

# 11 Operating information

## General

### How the boiler operates

The Knight XL uses an advanced stainless steel heat exchanger and electronic control module that allows fully condensing operation. The blower pulls in air and pushes flue products out of the boiler through the heat exchanger and flue piping. The control module regulates blower speed to control the boiler firing rate. The gas valve senses the amount of air flowing into the boiler and allows only the right amount of gas to flow.

### How the control module operates

The SMART SYSTEM control module receives input from boiler sensors and external inputs. The control module activates and controls the blower and gas valve to regulate heat input and switches the boiler, Domestic Hot Water (DHW), and system pumps on and off as needed. The user programs the module to meet system needs by adjusting control parameters. These parameters set operating temperatures and boiler operating modes. Boiler operation can be based on boiler outlet water temperature, boiler inlet water temperature, or system temperature, depending on the parameter setting.

### Control inputs and outputs

#### Room thermostat / zone control

This input tells the boiler to provide water for space heating.

#### Domestic Hot Water (DHW) tank thermostat

This input tells the boiler to provide water for heating an indirect DHW tank.

#### 0 - 10V input (set point or power)

The Knight XL can be controlled by a Building Management System (BMS) using a 0 - 10 VDC signal. The control can be configured by the installer to use this signal to either control set point or firing rate.

#### DHW priority

The SMART SYSTEM control module allows connection of a DHW thermostat to the low voltage connection board. When the DHW thermostat calls for heat, the module activates the DHW pump, shuts down the boiler pump, and immediately sets the target outlet water temperature to 180°F (82.2°C). This provides automatic priority heat allocation to the indirect water heater for maximum response and recovery. The DHW pump continues for 30 seconds after the heating cycle to deliver the most possible heat.

### DHW / space heating (SH) cycling

If a DHW call for heat is received while a space heating call is in progress, the control will start the DHW pump and shut the boiler pump off. The system pump will remain on. If the space heating call is still active while the DHW call is in operation, the control will wait for 30 minutes (time adjustable by installer) then it will switch back to the space heating demand. The control will switch back and forth until one of the heat demands end. This function does not apply to cascade systems.

### Programmable controlling sensor

The control module is programmed to use the outlet sensor as the control sensor by default. If a system supply sensor is connected, the control automatically uses it as the control sensor. The control sensor can be changed by the installer to the inlet sensor. If the inlet sensor is chosen as the controlling sensor, it is recommended that the system supply sensor be installed.

### Anti-cycling

After a space heating demand has been satisfied, the control will delay the next space heating call for a set time period (time is adjustable by the installer). The time delay will be bypassed if the inlet water temperature drops too far during the delay.

### Boiler, system, and DHW pump control

When a space heating call for heat starts and no DHW call is on, the system and boiler pumps are turned on. As long as the space heating call for heat is on, the system pump will remain on. If a DHW call for heat is on, the boiler pump will wait to turn on until just before the DHW pump turns off. After the space heating call for heat ends, both pumps will run for an additional period of time.

When a DHW call for heat starts, the DHW pump is turned on. If a space heating call for heat was on, the boiler pump will turn off a few seconds after the DHW pump turns on.

### Temperature control

#### Modulation

The Knight XL is capable of modulating its firing rate from a minimum of 20% to a maximum of 100%. The firing rate is dictated by the call for heat (i.e., space heating or domestic hot water), the heating load, ramp delay (if enabled), and various other temperature limitations.

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## Ramp delay

For systems with lower flow, the SMART SYSTEM can limit the firing rate (when enabled) when a space heating call for heat starts, or when switching from a DHW call for heat to a space heating call for heat. There are six (6) limits that can be programmed, as well as six (6) time intervals corresponding to each limit. The sixth limit will also limit the firing rate for the rest of the call for heat.

## Gradient limiting

If during operation of the boiler the outlet water temperature is rising too quickly, the control will reduce the firing rate to its lowest setting.

## Outdoor air reset

If an outdoor air sensor is connected, the control module will calculate the set point based on the programmed reset curve. The installer can change the slope of the reset curve by several adjustable parameters. The user can limit the maximum set point for the system using the space heating set point.

