



# COMMERCIAL ELECTRIC ENERGY SAVER WATER HEATER

## ASME SERIES IMMERSION THERMOSTAT WITH CONTACTORS

# SERVICE MANUAL

Troubleshooting Guide  
and Instructions for Service

(To be performed ONLY by  
qualified service providers)

**Models Covered  
by This Manual:**

CEA6, CEA12, CEA20, CEA30, CEA40,  
CEA50, CEA80, CEA120



As required by the state of California Proposition 65.

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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.

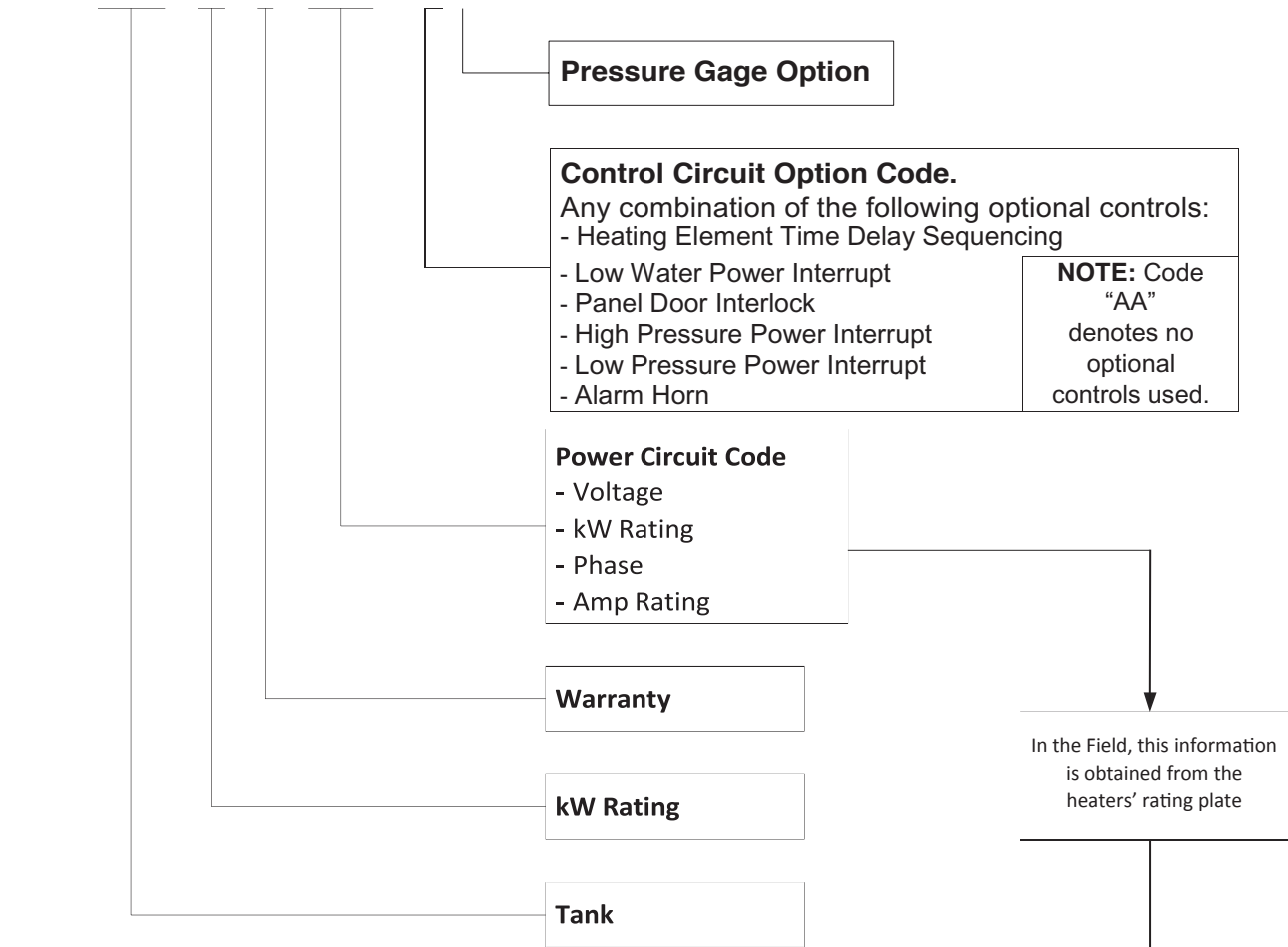
The text and illustrations in this manual provide step by step instructions to facilitate proper operation and troubleshooting procedures. Contact the Bradford White Technical Support Group immediately if diagnosis cannot be made using the methods described in this service manual.

## Tools

- |   |  |
|---|--|
| <ul style="list-style-type: none"> <li>- Multi Meter</li> <li>- 2-1/8" Deep Well Socket</li> <li>- 1-1/16" Deep Well Socket</li> <li>- 1/4" Nut Driver</li> </ul> | <ul style="list-style-type: none"> <li>- Phillips Head Screwdriver</li> <li>- Common Screwdriver</li> <li>- Thermometer</li> <li>- Drain Hose</li> </ul> |
|---|--|
- Other Hand Tools: Pipe Wrench, Channel Locks, Pliers (common & needle nose), Wire Cutters, Wire Strippers, Allen Wrench Set, Flash Light.

**Model Number Breakdown**

CEA120 - 24 - 3 - 108B - BBG



Model Number →

Electrical Characteristics {

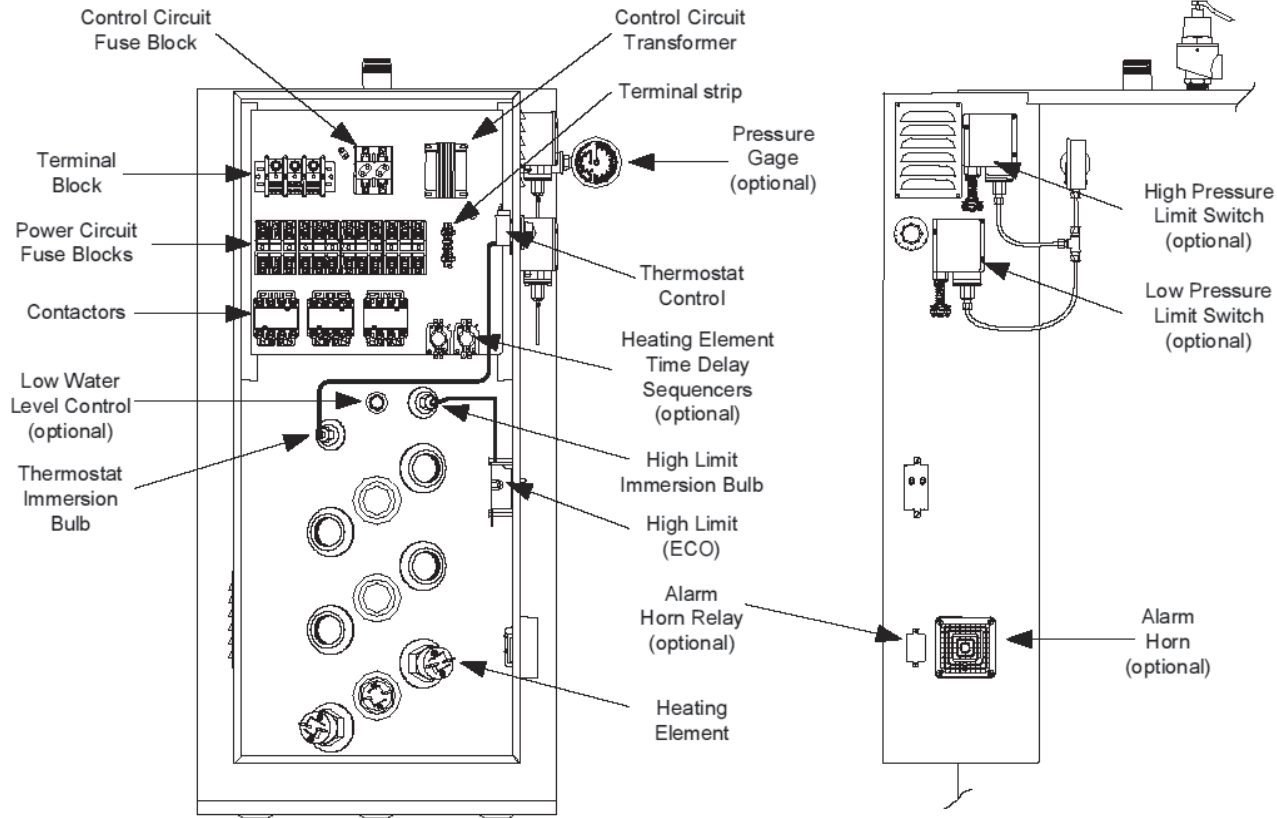
BRADFORD WHITE CORPORATION  
 200 LAFAYETTE ST. MIDDLEVILLE MI 49333  
 Model No: CEA120-24-3-108B-BBG  
 Serial No: ZB2564812  
 Cap. 120(gal.)/454.2(liters)  
 Press: Test 300(psi), Working 150(psi)

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Volts 240    Max Temp 180°  
 Phase Single    Amps 100  
 kW Each 6    Total kW 24    4 Elements  
 Wattage Rating Based Upon 60 Hz

Typical Rating Plate Located On Front Of Water Heater

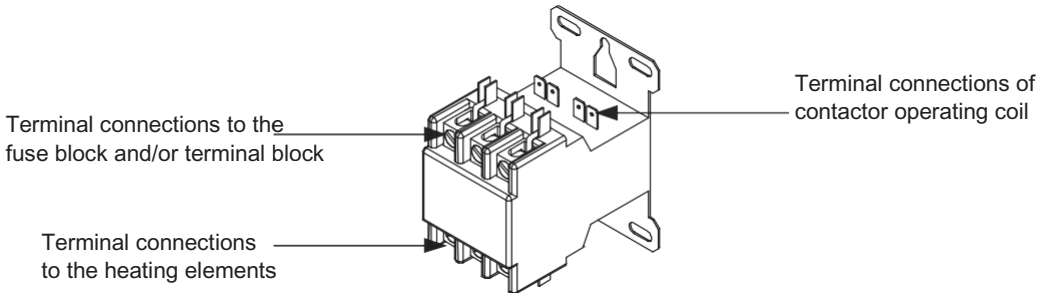
**General Controls Layout**



**Standard Controls**

**Contactor**

Contactor operation is achieved by energizing a 120 volt operating coil located within the contactor 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. Optionally, time delay sequencers may be used to stage contactor activation thereby reducing the inrush of current to the water heater.

