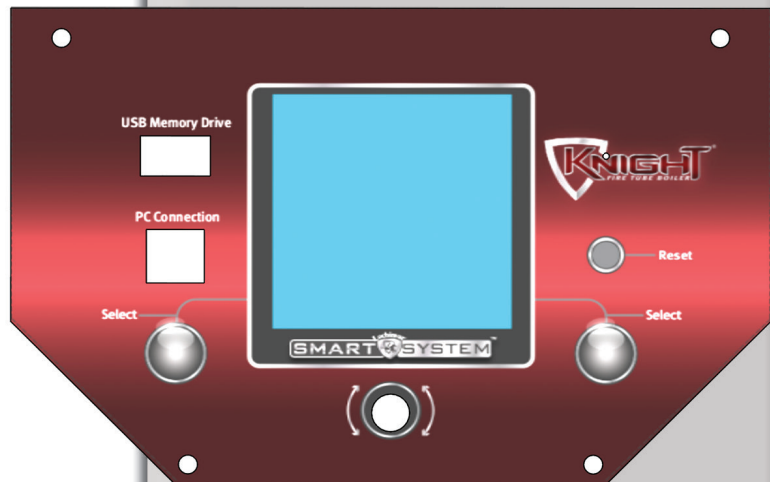




Service Manual

Models: 55 - 399
Series 100-101, 110-111,
& 120-121



DIR #2000544469 00



WARNING

This manual must only be used by a qualified heating installer / service technician. Read all instructions, including this manual and the Knight Fire Tube Boiler Installation and Operation Manual, before installing. Perform steps in the order given. Failure to comply could result in severe personal injury, death, or substantial property damage.



Save this manual for future reference.

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Hazard definitions

The following defined terms are used throughout this manual to bring attention to the presence of hazards of various risk levels or to important information concerning the life of the product.

⚠ DANGER DANGER indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

⚠ WARNING WARNING indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

⚠ CAUTION CAUTION indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.

CAUTION CAUTION used without the safety alert symbol indicates a potentially hazardous situation which, if not avoided, may result in property damage.

NOTICE NOTICE indicates special instructions on installation, operation, or maintenance that are important but not related to personal injury or property damage.

Please read before proceeding

WARNING

Installer – Read all instructions, including this manual and the Knight Fire Tube Boiler Installation and Operation Manual, before installing. Perform steps in the order given.

User – This manual is for use only by a qualified heating installer/service technician. Refer to the Knight Fire Tube Boiler User's Information Manual for your reference.

Have this boiler serviced/inspected by a qualified service technician at least annually.

Failure to comply with the above could result in severe personal injury, death or substantial property damage.

NOTICE

When calling or writing about the boiler – Please have the boiler model and serial number from the boiler rating plate.

Consider piping and installation when determining boiler location (see the Knight Fire Tube Boiler Installation and Operation Manual).

Any claims for damage or shortage in shipment must be filed immediately against the transportation company by the consignee.

Handling ceramic fiber materials

REMOVAL OF COMBUSTION CHAMBER LINING

WARNING

The combustion chamber insulation in this appliance contains ceramic fiber material. Ceramic fibers can be converted to cristobalite in very high temperature applications. The International Agency for Research on Cancer (IARC) has concluded, "Crystalline silica inhaled in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (Group 1)." Normal operating temperatures in this appliance are below the level to convert ceramic fibers to cristobalite. Abnormal operating conditions would have to be created to convert the ceramic fibers in this appliance to cristobalite.

The ceramic fiber material used in this appliance is an irritant; when handling or replacing the ceramic materials it is advisable that the installer follow these safety guidelines.

- Avoid breathing dust and contact with skin and eyes.
 - Use NIOSH certified dust respirator (N95). This type of respirator is based on the OSHA requirements for cristobalite at the time this document was written. Other types of respirators may be needed depending on the job site conditions. Current NIOSH recommendations can be found on the NIOSH website at <http://www.cdc.gov/niosh/homepage.html>. NIOSH approved respirators, manufacturers, and phone numbers are also listed on this website.
 - Wear long-sleeved, loose fitting clothing, gloves, and eye protection.
- Apply enough water to the combustion chamber lining to prevent airborne dust.
- Remove the combustion chamber lining from the appliance and place it in a plastic bag for disposal.
- Wash potentially contaminated clothes separately from other clothing. Rinse clothes washer thoroughly.

NIOSH stated First Aid.

- Eye: Irrigate immediately.
- Breathing: Fresh air.

Please read before proceeding

When servicing boiler –

- To avoid electric shock, disconnect electrical supply before performing maintenance.
- To avoid severe burns, allow boiler to cool before performing maintenance.

Boiler operation –

- Do not block flow of combustion or ventilation air to the boiler.
- Should overheating occur or gas supply fail to shut off, do not turn off or disconnect electrical supply to circulator. Instead, shut off the gas supply at a location external to the appliance.
- Do not use this boiler if any part has been under water. The possible damage to a flooded appliance can be extensive and present numerous safety hazards. Any appliance that has been under water must be replaced.

Boiler water –

- Thoroughly flush the system (without boiler connected) to remove sediment. The high-efficiency heat exchanger can be damaged by build-up or corrosion due to sediment.
- Do not use petroleum-based cleaning or sealing compounds in the boiler system. Gaskets and seals in the system may be damaged. This can result in substantial property damage.
- Do not use “homemade cures” or “boiler patent medicines”. Serious damage to the boiler, personnel, and/or property may result.
- Continual fresh make-up water will reduce boiler life. Mineral buildup in the heat exchanger reduces heat transfer, overheats the stainless steel heat exchanger, and causes failure. Addition of oxygen carried in by makeup water can cause internal corrosion. Leaks in boiler piping must be repaired at once to prevent the introduction of makeup water.

Freeze protection fluids –

- NEVER use automotive antifreeze. Use only inhibited propylene glycol solutions which are specifically formulated for hydronic systems. Ethylene glycol is toxic and can attack gaskets and seals used in hydronic systems.

What is in this manual?

Service

The Knight Fire Tube Boiler display

- Display panel readout, buttons and their functions

Control module inputs

- Control module inputs and options

Control module outputs

- Control module outputs and options

General

- How the boiler operates
- How the control module operates
- Access modes -- user and installer
- Sequence of operation -- Domestic Hot Water (DHW)/space heating

Control panel parameter access

- Accessing and changing parameters from the display panel

Quick start information -- parameter table

- An index of available adjustments and readouts, where to access them and where to find detailed information.

Knight Fire Tube Boiler parameters

- General
- Temperature Setting
- Data Logging
- Functions
- DHW Settings
- Outdoor Reset
- Anti-cycling
- Control Modes
- Building Management System (BMS)
- Circulation Pumps
- Service Notification
- Basic Setup
- USB

Maintenance

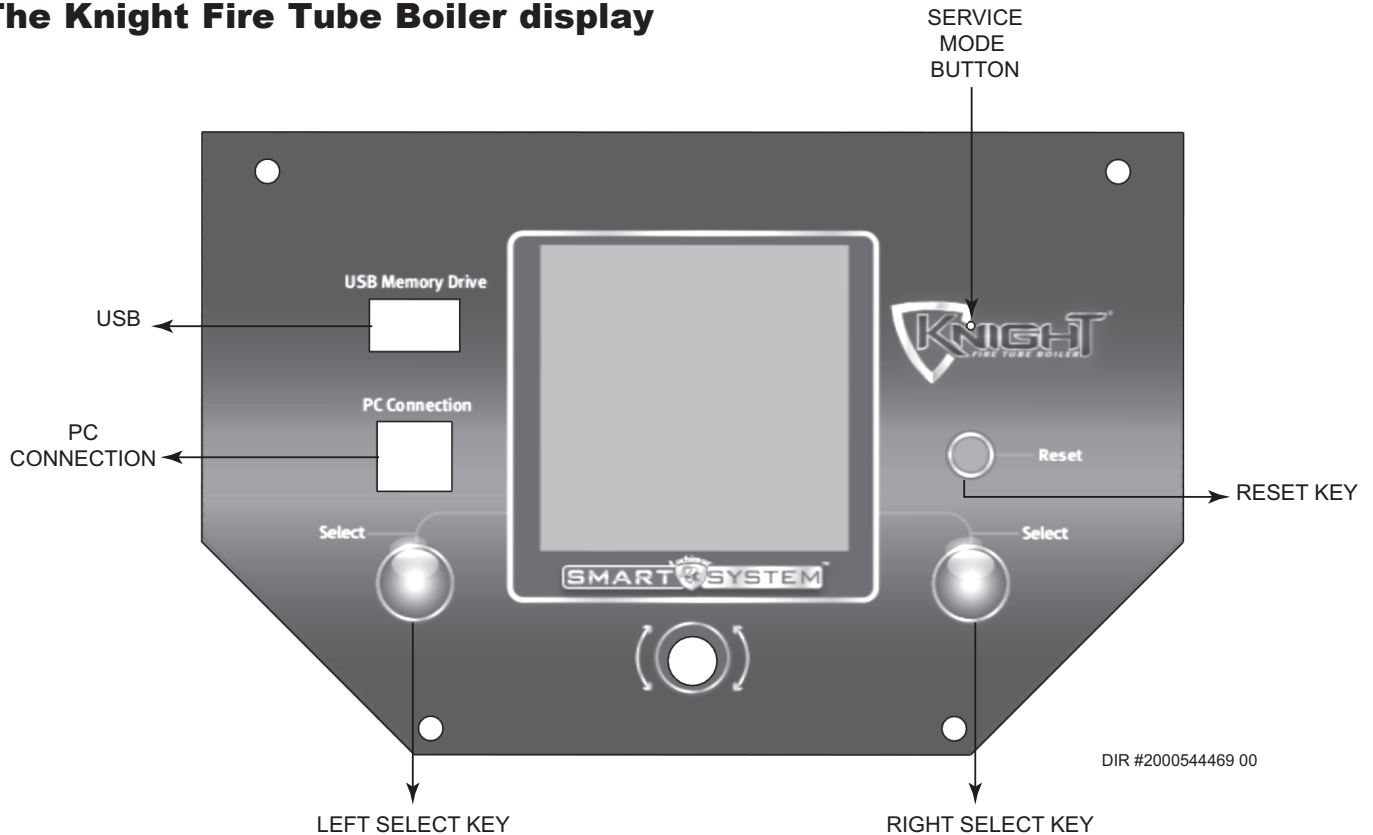
- Service and maintenance schedules
- Address reported problems
- Inspect boiler area and boiler interior
- Clean condensate trap
- Check all piping for leaks
- Check air openings
- Flue vent system and air piping
- Check water system
- Check expansion tank
- Check boiler relief valve
- Inspect ignition electrode
- Check ignition ground wiring
- Check all boiler wiring
- Check control settings
- Perform start-up and checks
- Check burner flame
- Check flame signal
- Check flue gas temperature
- General maintenance
- Review with owner
- Cleaning boiler heat exchanger

Troubleshooting

- Troubleshooting table - No display
- Checking temperature sensors
- Sensor tables
- Troubleshooting table - Fault messages displayed on boiler interface
- Combustion analysis procedure
- Gas valve adjustment procedure

1 Service

The Knight Fire Tube Boiler display



Status Screen Functions

NAVIGATION Dial Scroll - Operational Information

NAVIGATION Dial Press - Access User Menu

Left SELECT Key (Hold) - Access Installer Menu

Right SELECT Key - Shutdown Boiler

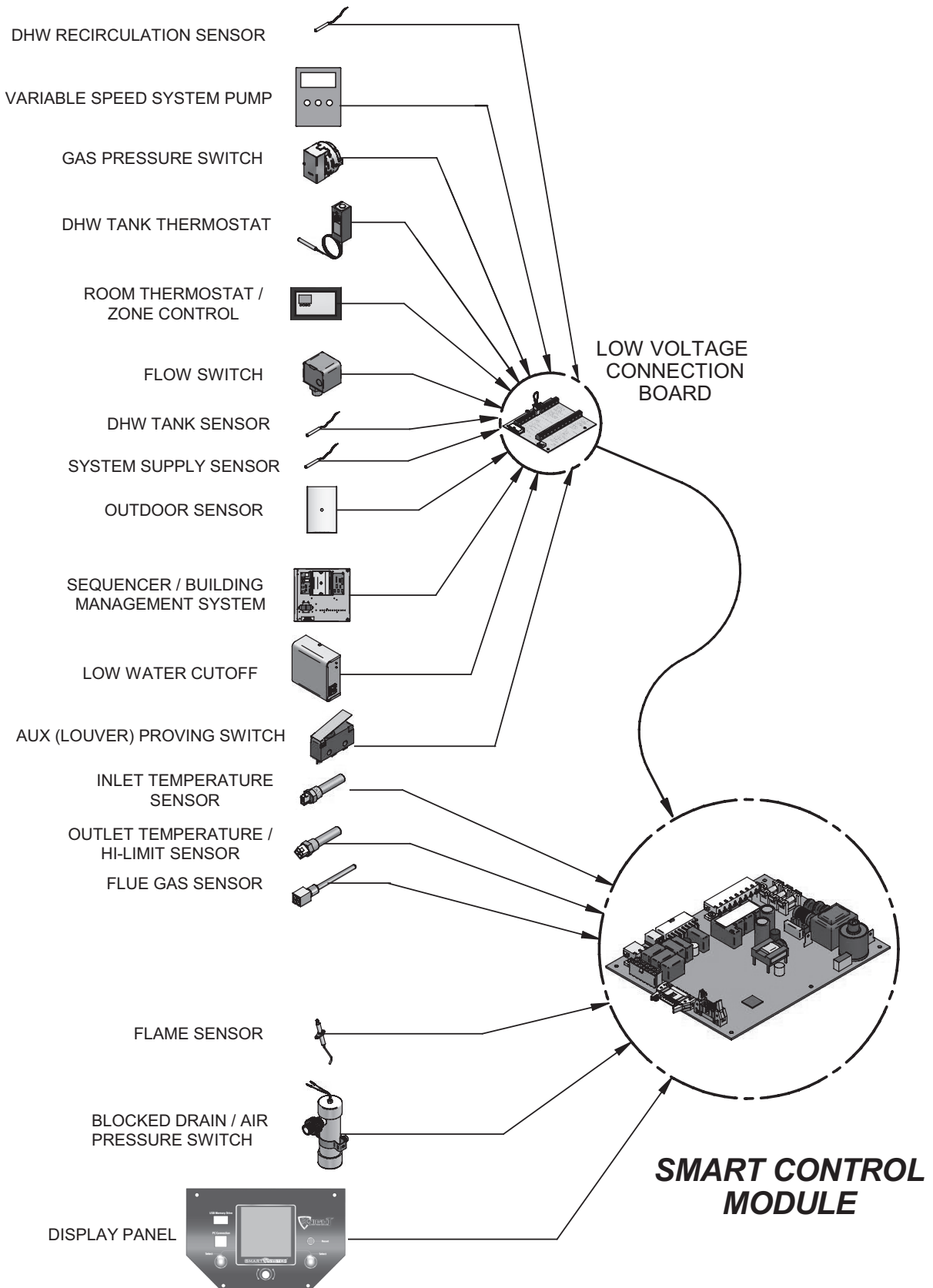
Boiler Status Indicators	
STANDBY	The unit has not received a thermostat or DHW call for heat.
START	The unit is checking all safety circuits before a burn cycle.
PREPURGE	The unit has initiated a prepurge period on a call for heat.
IGNITION	The unit has begun a spark period to ignite the main burner.
%	The unit has fired and is running at the displayed percentage.
POSTPURGE	A call for heat has ended and the fan is running to clear the combustion
SHUTDOWN	The unit has been placed in the OFF position.
SETPOINT MET	The boiler has exceeded the target set point temperature and offset.
BLOCKED	The unit has detected a condition that has interrupted the call for heat.

Call for Heat Indicators			
1	2	3	Room Thermostat 1-3 has a call for heat.
			DHW tank thermostat or sensor has a call for heat.
			Indicates which room thermostat demand has priority.
			The unit is being controlled by a 0 - 10V BMS signal.
			The member unit is supplying heat while in Cascade Mode.

Operational Information			
Details Screen 1	I/O Screen	History Screen	Cascade Status
Details Screen 2	BMS Screen	Last 10 Faults	Night Setback

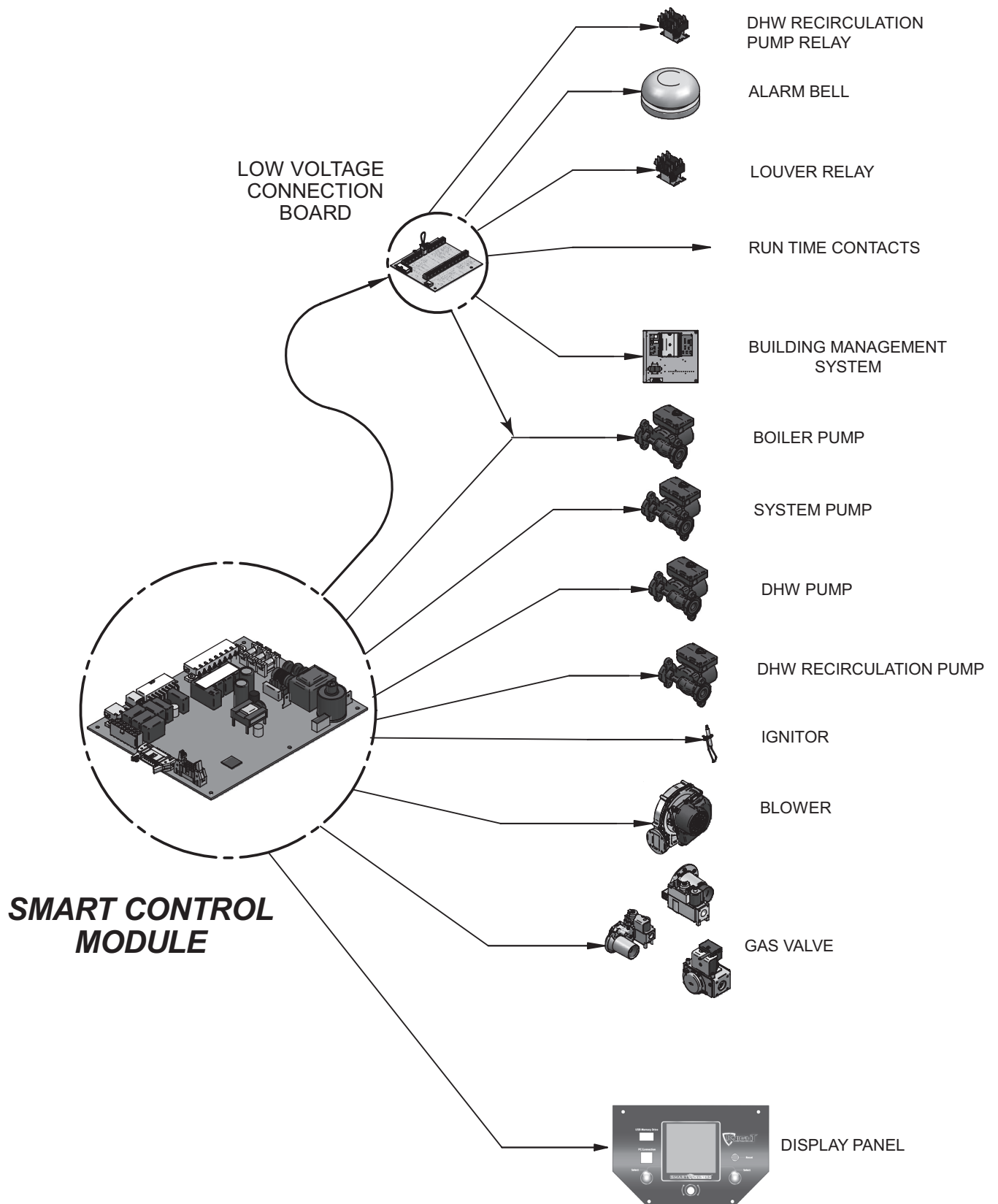
1 Service *(continued)*

Control inputs



1 Service

Control outputs



1 Service *(continued)*

Control inputs and outputs

Temperature control and protection

Modulation

The boiler will modulate its firing rate to satisfy heat demand. The firing rate is dictated by a space heating or DHW call for heat, the heating load, ramp delay, and various other temperature limitations.