## Boost function

If outdoor air reset is active, and a space heating demand has been active continuously for a set period of time (time adjustable by installer) and there has been no DHW demands, the control will increase the set point by a fixed number of degrees (adjustable by installer). This process will continue until the space heating demand ends, the set point reaches the programmed set point or a maximum of 20 increases has occurred. Once the system heat demand is satisfied, the set point will revert to the value determined by the reset curve.

## Night setback

The controller may be programmed to reduce the space heating set point during a certain time each day. A start and stop time can be programmed for each day of the week.

## Flame current support

To prevent nuisance shutdowns when the boiler is firing at minimum rates, the control will increase the firing rate when the flame signal drops too low.

## Protection features

### Outlet temperature, flue temperature, and temperature rise limiting

The outlet temperature is monitored by the boiler outlet temperature sensor. When the outlet temperature exceeds 185°F, the unit will reduce the fan speed. If the outlet water temperature exceeds 195°F (90°C) the control will shut the unit down until it cools off.

The control module monitors the flue temperature by a sensor located in the flue exhaust. If the flue temperature exceeds 215°F (102°C) the control will reduce the maximum fan speed. If the flue temperature exceeds 240°F (115°C) the control will shut the unit down. The unit will restart automatically once the flue temperature drops 25°F (-4°C) and the minimum off time has expired.

The control monitors the temperature difference between the inlet and the outlet sensor. If this difference exceeds 55°F (13°C) the control will reduce the fan speed. If the temperature difference exceeds 60°F (15°C) the control will shut the unit down. The unit will restart automatically once the temperature difference has dropped below 55°F (13°C) and the minimum off time has expired.

### Freeze protection

DO NOT install the boiler in a room likely to freeze.

The following integral feature of the SMART SYSTEM control module provides some protection for the boiler only -- not for the system.

- The SMART SYSTEM control module provides freeze-up protection as follows when the boiler water temperature drops below 45°F (7°C):
- Below 45°F (7°C), the boiler and system pumps operate constantly.
- Below 37°F (3°C), the boiler turns on.
- Boiler and pumps turn off if boiler water temperature rises above 45°F (7°C).

### **⚠ CAUTION**

This feature of the SMART SYSTEM control module does not eliminate the possibility of freezing. The installation must still use recognized design, installation and maintenance practice to prevent freeze potential for the boiler and system.

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## Monitor external limits

Connections are provided on the connection board for external limits such as flow switch, low water cutoff, gas pressure switches, and an auxiliary device proving switch. The SMART SYSTEM will shut off the burner and inhibit relighting whenever any of these external limits open.

## Run-time and alarm outputs

The boiler provides dry contacts for indicating when the boiler is running, and when it is unable to operate.

## Run-time and cycle counting

The control uses two timers to monitor the total hours of burner operation. One timer monitors the time the boiler is firing under 50% of rate. The other timer monitors the time the boiler is firing over 50% rate.

The control uses four (4) ignition counters to monitor the amount of boiler cycles. The first counter counts all ignitions of the control. The second counter counts only ignition attempts that have failed. The third and fourth counters are the same as the first and second respectively, but can be reset by the installer.

## Service reminder

The control can be programmed for service reminder notification. This notification will become active when either a set time frame has expired, or a set amount of running hours or cycles has expired (all adjustable by the installer). The display will alternate the standard text on the display screen with Service Due every 5 seconds. The service reminder notification can be reset by the installer.

## Error logging

The control will hold in memory the last 10 error codes as well as the last 10 turn-off functions. The date and time of the occurrence will be recorded as well. Only the 10 most current occurrences will be held in memory.

## Boiler temperature regulation

### Operating temperature (target)

The SMART SYSTEM control module senses water temperature and regulates boiler firing and firing rate to achieve a target temperature. The target temperature can be set between 70°F (21°C) and 190°F (88°C).

- Target temperature is fixed when the outdoor sensor is not installed.
- Target temperature is calculated as described on this page under “Outdoor Reset Operation” and “Target Temperature Boost” when the outdoor sensor is connected.

## High limit operations

When outlet temperature exceeds 200°F (93.3°C), high limit action occurs. The boiler shuts down until the outlet water cools down.