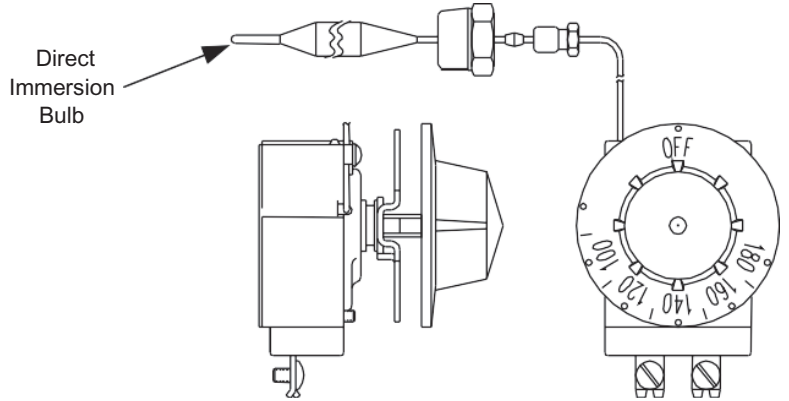


*Standard Controls (continued)*

**Immersion Style Thermostat Control**

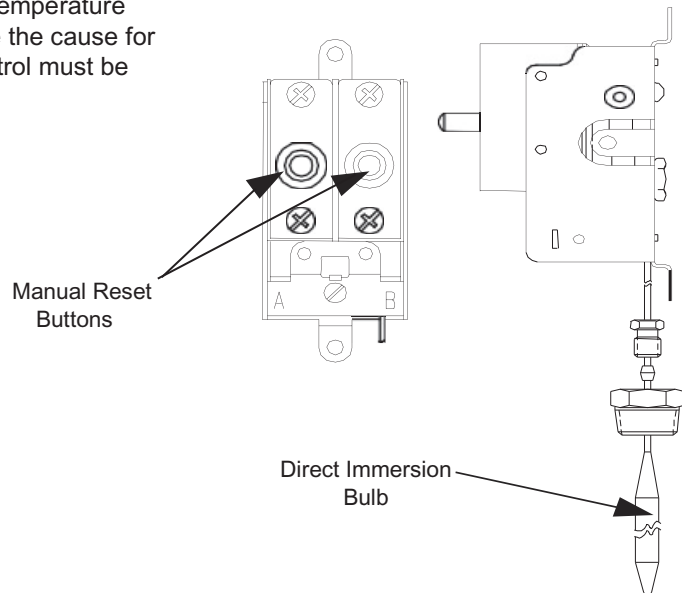
The thermostat will complete control circuit voltage upon a call for heat. Likewise, the control will interrupt control circuit voltage when the water temperature is sufficient to satisfy the adjustable temperature limit of control.

**Immersion Thermostat Control**



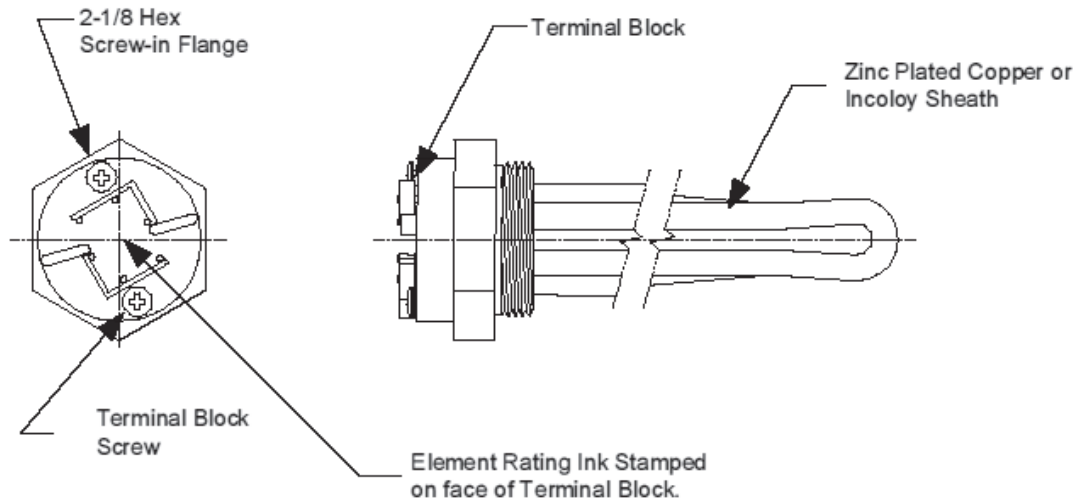
**Immersion Style High Limit (ECO) Control for Contactor Models**

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 overheated water has been determined, the control must be manually reset to restore normal operation.



*Standard Controls (continued)*

**Direct Immersion “Screw-in” Type Heating Element**



**Optional Controls**

Certain control components are available as “Optional.” When these optional components are installed with the water heater, the control circuit wiring diagram accordingly will include these components. The optional equipment available from the manufacturer includes the following:

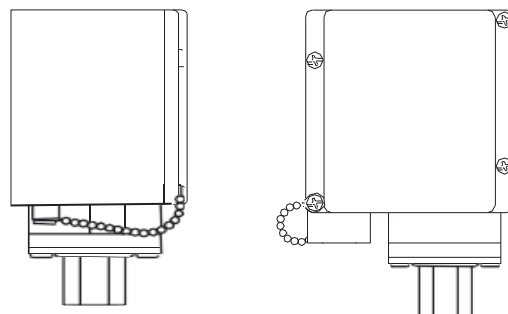
- High Water Pressure Switch
- Low Water Pressure Switch
- Low Water Level Switch
- Heating Element Time Delay Sequencers
- Electrical Door Lock
- Alarm Horn

**High and Low Water Pressure Controls**

These controls interrupt the electrical current to the contactor coil when the pressure settings are exceeded. The operation and setting of these controls are described in the manual provided by the control manufacturer. This manual is included with the water heater Installation and Operating Instruction manual provided with the water heater.

The pressure settings for these controls are adjustable. These controls are specified for use when the installation has unique pressure requirements that must be safeguarded. Therefore, before adjusting the pressure values, it is recommended that you consult the person responsible for the facility that the water heater is servicing.

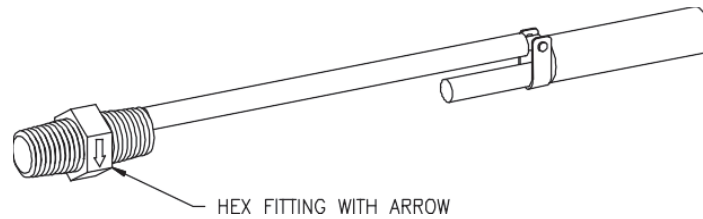
The electrical connections are referenced in the Control Circuit Wiring Diagram and in the pressure control manual provided by the control manufacturer. Refer to these instructions when servicing the controls.



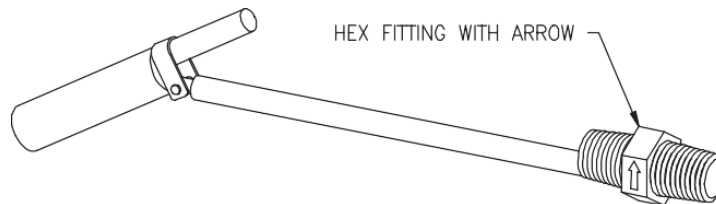
**Optional Controls (continued)****Low Water Level Control**

This control will interrupt the electrical current to the contactor coil when a low water level condition is sensed inside the water heater tank. When the low water level condition is corrected the control will automatically sense the new situation and electrical current will again energize the contactor coil. Normal water heater operation will be resumed.

To remove the low water level control from the tank you must first loosen the control by un-threading it from the tank fitting and then rotating the control until the arrow printed on the side of the hex fitting is pointing downward. This will enable the float orientation to align itself with the opening in the tank-fitting.



When installed, refer to the direction of the arrow on the hex and insure that it is pointing upwards. If it is not pointing upward, the control switch will not activate when the tank is refilled with water. Refer to illustration below for clarification.

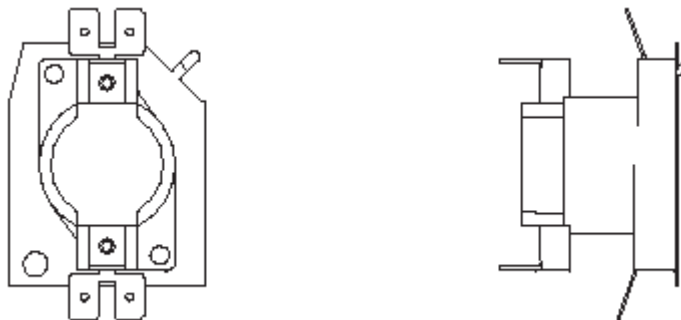
**Heating Element Time Delay Sequencers**

Heating element sequencers are available in order to stage the activation of the heating elements thereby reducing the inrush of electrical current to the water heater. The sequencers will control one or more contactor coils depending upon the water heater voltage, phase, and KW.

One contactor will be energized immediately when there is heating demand. The second contactor, controlled with a sequencer, will be activated approximately 20 seconds later, and the third contactor will be activated in another 20 seconds thereby, staging the three contactors over the 40 second time period. The staging occurs in a similar manner for applications having more than three contactors.

Refer to the Control Circuit Wiring Diagram for the specific application being serviced.

**Note:** On the occasion of servicing the water heater where frequent restarts in a short time interval are encountered (i.e. on, off, on, etc.), the timing sequences will not begin until the sequencers have experienced a time interval to reset.

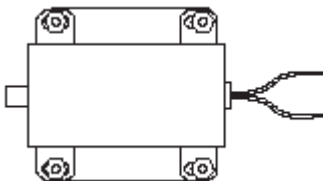


**Optional Controls (continued)**

**Electrical Door Lock**

An electrical door lock is offered in order to secure the access to the water heater control cabinet. This device will lock the control cabinet door when the 120VAC control circuit voltage is applied to it.