Target Operating Temperature

The control module regulates the boiler firing rate to achieve a target temperature set point.

High Limit Operations

The boiler is equipped with adjustable automatic reset (maximum set point 210°F) high limits. When the outlet temperature exceeds the automatic reset set point, the boiler shuts down until the outlet water temperature cools 10° below set point and a 60 second timer has expired. If the outlet temperature continues to increase to the manual reset set point, the boiler will shut down until the control is reset.

Low Water Cutoff Protection

The control uses inlet and outlet water temperature sensors to monitor flow and temperature rise across the heat exchanger. If the flow is too low or the outlet temperature too high, the control will modulate and shut down the boiler.

Gradient Limiting

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

Flame Current Support

When the boiler is firing at minimum rate, the control will increase the firing rate if the flame signal drops too low.

Outlet Temperature Limiting

When the outlet temperature exceeds 185°F the control will reduce the fan speed. If the temperature exceeds 195°F, the unit will shut down until the temperature drops.

Flue Temperature Limiting

The control will reduce the fan speed if the flue temperature exceeds 215°F, and shut down if the temperature exceeds 225°F. The boiler will restart once the temperature has dropped 25°F and the minimum off time has expired.

Temperature Rise Limiting

If the temperature difference between the inlet and outlet sensor exceeds 55°F, the control will reduce the fan speed. If the difference exceeds 60°F, the control will shut the unit down until the difference drops below 55°F and the minimum off time has expired.

Freeze Protection

The control module provides freeze protection by operating the boiler and system pump constantly when the water temperature drops below 45°F. If the temperature drops below 37°F, the control will fire the boiler until the temperature rises.

Field Wiring

Heat / Loop Demand

Room thermostat connections available for space heating. The SMART SYSTEM Multi-Temp Loop Control can be used to control the temperatures of up to three (3) separate loops.

DHW Tank Sensor and Tank Thermostat

The boiler can be programmed for DHW priority when a DHW thermostat or tank sensor is used. When there is a DHW and space heating call for heat, the control can be programmed to cycle between the two demands for a specified time period.

DHW Recirculation Pump Sensor and Relay

Used to control a DHW recirculation pump.

System Sensor

When installed, the control will adjust the boiler firing rate to maintain the system supply temperature set point.

0-10V System Pump In

When a variable speed system pump is installed in the primary loop, the control can use a 0-10V signal from the pump speed control to anticipate changes in building heat load.

0-10V Boiler Pump Out

When connected to a variable speed circulator, the control can use a 0-10V signal to adjust the speed in order to maintain a minimum ΔT across the heat exchanger.

Outdoor Air Sensor

The control will adjust boiler set point according to the outdoor air temperature.

High/Low Gas Pressure Switch

Connect to a pressure switch to detect excessive or low gas pressure.

Flow Switch

Install at the boiler outlet to verify flow before the boiler fires.

Low water cutoff (LWCO)

Required by some jurisdictions to ensure adequate water flow through the boiler.

AUX (Louver) Proving Switch

Verifies operation of louvers or auxiliary equipment before the boiler fires. A custom name can be configured through the SMART SYSTEM display.

1 Service

24 VAC Louver Relay Coil

If louvers need to operate when the boiler fires, they can be controlled by this output.

ModBus / BACnet

An optional ModBus or BACnet interface module can be used to provide a 0-10V input value for a Building Management System (BMS) set point or modulation control.

0-10V BMS In

Boiler set point or firing rate can be controlled using a BMS 0-10V signal.

0-10V Rate Out

This output provides a 0-10V signal proportional to the firing rate of the boiler. This may be used by a BMS controller to monitor the firing rate of the boiler.

Alarm Contacts

The control closes these contacts when the boiler is locked out or power is turned off. This can be used to turn on an alarm or signal a Building Management System.

Run Time Contacts

These contacts are closed whenever the boiler is firing. Typically used by Building Management Systems to verify the boiler is responding to a call for heat.

Cascade

The heating load may be divided among multiple boilers when they are wired together in Cascade.

General Operation

How the boiler operates

The Knight Fire Tube boiler uses an advanced stainless steel heat exchanger and an electronic control module that allows fully condensing operation. The blower pulls in gas and air and pushes flue products out of the boiler through the heat exchanger and flue piping. The control module regulates blower speed to control 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 Knight Fire Tube boiler control module receives input from boiler sensors. The control module activates and controls the blower and gas valve to regulate heat input and switches boiler, DHW, DHW recirculation, and system pumps on and off as needed. The user/installer 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 return water temperature or system supply temperature, depending on the parameter setting.

Sequence of operation

Table 1-1 shows control module normal sequences of operation for space heating and DHW operation. The combined operation sequence is for a typical application, programmed to provide DHW priority.

Parameter access modes

User Access

The user can adjust space heating set points, DHW target temperatures, and high limit settings from the Set Points Screen. This screen is accessed from the Main Status Screen by pressing the NAVIGATION dial. The date and time and the temperature units can also be changed.

Installer Access

Most parameters are available only to the installer, accessible by entering the password 5309 (see Table 1-2). For installer menu access, press and hold the LEFT SELECT key [MENU] key for 5 seconds. Turn the NAVIGATION dial until the first digit of the password is displayed. Press the NAVIGATION dial to keep this value and move to the next number. When the full password (5309) is displayed, press the RIGHT SELECT [SAVE] key. The screen will now display the installer parameter menu.

Setup wizard

The Knight Fire Tube boiler control has a Setup Wizard feature that is automatically accessed the first time the unit is powered. This feature allows setting of commonly required parameters without the need to enter the installer password. Once the Setup Wizard is completed or canceled, it can only be accessed through the installer menu.

Changing and saving parameters

NOTICE

Please note that the brackets ([]) denote screen status.

From the main parameter menu, scroll down to the desired listing and press the NAVIGATION dial to access the specific parameter menu (see Table 1-3). Scroll and press the NAVIGATION dial to adjust parameter settings. Press the RIGHT SELECT [SAVE] key to retain the settings for that menu. Once all adjustments for the current menu have been made, press the LEFT SELECT [EXIT] key to return to the main parameter menu. Repeat the process for each menu section as needed. Once all desired changes have been made, press the LEFT SELECT [HOME] key from the main parameter menu. This will save all settings to the control.

1 Service *(continued)*

Table 1-1 Sequence of Operation

OPERATION	DISPLAY
1. Upon a call for heat, the gas pressure switch(es) must be closed.	<p style="text-align: center;">STANDBY </p> <p>SYSTEM <input type="radio"/> DHW TANK <input type="radio"/> BOILER <input type="radio"/> DHW CIRC <input type="radio"/> SYSTEM: 117°F (118) TANK: 124°F (130) OUTDOOR: 56°F INLET: 109°F OUTLET: 124°F DHW RECIRC: 115°F</p> <hr/> <p>MENU SCREEN SHDN</p>
2. Once the gas pressure switch(es) are closed, the control turns on the appropriate pumps (system and boiler pumps for space heating, DHW pump for DHW). The flow switch and/or LWCO must close.	<p style="text-align: center;">STANDBY </p> <p>SYSTEM <input checked="" type="radio"/> DHW TANK <input type="radio"/> BOILER <input checked="" type="radio"/> DHW CIRC <input type="radio"/> SYSTEM: 117°F (118) TANK: 124°F (130) OUTDOOR: 56°F INLET: 109°F OUTLET: 124°F DHW RECIRC: 115°F</p> <hr/> <p>MENU SCREEN SHDN</p>
3. The control turns on power to the louver relay. The louver proving switch, and blocked drain switch must close.	<p style="text-align: center;">START </p> <p>SYSTEM <input checked="" type="radio"/> DHW TANK <input type="radio"/> BOILER <input checked="" type="radio"/> DHW CIRC <input type="radio"/> SYSTEM: 117°F (118) TANK: 124°F (130) OUTDOOR: 56°F INLET: 109°F OUTLET: 124°F DHW RECIRC: 115°F</p> <hr/> <p>MENU SCREEN SHDN</p>
4. The control starts a prepurge cycle by starting the blower.	<p style="text-align: center;">PRE-PURGE </p> <p>SYSTEM <input checked="" type="radio"/> DHW TANK <input type="radio"/> BOILER <input checked="" type="radio"/> DHW CIRC <input type="radio"/> SYSTEM: 117°F (118) TANK: 124°F (130) OUTDOOR: 56°F INLET: 109°F OUTLET: 124°F DHW RECIRC: 115°F</p> <hr/> <p>MENU SCREEN SHDN</p>
5. The control starts a trial for ignition by firing the spark electrode and opening the gas valve.	<p style="text-align: center;">IGNITION </p> <p>SYSTEM <input checked="" type="radio"/> DHW TANK <input type="radio"/> BOILER <input checked="" type="radio"/> DHW CIRC <input type="radio"/> SYSTEM: 117°F (118) TANK: 124°F (130) OUTDOOR: 56°F INLET: 109°F OUTLET: 124°F DHW RECIRC: 115°F</p> <hr/> <p>MENU SCREEN SHDN</p>
6. If flame is not detected after the sparking ends, the control will perform a postpurge, then start another prepurge cycle and try to light the burner again. The control will perform a total of 4 attempts before locking out.	<p style="text-align: center;">POST-PURGE </p> <p>SYSTEM <input checked="" type="radio"/> DHW TANK <input type="radio"/> BOILER <input checked="" type="radio"/> DHW CIRC <input type="radio"/> SYSTEM: 117°F (118) TANK: 124°F (130) OUTDOOR: 56°F INLET: 109°F OUTLET: 124°F DHW RECIRC: 115°F</p> <hr/> <p>MENU SCREEN SHDN</p>

1 Service






Table 1-1 (continued from previous page) *Sequence of Operation*

OPERATION	DISPLAY
7. If flame is detected, it holds the firing rate steady for a few seconds to let the flame stabilize, then it begins to modulate the firing rate based on a set point or some other command (such as a 0-10V BMS signal).	<pre> 41% 🔥 ⬆️ SYSTEM 🔘 DHW TANK ○ BOILER 🔘 DHW CIRC ○ SYSTEM: 117°F(118) TANK: 124°F(130) OUTDOOR: 56°F INLET: 109°F OUTLET: 124°F DHW RECIRC: 115°F MENU ⏪ SCREEN SHDN </pre>
8. If the space heating call for heat is active, and the tank thermostat or sensor starts a DHW call for heat, the boiler will switch to the DHW mode. If programmed for normal DHW operation (not as a zone), the DHW pump will turn on first, then the boiler pump will turn off (boiler and DHW pump operation briefly overlap to ensure flow is maintained through the unit). This will divert the boiler's outlet water from the heating system and send it to the tank coil instead. The control will then modulate to maintain the outlet temperature to the DHW boiler set point.	<pre> 41% 🔥 1 🚰 SYSTEM 🔘 DHW TANK 🔘 BOILER ○ DHW CIRC ○ SYSTEM: 117°F(118) TANK: 124°F(130) OUTDOOR: 56°F INLET: 109°F OUTLET: 124°F DHW RECIRC: 115°F MENU ⏪ SCREEN SHDN </pre>
9. If the boiler is not part of a Cascade, and both the space heating and DHW calls for heat remain active long enough, the boiler will switch back and forth between the two heating modes until one of them is satisfied.	<pre> 41% 🔥 ⬆️ 🚰 SYSTEM 🔘 DHW TANK ○ BOILER 🔘 DHW CIRC ○ SYSTEM: 117°F(118) TANK: 124°F(130) OUTDOOR: 56°F INLET: 109°F OUTLET: 124°F DHW RECIRC: 115°F MENU ⏪ SCREEN SHDN </pre>
10. Once both calls for heat are satisfied, the control will turn off the burner. The blower will continue to run during the postpurge period.	<pre> POST-PURGE ANTI-CYCLING SYSTEM 🔘 DHW TANK ○ BOILER 🔘 DHW CIRC ○ SYSTEM: 117°F(118) TANK: 124°F(130) OUTDOOR: 56°F INLET: 109°F OUTLET: 124°F DHW RECIRC: 115°F MENU ⏪ SCREEN SHDN </pre>
11. Any pumps that are running will continue to run for their respective pump delay times before turning off, unless programmed to remain on continuously. A 60 second anti-cycle period will start, which will delay any new call for heat until it times out.	<pre> BLOCKED ANTI-CYCLING SYSTEM 🔘 DHW TANK ○ BOILER 🔘 DHW CIRC ○ SYSTEM: 117°F(118) TANK: 124°F(130) OUTDOOR: 56°F INLET: 109°F OUTLET: 124°F DHW RECIRC: 115°F MENU ⏪ SCREEN SHDN </pre>
12. In Standby, ready to start a new cycle.	<pre> STANDBY SYSTEM ○ DHW TANK ○ BOILER ○ DHW CIRC ○ SYSTEM: 117°F(118) TANK: 124°F(130) OUTDOOR: 56°F INLET: 109°F OUTLET: 124°F DHW RECIRC: 115°F MENU ⏪ SCREEN SHDN </pre>

1 Service *(continued)*

Display panel menu access






Table 1-2 Use this procedure to access menus from the display panel

BUTTON	SCREEN STATUS	OPERATION	DISPLAY
	[MENU]	Press and hold the LEFT SELECT soft key [MENU] for five (5) seconds.	STANDBY SYSTEM <input type="radio"/> DHW TANK <input type="radio"/> BOILER <input type="radio"/> DHW CIRC <input type="radio"/> SYSTEM: 117°F (118) TANK: 124°F (130) OUTDOOR: 56°F INLET: 109°F OUTLET: 124°F DHW RECIRC: 115°F MENU <input type="radio"/> SCREEN SHDN
		Rotate the NAVIGATION dial clockwise until 5 is displayed (first digit on the left).	STANDBY SYSTEM <input type="radio"/> DHW TANK <input type="radio"/> BOILER <input type="radio"/> DHW CIRC <input type="radio"/> PASSWORD 0000 EXIT <input type="radio"/> NEXT SAVE
		Press the NAVIGATION dial to select the next digit. Rotate the NAVIGATION dial clockwise until 3 is shown in the display.	STANDBY SYSTEM <input type="radio"/> DHW TANK <input type="radio"/> BOILER <input type="radio"/> DHW CIRC <input type="radio"/> PASSWORD 5000 EXIT <input type="radio"/> NEXT SAVE
		Press the NAVIGATION dial 2 times to move to the last digit. Rotate the NAVIGATION dial counterclockwise until 9 is displayed.	STANDBY SYSTEM <input type="radio"/> DHW TANK <input type="radio"/> BOILER <input type="radio"/> DHW CIRC <input type="radio"/> PASSWORD 5300 EXIT <input type="radio"/> NEXT SAVE
	[SAVE]	Press the RIGHT SELECT soft key [SAVE].	STANDBY SYSTEM <input type="radio"/> DHW TANK <input type="radio"/> BOILER <input type="radio"/> DHW CIRC <input type="radio"/> PASSWORD 5309 EXIT <input type="radio"/> NEXT SAVE

1 Service

Display panel parameter access

Table 1-3 This is a typical example of accessing a parameter, shown for parameter Temperature Settings, MIN SH Setpt

BUTTON	SCREEN STATUS	OPERATION	DISPLAY
<p><i>This example shows how to access parameter Temperature Settings. The first display shown is at the beginning of the menu listings, after entering the installer access code.</i></p>			
		Rotate the NAVIGATION dial counterclockwise until the arrow (>) is next to TEMPERATURE SETTINGS .	<p>STANDBY</p> <p>SYSTEM <input type="radio"/> DHW TANK <input type="radio"/></p> <p>BOILER <input type="radio"/> DHW CIRC <input type="radio"/></p> <p>PASSWORD</p> <p>5309</p> <hr/> <p>EXIT ↓NEXT SAVE</p>
		Press the NAVIGATION dial one time.	<p>STANDBY</p> <p>SYSTEM <input type="radio"/> DHW TANK <input type="radio"/></p> <p>BOILER <input type="radio"/> DHW CIRC <input type="radio"/></p> <p>GENERAL</p> <p>>TEMPERATURE SETTINGS</p> <p>DATA LOGGING</p> <p>FUNCTIONS</p> <p>DHW SETTINGS</p> <p>ANTI-CYCLING</p> <p>CONTROL MODES</p> <hr/> <p>HOME ↵SCROLL</p>
		Rotate the NAVIGATION dial counterclockwise until the arrow (>) is next to MIN SETPT .	<p>STANDBY</p> <p>SYSTEM <input type="radio"/> DHW TANK <input type="radio"/></p> <p>BOILER <input type="radio"/> DHW CIRC <input type="radio"/></p> <p>>SH1 SETPT: 125°F</p> <p>MIN SH SETPT: 60°F</p> <p>MAX SH SETPT: 185°F</p> <p>SH1 OFFSET: 10°F</p> <p>SH1 DIFF: 20°F</p> <p>SH2 SETPT: 125°F</p> <p>SH2 DIFF: 10°F</p> <hr/> <p>EXIT ↵SCROLL HOME</p>
		Press the NAVIGATION dial one time.	<p>STANDBY</p> <p>SYSTEM <input type="radio"/> DHW TANK <input type="radio"/></p> <p>BOILER <input type="radio"/> DHW CIRC <input type="radio"/></p> <p>SH1 SETPT: 125°F</p> <p>>MIN SH SETPT: 60°F</p> <p>MAX SH SETPT: 185°F</p> <p>SH1 OFFSET: 10°F</p> <p>SH1 DIFF: 20°F</p> <p>SH2 SETPT: 125°F</p> <p>SH2 DIFF: 10°F</p> <hr/> <p>EXIT ↵SCROLL HOME</p>
		Rotate the NAVIGATION dial to the desired temperature.	<p>STANDBY</p> <p>SYSTEM <input type="radio"/> DHW TANK <input type="radio"/></p> <p>BOILER <input type="radio"/> DHW CIRC <input type="radio"/></p> <p>SH1 SETPT: 125°F</p> <p>>MIN SH SETPT: 60°F</p> <p>MAX SH SETPT: 185°F</p> <p>SH1 OFFSET: 10°F</p> <p>SH1 DIFF: 20°F</p> <p>SH2 SETPT: 125°F</p> <p>SH2 DIFF: 10°F</p> <hr/> <p>EXIT ↵ADJUST SAVE</p>

1 Service *(continued)*

Display panel parameter access (cont.)