## Low water cutoff protection

1. The SMART SYSTEM control module uses temperature sensing of both supply and return areas of the heat exchanger. If the flow rate is too low or the outlet temperature too high, the control module modulates and shuts the boiler down. This ensures boiler shutdown in the event of low water or low flow conditions.
2. Some codes and jurisdiction may accept these integral features of the control in lieu of requiring an additional limit control or low water cutoff. Consult local jurisdiction to determine. A low water cutoff is available from the factory (WTR20009).

## Outdoor reset operation, if used

### Target temperature with outdoor reset

This feature improves the system’s efficiency as the outdoor temperature warms up.

See the Knight XL Service Manual to change the settings.

### Reset curve

The reset curve looks at outdoor air temperature and adjusts the set point.

### Cascade

When multiple boilers are installed, they can be wired together in a cascade sequence. A maximum of eight boilers can be controlled from a single control. In this application one boiler would be designated as the Leader control and all others would be designated as Member controls.

Once the Leader boiler receives a call for heat from a room thermostat, the control will determine what the set point will be. If outdoor air reset is desired, connect the outdoor air sensor to the terminals on the Low Voltage Connection Board on the Leader boiler. The set point will be calculated based on the programmed reset curve parameters. See the Knight XL Service Manual to program the reset curve. If outdoor air reset is not desired, do not connect the outdoor air sensor. A fixed temperature set point can be programmed into the control. See page 54 of this manual to program the set point.

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## **Cascade** *(continued)*

If the water temperature at the system supply sensor is less than the set point + the turn-off offset - the off-on differential, then the control will initiate a call for heat on the Cascade (see the Knight XL Service Manual for an explanation of the offset and differential). The Leader will energize the lead boiler on the Cascade. For a new startup this will be the Leader boiler.

The boiler will fire at its ignition speed and will then modulate its firing rate to maintain the set point. If the first boiler reaches 100% of its firing rate, the Leader will calculate at what point the second boiler could fire at 20% of its firing rate. At this point, the Leader will fire the second boiler on the Cascade. For a new startup, this would be the first Member boiler. The boiler will fire at its ignition speed and will then modulate its firing rate to maintain the set point.

If the set point still cannot be met, the Leader will continue firing more Members until either the heat demand is met or all boilers on the Cascade are firing. As the heat demand decreases, the last boiler on will modulate down to 20% of its firing rate. Once the demand for that boiler is zero, it will shut down. As the heat demand decreases further, the second to last boiler will modulate down and shut off. This will continue until the demand is satisfied and all boilers are shut off.

### **Sequence of the cascade**

To equalize the run time of all boilers on the Cascade, the firing sequence will automatically be changed at set intervals.

For the first 24 hours after initializing the Cascade, the sequence will be changed every hour. After that the sequence will be changed once every 24 hours. The switching on/off sequence will be as follows:

DAY	SWITCHING ON SEQUENCE
Day 1	L-M1-M2-M3-M4-M5-M6-M7
Day 1 + 1 hour	M1-M2-M3-M4-M5-M6-M7-L
Day 1 + 2 hours	M2-M3-M4-M5-M6-M7-L-M1

## **DHW, Night Setback, and Ramp Delay operation with cascade**

For DHW operation any boiler(s) in the Cascade can be selected to provide heat for a DHW call. Select a boiler to be designated as the DHW boiler. Connect the DHW thermostat to the terminals on the Low Voltage Connection Board marked for the DHW Thermostat. When the boiler receives a DHW call, the Leader control will take that boiler out of the Cascade sequence. If another boiler is available, the Leader will start it up to take its place.

The DHW boiler will adjust its set point to the programmed DHW set point and will adjust its firing rate to maintain this. Once the DHW call has been satisfied, the Leader control will place that boiler back into the Cascade sequence.

Switching of the boiler between DHW operation and SH operation when there is a call for both does not occur. The boiler will provide heat for the DHW demand until it is satisfied.

Night Setback operation of the boilers within the Cascade is available. Programming of the Night Setback will be done through the Leader boiler. Refer to the Knight XL Service manual for information regarding Night Setback.

Ramp Delay operation of the boilers as described in the Knight XL Service Manual is not active when the boilers are part of a Cascade system.