**Note:** Once the door is opened, the water heater can be re-energized, if necessary, for service diagnosis.

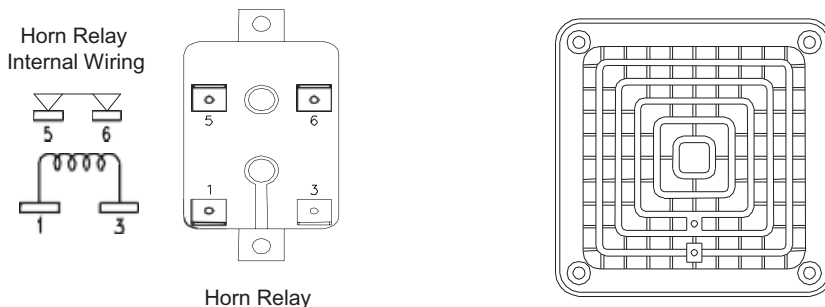


**Alarm Horn**

The Alarm Horn is an option specified when the installation desires an audible signal to immediately sound an alert when the water heater operation is interrupted for certain faults. Referring to the control circuit wiring diagram, the alarm will activate when any one of the following events occur:

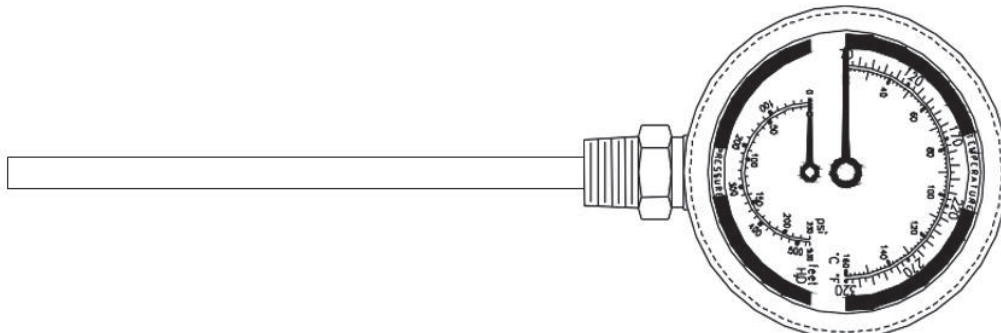
- The High-Limit control has been tripped
- The High Water Pressure Control senses excessive pressure
- The Low Water Pressure Control senses insufficient pressure
- The Low Water Level Control senses an insufficient quantity of water

The alarm will sound only for the options specified (i.e. if a low water level control is not specified then the alarm will not recognize a low water level condition).



**Combination Temperature and Pressure Gage**

A non-electrical device to visually reference water temperature and internal tank pressure.





**Commonly Used Formulas**

(Single Phase)

(balanced 3 phase)

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

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

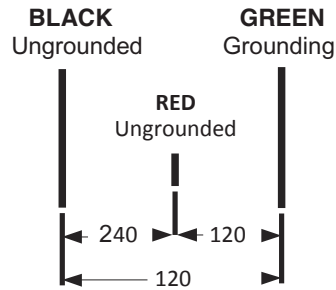
$$\text{Watts} = \text{Amps} \times \text{Volts}$$

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

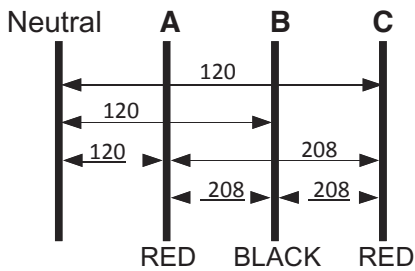
**Common Service Wire**

240V 1Ph

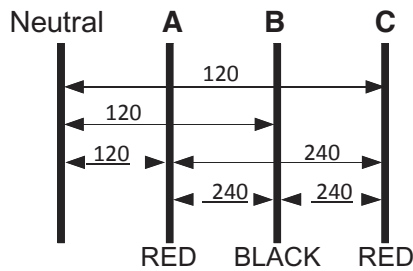
**Configurations**



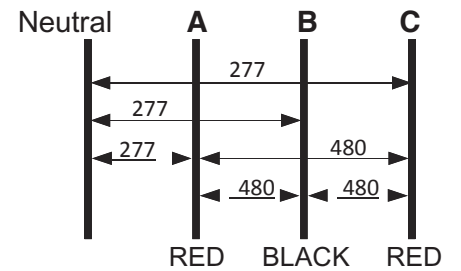
208 3Ph



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
3	14.4	-	12.5	-	10.8	-	-	6.3	-	-
6	28.8	16.6	25.0	14.4	21.6	9.1	8.3	12.5	7.2	5.7
9	43.2	25.0	37.2	21.6	32.4	13.6	12.5	18.7	10.8	8.66
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	64.9	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	28.8
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
81	389.4	224.8	337.5	194.8	292.4	123.1	112.6	168.7	97.4	78.0

## Sequence of Operation

This water heater has two distinct electrical systems. One system, referred to as the “Control Circuit”, controls the water heater operation, while the other system, referred to as the “Power Circuit”, connects the electrical power to the heating elements. The electrical contactors interconnect these two systems. In order to clearly illustrate the electrical circuits, two wiring diagrams are provided. These diagrams are labeled as the “Control Circuit Wiring Diagram” and the “Power Circuit Wiring Diagram” and they are attached to the surface of the panels inside the water heater control cabinet.

## Control Circuit Description

The control circuit operates with 120VAC electrical service. This voltage is provided by the multi-tap transformer which has the primary coil connected to the field wiring that is serving the water heater. The Transformer, Thermostat, High-Limit control, and the Contactor Coil are always included in the Control Circuit.

Certain other control components are available as “Optional”. When these optional components are installed with the water heater, the control circuit wiring diagram accordingly will include these components. The optional equipment available from the manufacturer includes the following:

High Water Pressure Switch

Low Water Pressure Switch

Low Water Level Switch

Alarm Horn

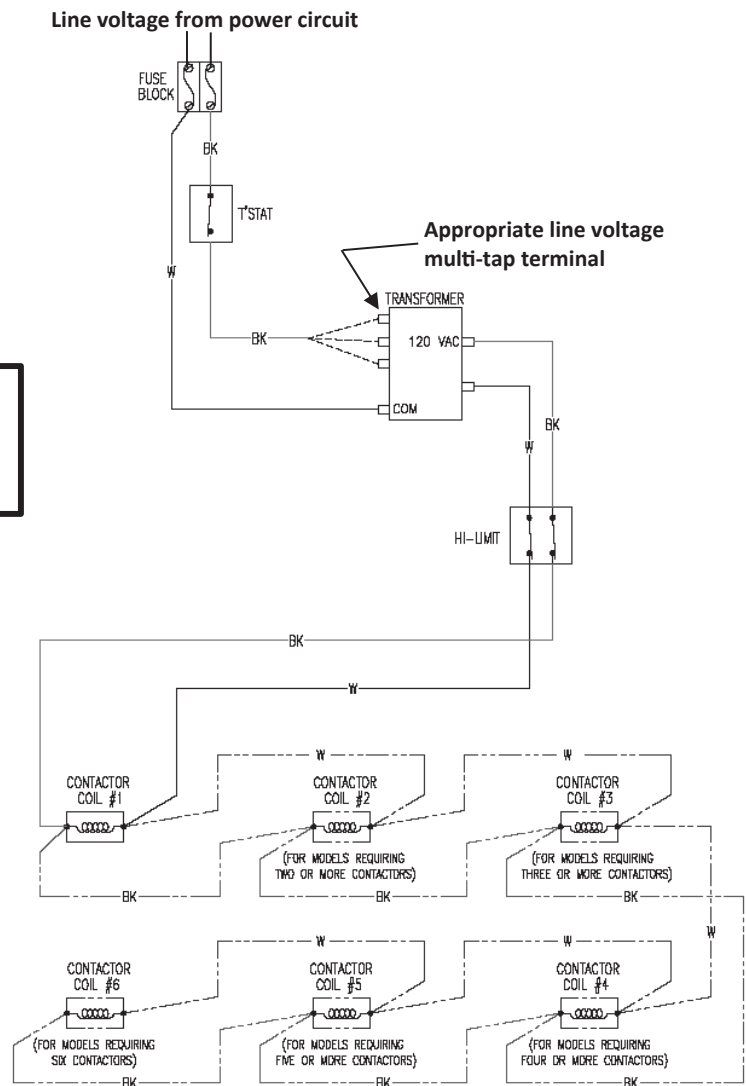
Heating Element Sequencers

Electrical Door Lock

## Control Circuit Sequence of Operation

**NOTE:** To help understand the concept of the operating sequence, the control circuit shown is without any optional controls. See page 11 for control circuit showing all available optional controls.

- 1 Line voltage is applied to control circuit fuse block.
- 2 Line voltage continues to transformer with one leg of voltage connecting to the common terminal and the other leg connecting to the appropriate line voltage multi-tap terminal. Transformer output (always 120 volts) continues to high limit (ECO) control.
- 3 Hi-limit (ECO) control is closed so one leg of 120 volts continues to one side of the contactor coil. The other leg is connected to the thermostat.
- 4 When the thermostat calls for heat, contacts close inside the thermostat, then completing the circuit and energizing the contactor coil.
- 5 The energized contactor coil causes the contactor to close, energizing the heating elements.
- 6 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.



**Control Circuit Wire Diagram**

- 7 The de-energized contactor coil causes the contactor to open, interrupting current flow through the heating elements.

