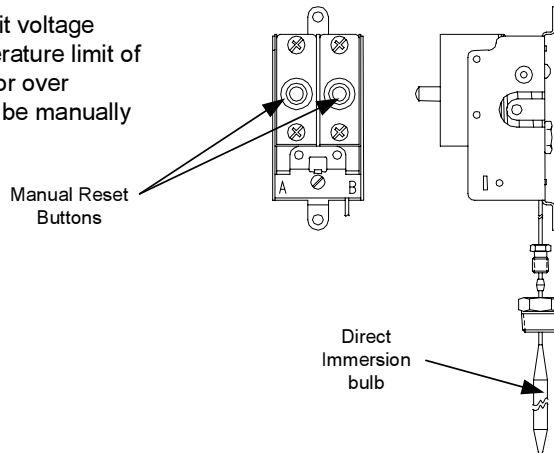
Immersion Style Thermostat Control for Contactor Models

The thermostat will complete control circuit voltage upon a call for heat. Likewise, the control will interrupt control circuit voltage when the water temperature is sufficient to satisfy the adjustable temperature limit of control.



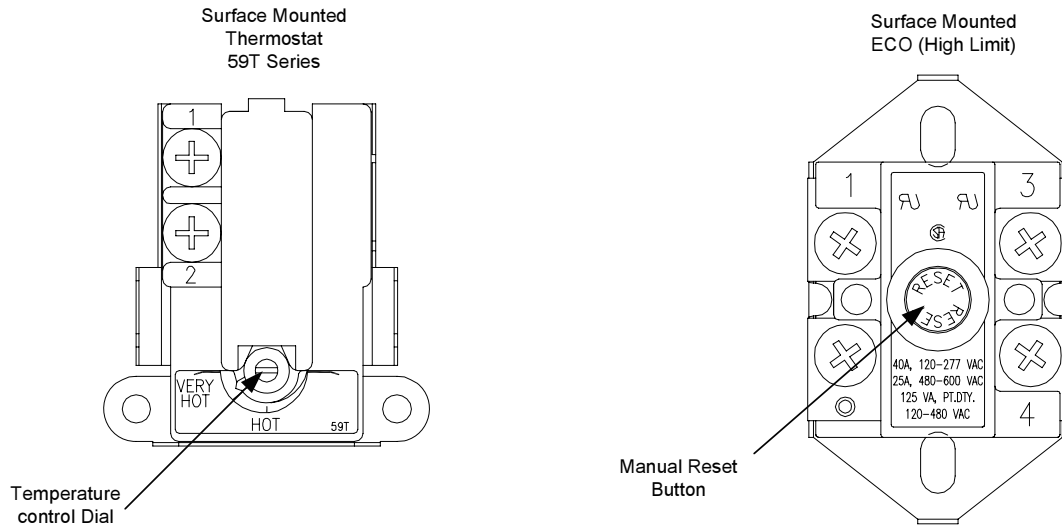
Immersion Style High Limit (ECO) Control for Contactor Models

The high limit (ECO) control will interrupt control circuit voltage causing the heater to shut down when the high temperature limit of the control is reached (196°F±4°F). Once the cause for over heated water has been determined, The control must be manually reset to restore normal operation.



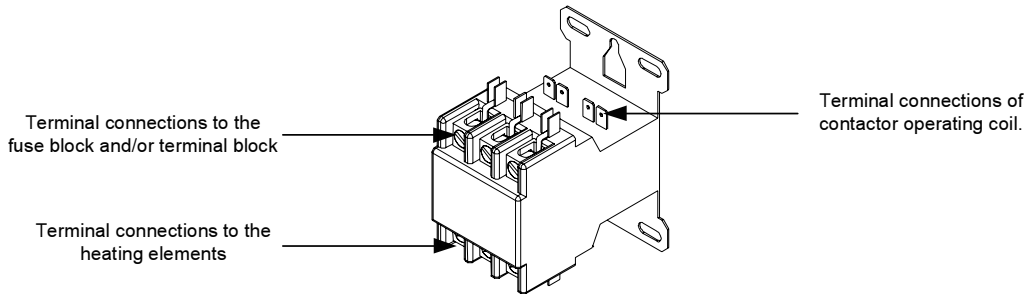
Surface Mounted Thermostats (w/Contactors) for 600V Models

600V models use contactors to deliver line voltage to the heating elements. However, rather than the immersion type high limit and thermostat devices, surface mounted thermostats are used to operate the control circuit of the water heater.

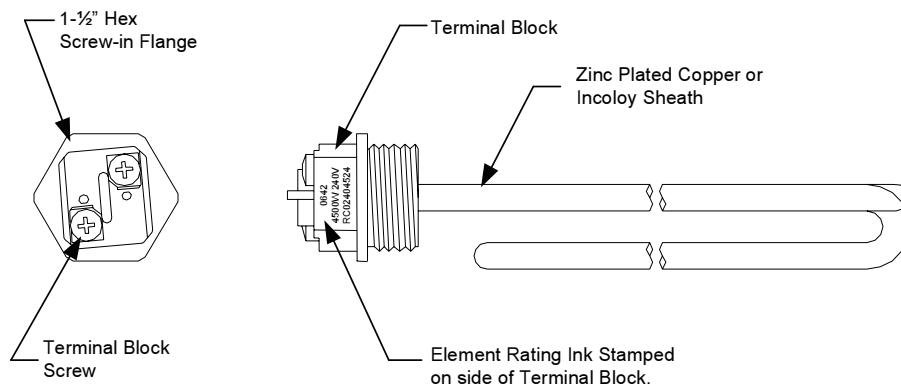


Contactors

Contactors operation is achieved by energizing an operating coil in response to a call for heat from the immersion thermostat. Upon a call for heat, one or more contactors will energize all heating elements simultaneously. The operating coils are voltage specific, When contactor replacement is required be sure to order the proper operating coil base on the voltage rating found on the rating plate located on the front of the water heater.



Direct Immersion “Screw-in” Type Heating Element



Commonly Used Formulas

(Single phase)

$$\text{Amps} = \frac{\text{Watts}}{\text{Volts}}$$

(balanced 3 phase)

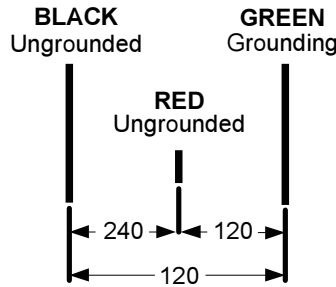
$$\text{Amps} = \frac{\text{Watts}}{\text{Volts} \times 1.732}$$

Watts = Amps x Volts

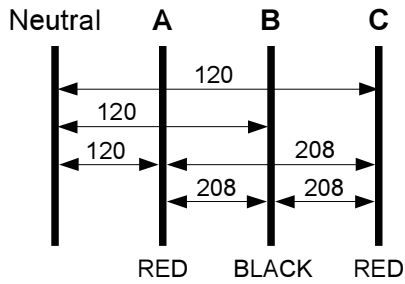
$$\text{Ohms} = \frac{\text{Volts}^2}{\text{Watts}}$$

Common Service Wire Configurations

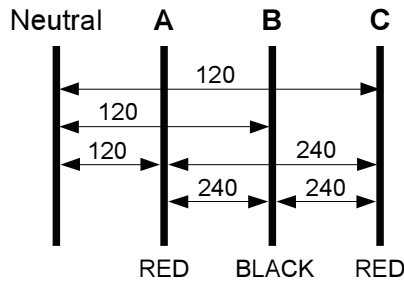
240V 1Ph



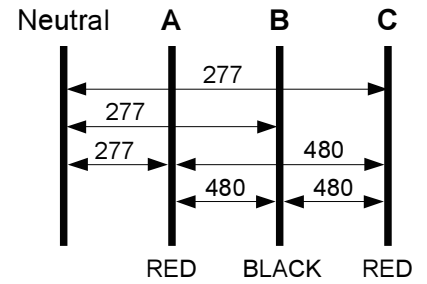
208 3Ph



240 3Ph



480 3Ph/277 1Ph



Full Load Current Amps

kW	208 Volt		240 Volt		277 Volt	380 Volt	415 Volt	480 Volt		600 Volt
	1 Ph	3 Ph	1 Ph	3 Ph	1 Ph	3 Ph	3 Ph	1 Ph	3 Ph	3 Ph
6	28.8	16.6	25.0	14.4	21.6	9.1	8.3	12.5	7.2	5.8
9	43.2	25.0	37.2	21.6	32.4	13.6	12.5	18.7	10.8	8.7
12	57.6	33.3	50.0	28.9	43.3	18.2	16.7	25.0	14.4	11.5
13.5	64.9	37.5	56.2	32.5	48.7	20.5	18.8	28.1	16.2	13.0
15	72.1	41.6	62.5	36.1	54.1	22.7	20.9	31.2	18.0	14.4
18	86.5	50.0	75.0	43.4	64.0	27.3	25.0	37.5	21.6	17.3
24	115.4	66.7	100.0	57.8	86.6	36.4	33.4	50.0	28.9	23.1
27	129.8	75.0	112.5	65.0	97.4	41.0	37.5	56.2	32.5	26.0
30	144.2	83.3	125.0	72.2	108.3	45.6	41.7	62.5	36.1	28.9
36	173.0	100.0	150.0	86.7	129.9	54.7	50.1	75.0	43.3	34.6
45	216.3	125.0	187.5	108.3	162.4	68.4	62.6	93.7	54.1	43.3
54	259.6	150.0	225.0	130.0	194.9	82.0	75.1	112.5	65.0	52.0

MII Series Commercial Electric Water Heaters can use either **immersion thermostat** (contactor models) or **surface mounted thermostats**. Sequence of operation for each configuration is explained below. It would be impractical to show all wire diagrams applicable to both configurations. A "typical wiring diagram" is illustrated to aid in understanding the principles of the operating sequence.

Immersion Thermostat (Contactor Models): Configured to use a single immersion thermostat to control one or more contactors to energize or de-energize all elements simultaneously. In addition, a separate high limit (ECO) control with manual reset is wired in series with the thermostat. Both controls use a direct immersion bulb inserted into the tank to sense water temperature. Immersion thermostat and high limit control are mounted to provide temperature adjustment and manual reset access from the exterior of the unit.

Surface Mounted Thermostats: Surface mounted thermostats are mounted inside the lower control box, in a bracket above each heating element. The bracket holds the thermostat against the side of the tank responding to tank surface temperatures to sense a call for heat, set point temperature and high limit (ECO) activation. As each element is controlled by a dedicated thermostat, it is possible to sequence the elements by varying the settings on the thermostat. However, 600V models w/ surface mounted thermostats operate contactors in the same manner as an immersion thermostat model, only using surface thermostats to sense the call for heat.