Table 1-3 This is a typical example of accessing a parameter, shown for parameter Temperature Settings, MIN SH Setpt

BUTTON	SCREEN STATUS	OPERATION	DISPLAY
<p><i>This example shows how to access parameter Temperature Settings. The first display shown is at the beginning of the menu listings, after entering the installer access code.</i></p>			
	[SAVE]	Press the RIGHT SELECT soft key [SAVE] one time.	<p>STANDBY</p> <p>SYSTEM <input type="radio"/> DHW TANK <input type="radio"/></p> <p>BOILER <input type="radio"/> DHW CIRC <input type="radio"/></p> <p>SH1 SETPT: 125°F</p> <p>>MIN SH SETPT: 40°F</p> <p>MAX SH SETPT: 185°F</p> <p>SH1 OFFSET: 10°F</p> <p>SH1 DIFF: 20°F</p> <p>SH2 SETPT: 125°F</p> <p>SH2 DIFF: 10°F</p> <hr/> <p>EXIT ↵ADJUST SAVE</p>
	[EXIT]	Press the LEFT SELECT soft key [EXIT] if all desired changes have been made.	<p>STANDBY</p> <p>SYSTEM <input type="radio"/> DHW TANK <input type="radio"/></p> <p>BOILER <input type="radio"/> DHW CIRC <input type="radio"/></p> <p>SH1 SETPT: 125°F</p> <p>>MIN SH SETPT: 40°F</p> <p>MAX SH SETPT: 185°F</p> <p>SH1 OFFSET: 10°F</p> <p>SH1 DIFF: 20°F</p> <p>SH2 SETPT: 125°F</p> <p>SH2 DIFF: 10°F</p> <hr/> <p>EXIT ↵SCROLL HOME</p>
	[HOME]	Press the LEFT SELECT soft key [HOME].	<p>STANDBY</p> <p>SYSTEM <input type="radio"/> DHW TANK <input type="radio"/></p> <p>BOILER <input type="radio"/> DHW CIRC <input type="radio"/></p> <p>GENERAL</p> <p>>TEMPERATURE SETTINGS</p> <p>DATA LOGGING</p> <p>FUNCTIONS</p> <p>DHW SETTINGS</p> <p>ANTI-CYCLING</p> <p>CONTROL MODES</p> <hr/> <p>HOME ↵SCROLL</p>
<p>Wait for the new settings to be saved.</p>			<p>STANDBY</p> <p>SYSTEM <input type="radio"/> DHW TANK <input type="radio"/></p> <p>BOILER <input type="radio"/> DHW CIRC <input type="radio"/></p> <p>Uploading Parameters</p> <p>Please wait..</p> <hr/>

1 Service

Parameter table

Table 1-4 SMART SYSTEM control module parameters

 Note: Parameter selections in **BOLD** are included in the Smart Setup Wizard.

Menu	Description	User Access	Installer Access
GENERAL (PAGES 20 - 21)	Vacation Mode (On/Off)	Yes	Yes
	Time and Date	Yes	Yes
	Software Version (read only)	No	Yes
	Temperature Units (°C/°F)	Yes	Yes
	SH Night Setback Offset > 0°F (0°C) i. SH Night Setback On Times ii. SH Night Setback Off Times	No	Yes
	DHW Night Setback Offset > 0°F (0°C) i. DHW Night Setback On Times ii. DHW Night Setback Off Times	No	Yes
	Display Timeout	No	Yes
	Display Contrast	Yes	Yes
TEMPERATURE SETTINGS (PAGE 21)	SH1 Set Point	Yes	Yes
	Minimum SH Set Point	No	Yes
	Maximum SH Set Point	No	Yes
	SH1 Offset Set Point	No	Yes
	SH1 Differential Set Point	No	Yes
	SH2 Set Point	Yes	Yes
	SH2 Offset Set Point	No	Yes
	SH2 Differential Set Point	No	Yes
	SH3 Set Point	Yes	Yes
	SH3 Offset Set Point	No	Yes
	SH3 Differential Set Point	No	Yes
3-Way Valve Time	No	Yes	
DATA LOGGING (PAGE 21)	Reset Last 10 Errors	No	Yes
FUNCTIONS (PAGES 21 - 22)	Service Mode Delay	No	Yes
	Freeze Protection Pump On	No	Yes
	Freeze Protection Burner On	No	Yes
	Freeze Protection Burner Differential	No	Yes
DHW SETTINGS (PAGES 22 - 23)	Tank Set Point	Yes	Yes
	Tank Set Point Differential	No	Yes
	DHW Boiler Set Point	No	Yes
	DHW Boiler Offset	No	Yes
	DHW Boiler Differential	No	Yes
	DHW Recirc Pump Offset	No	Yes
	DHW Recirc Pump Differential	No	Yes

1 Service *(continued)*

Parameter table

Table 1-4 (continued from previous page) SMART SYSTEM control module parameters

Note: Parameter selections in **BOLD** are included in the Smart Setup Wizard.

Menu	Description	User Access	Installer Access
DHW SETTINGS (CONT.) (PAGES 22 - 23)	Tank Minimum Set Point	No	Yes
	Tank Maximum Set Point	No	Yes
	DHW Max Rate	No	Yes
	DHW Type (NORMAL, ZONE) i. SH/DHW Switching Time ii. DHW/SH Switching Time DHW Type = ZONE i. DHW Forces Sys Pump (YES/NO) ii. DHW Blocks Sys Pump (YES/NO)	No	Yes
OUTDOOR RESET (PAGES 23 - 25)	Low Outdoor Temperature 1	No	Yes
	High Outdoor Temperature 1	No	Yes
	SH1 Set Point at Low Outdoor Temp	No	Yes
	SH1 Set Point at High Outdoor Temp	No	Yes
	Outdoor Air Shutdown SH1	No	Yes
	Outdoor Air Shutdown Differential SH1	No	Yes
	Shift Reset Curve SH1	No	Yes
	Low Outdoor Temperature 2	No	Yes
	High Outdoor Temperature 2	No	Yes
	SH2 Set Point at Low Outdoor Temp	No	Yes
	SH2 Set Point at High Outdoor Temp	No	Yes
	Outdoor Air Shutdown SH2	No	Yes
	Outdoor Air Shutdown Differential SH2	No	Yes
	Shift Reset Curve SH2	No	Yes
	Low Outdoor Temperature 3	No	Yes
	High Outdoor Temperature 3	No	Yes
	SH3 Set Point at Low Outdoor Temp	No	Yes
	SH3 Set Point at High Outdoor Temp	No	Yes
	Outdoor Air Shutdown SH3	No	Yes
	Outdoor Air Shutdown Differential SH3	No	Yes
Shift Reset Curve SH3	No	Yes	
Boost Temperature > 0°F (0°C) i. Boost Time	No	Yes	

1 Service

Parameter table

Table 1-4 SMART SYSTEM control module parameters

Note: Parameter selections in **BOLD** are included in the Smart Setup Wizard.

Menu	Description	User Access	Installer Access
ANTI-CYCLING (PAGES 25 - 26)	Anti-cycling Time	No	Yes
	Anti-cycling Override Differential	No	Yes
	Ramp Delay (Enable/Disable)	No	Yes
	Modulation Factor	No	Yes
	Ramp Settings	No	Yes
CONTROL MODES (PAGES 26 - 27)	Controlling Sensor (Outlet/Inlet)	No	Yes
	Cascade Address = 0 (Leader Boiler) <ul style="list-style-type: none"> i. Maximum Cascade Outlet Set Point ii. Cascade Offset iii. Cascade Differential iv. Cascade Type (L/L, EFF) v. Minimum On/Off Time vi. Minimum Next On Time vii. Minimum Pumps On Cascade Address = 1 (Member Boiler) <ul style="list-style-type: none"> i. Alternate Leader? (YES/NO) 	No	Yes
	Boiler Size <ul style="list-style-type: none"> i. Cascade Address (1 - 7) ii. Type (Condensing / Non-Condensing) iii. Input (kBtuh) 	No	Yes
BUILDING MANAGEMENT SYSTEM (BMS) (PAGES 27 - 28)	BMS = ACTIVE <ul style="list-style-type: none"> i. BMS Type = POWER <ul style="list-style-type: none"> 1. Rate at Minimum Volts 2. Rate at Maximum Volts ii. BMS Type = SETPOINT <ul style="list-style-type: none"> 1. Set Point at Minimum Volts 2. Set Point at Maximum Volts iii. Volts at Minimum iv. Volts at Maximum v. BMS Thermostat Input = INACTIVE <ul style="list-style-type: none"> 1. On Volts 2. Off Differential Volts vi. ModBus / BACnet (ACTIVE/INACTIVE) vii. BAS T/O 	No	Yes
CIRCULATION PUMPS (PAGE 29)	System Pump Delay	No	Yes
	Boiler Pump Delay	No	Yes
	DHW Pump Delay	No	Yes
	System Pump Anti-Seize Delay	No	Yes
	Boiler Pump Anti-Seize Delay	No	Yes
	DHW Pump Anti-Seize Delay	No	Yes
	System Pump Type (CFH, WWSD)	No	Yes

1 Service *(continued)*

Parameter table

Table 1-4 SMART SYSTEM control module parameters

 Note: Parameter selections in **BOLD** are included in the Smart Setup Wizard.

Menu	Description	User Access	Installer Access
CIRCULATION PUMPS CONT'D (PAGES 29 - 30)	Boiler Pump Delta T Set Point	No	Yes
	Boiler Pump Minimum Volts	No	Yes
	Boiler Pump Maximum Volts	No	Yes
	Boiler Pump Standby Volt	No	Yes
	Boiler Pump Type	No	Yes
SERVICE NOTIFICATION (PAGES 30 - 31)	Service Notification Months	No	Yes
	Service Notification Running Time	No	Yes
	Service Notification Cycles	No	Yes
	Reset Service Reminder	No	Yes
	Installer Name	No	Yes
	Installer Phone Number	No	Yes
	Aux Input Name	No	Yes
BASIC SETUP (PAGE 31)	Time & Date	No	Yes
	IF Outdoor Sensor Connected: <ol style="list-style-type: none"> i. Low Outdoor Temperature 1 ii. High Outdoor Temperature 1 iii. SH1 Set Point at Low Outdoor Temperature iv. SH1 Set Point at High Outdoor Temperature v. Outdoor Air Shutdown SH1 vi. Outdoor Air Shutdown Differential SH1 	No	Yes
	Cascade Address = 0 <ol style="list-style-type: none"> i. Maximum Cascade Set Point ii. Cascade Offset iii. Cascade Differential iv. Cascade Type 	No	Yes
	BMS (ACTIVE) <ol style="list-style-type: none"> i. BMS Type = POWER <ol style="list-style-type: none"> 1. Rate at Minimum Volts 2. Rate at Maximum Volts ii. BMS Type = SETPOINT <ol style="list-style-type: none"> 1. Set Point at Minimum Volts 2. Set Point at Maximum Volts iii. Volts at Minimum iv. Volts at Maximum v. BMS Thermostat Input = INACTIVE <ol style="list-style-type: none"> 1. On Volts 2. Off Differential Volts 	No	Yes
LOCH-N-LINK (PAGE 31)	Access or Create "Lochinvar" Folder <ol style="list-style-type: none"> i. Save Parameters from the Control ii. Load Parameters to the Control 	No	Yes

1 Service

Viewable and changeable control parameters

CAUTION

Before changing parameters, note the settings or save to USB so that the unit can be returned to its original operating parameters.

General

Vacation Mode

This parameter forces the Space Heating (SH) and DHW set points to decrease by the amounts programmed in the Night Setback Offset parameters. It is used to save energy, such as when the building is unoccupied for an extended period of time. For this function to work, the *Space Heating Night Setback Offset* and/or *DHW Night Setback Offset* parameters must be set to a value higher than 0°. The default value of this parameter is OFF.

Time and Date

The control uses an internal clock for the night setback feature and for logging of events. For these features to work correctly, the clock must be set when the boiler is first installed or anytime the boiler has been powered off for more than four (4) hours. This parameter must be accessed to set the clock.

NOTICE

The internal clock does not adjust for Daylight Savings Time and therefore, will require a manual adjustment.

The clock is automatically updated whenever a PC is connected and the Win_Pro-Installer program is started.

Software Version

The software version allows the user to view the software version in use by the control. This software controls the operation of the boiler. When a new software version becomes available, the existing control can be replaced with a new control to update the software.

Software version is read only.

Temperature units (°C / °F)

The control can be configured to display temperature in either °C or °F. This parameter can be changed by the user or the installer by accessing the *Temperature Units* parameter. The default is °F.

Space Heating (SH) and Domestic Hot Water (DHW) Night Setback Offset

Once the unit's internal clock has been set correctly, the Night Setback feature can be used to program a lower set point during unoccupied times. Both the space heating and DHW can be programmed for night setback. When in night setback, the control reduces the set point by a fixed amount. For space heating, it subtracts the space heating night setback offset from each of the SH user set points (*SH1, 2, and 3 Set point parameters*), or the calculated outdoor reset set point (if lower). For DHW, it subtracts the DHW night setback offset from the tank set point (*Tank Set point parameter*).

NOTE: The DHW night setback will not work without a tank sensor installed.

The installer may adjust the space heating night setback offset by accessing the *SH Night Setback Offset* parameter and the DHW night setback offset by accessing the *DHW Night Setback Offset* parameter. The minimum setting is 0°F (0°C) and the maximum setting is 90°F (50°C).

Space Heating (SH) and Domestic Hot Water (DHW) Night Setback On and Off Times

These are the times at which the SH Night Setback and DHW Night Setback Offsets become active and inactive. There are seven (7) stop times and seven (7) start times each for the SH and DHW night setback functions. Any start or stop time may be set to any time during the week. When a start time and a stop time are programmed for the same day and time, the stop time has priority (this is how a start time can be disabled). The installer can adjust the SH Night Setback start and stop times by accessing the parameter *SH NSB On/Off Times*. The installer can access the DHW Night Setback start and stop times by accessing the *DHW NSB On/Off Times* parameter. These settings can be adjusted as follows:

1. When the screen is first accessed, start and stop triggers 1 are displayed. If a different trigger number is desired, rotate the NAVIGATION dial until the desired trigger number appears. Once it is found, press the NAVIGATION dial to adjust the start and stop times. The day of the week for the start time will flash.
2. Rotate the NAVIGATION dial to adjust the day of the week of the start trigger. Once it is set to the desired day of the week, press the NAVIGATION dial again. The start time hour will flash.
3. Rotate the NAVIGATION dial to adjust the start time hour to the desired time. Press the NAVIGATION dial again. The start time minutes will flash.
4. This process may be continued until the start and stop days and times are adjusted as desired. When finished with this set of triggers, press the [SAVE] key.
5. Rotate the NAVIGATION dial to select another set of start and stop triggers, or press the [EXIT] key to return to the previous menu.

1 Service *(continued)*

Night Setback Override

Any Night Setback On trigger currently active or scheduled within the next seven (7) days can be skipped. To skip a trigger, go to the Night Setback Status Screen and press the SKIP button. Rotate the NAVIGATION dial until the arrow (>) is next to the trigger you wish to skip. Press the NAVIGATION dial once. "SK" will appear next to that trigger to indicate that it will be skipped. You can restore an upcoming trigger by selecting that trigger, and pressing the NAVIGATION dial again. The "SK" next to that trigger will disappear.

To save any changes and return to the Home Screen, press the RIGHT SELECT [HOME] key. To return to the Status Screen without saving the changes, press the LEFT SELECT [EXIT] key.

Display Timeout

This is the time in which the display remains illuminated. The range is 10 seconds to 10 minutes. The default is 10 minutes.

Display Contrast

The contrast of the LCD display can be adjusted to improve readability. The contrast is adjusted automatically when the display board is tested at the factory, but different ambient conditions may warrant changing the setting. This parameter can be changed by accessing the *Display Contrast* setting. The range of this parameter is -10 to +10. The default setting is 0.

Temperature Settings

Space Heating (SH1, SH2, SH3) Set Point

CAUTION

Mixing valves are required for the protection of any low temperature loops.

There are three (3) individual user set points for better zone control. These are listed as SH1 Set Point through SH3 Set Point. If multiple set points are calling for heat the highest set point has priority. The range is *SH Minimum Set point* to *SH Maximum Set point*. The default is 125°F (52°C).

Space Heating (SH) Minimum Set Point

The SH minimum set point sets the minimum water temperature set point that can be used for space heating operation. The user or installer will not be able to program the control with a lower SH set point. This parameter can only be changed by the installer by accessing *Minimum SH Set point parameter*. The temperature range of this parameter is 32°F (0°C) to the space heating maximum set point. The default value is 60°F (16°C).

Space Heating (SH) Maximum Set Point

The SH maximum set point sets the maximum water temperature set point that can be used for space heating. The user or installer will not be able to program the control with a higher SH set point. This parameter can only be changed by the installer by accessing *Maximum SH Set point parameter*. The temperature range of this parameter is the space heating minimum set point to 190°F (88°C). The default value is 185°F (85°C).

SH1 - SH3 Offset Set Point

The SH offset sets how many degrees above set point the temperature has to go before the boiler will shut off. This parameter can only be changed by the installer by accessing parameters *SH1, 2 and 3 Offset Set point parameters*. The temperature range of these parameters is 0°F to 20°F. The default value is 10°F.

SH1 - SH3 Differential Set Point

The SH differential sets how many degrees below the offset the temperature has to drop before the boiler turns back on. This parameter can only be changed by the installer by accessing the *SH1, 2 and 3 Differential Set point parameters*. The range is 0°F to 60°F. The default is 20°F.