**Control Circuit Sequence (continued)**

Certain other control components are available as "Optional". These controls are specified when the installation has unique requirements that must be safeguarded. When these optional components are installed the control circuit wiring diagram accordingly will include these components. The optional equipment available from the manufacturer includes the following:

- High Water Pressure Switch
- Low Water Pressure Switch
- Low Water Level Switch
- Alarm Horn
- Heating Element Sequencers
- Electrical Door Lock

**Control Circuit Sequence of Operation with Optional Controls**

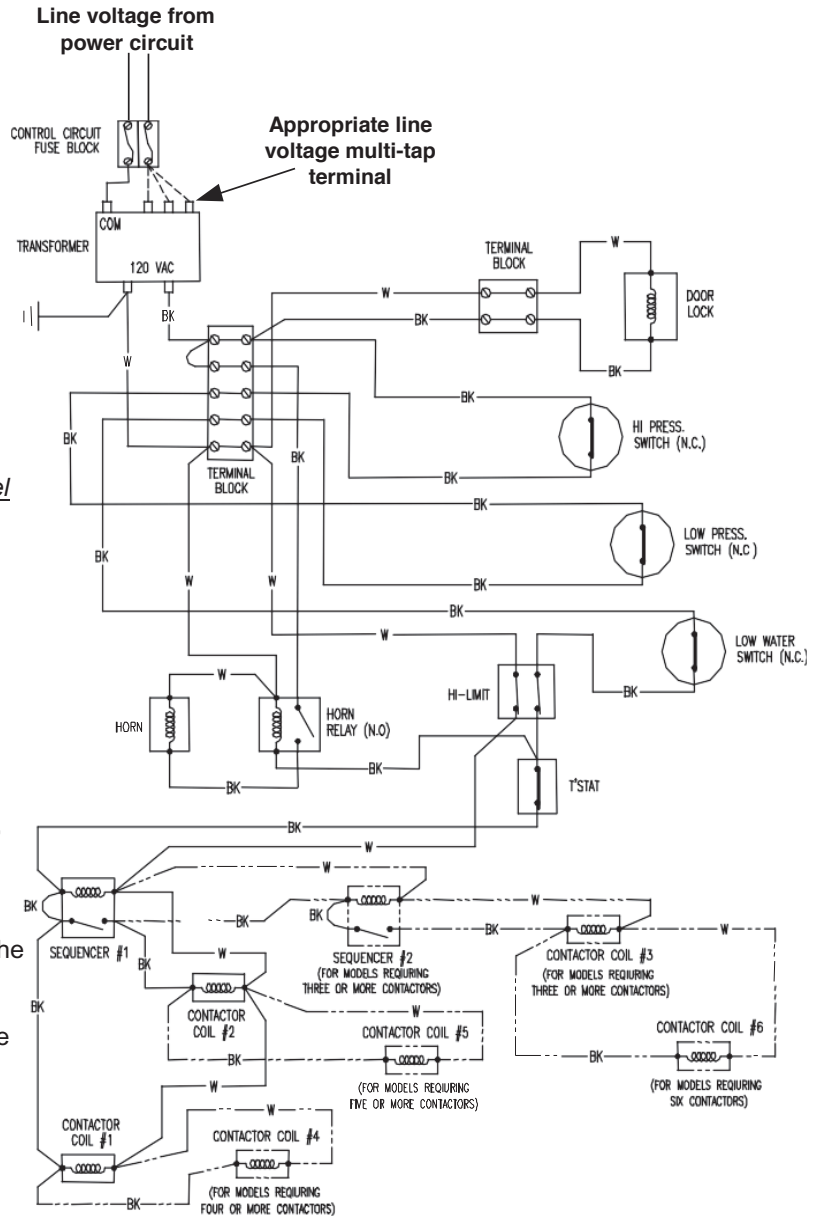
Same as explained on page 10 with the following exceptions:

-Hi and Low Pressure Switch and Low Water Level Switch when specified are always wired in series ahead of the high-limit control.

-Heating Element Sequencers are wired in series with contactor coils staging contactor activation at intervals of approximately 20 seconds.

-Alarm Horn is wired in series ahead of the thermostat. It monitors only the High and Low pressure switch, Low Water Level Switch and the High-Limit (ECO). If either of these switches open, power to the horn relay is interrupted causing the relay to close, sounding the alarm horn.

-Electrical Door Lock is wired in parallel to secure the access to the water heater control cabinet. This device will lock the control cabinet door when the 120VAC control circuit voltage is applied. Once the door is opened, the water heater can be re-energized, if necessary, for service diagnosis.



Control Circuit Wire Diagram  
Showing Optional Controls

## Power Circuit Description

The Power Circuit Wiring Diagram illustrates the electrical connections from the incoming power supply through the contactors to the heating elements. The power circuits are available with internal circuit fusing and without internal circuit fusing.

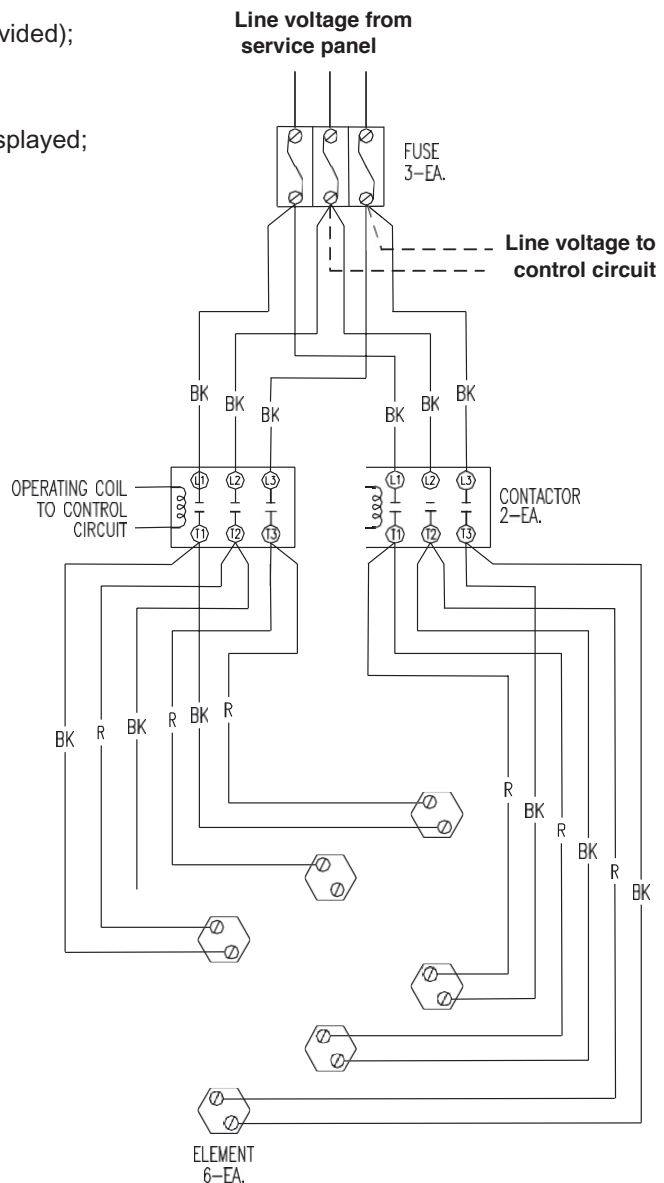
As it would be impractical to show all wired configurations in this service manual, a reference wiring diagram is illustrated below to aid in the understanding of the power circuit operating sequence. Service providers must refer to the water heaters power circuit wiring diagram attached to the inside panel of the control cabinet for the specific connections of the water heater being serviced.

The power circuit components and supporting information that appear on the wiring diagram include the following:

- Field wiring connection via terminal block or other connection point;
- Fuse block with amperage ratings displayed (when provided);
- Contactors with amperage ratings displayed;
- Electrical elements with voltage and wattage ratings displayed;
- Water heaters total amperage draw is displayed.

## Power Circuit Sequence

- 1 Line voltage is applied across terminals of a 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 as explained on pages 10 & 11.
- 2 The control circuit senses a call for heat and energizes the operating coil within the contactor.
- 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.



## Troubleshooting

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

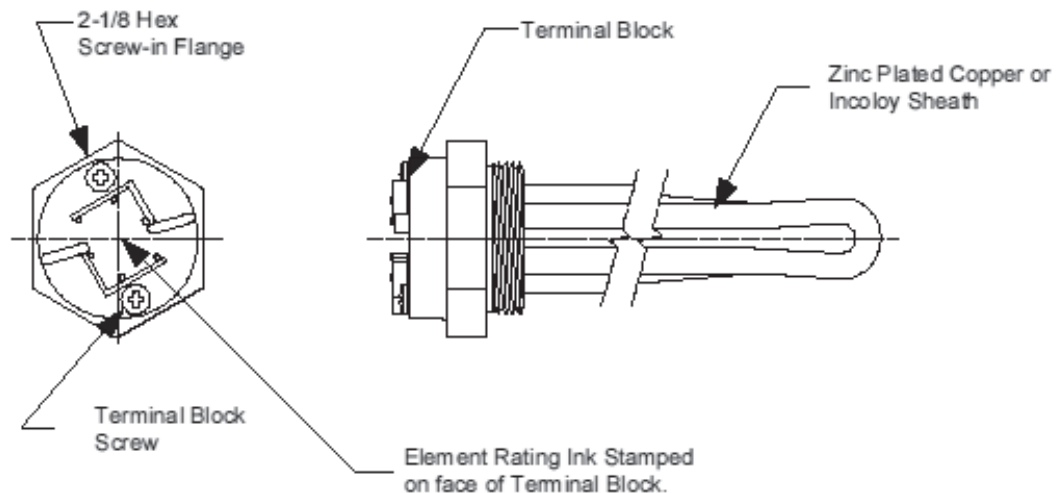
When troubleshooting an electric water heater with the incidence of “No Hot Water” or “Insufficient Amount of Hot Water,” it is always a good idea to check the heating elements first, following the procedure on page 15.

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 the 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 overheated water, limited only by the High-Limit (ECO) located in the control circuit. Repeated actuation of the High-Limit 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 cause a dry fired element over time.

If a heating element is found to be inoperative, it must be replaced. Follow service procedure ACE-IX on page 23.

