Chapter 10

Primary Controls


RESET

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Chapter 10

Primary Controls

Introduction

The safe, automatic operation of the system is dependent on the interaction between:

- The thermostat, which opens and closes a circuit based on temperature changes in the heated space
- The limit control, which opens and closes a circuit based on temperature or pressure changes in the boiler or furnace
- The primary control, which regulates the operation of the burner

In a properly designed, installed and serviced system, these three components work together to safely satisfy a call for space heating, cooling or water heating.

In a typical system, line voltage flows in a series circuit from the fuse or circuit breaker to a remote toggle (on/off) switch located away from the heating unit. From there, it continues to a service switch at the appliance, then to the limit controls, and then to the primary control, which distributes power to the burner components (motor, ignitor and oil valve).

Functions of the primary control

The primary control has three main functions:

1. To respond to the thermostat
2. To respond to the limit control
3. To control the startup, run cycle and shutdown of the burner

All primary controls, whether old thermo-mechanical or modern microprocessor, operate on the same basic principles.

The primary control accomplishes its mission by:

- Reacting to the presence or absence of flame
- Managing burner startup by checking for a flame before energizing ignitors, burner motors and oil valves
- Supervising burner shutdown once the thermostat is satisfied or the limit control opens

All primary controls have line voltage (120 VAC) circuits. In a basic heating system, line voltage is supplied to the primary control through the high limit control when the temperature in a water heater, water boiler or furnace, or the pressure in a steam boiler is below the limit setting. Once the limit control is satisfied, it breaks or opens the circuit, de-energizing the primary control and shutting down the burner.

Most primary controls also have low voltage circuits (24 VAC) to accommodate thermostats and/or other devices. The low voltage circuit is closed when the thermostat senses the need for an increase in room temperature. When the heat reaches the right temperature and the thermostat is satisfied, it opens the circuit.

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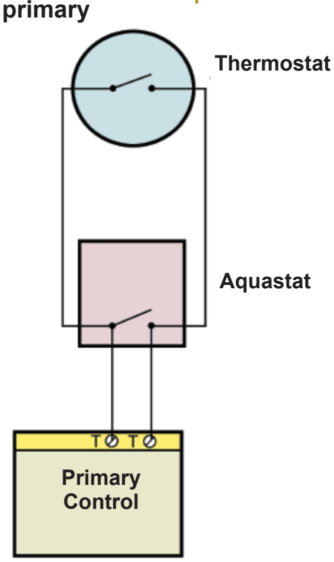
Figure 10-1: Parallel wiring for 24v thermostat and aquastat to the primary



For the primary control to activate the burner, both the line and low voltage circuits must be closed. In most cases, that means that if either the thermostat or the limit control is satisfied (open), the primary control will not activate the burner.

In systems with a line voltage thermostat, or with a low voltage thermostat connected to controls other than the primary control, a jumper is placed between the primary's thermostat terminals permanently closing the low voltage circuit. The primary control is then activated solely by the limit control.

Some systems have an additional control wired in parallel with the thermostat. In those cases, the primary's low voltage circuit can be completed through either the thermostat or the additional control. For example, a steam boiler with a domestic hot water coil will normally have an aquastat wired to the low voltage terminals on the primary control. This enables the boiler to maintain domestic hot water even when the room thermostat is not calling for heat. Figure 10-1.

Flame detection

Primary controls detect both the presence and absence of flame. A safety feature of primary controls is that they will not activate the burner for startup if the control senses a flame during the off cycle. This prevents additional fuel being pumped into a unit that has a fire before startup.

Primary controls must react quickly to the presence or absence of flame while the burner is running. The primary control must shut the burner off promptly if no flame is established on startup or if the flame is lost during the run cycle. If the primary control did not shut off the burner in these circumstances, the burner could continue to pump fuel into the unit, creating a hazardous condition.

Did you know?
Power outages do not affect flame detection. If power is lost during a running cycle, the control will NOT go off on safety and it will normally re-energize the burner after power is restored.

When the primary control shuts off the burner because no flame is detected, it is referred to as being "off on safety," "in safety" or "in lock-out." Once the primary control goes off on safety, it must be manually reset before it can send power to the burner again.

The amount of time that elapses from the start of a cycle in which flame is not detected to the time the control goes off on safety, is referred to as "trial for ignition" or "safety timing." Slight variations from an individual control's stated safety timing, often exist due to manufacturing tolerances, voltage variations and temperature changes.

Ignition modes

Systems operate in one of two ignition modes: intermittent duty or interrupted duty.

Intermittent duty ignition means that the spark across the electrodes that ignites the fuel is present whenever the burner is running.

Interrupted duty ignition means the spark comes on for a short time at the beginning of each burner operating cycle and is either:

- turned off once flame is established
- turned off after a period of time which may include time after trial for ignition (known as ignition carryover)—to ensure a stable flame is fully established

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Interrupted duty ignition is preferred because it makes for quieter combustion, increases the life of the ignition system components and uses less electricity.

Types of primary controls

There are two basic types of primary controls found in the field today:

- Thermo-mechanical primary controls. Although these have been obsolete for 50 years, there are still some out there.
- Cad cell primary controls. There are several different types of these in the field, the older models are also considered to be obsolete.