Sequence of operation for each system is explained below.

**Sequence of Operation:
Immersion Thermostat (Contactor Models).**

The system has two distinct circuits.

1. Power circuit (shown solid line).
2. Control Circuit (shown dotted line).

1 Line voltage is applied across terminals of fuse block or a terminal block. Line voltage continues down and connects to terminals L1, L2 & L3 of one or more contactors.

A) Contactor is open (no call for heat), so there is no voltage across terminal T1, T2 & T3 of contactor.

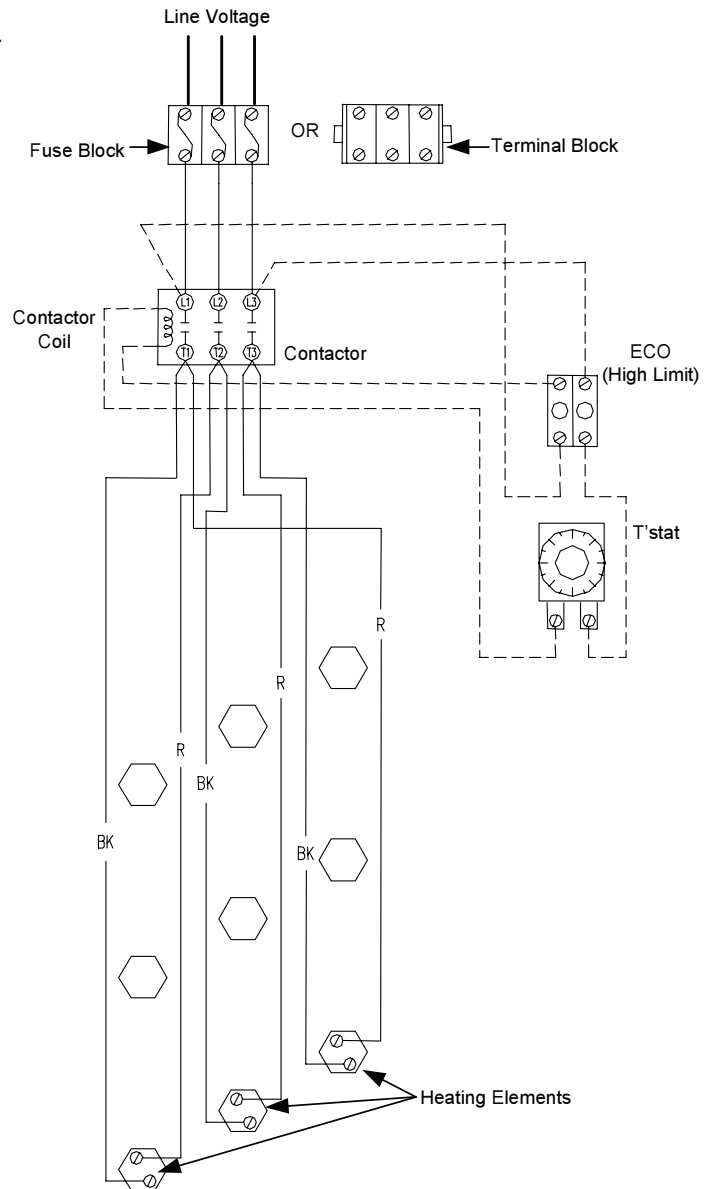
B) The contactor is controlled by the control circuit consisting of the immersion thermostat, ECO (hi limit) and contactor coil.

2 When the thermostat calls for heat, contacts close inside the thermostat completing the circuit through the ECO and energizing the contactor coil.

3 The energized contactor coil causes the contactor to close energizing the elements from terminals T1, T2 & T3 of the contactor.

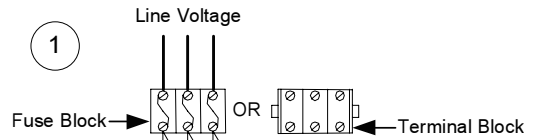
4 When the temperature setting of the thermostat is reached, the contacts in the thermostat open. This interrupts current flow through the control circuit de-energizing the contactor coil.

5 The de-energized contactor coil causes the contactor to open, interrupting current flow through the elements. The heater is now in stand-by waiting for the next call for heat.

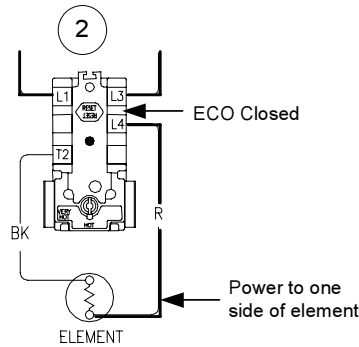


**Sequence of Operation:
Surface Mounted Thermostats.**

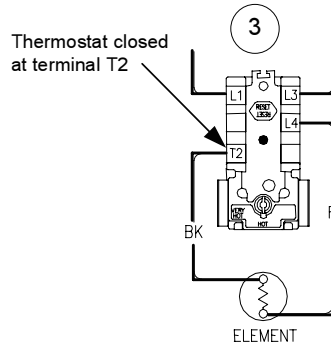
1 Line voltage is applied across terminals of fuse block or a terminal block. Line voltage continues down and connects to surface mounted thermostats at terminals L1 & L3.



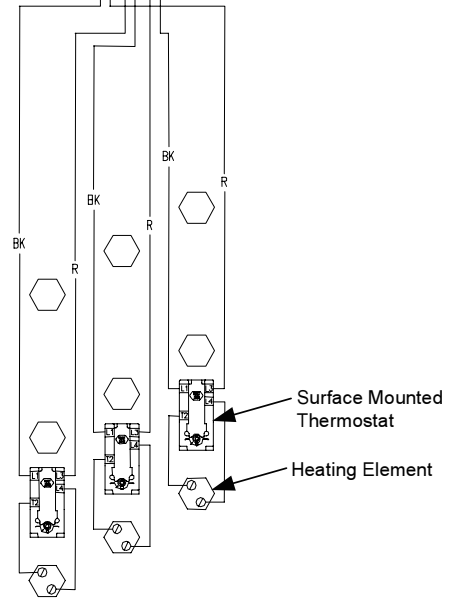
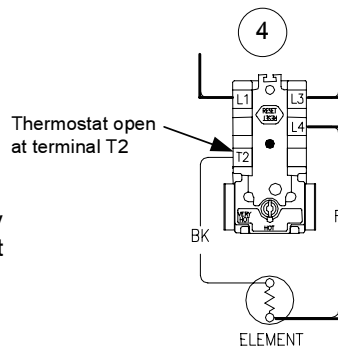
2 ECO (high limit) in thermostat is closed, so there is line voltage present at terminal L4 of thermostats and to one side of each element.



3 Water in tank is cold, so all thermostats are closed at terminal T2 (calling For heat). This completes the circuit and allows current to flow through heating elements.



4 As each thermostat is satisfied, it opens at terminal T2 interrupting current flow through the respective element. The system is now in stand-by mode, waiting for the next call for heat.

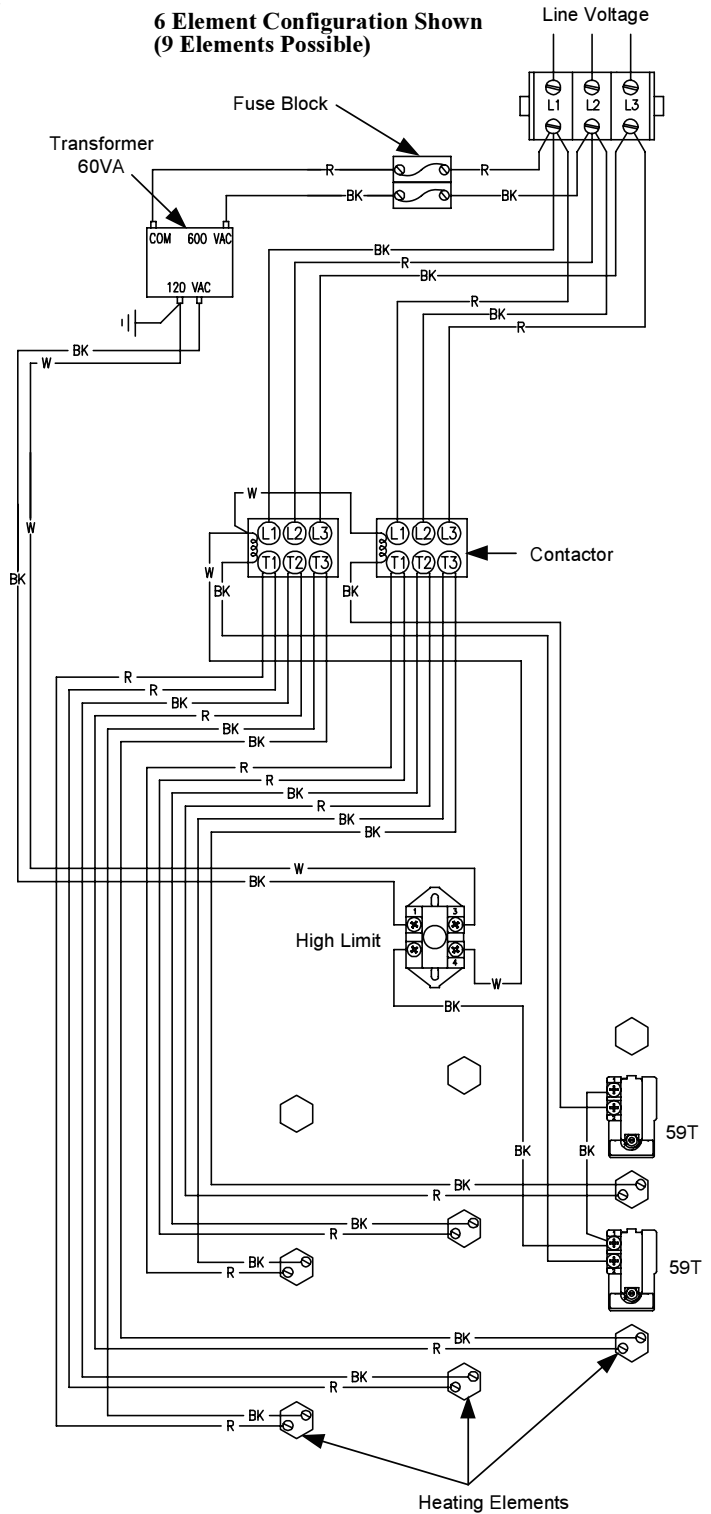


**Sequence of Operation:
600V Surface Mounted Thermostats (w/Contactors).**

The system has two distinct circuits.

