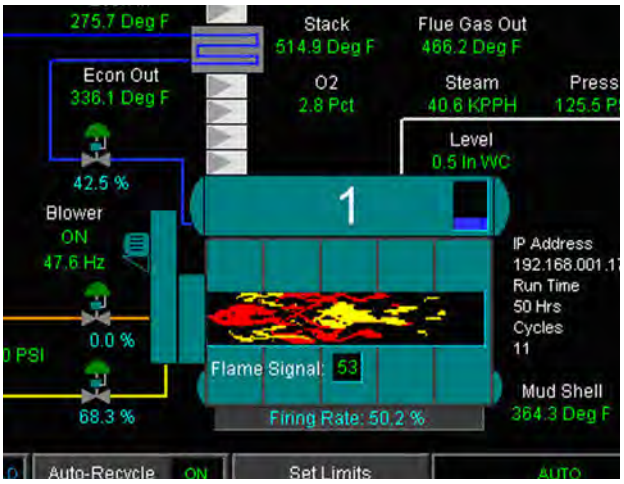
Hawk 5000

Industrial Watertube Boiler Control

Operation, Service, and Parts



750-349
10/2011

TO: Owners, Operators and/or Maintenance Personnel

This operating manual presents information that will help to properly operate and care for the equipment. Study its contents carefully. The unit will provide good service and continued operation if proper operating and maintenance instructions are followed. No attempt should be made to operate the unit until the principles of operation and all of the components are thoroughly understood.

It is the responsibility of the owner to train and advise not only his or her personnel, but the contractors' personnel who are servicing, repairing, or operating the equipment, in all safety aspects.

Cleaver-Brooks equipment is designed and engineered to give long life and excellent service on the job. The electrical and mechanical devices supplied as part of the unit were chosen because of their known ability to perform; however, proper operating techniques and maintenance procedures must be followed at all times.

Any "automatic" features included in the design do not relieve the attendant of any responsibility. Such features merely free him of certain repetitive chores and give him more time to devote to the proper upkeep of equipment.

It is solely the operator's responsibility to properly operate and maintain the equipment. No amount of written instructions can replace intelligent thinking and reasoning and this manual is not intended to relieve the operating personnel of the responsibility for proper operation. On the other hand, a thorough understanding of this manual is required before attempting to operate, maintain, service, or repair this equipment.

Operating controls will normally function for long periods of time and we have found that some operators become lax in their daily or monthly testing, assuming that normal operation will continue indefinitely. Malfunctions of controls lead to uneconomical operation and damage and, in most cases, these conditions can be traced directly to carelessness and deficiencies in testing and maintenance.

The operation of this equipment by the owner and his operating personnel must comply with all requirements or regulations of his insurance company and/or other authority having jurisdiction. In the event of any conflict or inconsistency between such requirements and the warnings or instructions contained herein, please contact Cleaver-Brooks before proceeding.

Cleaver-Brooks
HAWK 5000
Industrial Watertube Boiler Control

Operation, Service, and Parts

Please direct purchase orders for replacement manuals to your local Cleaver-Brooks authorized representative

Manual Part No. 750-349
10/2011

HAWK 5000
Industrial Water-Tube Boiler Controls
Operation, Service & Parts Manual

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1. SYSTEM OVERVIEW

1.1-Introduction

The Cleaver-Brooks Hawk 5000 is an exclusive boiler management and control system designed to integrate the functions of a Programmable Logic Controller (PLC) and Burner Management Controller. The PLC is of a modular design, providing flexibility for expansion with easily installed components. The Hawk 5000 incorporates a user-friendly Human Machine Interface (HMI) that displays boiler parameters, fault annunciation and alarm history, as well as providing access to boiler configuration and control functions.

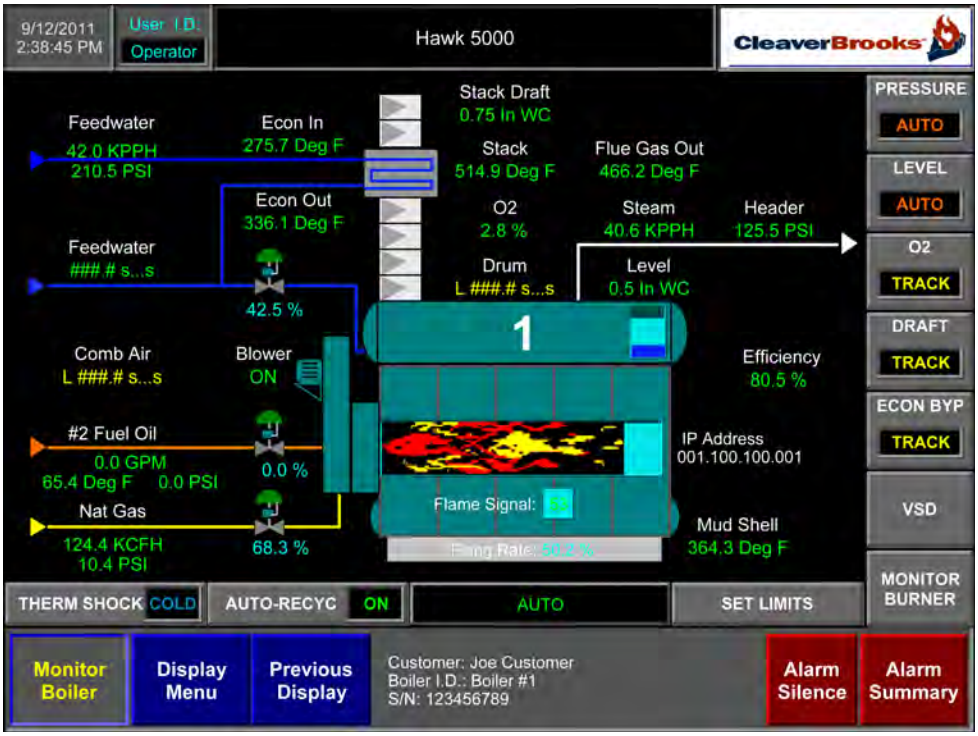


Figure 1-1 'Monitor Boiler' Display

1.2-System Description

The Hawk 5000 control system is designed for industrial watertube boiler applications. It utilizes a plc-based combustion control system and a burner management control (Flame Safety) System. The two Systems are integrated in a 10" color touch screen Graphical User Interface.

The burner management control monitors flame condition and the status of critical running interlocks to assure safe operation at all times. It also manages and sequences purge, pretrial for ignition, pilot, and main flame cycles as well as post-purge and burner shutdown.

The combustion control system's primary responsibility is to maintain the optimal fuel/ air ratio. The 5000 provides two distinct combustion control schemes – single-point positioning and parallel positioning.

Single-point combustion control maintains the optimal fuel/ air ratio by modulating a jackshaft actuator. The combustion air fan damper and the fuel valve are connected to the jackshaft via link/ lever arrangement. The proper ratio is set by mechanically characterizing the fuel valve to the available air throughout the firing range.

Parallel combustion control maintains the fuel/ air ratio by independently modulating a combustion air damper actuator and a fuel valve actuator. The strategy compares the actuator position feedback signals to set point values derived from the combustion testing process; and corrects each actuator if an offset from set point is detected.

In addition the maintenance of the proper fuel/ air ratio, an actuator position feedback cross-limiting strategy insures the fuel follows the air as the firing rate is increased, and the air follows the fuel as the firing rate is decreased.

Parallel combustion control systems are enhanced with the addition of a Flue Gas O2 analyzer and the implementation of O2 Trim control; where the measured O2 is compared to a set point and deviations are corrected by trimming the control signal to the air actuator. O2 Trim control is further enhanced with the addition of a Variable Frequency Drive (VFD) the speed of which is trimmed in lieu of the air actuator to maintain O2 on set point.

Additional monitoring and control functions available in the 5000 Control System include:

- Drum Level Control (1, 2 or 3 element)
- Stack Draft Control
- Economizer Bypass Control
- VSD Bypass (A-B PowerFlex 400)
- Thermal Shock Protection
- Auto Recycle Control
- Remote Modulation
- Economizer Flue Gas and Feedwater temperature monitoring
- Alarm annunciation, acknowledgement and display
- Combustion Set Data Capture
- Control Loop Tuning and Process Variable Trending
- Integrated Alarm Management System
- Continuous monitoring of all discrete and analog I/O
- Secured access to critical displays and system parameters

2. SPECIFICATIONS

The Hawk 5000 operational and environmental specifications are as follows:

Table 2-1 Operational & Environmental Specifications

Power Supply Voltage	120 VAC (102-VAC – 132 VAC)
Power Supply Frequency	50 or 60 Hz
Maximum Total Connected Load	1200 VA
Ambient Operating Temperature Limits	32-130 Deg F
Humidity	85% RH continuous, non-condensing
Vibration	Continuous to 0.5 G
Fusing/ Circuit Breakers:	
Boiler Controller Power Supply	4.0 A
Analog Power Supply	2.0 A
Panelview Plus HMI CB	2.0 A
Control Panel Main CB	10 A
120 VAC Recepitcal	6.0 A

3. SYSTEM COMPONENTS

3.1-PLC Hardware Components

The Hawk 5000 is a DIN rail mounted PLC-based hardware system using modular I/O that includes a Burner Management Controller and a 10” color touch screen graphical user interface.

The PLC components consist of the following:

Table 3-1 PLC

Qty	Slot	Description	C-B p/n
1	0	Processor	833-2959
1	1	Modbus Communications Module	833-3099
2	2, 4	16-Channel Discrete Input Module	833-2842
1	3	8-Channel Isolated Contact Output Module	833-2872
1	5	16-Channel Solid State Output Module (required for pulse positioning systems)	833-3050
1	6, 7	8-Channel Universal Analog Input Module (mA, VDC, TC, RTD, resistance)	833-3714
1	8	4-Channel Analog Output Module	833-3123
1	9	8-Channel Analog Input Module (required for parallel combustion systems)	833-3106
1	10	8-Channel Analog Output Module (required for current positioning systems)	833-3107
1	n/a	Right Termination End Cap	833-2838
1	n/a	Power Supply	833-2960

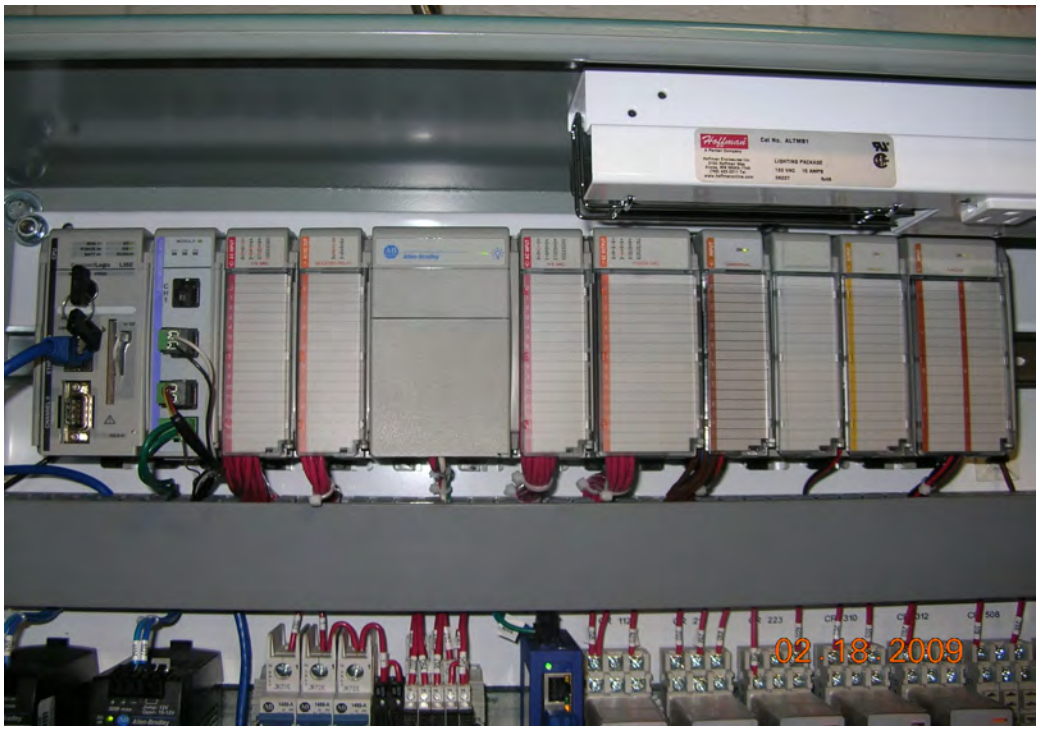


Figure 3-1 PLC Module Assembly

Note: The makeup of the module assembly will vary depending on the options selected.

3.2-Burner Management Control Hardware Components

The standard Burner Management Control for the Hawk 5000 is the CB-120E which consists of the following components:

Table 3-2 Burner Management Control

Qty	Description	C-B p/n
1	Burner Management Control YB110UV-CB	833-3135
1	Programmer YP100-CB	833-3143
1	Display LCD BLL510-CB	833-3151
1	Base 60-2814-1-CB	833-3153

Figure 3-2 Sub-Panel Layout

3.3-Panel Door-Mounted Components

- Boiler START pushbutton
- Boiler STOP/ RESET pushbutton
- Forced Draft Fan Motor HAND/ OFF/ AUTO selector switch
- GAS/ OFF/ OIL Selector Switch
- AIR/ STEAM Atomizing Media selector switch (dual fuel systems)
- Burner START Relay Energized pilot light
- 10” Color Graphical User Interface

Additional Panel-Mounted Components:

Table 3-3

Qty	Description	C-B p/n
1	Color Graphical User Interface	833-3512
1	5-port Ethernet Switch	833-2862
1	Alarm Horn	817-1698
1	24 VDC Power Supply	832-2037
1	12 VDC Power Supply (pulse positioning only)	832-2179

3.4-Sensors

The Hawk 5000 is designed to accept both Drum Pressure and Steam Header Pressure sensors.

A drum pressure sensor is required for the auto-recycle operating mode, and can also be used as either the primary or the backup pressure control loop process variable.

A steam header pressure sensor is required when the pressure in the main steam header is used as the primary pressure control loop process variable.

The standard flue gas O2 analyzer is the Yokogawa ZR202G. The Hawk ICS Ultra 100 will also accept other analyzers which output a 4-20 mA signal.

Table 3-4

Sensor	Range	Signal Type	C-B p/n
Drum/Steam Header Pressure	TBD*	4-20 mA	Endress-Hauser: 834-00117
			Rosemount: 834-00121
Drum Level	TBD*	4-20 mA	Endress-Hauser: 834-00119
			Rosemount: 834-00122
Draft	TBD*	4-20 mA	Endress-Hauser: 834-00120
			Rosemount: 837-00123
O2	0-25 %	4-20 mA	Yokogawa ZR202G-040
Stack Temperature	Type J	mV	832-2091
Mud Drum Shell Temperature	Type J	mV	832-2091
Combustion Air Temperature	Type J	mV	832-2091
Econ Outlet Flue Gas Temperature	Type J	mV	832-2091
Econ Inlet Feedwater Temperature	Type J	mV	832-2091
Econ Outlet Feedwater Temperature	Type J	mV	832-2091

*Calibration range to be determined by end user

The Hawk 5000 thermal shock protection measures both the stack and the mud drum shell temperatures. The stack temperature and mud drum shell temperature sensors are Type J thermocouples wired directly to the input module.

Refer to **Appendix B – Hawk 5000 Build Kits** for complete listings of custom hardware components available with each system configuration.