Obsolete Thermo-mechanical controls

This section is provided as a reference because there are, unfortunately, a number of these controls still operating in the field today. Modern systems operate much more efficiently and safely than systems that were installed when these controls were considered to be "state of the art." Technicians should recommend that their customers consider updating these systems.

Thermo-mechanical controls, commonly called "stack switches" or "stack relays", utilize bi-metals to detect flame and to mechanically open and close electrical contacts to provide burner control. They have spring loaded reset buttons and a thermal safety switch that must cool before the control is allowed to be removed from lockout. Figure 10-2.

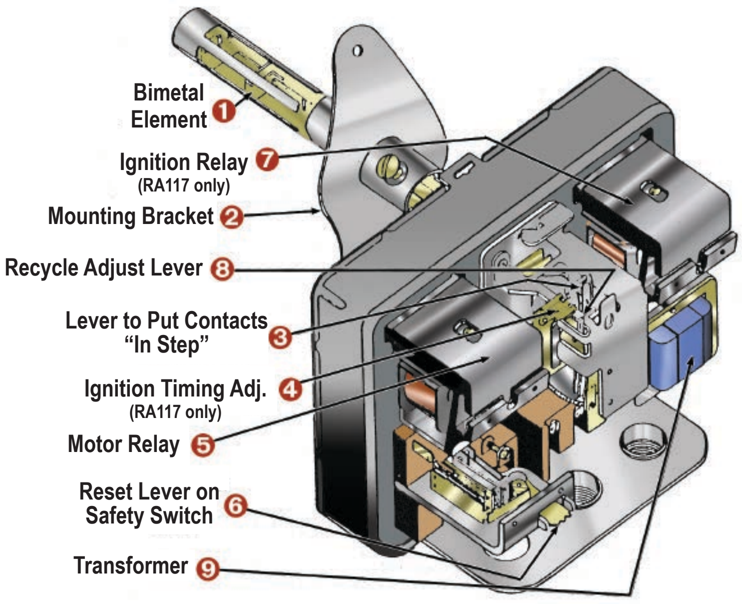
Through the 1960's, stack relays were the industry's standard primary control and there are many types of stack relays still operating in the field today. Fortunately, the manufacturers designed the wiring to be the same regardless of the make and model.

Stack relays are typically mounted in the flue pipe, although they may occasionally be found mounted directly into the flue collector or heat exchanger.

Flame detection

Stack relays employ a bi-metal heat-sensing element for flame detection. This heat-sensing element MUST be in the path of the combustion gases, between the heating unit and the draft regulator. It should be centered in the flue pipe at a point where it will be exposed to flue gases between 300° and 1000°F. When the burner operates, heat rises and passes over the bi-metal element, which expands and moves a shaft. This closes contacts that enable the burner to continue operating. If the bi-metal is not sufficiently heated, a built-in safety switch shuts the burner off in approximately 75 to 120 seconds and it cannot be started

Figure 10-2: Honeywell RA117a primary control



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again until the safety switch cools down and is manually reset.

Wiring

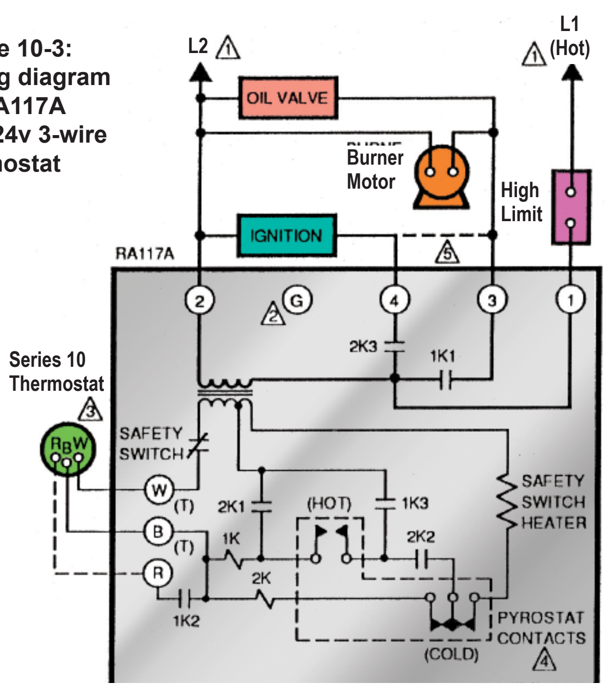
- The power or “hot” lead from the limit control is connected to Terminal 1
- All neutrals are connected to Terminal 2
- One wire from the burner motor and one from the oil valve, if used, are connected to Terminal 3
- If the unit operates as interrupted duty ignition, one wire from the transformer is connected to Terminal 4
- For intermittent duty ignition, connect the transformer lead to Terminal 3 along with the burner motor lead, leaving terminal 4 empty
- If the control has a green terminal, it should be connected to ground. Figure 10-3

Thermostat connections

If the control has two low voltage terminals for the thermostat connection, one of the thermostat wires connects to each.

If the control has three low voltage terminals and the system has a two-wire thermostat, it is connected to the W and B terminals. If a 3-wire heat-only thermostat is used, connect the red wire to Terminal R, white wire to W and black wire to B.