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## Sequence of operation

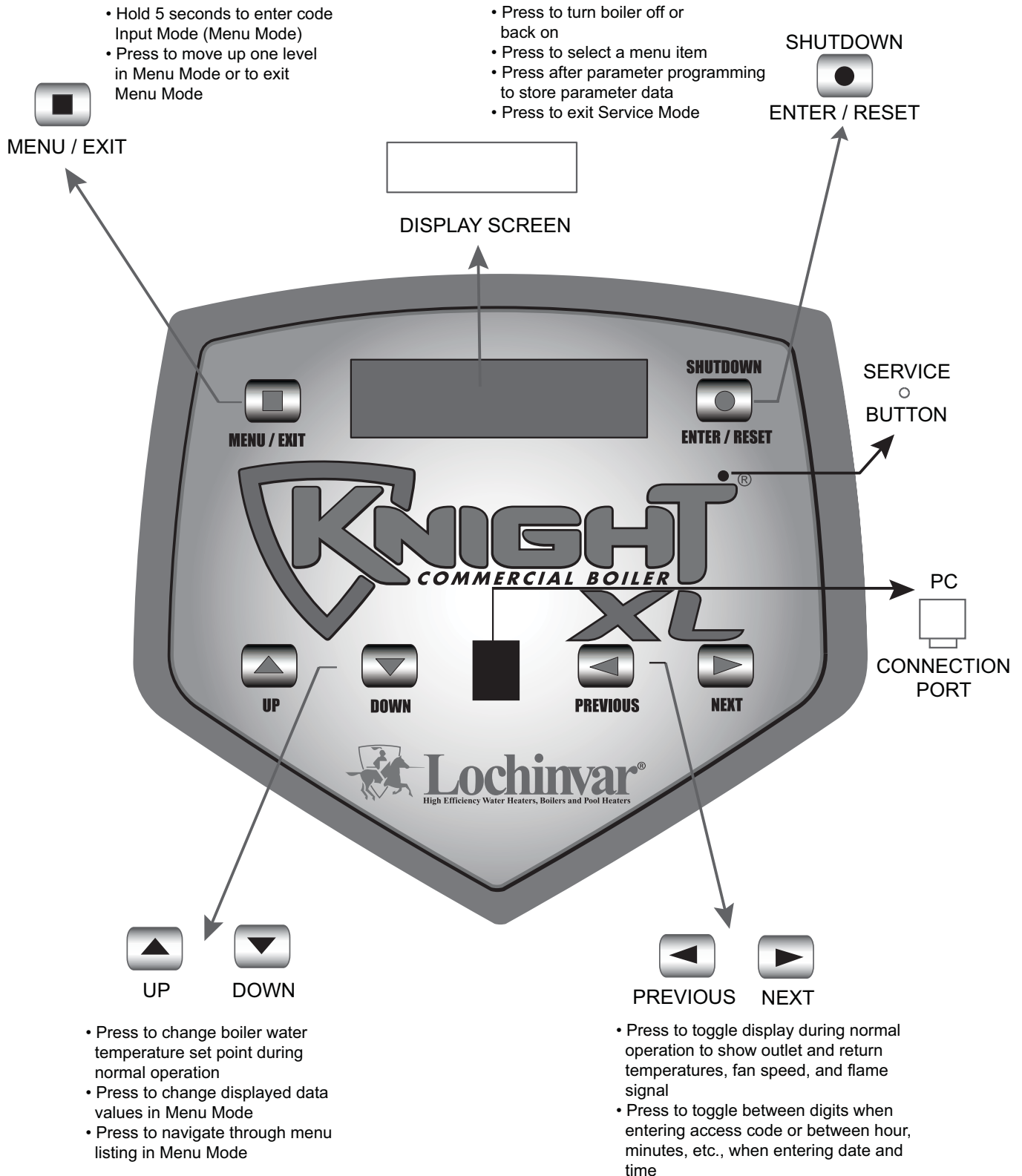
OPERATION	DISPLAY
1. Upon a call for heat, the control turns on the appropriate pumps (system and boiler pumps for space heating call; DHW pump for DHW call).	BLR: Standby OUT: 123.8F (129)
2. The control connects 120 VAC to the blower. The blower does not run at this time. <ul style="list-style-type: none"> <li>• The manual reset high limit must be closed and reset.</li> <li>• Once the pumps are turned on, the flow switch must close.</li> <li>• If the unit is equipped with gas pressure switches, they must close.</li> <li>• If an auxiliary limit is connected to the unit, it must close.</li> <li>• The air pressure switch must be closed.</li> </ul>	BLR: Standby OUT: 123.8F (129)
3. The control then starts a 15 second prepurge cycle.	BLR: PREPURGE OUT: 123.9F (129)
4. Once the prepurge cycle is complete, and the blocked drain switch is closed, the control starts the 4 second trial for ignition by sending spark voltage to the spark electrode and opening the gas valve.	BLR: IGNITION OUT: 123.9F (129)
5. If the control does not detect flame before the trial for ignition ends, the control will perform a 10 second postpurge. The 399 model will start another prepurge and trial for ignition. If the burner does not light after 4 trials on the 399 model, the control will lock out for one hour and then try again.  If the burner does not light after 1 retry on Models 500 - 800 the control will lock out.	BLR: POSTPURGE, PREPURGE OUT: 123.9F (129)
6. If the control detects a flame before the trial for ignition ends, it begins to modulate the burner in order to maintain the set point. If the boiler lights due to a space heating call for heat, and the ramp delay function is active (default is off), the modulation will be held to a series of increasing limits after the burner has lit.	BLR: SH 20% RATE OUT: 124.8F (129)
7. If the space heating call for heat is active, and the DHW thermostat or sensor starts a DHW call for heat, the control will turn on the DHW pump, wait 2 seconds, and then turn off the boiler pump. This will divert the hot water away from the heating zone(s) and send it to the DHW tank instead. The control will then modulate to maintain the outlet temperature to the DHW boiler set point.	BLR: DHW 85% RATE OUT: 177.8 (180)
8. If the boiler is not part of a cascade, and the DHW call for heat remains active for more than 30 minutes, and the space heating call for heat is also active, then the control will turn on the boiler pump, turn off the DHW pump after 2 seconds, and resume modulating based on the space heating set point. As long as both the space heating and DHW calls for heat remain active, the control will switch back and forth between the two modes until one of them is satisfied.	BLR: SH 41% RATE OUT: 123.0F (129)
9. Once both calls for heat are satisfied, the control will turn off the burner. The blower will remain on for the 10 second postpurge cycle. Any pumps that are running will continue to run for their respective pump delay times, then turn off.	BLR: POSTPURGE OUT: 127.4F (129)
10. Boiler pump off, system pump continues its delay if longer.	BLR: Standby OUT: 124.7F (129)
11. System pump off.	BLR: Standby OUT: 122.9F (129)