4. INITIAL SYSTEM CHECKOUT

4.1-Pre-Power-Up Checks

Prior to commissioning the Hawk 5000 Control System it is necessary to confirm that all of the integral components and interconnecting wiring are in place and secure. Vibration and jarring from transport or installation may have loosened components or wiring terminals. It is good practice to check all system components for integrity and tightness prior to the initial power-up of the system.

All external interlocks, control devices, and process instrumentation should first be checked for proper installation and wired properly into the system.

Remove any packing material and shipping fasteners.

Check that all I/O module DIN rail latches, and all module bus locking levers are properly engaged.

Verify modbus communication cables are properly connected to the SM2 modbus communications module, and to the Flame Safeguard and VSD (optional).

Verify the PLC and PanelView Plus GUI are both connected via Cat5 Ethernet cable to the Ethernet switch.

4.2-Post-power-up Checks

Verify Flame Safeguard modbus address is set to **5** and the baud rate to **4800.** Verify the CH3 LED on the SM2 Modbus Communications Module (CH1 if CB780E) is flashing – indicating communication is established to the PLC.

In systems equipped with a Power-Flex 400 VSD, verify the drives' modbus address is set to **4** and the baud rate to **9600**. Verify the CH2 LED on the SM2 Modbus Communications Module is flashing – indicating communication is established to the PLC. Set all applicable drive parameters.

Refer to **Appendix A - Allen Bradley PowerFlex 400 Drive Parameters**

Verify PLC key-switch is in the RUN position and the RUN, I/O and OK LED's are solid green.

Verify the OK LED's on all analog I/O modules are solid green, and the green power LED on the PA4 power supply lit.

Verify PLC is communicating with the HMI. Go to Alarm History display and verify PLC program number is displayed.

Figure 4-1

5. SYSTEM CONFIGURATION

5.1-Security Login/ Logout

The Graphical User Interface utilizes a four tier security system. Each tier is identified by a User I.D.; each User I.D. has a unique 4 digit numeric password.

1. Blank (no user currently logged in)
2. Operator
3. Service
4. CB

Users log in from the **Display Menu** by entering the 4-digit numeric password on a numeric keypad that appears when pressing the Log In button. The identity of the currently logged in user is displayed in the header section of the **Display Menu**.

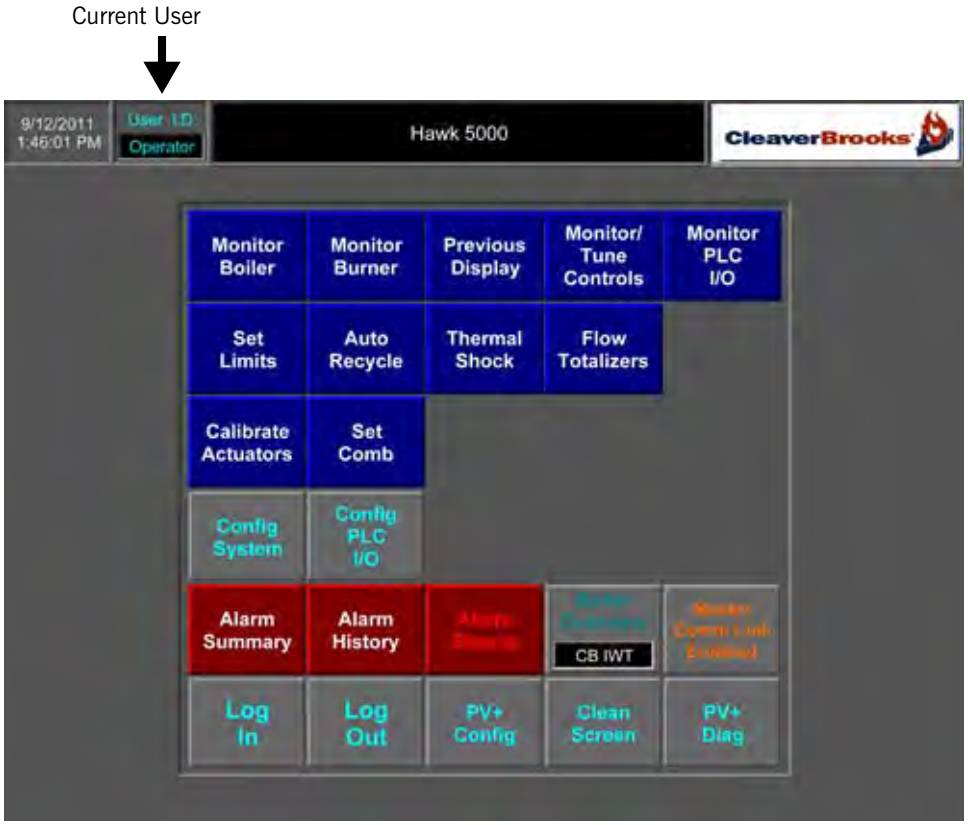


Figure 5-1 Display Menu

Table 5-1 Display access rights

Display	Logged Out	Operator	Service	CB
Monitor Boiler	X	X	X	X
Monitor Burner	X	X	X	X
Tune Controls			X	X
Monitor PLC I/O	X	X	X	X
Set Limits		X	X	X
Auto Recycle		X	X	X
Thermal Shock		X	X	X
Flow Totalizers	X	X	X	X
Calibrate Actuators			X	X
Set Combustion			X	X
Config System				X
Config PLC I/O			X	X
Alarm Summary	X	X	X	X
Alarm History	X	X	X	X
PV+ Config			X	X

Table 5-2 Control Function Access Rights

Function	Logged Out	Operator	Service	CB
Control Faceplates		X	X	X
Tuning Parameters			X	X
Reset Totalizer				
Adjust Totalizer Time Base			X	X
Reset Alarm History				X

5.2-System Configuration Displays

This section describes the general functionality of the user-selectable options presented on the System Configuration displays and identifies the process inputs each option requires.

Refer to Section 7 - Operating the Boiler from the Graphical User Interface - for more detailed descriptions of the options' control functionality.

Access to the Config System button requires logging in with the User I.D. of "CB". Upon successful log in, the following messages are displayed. ***Please read all screen messages carefully before proceeding.***

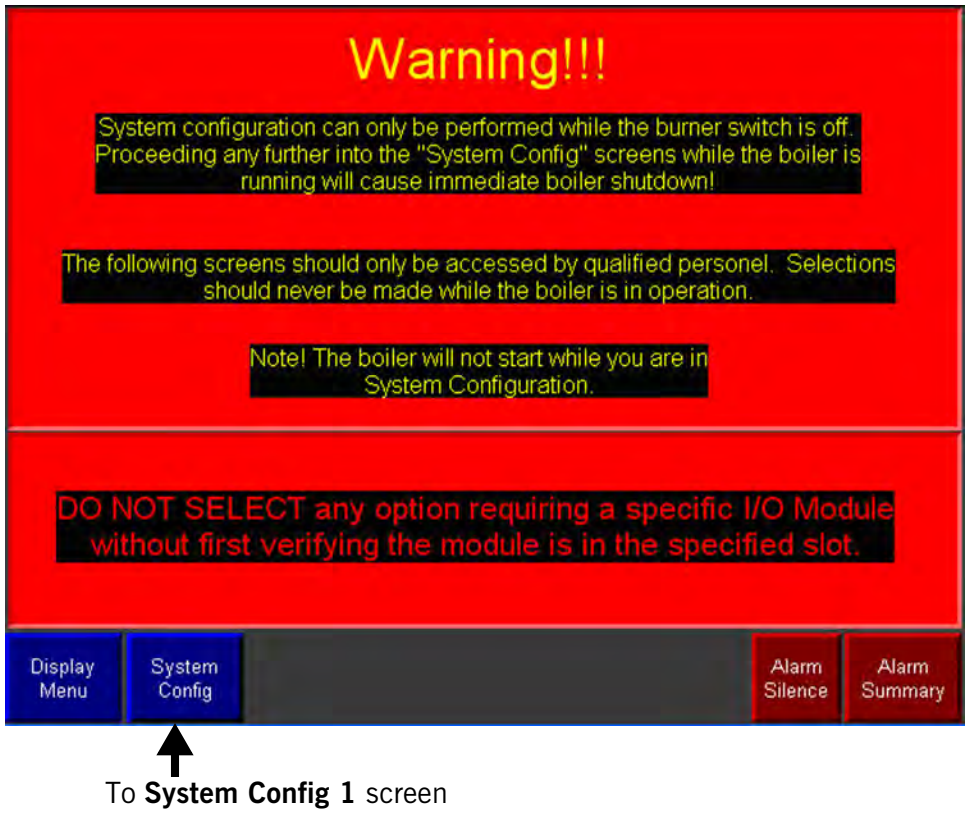


Figure 5-2 Warning Message

After reading the warning messages proceed to the **System Config 1** display by pressing System Config.

For options requiring a specific I/O module, check that the module is indeed present and located in its proper slot **BEFORE** selecting that option.

Failure to do so will fault the processor if the module is not present and require the PLC program to be reloaded.

System Configuration 1

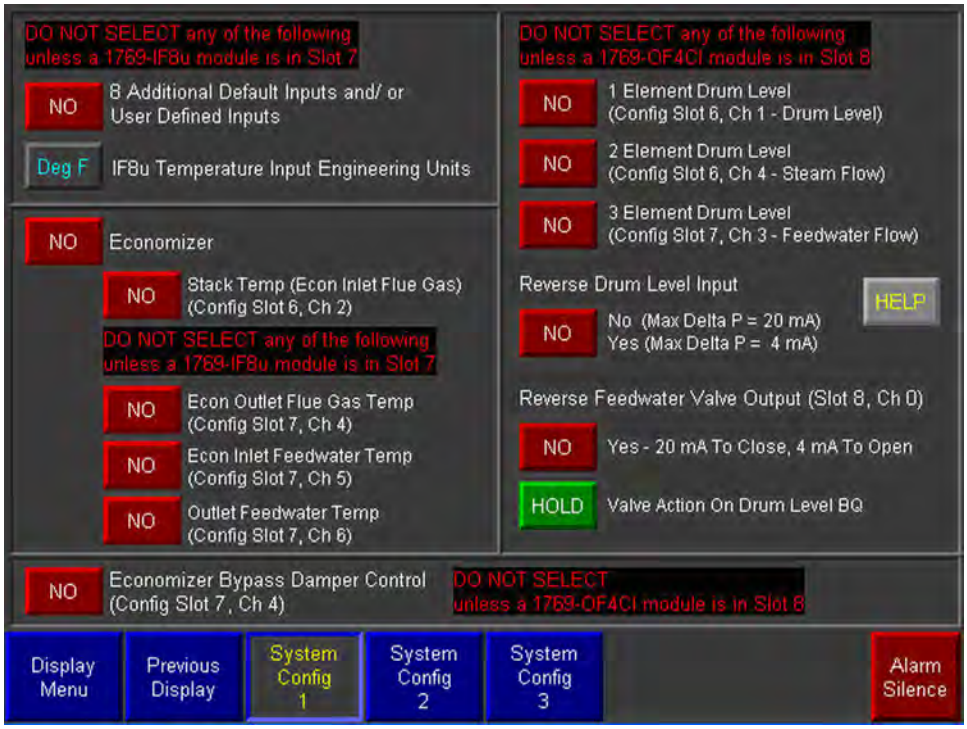


Figure 5-3 System Configuration 1 display

Option – Eight (8) Additional Default/ User Defined Inputs

The Hawk 5000 design supports up to 8 additional analog inputs if a universal input module is present in slot 7 (CB p/n 833-3123). Initially each input assumes the dual status of a *Default* input and as a *User Defined* input.

The following process variables are available to the user as Default inputs:

Table 5-3 Default Input Channel Assignments

Slot/ Ch	Default Input	Control Option Requiring Input	Signal Type
7/ 0	Fuel 1 Flow	none	4-20 mA
7/ 1	Fuel 2 Flow	none	4-20 mA
7/ 2	Stack Draft	Draft Control	4-20 mA
7/ 3	Feedwater Flow	3-Element Drum Level Control	4-20 mA
7/ 4	Econ Outlet Flue Gas Temperature	Economizer Bypass Control	Type J TC
7/ 5	Econ Inlet Feedwater Temperature	none	Type J TC
7/ 6	Econ Outlet Feedwater Temperature	none	Type J TC
7/ 7	Combustion Air Temperature	none	Type J TC

Default inputs are consumed in one of two ways: if a control option requiring the Default input is selected, or if the user has the instrumentation available and wants to monitor and display the variable on the Monitor Boiler display.

For example Default input Feedwater Flow is automatically consumed when selecting the **3-Element Drum Level Control** option. The Default input Fuel 1 Flow would be consumed if the user wanted to wire a new or existing Fuel 1 Flow transmitter into the system.

As Default inputs are consumed the number of User Defined inputs available decreases. For a detailed description on how to configure a User Defined input refer to Section 5.4 – PLC Process Variable Input Definition.

All Default inputs are automatically displayed on the Monitor Boiler display (Figure 1-1).

Option – Economizer

When selecting the Economizer option a graphical symbol of an economizer appears in the outlet duct section of the Monitor Boiler display. The user can also select for display the instrumentation measuring inlet and outlet flue gas and feedwater temperatures.

Option – Economizer Bypass Damper Control

As illustrated in Table 5-3, selecting **Economizer Bypass Damper Control** consumes the Default input Econ Outlet Flue Gas Temperature. The input is compared to an adjustable set point value, and if the input is less than set point the damper is modulated closed. If the input is greater than set point the damper is modulated full open.

Before selecting the **Economizer Bypass Damper Control** option, verify a 4-channel analog output module is present in Slot 8 (CB p/n 833-3123). The bypass damper is wired to field terminals connected to slot 8, channel 2.

Note that Economizer Bypass Damper Control is not available in systems utilizing single-point combustion control.

Option – Drum Level Control

There are three (3) **Drum Level Control** options: 1-Element, 2-Element, and 3-Element.

1-Element consumes the fixed input Drum Level which is permanently assigned to slot 6, channel 1. Along with fixed input Drum Level, 2-Element consumes the fixed input Steam Flow which is permanently assigned to slot 6, channel 5. Along with the fixed inputs Drum Level and Steam Flow, 3-Element consumes the Default input Feedwater Flow which is assigned to slot 7, channel 4.

Before selecting a **Drum Level Control** option, verify a 4-channel analog output module is present in slot 8 (CB p/n 833-3123). The Feedwater FCV is wired to field terminals connected to slot 8, channel 0.

The Drum Level section includes the following additional selections:

- Reverse the Drum Level input signal (press the Help button for details).
- Reverse the control output signal to the Feedwater FCV.
- Specify the Feedwater FCV action if the Drum Level input is out of range.