Figure 10-3: Wiring diagram for RA117A with 24v 3-wire thermostat



1. Power Supply, Provide Disconnect Means and Overload Protection as Required
2. Use Green Terminal to Connect Control Case to Ground
3. If Using a Two-Wire Thermostat, Tape Loose Ends of Red Wire (If Necessary)
4. Contacts Break in Sequence on Temperature Rise
5. To Replace an Intermittent Ignition Device, Connect Ignition Leadwire to Terminal 3, Instead of Terminal 4

Operation of a stack relay

If all components are functioning properly, the control is in standby mode until:

- Line voltage is applied through the limit control to Terminal 1, AND a call for heat from the thermostat completes the circuit between W and B, or T-T
- Then Terminal 4 will be powered and Terminal 3 will be powered a split second later
- The transformer will generate ignition through the electrodes
- The motor will turn the fuel pump and burner fan. If there’s a delayed oil valve installed, it will open based on its delay timing
- Once flame is established and heated flue gases pass over and expand the bi-metal detector element, the safety switch heater will be de-energized, preventing the unit from shutting off on safety
- The ignition circuit will be de-energized, shutting off the transformer if the unit operates on interrupted ignition

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11:01

- The burner will then continue to run until either the thermostat is satisfied, opening the low voltage circuit, or the limit control is satisfied, opening the line voltage circuit. Either of these actions causes the primary control to cut power to Terminals 3 and 4, safely shutting down the burner. The primary control then returns to standby mode

Safety check

It is important to check the safety timing of primary controls every time a service call is performed. To check the safety timing:

- Turn off the service switch at the unit
- Remove the stack switch from the flue pipe or block the flow of fuel by installing a pressure gauge in the nozzle port
- Turn on the service switch
- Make sure that both the line and low voltage circuits are complete
- The control should energize and shut off on safety in approximately 75 seconds
- If the control goes off on safety within 120 seconds, clean the bi-metal and reinstall it
- If the control does not go off on safety, replace it and be sure to check the timing on the new control
- Any system still operating with a stack relay is probably a good candidate for replacement with a high-efficiency system

Obsolete first generation cad cell primary controls

This information is included for reference only. These controls became popular in the early 1970’s and they offer several advantages over thermo-mechanical controls, Figure 10-4. However, today’s controls offer additional operational, safety and efficiency features that make it wise to offer them to customers.

Figure 10-4: First Generation CAD Cell Relay

While the basic functions of cad cell primary controls are the same as those of stack relays, they feature a much quicker reaction time through visual, as opposed to thermal, flame detection.

The cad cell primary control circuit is made up of two components: the flame detector and the primary control.

Flame detection

The flame detector consists of a cad cell, a holder to secure it in place, and a wiring harness to connect it to the primary control, Figure 10-5. The detector is installed in the air tube of the burner where it can view the flame.

Figure 10-5:Cad cell

Did you know? The burner manufacturer determines the location of the cad cell. If for some reason an alternate location must be used, make sure that:

- The cell has a clear view of the flame
- Ambient light does not reach the cell
- Ambient temperature is below the cell’s rating (approx. 140°F, see specs)
- Movement, shielding or radiation of metal surfaces near the cell does not affect cell function

The cad cell is a ceramic disc coated with cadmium sulfide and overlaid with a

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conductive grid. Electrodes attached to the ceramic disc transmit an electrical signal to the primary control. In darkness, cadmium sulfide has a very high resistance to the passage of electrical current. As the cell is exposed to light, its resistance decreases and current is allowed to pass.

For a cad cell relay to start the burner, the flame detector must sense the absence of flame and resist the passage of current. Once the burner starts and flame is established, the cell senses light, resistance drops and the burner continues to run.

If the cad cell does not sense enough light when the burner starts, the control will shut off on safety. It cannot be started again until the safety switch is manually reset. Note that electronic safety switches do not have to cool down before resetting. If the flame is lost during the running cycle, very early model controls will shut the system down after the safety timing (15 to 45 seconds) is reached; later models will make one attempt to restart.

Wiring

As with stack mounted primary controls, the major manufacturers adopted uniform standards regarding wiring connections for first generation cad cell primary controls.

In place of the numbered screw terminals on stack relays, cad cell relays have color-coded wire leads pre-attached to the solid-state circuitry. These wire leads from the control are connected to the wiring for the system components with wire nuts. Figure 10-6.

Cad cells can only see yellow and white flames. This is why they are not used on gas controls. New low NOx oil burners burn with a transparent to blue flame. Manufacturers are using infrared or ultraviolet detectors to see these new flames.

- The hot wire from the limit control is connected to the black wire of the cad cell relay
- The hot wire of the burner motor, ignitor and oil valve are connected to the orange wire
- The white wire is connected to the neutral lead along with the neutrals from the burner components
- The low voltage side of cad cell relays typically has two terminals labeled T-T, which can be connected to the thermostat
- The cad cell flame detector leads are connected to the F-F terminals

Operation

The most common first-generation cad cell primary controls a technician is likely to come across in the field are the Honeywell R8184G or the White Rogers 668. They both feature intermittent duty ignition and operate as follows:

If all components are functioning properly, the control is in stand-by mode until:

- Power is applied through the limit control to the black wire, AND a call for heat from the thermostat completes the circuit between T and T.
- Then, assuming that the cad cell does NOT sense light, the control is energized and the orange wire is powered.
- The ignitor generates ignition through the electrodes and the motor turns the fuel unit and burner fan. If there is an oil valve installed, it opens based on its delay timing.
- Flame is established and the cad cell resistance decreases to fewer than 1600 ohms, de-energizing the safety switch heater and preventing the unit from shutting off on safety.
- As long as the cad cell senses flame, the burner continues to run until either the thermostat or limit control is satisfied.