# 11 Operating information *(continued)*

## **SMART SYSTEM™** Knight XL control module

Use the control panel (FIG. 11-1) to set temperatures, operating conditions, and monitor boiler operation.

**Figure 11-1 Control Panel**



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## Access modes

### User

The user can adjust space heating target temperature by using the UP and DOWN buttons (FIG. 11-1) at any time during normal operation. By entering the USER code (0704), the user can also change temperature units, time and date, and night setback settings. In User Mode, the following parameters can be viewed but not changed:

- Boiler outlet water target temperature in DHW Mode
- Boiler model number
- Software version
- Total operating hours
- Total cycles

### Installer

Most parameters are available only to the installer, accessible only by entering the installer access code, see the Knight XL Service Manual.

**Saving parameters** (*reference the Parameter Table in the Knight XL Service Manual*)

**To save parameters and exit programming:**

Press the ENTER/RESET button.

**To keep parameter settings only for a current operating cycle:**

Press the MENU/EXIT button 3 times after making all desired parameter changes.

**To enter a parameter and continue programming:**

Press the MENU/EXIT button 1 time to return to the parameter listings; press again to return to the menu listings. Remember to press the ENTER/RESET button when finished programming in order to save the changes made.

See the Knight XL Service Manual for a detailed description of parameters and access modes.