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 ensure they are snug and corrosion free.
3. Reset High-Limit (ECO) (page 18).
4. Check for inoperative heating element (page 15).
5. Check line voltage (page 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. To avoid hazard to life or property use extreme caution when making voltage checks.**

SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION	SERVICE PROCEDURE
No Hot Water	<ol style="list-style-type: none"> <li>1.No power to heater.</li> <li>2.Blown water heater fuses.</li> <li>3.Loose wire connections.</li> <li>4.Inoperative heating element(s).</li> <li>5.Check thermostat operation.</li> <li>6.Reset (check) ECO.</li> <li>7.Check contactor operation.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check circuit breakers at service panel.</li> <li>2. Check water heater fuses.</li> <li>3. Check all wire connections.</li> <li>4. Check heating element(s).</li> <li>5. Check thermostat operation.</li> <li>6. Reset (check) ECO.</li> <li>7. Check contactor operation.</li> </ol>	<ol style="list-style-type: none"> <li>2. ACE-III, page 17</li> <li>4. ACE-I, page 15</li> <li>5. AVE-V, page 19</li> <li>6. ACE-IV, page 18</li> <li>7. AVE-VI, page 20</li> </ol>
Not Enough Hot Water	<ol style="list-style-type: none"> <li>1. Inoperative heating element(s).</li> <li>2. Thermostat set to low.</li> <li>3. Inoperative thermostat.</li> <li>4. Inoperative contactor(s).</li> <li>5. Loose wire connection.</li> <li>6. High demand period.</li> <li>7. Undersized heater.</li> <li>8. Very cold inlet water to heater.</li> <li>9. Plumbing connections reversed.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check heating element(s).</li> <li>2. Increase thermostat setting.</li> <li>3. Check thermostat.</li> <li>4. Check contactor operation.</li> <li>5. Check all wire connections.</li> <li>6. Reduce demand.</li> <li>7. Replace with larger heater.</li> <li>8. Temper water to heater.</li> <li>9. Correct plumping connections.</li> </ol>	<ol style="list-style-type: none"> <li>1. ACE-I, page 15</li> <li>3. ACE-V, page 19</li> <li>4. ACE-VI, page 20</li> </ol>
Slow Hot Water Recovery	<ol style="list-style-type: none"> <li>1. Sediment or lime build up on element(s).</li> <li>2. Loose wire connections.</li> <li>3. Inoperative contactor(s).</li> <li>4. Derated heating element installed.</li> </ol>	<ol style="list-style-type: none"> <li>1. Clean or replace heating elements.</li> <li>2. Check all wire connections.</li> <li>3. Check contactor operation.</li> <li>4. Verify element voltage and wattage rating.</li> </ol>	<ol style="list-style-type: none"> <li>1. ACE-IX, page 23</li> <li>3. ACE-VI, page 20</li> <li>4. See page 6</li> </ol>
Over Heated Water	<ol style="list-style-type: none"> <li>1. Grounded heating element(s).</li> <li>2. Thermostat set to high.</li> <li>3. Inoperative thermostat.</li> <li>4. Inoperative ECO.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check heating element(s).</li> <li>2. Adjust thermostat to desired setting.</li> <li>3. Check thermostat.</li> <li>4. Check ECO.</li> </ol>	<ol style="list-style-type: none"> <li>1. ACE-I, page 15</li> <li>3. ACE-V, page 19</li> <li>4. ACE-IV, page 18</li> </ol>
Noisy (singing or hissing) Elements	<ol style="list-style-type: none"> <li>1. Lime formation on elements.</li> <li>2. High or low line voltage.</li> </ol>	<ol style="list-style-type: none"> <li>1. Clean or replace heating elements.</li> <li>2. Verify line voltage to heater.</li> </ol>	<ol style="list-style-type: none"> <li>1. ACE-IX, page 23</li> <li>2. ACE-II, page 16</li> </ol>
Noisy Contactor	<ol style="list-style-type: none"> <li>1. Low line voltage.</li> <li>2. Debris between contactor plates.</li> <li>3. Incorrect or defective operating coil.</li> <li>4. Loose wire connections.</li> </ol>	<ol style="list-style-type: none"> <li>1. Verify line voltage to heater.</li> <li>2. Replace contactor.</li> <li>3. Check wire connections.</li> </ol>	<ol style="list-style-type: none"> <li>1. ACE-II, page 16</li> </ol>

### Heating Element Testing

1. **STOP, DANGER!** Turn power “OFF” to water heater.
2. Open control panel access door.
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 Figure 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

	Voltage Rating of Elements			
<u>Element Wattage</u>	<u>208</u>	<u>240</u>	<u>480</u>	<u>600</u>
2000	21.6	28.8	115.2	180
3000	14.4	19.2	76.8	120
4000	10.8	14.4	57.6	90
4500	9.6	12.8	51.2	80
5000	8.7	11.5	46.1	72
6000	7.2	9.6	38.4	60
9000	4.8	6.4	25.6	40

### Test For Grounded Heating Element (Damaged Heating Element With Short Circuit To Ground)

1. **STOP, DANGER!** Turn power “OFF” to water heater.
2. Open control panel access door.
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 Figure 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.

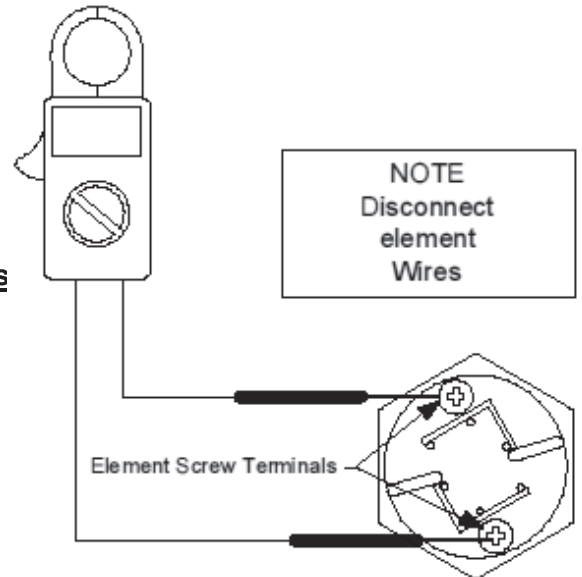


Figure 1

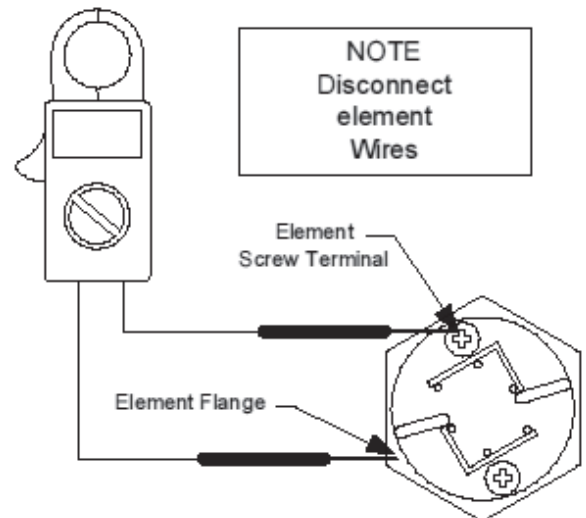


Figure 2

## Line Voltage Testing

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

Determine the heater's 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 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" setting. 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 Figure 3).
  - A) Rated voltage **IS** present, power to the water heater is okay.
  - B) Rated voltage **NOT** present, check service panel.

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

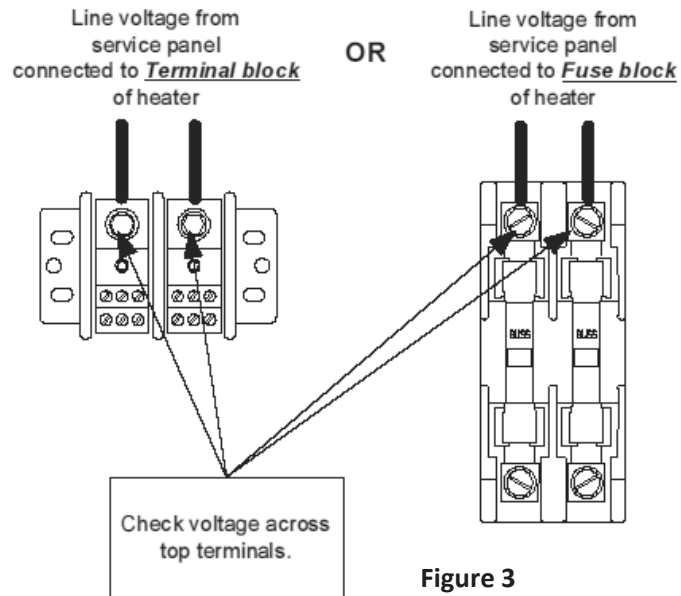


Figure 3

### Three Phase Line Voltage Testing

1. **STOP, DANGER!** Turn power "OFF" to water heater.
2. Open 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" setting. 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 Figure 4).
  - A) Rated voltage **IS** present, power to the water heater is okay.
  - B) Rated voltage **NOT** present, Check service panel.

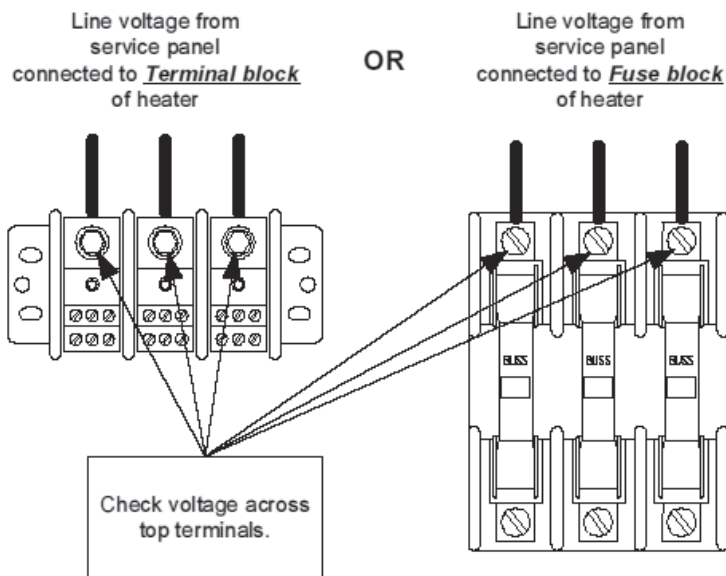


Figure 4



## Fuse Testing

1. **STOP, DANGER!** Turn power “OFF” to water heater.
2. Open control panel door 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 Figure 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.