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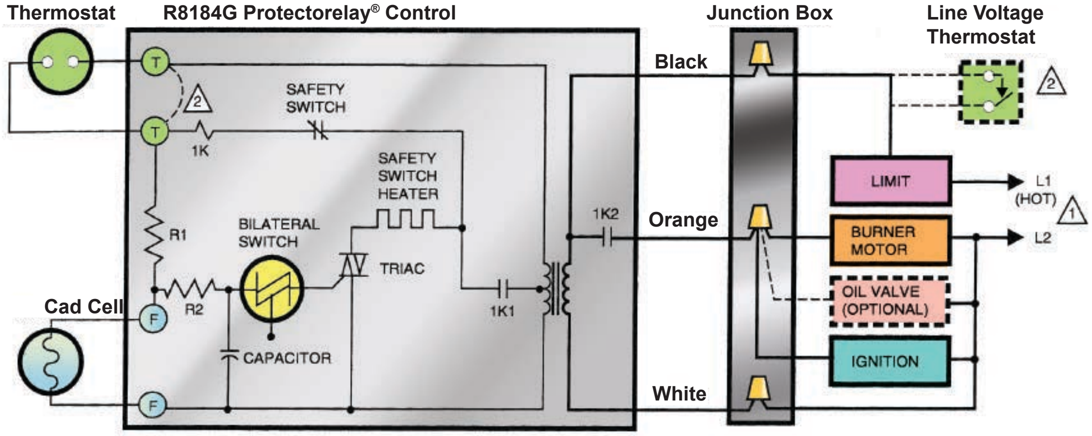

1 Power Supply, Provide Disconnect Means and Overload Protection as Required

2 To Use R8184 with Line Voltage Controller, Jumper T-T Terminals and Connect Line Voltage Thermostat in Series with Limit Controller.

Figure 10-6: Cad cell primary control & wiring

Safety check

To check the safety:

1. Turn off the power at the service switch.
2. Install a 1,000 ohm resistor across the F-F terminals to reduce resistance and simulate flame. It is OK to leave the cad cell leads hooked up.
3. Turn on the service switch and make sure that both the line and low voltage circuits are complete.
4. The control should NOT energize because the resistor connected to the F-F terminals simulates a fire in the chamber. If it does energize, replace the control.

If it does not …

1. Turn off the service switch and remove the resistor.
2. Disconnect one lead from the F-F terminals.
3. Turn on the electrical switch. The control should energize and the burner should lock-out based on safety switch timing (15 – 45 seconds). If the control does not go off on safety, replace it and be sure to check the timing on the new control.
4. If the control does go off on safety, reconnect the lead to the F terminal and press the reset button. The safety is working properly.

Troubleshooting tips

If the burner does not start:

Verify that electrical switches are in the 'ON' position and that the thermostat is set above room temperature. Be sure that there is not a fire burning in the unit.

Remove the primary control's cover and visually check to see if the spring-loaded mechanism has locked off on safety.

If the primary control is NOT off on safety, check for proper voltage coming from the limit control.

If there is sufficient line voltage, remove one lead from the F-F terminals. If the burner starts, the problem is in the cad cell sensor or wires. The cell may be sensing light or the wires may have been shorted.

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19:10

If the burner does not start, disconnect all the thermostat leads and install a jumper. If the burner starts, the problem is in the thermostat or its wiring.

If the primary is off on safety, check the combustion chamber to be sure the unit is not saturated with fuel. If the chamber contains excess fuel, follow company procedures to eliminate the fuel. Never attempt to fire a burner into a saturated chamber

If the chamber is free of excess fuel, press the reset button.

If the primary control energizes but the burner motor does not turn—shut off the service switch and check the electrical connections and the burner motor reset button.

If the burner runs and flame is established but the control shuts off on safety, disconnect the cad cell leads, press the reset and, before the unit shuts off on safety again, place a 1000-ohm resistor across the F-F terminals. If the burner continues to operate with the resistor in place, the cad cell relay is operating as designed and the problem is with the cad cell flame detector.

With the unit operating, connect the cad cell leads to an ohmmeter. A reading of zero ohms indicates a short circuit. Check for pinched or shorted cad cell wires.

If the resistance is infinite, check for broken cad cell wires or a loose or defective cell.

On most properly adjusted burners, the reading will be 400 ohms or less. Some burners with large static plates or small openings in the retention head operate in the 400–800-ohm range. Very few burners operate with resistance over 800 ohms.

If the reading is greater than 1600 ohms, there is a serious problem with the fire, the cad cell eye, its holder, its leads or its alignment. Remember the cad cell needs to have a good view through the air tube to the fire. Figure 10-7, below.

If the eye is coated with soot, it will not be able to "see" the flame. Clean the eye and continue troubleshooting to find out why the eye is dirty.

Obsolete second generation cad cell primary controls

Second generation cad cell primary controls have the same basic features as first generation controls, but steady advances in technology have led to a number of improvements.