1. Power circuit - Line Voltage (600V)
2. Control Circuit - 120V

- 1 Line voltage is applied across terminals of fuse block or a terminal block. Line voltage continues down and connects to terminals L1, L2 & L3 of one or more contactors.
- A) Contactor is open (no call for heat), so there is no voltage across terminal T1, T2 & T3 of contactor.
- B) The contactor is controlled by the control circuit consisting of the surface mounted thermostat, ECO (hi limit) and contactor coil.
- 2 When the thermostat calls for heat, contacts close inside the thermostat completing the circuit through the ECO and energizing the contactor coil.
- 3 The energized contactor coil causes the contactor to close, energizing the elements from terminals T1, T2 & T3 of the contactor.
- 4 When the temperature setting of the thermostat is reached, the contacts in the thermostat open. This interrupts current flow through the control circuit de-energizing the contactor coil.
- 5 The de-energized contactor coil causes the contactor to open, interrupting current flow through the elements. The heater is now in stand-by waiting for the next call for heat.
- 6 Notice in the wiring diagram at right that each row of elements is equipped with a surface mounted thermostat on the highest element in the row. These thermostats are individually wired in series to the contactor whose line voltage corresponds to the same row of elements. Each thermostat and contactor combination are wired to the high limit (ECO) device in parallel. This allows for each row of elements to be powered "ON" independent of the other element rows. However, the high limit (ECO) is wired in series so that voltage can be interrupted to the entire control circuit if the ECO senses that the tank water has become overheated.



Most common cause for improper electric water heater operation can be linked to heating element failure.

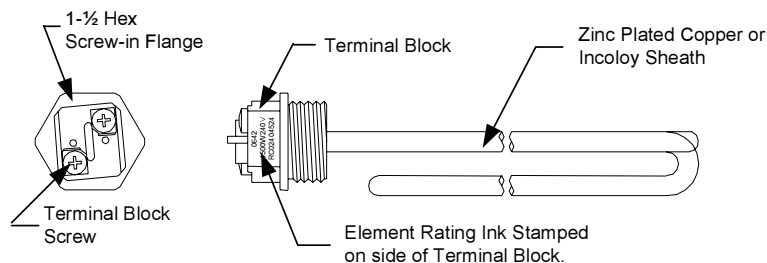
When troubleshooting an electric water heater with the incidence of “No Hot Water” or “Insufficient Amount of Hot Water” It is always a good idea to check the heating elements first following the procedure on page 15.

Common Heating Element Failures Are:

1. **Dry Firing.** Elements may be partially submerged in water or most likely, completely exposed with no water in the tank at all. In open air, an energized element (*Dry Fired*) will become completely inoperable within seconds. In some cases sediment or lime build up around an element can eventually cause an air pocket, resulting in a dry fired element. When element replacement is required, be sure tank is full of water prior to energizing the water heater.
2. **Grounded Element.** In most cases, an element with a short circuit to ground will cause the circuit breaker in the service panel to open or shut off. In some cases there may not be enough current draw for the circuit breaker to open. This will allow the heating element to be in continuous operation resulting in over heated water, limited only by the ECO or Energy Cut Off located in the thermostat circuit. Repeated actuation of the ECO usually is the result of a grounded heating element.
3. **Sediment build up.** Slow hot water recovery can usually be traced back to sediment or lime build up around heating element. Sediment build up can also over time cause a dry fired element.

If a heating element is found to be inoperative, it must be replaced. Follow service procedure MCE-XV on page 30.

The illustration below shows a common “Screw-In” type heating element identifying certain features commonly referred to throughout this manual.



**Typical Direct Immersion “Screw-In”
Type Heating Element**

Quick Step Plan to Hot Water

1. **STOP, DANGER! Turn power "OFF" to water heater.**
2. Check all wire connections to insure they are snug and corrosion free.
3. Reset high limit (ECO) (page 18-20).
4. Check for inoperative heating element (page 15).
5. Check line voltage (pg 16), and internal fuses (page 17).
6. Refer to table below if items 1 through 5 above do not correct problem.

▲ WARNING
High voltage exposure. Use caution when making voltage checks to avoid hazard to life or property.

<u>SYMPTOM</u>	<u>PROBABLE CAUSE</u>	<u>CORRECTIVE ACTION</u>	<u>SERVICE PROCEDURE</u>
No Hot Water	<ol style="list-style-type: none"> 1. No power to heater. 2. Blown water heater fuses. 3. Loose wire connections. 4. Inoperative heating elements. 5. Inoperative thermostat(s). 6. Open ECO. 7. Inoperative contactor(s). 	<ol style="list-style-type: none"> 1. Check circuit breakers at service panel. 2. Check water heater fuses. 3. Check all wire connections. 4. Check heating element(s). 5. Check thermostat(s) operation. 6. Reset (check) ECO. 7. Check contactor operation. 	<ol style="list-style-type: none"> 2. MCE-III, Page 17 4. MCE-I, Page 15. 5. MCE-VII-IX, Page 21-23. 6. MCE-IV-VI, Page 18-20. 7. MCE-X, Page 24,25
Not Enough Hot Water or Continues Operation	<ol style="list-style-type: none"> 1. Inoperative heating element. 2. Sediment or lime build up on element(s). 3. Thermostat(s) set to low. 4. Inoperative thermostat(s). 5. Inoperative contactor(s). 6. Loose wire connection. 7. High demand period. 8. Undersized heater. 9. Very cold inlet water to heater. 10. Plumbing connections reversed. 	<ol style="list-style-type: none"> 1. Check heating element(s). 2. Clean or replace heating element(s) 3. Increase thermostat setting. 4. Check thermostat(s). 5. Check contactor operation. 6. Check all wire connection. 7. Reduce demand. 8. Replace with larger heater. 9. Temper water to heater. 10. Correct plumbing connections. 	<ol style="list-style-type: none"> 1. MCE-I, Page 15. 2. MCE-XV, Page 30. 4. MCE-VII-IX, Page 21-23. 5. MCE-X, Page 24,25
Slow Hot Water Recovery	<ol style="list-style-type: none"> 1. Sediment or lime build up on element(s). 2. Loose wire connections. 3. Inoperative thermostat(s). 4. Inoperative contactor(s). 5. Derated heating element installed. 	<ol style="list-style-type: none"> 1. Clean or replace heating elements. 2. Check all wire connections. 3. Check thermostat(s). 4. Check contactor operation. 5. Verify element voltage and wattage rating. 	<ol style="list-style-type: none"> 1. MCE-XV, Page 30. 3. MCE-VII-IX, Page 21-23. 4. MCE-X, Page 24-25 5. See page 8.
Over Heated Water	<ol style="list-style-type: none"> 1. Surface thermostat(s) not flush with tank. 2. Grounded heating element(s). 3. Thermostat set to high. 4. Inoperative thermostat(s). 5. Inoperative ECO. 	<ol style="list-style-type: none"> 1. Check surface thermostat(s) mounting. 2. Check heating element(s). 3. Adjust thermostat(s) to desired setting. 4. Check thermostat(s). 5. Check ECO. 	<ol style="list-style-type: none"> 1. MCE-XI, Page 26. 2. MCE-I, Page 15. 4. MCE-VII-IX, Page 21-23. 5. MCE-IV-VI, Page 18-20.
Noisy (singing or hissing) Elements	<ol style="list-style-type: none"> 1. Lime formation on elements. 2. High or low line voltage. 	<ol style="list-style-type: none"> 1. Clean or replace heating elements. 2. Verify line voltage to heater. 	<ol style="list-style-type: none"> 1. MCE-XV, Page 30. 2. MCE-II, Page 16.
Noisy Contactor	<ol style="list-style-type: none"> 1. Low line voltage. 2. Debris between contactor plates. 3. Incorrect or defective operating coil. 4. Loose wire connections. 	<ol style="list-style-type: none"> 1. Verify line voltage to heater 2. Replace contactor. 3. Replace contactor. 4. Check wire connections. 	<ol style="list-style-type: none"> 1. MCE-II, Page 16

Test for Open or Burned Out Element.

1. **STOP, DANGER! Turn power "OFF" to water heater.**
2. Remove access cover from lower control box.
Remove insulation from inside of control box.
3. Disconnect wires from heating element.
4. Set multi-meter to "ohms" setting.
5. Touch probes of multi-meter to screw terminals of heating element (see illustration 1).
6. Reading should be 12.8 ohms (±6%) for a 240 volt, 4500 watt element, see table below for other elements.

$$\text{Ohms} = \frac{\text{Volts}^2}{\text{Watts}}$$

A reading outside the range using the formula above (±6%), indicates a bad element and the element must be replaced.

**Ohms of electrical Resistance
For commonly Used Elements**

Element Wattage	<u>Voltage Rating of Element</u>		
	<u>208</u>	<u>240</u>	<u>480</u>
2000	21.6	28.8	115.2
3000	14.4	19.2	76.8
4000	10.8	14.4	57.6
4500	9.6	12.8	51.2
5000	8.7	11.5	46.1
6000	7.2	9.6	38.4

**Test For Grounded Heating Element
(damaged heating element with short circuit to ground).**

1. **STOP, DANGER! Turn power "OFF" to water heater.**
2. Remove access cover from lower control box.
Remove insulation from inside of control box.
3. Disconnect wires from heating element.
4. Set multi-meter to "ohms" setting.
5. Touch one probe of multi-meter to either screw terminal of heating element and the other on the element flange (see illustration 2). There should be no reading on the ohm meter. Any reading indicates a grounded element and the element must be replaced. Repeat this step for the other screw terminal.

▲ DANGER
High voltage exposure. To avoid hazard to Life or property, be sure power is turned OFF to water heater while performing this procedure.

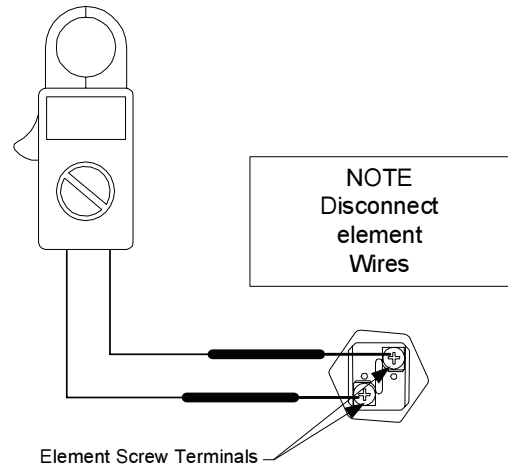


Illustration 1

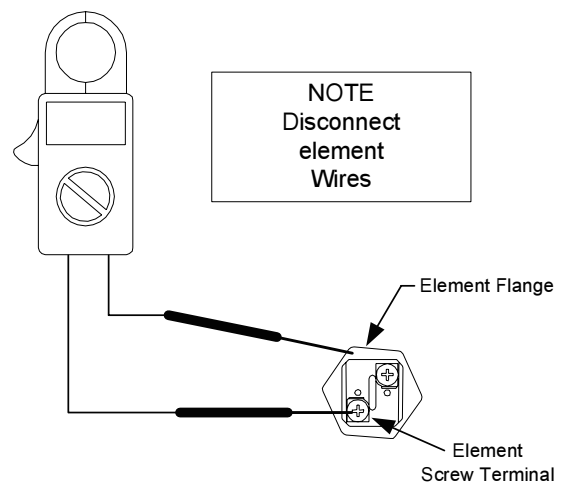


Illustration 2

Line Voltage Testing

Line voltage (single phase or three phase) will connect to a terminal block or directly to a fuse block located inside control panel.