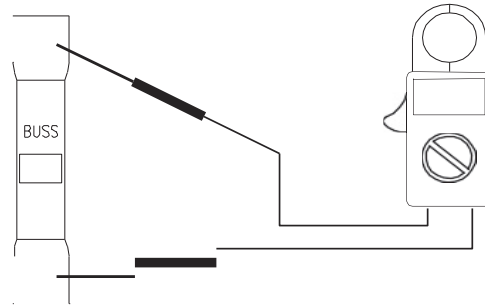


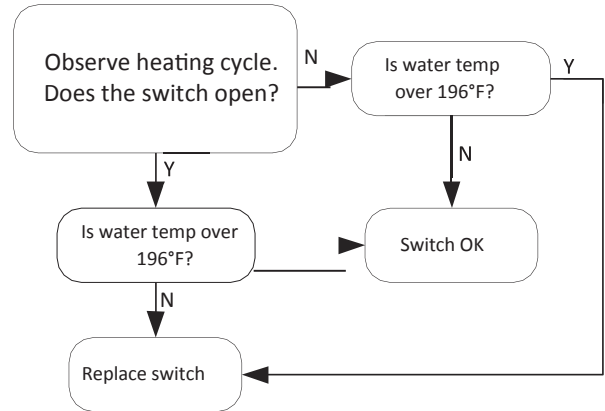
Figure 5

### High Limit Control (ECO) Operation

#### Switch Contacts:

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

1. Determine if High-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 High-Limit Heating Cycle flow chart.



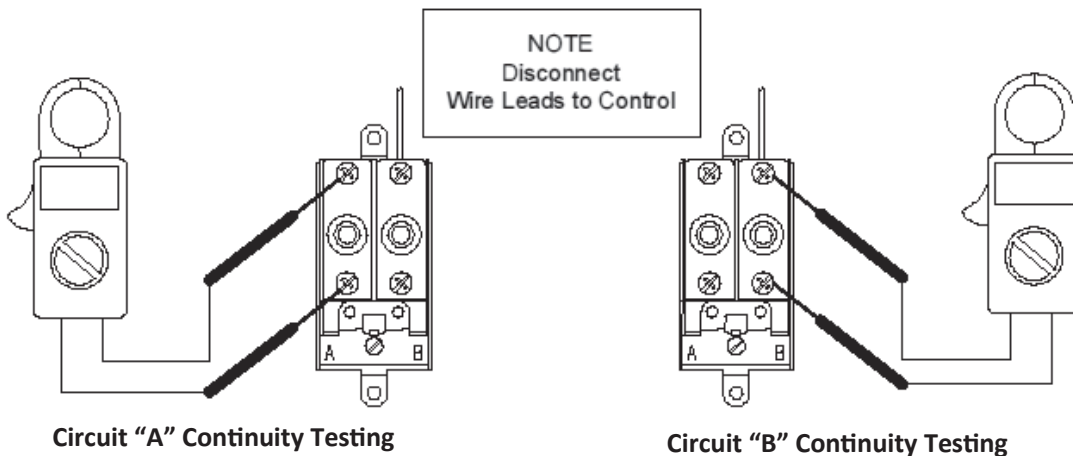
High Limit Heating Cycle Flow Chart

### High Limit Control Continuity Testing

1. **STOP, DANGER!** Turn power “OFF” to water heater.
2. Water temperature must be below 196°F ±4°F
3. Remove High-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 High-Limit Control.
5. Depress reset buttons to insure switch contacts are closed.
6. Set multi-meter to “ohms” setting. Check continuity through circuit A & B as shown in the diagrams 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.



## Immersion Thermostat Operation Testing

### Thermostat Specification:

Calibration: 184°F/176°F

Max Differential: 6°F

Operating Range 80 to 180°F

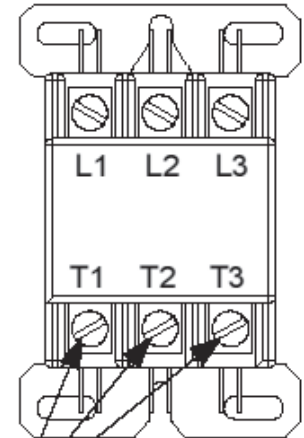
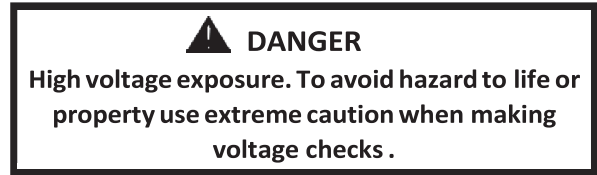
Provided that the water temperature in the tank is within the operating range of the thermostat, checking thermostat operation can be as simple as rotating the thermostat dial and listening to the contactor(s) to see if they respond to a call for heat.

Using caution, 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 Figure 6), 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)

Figure 6

## 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. Open control panel door.
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 Figure 7).
  - 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 Figure 7).
  - A) Continuity **NOT** present, thermostat is okay.
  - B) Continuity **IS** present, replace thermostat.

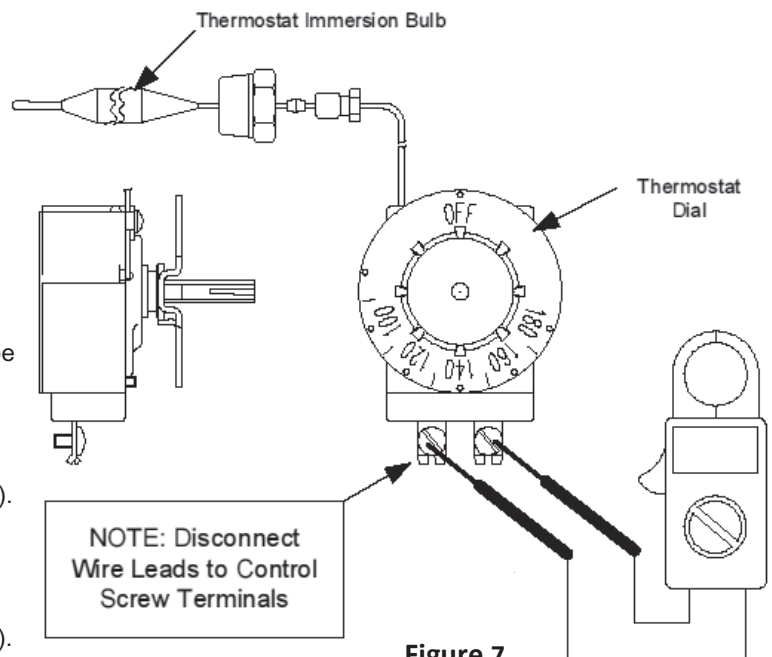


Figure 7

### Contactor Operating Coil

Contactor operation is achieved by energizing an operating coil located within the contactor. The contactor coil is considered part of the control circuit operating at 120 volts as described on page 10.

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

### Noisy Contactor

In most cases, noisy or chattering contactor operation 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, see page 16.

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

### Contactor Operation Testing

*This procedure assumes control circuit is operating correctly.*

Provided that 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 120 volts across operating coil terminals (see Figure 8).
  - A) 120 volts **IS** present, okay, go to step 2.
  - B) 120 volts **NOT** present, verify control circuit operation.
2. Check for rated voltage across lower terminals of contactor(s) (see Figure 9).
  - 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 120 volts across operating coil terminals (see Figure 8).
  - A) 120 volts **IS** present, verify control circuit operation.
  - B) 120 volts **NOT** present, okay go to step 5.
5. Check for rated voltage across lower terminals of contactor(s) (see Figure 9).
  - A) Rated voltage **IS** present, replace contactor.
  - B) Rated voltage **NOT** present, contactor is okay.

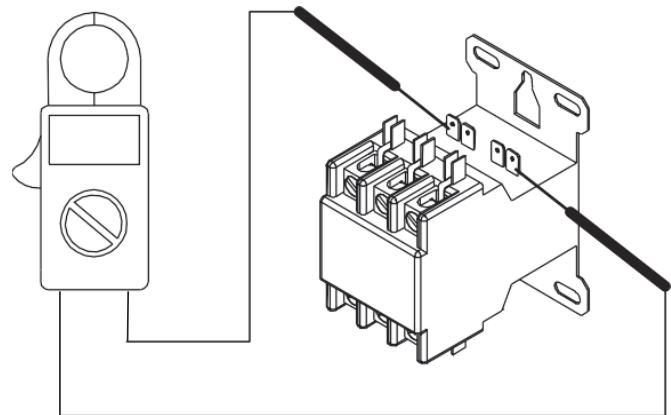
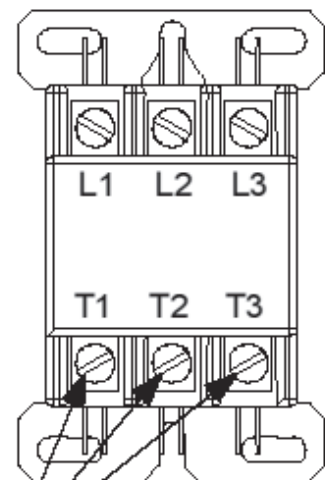


Figure 8



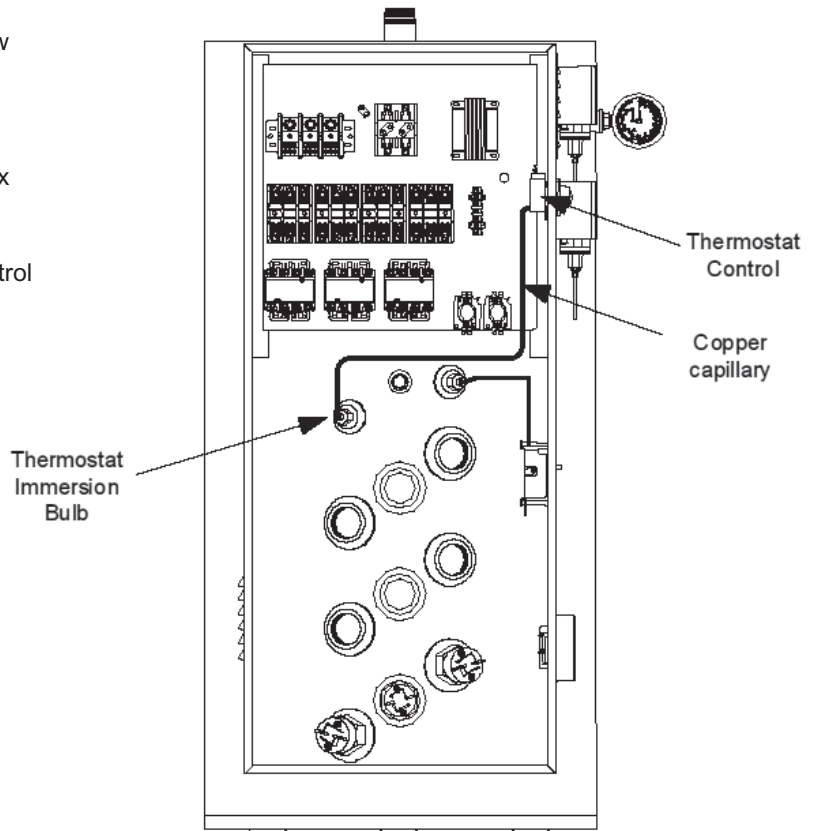
Check voltage across lower terminals of contactor(s)