For example, second generation cad cell primary controls have electronic reset

Figure 10-7

Cad Cell Check List

Ohmmeter Reading	Cause	Action
0 ohms	Short circuit	Check for pinched cad cell leadwires
Less than 1600 ohms but not zero	Cad cell and application are working correctly	None
Over 1600 ohms but not infinite	Dirty or defective cell, improper sighting or improper air adjustment	1. Clean cell face, recheck 2. Check flame sighting 3. Replace cell, recheck 4. Adjust air band to get good reading
Infinite resistance	Open circuit	Check for improper wiring, loose cell in holder or defective cell

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21:48

mechanisms which are not spring loaded. The reset button on these controls does not "pop-up" when the unit shuts off on safety. The reset does not have a thermal component so there's no cooling time required before the control can be reset. To bring the control out of safety lockout, simply depress the reset button for three seconds.

Typical second generation cad cell primary controls include:

Safety monitoring circuit

This circuit monitors the contacts of two separate, redundant motor relays. Safety lockout occurs if the contacts of either motor relay are found closed when they should be open, thus ensuring shutdown, even if one motor relay fails.

Interrupted duty ignition

These controls have an additional wire that is connected to the transformer or ignitor. With interrupted duty ignition:

- Electrodes and ignitors/transformers last longer
- Electrical consumption and operational noise are reduced
- Combustion problems leading to dirty boilers and running saturations are minimized

Recycle-on-flame-failure

Recycle-on-flame-failure means that instead of shutting off on safety on loss of flame during the run cycle, the burner will shut off within approximately 1.5 seconds. After a wait of 60-90 seconds, the control will attempt to restart the burner.

Operation

Second generation cad cell primary controls operate similarly to first generation controls.

If all components are functioning properly, the control is in stand-by mode until:

- Power is applied through the limit control to the black wire, AND the circuit between T and T is closed
- Then assuming that the cad cell does NOT sense light
- The control is energized and the orange and blue wires are powered
- The ignition and motor start
- After the cad cell senses flame, the ignition stays on for another 10 seconds, then shuts off

As long as the cad cell senses flame, the burner continues to run until the thermostat or limit control is satisfied.

If the control does not sense flame within the control's safety timing, lockout occurs. Pressing the reset button for 3 seconds resets the control.

Third generation cad cell primary controls

Third generation primary controls, such as the Honeywell R7184 and Carlin 50200 and 60200, include a microprocessor in the printed circuit boards. They feature interrupted duty ignition, fifteen-second safety timing and include several new features.

"Valve-delay-on" technology—depending on the manufacturer, this feature may be referred to as "valve-on-delay," "delayed-valve-on," or other similar wording. Through the use of an oil valve, "valve-delay-on" allows the burner motor to get up to speed delivering full flow from the fuel unit and full airflow from the fan before fuel flows from the nozzle. This optimizes fuel/air mixing at start up resulting in increased efficiency and a significant reduction of soot build-up.

"Motor-delay-off" technology—may also be referred to as "burner-motor-off-delay," or other similar wording. This feature

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Did you know?

Many people in our industry refer to **"valve-delay-on"** as "pre-purge" and **"motor-delay off"** as "post purge."

This is not correct. The primary controls' operations do not fit the Underwriters' Laboratories (UL) definition of pre- and post-purge.

allows the motor/fan combination to continue delivering full air flow for a period of time after the fuel flow through the nozzle has been cut off by an oil valve, resulting in cleaner shut downs.

Dry alarm contacts—These auxiliary electrical contacts close when the control goes into lock-out or latch-up. Through various added controls (i.e. an auto dialer) this can alert the homeowner, alarm company, and/or service company of the situation.

Limited reset—This feature protects against the repeated pressing of the reset button which floods the chamber with fuel.

If the control goes into lockout three times during a single call for heat, it goes into a restricted mode commonly called "latch-up." The control can be reset only twice, regardless of the number of times the reset button is pressed. Instructions for removing these controls from latch-up are printed on the underside of the control where the customer cannot see them.

Limited recycle—This feature limits the number of times the control will attempt to restart if the flame is repeatedly established and then lost, preventing excessive sooting from repeated combustion failure.

Diagnostic LEDs—These small, low-power lights provide a significant amount of information to help the service technician quickly and accurately diagnose the situation.

Figure 10-8

Fourth generation cad cell primary controls

The newest primary controls on the market include the Honeywell 7284, Beckett Genysys and Carlin ProX. 70200. Figure 10-8.

Fourth generation controls include the features of third generation and may include additional features such as:

- A pump priming cycle to facilitate purging air from the fuel lines and filter(s).
- Adjustable trial for ignition, valve-on delay and motor-off delay, flame stabilization and lock out threshold.
- User interfaces that allow the technician to program and troubleshoot the control.
- LCD screens that display burner status and fault history.

Video training for some current controls can be found on NORA's technical website: *Learning.NORAweb.org*.

Primary controls have evolved from simple stack switches to microprocessor-based controls that offer greater reliability, safety and efficiency. Control manufacturers continue to develop new products with advanced features that will make the controls in use today seem as obsolete as thermo-mechanical controls are now.

For specific information regarding wiring, operation and troubleshooting refer to the manufacturer's instructions.

The next section contains specific information for third generation controls and Riello controls.

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28:34

Specific Microprocessor-Based Primary Controls

The following section is intended strictly as an overview. While other manufacturers may have similar controls, these are the units that you are most likely to encounter. Also, remember that manufacturers periodically add improvements and additional features to their controls.