⚠ DANGER
High voltage exposure. To avoid hazard to life or property use extreme caution when making voltage checks .

Determine heaters voltage and phase by referring to the rating plate located on the front of the heater. Apply the appropriate phase procedure below to determine if proper line voltage is present.

Single Phase Line Voltage Testing

1. **STOP, DANGER! Turn power "OFF" to water heater.**
2. Open upper control panel door.
3. Determine connection point for line voltage from service panel, **terminal block** or **fuse block**
4. Set multi-meter to volts AC. Be sure to scale meter for appropriate voltage.
5. Use caution and turn power "ON" to water heater.
6. Use caution and check voltage across top terminals where service voltage connects to water heater. (see illustration 3).
 - A) Rated voltage IS present, power to the water heater is okay.
 - B) Rated voltage NOT present, Check service panel.

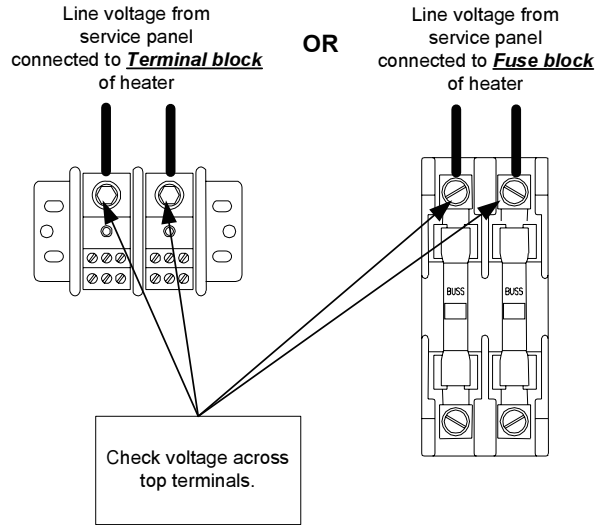


Illustration 3

Three Phase Line Voltage Testing

1. **STOP, DANGER! Turn power "OFF" to water heater.**
2. Open upper control panel door.
3. Determine connection point for line voltage from service panel, **terminal block** or **fuse block**
4. Set multi-meter to volts AC. Be sure to scale meter for appropriate voltage.
5. Use caution and turn power "ON" to water heater.
6. Use caution and check voltage across top terminals where service voltage connects to water heater. (see illustration 4).
 - A) Rated voltage IS present, power to the water heater is okay.
 - B) Rated voltage NOT present, Check service panel.

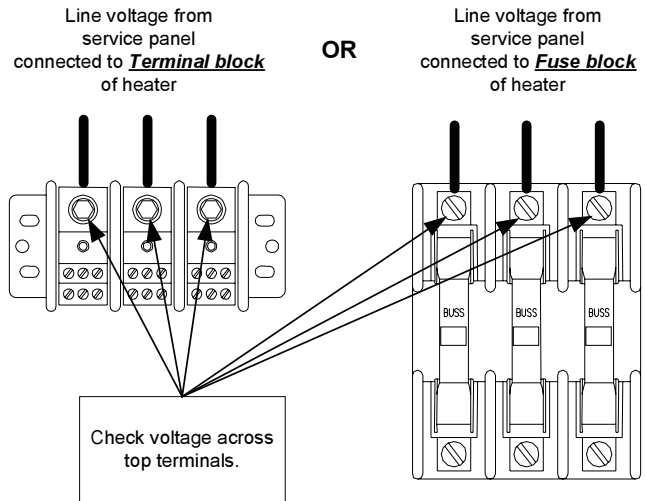


Illustration 4

Fuse Testing

1. Turn "OFF" power to water heater.
2. Open upper control box to allow access to fuse block.
3. Locate fuse block and remove fuses.
4. Set multi-meter to the "Ohms" setting.
5. Check continuity across fuse (see illustration 5).
 - A) Continuity IS present, fuse is okay.
 - B) Continuity NOT present, Replace with new fuse

⚠ DANGER
High voltage exposure. To avoid hazard to Life or property, be sure power is turned OFF to water heater while performing this procedure.

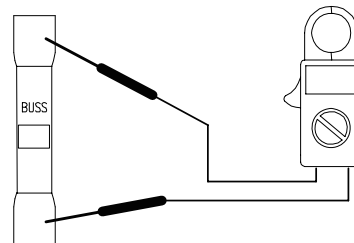


Illustration 5

**High Limit Control (ECO) Testing for
Surface Thermostat models (not including 600V)**

⚠ DANGER
**High voltage exposure. To avoid hazard to
life or property use extreme caution when
making voltage checks .**

1. This procedure assumes line voltage and fuses are in working order.
2. This procedure illustrates testing of just one surface thermostat. Repeat this procedure for all surface thermostats on the unit.
3. Turn power "OFF" to water heater.
4. Remove lower control box cover and remove insulation from inside of control box.
5. Remove plastic cover from thermostat(s).
6. Turn power "ON" to water heater.
7. Check voltage across terminals L1 & L4 for all thermostats (see illustration 6).

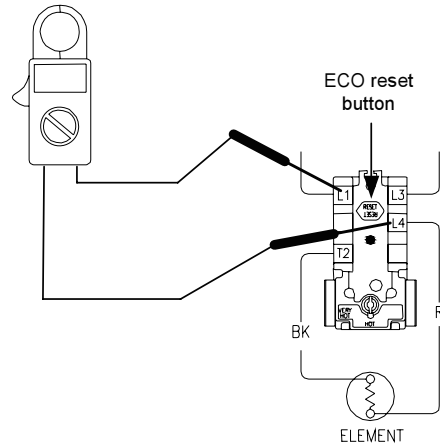


Illustration 6

- A) Rated Voltage IS present, ECO is okay.
 - B) Rated voltage NOT present, proceed to step 8.
8. Turn power "OFF" to water heater and firmly press ECO reset button on thermostat(s). Turn power "ON" to water heater and recheck voltage across terminals L1 & L4 of thermostat(s).
 - A) Rated voltage IS present, the ECO has previously opened indicating the water in the tank, at some point did overheat, Check the following:
 1. Thermostat must be in full contact with tank.
 2. Be sure heating element(s) is not shorted to ground (see page 15).
 3. Proper thermostat operation (see page 21).
 - B) Rated voltage NOT present, water in tank may be over heated.
 1. If water is overheated, turn "OFF" power to water heater and flow water through tank to cool below set point of upper thermostat. Reset ECO and recheck voltage.
 2. If water is cool, Replace thermostat(s).

**High Limit Control (ECO) Testing for
600V Surface Thermostat Models**

1. This procedure assumes line voltage, transformer, fuses, and thermostat are in working order.
2. Turn power "OFF" to water heater.
3. Remove lower control box cover and remove insulation from inside of control box.
4. Check for continuity across terminals 1 & 2.
(see illustration 7)
 - A) Continuity IS present, ECO is okay.
 - B) Continuity NOT present, proceed to step 5.
5. Verify power to the water heater is "OFF", firmly press the ECO reset button. Recheck continuity across terminals 1 & 2
(see illustration 7).
 - A) Continuity IS present, the ECO has previously opened indicating the water in the tank, at some point did overheat, Check the following:
 1. Thermostat must be in full contact with tank.
 2. Be sure heating element(s) is not shorted to ground (see page 15).
 3. Proper thermostat operation (see page 22).
 - B) Continuity NOT present, water in tank may be over heated.
 1. If water is overheated, verify that power to water heater is "OFF". Flow water through the tank to cool below set point of upper thermostat. Reset ECO and recheck continuity.
 2. If water is cool, Replace ECO (High Limit).

⚠ DANGER
High voltage exposure. To avoid hazard to life or property use extreme caution when making voltage checks .

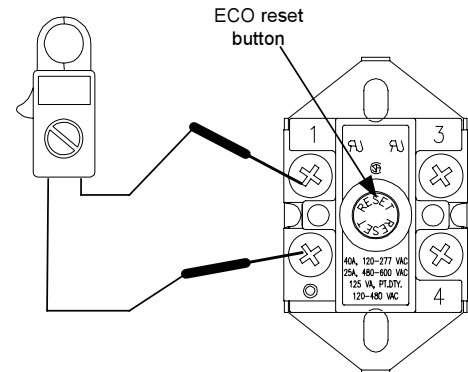


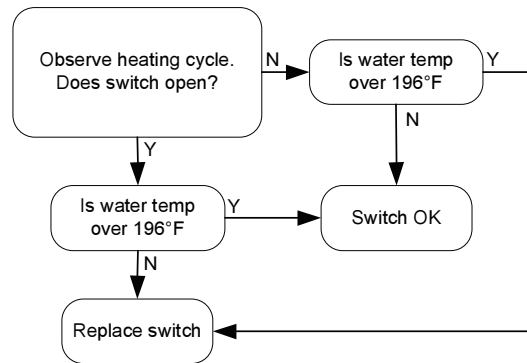
Illustration 7

**High Limit Control (ECO) Testing for
Contactor Models**

Switch Contacts:

Normally closed.
Open on rise @ 196°F ±4°F
Manual Reset.

1. Determine if Hi-Limit has actuated. This can be done by simply depressing the reset buttons. If you hear and/or feel a small click, the switch has actuated.
2. Use caution and turn power on to water heater and observe heating cycle following the Hi-Limit Heating Cycle flow chart.