Figure 9

### Immersion Thermostat Removal

1. **STOP, DANGER!** Turn power "OFF" to water heater.
2. Open control box door.
3. 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 Figure 10 for location).
4. Close drainspigot and remove hose.
5. Locate thermostat control inside lower control box mounted to the right inside surface of the control box (see Figure 10).
6. Follow copper capillary tube from thermostat control to the immersion bulb location and remove immersion bulb from tank, 11/16" wrench.
7. Remove (pull) thermostat dial from stem of thermostat control.
8. Remove the two control mounting screws and remove thermostat control from control panel.
9. Disconnect wire leads to the thermostat control.  
**NOTE:** It may be necessary to identify wires for proper reconnection to new thermostat.

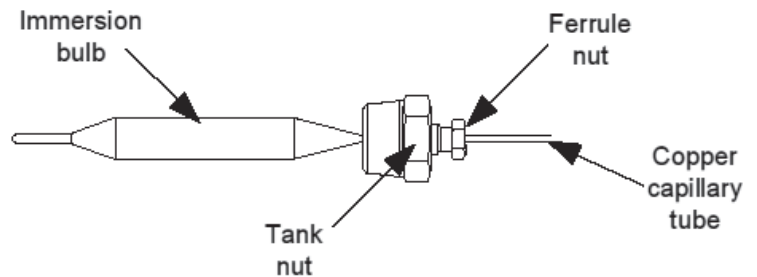
**▲ DANGER**  
High voltage exposure. To avoid hazard to life or property be sure power is turned OFF to water heater while performing this procedure.



**Figure 10**

### Immersion Thermostat Replacement

1. Referring to Control Circuit Wire Diagram, properly reconnect wire leads to new thermostat control and install new control inside control box using screws from step 8 of Immersion Thermostat Removal.
2. Replace control dial to stem of thermostat.
3. Loosen ferrule nut of the immersion bulb (see Figure 11).
4. Position tank nut at end of immersion bulb as shown in Figure 11. Insert immersion bulb into tank and tighten tank nut.
5. Gently pull copper capillary tube to insure the immersion bulb is in a horizontal position as shown in Figure 11 and tighten ferrule nut.
6. Resume the water supply, fill tank, and check for leaks.
7. Be sure tank is full of water and resume power supply to water heater. Verify proper thermostat operation.



**Figure 11**

### High Limit Control (ECO) Removal

1. **STOP, DANGER!** Turn power "OFF" to water heater.
2. Open control box door.
3. 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 the drain spigot of the water heater and allow heater to drain to a point below the Immersion bulb location (see Figure 12).
4. Close drainspigot and remove hose.
5. Locate High-Limit Control inside the lower control box mounted to the right inside surface of control box (see Figure 12).
6. Follow copper capillary tube from control to the immersion bulb location and remove immersion bulb from tank using an 11/16" wrench.
7. Remove the two control mounting screws located outside the control box.
8. Disconnect wire leads to the control. **NOTE:** It may be necessary to identify wires for proper reconnection to new control.

### High Limit Control (ECO) Replacement

1. Refer to control circuit wiring diagram located on the inside of the control box and properly reconnect wire leads to new control and install new control inside control box using screws from step 7 of High Limit Control (ECO) Removal.
2. Loosen ferrule nut of immersion bulb (see Figure 13).
3. Position tank nut at end of immersion bulb as shown in Figure 13. Insert immersion bulb into tank and tighten tank nut.
4. Gently pull copper capillary tube to insure the immersion bulb is in a horizontal position as shown in Figure 13 and tighten ferrule nut.
5. Resume the water supply, fill tank, and check for leaks.
6. Be sure tank is full of water and resume power supply to water heater. Verify proper High Limit 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.

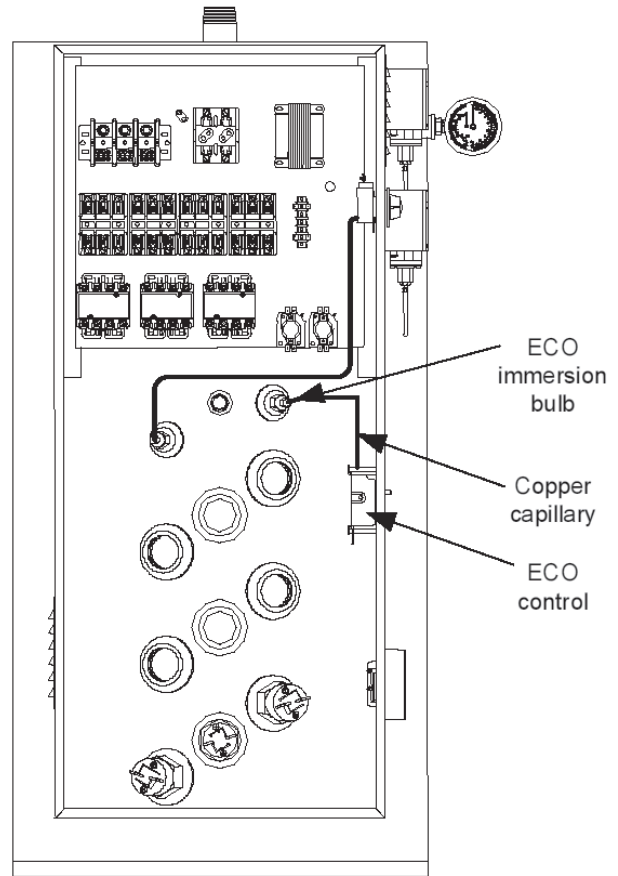


Figure 12

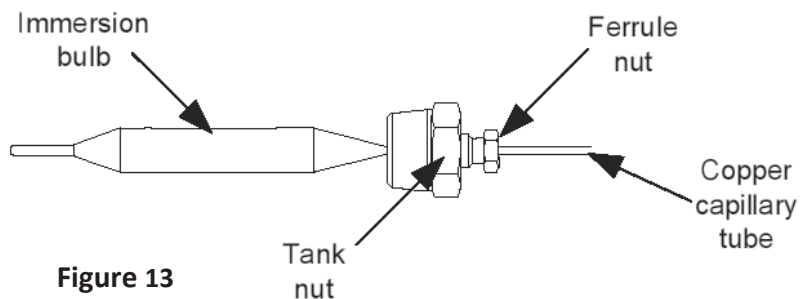


Figure 13

### Heating Element Removal

1. **STOP, DANGER!** Turn power "OFF" to water heater.
2. Open control box door.
3. 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 heating element(s).
4. Close drain spigot and remove hose.
5. Disconnect wires from heating element terminals.
6. Remove heating element from tank using a 2-1/8" 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 heating element terminal block for proper electrical rating. **NOTE:** Some heating elements have dual ratings, be sure to check all surfaces of the heating element terminal block (see Figure 14).
2. Apply new gasket to the new heating element. Be sure gasket is seated flat against heating element flange without rolls or gaps (see Figure 14).
3. Clean any debris from tank fitting where heating element is to be installed. Lubricate heating element threads as needed with thread lubricant.
4. Thread new heating element clockwise into tank fitting. Tighten heating element using a 2-1/8" deep well socket or appropriate wrench. **DO NOT** over tighten, over tightening may damage gasket.
5. Reconnect wires to heating element, be sure connections are snug and corrosion free. **DO NOT** over tighten, as doing so may damage the terminal block.
6. Resume water supply to heater, be sure tank is full of water, and check for leaks.
7. To resume operation, **BE SURE TANK IS FULL OF WATER** and restore power to water heater. Verify proper heater operation.

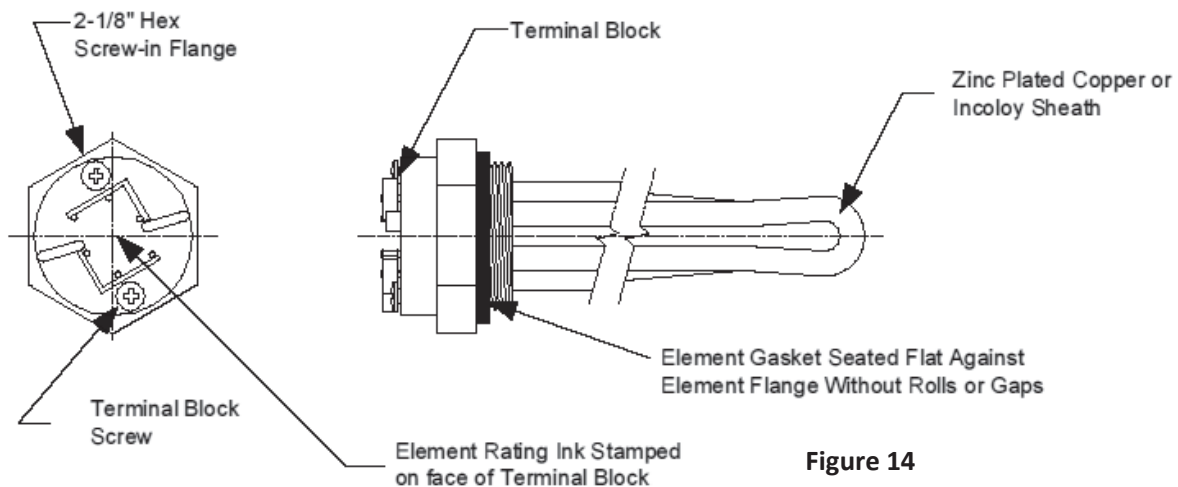


Figure 14

## Anode Inspection 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 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 the anode. The anode should show signs of depletion; this is normal.  
If depletion is 1/2 of the original anode diameter (original diameter approximately 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 the 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.