It is critical to consult product specific literature to verify information regarding individual controls, even if they are familiar to you.

Honeywell

Honeywell R7184 (also sold as Beckett R7184)

Honeywell's controls differ from Carlin's. It is extremely important to note that some Honeywell models utilize different wire color-coding.

Standard features of the Honeywell R7184 include:

Limited reset—This control can be reset only two times before it goes into "restricted lockout," or latch-up mode. The reset count returns to zero each time a call for heat is successfully completed. To reset the control from latch-up, press and hold the reset button. The LED will go out. Continue holding the button for approximately 30 to 45 seconds until the light comes on again.

Limited recycle—Should the flame be lost while the burner is firing, the control shuts down the burner, enters a 60 second recycle delay and then attempts a restart. During the recycle delay, the LED will flash slowly—two seconds on, two seconds off. Do not confuse this with the burner being "in lockout." If the flame is lost three consecutive times without successfully satisfying a call for heat, the control goes into lockout and must be reset manually.

Diagnostic LED—The diagnostic LED has four states:

- On—flame present
- Off—no flame
- 2 seconds on, 2 seconds off—recycle
- 1/2 second on, 1/2 second off—lockout and latch-up

The LED can also be used to check cad cell resistance. When the burner is running after the ignition has turned off, quickly press and release the reset button. Hold it for only a half-second or less. The LED will flash from one to four times depending on the cad cell resistance:

- If the light flashes once—cad cell resistance is normal: 0-400 ohms
- Two flashes mean resistance is normal: 400–800 ohms
- Three flashes are normal: 800–1600 ohms
- Four flashes indicate limited resistance of more than 1600 ohms
- Lockout can occur above 4000 ohms

Pump priming cycle—To facilitate priming, the control can be placed in a purge routine by pressing and quickly releasing the reset button while the ignition is on. If the control has not locked out since its last complete heating cycle, the lockout timing will be extended for up to 4 minutes and the ignition will operate in the intermittent mode for this cycle only.

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31:57

Honeywell—continued

Communications port—Many Honeywell residential combustion controls have a communications port that allows for data interchange between the control and other products, such as diagnostic tools, modems, zoning systems, and home automation.

Wiring the Honeywell R7184

Currently there are four models of the R7184: A, B, P and U. On each model, the thermostat leads and cad cell leads connect to the appropriate terminals.

R7184A

- The black wire connects to the limit control
- The white wire connects to all neutrals
- The blue wire connects to the ignitor or transformer
- The orange wire connects to the burner motor

R7184B

The B model has a 15-second "valve-on delay" feature requiring the installation of an oil valve. This control has an added violet wire that connects to that valve. The other wire from the valve is connected to the neutrals. All other wiring is consistent with the A model.

R7184P

The P model has both a fixed 15-second "valve-on delay" and a "burner motor-off-delay" feature which may be field selected to 30 seconds, 2 minutes, 4 minutes or 8 minutes or fixed at 15 seconds. In addition to the violet wire for "valve on delay," there is a red wire that connects to the limit control, while the black wire connects to constant power to achieve the "burner motor-off delay" feature. All other wiring is consistent with the B model.

R7184U

The U model has all the features of the P models with selectable on and off delays, plus low voltage dry alarm contacts that are located above the thermostat terminals. The U model offers the ability to adjust dip switches that enable or disable both the valve on delay and the "burner motor-off delay." This makes the U model control the same as the A control. This way only one control needs to be carried in the service vehicle. All other wiring is consistent with the P model.

Model designations and revisions

Honeywell puts the model designations and revision information for the R7184 next to the control part number and/or prints it on the side of the control. Revisions are numerical and indicate which improvements or changes are included in the particular control. For example, Series 1 controls have different cad cell indicator ranges; Revision 2 changed the pump priming cycle from 45 seconds to 4 minutes and added the limited recycle. Some revisions have wires, while others have spade connectors.

Series 4 and later controls have added

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safety features. If a Series 4 control detects flame eight seconds into "valve on delay" or 30 seconds into "burner motor-off-delay," the control will go into lock-out. This is to prevent poor starts and shutdowns due to bad oil valves. This means that these controls CANNOT be operated without an oil valve. If the fuel unit must be replaced, the replacement model MUST be equipped with either an integral or external oil valve. It also means that when replacing an earlier control with a Series 4 or later control, the violet and/or black wires cannot simply be "capped off "as could be done with earlier revisions.

Sequence of operation

The Honeywell R7184U is considered a universal replacement since it can be configured to replace all other 7184 models by adjusting dip switches. This is how it operates:

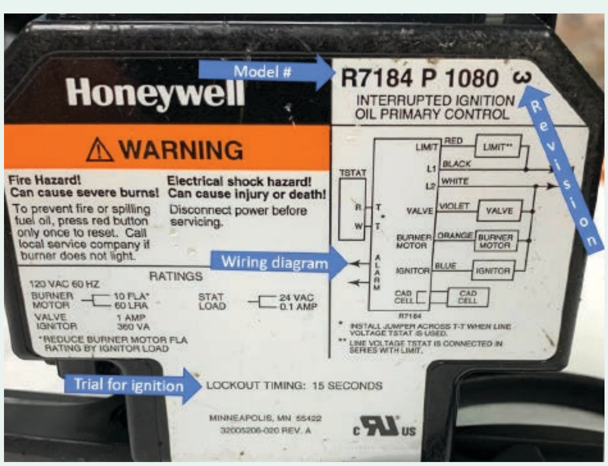
Standby: When a call for heat is initiated, there is a 2 to 6 second delay while the control performs a safe start check. If no flame is sensed and all internal conditions are correct, the control enters "valve on delay" mode and the ignition and motor are powered for 15 seconds.