System Configuration 2

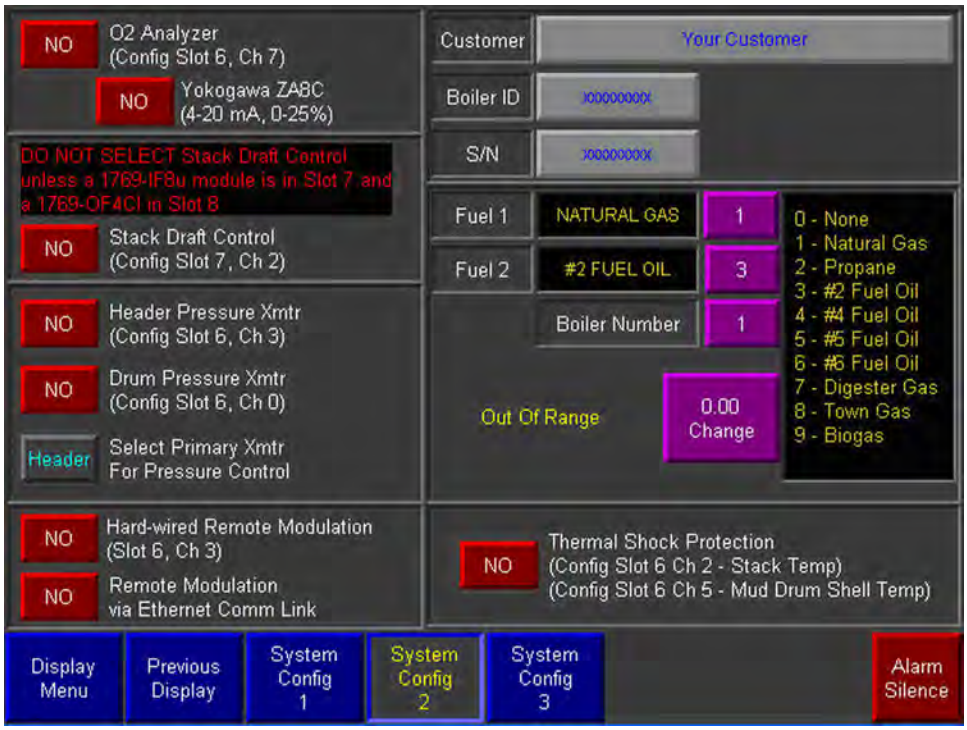


Figure 5-4 System Configuration 2 display

Option – O2 Analyzer

The option O2 Analyzer consumes the fixed input 'Flue Gas O2' permanently assigned to Slot 6, Channel 7.

The option O2 Analyzer is automatically selected when the control option **O2 Trim Control** is selected from Configuration 3. However, selecting the O2 Analyzer option does not automatically select the control option O2 Trim.

The standard O2 Analyzer is the Yokogawa Model ZA8C w/ Z021D probe, CB p/n 99413257.

Please contact the Cleaver-Brooks controls group with any compatibility concerns when using an analyzer by another vendor.

Option – Stack Draft Control

The option Stack Draft Control consumes the default input 'Stack Draft' assigned to Slot 7, Channel 2.

Before selecting the **Stack Draft Control** option, verify a 4-channel analog output module is present in slot 8 (CB p/n 833-3123). The Outlet Damper Actuator is wired to field terminals connected to slot 8, channel 3.

Option – Steam Header Pressure/ Drum Pressure Transmitter(s)

The Hawk 5000 is designed to accept inputs from Steam Header and/ or Drum Pressure instrumentation. Drum Pressure consumes fixed input wired to slot 6, channel 0. Steam header Pressure consumes the fixed input wired to slot 6, channel 3.

The Drum Pressure input is required for the **Auto-Recycle Control** function and can also be used to control Steam Pressure in the following scenarios:

a) System without a Steam Header Pressure instrument.
b) System with a Steam Header Pressure instrument as the primary and Drum Pressure as the backup.

A Steam Header Pressure sensor cannot be used in systems with a hard-wired Remote Modulation input.

Scenario (b) requires the user to select a primary instrument with a control included in the group and shown below.

Option – Remote Modulation

The Hawk 5000 is designed to accept a remote modulation input from a plant master; two user selectable methods are available to receive the input:

a) Hard-wired 4-20 mA input signal
b) Ethernet Communication Link

Option (b) is required when using the Hawk Master Panel.

Selecting option (a) will consume fixed input Remote Modulation, wired to Slot 6, Channel 3.

Option (a) cannot be selected in systems using a Steam Header Pressure instrument.

Option – Thermal Shock Protection

The Hawk 5000 Thermal Shock Protection scheme considers both stack temperature and mud drum shell temperature in its calculations to determine if a boiler is warm enough to take up a load. Both inputs are required for thermal shock protection.

Thermal Shock Protection consumes two fixed inputs: Stack Temperature (wired to Slot 6, Channel 2) and Mud Drum Shell Temperature (wired to Slot 6, Channel 6).

Fuel Type Selection

The Hawk 5000 is designed for single-burner boilers firing up to two fuel types (not in combination). Enter the corresponding number of your application's fuel type as shown in Figure 5-5 below.

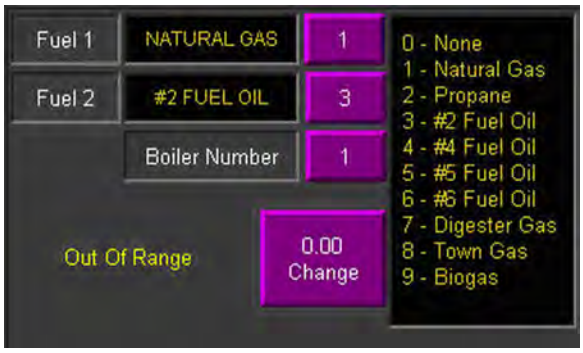


Figure 5-5 Fuel Selection Panel

Boiler Number

Figure 5-5 above contains an additional control to enter a unique boiler number (1-99). The boiler number is displayed on the Monitor Boiler graphic.

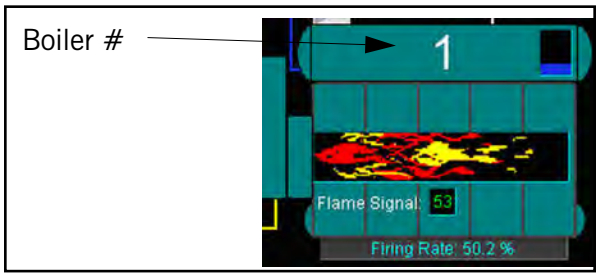


Figure 5-6

Customer Name/ Boiler ID/ Serial Number

Controls are available from Configuration 2 to enter the Customer Name, Boiler ID and Serial Number. The information is displayed on the Monitor Boiler graphic.

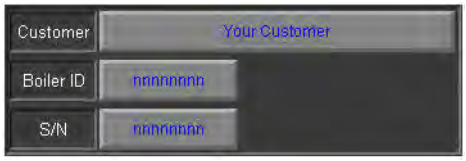


Figure 5-7

Figure 5-8 Location of Customer/ Boiler ID/ Serial Number on Monitor Boiler display

System Configuration 3

Figure 5-9 System Configuration 3 display

The major control options available in the Hawk 5000 are selected from Configuration 3 display.

Major options, once set, should not be changed. Doing so after the system is commissioned will erase the entire combustion setup for both fuels.

Option – Pulse Positioning or 4-20 mA Positioning

The Hawk 5000 is designed to work in systems using either servomotors or electro-pneumatic actuators to position final control elements such as air dampers and fuel valves. **Note:** All actuators must be of the same type. *The system is not designed to work with a combination of servomotor and electro-pneumatic actuators..*

Select Pulse Positioning when lower torque servomotors are used. A 16-channel solid state output module is required in slot 5 (CB p/n 833-2060).

Select 4-20 mA Positioning when higher torque electro-pneumatic actuators are used. An 8-channel analog output module is required in slot 10 (CB p/n 833-3106). A filler module is required in slot 5 (CB p/n 833-3073).

Option – Single-Point Combustion or Parallel Combustion Control

The Hawk 5000 provides two combustion control strategies: Single-Point and Parallel.

Single-Point Combustion requires that a 4-channel analog output module be present in slot 8 (CB p/n 833-3123). The Jackshaft actuator is wired to slot 8, channel 2.

Note that Single-Point Combustion is not an available option in systems utilizing the Economizer Bypass Control option because they share the same output channel.

Parallel Combustion requires that either a 16-channel solid state output module be present in slot 5 (pulse positioning) or an 8-channel analog output module be present in slot 9 (4-20 mA positioning).

In both pulse and 4-20 mA systems an 8-channel analog input module is required in slot 9 (CB p/n 833-3106). The purpose of the module is to input the actuator position feedback signals into the system. Note also that the feedback signal wiring method to the module will be different for servos (0-10 VDC) and electro-pneumatic actuators (4-20 mA).

Option – Center Gas Valve Actuator

The Hawk 5000 is designed to support burner designs that use lance gas and center (core) gas actuators – both servo and electro-pneumatic. Selecting this option activates the PLC logic to characterize and control the output to the actuator.

Option – 2nd Combustion Air Damper Actuator

The Hawk 5000 is designed to support burner designs that use a 2nd Combustion Air Damper actuator (FD Inlet/Outlet, Windbox). Selecting this option activates the PLC logic to characterize and control the actuator.

Option – 2nd FGR Damper Actuator

The Hawk 5000 is designed to support burner designs that utilize Flue Gas Recirculation (FGR) to control NOx. Both servo and electro-pneumatic actuators are supported. Selecting this option activates the PLC logic to characterize and control the output to the actuator.

Option – AB PowerFlex VSD or Other Manufacturer's VSD

The standard VSD is the AB PowerFlex 400 with built-in modbus communication port. The modbus link allows for the integration of drive diagnostic data and alarms into Hawk 5000 HMI displays designed specifically to support the drive.

The Hawk 5000 can control VSDs by other manufacturers but the Modbus communications feature is turned off, as are the integrated diagnostics.

All VSDs regardless of manufacture must be able to receive and send the following commands:

- Input a 4-20 mA speed reference signal
- Output a 4-20 mA speed feedback signal
- Input a dry contact START/ RUN signal

The maximum speed setting for all VSDs regardless of manufacture is 60 Hz.

Selecting the VSD option activates the PLC logic to characterize and control the output to the drive.

Option – O2 Trim Control

The option O2 Trim Control consumes the fixed input Flue Gas O2 permanently assigned to slot 6, channel 7. The standard O2 Analyzer is the Yokogawa Model ZA8C w/ Z021D probe, CB p/n 99413257.

O2 Trim Control makes continuous corrections to the position of the combustion air damper to maintain O2 on set point. In systems with a VSD continuous corrections are made to the VSD speed reference signal.

Option – Burner Management Control

The Hawk 5000 supports both the latest and legacy versions of the burner management controls provided by Honeywell and Fireye. Selecting one of the above enables the Modbus communications link between the burner management controller and the Hawk 5000 PLC. The standard burner management control is the CB120E. Refer to Publication 750-264 for details.

5.3-Changing The PLC and Panelview Plus Ethernet Addresses

Non-custom Hawk 5000 systems shipped from the factory are all loaded with the same source PLC and Panelview Plus application programs. The program identification numbers are displayed in a panel on the Alarm History display

The two programs are factory set to the Ethernet address assigned to Boiler 1.

Table 5-4 Hawk 5000 Ethernet IP Address Assignments

Boiler #	PLC	PV+
1	**192.168.1.171**	**192.168.1.181**
2	192.168.1.172	192.168.1.182
3	192.168.1.173	192.168.1.183
4	192.168.1.174	192.168.1.184
5	192.168.1.175	192,168,1,185
6	192.168.1.176	192.167.1.186
7	192.168.1.177	192.168.1.187
8	192.168.1.178	192.168.1.188
Master Panel	192.168.1.170	192.168.1.180

Two boilers in a system can both use Boiler 1 PLC and PV+ programs but cannot be connected together on the Ethernet network.

Each boiler PLC and PV+ in a multiple boiler system, where the boiler panels are networked together via Ethernet communications link, *must have a unique Ethernet address* per the convention in Table 5-4. Since all systems ship with the Boiler 1 Ethernet addresses it is necessary to change the PLC and PV+ addresses in the field.

Procedure to change Ethernet address

From Configuration 3 press the <Change Ethernet Address> button to navigate to the display shown in Figure 5-10.

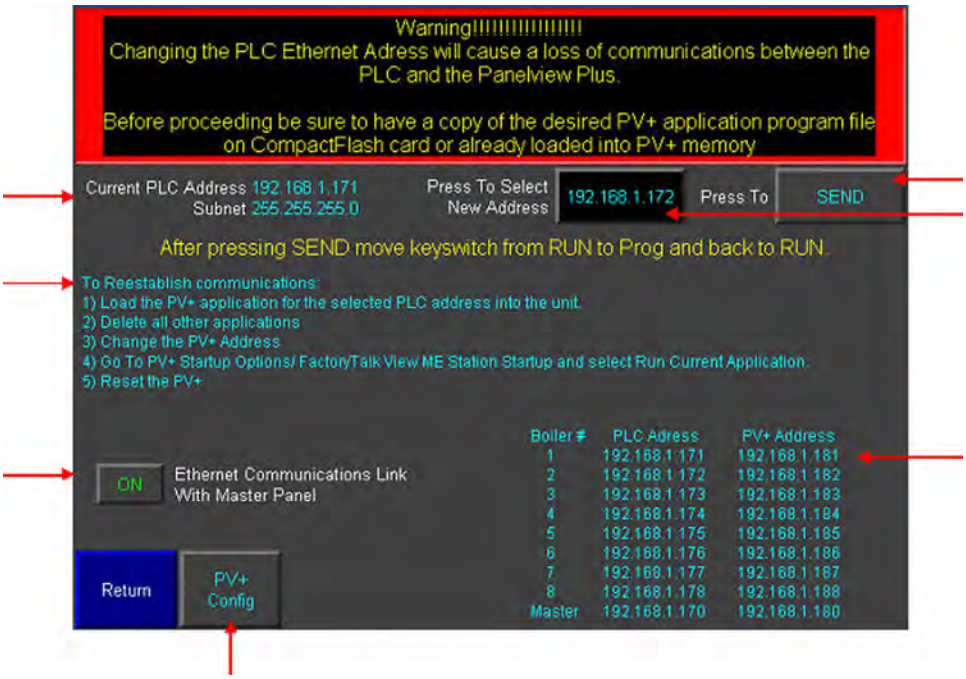


Figure 5-10 Change PLC Ethernet Address display

Figure 5-10 shows the current PLC Ethernet address to be 192.168.1.171 and the table shows that the corresponding PV+ Ethernet address is 192.168.1.181.

The boiler must be off to change the PLC and PV+ Ethernet addresses.

To change the PLC Ethernet address:

- Use the Press to Select New Address control to select a new Ethernet address (shown selected above is the address 192.168.1.172).
- Press the SEND button.
- Toggle the PLC key switch from RUN to PROG and back to RUN.

Communications to the PV+ have now been interrupted and won't be reestablished until steps 1 through 5 shown on the display (see Figure 5-10) are completed.

Refer to **Appendix C – Procedure To Load Program and Set Up Panelview Plus** for expanded descriptions of steps 1-5.

An additional control is provided to turn ON or OFF the Ethernet communications link between the Boiler Panel PLC and a Hawk ICS Ultra 100 Master Panel.

Do not change the PLC Ethernet address unless you have in your possession a copy of the corresponding PV+ application program file.

5.4-PLC Process Variable Input Definition

The Ultra 100 Boiler Control System design provides maximum flexibility in regards to the connection of both existing and new process instrumentation supplied by the major control instrumentation manufactures today. The system utilizes the Spectrum Controls Universal Input Module (CB p/n 833-3714) which can be configured to accept eight (8) voltage, current, or thermocouple inputs, or a maximum of four (4) RTD or resistance inputs.

All Ultra 100 system configurations have a universal module located in Slot 6. The process variables shown in Table 5-5 are used for control and are thereby fixed.