3-Way Valve Time

The optional Lochinvar Multi-Temperature Loop Control Board (MTLC) can be used to control the supply temperature in up to three (3) sub-loops, corresponding to each of the three (3) SH set points, through the use of 3-way mixing valves. To ensure the MTLC will control these temperature properly, it is necessary to let the control know how much time these mixing valves require to fully open and close. Program this time into the *3-Way Valve Time* parameter. Since this parameter applies to all of the mixing valves used, the actual open/close time must be approximately the same for each one. The minimum setting is 1 second, and the maximum setting is 255 seconds. The default setting is 20 seconds.

Data Logging

Reset log errors

The reset log errors function clears the last 10 errors log.

Functions

Service Mode Delay

By pressing the pin button on the front of the display for five (5) seconds, the control will be placed in Service Mode. This will override all other heat demands. The Service Mode allows the installer to set the unit to any firing rate for the purpose of combustion analysis. The delay sets the length of time the boiler will stay in the Service Mode if no keys have been pressed before going back to its original state. This parameter can only be changed by the installer by accessing the *Service Mode Delay parameter*. The time range of this parameter is 1 to 10 minutes. The default value is 10 minutes.

1 Service

Freeze Protection Pump On

The SMART SYSTEM control will turn on the boiler and system pump outputs whenever the inlet temperature drops below this setting. This is done to prevent the water in the heat exchanger from freezing. Certain low-temperature applications (such as snow melt) can operate at temperatures around freezing, so this setting needs to be lowered in these cases. The installer can adjust the temperature at which the pump outputs are turned on by accessing the *Freeze Protection Pump On parameter*. The minimum setting is -4°F (-20°C), and the maximum setting is 45°F (7.2°C). The default setting is 45°F (7.2°C).

Freeze Protection Burner On

If running the pumps does not prevent the inlet temperature from falling closer to freezing, the SMART SYSTEM control will fire the burner at low fire. The installer can adjust the temperature at which the burner fires by adjusting the *Freeze Protection Burner On parameter*. The minimum setting is -4°F (-20°C), and the maximum setting is the *Freeze Protection Pump On parameter*. The default setting is 37°F (2.8°C).

Freeze Protection Burner Differential

Once the burner has started firing due to a low inlet temperature, the inlet temperature must increase by this amount before the burner turns back off. The installer can adjust this differential by accessing the *Freeze Protection Burner Differential parameter*. The minimum setting is 0°, and the maximum is 20°F (11°C). The default setting is 5°F (2.8°C).

DHW Settings

DHW Tank Set Point

By installing a tank sensor, the SMART SYSTEM control can perform the tank thermostat function. The SMART SYSTEM control automatically detects the presence of this sensor, and generates a DHW call for heat when the tank temperature drops below the tank set point differential (*Tank Set point Differential parameter*), and finishes the call for heat when the tank temperature reaches tank set point. This parameter can be changed by the installer by accessing the *DHW Tank Set point parameter*. The temperature range of this parameter is from the tank minimum set point to the tank maximum set point. The default value is 120°F (49°C).

Tank Set Point Differential

When a tank sensor is installed, the tank temperature must drop this amount below the tank set point (*DHW Tank Set point parameter*) before the boiler turns back on. The installer can adjust this setting by accessing the *Tank Set point Differential parameter*. The minimum setting is 0° (0°C), and the maximum is 40°F (22°C). The default setting is 6°F (3°C).

DHW Boiler Set Point

When a DHW call for heat becomes active, the control will use the DHW boiler set point to determine the firing rate of the boiler based on the boiler outlet water temperature, or system temperature when DHW is programmed as a zone. This parameter can be changed by the installer by accessing the *DHW Boiler Set point parameter*. The temperature range of this parameter is 68°F (20°C) to 190°F (88°C). The default value is 180°F (82°C).

DHW Boiler Offset

This parameter reflects the degrees above DHW boiler set point the temperature has to go before the boiler will shut off. The range is 0°F (0°C) to 20°F (11°C). The default setting is 10°F (2.8°C).

DHW Boiler Differential

This parameter reflects the degrees below DHW boiler offset set point the temperature has to go before the boiler turns back on. The range is 0°F (0°C) to 60°F (33°C). The default setting is 20°F (6°C).

DHW Recirculation Pump Offset (Recirculation Pump)

The SMART SYSTEM control will turn the DHW recirculation pump on when the DHW return water temperature drops below the *DHW Tank Set Point* minus the *DHW Recirculation Pump Offset*. The range for this parameter is 0° to 54°F (30°C). The default value is 10°F (5°C).

DHW Recirculation Pump Differential

Once the SMART SYSTEM control turns the DHW recirculation pump on, the DHW return water temperature must increase by the *DHW Recirculation Pump Differential* before the control turns the DHW recirculation pump back off. The range of this parameter is 0° to 90°F (50°C). The default value is 5°F (2°C).

Tank Minimum Set Point

This setting controls the minimum tank set point for the tank temperature. The installer can adjust this by accessing the *Tank Minimum Set point parameter*. The minimum setting is 60°F (16°C) and the maximum setting is the maximum tank set point (*Tank Maximum Set point parameter*). The default value is 60° (16°C).

Tank Maximum Set Point

This setting controls the maximum tank set point for the tank temperature. The installer can adjust this by accessing the *Tank Maximum Set point parameter*. The minimum setting is the minimum tank set point (*Tank Minimum Set point parameter*) and the maximum setting is 190°F (88°C). The default value is 140°F (60°C).

1 Service *(continued)*

Fan Speed Limiting for Indirect DHW Tank

This parameter determines the maximum fan speed (and therefore the maximum rate) to be used when heating an indirect DHW tank. This setting may be used when the tank is unable to accept all of the BTU's available from the boiler. This parameter may be adjusted by the installer by accessing the *Fan Speed Limiting for Indirect DHW Tank parameter*. The default value is the maximum fan speed for that model.

DHW Type

This parameter determines whether the Fire Tube boiler treats the indirect DHW tank as a separate load, or as a zone on the primary loop. When programmed as a separate load, the boiler will turn on the DHW pump and then turn off the boiler pump when an indirect DHW demand begins. When programmed as a zone, the boiler will turn on the DHW pump, leave the boiler pump on and change the system set point to the DHW boiler set point (*DHW Boiler Set point parameter*).

This setting may be changed by the installer by accessing the *DHW Type parameter*. The choices are NORMAL and ZONE. The default setting is NORMAL.

SH/DHW Switching Time

When a boiler has a space heating demand and it receives a DHW demand, it will immediately switch to the DHW demand and start a timer. Once the timer has expired, the boiler will switch back to the space heating demand and start another timer. Once this other timer expires, it will switch back to the DHW demand. The installer can adjust the length of time the boiler will service the space heating demand by accessing the *SH/DHW Switching Time parameter*. The minimum setting is 0 minutes and the maximum setting is 55 minutes. The default time is 30 minutes.

DHW/SH Switching Time

When a boiler has a DHW demand and it receives a space heating demand, the SMART SYSTEM control will start a timer. Once the timer expires, it will stop the DHW demand and service the space heating demand. The installer can adjust the length of time the boiler will service the DHW demand by accessing the *DHW/SW Switching Time parameter*. The minimum setting is 0 minutes and the maximum setting is 55 minutes. The default setting is 30 minutes.

DHW Forces System Pump

When the indirect DHW tank is connected as a zone on the primary loop, the *DHW Forces Sys Pump* parameter tells the system pump if it must run when there is a DHW demand. To have the system pump constantly running during a DHW demand, set the *DHW Forces Sys Pump* parameter to YES (the parameter *DHW Blocks Sys Pump* must be set to NO). If this parameter and the *DHW Blocks Sys Pump* parameter are both set to NO, the system pump operation will be based strictly on the *System Pump Type* parameter setting. The default setting of this parameter is YES.

DHW Blocks System Pump

When the indirect DHW tank is connected as a zone on the primary loop, the *DHW Blocks Sys Pump* parameter tells the system pump if it is allowed to run during a DHW demand. To force the system pump to turn off during a DHW demand, set the *DHW Blocks Sys Pump* parameter to YES. The default setting is NO.

Outdoor reset

Knight Fire Tube boilers are equipped with outdoor reset, a feature that saves energy by reducing the boiler water temperature as the heating load decreases. In accordance with the United States Energy Policy and Conservation Act, boilers with inputs less than 300,000 Btu/hr must use either outdoor air reset or an external energy management system. To use the outdoor reset feature, the outdoor sensor provided with the boiler must be properly installed.

For better zone control, three (3) individual outdoor resets for low outdoor temperatures are available. If multiple zones are calling for heat, the highest set point has priority. Each curve is created using four (4) adjustable parameters: low outdoor air temperature, high outdoor air temperature, set point at low outdoor air temperature, and set point at high outdoor air temperature. The set point is calculated using the individual curve for each zone.

Outdoor (1 - 3) Low

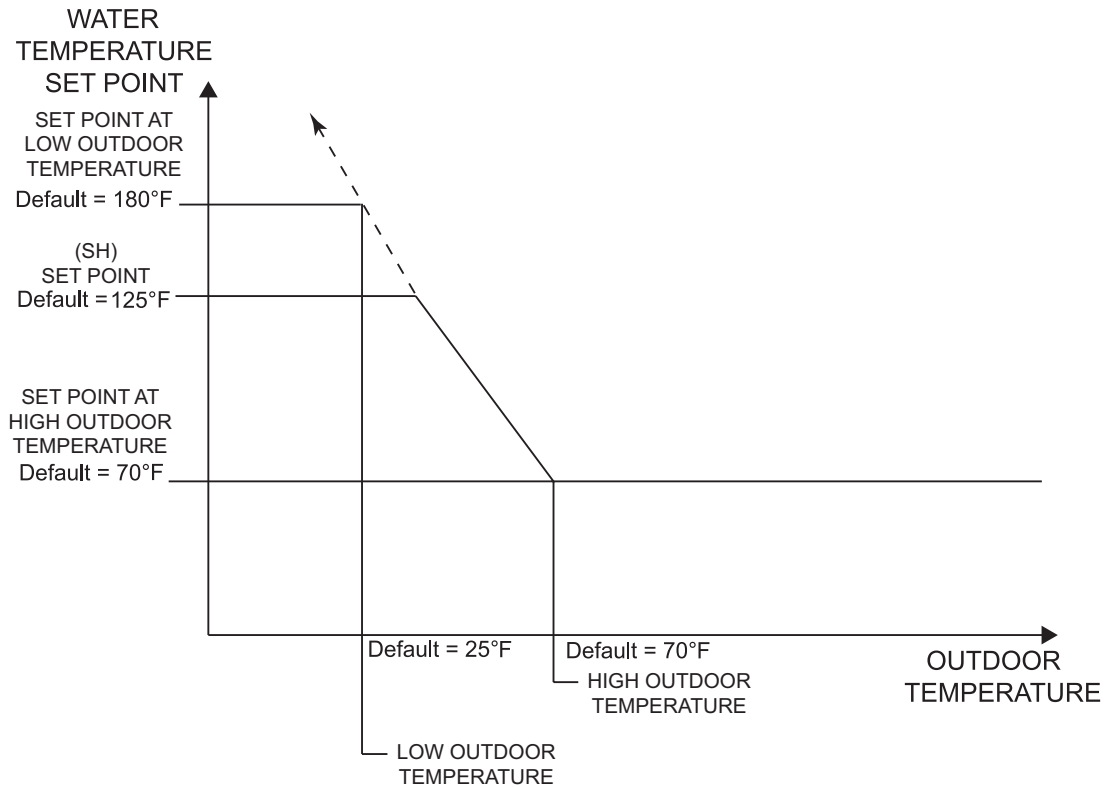
When the outdoor air temperature drops to this point, the water temperature will be at the *Set point 1 at Low Outdoor Temp 1, Set point 2 at Low Outdoor Temp 2 and Set point 3 at Low Outdoor Temp 3 parameters* (FIG. 1-1). If the outdoor air temperature drops further, the set point will continue to increase above this setting. This parameter can be changed by the installer by accessing the *Outdoor (1-3) Low parameter*. The temperature range of this parameter is -39°F (-39°C) to high outdoor temperature set point. The default value is 25°F (-4°C).

Outdoor (1 - 3) High

When the outdoor air temperature rises to or above this point, the water temperature will be at the *Set point 1 at High Outdoor Temp 1, Set point 2 at High Outdoor Temp 2 and Set point 3 at High Outdoor Temp 3 parameters* (FIG. 1-1). This parameter can be changed by the installer by accessing the *Outdoor (1-3) High parameter*. The temperature range of this parameter is low outdoor temperature set point to 104°F (40°C). The default value is 70°F (21°C).

1 Service

Figure 1-1 Outdoor Air Reset Curve



Set Point (1 - 3) at Low Outdoor Temperature

When the outdoor air temperature drops to the *Outdoor (1 - 3) Low parameters*, the calculated set point will be at this setting (FIG. 1-1). If the outdoor air temperature drops further, the set point will continue to increase above this setting. However, if SH1, SH2, and SH3 are set lower, the water temperature will be limited by these set points instead. These parameters can be changed by the installer by accessing the *Set point 1 at Low Outdoor Temp 1*, *Set point 2 at Low Outdoor Temp 2* and *Set point 3 at Low Outdoor Temp 3 parameters*. The temperature range of this parameter is 68°F (20°C) to 190°F (88°C). The default value is 180°F (82°C).

Set Point (1 - 3) at High Outdoor Temperature

When the outdoor air temperature rises to or above *Outdoor (1 - 3) High parameters*, the calculated set point will be at this setting (FIG. 1-1). These parameters can be changed by the installer by accessing the *Set point 1 at High Outdoor Temp 1*, *Set point 2 at High Outdoor Temp 2* and *Set point 3 at High Outdoor Temp 3 parameters*. The temperature range of this parameter is 68°F (20°C) to 190°F (88°C). The default value is 70°F (21°C).

Outdoor Air Shutdown (SH1 - SH3)

When the outdoor temperature rises above this point, the control will block the corresponding SH demand (DHW demands will still be active). These parameters can be changed by the installer by accessing the *Outdoor Air Shutdown SH1*, *SH2*, and *SH3 parameters*. The temperature range of this parameter is 32°F (0°C) to 104°F (40°C). The default value is 70°F (21°C).

Outdoor Air Shutdown Differential (SH1 - SH3)

The outdoor air shutdown differential parameter is the number of degrees below *Outdoor Air Shutdown SH1*, *SH2*, and *SH3 parameters* the outdoor air temperature must go before the boiler will respond to the corresponding SH demand. These parameters can be changed by the installer by accessing the *Outdoor Air Shutdown Differential SH1*, *SH2*, and *SH3 parameters*. The temperature range of this parameter is 0°F (0°C) to 54°F (30°C). The default value is 10°F (6°C).

Shift Reset Curve (SH1 - SH3)

There is a shift reset parameter for each outdoor reset curve. The shift reset parameter shifts the actual set point above or below the calculated set point by the number of degrees in this parameter. These parameters can be changed by the installer by accessing the *Shift Reset Curve SH1*, *SH2*, and *SH3 parameters*. The temperature range of this parameter is -18°F (-10°C) to 18°F (10°C). The default value is 0°F (0°C). This feature will be active if this parameter is set to anything other than 0°F (0°C).

1 Service *(continued)*

Boost Temperature

If a SH demand lasts longer than the programmed time delay setting and there have been no DHW demands, the control will increase the water temperature set point by the amount in this parameter. If the SH demand continues through another time period, the set point will be increased again. This will continue until either the SH demand ends, a maximum of 20 increases has occurred, or SH1, SH2, SH3 maximum set point has been reached. Once the SH demand has been satisfied the set point will revert back to its calculated setting. The boost temperature can be changed by the installer by accessing the *Boost Temperature parameter*. The temperature range of this parameter is 0°F (0°C) to 25°F (14°C). The default value is 0°F (0°C). This feature will be active if this parameter is set to anything other than 0°F (0°C).

Boost Time

The boost time parameter sets the amount of time that must elapse with a SH demand before the water temperature calculated set point will be increased. This parameter can be changed by the installer by accessing the *Boost Time parameter*. The time range for this parameter is 0 minutes to 55 minutes. The default value is 0 minutes.

Anti-cycling

Anti-Cycling Time

Once the burner turns off, a set amount of time must elapse before the control will respond to a new demand. The control will block the new heat demand and anti-cycling will be shown in the display until the time has elapsed or the water temperature drops below the *Anti-Cycling Override Differential parameter*. This parameter can be changed by the installer by accessing the *Anti-Cycling Time parameter*. The time range for this parameter is 1 minute to 10 minutes. The default value is 1 minute.

Anti-Cycling Override Differential

The control will bypass the anti-cycling time if the inlet water temperature drops too much. The control will use the inlet water temperature present at the boiler when it shuts off as the starting point. If the inlet temperature drops below the temperature parameter the control will abort anti-cycling and allow the boiler to fire. This parameter can be changed by the installer by accessing the *Anti-Cycling Override Differential parameter*. The temperature range of this parameter is 0°F (0°C) to 54°F (30°C). The default value is 10°F (6°C).

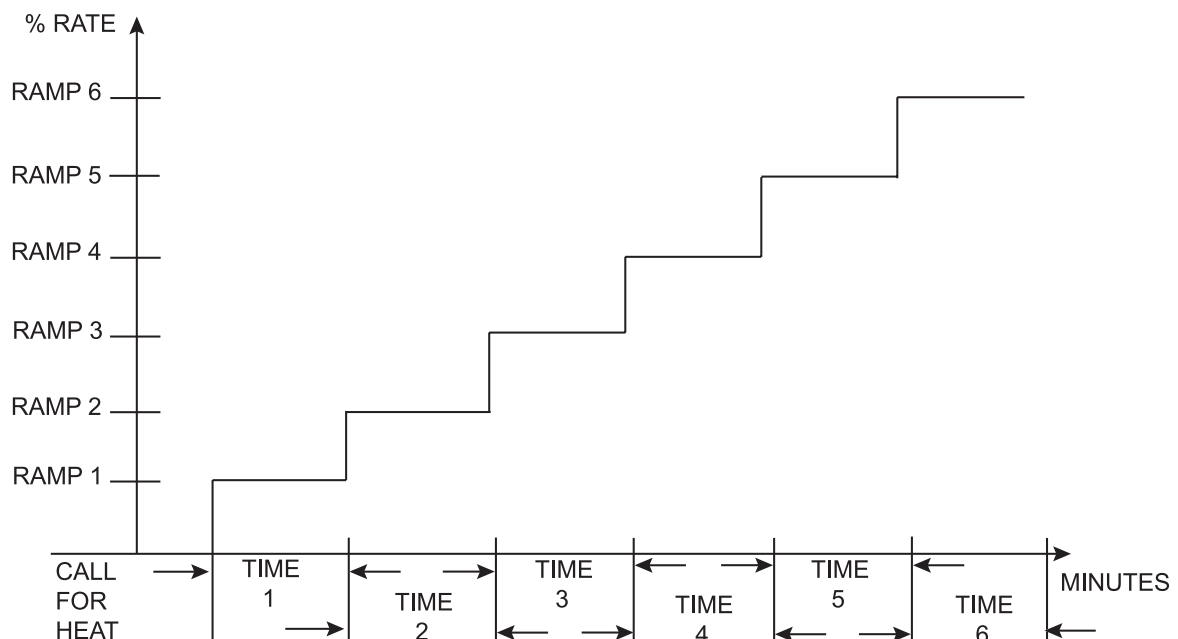
Ramp Delay (Enable / Disable)

This parameter allows the installer to enable or disable the SH ramp delay. The default setting is disabled.