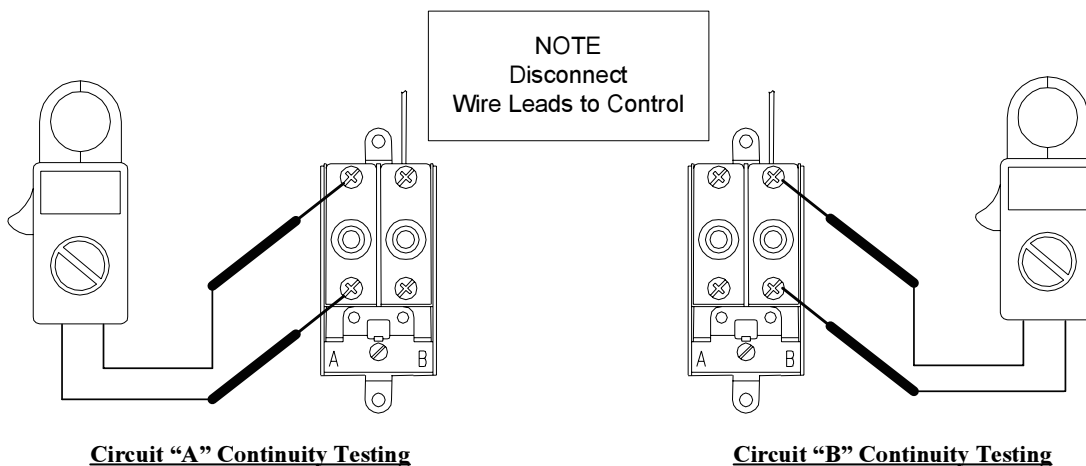


High Limit Heating Cycle Flow Chart

**High Limit Control Continuity Testing for
Contactor Models**

1. **STOP, DANGER! Turn power “OFF” to water heater.**
2. Water temperature must be below 196°F ±4°F
3. Remove Hi-Limit switch from control panel. It is not necessary to remove immersion bulb from tank at this time. See general controls layout on page 4 for location.
4. Disconnect wire leads to Hi-Limit Control during this test.
5. Depress reset buttons to insure switch contacts are closed.
6. Set multi-meter to Ohms setting, Check continuity Thru circuit A & B as shown in the illustrations below.
 - Continuity **IS** present, Switch is okay.
 - Continuity **NOT** present, Replace switch.

⚠ DANGER
High voltage exposure. To avoid hazard to Life or property, be sure power is turned OFF to water heater while performing this procedure.



Surface Mounted Thermostat.
Operation Testing (not including 600V models)

⚠ DANGER
High voltage exposure. To avoid hazard to life or property, use extreme caution when making voltage checks .

Water In Tank Is Cold With Power ON.

1. This procedure assumes line voltage, ECO and elements are in working order.

2. TURN OFF POWER TO WATER HEATER.

3. Remove access cover from lower control box. Remove insulation from inside of control box. Remove plastic cover from thermostat.

4. Turn power "ON" to water heater.

5. Set multi-meter to "Volts AC".

6. Check across terminals L1 & L3 of thermostat (see illustration 8)

- A) Rated voltage NOT present, Check fuses and or line voltage.
- B) Rated voltage IS present, proceed to next step.

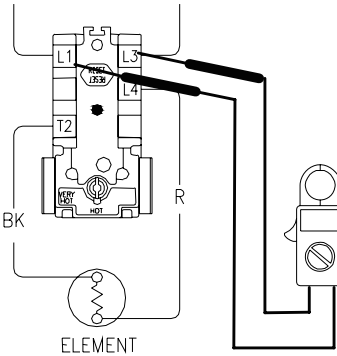


Illustration 8

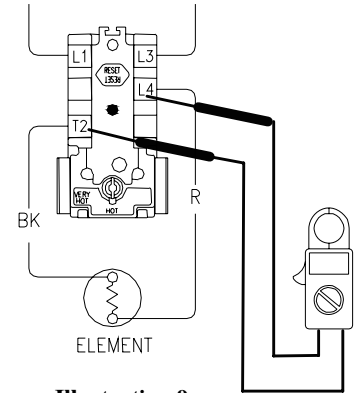


Illustration 9

7. Check across terminals L4 and T2 of thermostat (see illustration 9).

- A) Rated voltage NOT present, Recheck ECO. If ECO is okay, replace thermostat.
- B) Rated voltage IS present, okay, thermostat is calling for heat, go to next step.

8. Check across element terminals (see illustration 10).

- A) Rated voltage NOT present, check wire connections from thermostat to element.
- B) Rated voltage IS present, Repeat element testing, see page 15.

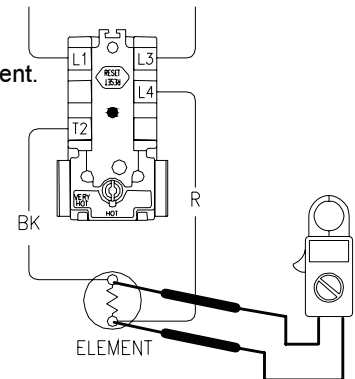


Illustration 10

Water Temperature In Tank Is Above Thermostat Setting.

1. This procedure assumes line voltage, ECO and elements are in working order.

2. Turn power "ON" to water heater.

3. Set multi-meter to "Volts AC".

4. See illustration 9 above, check across terminals L4 and T2 of thermostat.

- A) Rated voltage IS present, replace thermostat.
- B) Rated voltage NOT present, thermostat is okay.
- C) Lower than rated voltage IS present, recheck for grounded element (see page 15).

**600V Surface Mounted Thermostat Models.
Operation Testing**

Water In Tank Is Cold With Power ON.

1. This procedure assumes line voltage, ECO, transformer thermostat, and elements are in working order.
2. **TURN OFF POWER TO WATER HEATER.**
3. Remove access cover from lower control box.
Remove insulation from inside of control box.
4. Using a phillips head screw driver, disconnect the wire lead at terminal 2 of the thermostat. Only check one thermostat at a time to insure wires are correctly reinstalled upon completion. Mark wires if necessary for reinstallation.
5. Set multi-meter to check continuity.
6. Check continuity across terminals 1 & 2 of thermostat (see illustration 11).
 - A) Continuity NOT present, replace thermostat.
 - B) Continuity IS present, thermostat is okay.

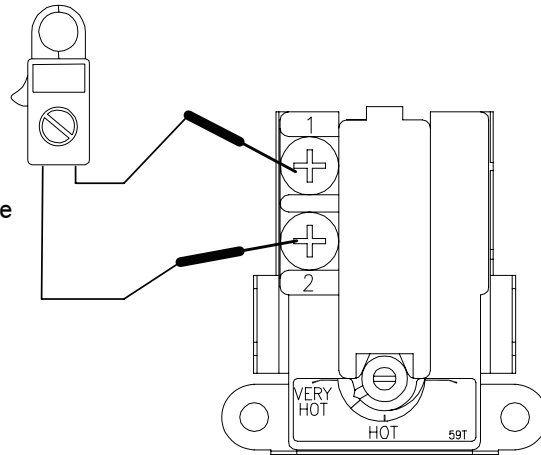
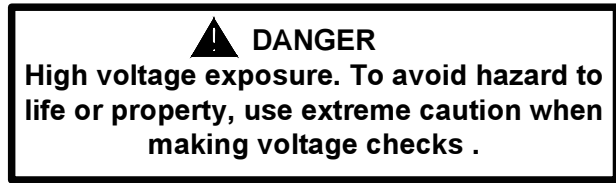


Illustration 11

Water Temperature In Tank Is Above Thermostat Setting.

1. This procedure assumes line voltage, ECO, thermostat, transformer, and elements are in working order.
2. **TURN OFF POWER TO WATER HEATER.**
3. Remove access cover from lower control box.
Remove insulation from inside of control box.
4. Using a phillips head screw driver, disconnect the wire lead at terminal 2 of the thermostat. Only check one thermostat at a time to insure wires are correctly reinstalled upon completion. Mark wires if necessary for reinstallation.
5. Set multi-meter to check continuity.
6. See illustration 11 above, check across terminals 1 & 2 of thermostat.
 - A) Continuity IS present, replace thermostat.
 - B) Continuity NOT present, thermostat is okay.

Immersion Thermostat Operation Testing

Thermostat Specification:

Calibration: 184°F/176°F
Max Differential: 6°F
Operating Range 80 to 180°F

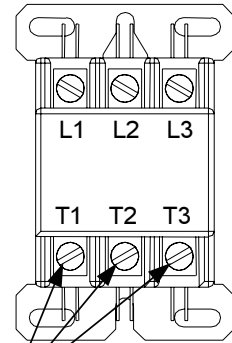
▲ DANGER
High voltage exposure. To avoid hazard to life or property use extreme caution when making voltage checks .

Providing the water temperature in tank is within the operating range of the thermostat, checking thermostat operation can be as simple as rotating the thermostat dial and listening to the contactor(s) to see if they respond to a call for heat.

Use caution and turn Power "ON" and rotate the thermostat dial to call for heat. With water temperature below the thermostat setting, the contactor(s) close. With the contacts closed, use caution and check for rated voltage across lower terminals of contactor(s) (see illustration 12), If rated voltage is present, the thermostat is calling for heat.

Rotate thermostat dial to the minimum setting. With water temperature above the thermostat setting the contactor(s) will open. With the contacts open, voltage should not be present at lower terminals of contactor(s).

Follow the procedure below If preliminary testing above does not verify thermostat operation.



Check voltage across lower terminals of contactor(s) **Illustration 12**

Thermostat Control Continuity Testing.

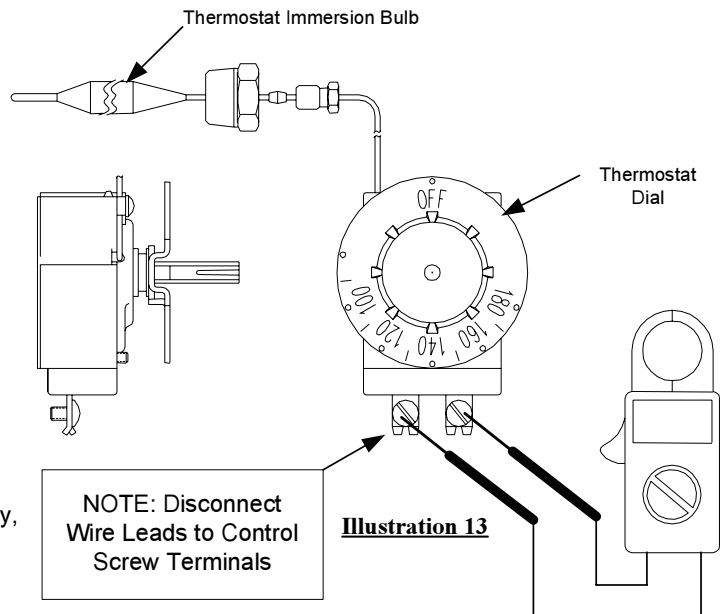
1. This procedure assumes line voltage, ECO and contactor(s) are in working order.
2. **STOP, DANGER! Turn power "OFF" to water heater.**
3. Remove lower control box cover and insulation.
4. Locate thermostat control (see general controls layout on page 4) and remove wire leads to control screw terminals.
5. Water temperature in tank must be within operating range of thermostat for this test. If above or below, it will be necessary to drain tank and remove thermostat immersion bulb from tank to warm or cool the bulb to be within operating range of thermostat.

6. Set multi-meter to the "Ohms" setting.
7. Rotate thermostat dial to highest setting.
8. Check across screw terminals of control (see illustration 13).