Trial for ignition: Then the control goes into "trial for ignition." The oil valve is powered and opens. Flame should be established within the "trial for ignition" timing of 15 or 30 seconds. If no flame is sensed by the end of "trial for ignition," the control goes into lockout and must be manually reset. The dry alarm contacts close and complete the circuit to activate any remote alarm that is connected.

Carryover: Once the flame is established, the ignition remains on for 10 seconds to ensure flame stability, then shuts off. The burner will then run until the call for heat is satisfied, at which time the power to the oil valve will shut down.

Burner motor off delay: The motor will continue to operate from 30 seconds to 8 minutes depending on how the dip switches are set. Once this "burner motor-off delay" cycle has been completed, the control returns to standby mode.

Model 7184



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Specific Microprocessor-Based Primary Controls

The following section is intended strictly as an overview. While other manufacturers may have similar controls, these are the units that you are most likely to encounter. Also, remember that manufacturers periodically add improvements and additional features to their controls.

It is critical to consult product specific literature to verify information regarding individual controls, even if they are familiar to you.

Carlin

- Model numbers can be found just above the thermostat and flame detector terminals
- Wiring diagrams are to the left, and the controls timings are listed above the model number
- For example, the model 60200 control has a 10 second valve delay on (Pre), a 15 second trial for ignition (TR) and a 10 second motor delay off (Post).
- There may also be a revision designation printed on the lower right side of the label. This control is a Revision C.

Carlin's microprocessor based controls, models 50200 and 60200 feature:

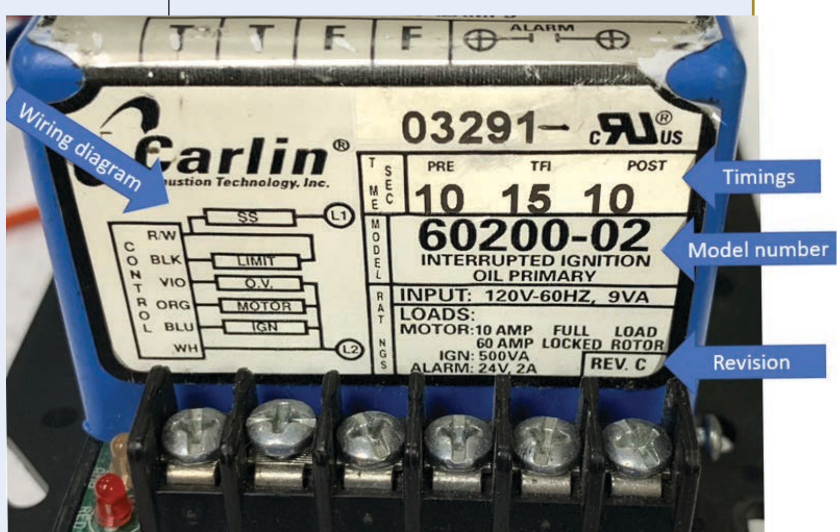
Limited reset—also known as "Serviceman Reset Protection." Once these controls go into lockout three consecutive times without establishing flame, the control will go into latch-up. In order to release them from latch-up, depress and hold the reset button. After 10 seconds, the two diagnostic lights will blink alternately. After another 20 seconds, the lights will stop blinking. Release the button to complete the reset procedure.

Recycle-on-flame-failure—in the event of flame loss during the run cycle, within approximately two seconds the 50200 will shut the burner off and the 60200 will turn off power to the oil valve and complete a "motor-delay-off" cycle. After a wait of 60-90 seconds, the red LED light will flash for 65 seconds, then the control will attempt to restart the burner.

If flame is established during the "trial for ignition" period, the burner will resume normal operation. If flame is not established in the "trial for ignition" period— the control will go into lockout.

Diagnostic LEDs—these primary controls have two diagnostic LEDs: one red and one amber.

- Amber-on signals that the control is in self-test
- Red-on indicates that the control is in lockout



Model 60200

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- Amber and red-on indicates that the control has locked out three times during a single call for heat and is in latch-up
- Red flashing indicates that flame has been lost during a run cycle, after trial for ignition
- Amber blinking-off every 3 to 4 seconds while the control is in the standby mode indicates that the cad cell is sensing light, or a diagnostic fault which disallows startup

Wiring

Thermostat and cad cell leads connect to the appropriate terminals.

The 50200 is connected in the same way as earlier interrupted-ignition cad cell relays:

- The black wire connects to the limit control
- The white wire connects to all neutrals
- The blue wire connects to the ignitor or transformer
- The orange wire connects to the burner motor

The 60200 control has both "valve-delay-on" and "motor-delay-off" features, so the wiring is slightly more complicated:

- The black wire connects to the limit control
- The white wire connects to all neutrals
- The blue wire connects to the ignitor or transformer
- The orange wire connects to the burner motor
- The violet wire connects to the oil valve
- The red wire with white tracer (stripe) connects to constant power

Operation

The Carlin 60200 operates as follows:

Each time power is applied to the red wire with white tracer, the control performs a boot up test to verify internal operation. After about 4 seconds, the amber LED comes on. The test continues for 6 more seconds and, if successful, the amber light turns off. If the test is not successful, the control repeats the test until successful.