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Status Display Screens		
By using the Previous/Next (◀, ▶) arrow keys on the SMART SYSTEM display panel, you can navigate through the eight (8) display screens. Each screen will contain two (2) viewable items. The following is a description of the individual items and what they can display:		
Screen	Display shows:	Description
#1	BLR: OFF	The unit has been turned OFF by the Enter/Reset button on the SMART SYSTEM display panel.
	Standby	The unit has not received a call for heat from a remote thermostat nor has it received a call for heat from a DHW thermostat.
	Set Point Met	The unit has met the water temperature set point, but is still receiving a call for heat from either a remote thermostat or a DHW thermostat.
	Prepurge	The unit has initiated a 10 second purge period on a call for heat. <b>Note:</b> On the 800 model the unit will initiate a 20 second purge period on a call for heat.
	Ignition	The unit has begun a 5 second spark period to ignite the main burner.
	SH***% Rate	The unit has fired and is running at the displayed percentage.
	Postpurge	The call for heat has been satisfied and the unit runs the fan for an additional 10 seconds to clear the combustion chamber and vent system of residual flue products.
	Service	The unit has been placed in a temporary mode that will allow the unit to fire at 100% of rate for the purpose of combustion analysis.
	OUT: ***.°F(***)	When the outlet sensor has been selected as the control sensor (default), the control will display the outlet temperature as well as the set point in parenthesis.
	***.°F	If the outlet sensor has not been selected as the control sensor, only the outlet temperature will be displayed.
	Open	The control does not detect the outlet sensor.
Shorted	The outlet sensor wires or the sensor itself has become shorted.	
Press the Next ▶ arrow key on the SMART SYSTEM display to access Screen #2.		
#2	IN: ***.°F	If the inlet sensor has not been selected as the control sensor, only the inlet temperature will be displayed.
	***.°F (***)	When the inlet sensor has been selected as the control sensor, the control will display the inlet temperature as well as the set point in parenthesis.
	Open	The control does not detect the inlet sensor.
	Shorted	The inlet sensor wires or the sensor itself has become shorted.
	RISE: ***.°F	The difference between the inlet temperature and the outlet temperature.
Press the Next ▶ arrow key on the SMART SYSTEM display to access Screen #3.		



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## Status Display Screens (cont'd)

By using the Previous/Next (◀, ▶) arrow keys on the SMART SYSTEM display panel, you can navigate through the eight (8) display screens. Each screen will contain two (2) viewable items. The following is a description of the individual items and what they can display:

Screen	Display shows:	Description
#3	SYS: ***.°F	If the system supply sensor has not been selected as the control sensor, only the system temperature will be displayed.
	***.°F (***)	When the system supply sensor has been selected as the control sensor, the control will display the system temperature as well as the set point in parenthesis.
	Open	The control does not detect the system supply sensor.
	Shorted	The system supply sensor wires or the sensor itself has become shorted.
	OUTDOOR: ***.°F	The control will display the outdoor air temperature as sensed by the outdoor air sensor.
	Open	The control does not detect the outdoor air sensor.
	Shorted	The outdoor air sensor wires or the sensor itself has become shorted.
Press the Next ▶ arrow key on the SMART SYSTEM display to access Screen #4.		
#4	FLUE: ***.°F	The control will display the flue temperature.
	Open	The control does not detect the flue sensor.
	Shorted	The flue sensor wires or the sensor itself has become shorted.
	AUX: ***.°F	The control will display the temperature.
	Open	The control does not detect the auxiliary sensor.
	Shorted	The auxiliary sensor wires or the sensor itself has become shorted.
Press the Next ▶ arrow key on the SMART SYSTEM display to access Screen #5.		
#5	FAN SPD: ****RPM	The control will display the actual fan motor RPM.
	FLAME SIG: **, *uA	The control will display the flame signal in dc microamps.
Press the Next ▶ arrow key on the SMART SYSTEM display to access Screen #6.		
#6	SH CFH: OFF	The control has not received a call for heat from a remote thermostat.
	ON	The control has received a call for heat from a remote thermostat.
	DHW CFH: OFF	The control has not received a call for heat from a SH remote thermostat.
	ON	The control has received a call for heat from a DHW thermostat.
Press the Next ▶ arrow key on the SMART SYSTEM display to access Screen #7.		