Table 5-5 Fixed Input Channel Assignments

Slot/ Ch	Fixed Input	Control Option Requiring Input	Signal Type
6/ 0	Drum Pressure	Steam Pressure Control	4-20 mA
6/ 1	Drum Level	Drum Level Control (1, 2, or 3 Element)	4-20 mA
6/ 2	Stack Temperature	Thermal Shock Protection	Type J TC
6/ 3	Steam Header Pressure/ Remote Modulation	Steam Pressure Control/ Hard-Wired Remote Modulation Input	4-20 mA
6/ 4	Steam Flow	2-Element Drum Level Control	4-20 mA
6/ 5	Mud Drum Shell Temperature	Thermal Shock Protection	RTD
6/ 6	VSD Speed Feedback	VSD Control option	4-20 mA
6/ 7	Flue Gas O2	O2 Trim Control	4-20 mA

The Ultra 100 system configuration can include a second universal module located in slot 7. The 8 available channels can be configured as User Defined inputs, or as Default inputs. Table 5-6 shows the Default input channel assignments and the Control Option requiring the input.

Table 5-6 Default Input Channel Assignments

Slot/ Ch	Default Input	Control Option Requiring Input	Signal Type
7/ 0	Fuel 1 Flow	none	4-20 mA
7/ 1	Fuel 2 Flow	none	4-20 mA
7/ 2	Stack Draft	Draft Control	4-20 mA
7/ 3	Feedwater Flow	3-Element Drum Level Control	4-20 mA
7/ 4	Econ Outlet Flue Gas Temperature	Economizer Bypass Control	Type J TC
7/ 5	Econ Inlet Feedwater Temperature	none	Type J TC
7/ 6	Econ Outlet Feedwater Temperature	none	Type J TC
7/ 7	Combustion Air Temperature	none	Type J TC

Refer to **System Configuration 1** (page 5-4) for more information on Default and User Defined inputs.

Process Variable Input Definition

Process variable inputs are consumed by the system during the option selection process. For example when selecting the option 2-Element Drum Level the process variable Drum Level and the process variable Steam Flow are consumed and require further definition. Do begin this process go to the Display Menu and select Config PLC I/O to navigate to display shown in Figure 5-11.

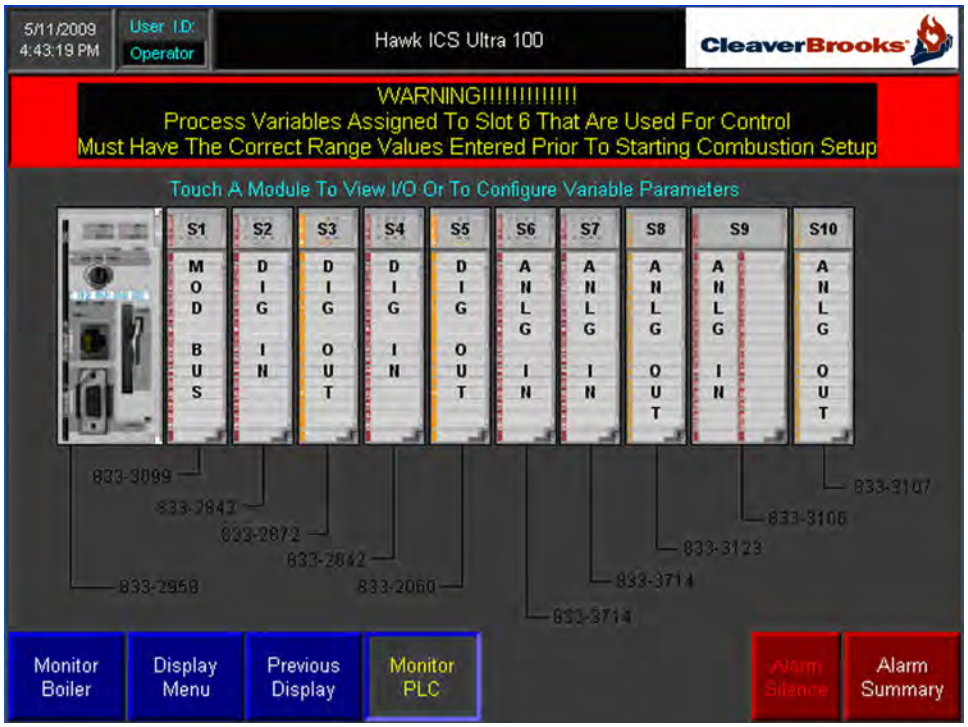


Figure 5-11 PLC I/O Module Assembly display

Touch either slot 6 (S6) or slot 7 (S7) to access the Variable Parameter Definition. The display shown in Figure 5-12 will appear.

Figure 5-12 Slot 6 Analog Input Module display

The variables shown in black background have been activated during the option selection process or activated manually by the user. Pressing the Edit button accesses the Analog Input Definition pop-up shown in Figure 5-13.

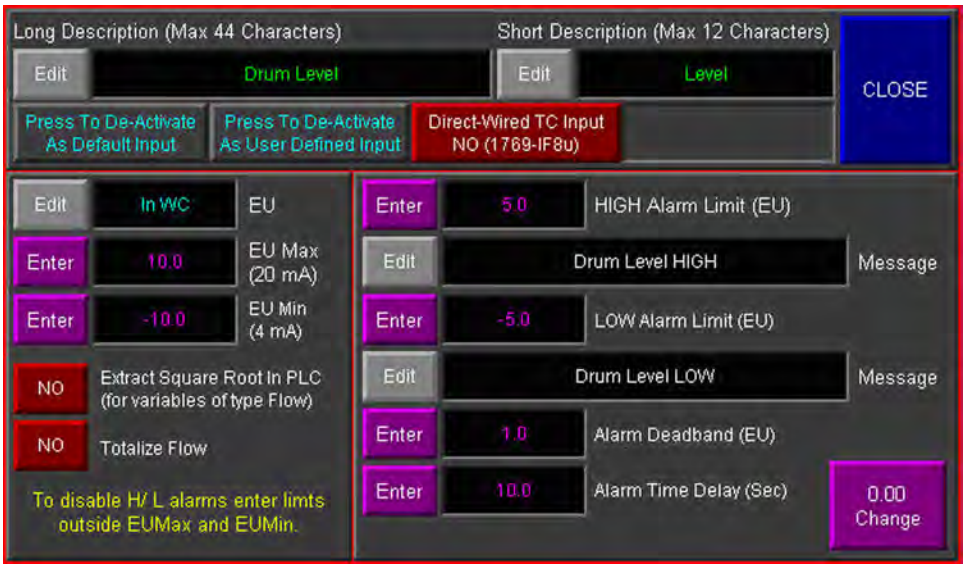


Figure 5-13 Slot 6 Analog Input Definition pop-up

Figure 5-13 shows the Analog Input Definition for the process variable 'Drum Level'. Values have been entered for the following parameters:

- EU – Engineering Units
- EUMax – Value of input at 20 mA in engineering units
- EUMin – Value of input at 4 mA in engineering units
- HIGH Alarm Limit – in engineering units
- HIGH Alarm Description
- LOW Alarm Limit – in engineering units
- LOW Alarm Description
- Alarm Deadband
- Alarm Time Delay

For variables of type 'flow' the following additional controls are provided:

- Extract Square Root in PLC (differential pressure flow instruments)
- Flow Totalization

Certain process variables used for control must be properly defined prior to commissioning the boiler. The variables requiring definition will vary depending on the options selected. Undefined variables will produce a warning message on the Main Menu as shown below.

Table 5-7 lists all of the process variables that fall into this category along with the associated control options.

Table 5-7 Process Variables used for Control

Slot/ Ch	Process Variable	Control Option
6/ 0	Drum Pressure	Drum Pressure Control
6/ 1	Drum Level	1, 2, or 3 Element Drum Level Control
6/ 2	Stack Temperature	Thermal Shock Protection
6/ 3	Steam Header Pressure	Steam Header Pressure Control
6/ 4	Steam Flow	2 or 3 Element Drum Level Control
6/ 5	Mud Drum Shell Temperature	Thermal Shock Protection
6/ 6	VSD Speed Feedback	VSD Control
6/ 7	Flue Gas O2	O2 Trim
7/ 2	Stack Draft	Draft Control
7/ 3	Feedwater Flow	3 Element Drum Level Control
7/ 4	Econ Outlet Flue Gas Temp	Economizer Bypass Control

6. FUEL COMMISSIONING PROCESS

6.1-Introduction

Fuel Commissioning is required in systems where the Parallel Combustion Control option is selected. Fuel Commissioning is not required for the Single-Point Combustion Control option. Proceed to Appendix E– Boiler START/ STOP Sequence for the steps to follow when commissioning a Single-Point system.

Fuel Commissioning is only possible after all of the process variables associated with the control of the boiler are properly configured. For a full list of these process variables and the control loops involved, refer to Table 5-7. The actual process variables requiring configuration are fully dependent on the options selected in the System Configuration process. Refer to Section 5 for a full discussion of that process.

The Fuel Commissioning process consists of three steps: Actuator Calibration, Set Combustion, and Control Loop Tuning.

6.2-Actuator Calibration

On new boiler installations actuator travel will be preset from the factory for 90 degrees rotation. On service conversions the actuators are shipped loose and will require setting of the actuator stroke.

Refer to **Appendix D – Procedure To Set Actuator Stroke** for details.

After setting the stroke, the actuator is ready for calibration. The Actuator Calibration process is required to identify the range of travel of an actuator in terms of its feedback voltage signal when the actuator is connected to its final control element (i.e. fuel valve or air damper).

The Hawk 5000 supports two (2) actuators with torque ranges of 15 ft-lb and 37 ft-lb. It is important to confirm that the torque rating of the actuator in hand is sufficient to move the final control element.

From the Display Menu log in as either “Service” or “Factory” and select <Calibrate Actuators>. The display shown in Figure 6-1 will appear.

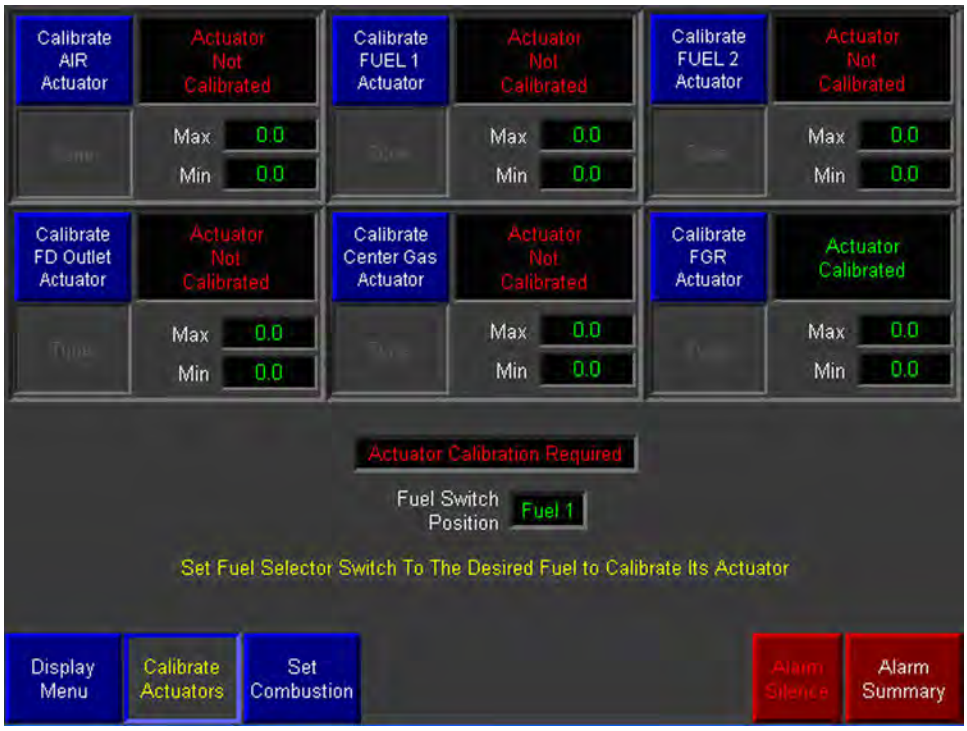


Figure 6-1 Actuator Selection display

Figure 6-1 shows panels for up to six (6) actuators – the maximum number of actuators available. The actual number of actuators shown is directly linked to the options selected from the Configuration 3 display (refer to **Configuration 3** in Section 5).

Each actuator has a panel consisting of a Calibration button, a Calibration Status message, and numeric display of the actuator minimum and maximum values. The panel for the Air Actuator is shown below.

Figure 6-2

Press the <Calibrate Air Actuator> button. The display shown in Figure 6-3 will appear.

Cells are provided to display the name of the actuator to be calibrated, the actuator's position feedback voltage, and the calibration status – either "Required" or "Complete".

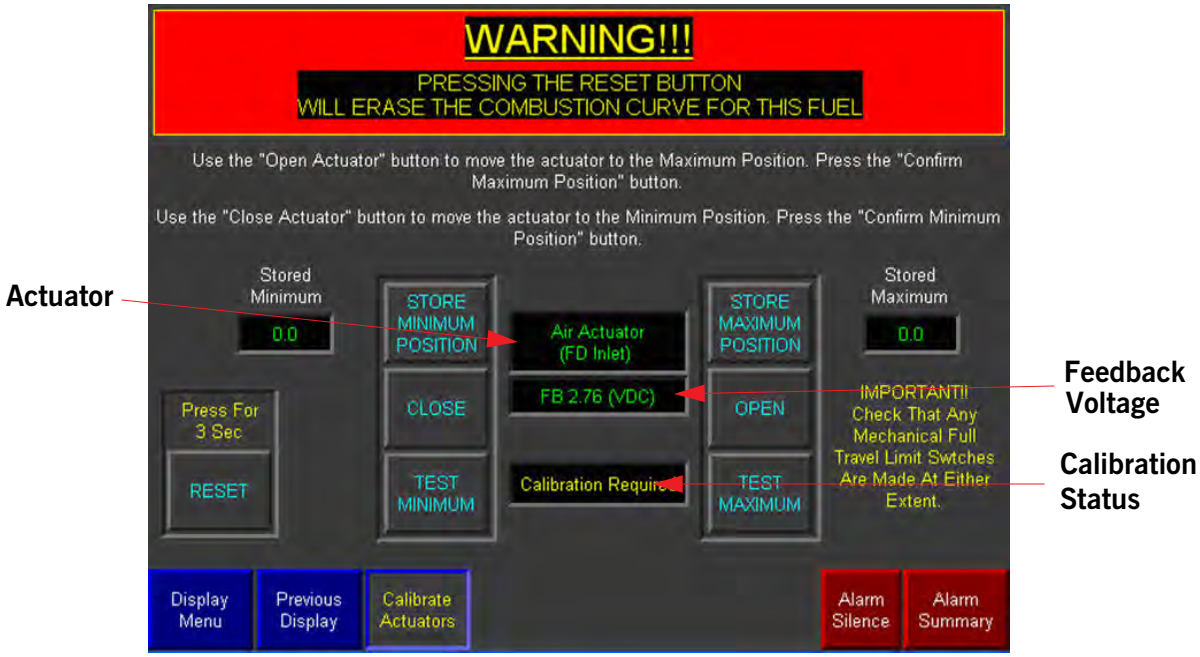


Figure 6-3 Calibrate Actuator display

Before proceeding further, make sure that all output shafts, couplings, and setscrews are loose and the control element (fuel valve/ air damper) can move freely.

Press the CLOSE button to move the actuator to the closed position. Move the control element to its closed position and tighten the couplings and setscrews.