Modulation Factor

This parameter allows the installer to reduce the responsiveness of the temperature control function, for situations where, for example, redundant heating capacity is installed. The values that are available are 40, 50, 60, 70, 80, 90, and 100, with 100 being the most responsive. The default value is 100.

Figure 1-2 Ramp Delay Interval



1 Service

Ramp Settings

NOTICE

Please note that the brackets ([]) denote screen status.

The SMART SYSTEM control can be programmed to limit the firing rate for a fixed period of time at the start of a space heating or BMS set point demand. There are six (6) possible limits, each with their own time delay. The first limit applies as soon as the burner starts. Once its time delay expires, the second limit is applied and its timer begins. The control steps through these limits until the 6th (sixth) limit expires. Note, however, that the 6th limit will also limit the rate for the rest of that heat demand. The installer can adjust the firing limits and time delays by accessing the *Ramp Settings parameter*. Once this parameter is selected, the screen will show the step number, the time delay for that step and the limit value corresponding with that step. If the installer wishes to adjust one of the values in that step, he can press the NAVIGATION dial until the value he wishes to change is flashing. The installer can then rotate the NAVIGATION dial to adjust that value. If the installer presses the RIGHT SELECT [SAVE] key while the limit value is flashing, the step value will flash again. The installer can then select the next step and adjust the delay and limit values corresponding with that step.

When finished, the installer can press the RIGHT SELECT [SAVE] key to store the new settings, or the LEFT SELECT [EXIT] key to return to the **Anti-Cycling** parameter list without saving the changes. The delay value can be set between 0 minutes and 40 minutes. The limit value can be set between 0% and 100%.

Control modes

Controlling Sensor

The SH controlling sensor parameter selects the sensor the control will use to regulate the boiler firing rate. This parameter is adjustable by the installer by accessing the *Controlling Sensor parameter*. The sensor selections are as follows: The outlet sensor regulates the firing rate based on the outlet water temperature of the boiler and the inlet sensor regulates the firing rate based on the inlet water temperature of the boiler. If the outlet sensor is selected, and the optional system supply sensor is connected, the control will regulate the firing rate based on the system supply sensor temperature. The default sensor is the Outlet Sensor.

Cascade Address

The boiler designated as the Leader needs to be programmed with address 0. All the Member boilers require addresses from 1 to 7, and the addresses must be different for each Member. The addresses can be in any order, regardless of the order in which the units are wired together. This parameter is adjustable by the installer by accessing the *Cascade Address parameter*. The outdoor air (if used) and system supply sensor must be connected to the Leader boiler. The default address is 1.

Maximum Cascade Set Point

This parameter determines the set point used by the individual boilers in a Cascade when a system sensor is connected to the Leader boiler. When a boiler is commanded to fire by the Leader boiler, it will attempt to achieve this temperature at its outlet. The Leader boiler will limit the modulation of the boiler(s) in order to hold the temperature at the system supply sensor to the user set point. If any of the boiler outlet temperatures reach the maximum cascade set point, that boiler will then modulate down on its own in order to keep its outlet temperature within the maximum cascade set point. Therefore, this parameter can be used to limit the outlet temperatures of all the boilers in a Cascade. Note that this parameter does not apply when the boiler is heating an indirect DHW tank programmed as normal. This parameter is adjustable by the installer by accessing the *Maximum Cascade Set Point parameter*. The temperature range of this parameter is 32°F (0°C) to 190°F (88°C). The default maximum cascade set point is 185°F (85°C).

Cascade Offset

This parameter determines how much the temperature must go above set point before the lead boiler will turn off. This parameter can be adjusted by the installer by accessing the *Cascade Offset parameter*. The temperature range of this parameter is 0° to 20°F (11°C) The default value is 10°F (6°C).

Cascade Differential

This parameter determines how much the temperature must go below the turn off temperature (Set point + Offset) before the lead boiler turns on. This parameter can be adjusted by the installer by accessing the *Cascade Differential parameter*. The temperature range of this parameter is 0°F to 60°F (33°C) The default value is 20°F (11°C).

Cascade Type (L/L / EFF)

There are two (2) options for the way a Cascade divides the load between its heaters. The first is Lead/Lag, designated as L/L in the menu. This method is used when it is desired to have the least amount of total flow through the boilers. This method will modulate the last two (2) boilers that are firing. This provides for smooth transitions when a boiler turns on or off. When the last boiler reaches 100% and the calculated load is still increasing, it will start the next boiler at its minimum rate and reduce the previous boiler to compensate, thus eliminating the sudden jump in total output of the Cascade. When the calculated load is decreasing and the last boiler gets down to minimum rate, it will hold it there and start lowering the firing rate on the next-to-last boiler. When the next-to-last boiler reaches minimum rate, it will turn the last boiler off and raise the rate of the next-to-last boiler to compensate for the decreased load, thus eliminating the sudden drop in total output of the Cascade.

1 Service *(continued)*

The other Cascade divider method is Efficiency Optimization, designated as EFF in the menu. This method is used, as the name implies, when it is desired to have the most efficient system. When the first boiler reaches 100% rate, it lowers its rate to 50% and turns on the next boiler at 50%. The two (2) boilers then modulate at the same rate. As the calculated load increases further and both boilers ramp up to 100%, it lowers the rate of the first two (2) boilers to 67% and brings the next boiler on at 67%. The three (3) boilers then modulate together. As the calculated load decreases, the boilers will reach 20%, at which time the last boiler (the third in our example) will turn off and the Cascade will increase the rates of the remaining boilers to provide the equivalent total output as before ($(3 \times 20\%) / 2 = 30\%$ in our example). Efficiency optimization is automatically selected when boilers of different sizes are programmed into the Leader control.

Minimum On/Off Time

In order to prevent units in a Cascade from short cycling, this parameter defines the minimum ON and OFF time for each unit. The installer can adjust this time by accessing the *Minimum On/Off Time* parameter. The minimum setting is 0 seconds and the maximum setting is 10 minutes. The default is 30 seconds.

Minimum Next On Time

In order to reduce the risk of temperature overshoot with a Cascade, this parameter defines the minimum time delay from starting one unit until the next unit may be started. The installer can adjust this time delay by accessing the *Minimum Next On Time* parameter. The minimum setting is 0 minutes and the maximum setting is 10 minutes. The default is 60 seconds.

Minimum Number of Pumps On

When the boiler is a Cascade Leader, it can force a minimum number of boiler pump outputs to be on continuously, regardless of how many boilers are firing. This is normally used when the boilers are piped in a full-flow configuration, and the boiler pump outputs are controlling isolation valves. The Leader will force the boiler pump output on the highest priority boiler to turn on first, then the boiler pump output on the second highest priority boiler, and so forth, until the minimum number of pump outputs are turned on. The range of this parameter is 0 to 8. The default value is 0.

Alternate Leader

This parameter allows the Member 1 boiler to automatically assume control of the Cascade should it lose communication with the Leader boiler. When programmed to YES, it is recommended that the Member 1 boiler have its own set of external sensors installed (such as the system supply sensor), to maintain the same level of temperature control as with the Leader boiler. Voltage signals (such as the 0 - 10V system pump speed input) can be connected to both boilers.



DO NOT connect the sensors connected to the Leader boiler to the Member 1 boiler. The actual water temperatures will be higher than expected, which could lead to property damage, personal injury, or death.

When communication is re-established with the Leader boiler, Member 1 will automatically relinquish control of the Cascade to the Leader boiler.

The default value of this parameter is NO.

Boiler Size

When boilers of different sizes are connected together in a Cascade, the Leader boiler has to know the size of each boiler in that Cascade. The Knight Fire Tube boiler models are pre-programmed with their respective sizes. Each Member will send its input rating to the Leader. There are previous generation boilers that do not have this capability. When operating in Cascade with these boilers it may be necessary to input each member boiler size to the Leader boiler. This may be done by accessing the *Boiler Size* parameter (for additional information reference the Programming Smart System Controls for Multiple Size Units & Front End Loading Instruction Sheet provided in the literature package attached to the appliance).

Building Management System (BMS)

BMS

The set point or modulation of the boiler may be controlled through the 0 - 10V BMS input, BACnet, or ModBus. When the *BMS parameter* is set to INACTIVE, the 0 - 10V input will be ignored. When set to ACTIVE, the set point or modulation will be controlled by the voltage on the 0 - 10V input (in the case of 0 - 10V BMS control), or the 0 - 10V input value received through ModBus or BACnet. The default value is INACTIVE.

BMS Type

When programmed for BMS control through the 0 - 10V BMS input or through ModBus/BACnet, the 0 - 10V signal can be interpreted as either a modulation command or a set point. When the *BMS Type* parameter is set to POWER, the 0 - 10V signal will control the modulation. When set to SETPOINT, the 0 - 10V signal will control the SH set point. The default setting is SETPOINT.

1 Service

Rate at Minimum Volts

When programmed for BMS control through the 0 - 10V BMS input or through ModBus/BACnet and the BMS Type is programmed as POWER, the modulation percentage represented by the *Volts at Minimum* parameter is set by the *Rate at Minimum Volts* parameter. The minimum value is 0% and the maximum is the *Rate at Maximum Volts* setting. The default value is model dependant.

Rate at Maximum Volts

When programmed for BMS control through the 0 - 10V BMS input or through ModBus/BACnet and the BMS Type is programmed as POWER, the modulation percentage represented by the *Volts at Maximum* parameter is set by the *Rate at Maximum Volts* parameter. The minimum value is the *Rate at Minimum Volts* setting and the maximum is 100%. The default value is 100%.

Set Point at Minimum Volts

When programmed for BMS control through the 0 - 10V BMS input or through ModBus/BACnet and the BMS Type is programmed as SETPOINT, the set point represented by the *Volts at Minimum* parameter is set by the *Set Point at Minimum Volts* parameter. The minimum value is 32°F (0°C) and the maximum is the *Set Point at Maximum Volts* setting. The default value is 70°F (21°C).

Set Point at Maximum Volts

When programmed for BMS control through the 0 - 10V BMS input or through ModBus/BACnet and the BMS Type is programmed as SETPOINT, the set point represented by the *Volts at Maximum* parameter is set by the *Set Point at Maximum Volts* parameter. The minimum value is the *Set Point at Minimum Volts* setting and the maximum is 190°F (88°C). The default value is 180°F (82°C).

Volts at Minimum

When programmed for BMS control through the 0 - 10V BMS input or through ModBus/BACnet, the *Volts at Minimum* parameter should be set to the minimum voltage signal sent to the SMART SYSTEM control. The range of this parameter is 0.0V to the *Volts at Maximum* value. The default setting is 2.0V.

Volts at Maximum

When programmed for BMS control through the 0 - 10V BMS input or through ModBus/BACnet, the *Volts at Maximum* parameter should be set to the maximum voltage signal sent to the SMART SYSTEM control. The range of this parameter is the *Volts at Minimum* value to 10.0V. The default value is 10.0V.

BMS Thermostat Input

When controlling the boiler through the 0 - 10V BMS input, BACnet, or ModBus, the boiler can be enabled one of two ways. With the *BMS Thermostat Input parameter* set to ACTIVE, the boiler will be enabled by closing the Heat/Loop Demand 1 input. When set to INACTIVE, the boiler will be enabled by the voltage level on the 0 - 10V input (in the case of 0 - 10V BMS control), or the 0 - 10V input value received through BACnet or ModBus. The default value is INACTIVE.

On Volts

When programmed for BMS control through the 0 - 10V BMS input or through ModBus/BACnet and the BMS Thermostat Input is set to INACTIVE, the *On Volts* parameter determines the 0 - 10V BMS input voltage at which the boiler is enabled. The minimum value is 0.5V and the maximum is 10.0V. The default value is 2.0V.

Off Differential Volts

When programmed for BMS control through the 0 - 10V BMS input or through ModBus/BACnet and the BMS Thermostat Input is set to INACTIVE, the *Off Differential Volts* parameter determines how far below the *On Volts* setting the 0 - 10V BMS input voltage must be in order to disable the boiler. The minimum value is 0.2V and the maximum is the *On Volts* setting. The default value is 1.0V.

ModBus/BACnet

When BMS is set to ACTIVE (see BMS Active / Inactive) and the boiler is being controlled through BACnet or ModBus, set *ModBus/BACnet* parameter to ACTIVE. Otherwise, set the *ModBus/BACnet* parameter to INACTIVE. Note that the boiler can still be monitored by ModBus or BACnet with this parameter set to INACTIVE. The default value is INACTIVE.

BAS T/O

This is the amount of time the unit controls will wait to receive a communication string from the BMS controller before reverting back to its own internal parameters. This parameter is adjustable by the installer by accessing the *BAS T/O* parameter. The adjustment range of this parameter is 5 seconds to 2 minutes. The default value is 10 seconds.

1 Service *(continued)*

Circulation pumps

System Pump Delay

The system pump delay parameter sets the length of time the system pump (if connected) will run after a SH demand has been satisfied or outdoor shutdown has begun. This parameter is adjustable by the installer by accessing the *System Pump Delay* parameter. The time range for this parameter is 1 second to 40 minutes. The default time is 30 seconds.

Boiler Pump Delay

The SH pump delay parameter sets the length of time the boiler pump will run after a SH demand has been satisfied. Setting the delay time to 0 will disable the pump. This parameter is adjustable by the installer by accessing the *Boiler Pump Delay* parameter. The time range for this parameter is 1 second to 40 minutes. The default time is 30 seconds.

DHW Pump Delay

The DHW pump delay parameter sets the length of time the DHW pump (if connected) will run after a DHW demand has been satisfied. This parameter is adjustable by the installer by accessing the *DHW Pump Delay* parameter. The time range for this parameter is 10 seconds to 40 minutes. The default time is 1 minute.

System Pump Anti-Seize Delay

If the boiler pump does not run for 24 hours, it will be turned on briefly to prevent it from seizing. The length of time it runs is determined by the *System Pump Anti-Seize Delay* parameter. The range of this setting is 0 seconds to 40 minutes. The default setting is 20 seconds.

Boiler Pump Anti-Seize Delay

If the boiler pump does not run for 24 hours, it will be turned on briefly to prevent it from seizing. The length of time it runs is determined by the *Boiler Pump Anti-Seize Delay* parameter. The range of this setting is 0 seconds to 40 minutes. The default setting is 20 seconds.

DHW Pump Anti-Seize Delay

If the boiler pump does not run for 24 hours, it will be turned on briefly to prevent it from seizing. The length of time it runs is determined by the *DHW Pump Anti-Seize Delay* parameter. The range of this setting is 0 seconds to 40 minutes. The default setting is 20 seconds.

System Pump Type

The system pump can be programmed to operate in response to any of the Room Thermostat inputs, or to run continuously until all three (3) SH demands go into Outdoor Shutdown. To program the system pump to operate only with a space heating call for heat, set the *System Pump Type* parameter to CFH. To program the system pump to run continuously until outdoor shutdown starts, set the *System Pump Type* parameter to WWSD. The default setting is CFH.

Boiler Pump Type

This parameter determines how the control turns the boiler circulating pump on and off. The choices are CONSTANT and VARIABLE. When set to CONSTANT, the control will use an external relay to cycle power supply to the boiler pump. The CONSTANT setting can be used with either a fixed or variable speed circulating pump. When set to VARIABLE and wired to 0 - 10V BLR PUMP OUT on the low voltage board, the control will send a standby signal to turn off the pump. The VARIABLE setting should be used when controlling the ECM variable speed boiler pump provided by the factory. The default setting is CONSTANT.

Boiler Pump Delta T Set Point

When using a variable speed boiler pump, and controlling it by means of the 0 - 10V Boiler Pump Speed Output, the boiler pump will be controlled in order to maintain a minimum Delta T across the heat exchanger in the boiler (other factors may override this target). This feature is to be used with Primary / Secondary piping systems only. A system supply sensor MUST be installed. This parameter sets the target minimum Delta T it will use. The range of this parameter is 15°F (8°C) to 60°F (33°C). The default value is 20°F (11°C).

Boiler Pump Minimum Voltage

The speed of the boiler pump can be controlled by the SMART SYSTEM control in order to maintain a minimum ΔT through the heat exchanger. Thus, as the firing rate decreases, the speed of the boiler pump can decrease as well. The SMART SYSTEM control outputs a 0 - 10V signal to the boiler pump to control its speed. The *Boiler Pump Minimum Voltage* parameter determines the minimum voltage given to the boiler pump, thereby setting its minimum speed. The range of this setting is 0V to 10V. The default setting is 3V.

Boiler Pump Maximum Voltage

The SMART SYSTEM control outputs a 0 - 10V signal to control the speed of the boiler circulator. The *Boiler Pump Maximum Voltage* parameter sets the maximum voltage signal to the boiler pump, thereby limiting its maximum speed. The range of this setting is Boiler Pump Minimum Voltage setting to 10V. The default setting is 10V.

1 Service

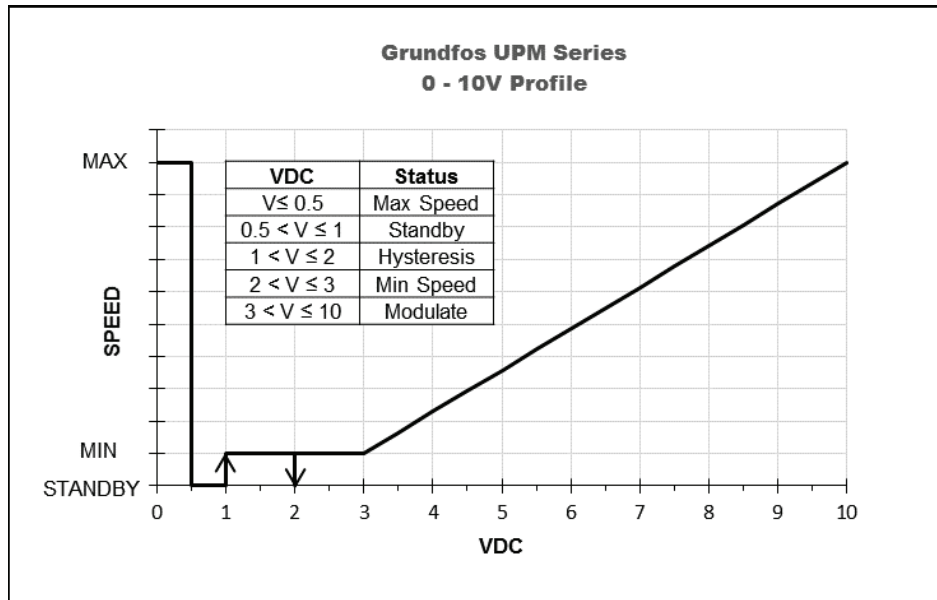
Boiler Pump Standby Voltage

When the *Boiler Pump Type* parameter is set to VARIABLE, the control will turn off the pump in standby conditions using a 0 – 10V signal. The range of this setting is 0V to Boiler Pump Minimum Voltage setting. To accommodate the 0 – 10V profile (FIG. 1-3) of the factory supplied circulator, the default setting is 0.9V.