# 11 Operating information *(continued)*

## Status Display Screens *(cont'd)*

By using the Previous/Next (◀, ▶) arrow keys on the SMART SYSTEM display panel, you can navigate through the eight (8) display screens. Each screen will contain two (2) viewable items. The following is a description of the individual items and what they can display:

Screen	Display shows:	Description
<b>#7</b>	<b>DHW PUMP: OFF</b>	The control has not received a DHW call for heat and has not powered the DHW pump.
	<b>ON</b>	The control has received a DHW call for heat and has powered the DHW pump.
	<b>Delay</b>	The DHW call for heat has been satisfied and the DHW pump is running for a fixed time to remove any residual heat.
	<b>0-10V IN: **.Vdc</b>	The control will display a 0-10Vdc signal received from a Building Management System (BMS) connected to the unit.

Press the Next ▶ arrow key on the SMART SYSTEM display to access Screen #8.

<b>#8</b>	<b>SYS PUMP: OFF</b>	The control has not received a call for heat from a remote thermostat and has not powered the system pump.
	<b>ON</b>	The control has received a call for heat from a remote thermostat and has powered the system pump.
	<b>Delay</b>	The system call for heat has been satisfied and the system pump is running for a fixed time to remove any residual heat.
	<b>BLR PUMP: OFF</b>	The control has either not received a call for heat from a remote thermostat, a remote thermostat is not connected to the unit and the water temperature has not dropped below the temperature set point of the control to initiate a call for heat, or the control has received a DHW call for heat from a DHW thermostat.
	<b>ON</b>	The control has received a call for heat from a remote thermostat or a remote thermostat is not connected and the water temperature has dropped below the temperature set point of the control to initiate a call for heat.
	<b>Delay</b>	The call for heat has been satisfied and the boiler pump is running for a fixed time to remove any residual heat.

Press the Next ▶ arrow key on the SMART SYSTEM display to access Screen #9.

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## Status Display Screens (cont'd)

### Operation of the cascade

The boiler designated as the Leader will have two additional display screens that can be viewed. These screens will provide information regarding the operation of the Cascade. Each screen will contain two viewable items. The following is a description of the individual items and what they can display:

Screen	Display shows:	Description
#9	Cas: Off	The Leader control has been turned off by the <b>Enter/Reset</b> button on the Smart System display.
	Cas: Standby	The Leader boiler has not received a call for heat from a remote thermostat.
	Cas: 127.4F (130)	The Cascade is now active. The system supply temperature will be displayed. The Cascade set point will be displayed in parenthesis.
	Cas: Setpoint Met	The Cascade has met the water temperature set point, but is still receiving a call for heat from a remote thermostat.
	Cas: No Members	The Leader control could not detect any Member controls to participate in the Cascade.
	Cas: S6 Not Present	The system supply sensor is not connected to the Leader boiler.
	PMP: Off	The Leader control has not received a call for heat from a remote thermostat and has not powered the system pump.
	PMP: On	The Leader control has received a call for heat from a remote thermostat and has powered the system pump.
	PMP: Delay	The system call for heat has been satisfied and the system pump is running for a fixed time to remove any residual heat.

Press the Next ► arrow key on the SMART SYSTEM display to access Screen #10.

#10	Cas Pow: ***% ***%	The first percentage shows the firing rate that is being sent to the last boiler called on. The second percentage shows the total power available to the Cascade.
	Present: 01234567  Example: Present: 23----d1	Shows the number of boilers connected to the Cascade. The Leader is designated as 0. Members will be designated 1 - 7. If a “-” is used in place of a number, that boiler is either not connected, or in a lockout mode and not available for the Cascade. If a “d” is used in place of a number, that boiler is handling a DHW demand and is not available for the Cascade. If the number is flashing, then that boiler is providing heat to the Cascade. As the lead boiler is changed from day to day, that boiler’s address will be shown first in the string of numbers. In the example, boilers 0 - 3 are present, boiler 2 is the lead boiler, and boiler 0 is heating an indirect DHW tank.

Press the Next ► arrow key on the SMART SYSTEM display to roll back to Screen #1. At any point if you wish to access an earlier screen, press the Previous ◀ arrow key on the SMART SYSTEM display.