Press the OPEN button to drive the actuator to the mechanically full open position. Once there, use the CLOSE button to back the actuator off slightly, and press the STORE MAXIMUM POSITION button. The feedback voltage value at this position is captured and displayed in the Stored Maximum cell.

Press the CLOSE button to drive the actuator and control element the mechanically full closed position; and then use the OPEN button to move the control element back open slightly. Press the STORE MINIMUM POSITION button. The feedback voltage value at this position is captured and displayed in the Stored Minimum cell.

After calibration, an actuator can be tested by pressing the TEST MAXIMUM and TEST MINIMUM buttons.

An actuator can be recalibrated by first pressing the RESET button.

Pressing the RESET button AFTER the Fuel Commissioning process is completed will ERASE all commissioning data for that fuel type.

After calibrating all of the actuators the Actuator Selection display will look something like Figure 6-4, which shows three calibrated actuators (AIR, FUEL 1 and FGR).

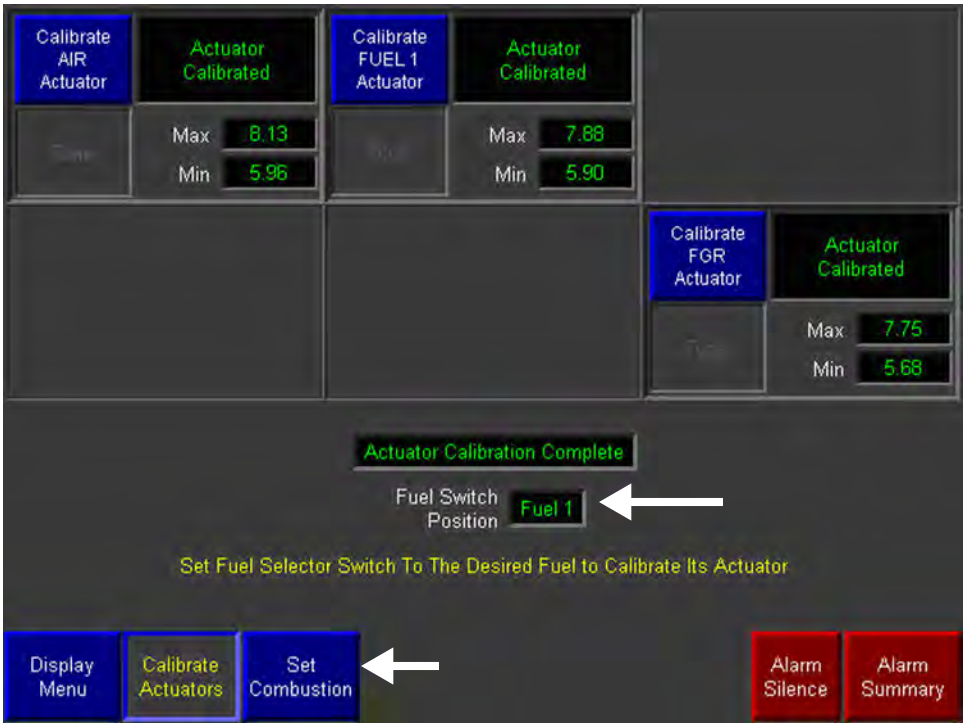


Figure 6-4 Actuator Selection display

Note that the Fuel Switch Position cell indicated Fuel 1. To calibrate the Fuel 2 actuator, move the Fuel Selector switch to the Fuel 2 position. It is not necessary to calibrate the Fuel 2 actuator prior to commissioning Fuel 1.

After the actuator calibration process is completed the Set Combustion navigation button will appear. Press it to move to the 2nd step in the Fuel Commissioning Process. Also, an identical button is made visible on the Display Menu.

6.3-Set Combustion

The combustion must be set in Parallel Combustion control systems with either pulse positioning, or current positioning actuators. The combustion set process captures the value of actuator feedback signals and process variables at various firing rates or points. A minimum of nine (9) points must be captured. The maximum is sixteen (16).

Before proceeding it is vital that all process variable inputs be configured, scaled and indicating properly; and that all actuator feedback signals are within their respective calibration range.

A typical Set Combustion display is shown in Figure 6-5. The example shown is for a 2-fuel system (NG and Fuel Oil) with the VSD, FGR, O2 Trim, Stack Draft, and Drum Level options selected.

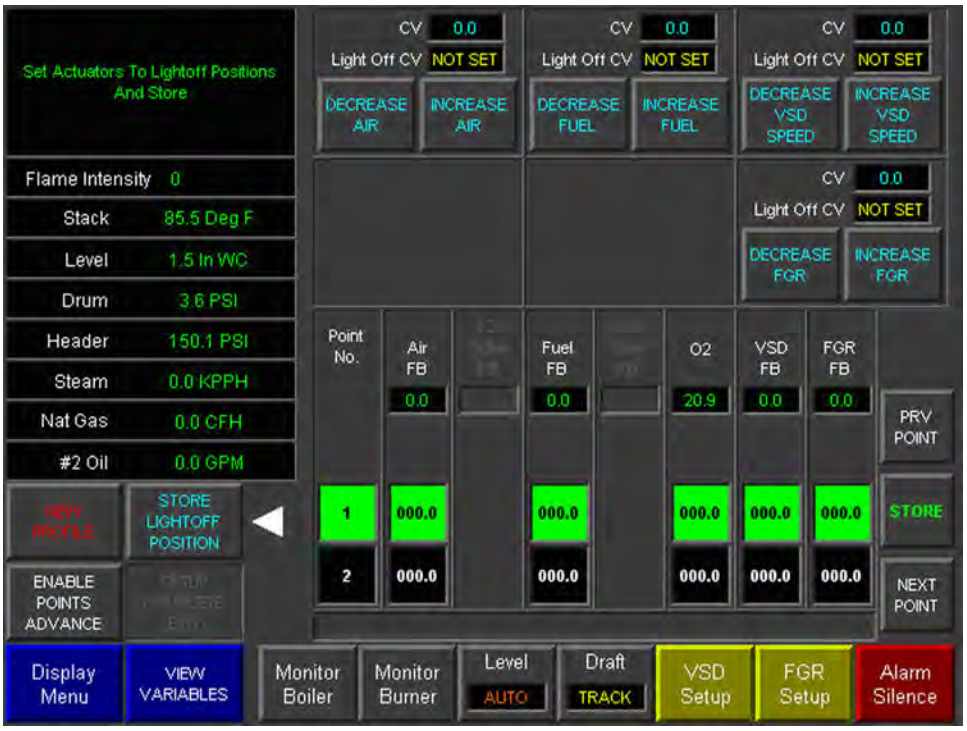
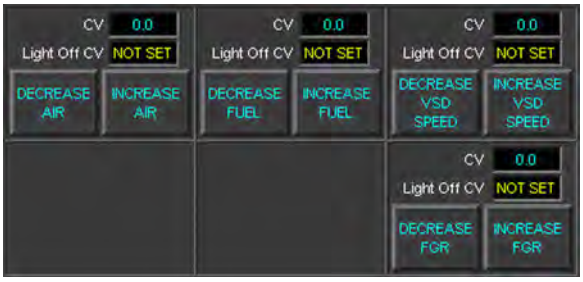


Figure 6-5 Set Combustion display

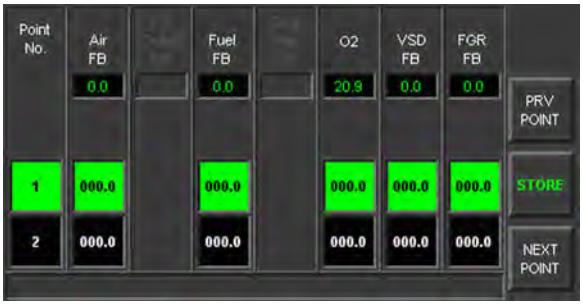
The display content is partitioned into sections described below.

The top left section is a panel of process variables. The process variable inputs displayed are determined in the System Configuration process.

On top is a “Help Text” message display that guides the technician through the process.

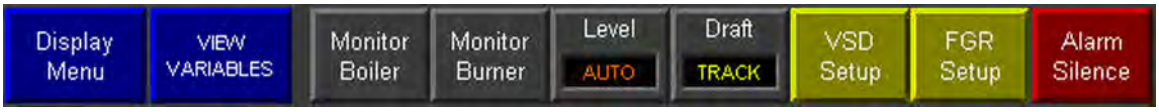


The center/top section consists of actuator control panels with buttons to change the value of the CV; and an indicator showing the value of the Light Off CV.



The center section shows the real-time values of the actuator feedback signals and the flue gas O2.

The stored values of the current point are displayed along with the STORE, PRV point, and NEXT POINT buttons.



The bottom section consists of screen navigation, control faceplate, and device Set Up buttons. The content of this section is determined by the System Configuration process.

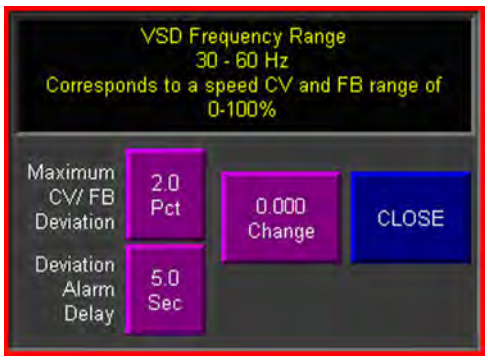
The purpose of the section is to allow easy access to displays that monitor all of the boiler systems, and control ancillary loops such as Drum Level and Stack Draft.

Device Set Up buttons are provided the VSD and FGR Damper to set additional parameters associated with this equipment.

Additional parameters associated with the control of a VSD or a FGR Damper must be checked and properly set before proceeding further with the Set Combustion process.

VSD Setup

Pressing the VSD Setup button displays the VSD Setup popup panel.



The maximum Frequency Range is fixed at 30-60 Hz.

The CV/ FB Deviation Limit and associated time delay are adjustable.

The boiler will shut down if the actual CV/ FB deviation is greater than the limit value.

FGR Setup

Pressing the FGR Setup button displays the popup panel shown in Figure 6-6.

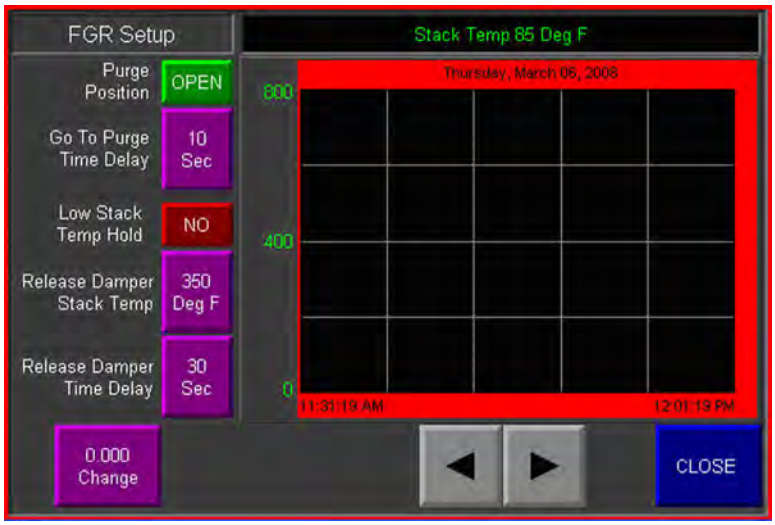


Figure 6-6 FGR Setup dislay

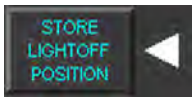
The purge position of the FGR Damper is selectable (OPEN or CLOSED). If OPEN is selected, that event can be delayed by setting the related time delay.

The boiler can be held at low fire until the Stack Temperature exceeds the release temperature value. That event can be delayed by setting the related time delay.

Storing Light Off CV

Storing the light off CV for each actuator should be done after making any adjustments to the set up of devices such as a VSD and a FGR Damper.

To do so use the actuator controls to set each actuator to its approximate light off position and then press the STORE LIGHTOFF POSITION button.



After storing the light off positions start the boiler by pressing the Boiler START pushbutton located on the control panel door.

Refer to **Appendix E - Boiler START/ STOP Sequence** for a detailed description of the start sequence.

It may be necessary to adjust the light off CV values a number of times to achieve the desired flame pattern and fuel/ air mixture.

• **The boiler should be allowed to thoroughly warm up before proceeding further with the Set Combustion process.**
• **If the Stack Draft and/ or Drum Level control options are selected it is recommended that preliminary tuning parameters be entered and the controls be placed in Auto.**

Capturing Combustion Data

The primary function of the Set Combustion process is to capture data pertaining to the position of the actuators and of certain process variables as the boiler is fired manually from low fire to high fire. This data is then organized by the program to populate arrays that are used to generate actuator position set points that correspond to the firing rate.

The minimum number of capture points is nine (9) and the maximum is sixteen (16). The first point is number 1.

The data capture process involves using the actuator controls to position the fuel, air, VSD and FGR in increments approximating a segment of the full firing rate range.

Figure 6-7 shows an example of the Set Combustion display at the point where the first data point is captured.

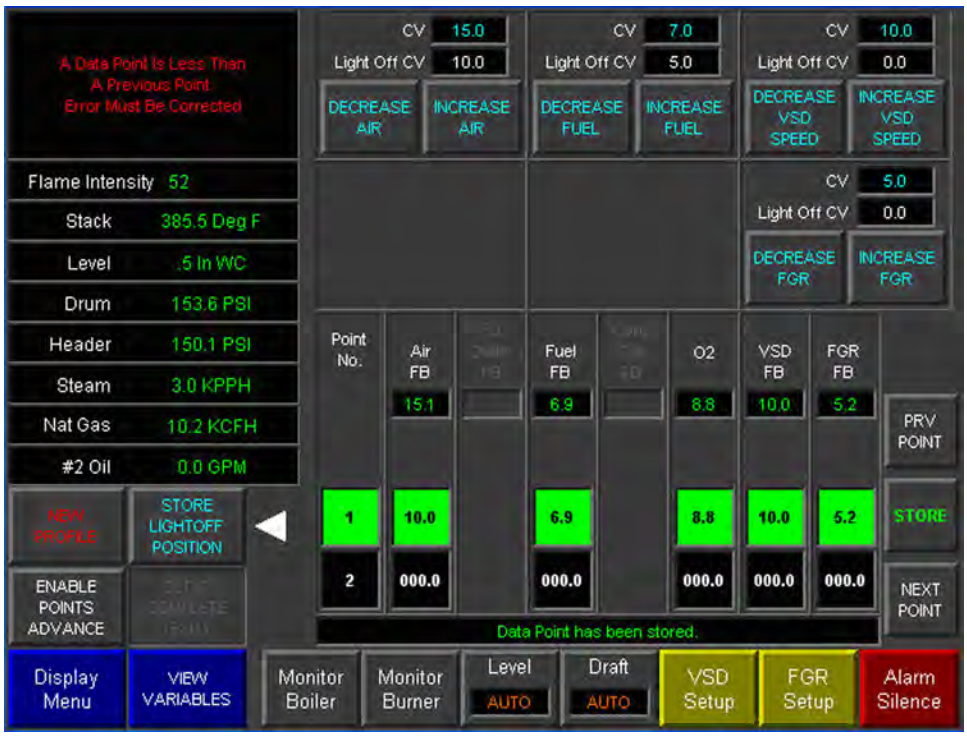


Figure 6-7 Set Combustion display at point 1

The STORE button has been pressed as indicated by the text message “Data Point has been stored”. The actuator CV values have changed from their respective light off values as have the feedback values. The process variables O2, Steam Flow, Gas Flow, Drum and Header Pressure have also changed.