- A) Continuity IS present, okay, Go to step 9.
- B) Continuity NOT present, replace thermostat.

9. Rotate thermostat dial to lowest setting.
10. Check across screw terminals of control (see illustration 13).

- A) Continuity NOT present, thermostat is okay,
- B) Continuity IS present, replace thermostat.



Contactor Operation Testing

▲ DANGER
High voltage exposure. To avoid hazard to life or property, use extreme caution when making voltage checks .

Noisy Contactor

Noisy or chattering contactor operation in most cases is due to voltage variations being supplied to the water heater. Extended periods of voltage variations will cause damage to the operating coil of the contactor causing noisy operation. Determine that service voltage to the unit meets the electrical requirements per the rating plate located on the front of the water heater.

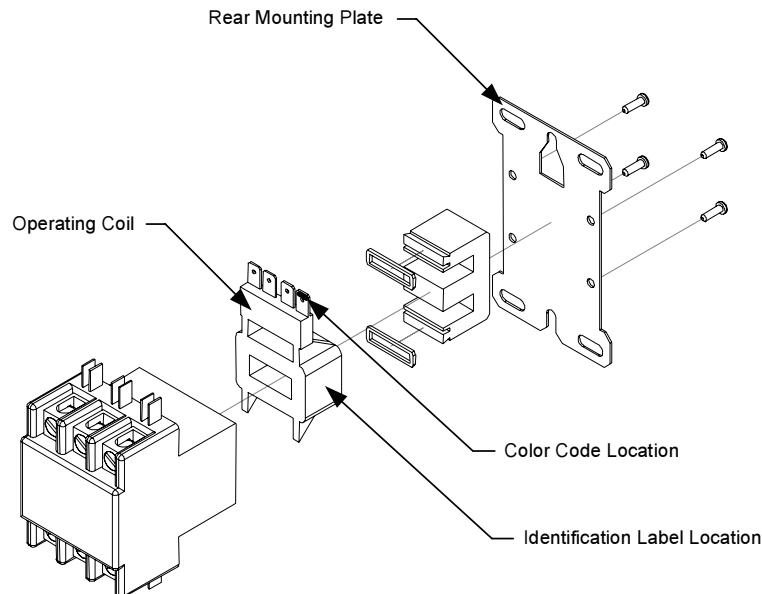
In addition, debris between the contact plates will cause noisy operation.

Contactor Operating Coils

Contactor operation is achieved by energizing an operating coil in response to a call for heat from the thermostat. There are three different operating coils used depending on voltage rating of the water heater as follows:

<u>Description</u>	<u>Color Code</u>
208/240 Volt Coil	Green
277 Volt Coil	Blue
480 Volt Coil	Black

All the coils have a color code for visual conformation. In addition, the 277 & 480 volt coils are labeled with voltage rating for proper identification. All contactors supplied for replacement are equipped with The 208/240 volt operating coil. By removing the rear mounting plate of the contactor, the operating coils can be changed based on desired service voltage. When contactor replacement is required be sure to order the proper operating coil base on the voltage rating found on the rating plate located on the front of the water heater.



Contactor Operation Testing (continued)

This procedure assumes control circuit is operating correctly.

Providing the water temperature in tank is within the operating range of the thermostat, checking contactor operation can be as simple as rotating the thermostat dial and listening to the contactor(s) to see if they respond to a call for heat.

1. Turn Power "ON" and rotate thermostat dial to the maximum setting, with water temperature in tank below the thermostat setting, the contactor(s) will close. With the contacts closed, check for line voltage across operating coil terminals (see illustration 14).

A) Line voltage IS present, okay, go to step 2.

B) Line voltage NOT present, verify control circuit operation.

2. Check for rated voltage across lower terminals of contactor(s) (see illustration 15).

A) Rated voltage IS present, okay, go to step 3.

B) Rated voltage NOT present, replace contactor.

3. Rotate thermostat dial to the minimum setting. With water temperature in tank above thermostat setting, the contactor(s) will open. With the contacts open, voltage should not be present at lower terminals of contactor(s).

4. Check for line voltage across operating coil terminals (see illustration 14).

A) Line voltage IS present, verify control circuit operation.

B) Line voltage NOT present, okay go to step 5.

5. Check for rated voltage across lower terminals of contactor(s) (see illustration 15).

A) Rated voltage IS present, replace contactor.

B) Rated voltage NOT present, contactor is okay.

▲ DANGER
High voltage exposure. To avoid hazard to life or property, use extreme caution when making voltage checks .

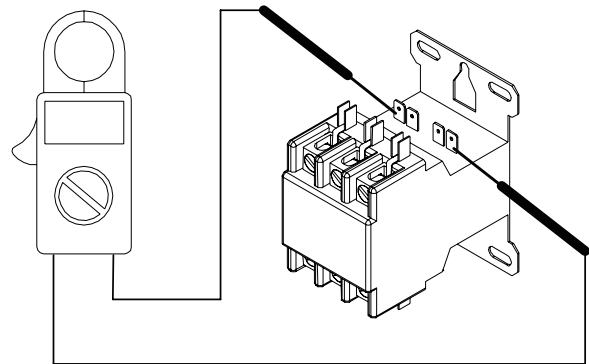
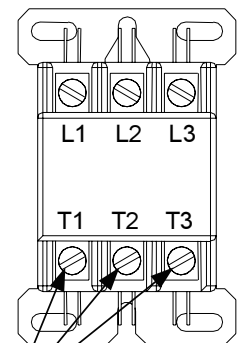


Illustration 14



Check voltage across lower terminals of contactor(s)

Illustration 15

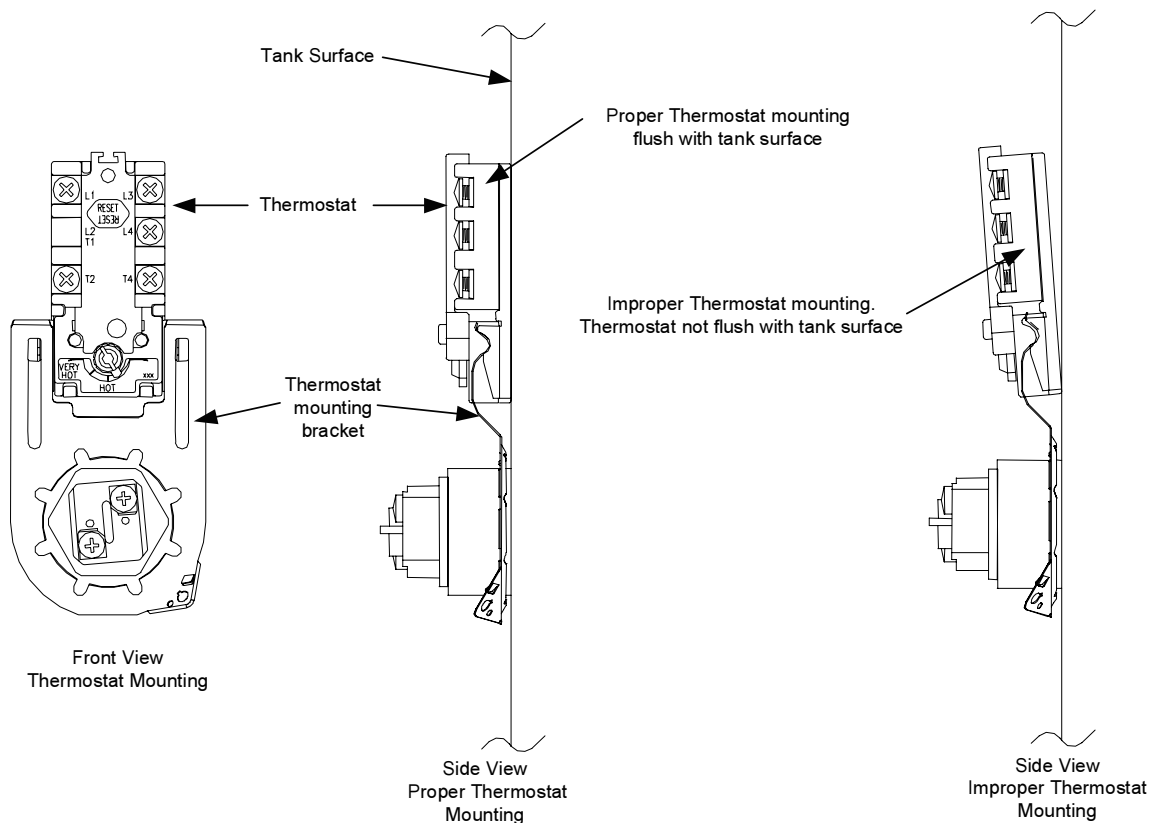
Surface Mounted Thermostat Removal

1. STOP, DANGER! Turn power "OFF" to water heater.
2. Remove access cover from lower control box.
Remove insulation from inside of control box.
Remove plastic cover from thermostat.
3. Disconnect wires from thermostat terminals. It may be necessary to label wires for proper re-connection to new thermostat.
4. Note thermostat temperature setting for proper setting of new thermostat.
5. Slide thermostat upwards and out of mounting bracket.

▲ DANGER
High voltage exposure. To avoid hazard to Life or property, be sure power is turned OFF to water heater while performing this procedure.

Surface Mounted Thermostat Replacement

1. Use a stiff brush to remove any debris or loose scale from tank surface where new thermostat will be installed.
2. Slide new thermostat down into thermostat bracket until it snaps into place. IMPORTANT! Thermostat must set completely flat or flush to tank surface. An improperly installed thermostat will cause improper water heater operation.
3. Refer to the wire diagram located on the inside of the upper control box cover and re-connect wires to the thermostat. Be sure wire connections are snug and corrosion free. Do not over tighten, doing so may damage thermostat.
4. Set thermostat to the original thermostat setting found on the old thermostat.
5. Restore power to water heater and verify proper heater operation.



Immersion Thermostat Removal & Replacement

1. **STOP, DANGER!** Turn power "OFF" to water heater.
2. Turn off cold water supply to heater. Connect hose to drain spigot of water heater and route to an open drain. Open a nearby hot water faucet to vent heater for draining. Open drain spigot of water heater and allow heater to drain to a point below the Immersion bulb location (see illustration 16).
3. Close drain spigot and remove hose.
4. Remove lower control box cover and insulation.
5. Locate thermostat inside lower control box mounted to the right side of the box, below the ECO control (see illustration 16).
6. Follow copper capillary tube from thermostat to the immersion bulb location and remove immersion bulb from tank, 11/16 wrench.
7. Remove (pull) thermostat control dial from stem of thermostat.
8. Remove the two thermostat mounting screw screws located under thermostat dial (see illustration 16).
9. Once thermostat is removed, disconnect wire leads to the thermostat. **NOTE:** It may be necessary to identify wires for proper reconnection to new thermostat.
10. Refer to wiring diagram located on the inside of the upper control box cover and properly reconnect wire leads to new thermostat and remount control inside control box using screws from step 8.
11. Replace control dial to stem of thermostat.
12. Loosen ferrule nut of immersion bulb. (see illustration 17)

▲ DANGER
High voltage exposure. To avoid hazard to Life or property, be sure power is turned OFF to water heater while performing this procedure.