When a call for heat is initiated, the amber LED turns on and there is a 3 to 4 second delay while the control performs a safe start check. If no flame is sensed and all internal conditions are correct, the LED turns off and the control enters "valve-delay-on" mode. The ignition is powered and one second later, the motor is powered.

After completion of the "valve-delay-on" cycle, the control goes into "trial for ignition." The fuel valve is powered and opens. Flame should be established within the "trial for ignition" period of 15 seconds. If the flame is not sensed by the end of "trial for ignition," the control goes into lockout, the red LED comes on and the dry alarm contacts close. The control must be manually reset by pushing the reset button for one second and releasing.

Once the flame is established, the ignition remains on for a short time to ensure flame stability and then shuts off.

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Specific Microprocessor-Based Primary Controls

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It is critical to consult product specific literature to verify information regarding individual controls, even if they are familiar to you.

Riello primary controls

Riello primary controls are designed exclusively for use on Riello burners.

The Riello primary control, in combination with the coil of the oil valve and a cad cell, monitors and controls all functions of the burner. An auxiliary tap on the motor windings provides a 46-volt AC power supply to operate the control. The oil valve provides the starting and running circuits for the primary control through a logic board and safety lockout switch. The ignition transformer is integrated into the primary control and provides interrupted-duty ignition.

There are no thermostat terminals on current Riello primary controls. An additional device, such as a switching relay, must be used for low voltage thermostat connections.

The Riello control's safety switch is equipped with a contact allowing remote sensing of burner safety lockout. Should burner lockout occur, 120 Volts AC is supplied to sub-base Terminal 4 to activate any connected remote alarm systems.

Wiring

- All wiring is connected through the control's sub-base terminals
- A wiring diagram is supplied with each control and serves as an insulator on the underside of the control. This diagram should always be left in place to protect the printed circuit board of the control
- When working on these controls, most experienced Service Technicians refer to Riello's plastic laminated troubleshooting card or the troubleshooting guide provided in the training manual

Operation

If all components are functioning properly, the control is in standby mode until 120 volts is supplied through the limit control to Terminal 5. Then assuming that the cad cell does NOT sense light:

- The control is energized and Terminal 6 is powered, providing 120 Volts AC to the motor
- The auxiliary winding tap provides 46 Volts AC to power the control
- The motor starts and establishes a 10-second "valve-delay-on"
- The oil valve opens, supplying fuel to the nozzle line, and at the same time the ignition is powered
- Once the cad cell senses flame, the ignition circuit is opened and the spark shuts off
- As long as the cad cell senses flame, the burner continues to run until the demand for heat is satisfied
- If the control does not sense flame within approximately 5 seconds after

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"valve delay-on," the control shuts the burner "off on safety"

- If the cad cell loses sight of the flame at any time during the firing cycle, the control immediately closes the oil valve to prevent fuel flow, then goes back into "valve-delay-on" mode and makes one attempt to relight

Safety check

- Turn off the service switch
- Remove the control box from the sub-base
- Remove the cad cell from the control box
- Replace the control box on the sub-base
- Turn on the service switch and make sure that the line voltage circuit is complete

The control should energize and the burner should "go off on safety" approximately 5 seconds after the "valve-delay-on" cycle. If the control does NOT "go off on safety", replace it and be sure to check the timing on the new control.

Troubleshooting tips

In general, it is good practice to check that the control box spades and sub-base terminals are making good contact, and to verify that there is between 42 and 52 Volts AC between terminals 3 and 7 while the motor is running.

If the burner stays in "valve-delay-on," check for the following before condemning the control:

- Cad cell faulty or sensing light before "trial for ignition"
- Coil wires are reversed on Terminals 1 and 2 or on Terminals 1 and 8
- Open coil circuit, Terminals 2 and 8. To check this, connect an ohmmeter between terminals 2 and 8; if the coil circuit is open, the reading will be 0 ohms
- Open coil circuit, Terminals 1 and 2. Reading should be 1235 ohms or less
- *Note—this is for the 530 SE primary control only. An open coil circuit on Terminal 1 will cause the 483 SE control to lock-out*
- Insufficient voltage between Terminals 3 and 7. It should read 42 to 52 Volts AC. If the voltage is lower, check the incoming supply. If there is proper incoming voltage, above 102 Volts AC, change the burner motor

If a burner with a 530 SE control continues to purge and light off with immediate flame dropout, or a burner with a 483 SE control cycles on and off in quick succession, check the following:

- The metal yoke for the coil may be missing or improperly installed
- Coil wires 2 and 8 may be reversed
- There may be low resistance on the coil holding circuit, Terminals 1 & 2. Resistance should be 1350 ohms, plus or minus 10%. If the resistance is low, change the coil

Chapter 10: Additional Resources

NORA has compiled a library of additional technical resources for your continued education. Scan the QR code or go to the web address. Check back often, as NORA will continually add content as it becomes available.

You will find:

- Videos
- Technical Bulletins
- Instructions
- and More

https://Learning.NORAweb.org/primary_controls