NOTICE

When connected to the low voltage board, the Knight Fire Tube boiler will control the pump via a 0 - 10 VDC signal. In case the pump does not receive a signal from the control (cable break), it will run at maximum speed.

Figure 1-3 Boiler Pump Voltage Settings



Service Notification

Service Notification in Months

When the boiler control determines that a scheduled service is due based on days of installation, the boiler display will turn yellow and a new status screen will appear informing the user that maintenance is required. This parameter is adjustable by the installer by accessing the *Service Notification in Months* parameter. The time range for this parameter is 0 months to 100 months. The default time is 13 months.

Service Notification Running Time

When the boiler control determines that a scheduled service is due based on the hours of actual operation, the boiler display will turn yellow and a new status screen will appear informing the user that maintenance is required. This parameter is adjustable by the installer by accessing the *Service Notification Running Time* parameter. The time range for this parameter is 0 hours to 17,500 hours. The default time is 8,760 hours.

Service Notification Cycles

When the boiler control determines that a scheduled service is due based on the number of boiler cycles, the boiler display will turn yellow and a new status screen will appear informing the user that maintenance is required. This parameter is adjustable by the installer by accessing the *Service Notification Cycles* parameter. The range for this parameter is 0 cycles to 100,000 cycles. The default is 50,000 cycles.

1 Service *(continued)*

Reset Maintenance Reminder

Once servicing has been completed, the service notification counter should be reset. This parameter can be reset by the installer by accessing the *Reset Maintenance Reminder* parameter. Once accessed, press the RESET key to reset the service notification counter.

Service Name and Phone Number

NOTICE

Please note that the brackets ([]) denote screen status.

When a Maintenance Reminder timer or counter has expired, a Maintenance Reminder screen will appear on the display. By programming the installer's name and phone number, this information will appear on the Maintenance Reminder Screen at that time. This can be programmed by accessing the *Service Name and Phone Number* parameter. When selected, another menu will appear with PHONE and NAME.

1. Rotate the NAVIGATION dial to point to the desired input parameter menu to program and press the NAVIGATION dial. The screen will now display the selected item (either PHONE or NAME).
2. Press the NAVIGATION dial again. A cursor will appear at the bottom of the screen. By rotating the NAVIGATION dial, various numbers and characters will appear. When the desired number/character is found, press the NAVIGATION dial. The cursor will move to the next position.
3. Repeat this procedure until the entire text is entered. If you make a mistake and wish to back up one character, rotate the NAVIGATION dial until the back arrow (←) character is displayed and press the NAVIGATION dial.
4. When finished, press the RIGHT SELECT [SAVE] key to return to the previous menu.

Aux Contact Name

An optional remote proving switch may be wired to the AUX (LOUVER) PROVING SWITCH contacts on the low voltage connection board. By accessing the *Aux Contact Name* parameter, the installer can enter a custom name, up to 12 characters, to identify the device. In the case of a fault, AUX: [CUSTOM NAME] will be displayed. The default display fault is AUX CONTACT.

Basic Setup

The Basic Setup Menu contains the most frequently used parameters from the list above. See the descriptions above to set these parameters.

Loch-N-Link™

Parameter files can be copied directly to and from a USB flash drive. When USB is selected from the Main Menu, the display will ask you to insert a flash drive into the USB-A (rectangular) port next to the display. Once a drive is inserted, the display will search the root directory of this drive for a folder named "lochinvr". If it does not find it, the display will ask if you want it to create this folder? Press either the [YES] or [NO] key. If you press [NO], no further operations are allowed, so you must remove the flash drive. If you press [YES], it will create the folder in the flash drive. If the flash drive contains a folder named lochinvr, the display will show all of the parameter files stored in that folder.

If you wish to copy the parameters from the Smart System control into the flash drive, press the [SAVE] key. The display will create a file name based on the current date and time (year-month-date-hours-minutes). If you wish to cancel this operation, press the [NO] key. If you wish to change the filename, press the NAVIGATION dial. The first character of the filename will flash. Rotate the NAVIGATION dial to change this character. Once it is correct, press the NAVIGATION dial again, and edit the next character as before. When the new filename is ready, press the [SAVE] key. The control will save the parameters to the flash drive, and the new file will appear in the list of parameter files. Press the [EXIT] key to return to the Main Menu.

If you wish to copy a parameter file from the flash drive into the Smart System control, rotate the NAVIGATION dial until the file you wish to copy is selected. Press the NAVIGATION dial once. The display will ask you if you want to load the parameters from the file you selected. You can press [NO] to cancel the operation, or press [YES] to continue with writing the parameters into the control. Once the loading process is complete, the display will return to the Main Status Screen.

2 Maintenance

Maintenance and annual startup

Table 2-1 Service and Maintenance Schedules

		Service technician (see the following pages for instructions)	Owner maintenance (see the Knight Fire Tube Boiler User's Information Manual for instructions)
ANNUAL START-UP		<p>General:</p> <ul style="list-style-type: none"> • Address reported problems • Inspect interior; clean and vacuum if necessary; • Clean condensate trap and fill with fresh water • Check for leaks (water, gas, flue, condensate) • Verify flue and air lines in good condition and sealed tight • Check system water pressure/system piping/expansion tank • Check fill water meter • Test boiler water. When test indicates, clean system water with approved system restorer following manufacturer's information. • Check control settings • Check ignition and flame sense electrodes (sand off any deposits; clean and reposition) • Check wiring and connections • Perform start-up checkout and performance verification per Section 10 in the Knight Fire Tube Boiler Installation and Operation Manual. • Flame inspection (stable, uniform) • Flame signal (at least 10 microamps at high fire) • Clean the heat exchanger if flue temperature is more than 54°F (30°C) above return water temperature. • Test low water flow conditions. • Check venturi flapper for free motion. <p>If combustion or performance indicate need:</p> <ul style="list-style-type: none"> • Clean heat exchanger • Remove and clean burner using compressed air only • Clean the blower wheel 	<p style="background-color: black; color: white; text-align: center;">Daily</p> <ul style="list-style-type: none"> • Check boiler area • Check pressure/temperature gauge
		<p style="background-color: black; color: white; text-align: center;">Monthly</p> <ul style="list-style-type: none"> • Check vent piping • Check air piping • Check air and vent termination screens • Check relief valve • Check condensate drain system • Check air vents 	
		<p style="background-color: black; color: white; text-align: center;">Periodically</p> <ul style="list-style-type: none"> • Test low water cutoff • Reset button (low water cutoff) 	
		<p style="background-color: black; color: white; text-align: center;">Every 6 months</p> <ul style="list-style-type: none"> • Check boiler piping (gas and water) for leaks • Operate relief valve 	
		<p style="background-color: black; color: white; text-align: center;">End of season months</p> <ul style="list-style-type: none"> • Shut boiler down (unless boiler used for domestic hot water) 	

2 Maintenance *(continued)*

⚠ DANGER

If this boiler may be frozen, immediately shut off power and gas to the appliance and contact the factory for further instructions. Operation when the heat exchanger, internal pipes, or pressure relief valves are frozen, will result in internal pressure build-up and a deadly steam explosion. Neither the Freeze Protection feature of the boiler control module nor the use of glycol eliminates the possibility of freezing.

⚠ WARNING

Follow the Service and maintenance procedures given throughout this manual and in component literature shipped with the boiler. Failure to perform the service and maintenance could result in damage to the boiler or system. Failure to follow the directions in this manual and component literature could result in severe personal injury, death, or substantial property damage.

⚠ WARNING

The boiler should be inspected annually only by a qualified service technician. In addition, the maintenance and care of the boiler designated in Table 2-1 and explained on the following pages must be performed to assure maximum boiler efficiency and reliability. Failure to service and maintain the boiler and system could result in equipment failure.

⚠ WARNING

Electrical shock hazard – Turn off power to the boiler before any service operation on the boiler except as noted otherwise in this instruction manual. Failure to turn off electrical power could result in electrical shock, causing severe personal injury or death.

Address reported problems

1. Inspect any problems reported by the owner and correct before proceeding.

Inspect boiler area

1. Verify that boiler area is free of any combustible materials, gasoline and other flammable vapors and liquids.
2. Verify that air intake area is free of any of the contaminants listed in Section 1 of the Knight Fire Tube Boiler Installation and Operation Manual. If any of these are present in the boiler intake air vicinity, they must be removed. If they cannot be removed, reinstall the air and vent lines per this manual and the Knight Fire Tube Boiler Installation and Operation Manual.

Inspect boiler interior

1. Remove the front access cover and inspect the interior of the boiler.
2. Vacuum any sediment from inside the boiler and components. Remove any obstructions.

Inspect condensate trap

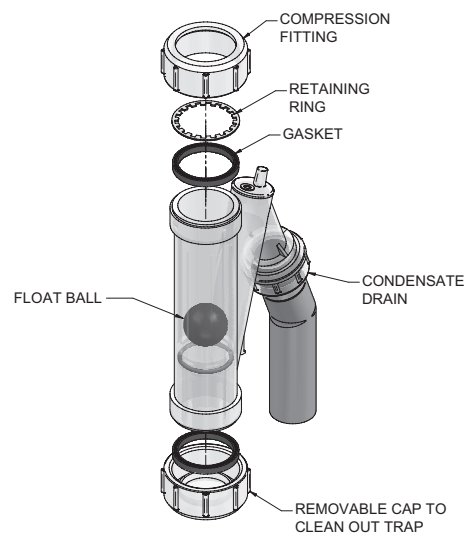
1. Inspect the condensate trap and drain line monthly to ensure it is properly installed and there are no obstructions in the drain line.
2. Inspect the neutralizing kit (if installed) monthly to ensure the condensate is draining properly and there is an adequate amount of neutralizing agent available.

Annual cleaning

1. The condensate trap should be cleaned at least once annually, or at the end of each heating season. Remove the clean out cap on the bottom of the trap (FIG. 2-1). Let the condensate and any debris drain out and clean out any sediment that exists. Ensure the gasket is seated in the cap before reinstalling.

2. To remove the condensate trap from the unit, loosen the compression fitting located on top of the condensate (FIG. 2-1). Condensate fluid may run out of the heat exchanger.
3. The provided condensate trap is equipped with a ball that acts as a seal against harmful flue gases escaping in case there is no condensate in the trap. If this ball is not present, flue gases may be able to pass through the trap when there is no condensate present, resulting in an unsafe environment. It is important to check and make sure the ball is located in the trap, acting as a seal against flue gases.
4. Fill condensate trap with enough water to make the ball float (FIG. 2-1).
5. Reinstall the condensate trap onto the condensate drain. The stainless steel retaining ring, which allows the trap to be pushed on, but not pulled off, must be installed between the rubber sealing gasket and the compression fitting. The compression fitting must be tightened.
6. Ensure condensate tubing slopes down and away from the boiler into a drain or condensate neutralizing filter (if installed).

Figure 2-1 Condensate Trap



IMG00209

2 Maintenance

Check all piping for leaks

⚠ WARNING

Eliminate all system or boiler leaks. Continual fresh makeup water will reduce boiler life. Minerals can build up in sections, reducing heat transfer, overheating heat exchanger, and causing heat exchanger failure. Leaking water may also cause severe property damage.

1. Inspect all water and gas piping and verify to be leak free.
2. Look for signs of leaking lines and correct any problems found.
3. Check gas line using the procedure found in Section 7 - Gas Connections of the Knight Fire Tube Boiler Installation and Operation Manual.

Flue vent system and air piping

1. Visually inspect the entire flue gas venting system and air piping for blockage, deterioration or leakage. Repair any joints that show signs of leakage. Verify that air inlet pipe is connected and properly sealed.
2. Verify that boiler vent discharge and air intake are clean and free of obstructions.
3. Verify the venturi is freely moving and does not have any sticky residue on the flapper. If necessary, clean surface with a non-abrasive bristle brush and alcohol; make sure to remove any excess alcohol before reinstalling.

⚠ WARNING

Failure to inspect for the above conditions and have them repaired can result in severe personal injury or death.

Check water system

1. Verify all system components are correctly installed and operational.
2. Check the cold fill pressure for the system. Verify it is correct (must be a minimum of 12 psi (82.7 kPa)).
3. Watch the system pressure as the boiler heats up (during testing) to ensure pressure does not rise too high. Excessive pressure rise indicates expansion tank sizing or performance problem.
4. Inspect automatic air vents and air separators. Remove air vent caps and briefly press push valve to flush vent. Replace caps. Make sure vents do not leak. Replace any leaking vents.

Check expansion tank

1. Expansion tanks provide space for water to move in and out as the heating system water expands due to temperature increase or contracts as the water cools. Tanks may be open, closed or diaphragm or bladder type. See Section 6 - Hydronic Piping of the Knight Fire Tube Boiler Installation and Operation Manual for suggested best location of expansion tanks and air eliminators.

Check fill water meter

1. Check fill water meter for water usage. If the amount exceeds 5% of your system volume, you could have a leak. Have the system checked for leaks and fixed by a qualified service technician.

Test boiler water

1. Test boiler water. Reference the Knight Fire Tube Installation and Operation Manual for guidelines. When test indicates, clean system water with approved system restorer following the manufacturer's information.

Check boiler relief valve

1. Inspect the relief valve and lift the lever to verify flow. Before operating any relief valve, ensure that it is piped with its discharge in a safe area to avoid severe scald potential. Read Section 6 - Hydronic Piping of the Knight Fire Tube Boiler Installation and Operation Manual before proceeding further.

⚠ WARNING

Safety relief valves should be re-inspected AT LEAST ONCE EVERY THREE YEARS, by a licensed plumbing contractor or authorized inspection agency, to ensure that the product has not been affected by corrosive water conditions and to ensure that the valve and discharge line have not been altered or tampered with illegally. Certain naturally occurring conditions may corrode the valve or its components over time, rendering the valve inoperative. Such conditions are not detectable unless the valve and its components are physically removed and inspected. This inspection must only be conducted by a plumbing contractor or authorized inspection agency – not by the owner. Failure to re-inspect the boiler relief valve as directed could result in unsafe pressure buildup, which can result in severe personal injury, death, or substantial property damage.

⚠ WARNING

Following installation, the valve lever must be operated AT LEAST ONCE A YEAR to ensure that waterways are clear. Certain naturally occurring mineral deposits may adhere to the valve, rendering it inoperative. When manually operating the lever, water will discharge and precautions must be taken to avoid contact with hot water and to avoid water damage. Before operating lever, check to see that a discharge line is connected to this valve directing the flow of hot water from the valve to a proper place of disposal. Otherwise severe personal injury may result. If no water flows, valve is inoperative. Shut down the boiler until a new relief valve has been installed.

2. After following the above warning directions, if the relief valve weeps or will not seat properly, replace the relief valve. Ensure that the reason for relief valve weeping is the valve and not over-pressurization of the system due to expansion tank waterlogging or undersizing.

2 Maintenance *(continued)*

Inspect ignition and flame sense electrodes

1. Remove the ignition and flame sense electrodes from the boiler heat exchanger access cover.
2. Remove any deposits accumulated on the ignition/flame sense electrode using sandpaper. If the electrodes cannot be cleaned satisfactorily, replace with new ones.
3. Replace ignition/flame sense electrode, making sure gasket is in good condition and correctly positioned.

Check ignition ground wiring

1. Inspect boiler ground wire from the heat exchanger access cover to ground terminal strip.
2. Verify all wiring is in good condition and securely attached.
3. Check ground continuity of wiring using continuity meter.
4. Replace ground wires if ground continuity is not satisfactory.

Check all boiler wiring

1. Inspect all boiler wiring, making sure wires are in good condition and securely attached.

Check control settings

1. Set the SMART SYSTEM control module display to Parameter Mode and check all settings. See Section 1 of this manual. Adjust settings if necessary. See Section 1 of this manual for adjustment procedures.
2. Check settings of external limit controls (if any) and adjust if necessary.

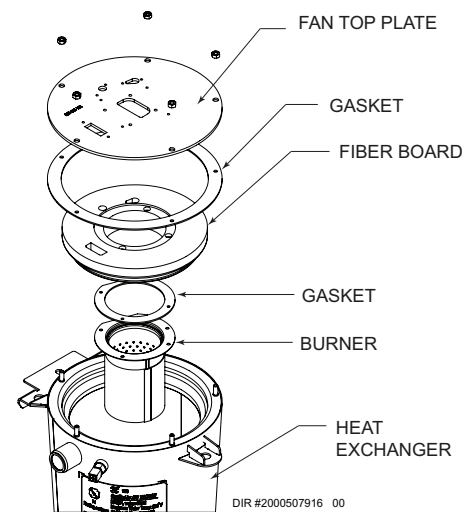
Perform start-up and checks

1. Start boiler and perform checks and tests specified in Section 10 - Start-up of the Knight Fire Tube Boiler Installation and Operation Manual.
2. Verify cold fill pressure is correct and that operating pressure does not go too high.

Check burner flame

1. Inspect flame through observation window.
2. If the flame is unsatisfactory at either high fire or low fire, turn off boiler and allow boiler to cool down. Remove the burner and clean it thoroughly using a vacuum cleaner or compressed air. Do not use compressed air to clean burner if performed inside a building.
3. Remove the burner, reference FIG. 2-2.
4. When replacing the burner, ensure gasket is in good condition and positioned correctly (FIG. 2-2).

Figure 2-2 Burner Assembly



2 Maintenance

Check flame signal

1. At high fire the flame signal shown on the display should be at least 10 microamps.
2. A lower flame signal may indicate a fouled or damaged flame sense electrode. If cleaning the flame sense electrode does not improve, ground wiring is in good condition, and ground continuity is satisfactory, replace the flame sense electrode.
3. See Section 3 - Troubleshooting in this manual for other procedures to deal with low flame signal.