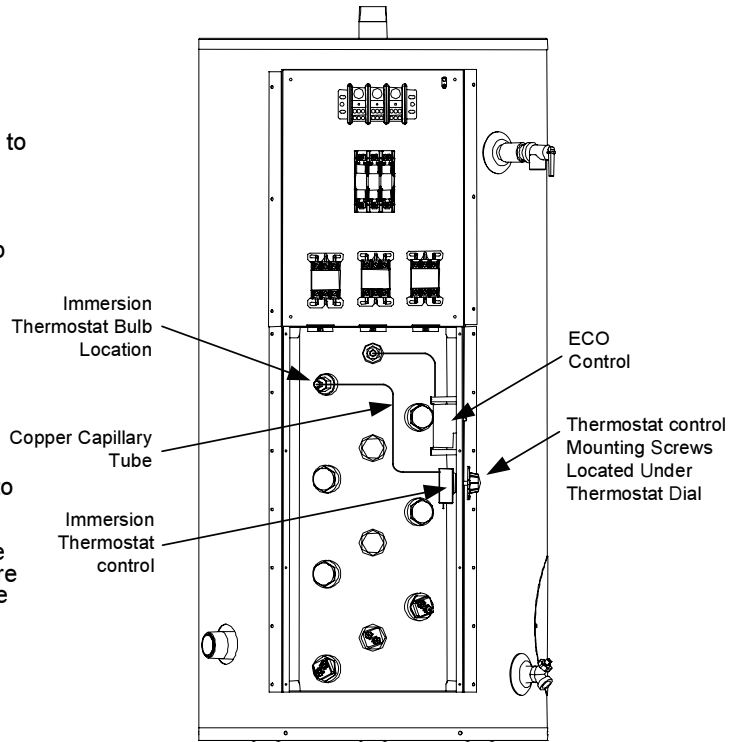


Illustration 16

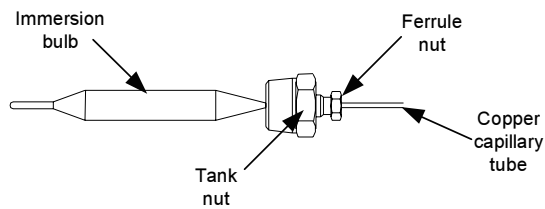


Illustration 17

13. Position tank nut at end of immersion bulb as shown in illustration 17. Insert immersion bulb into tank and tighten tank nut.
14. Gently pull copper capillary tube to insure the immersion bulb is in a horizontal position as shown in illustration 17 and tighten ferrule nut.
15. Resume water supply, fill tank and check for leaks.
16. Be sure tank is full of water and resume power supply to water heater. Verify proper thermostat operation.

**Contactor Model High Limit (ECO) Control
 Removal and Replacement**

1. **STOP, DANGER!** Turn power “OFF” to water heater.
2. Turn off cold water supply to heater. Connect hose to drain spigot of water heater and route to an open drain. Open a nearby hot water faucet to vent heater for draining. Open drain spigot of water heater and allow heater to drain to a point below the Immersion bulb location (see illustration 18).
3. Close drain spigot and remove hose.
4. Remove lower control box cover and insulation.
5. Locate ECO control inside lower control box mounted to the right side of the box, above the thermostat control (see illustration 18).
6. Follow copper capillary tube from ECO control to the immersion bulb location and remove immersion bulb from tank, 11/16 wrench.
7. Remove the two ECO control mounting screws located outside the lower control box.
8. Once ECO control is removed, disconnect wire leads to the control. NOTE: It may be necessary to identify wires for proper reconnection to new control.
9. Refer to wiring diagram located on the inside of the upper control box cover and properly reconnect wire leads to new ECO control and remount control inside control box using screws from step 7.
10. Loosen ferrule nut of immersion bulb. (see illustration 19)

▲ DANGER
**High voltage exposure. To avoid hazard to
 Life or property, be sure power is turned
 OFF to water heater while performing this
 procedure.**

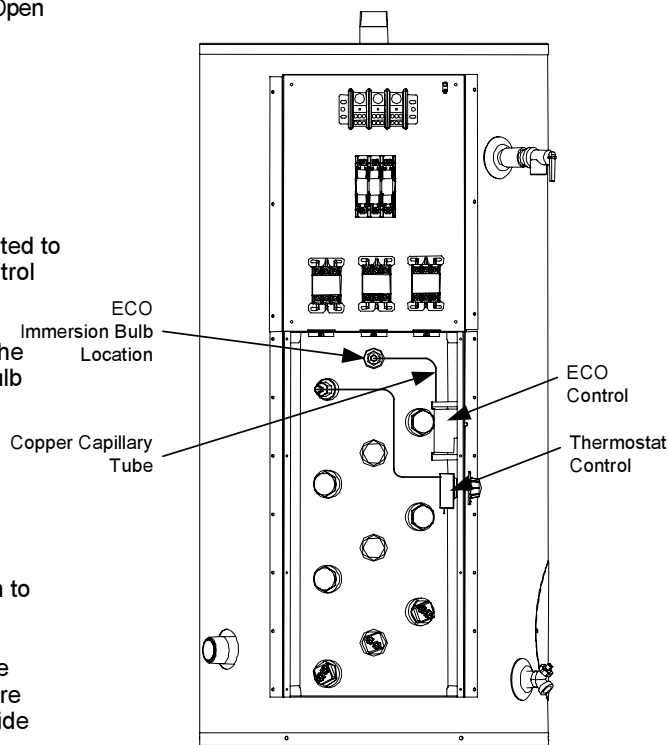


Illustration 18

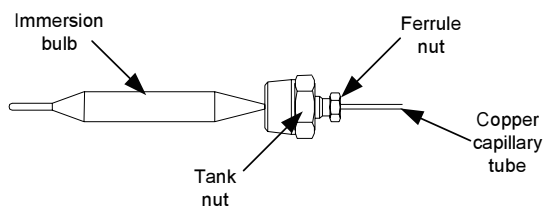


Illustration 19

11. Position tank nut at end of immersion bulb as shown in illustration 19. Insert immersion bulb into tank and tighten tank nut.
12. Gently pull copper capillary tube to insure the immersion bulb is in a horizontal position as shown in illustration 19 and tighten ferrule nut.
13. Resume water supply, fill tank and check for leaks.
14. Be sure tank is full of water and resume power supply to water heater. Verify proper ECO operation.

600V Surface Thermostat Model
High Limit (ECO) Control
Removal and Replacement

1. STOP, DANGER! Turn power "OFF" to water heater.
2. Remove lower control box cover and insulation.
3. Locate high limit switch mounted to the tank above the element spuds (see illustration 20).
4. Disconnect wire leads to the high limit. NOTE: It may be necessary to identify wires for proper reconnection to new control.
5. Remove the two high limit mounting nuts holding the sensor to the tank. Take care not to damage the mounting studs.
6. Fasten the replacement high limit to the tank using the nuts from step 5. Take care not to damage the mounting studs. Refer to wiring diagram located on the inside of the upper control box cover and properly reconnect wire leads to new high limit.
7. Verify proper ECO operation.

⚠ DANGER
High voltage exposure. To avoid hazard to Life or property, be sure power is turned OFF to water heater while performing this procedure.

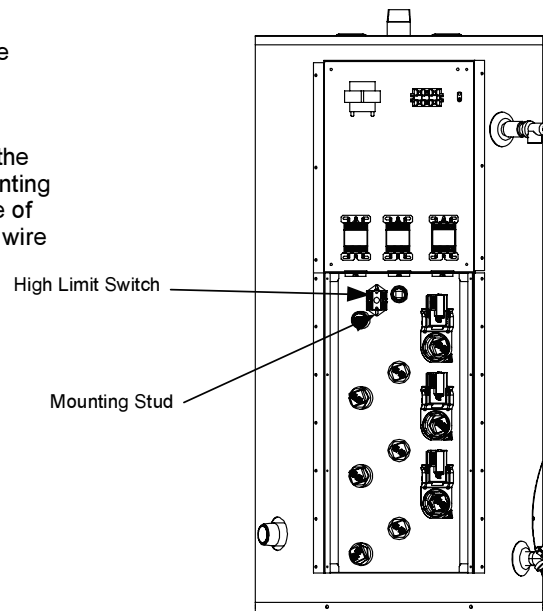


Illustration 20

Heating Element Removal

1. **STOP, DANGER!** Turn power "OFF" to water heater.
2. Turn off cold water supply to heater. Connect hose to drain spigot of water heater and route to an open drain. Open a nearby hot water faucet to vent heater for draining. Open drain spigot of water heater and allow heater to drain to a point below the Element(s).
3. Close drain spigot and remove hose.
4. Remove access cover from lower control box. Remove insulation from inside of control box. Remove plastic cover from thermostat.
5. Disconnect wires from element terminals.
6. Remove element from tank using 1-1/2" deep well socket or appropriate wrench. Unscrew element counter-clockwise to remove from tank.
7. Be sure to remove old element gasket from the tank. It is not recommended to be re-used.

**DANGER**

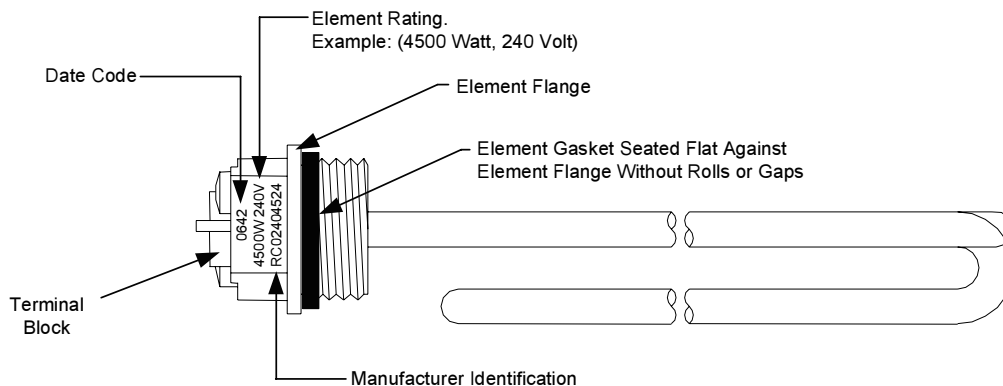
High voltage exposure. To avoid hazard to Life or property, be sure power is turned OFF to water heater while performing this procedure.