The Drum Level and Stack Draft control loops are in Auto.

It is recommended that a total of ten (10) points be captured to simplify the calculation of input at each capture point. For example, if full load Steam Flow is 60 KPPH the first capture point would be at 6.0 KPPH. The same calculation would apply if a Fuel Flow variable is available.
It is important to have some method of measuring input to avoid over-firing the boiler.

After 9 points have been captured the Set Complete (Exit) button is visible; indicating that the minimum number of points is captured and the data is of good quality.

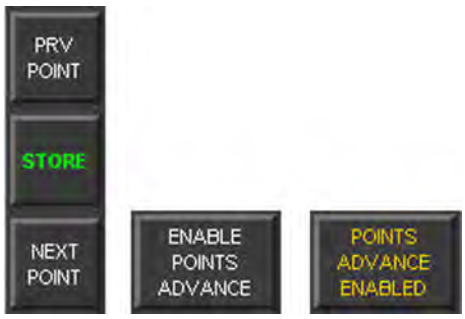
The SET COMPLETE button must be pressed to fully transition out of commissioning mode.

The definition of a Bad Quality Data Point is an instance where one of the values of a captured data point is less than a corresponding value of a previously captured data point. An example of an instance Bad Quality Data is if the Air feedback at point 6 is 30% and at point 7 it is 29%.

This condition must be rectified to complete the Set Combustion process.

Enable Points Advance

The Points Advance mode drives all of the actuators simultaneously from point to point by pressing either the PRV POINT or the NEXT POINT button. The mode is useful to quickly move the firing rate up or down to check combustion.



Editing Stored Data Points

To change a point already stored, enable Points Advance and set the boiler firing rate to the point number to be changed. Use the actuator controls to adjust the fuel/ air ratio then press the STORE button.

For example, Figure 6-8 shows Points Advance Enabled and the boiler firing at point 7. The Air CV has been changed to 62.0 from the previously stored value of 66.6. The O2 is now 3.0% vs. the previously stored value of 3.8.

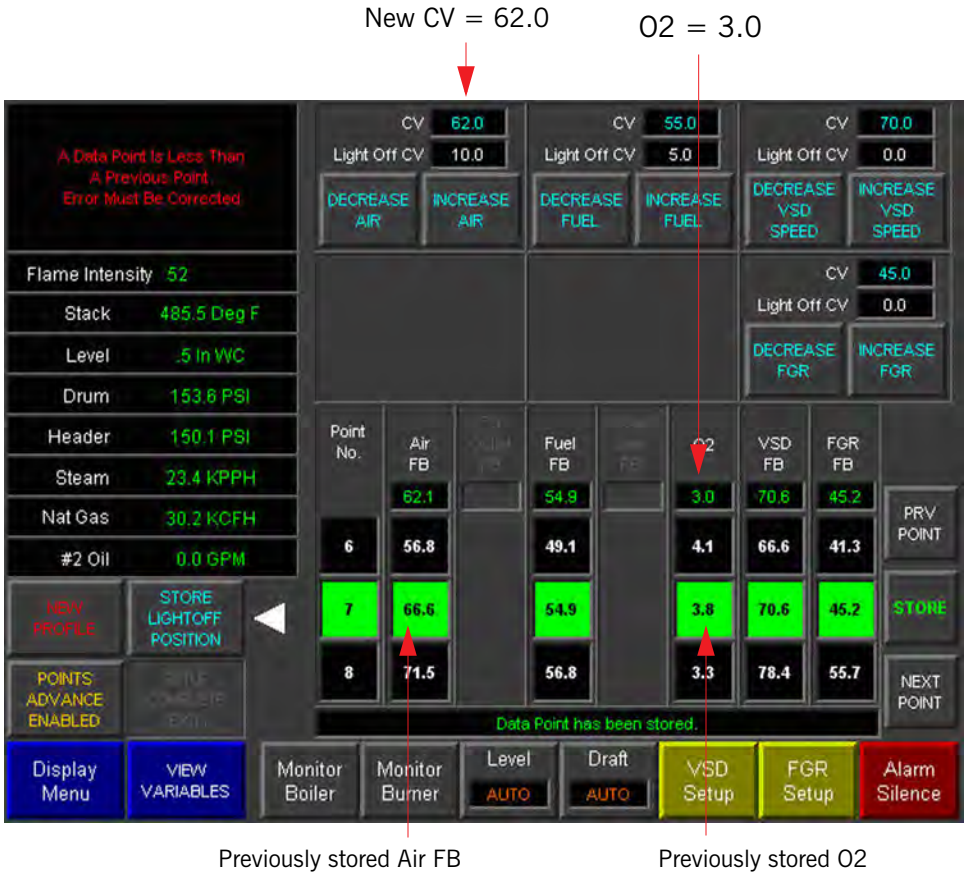


Figure 6-8

Pressing the STORE button will then edit the point 7 data as shown below.

6.4-Tune Controls

Pressing the SETUP COMPLETE (Exit) button will navigate to the Tune Controls display shown in Figure 6-9.

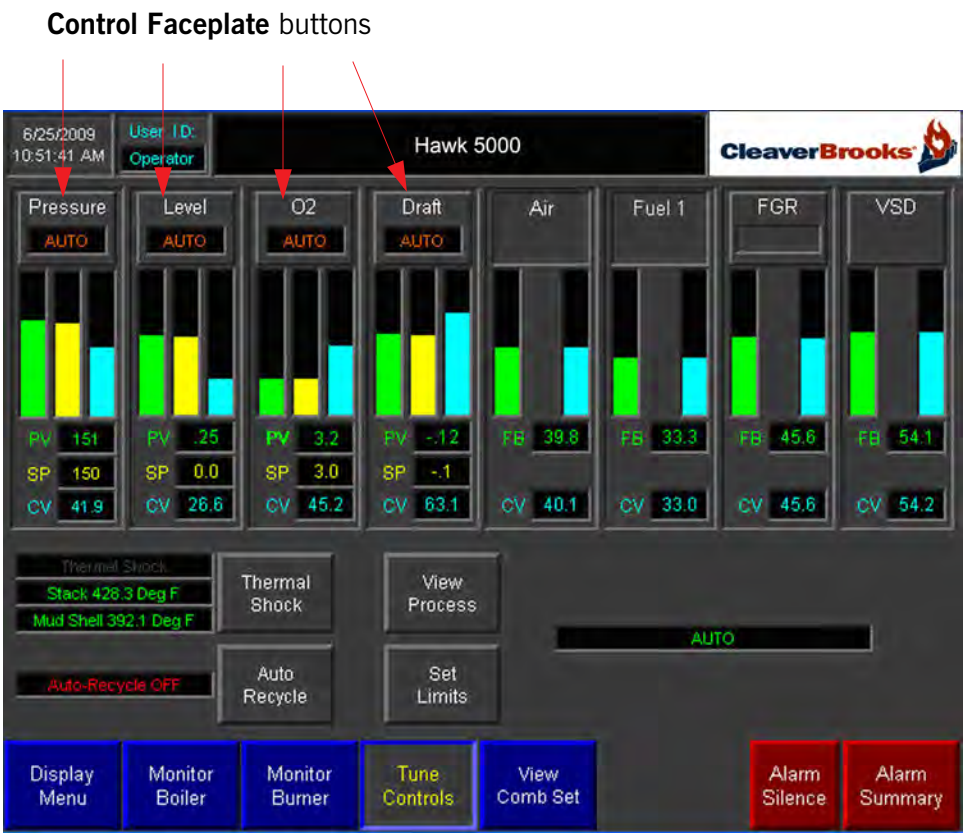


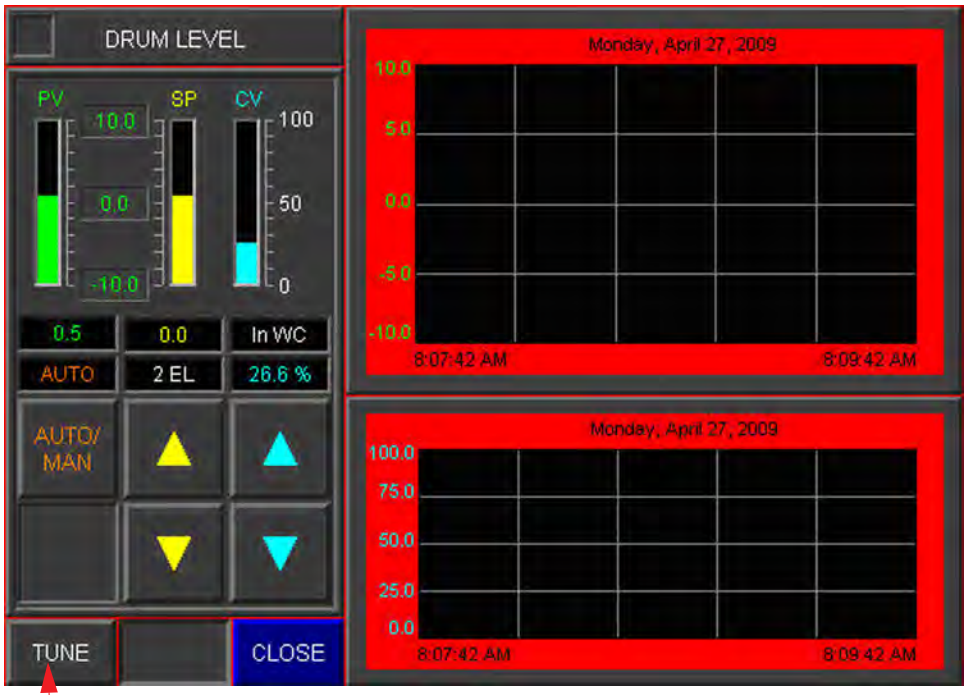
Figure 6-9 Tune Controls

The purpose of the Tune Controls display is to observe the performance of the actuators and control loops, and to make any adjustments to the tuning parameters.

The content of the display is directly linked to the control options selected during System Configuration. Control options requiring tuning are:

- Steam Pressure Control
- Drum Level Control
- O2 Trim Control
- Stack Draft Control

Adjustments are made by pressing the Control Faceplate button for the loop of interest and then pressing its TUNE button. For example, to tune the Drum Level press the Level control faceplate button to access the Drum Level control faceplate shown below in Figure 6-10.



Press TUNE to access the tuning parameter popup

Figure 6-10 Drum Level control faceplate

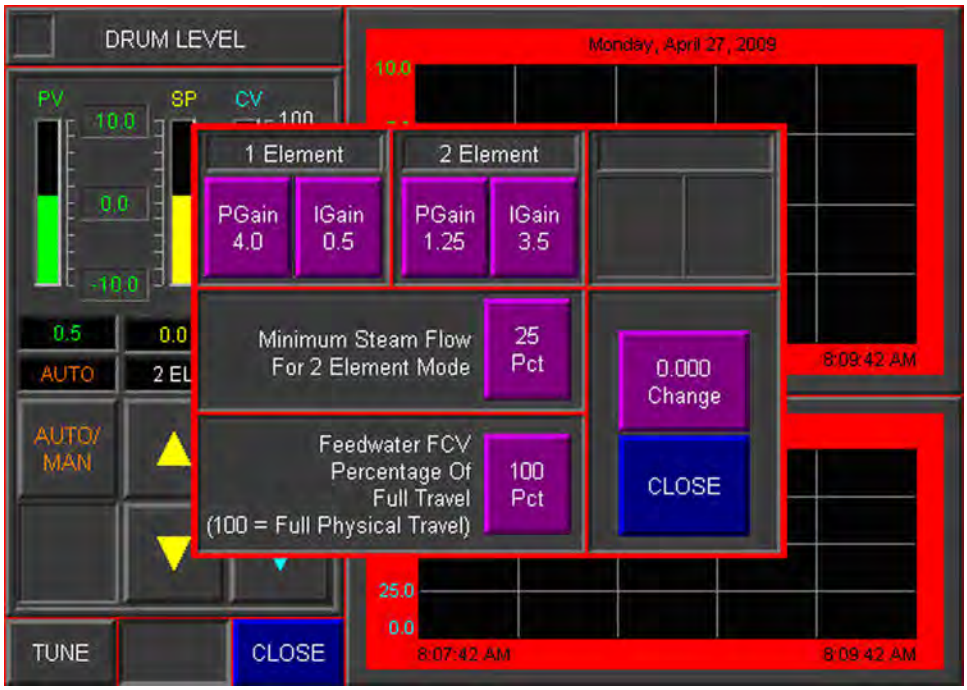


Figure 6-11 Drum Level control faceplate with tune popup

7. OPERATING THE BOILER FROM THE HUMAN MACHINE INTERFACE

7.1-Introduction

The Cleaver-Brooks Hawk 5000 utilizes a 10" color touch-screen Human Machine Interface (HMI) programmed to combine the monitoring of the Combustion Control and Burner Management Control into one user interface.

In addition to monitoring these systems, the HMI is programmed to service all incoming alarms, and to provide the operator with controls to adjust set points and other performance parameters; and to enable control functions as Auto-Recycle and Thermal Shock Protection.

Access to these functions is built into the Boiler Overview display which consists of the following sections:

- Header - showing time and date, current User I.D., and alarm banner.
- Footer - consisting of navigation buttons and Alarm Silence button.
- Control - consisting of buttons that access pop up control faceplates.
- Main - where process variable data is displayed.

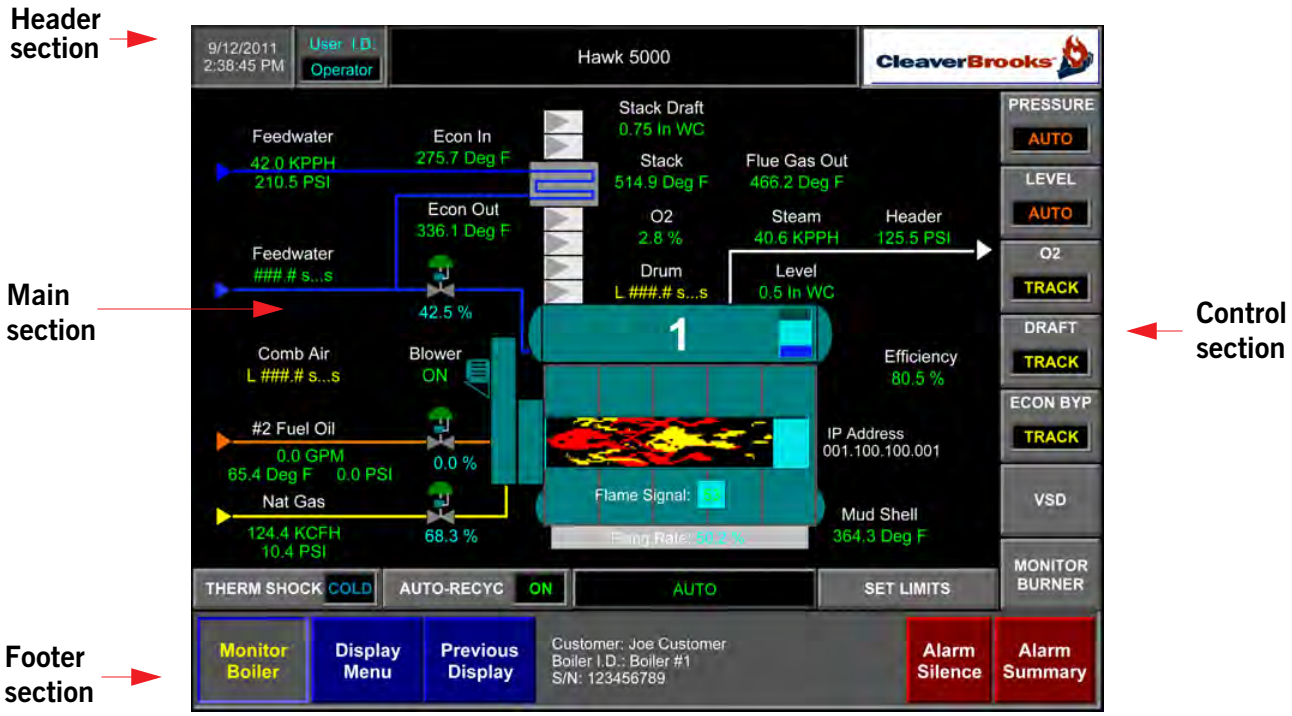
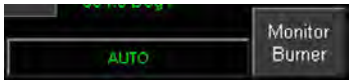


Figure 7-1 Monitor Boiler display

7.2-Monitoring the Burner Management Control from the Overview

Next to the Monitor Burner navigation button is a multistate message display showing the current status of the Burner Management Control.