**▲ 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.

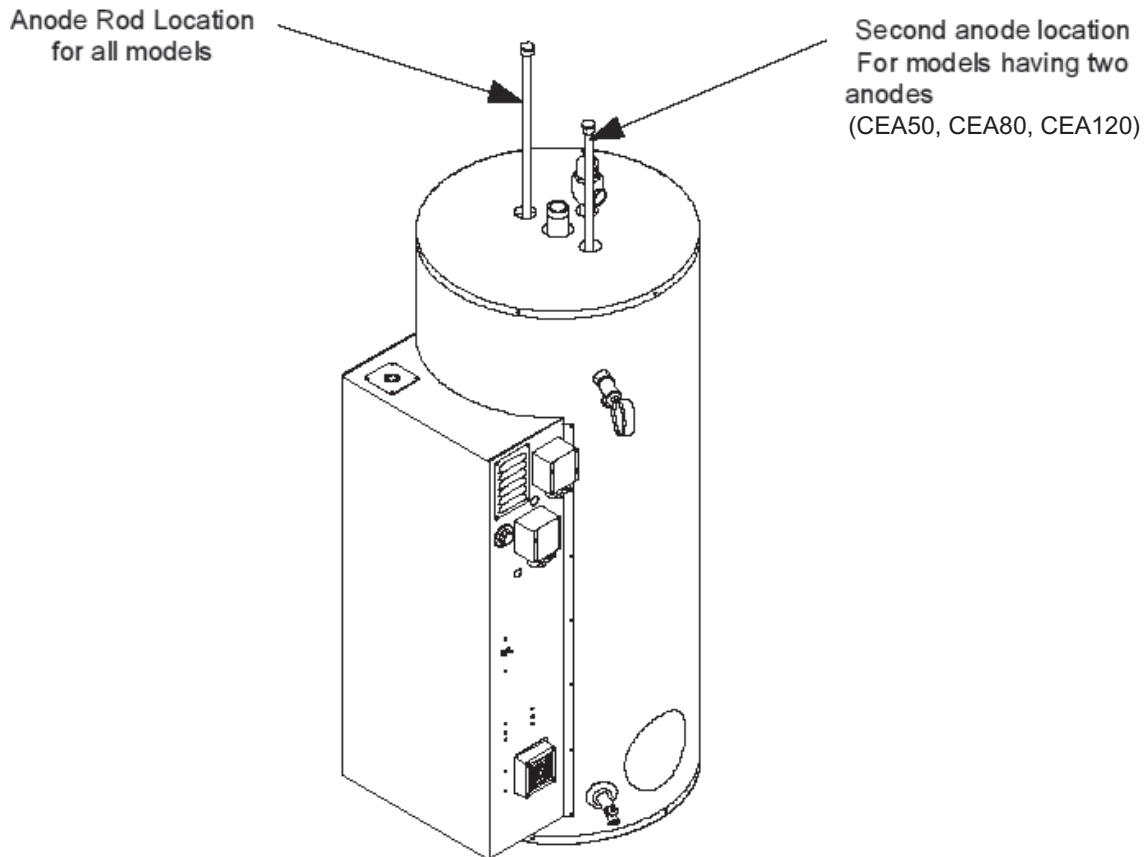
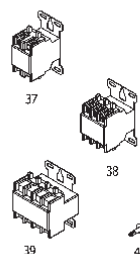
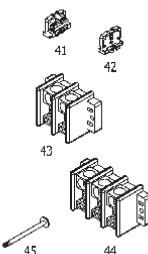
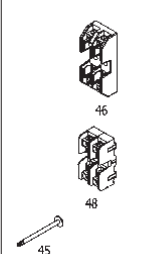
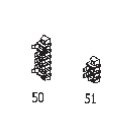
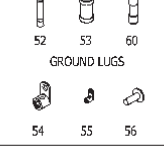
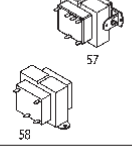

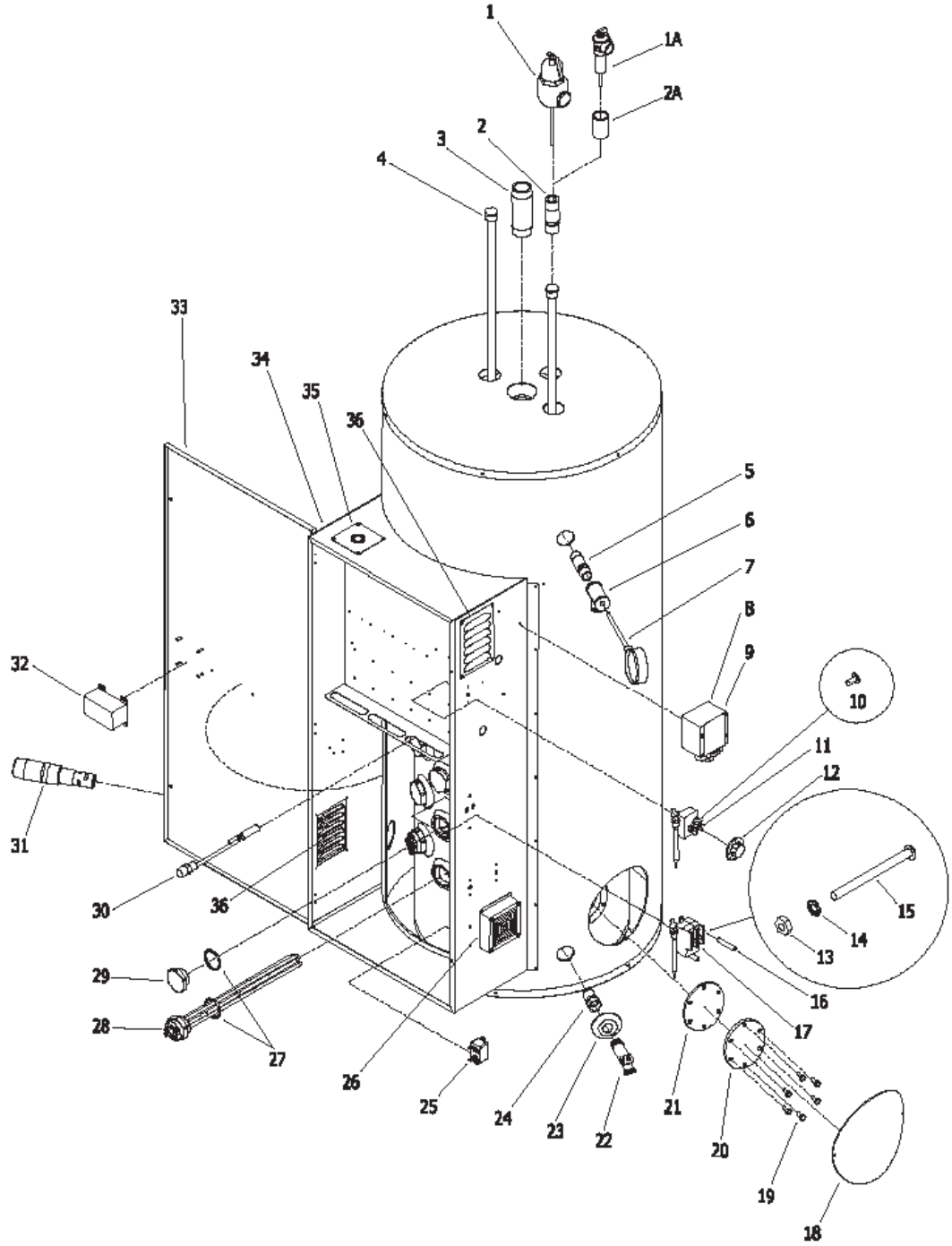


Figure 15



# Generic Parts List

CONTACTORS	TERMINAL BLOCKS	FUSE BLOCKS	TERMINAL STRIPS	FUSES	TRANSFORMERS	SEQUENCERS
						



<u>Item</u>	<u>Description</u>	<u>Item</u>	<u>Description</u>	<u>Item</u>	<u>Description</u>
1	T&P Relief Valve	21	Cleanout Gasket	41	Terminal Block "A"
2	Nipple Plastisert	22	Brass Drain Valve	42	Terminal Block End "A"
3	Hot Water Outlet Nipple	23	Finish Flange	43	Terminal Block 2 Pole
4	Magnesium Anode	24	Extender	44	Terminal Block 3 Pole
5	Nipple Galvanized	25	Alarm Horn Relay (optional)	45	Screw
6	Pipe Tee Galvanized	26	Alarm Horn (optional)	46	Fuse Block 2 Pole Class G
7	Combination T&P Gage (optional)	27	Heating Element Gasket	47	Fuse Block 3 Pole Class G
8	High Pressure Switch (optional)	28	Heating Element	48	Fuse Block 2 Pole Class T
9	Low Pressure Switch (optional)	29	Heating Element Plug	49	Fuse Block 3 Pole Class T
10	Screw	30	Low Water Switch (optional)	50	Terminal Strip
11	Immersion Thermostat	31	Low Water Switch (optional)	51	Terminal Strip 2 post
12	Thermostat Dial	32	Electrical Door Lock (optional)	52	Fuse Class G
13	Hex Nut	33	Control Box Door	53	Fuse Class T
14	Lock Washer	34	Control Box	54	Ground Lug Large
15	Screw	35	Knockout Plate	55	Ground Lug Small
16	High Limit Spacer	36	Louver Plate	56	Screw
17	High Limit Switch	37	Contactactor 2 Pole	57	Control Circuit Transformer
18	Cleanout Access Cover	38	Contactactor 3 Pole	58	Control Circuit Transformer (600 Volt)
19	Cleanout Cover Screw	39	Contactactor 4 Pole	59	Time Delay Sequencer
20	Cleanout Cover	40	Screw	60	Fuse Class CC

**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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