**WARNING**

Heater components and stored water may be HOT when performing the following steps in this procedure. Take necessary precaution to prevent personal injury.

Heating Element Replacement

1. Check new element terminal block for proper electrical rating. NOTE: Some elements have dual ratings, be sure to check all surfaces of the element terminal block (see illustration below).
2. Apply new element gasket to the new element. Be sure gasket is seated flat against element flange without rolls or gaps (see illustration below).
3. Clean any debris from element fitting on tank.
4. Thread new element clockwise into tank. Tighten element using 1-1/2" deep well socket or appropriate wrench. Do not over tighten, over tightening may damage element gasket.
5. Reconnect wires to element, be sure connections are snug and corrosion free. Do not over tighten, doing so may damage terminal block.
6. Resume water supply to heater, be sure tank is full of water and check for leaks.
7. Re-install plastic thermostat protector(s).
8. Re-install insulation and control box cover.
9. To resume operation, **BE SURE TANK IS FULL OF WATER** and restore power to water heater. Verify proper heater operation.

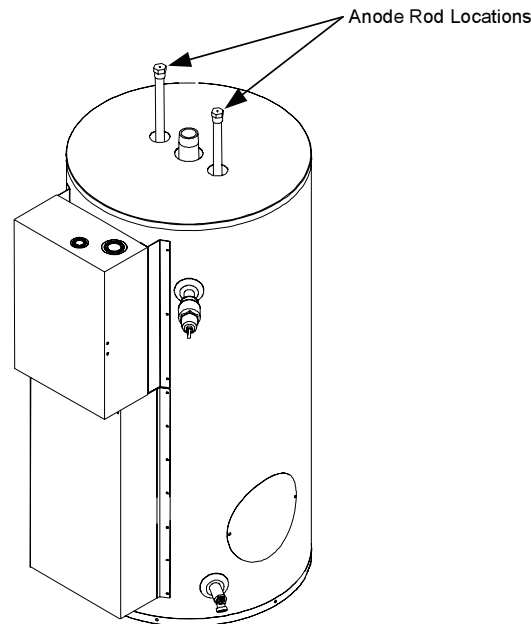


Anode Inspection and Replacement

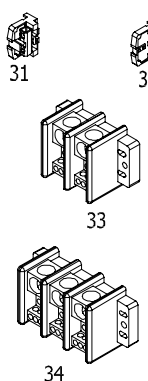
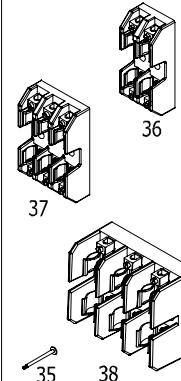
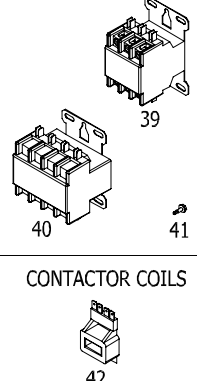
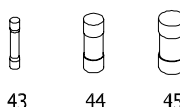
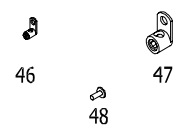
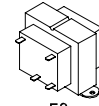
▲ DANGER
High voltage exposure. To avoid hazard to Life or property, be sure power is turned OFF to water heater while performing this procedure.

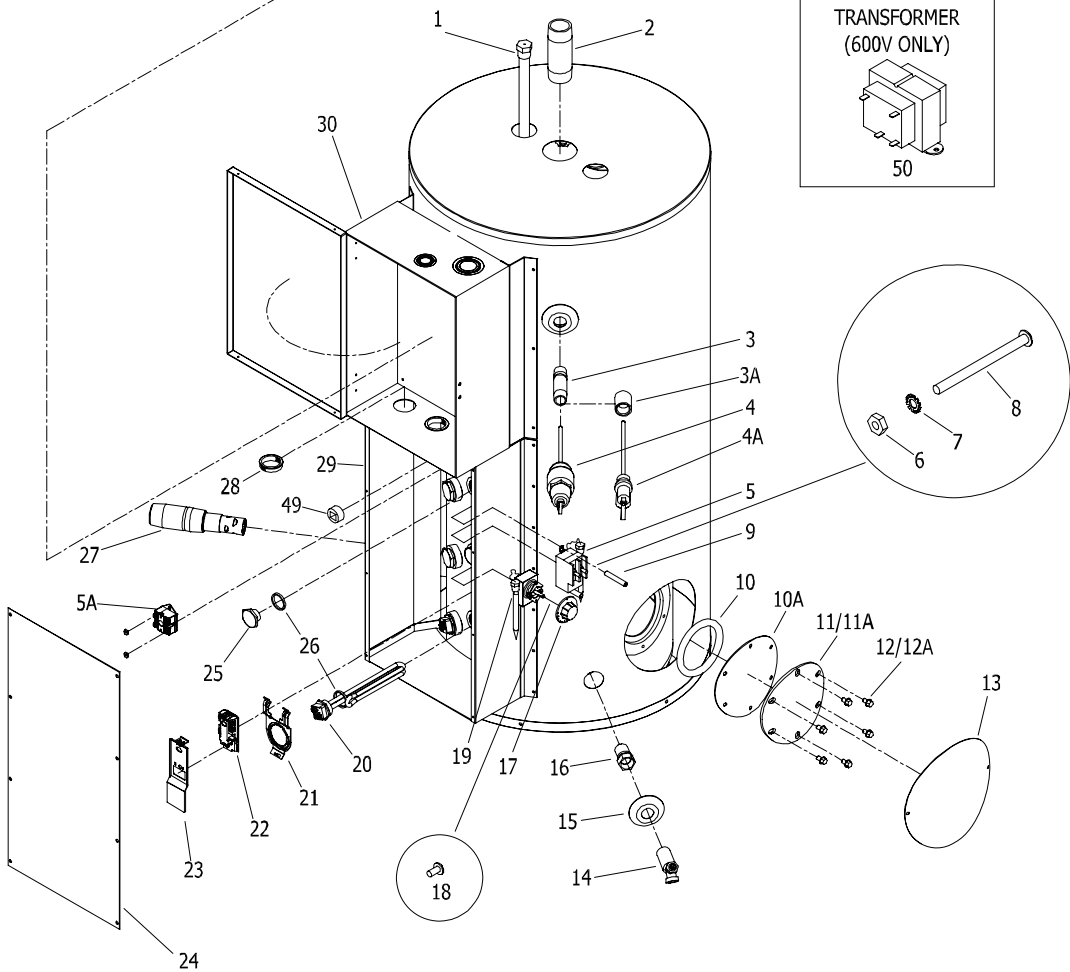
▲ WARNING
Heater components and stored water may be HOT when performing the following steps in this procedure. Take necessary precaution to prevent personal injury.

1. Turn power "OFF" to water heater.
2. Turn off cold water supply to heater. Connect hose to drain spigot of water heater and route to an open drain. Open a nearby hot water faucet to vent heater for draining. Open drain spigot of water heater and allow heater to drain to a point below the anode locations at the top of the tank.
3. Close drain spigot and remove hose.
4. Remove the plastic anode access plugs at the anode locations.
5. Remove anode from the water heater (1-1/16" socket).
6. Visually inspect anode. Anode should show signs of depletion, this is normal. If depletion is $\frac{1}{2}$ of the original anode diameter (original diameter approximately $\frac{3}{4}$ "), replacement is recommended. If any of the steel core of the anode is exposed, replacement is recommended.
7. Upon completion of inspection or subsequent replacement, reinstall anode into heater. resume water supply, refill heater with water and check for leaks.
8. To resume operation, **BE SURE HEATER IS FULL OF WATER** and turn power "ON" to water heater.



Generic Parts List

TERMINAL BLOCKS	FUSE BLOCKS	CONTACTORS	FUSES
 <p>31 32 33 34</p>	 <p>36 37 38</p>	 <p>39 40 41 CONTACTOR COILS 42</p>	 <p>43 44 45</p>
			GROUND LUGS
			 <p>46 47 48</p>
			TRANSFORMER (600V ONLY)
			 <p>50</p>



<u>Item</u>	<u>Description</u>	<u>Item</u>	<u>Description</u>
1	Anode.	26	Heating Element Gasket.
2	Hot Water Outlet Nipple.	27	Cold Water Inlet Nipple.
3	T&P Nipple.	28	Plastic Snap Bushing.
3A	T&P Coupling.	29	Lower Control Box.
4	T&P Relief Valve.	30	Upper Control Box.
5	High Limit Switch.	31	Terminal Block (Block A)
5A	Surface High Limit Switch.	32	Terminal Block End (used for block A).
6	Hex Nut	33	Terminal Block 2 pole.
7	Lock Washer	34	Terminal Block 3 Pole.
8	Screw	35	Screw.
9	High Limit Spacer.	36	Fuse Block 2 Pole Class G
10	Cleanout O-Ring.	37	Fuse Block 3 Pole Class G
10A	Cleanout Gasket (ASME).	38	Fuse Block 3 Pole Class J
11	Cleanout Cover.	39	Contactor 3 Pole.
11A	Cleanout Cover (ASME).	40	Contactor 4 Pole.
12	Cleanout Cover Screw.	41	Screw.
12A	Cleanout Cover Screw (ASME)	42	Contactor Coil
13	Cleanout Access Cover.	43	Fuse Class G
14	Brass Drain Valve.	44	Fuse Class J
15	Escutcheon.	45	Fuse Class J
16	Drain Extender.	46	Ground Lug Small.
17	Thermostat Dial	47	Ground Lug Large.
18	Screw.	48	Screw.
19	Immersion Thermostat.	49	¾ NPT Plug.
20	Heating Element.	50	Transformer - 120V
21	Surface thermostat Bracket.		
22	Surface Thermostat.		
23	Surface Thermostat Cover.		
24	Lower Control Box Cover.		
25	Heating Element Plug.		

Glossary of Terms

<u>Term</u>	<u>Definition</u>	<u>Unit of measure</u>
Voltage -	Electrical potential	Volts
Current-	Rate of voltage flow	Amperes (amp)
Resistance-	Ability of a device to dissipate power irreversibly	Ohms
Energy-	Ability to do work	kW/hr, Joule
Power-	Energy per unit of time	Watts, kW, VA

One kilowatt (1kW) = 1,000 Watts. = 3,412 BTU

DC = Direct Current

AC = Alternating Current

Hz = Hertz

°F = Degrees Fahrenheit

°C = Degree Centigrade

BTUH = British thermal units per hour

PSI = Pounds per square inch

GPM = Gallons per minute

GPH = Gallons per hour

ECO = Energy cut off

NPT = National pipe thread

ASME = American Society of Mechanical Engineers



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