A more detailed view of the Burner Management Control (Figure 7-2) is accessible by pressing the Monitor Burner button.

Figure 7-2 Monitor Burner display

7.3-Monitoring the Boiler from the Overview

The main section of the Boiler Overview display consists of a graphical representation of a typical industrial watertube boiler populated with dynamic process data. The dynamic data will change from green (normal state) to yellow (alarm state). An example using the variable 'Drum Level' is shown below.

Other variables monitored are:

- Flame signal strength and current firing rate

- Output signals to control valves & blower motor status

- Processor IP Address, Run Time, # of Cycles

7.4-Control of Operating Set Points

Along the right side of the Boiler Overview display is a column of buttons that access control faceplates for Pressure, Level, O2, Draft and Econ Bypass. The current control mode of the loop (AUTO, MAN, TRACK) is built into the button.

The actual buttons available are determined through the System Configuration process described in Section 5.

The description of the functionality of the Drum Level control faceplate that follows is applicable for the Pressure, O2 Trim, Draft and Econ Bypass loops.

The Drum Level control faceplate contains the following features:

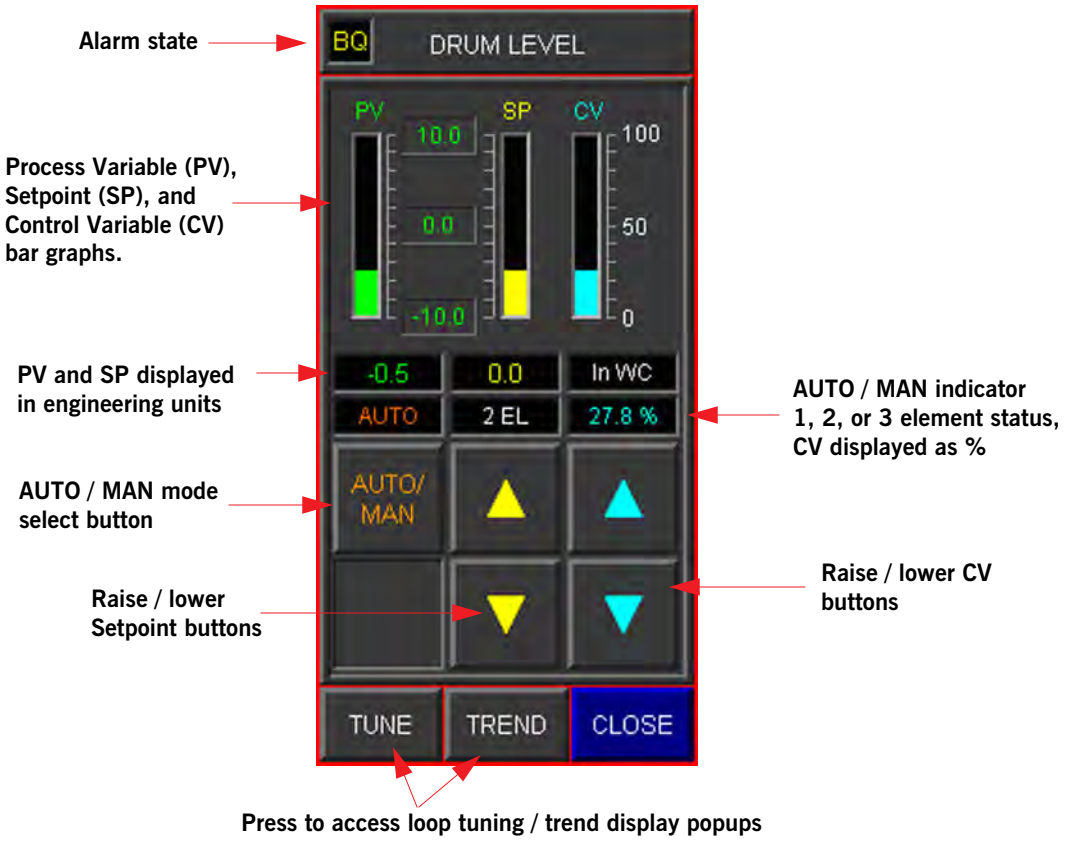


Figure 7-3

The Alarm State indicator has four possible states:

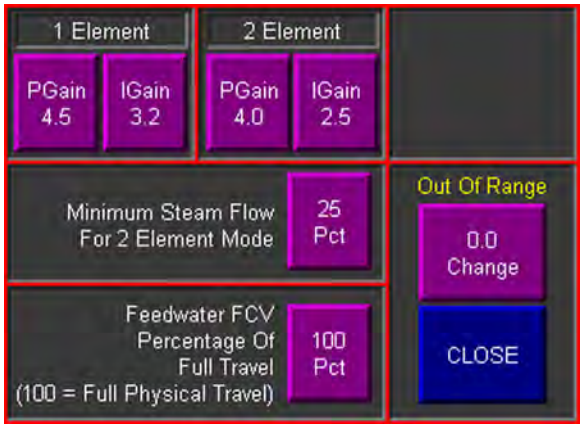
- BQ – process variable is out of range or Bad Quality
- H – process variable > HIGH alarm value
- L – process variable < LOW alarm value
- Blank – no alarm to report

The Set Point (SP) can be changed in either AUTO or MANUAL.

The Control Variable (CV) can only be changed while in MANUAL. The CV is the signal to the Feedwater Control Valve.

The 1, 2 or 3 Element status indicator is functional if the control options 2-Element Drum Level or 3-Element Drum Level is selected during the System configuration process. The text 1 EL is displayed if the Steam Flow variable is less than the 1-element maximum. 2 EL or 3 EL is displayed when Steam Flow exceeds the 1-element maximum. The value of the steam flow limit is adjustable from the TUNE pop-up.

The TUNE Drum Level pop-up is shown below and contains the control loop gain and integral settings, the minimum steam flow setting for 2 (or 3) element control, and the setting to short-stroke the feedwater FCV.



Pressing the TREND button displays the Drum Level trend shown below. The trend view is twenty minutes long. The arrow buttons will scroll backward and forward in time.

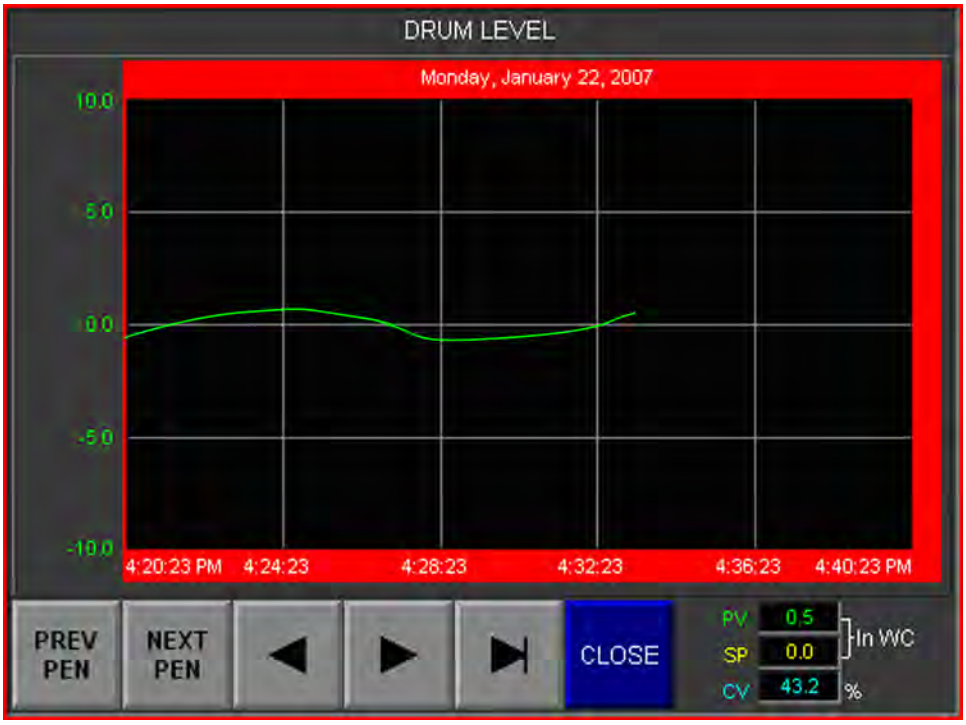


Figure 7-4 Drum Level Trend display

7.5-Alarm Management System

The Boiler Overview display has a built-in alarm banner imbedded in the Header section. The banner is designed to scroll though all of the active alarms, displaying each for 2 seconds and then replacing it with the next alarm in the cue.

In Footer section of the Boiler Overview display is a navigation button for the Alarm History display. The system stores the last 250 alarms.

The CLEAR button is only visible if the current User I.D. is “Factory” or “CB”. It is invisible if the User I.D. is “Operator” or is blank.

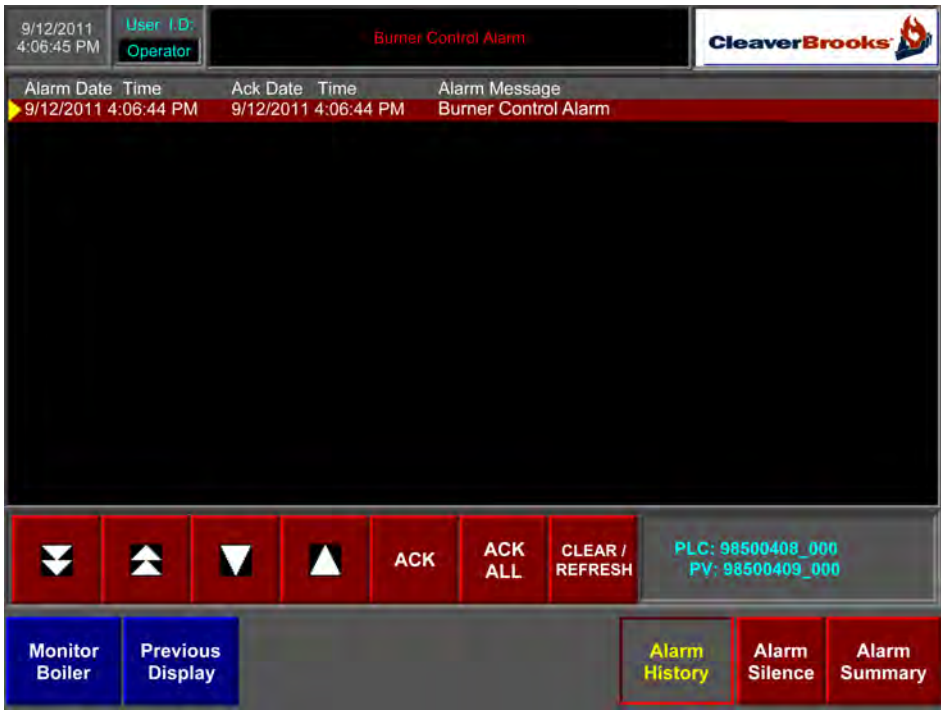


Figure 7-5 Alarm History display

Refer to Appendix G for complete listing of system alarms.

7.6- Monitor PLC I/O

The Monitor PLC I/O display monitors the I/O assigned to module channels.

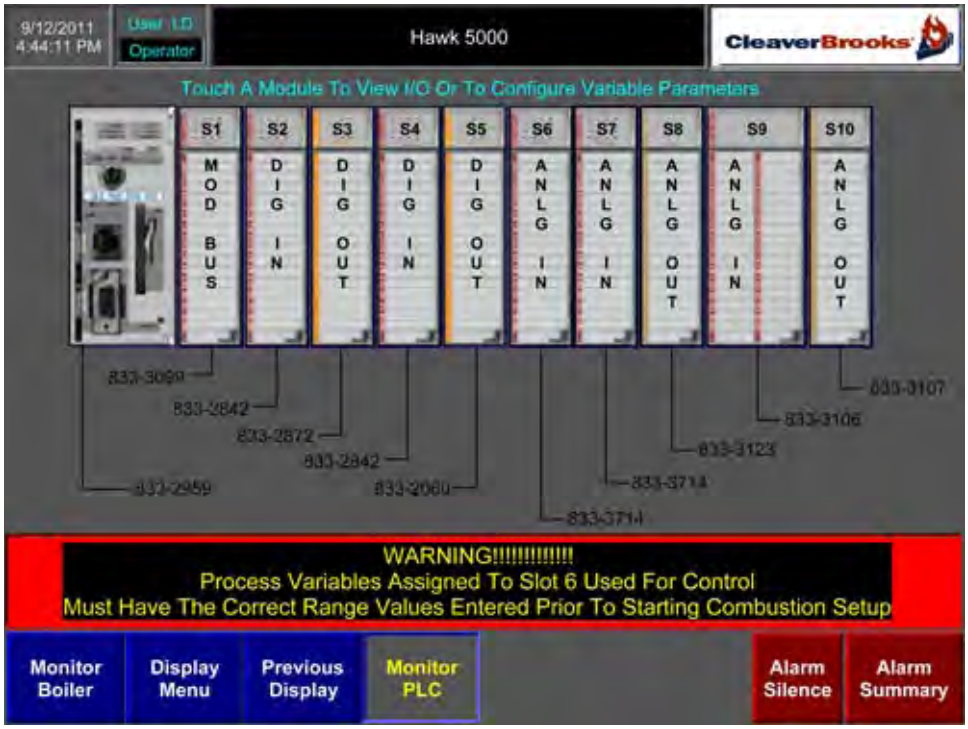


Figure 7-6 Monitor PLC I/O

Touch a module to access a display showing the variables wired to each channel. For example, touching Slot 6 (S6) reveals the display shown in Figure 7-7.

Figure 7-7 Monitor Analog Input display (S6)

Figure 7-7 shows the variables wired to Slot 6; an 8-channel analog input module. Fields identify the variable description, current value in engineering units, the channel input signal (in mA for transmitters, mv for thermocouples), and the HIGH/ LOW alarm limits.

A User I.D. of “Service” or “CB” is required to edit the channel data.

7.7-Set Limits

The Set Limits pop-up is shown in Figure 7-8, and the following limits are set using the Change button provided:

- High Stack Temp alarm value
- High-High Stack Temp Shutdown value
- Enable/ Disable Low-Low O2 Shutdown option button
- Low-Low O2 Shutdown limit value
- Low-Low O2 Shutdown time-delay setting
- External Start Interlock Proven time delay setting (if applicable)
- Extended Purge Time Delay setting (if applicable)
- Oil Purge Pump Time Delay setting (runs Purge Pump for the additional time period after shutdown on oil to clear oil gun)

Figure 7-8 Set Limits popup

7.8-Auto-Recycle

When ENABLED, the Auto-Recycle mode of operation will start and stop the boiler at preset pressure limits. The mode is used in situations where the demand for steam is so low that steam header pressure continues to rise even though the boiler is firing at low fire.