Review with owner

1. Review the Knight Fire Tube Boiler User's Information Manual with the owner.
2. Emphasize the need to perform the maintenance schedule specified in the Knight Fire Tube Boiler User's Information Manual (and in this manual as well).
3. Remind the owner of the need to call a licensed contractor should the boiler or system exhibit any unusual behavior.
4. Remind the owner to follow the proper shutdown procedure and to schedule an annual start-up at the beginning of the next heating season.

Cleaning boiler heat exchanger

1. Shut down boiler:
 - Follow the "To Turn Off Gas to Appliance" instructions for the boiler in Section 10 - Startup of the Knight Fire Tube Installation and Operation Manual.
 - Do not drain the boiler unless it will be exposed to freezing temperatures. If using freeze prevention fluid in system, do not drain.
2. Allow time for the boiler to cool to room temperature if it has been firing.
3. Remove the top and front access panels (no tools required for removal) along with the bezel.
4. Remove the wiring from the ignitor, flame rod, and the fan. Remove the reference tubing from the air intake.
5. Loosen the band clamp on the air intake coupling using a field provided 5/16" driver.
6. Remove the 4mm screws holding the fan to the heat exchanger top plate.
7. Loosen the union on the venturi
8. The fan and the venturi may now be removed from the unit together by sliding the fan away from the air intake.
9. Remove the 10mm nuts securing the heat exchanger top plate to gain access to the heat exchanger and set aside.

WARNING The boiler contains ceramic fiber materials. Use care when handling these materials per instructions in this manual. Failure to comply could result in severe personal injury.

10. Disconnect the condensate hose from the condensate trap and route to drain.
11. Use a vacuum cleaner to remove any accumulation on the boiler heating surfaces. Do not use any solvent.
12. Using a clean cloth dampened with warm water, wipe out the combustion chamber. Rinse out debris with a low pressure water supply.
13. Allow the heat exchanger to thoroughly dry.
14. Reassemble the unit in reverse order of component removal, and re-install the condensate hose.

WARNING Damaged gaskets and seals in the system can result in substantial property damage. Ensure that damaged or torn gaskets are replaced.

15. Perform a combustion analysis by following the instructions in Section 3 - Troubleshooting - Check Flame and Combustion of this manual.
16. Resume operation.

2 Maintenance *(continued)*

Test low water flow conditions

NOTICE

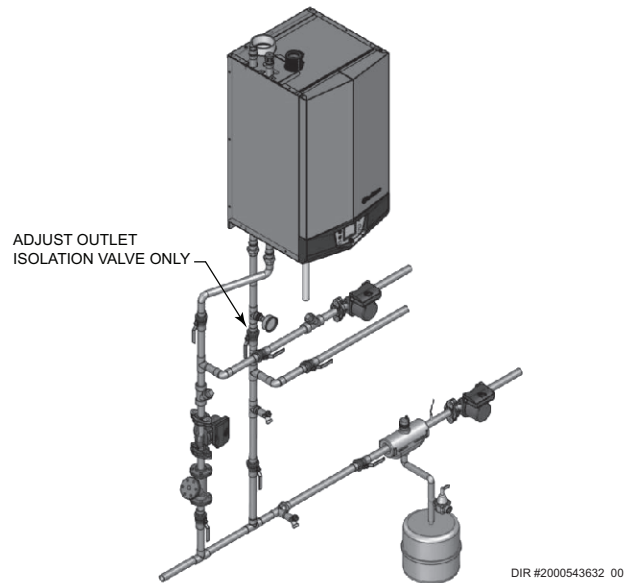
These tests are to be carried out once the Knight Fire Tube boiler is completely piped in with adequate gas and water flow. Once the low water cutoff test is completed, ensure that the isolation valve is opened up to allow full water flow.

Test procedure - low water cutoff (LWCO)

1. Locate the pinhole button above the RESET button on the display board. Insert a thin wire (such as a paper clip) into the hole and press the button once and hold for 5 seconds to place the boiler into Service Mode. In Service Mode the boiler will fire at ignition speed and will then modulate up to full fire.
2. Allow the unit to progress through its normal diagnostics and pre-purge programming.
3. Allow the unit to fire and operate until the temperatures stabilize. This occurs when the inlet and outlet temperatures are rising together and the Delta T (ΔT) is maintained.
4. When the unit stabilizes, begin to slowly shut off the isolation valve on the outlet piping of the boiler (see FIG. 2-3). This will begin to restrict the flow and simulate a low flow condition.
5. While slowly shutting off the isolation valve, refer to the Status Screens to watch the behavior of the boiler. These screens allow you to monitor the inlet temperature, outlet temperature, and ΔT .
6. When the ΔT reaches 55°F (13°C), the control will attempt to modulate the firing rate down to protect it from low flow conditions.
7. When the ΔT reaches 60°F (16°C), the control module will turn off the burner. If the control module shuts down, the test was successful.
8. Completely open the isolation valve on the outlet piping of the boiler.
9. Resume operation.

NOTE: This lockout is a soft lockout. Once the ΔT has decreased to an acceptable level and there is a call for heat, the unit will fire again to meet the demand.

Figure 2-3 Adjust outlet isolation valve



Test procedure - manual reset high limit (MRHL)

1. Follow steps 1 - 3 in the low water cut off test procedure.
2. From the Status Screen, press the NAVIGATION dial to access the Set Points Screen.
3. Press the LEFT SELECT [LIMITS] key.
4. Select the manual reset high limit (MRHL) by rotating and pressing the NAVIGATION dial.
5. Decrease the set point of the MRHL to below the current outlet temperature (or to its minimum setting, whichever is higher). Press the RIGHT SELECT [SAVE] key.
6. Press the RIGHT SELECT [HOME] key. The new parameter will upload to the control.
7. If the current outlet temperature is above the new MRHL set point, the MRHL will function causing boiler lockout.
8. Repeat steps 2 - 7 to adjust the MRHL back to its normal settings.

3 Troubleshooting

WARNING

Label all wires prior to disconnection when servicing controls. Wiring errors can cause improper and dangerous operation. Always disconnect power to the boiler before servicing. Failure to comply could result in severe personal injury, death, or substantial property damage.

WARNING

Never jumper (bypass) any device except for momentary testing as outlined in the Troubleshooting chart. Severe personal injury, death, or substantial property damage can result.

Before troubleshooting:

1. Have the following items:
 - a. Voltmeter that can check 120 VAC, 24 VAC, and 12 VDC.
 - b. Continuity checker.
 - c. Contact thermometer.
2. Check for 120 VAC (minimum 102 VAC to maximum 132 VAC) to boiler.
3. Make sure thermostat is calling for heat and contacts (including appropriate zone controls) are closed. Check for 24 VAC between thermostat wire nuts and ground.
4. Make sure all external limit controls are installed and operating.

Check the following:

1. Wire connectors to control module are securely plugged in at the module and originating control.
2. Gas pressures:
 - Maximum: 14 inches w.c. (3.5 kPa) (natural and LP) with no flow (lockup) or with boiler on
 - Minimum: 4 inches w.c. (1.0 kPa) (natural), 8 inches w.c. (2.0 kPa) (LP) with gas flowing (verify during boiler startup)

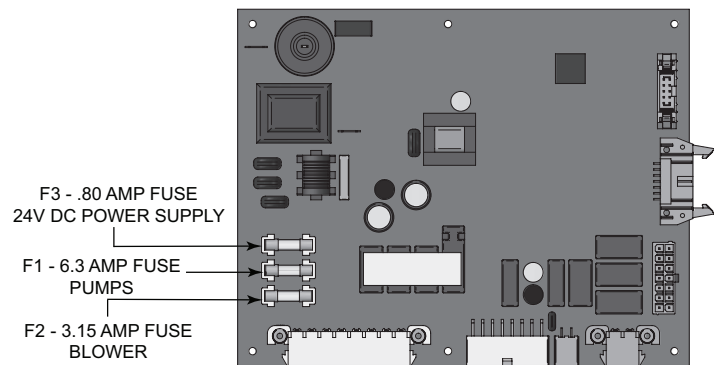
Check control module fuses

NOTICE

ALWAYS check control module fuses before replacing control module or any major components (blower, etc.). If one of these fuses is blown, it can prevent the control module or other components from operating.

1. Turn OFF the power to the boiler at the external line switch.
2. Remove front access cover.
3. Remove the control module cover.
4. Inspect fuses F1, F2, and F3, see FIG 3-1 below.

Figure 3-1 Control Module Fuses



5. The boiler is shipped with three (3) spare fuses in a plastic bag attached to the control module cover.
6. If necessary, replace open fuse (F3 is .80 amps, F2 is 3.15 amps and F1 is 6.3 amps).

Note: Fuses F1, F2, and F3 are all slow blow fuses.

WARNING

Do not jumper fuse or replace with any fuse except as specified. Failure to comply could result in severe personal injury, death, or substantial property damage.

7. Install control module cover and front access cover after fuse inspection.
8. Restore power to the boiler at the external line switch and verify boiler operation (Section 10 - Start-up in the Knight Fire Tube Boiler Installation and Operation Manual) after completing boiler service.

3 Troubleshooting *(continued)*

Table 3-1 Troubleshooting Chart - No Display

FAULT	CAUSE	CORRECTIVE ACTION
No Display	- No 120 vac supplied to unit.	<ul style="list-style-type: none"> • Check external line switch, fuse, or breaker. • Check position of ON/OFF switch. Turn switch to the ON position. • Check 120 vac through the ON/OFF switch. • Check wiring harness connection between display board and main control board. Connect harness at both points.
	- No voltage through the switch.	• Replace switch.
	- Bad display board.	• Replace board.
	- Bad main control board.	• Replace the main control board.
	- Blown fuse.	• Replace fuse F3 on the main control board.
Error SW Version Mismatch	- Incorrect control board or display	• Verify correct model and number for replacement.
No Burner Operation	- Main control board temperature set point satisfied.	• Review temperature setting.
	- Remote thermostat satisfied.	• Review remote thermostat setting.
	- Outside air temperature above Warm Weather Shutdown (WWSD) set point for main control board.	• Check location of outside air sensor. Check resistance of outdoor air sensor and compare to Table 3-2B.
	- Unit locked out on fault.	• Consult display for specific fault. Refer to fault descriptions for corrective actions.
	- Unit in Shutdown Mode.	• Take unit out of Shutdown Mode.
Unit Does Not Modulate Above 50%	- Ramp delay active.	• Check ramp delay parameter settings.
		• Turn ramp delay feature off. See the Outdoor Reset Section of this manual for instructions on how to turn this feature off.
	- Boiler controlled by BMS.	• Check BMS parameter settings.
	- Flue sensor open.	• Verify that the flue sensor is located in the flue outlet.
• Check wiring connections at the flue sensor.		
• Check the resistance of the flue sensor and compare to Table 3-2D.		

3 Troubleshooting

Checking temperature sensors

The boiler temperature sensors (inlet water, outlet water, system water, flue, and outdoor air) are all resistance type devices. The following tables show the correct values for the sensors at various temperatures. Use an ohmmeter to read the resistance of the sensor at a known temperature. If the resistance of the sensor does not closely match its corresponding table, replace the sensor

It is important to note that the flue and outlet water sensors have two temperature sensing devices in one housing. These devices are designated as S1a/S1b, outlet sensor and S3a/S3b, flue sensor. Please reference the wiring diagram in the Knight Fire Tube Boiler Installation and Operation Manual for correct terminal location.

Table 3-2A - Inlet Water/System Sensor Resistance vs. Temperature

Temperature	Resistance	Temperature	Resistance
50	18,780	158	1,990
68	12,263	176	1,458
86	8,194	194	1,084
104	5,592	212	817
122	3,893		
140	2,760		

Table 3-2B - Outdoor Air Sensor Resistance vs. Temperature

Temperature	Resistance	Temperature	Resistance
-50	490,813	20	46,218
-40	336,606	30	34,558
-30	234,196	40	26,099
-20	165,180	50	19,900
-10	118,018	60	15,311
0	85,362	70	11,883
10	62,465	80	9,299

Table 3-2C - Outlet Water Sensor Resistance vs. Temperature

S1a (Wire Color - R/BK and Y)				S1b (Wire Color - G and Y)			
Temperature	Resistance	Temperature	Resistance	Temperature	Resistance	Temperature	Resistance
50	19,553	158	2,004	50	40,030	158	3,478
68	12,690	176	1,464	68	25,030	176	2,492
86	8,406	194	1,084	86	16,090	194	1,816
104	5,715	212	816	104	10,610	212	1,344
122	3,958			122	7,166		
140	2,786			140	4,943		

Table 3-2D - Flue Sensor Resistance vs. Temperature

S3a (Wire Color - W/B and Y)				S3b (Wire Color - PR and Y)			
Temperature	Resistance	Temperature	Resistance	Temperature	Resistance	Temperature	Resistance
50	40,030	158	3,478	50	258,500	158	16,870
68	25,030	176	2,492	68	125,500	176	12,000
86	16,090	194	1,816	86	80,220	194	8,674
104	10,610	212	1,344	104	52,590	212	6,369
122	7,166			122	35,270		
140	4,943			140	24,160		

3 Troubleshooting *(continued)*

Table 3-3 Troubleshooting Chart - Noisy System

FAULT	CAUSE	CORRECTIVE ACTION
Noisy Operation	- Supply gas problem. Natural gas pressures should be between 4 inches w.c. and 14 inches w.c. LP gas pressures should be between 8 inches w.c. and 14 inches w.c.	• Refer to Section 7 - Gas Connections of the Fire Tube Boiler Installation and Operation Manual for detailed information concerning the gas supply.
	- Gas/air mixture problem.	• Refer to the Gas Valve Adjustment Procedure of this manual for the proper gas valve setting. Verify that the vent/air intake lengths do not exceed the maximum listed in the General Venting section of the Knight Fire Tube Boiler Installation and Operation Manual.
	- Dirty/damaged burner.	• Refer to the burner removal and inspection procedure section of this manual. Clean or replace the burner as necessary.
	- Low water flow through the heat exchanger.	• Refer to Section 6 - Hydronic Piping of the Knight Fire Tube Boiler Installation and Operation Manual for minimum flow rates. Verify that the boiler and system pump are running on a call for heat.
	- Air in the piping system.	• Properly purge all air from the piping system.
	- Low system water pressure.	• Verify system pressure is a minimum of 12 psi.
No Pump Operation - Boiler Pump System Pump or DHW Pump	- Blown fuse.	• Replace fuse F1 on the control board. Note: Make sure pump amperage does not exceed 1.8 amps.
	- Faulty pump.	• Replace pump.
	- Internal fault on control board.	• Replace main control board.
No Blower Operation	- Internal fault on control board.	• Replace control board.
	- Faulty blower.	• Replace blower.
Relief Valve Opening	- System pressure exceeds relief valve setting.	• Lower the system pressure below the 30 psi rating of the supplied relief valve or replace the standard relief valve with a higher rated valve up to the maximum pressure of the heat exchanger. • Improperly sized expansion tank.
No Pump Operation - DHW Recirculation Pump	- Failed external relay. - Line voltage shut off. - Faulty pump. - Faulty DHW recirculation sensor. - Fault in connection board. - Fault in control board.	• Check function of external relay. • Check line voltage to external relay. • Check recirculation pump. • Check DHW recirculation sensor. • Check low voltage connection board. • Replace control board.

3 Troubleshooting

Table 3-4 Troubleshooting Chart - Fault Messages Displayed on Boiler Interface

FAULT	DESCRIPTION	CORRECTIVE ACTION
<p>Gas Pressure SW (will require a manual reset once the condition has been corrected. Press the RESET button on the SMART SYSTEM display to reset.)</p>	<p>- The gas pressure switch contacts on the Low Voltage Connection Board are open.</p>	<ul style="list-style-type: none"> • Check for a loose or misplaced jumper on the Low Voltage Connection Board. • Check for the addition of a device wired across the gas pressure switch terminals on the Low Voltage Connection Board.
<p>Flow Switch/ LWCO (will require a manual reset once condition has been corrected. Press the RESET button on the SMART SYSTEM display to reset.)</p>	<p>- Either the optional flow switch or the low water cutoff (LWCO) is not making.</p>	<ul style="list-style-type: none"> • Check boiler pump operation on a call for heat. • Check for closed valves or obstructions in the boiler piping. • Verify system is full of water and all air has been purged from the system. • Check for a loose or misplaced jumper if flow switch is not installed. • Replace LWCO.
<p>Air Pressure SW (will require a manual reset once condition has been corrected. Press the RESET button on the SMART SYSTEM display to reset.)</p>	<p>The air pressure switch contacts are open,</p>	<ul style="list-style-type: none"> • Check the wiring connections to switch. Wires should be connected to the common and normally closed terminals. • Air intake lengths exceed the maximum allowed lengths. Refer to Section 3 - General Venting of the Knight Fire Tube Installation and Operation Manual for proper lengths. • Check for obstruction or blockage in the air intake pipes or at terminations. • Check reference hoses connected to the air pressure switch for blockage or obstruction. • Inspect the burner. Reference the Maintenance Section of this manual for removal and cleaning procedures. Replace if necessary. • Inspect the heat exchanger. Reference the Maintenance Section of this manual for removal and cleaning procedures. Replace if necessary. • Faulty air pressure switch. Replace switch.
<p>Too Many Recyclings</p>	<p>One or more limit switches has opened more than five (5) times during the last call for heat.</p>	<ul style="list-style-type: none"> • Check the following limit switches for intermittent operation: <ul style="list-style-type: none"> - Aux Louver Switch - Air Pressure Switch - Gas Pressure Switch • Check harness connections at the control board and low voltage connection board.

3 Troubleshooting *(continued)*

Table 3-4 (continued from previous page) *Troubleshooting Chart - Fault Messages Displayed on Boiler Interface*

FAULT	DESCRIPTION	CORRECTIVE ACTION
Anti-cycling	The burner recently turned off.	<ul style="list-style-type: none"> • The control board will release the call for heat after a set time period. • The control board will release the call for heat if the outlet temperature drops too quickly.
Flame Fail Ign (will require a manual reset once the condition has been corrected. Press the RESET button on the SMART SYSTEM display to reset.)	The unit has failed to prove main burner ignition after several attempts.	<ul style="list-style-type: none"> • Inspect spark electrode and associated wiring for damage and connection. Reference the Maintenance Section of this manual for removal and cleaning procedures. Replace if necessary. • Check for proper electrical grounding of the unit. • Check incoming supply gas pressure. Natural gas pressures should be between 4 - 14 inches w.c. and LP gas pressures should be between 8 - 14 inches w.c. Refer to Section 7 - Gas Connections of the Knight Fire Tube Boiler Installation and Operation Manual for detailed information concerning the gas supply. <hr/> <ul style="list-style-type: none"> • Verify that the plastic hose from the gas valve to the air inlet is connected and is not damaged. • Verify that the vent/air intake pipes are correctly installed and that there are no obstructions. • Check for 24 vac to the gas valve at the 2-pin connection on the side of the main control board during the ignition attempt. If no voltage is present, replace the main control board. • If 24 vac is present at the main control board, check the wiring between the main control board and the gas valve. Replace the wiring if necessary. Do not disconnect the wiring from the gas valve and attempt to measure voltage at that point. • If 24 vac is present, check the outlet of the valve to ensure the valve is flowing gas. With a manometer connected to the outlet tap of the gas valve, when the unit is in the prepurge period, there should be a negative pressure present. When the valve is energized a change in pressure should occur. If the pressure change does not occur, the gas valve is not opening. Replace the gas valve. • Inspect flame sensor and associated wiring. Reference the Maintenance Section of this manual for removal and cleaning procedures. Replace if necessary. • Inspect and clean the heat exchanger as necessary. Reference the Maintenance Section of this manual for cleaning procedures. • Inspect the burner. Reference the Maintenance Section of this manual for removal and cleaning procedures. Replace if necessary. • Replace the main control board. • Verify the venturi is moving freely and does not have any sticky residue on the flapper. Reference page 34 of this manual for the proper cleaning procedure.

3 Troubleshooting

Table 3-4 (continued from previous page) *Troubleshooting Chart - Fault Messages Displayed on Boiler Interface*

FAULT	DESCRIPTION	CORRECTIVE ACTION
<p>Flame Sequence (will require a manual reset once the condition has been corrected. Press the RESET button on the SMART SYSTEM display to reset.)</p>	<p>The flame detector circuit is seeing a flame signal while the gas valve is off.</p>	<ul style="list-style-type: none"> • Check supply voltage for proper polarity. • Check external wiring for voltage feedback. • Check the flame rod and make sure it is clean. • Check the internal wiring for bad connections. • Replace main control board.
<p>Outlet ARHL</p>	<p>The outlet water temperature has exceeded the setting of the automatic reset high limit.</p>	<ul style="list-style-type: none"> • Adjust the set point of the auto reset limit to a higher setting up to a maximum of 200°F. Reference the Knight Fire Tube Boiler Installation and Operation Manual for adjusting procedures. • Verify that the system is full of water and that all air has been properly purged from the system. • Verify that the boiler is piped properly into the heating system. Refer to Section 6 - Hydronic Piping of the Knight Fire Tube Boiler Installation and Operation Manual for the proper piping methods for the Fire Tube boiler. • Check 120 vac to boiler pump motor on a call for heat. If voltage is not present, check wiring back to the main control board. • If 120 vac is present on a call for heat and the boiler pump is not operating, replace the pump. • If the system pump is a variable speed pump, ensure that the system flow is not less than the boiler flow. • If operating on something other than an outlet sensor, check temperature setting of the main control board. • Check resistance of water sensors and compare to Table 3-2A of this manual. Replace sensor if necessary. • Replace the main control board if necessary.
<p>Outlet MRHL (will require a manual reset once the condition has been corrected. Press the RESET button on the SMART SYSTEM display to reset.)</p>	<p>The outlet water temperature has exceeded the setting of the manual reset high limit.</p>	<ul style="list-style-type: none"> • Adjust the set point of the manual reset limit to a higher setting up to a maximum of 210°F. Reference the Knight Fire Tube Boiler Installation and Operation Manual for adjusting procedures. • Verify that the system is full of water and that all air has been properly purged from the system. • Verify that the boiler is piped properly into the heating system. Refer to Section 6 - Hydronic Piping of the Knight Fire Tube Boiler Installation and Operation Manual for the proper piping methods for the Fire Tube boiler. • Check 120 vac to boiler pump motor on a call for heat. If voltage is not present, check wiring back to the main control board.

3 Troubleshooting *(continued)*

Table 3-4 (continued from previous page) *Troubleshooting Chart - Fault Messages Displayed on Boiler Interface*

FAULT	DESCRIPTION	CORRECTIVE ACTION
<p>Outlet MRHL (cont'd) (will require a manual reset once the condition has been corrected. Press the RESET button on the SMART SYSTEM display to reset.)</p>	<p>The outlet water temperature has exceeded the setting of the manual reset high limit.</p>	<ul style="list-style-type: none"> • If 120 vac is present on a call for heat and the boiler pump is not operating, replace the pump. • If the system pump is a variable speed pump, ensure that the system flow is not less than the boiler flow. • If operating on something other than an outlet sensor, check temperature setting of the main control board. • Check resistance of water sensors and compare to Table 3-2A of this manual. Replace sensor if necessary. • Replace the main control board if necessary.
<p>Fan Speed (will require a manual reset once the condition has been corrected. Press the RESET button on the SMART SYSTEM display to reset.)</p>	<p>The actual fan RPM is 30% lower or higher than the fan speed target.</p>	<ul style="list-style-type: none"> • Vent/air intake lengths exceed the maximum allowed lengths. Refer to Section 3 - General Venting of the Knight Fire Tube Boiler Installation and Operation Manual for proper lengths. • Check for obstruction or blockage in the vent/air intake pipes or at terminations. • Check the wiring connections at the fan and at the main control board. • Check the fan using the fan test tool. • Replace the fan. • Replace the main control board.
	<p>Blown fuse.</p>	<ul style="list-style-type: none"> • Replace fuse F2 on the control board.
<p>Inlet, Outlet, or Flue Sensor Fault (will require a manual reset once the condition has been corrected. Press the RESET button on the SMART SYSTEM display to reset.)</p>	<p>Either the flue, inlet water, or outlet water temperature sensor has been disconnected or shorted.</p>	<ul style="list-style-type: none"> • Check the sensors and their associated wiring. Repair or replace the sensor or wiring if damaged. • Measure the resistance of the sensors and compare the resistance to the tables in the Checking Temperature Sensors Section of this manual. • Replace the sensor if necessary.

3 Troubleshooting

Table 3-4 (continued from previous page) *Troubleshooting Chart - Fault Messages Displayed on Boiler Interface*

FAULT	DESCRIPTION	CORRECTIVE ACTION
<p>AUX Contact Sw (will require a manual reset once the condition has been corrected. Press the RESET button on the SMART SYSTEM display to reset.)</p>	<p>An optional remote proving switch is not making.</p>	<ul style="list-style-type: none"> • Check function of remote devices. • Check for loose or misplaced jumper if AUX contact switch is not connected.
<p>Outlet Temp Diff (will require a manual reset once the condition has been corrected. Press the RESET button on the SMART SYSTEM display to reset.)</p>	<p>The temperature difference between the two (2) outlet sensors is too high.</p>	<ul style="list-style-type: none"> • Check wiring to sensor. Make sure wiring is connected and not damaged. Reconnect / repair wiring if necessary. • Measure the resistance of the sensor and compare to the resistance in Table 3-2C of this manual. Replace sensor if necessary. • Restore control parameter defaults from optional PC software. • Replace control module.
<p>Fatal Error</p>	<p>The control module has detected parameter settings that are corrupted.</p>	<ul style="list-style-type: none"> • Restore the parameter defaults from the optional PC software. • Replace control module.
<p>Memory Error</p>	<p>A lockout occurs at the same time as a power outage.</p>	<ul style="list-style-type: none"> • Reset control module.
<p>Flue Temp High / Flue Temp Limit</p>	<p>The stack temperature has exceeded the set parameters for the boiler.</p>	<ul style="list-style-type: none"> • Inspect the heat exchanger. Reference the Maintenance Section of this manual for the procedure on how to clean the flue side of the heat exchanger. • Inspect the flue sensor and associated wiring. Measure the resistance of the flue sensor and compare to Table 3-2D of this manual. Replace the sensor if necessary. • Verify that the vent/air intake pipes are properly installed and that there are no obstructions. • Replace the main control board.

3 Troubleshooting *(continued)*

Table 3-4 (continued from previous page) *Troubleshooting Chart - Fault Messages Displayed on Boiler Interface*

FAULT	DESCRIPTION	CORRECTIVE ACTION
Delta T High / Delta T Limit	The temperature rise across the heat exchanger has exceeded the set parameters for the boiler.	<ul style="list-style-type: none"> • Verify that the system is full of water and that all air has been properly purged from the system. • Verify that the boiler is piped properly into the heating system. Refer to Section 6 - Hydronic Piping of the Knight Fire Tube Boiler Installation and Operation Manual for the proper piping methods for the Fire Tube boiler. • Check for 120 vac to the boiler pump motor on a call for heat. If voltage is not present, check the wiring back to the main control board. Replace the main control board if necessary. • If 120 vac is present on a call for heat and the boiler pump is not operating, replace the pump. • Verify that the boiler pump is set to the proper speed or that the pump is the proper size. Reference Section 6 - Hydronic Piping of the Knight Fire Tube Boiler Installation and Operation Manual for boiler pump specifications.
Outlet Temp High / Outlet Temp Limit	Outlet water temperature has exceeded the maximum outlet water temperature.	<ul style="list-style-type: none"> • Verify that the system is full of water and that all air has been properly purged from the system. • Verify that the boiler is piped properly into the heating system. Refer to Section 6 - Hydronic Piping of the Knight Fire Tube Boiler Installation and Operation Manual for the proper piping methods for the Fire Tube boiler. • Check for 120 vac to the boiler pump motor on a call for heat. If voltage is not present, check wiring back to the main control board. Replace the main control board if necessary. • If 120 vac is present on a call for heat and the boiler pump is not operating, replace the pump. <ul style="list-style-type: none"> • Verify that the boiler pump is set to the proper speed or that the boiler pump is the proper size. Reference Section 6 - Hydronic Piping of the Knight Fire Tube Boiler Installation and Operation Manual for boiler pump specifications. • Replace the main control board.

3 Troubleshooting

Table 3-4 (continued from previous page) *Troubleshooting Chart - Fault Messages Displayed on Boiler Interface*

FAULT	DESCRIPTION	CORRECTIVE ACTION
Low 24 vac	120 vac input to the main control board has dropped below 80 vac.	<ul style="list-style-type: none"> • Check 120 vac supply to the transformer. • Check wiring connections at the low voltage terminal strip. • Check the wire size/length to remote devices. • Replace the transformer.
Watch Dog Error	The main control board has detected an internal fault.	<ul style="list-style-type: none"> • Cycle power to the boiler. • Replace the main control board.
Write EEPROM	The main control board has detected an internal fault.	<ul style="list-style-type: none"> • Cycle power to the boiler. • Replace the main control board.
CRC Parameters	The main control board has detected an internal fault.	<ul style="list-style-type: none"> • Cycle power to the boiler. • Replace the main control board.
No Error Stored	The particular lockout information has been lost.	<ul style="list-style-type: none"> • Press the RESET button. • Replace the main control board.

3 Troubleshooting *(continued)*

Combustion Analysis Procedure

1. Turn the main power off to the boiler by placing the “On/Off” switch in the OFF position.
2. Remove the combustion plug from the vent connector provided on the unit. Insert the probe from a combustion analyzer into the opening on the vent connector. Note: Combustion measurements will be made at this point.
3. Turn the main power on to the boiler by placing the “On/Off” switch in the ON position. Place the boiler into the active position by pressing the RIGHT SELECT [ON] key (see the Knight Fire Tube Boiler Display in Section 1 of this manual). Note: The brackets ([]) denote screen status.
4. Locate the pinhole button above the RESET button on the display board. Insert a thin wire (such as a paper clip) into the hole and press the button once and hold for 5 seconds to place the boiler into Service Mode.

NOTE: In Service Mode, the boiler will fire at normal ignition speed and will then modulate up to full fire. You can switch between high fire and low fire by pressing the Right Arrow Key (>).

5. Once the boiler has modulated up to full fire, measure the combustion. The values should be in the range listed in Table 3-5. The CO levels should be less than 200 ppm for a properly installed unit.

If the combustion is not within the specified range, reference the Troubleshooting Section of this manual for possible causes and corrective actions.

6. Once the combustion analysis is complete, re-install the plug in the vent connector.

Test the safety shutoff device by switching the manual shutoff switch to the OFF position and ensuring that the boiler shuts down and registers an alarm. Turn the manual shutoff switch to the ON position and reset the control. Place the boiler back into normal operation.

Table 3-5 Flue Products Chart

Natural Gas				
Input Rate	Target		Range	
	CO ₂	O ₂	CO ₂	O ₂
High Fire	9.2%	4.5%	9.0% - 10.5%	2.1% - 4.8%
Low Fire	9.0%	4.8%	8.8% - 9.5%	3.9% - 5.2%
CO levels should be less than 200 ppm.				

Propane				
Input Rate	Target		Range	
	CO ₂	O ₂	CO ₂	O ₂
High Fire	10.8%	4.5%	10.5% - 11.5%	3.5% - 5.0%
Low Fire	10.5%	5.0%	10.0% - 11.0%	4.2% - 5.8%
CO levels should be less than 200 ppm.				



WARNING You must replace the combustion plug in the vent connector to prevent flue gas spillage into the room. Failure to comply could result in severe personal injury, death, or substantial property damage.

Table 3-6 Troubleshooting Chart - Combustion Levels

POSSIBLE CAUSE	CORRECTIVE ACTION
Vent/Air Intake Length or Obstruction	<ul style="list-style-type: none"> • Refer to Section 3 - General Venting of the Knight Fire Tube Boiler Installation and Operation Manual for the proper venting and air intake methods for the Fire Tube Boiler. • Check for obstructions at the vent/air intake terminals.
Gas Supply Pressure	<ul style="list-style-type: none"> • Refer to Section 7 - Gas Connections of the Knight Fire Tube Boiler Installation and Operation Manual for the proper gas supply for the Fire Tube boiler.
Dirty/Damaged Burner	<ul style="list-style-type: none"> • Refer to the Maintenance Section of this manual for burner removal and cleaning procedures. • Replace burner if necessary.
Gas Valve Adjustment	<ul style="list-style-type: none"> • Refer to the Troubleshooting Section of this manual for the gas valve adjustment procedure.

3 Troubleshooting

Gas valve adjustment procedure

CAUTION

This gas valve is factory set. Under normal operating conditions this valve should not need adjusting.

If adjustment of the gas valve is deemed necessary, use the following procedure:

High Fire

Locate the throttle adjustment screw on the gas valve (FIG. 3-3A & 3-3B). Using a 2.5 mm hex-key wrench, turn the screw 1/10 to 1/8 turn **counterclockwise** to increase CO₂ levels or 1/10 to 1/8 turn **clockwise** to decrease CO₂ levels. After one adjustment on the valve, follow the Combustion Analysis Procedure of this manual to measure the combustion.

Low Fire

Locate the bias/offset adjustment screw on the gas valve (FIG. 3-3A & 3-3B). Using a 4 mm hex-key wrench, turn the screw 1/10 to 1/8 turn **clockwise** to increase CO₂ levels or 1/10 to 1/8 turn **counterclockwise** to decrease CO₂ levels. After one adjustment on the valve, follow the Combustion Analysis Procedure of this manual to measure the combustion.

NOTE: The low fire adjustment responds very slowly. Make extremely small adjustments and allow the boiler to run for a couple of minutes between adjustments. Use a combustion analyzer to check the adjustment effects.

If combustion is still not within the specified range, repeat the procedure. This procedure **SHOULD NOT** be performed more than four (4) times. If after four (4) adjustments and the combustion is still not within the specified range, revisit the possible causes in Table 3-6 and call Technical Support before replacing the gas valve.

Figure 3-3A Gas Valve Adjustment - Models 55-285

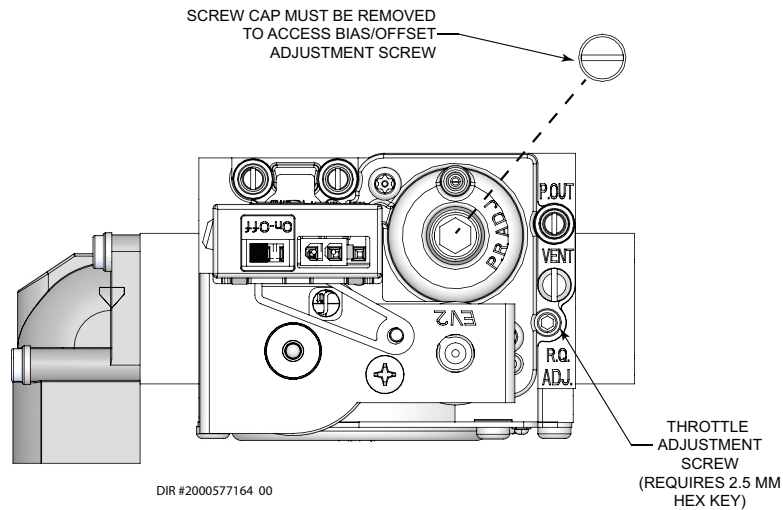
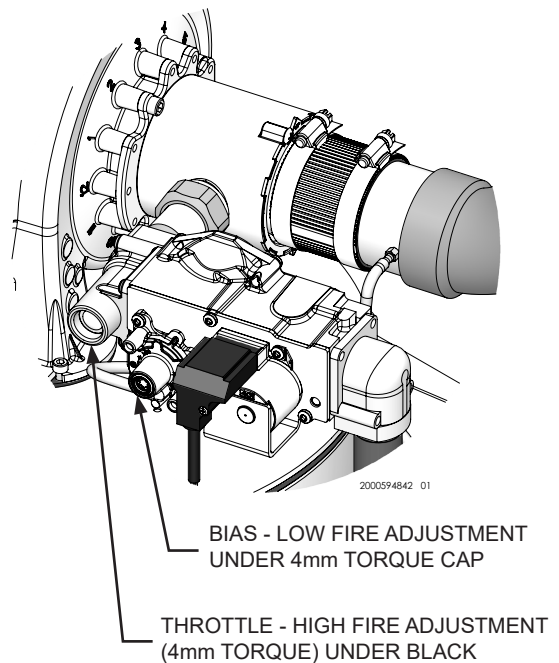


Figure 3-3B Gas Valve Adjustment - Model 399



Notes

Revision Notes: *Revision A (PCP# 3000024795 / CN# 500014734) initial release.*

Revision B (PCP #3000034309 / CN #500022970) reflects an update to the gas valve adjustment procedure.

Revision C (PCP #3000041475 / CN #500029402) reflects the addition of the gas valve adjustment image for the 399 models.

Revision D (PCP #3000042716 / CN #500030589) reflects a new boiler pump voltage chart on page 30, along with venturi cleaning and troubleshooting additions.

Revision E (PCP #3000049060 / CN #500036184) reflects changes to the table on page 39 and a new image for Figure 3-3B on page 50.

Revision F (PCP #3000052201 / CN #500041738) reflects the addition of series 110-111 and 120-121.

Revision G (PCP #3000067405 / CN #500052923) reflects added callouts to figure 3-3B.