The limits are calculated as Offsets from the current operating set point, as shown below in Figure 7-9.

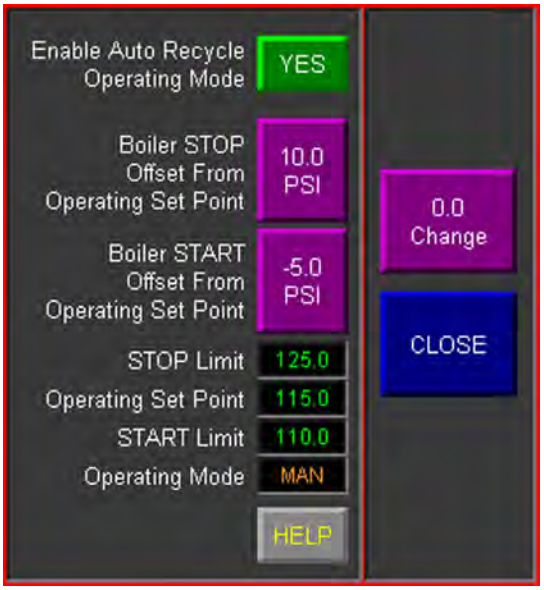


Figure 7-9 Auto-Recycle popup

7.9-Thermal Shock Protection

The Thermal Shock Protection routine holds the boiler at low fire until the Stack and Mud Drum Shell temperatures exceed limits set from the Thermal Shock pop-up (Figure 7-10).

Figure 7-10 Thermal Shock Protection popup

Thermal Shock can be overridden by the operator in situations where the boiler is needed and is not quite warm enough to be released based on the set points set here.

7.10-Flow Totalizers

The following process variables are totalized by the System:

- Steam Flow
- Feedwater Flow
- Gas Flow
- Oil Flow

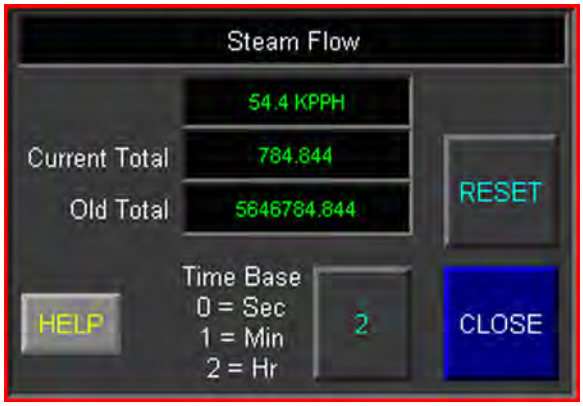


Figure 7-11 Flow Totalizer popup

The Totalizer display shows the current total and the old total. The old total is total realized at the time of the last RESET.

The Time Base is set to the value of the process variable engineering unit. For example, if the engineering unit for the variable Steam Flow is KPPH (thousand pounds per hour) the Time Base should be set to 2. If the variable is Oil Flow in GPM the Time Base is set to 1 (minutes).

8. TROUBLESHOOTING

To avoid communication problems between the PLC and its associated components, ensure that all units are properly assembled on the DIN rail. Two locking tabs attach each module to the rail.

The PLC, power supply, and I/O modules are connected to each other with module bus locking levers. All locking levers should be completely to the left. Unlocked levers will cause the modules to the right of the unlocked lever to be disabled.

8.1-Processor (PLC)

The PLC has a key switch which is used for programming purposes. The key should not be kept in the PLC but should be available in the cabinet for service personnel. If the key is installed while the system is operating, the key switch must be in the RUN position.

Troubleshooting the PLC is facilitated by multi-state LED indicators that provide information about control and communication status. See table below.

Table 8-1 PLC LED Codes

RUN	Off	No task(s) running; controller in Program mode
	Green	One or more tasks are running; controller is in the Run mode.
FORCE	Off	No forces enabled
	Amber	Forces enabled
	Amber flashing	One or more input or output addresses have been forced to an On or Off state, but the forces have not been enabled.
BATT	Off	Battery supports memory
	Red	Battery may not support memory. Replace battery.
OK	Off	No power applied
	Green	Controller OK
	Flashing red	Recoverable controller fault. To recover fault, switch the processor to the PROGRAM position and back to RUN twice.
	Red	Non-recoverable controller fault: Turn off power, make sure that the module bus locking levers are secured, then turn power back on.. The OK LED should change to flashing red. Switch the processor to the PROGRAM position and back to RUN twice. The OK LED should change to green.If LED remains solid red, replace the controller.
I/O	Off	(1) If the controller does not contain an application (controller memory is empty), the I/O indicator will be off. (2) No activity; no I/O or communications configured
	Green	Communicating to all devices
	Flashing green	One or more devices not responding
	Flashing red	Not communicating to any devices; controller faulted.
RS-232 Serial Port		
DCH0	Off	Channel 0 configured differently from default configuration
	Green	Channel 0 has the default serial configuration
Channel 0	Off	No R-S232 Activity
	Flashing green	RS-232 Activity
CompactFlash Card		
CF	Off	No Activity
	Flashing green	Controller is reading from or writing to the CompactFlash card
	Flashing red	CompactFlash card does not have a valid file system

Table 8-1 PLC LED Codes (Continued)

Ethernet/IP Port		
MS (module status)	Off	No power
	Flashing green	Ethernet port is in standby mode; port does not have an IP address and is operating in BOOTP mode.
	Green	Normal operation
	Red	• Controller is holding the port in reset. • Controller has faulted. • Power-up self test in progress; no action required. • Non-recoverable fault.
	Flashing red	Port firmware is being updated.
NS (network status)	Off	Port is not initialized; it does not have an IP address and is operating in BOOTP mode. Verify BOOTP server is running.
	Flashing green	No CIP connections are established. If no connections are configured, no action is required. If connections are configured, check connection originator for connection error code.
	Green	Normal operation
	Red	Assigned IP address already in use. Verify that each IP address is unique.
	Flashing red/green	Power-up self test in progress; no action required.
LNK (link status)	Off	Port is not connected to a powered Ethernet device. • Verify that all Ethernet cables are connected. • Verify that Ethernet switch is powered.
	Flashing green	Normal operation: • Port is communicating on Ethernet. • Power-up self test in progress.
	Green	Normal operation - port is connected to a powered Ethernet device and is available for Ethernet communications.

8.2-Analog I/O Modules

At module power-up, a series of internal diagnostic tests are performed for each module. These diagnostic tests must be successfully completed or the module status LED will remain off and a module error will be reported to the PLC.

Table 8-2 Analog I/O Status

On	Proper Operation. No action required.
Off	Module Fault, Cycle power. If condition persists, replace the module.

The Hawk 5000 uses the 8-channel Spectrum Controls Universal input module for analog I/O. The module has a status LED (green) that must be lit for the module to function properly.

Each channel of the universal input module can be configured to accept voltage, current, thermocouple, or RTD/resistance type inputs. The 5000 I/O design uses specific channels for current (4-20 mA) inputs, and specific channels for Type J thermocouple inputs. Refer to the wiring diagrams for the correct wiring scheme for each input type.

In addition to the channel wiring, there is a jumper for each input channel on the module circuit board. This jumper is set in the factory, and must be positioned correctly for the channel to function as either a current input or as a thermocouple input. For current, the jumper must be in position 2-3. For thermocouple inputs the jumper must be in position 1-2.

The jumpers are identified as follows:

Channel	Jumper
0	J5
1	J7
2	J9
3	J11
4	J6
5	J8
6	J10
7	J12

8.3-Digital I/O Modules

The digital I/O modules do not have status LED indicators. The modules have amber LED's, one for each channel, that indicate whether a channel is on or off.

8.4-Power Supply

The power supply LED indicates power to the PLC. If the LED is not lit check for 120 VAC at the AC input terminals. If power is present and the LED is not lit, check the power supply fuse located under the power supply cover. Refer to the parts section for replacement fuse part number. If the fuse is good, replace power supply.

If a voltage spike occurs, the power supply will shut off. To reset, turn power off for 10 minutes, then turn power back on.

8.5-PanelView Plus

The PanelView Plus HMI communicates to the PLC via Ethernet cable. The HMI Ethernet connection has a green LED and an amber LED. When communications with the PLC are established the green LED is solid and the amber LED will flash. Both LEDs are off if the communications link with the processor is lost.

8.6-PLC Battery Replacement

The controller uses a lithium battery, which contains potentially dangerous chemicals. Follow the procedure below to install a new battery and to safely dispose of the old one.

NOTE:
To prevent accidental program loss, the PLC program should be saved to Flash memory before the battery is removed.

Important

Do not remove the plastic insulation covering the battery. The insulation is necessary to protect the battery contacts.

1. Make sure the new 1769-BA battery is available and ready for installation.
2. Remove the old battery; check for signs of leakage or damage.

Warning

When the battery is connected or disconnected an electrical arc can occur. Ensure that the area is free of explosion hazards before proceeding.

Warning

When replacing battery 110V power is present. Proceed with caution.

Caution

The 1769-BA is the only battery compatible with the L32E and L35E controllers. Installing a different battery may damage the controller.

3. Install a new 1769-BA battery.

Note: If control power is cycled while battery is removed, the L32E and L35E processors will have immediate program loss.

Note: When the battery LED is red, order a replacement battery immediately (for the L32E and L35E processor part # 808-00020)**.**

4. Write the battery date on the door of the controller.
5. Check the BATTERY LED on the front of the controller:
   - If the BATTERY LED is OFF, proceed to step 6.
   - If the BATTERY LED remains on after installing a new battery, contact your Cleaver-Brooks representative.
6. Dispose of the old battery according to state and local regulations.

Important

Do not incinerate or dispose of lithium batteries in general trash collection. They may explode or rupture violently. Follow state and local regulations for disposal of these materials. You are legally responsible for hazards created while disposing of your battery.

8.7-Boiler will not start (Recycle Limit Relay)

PLC logic starts the boiler by energizing the Recycle Limit Relay (RLR) via discrete output on slot 3 channel 0. The following conditions must be met to energize the relay:

- Boiler Start pilot light is lit.
- External start interlock proven (jumper this input if not used.)
- Boiler Outlet Damper proven open (systems with Draft control option only)

8.8-Boiler will not start (Non-Recycle Limit Relay)

The NRLR must be energized for the boiler to start, and PLC logic energizes the NRLR via discrete output on slot 3 channel 2. The following conditions must be met to energize the relay:

- Actuator Calibration process is complete.
- Lightoff positions stored.
- No RLR fault detected.
- Actuators proven in lightoff positions.
- Combustion curve data integrity check passed. (Parallel systems only)
- No I/O module fault detected.
- No Burner Control alarm detected.
- Major control options have been selected. (parallel or single-point; pulse or current positioning)
- No Low-Low O2 condition detected. (systems with O2 analyzer and Low-Low O2 Shutdown option turned on.)
- No High-High Furnace Pressure condition detected.
- No High-High Stack Temperature condition detected. (systems with Stack Temperature input activated and High-High Stack Temp shutdown option turned on)

8.9-Analog Input Channel Bad Quality

Each analog input is continuously checked for signal quality. Good quality inputs are within the range of 3.2 to 20.7 mA, and a bad quality input would fall outside of these limits.

If an input is detected as bad quality the condition is annunciated and the status text “BQ” displayed. The figure below shows the input ‘Steam Flow’ as bad quality.

In addition to annunciating a bad quality condition, the system will take the following actions if specific process inputs are out of range:

Table 8-3 Bad Quality Input

Input Variable	Slot/ Ch	Bad Quality Action
Drum Pressure	06:00	Pressure control forced to manual mode.
Drum Level	06:01	Drum Level control forced to manual, control output signal set to 0.0.
Stack Temperature	06:02	Thermal Shock Protection routine disabled.
Steam Header Pressure	06:03	Steam Header Pressure control forced to manual. Auto-transfer to Drum Pressure control.
Steam Flow	06:04	Auto-transfer to 1-element Drum Level control.
Mud Drum Shell Temperature	06:05	Thermal Shock Protection routine disabled.
VSD Speed Feedback	06:06	Boiler shutdown
Flue Gas O2	06:07	O2 Trim forced to null position.
Stack Draft	07:02	Stack Draft control forced to manual. Damper moved to full open position.
Feedwater Flow	07:03	Auto-transfer to 1-element Drum Level control.

Appendix A — PowerFlex 400 Parameters

Set Switches AI1 & AI2 to 4-20mA.
Set Switches AO1 to 4-20mA.
Set SNK/SRC switch to SRC.

Par. No.	Parameter Name	Default Value	W/Hawk
Basic Display			
b1	Output Freq	Read Only	
b2	Commanded Freq	Read Only	
b3	Output Current	Read Only	
b4	Output Voltage	Read Only	
b5	DC Bus Voltage	Read Only	
b6	Drive Status	Read Only	
b7	Fault 1 Code	Read Only	
b8	Process Display	Read Only	
b9	Not Used		
b10	Output Power	Read Only	
b11	Elapsed MWh	Read Only	
b12	Elapsed Run Time	Read Only	
b13	Torque Current	Read Only	
b14	Drive Temp	Read Only	
Basic Program			
P31	Motor NP Volts	Rated Volts	Motor NPL Volts
P32	Motor NP Hertz	60 Hz	Motor NPL Hertz
P33	Motor OL Current	Rated Amps	Motor NPL F.L. Amps x 1.15
P34	Minimum Freq	0.0 Hz	OK
P35	Maximum Freq	60 Hz	OK
P36	Start Source	2-W Lvl Sens	2 Wire, 002
P37	Stop Mode	Coast,CF	OK
P38	Speed Reference	Analog In1	Analog In 2 - 003
P39	Accel Time 1	20.00 Secs	5 Secs
P40	Decel Time 1	20.00 Secs	45 Secs
P41	Reset to Defaults	Ready/Idle	OK
P42	Auto Mode	Hnd-Off-Auto	No Function - 000
Terminal Block			
T51	Digital In 1 Sel	Purge	OK
T52	Digital In 2 Sel	Local	OK
T53	Digital In 3 Sel	Clear Fault	OK
T54	Digital In 4 Sel	Comm Port	OK
T55	Relay Out 1 Sel	Ready/Fault	OK
T56	Relay Out 1 Level	0.0	OK
T57	Not Used		
T58	Relay 1 On Time	0.0 Secs	OK
T59	Relay 1 Off Time	0.0 Secs	OK
T60	Relay Out 2 Sel	MotorRunning	Anlg In Loss - 011
T61	Relay Out 2 Level	0.0	OK

T62	Not Used		
T63	Relay 2 On Time	0.0 Secs	0.5 Secs
T64	Relay 2 Off Time	0.0 Secs	OK
T65	Opto Out Sel	At Frequency	OK
T66	Opto Out Level	0.0	OK
T67	Not Used		
T68	Opto Out Logic	0	OK
T69	Analog In 1 Sel	2	4-20 mA, 001
T70	Analog In 1 Lo	0.0%	OK
T71	Analog In 1 Hi	100.0%	OK
T72	Analog In 1 Loss	Disabled	OK
T73	Analog In 2 Sel	2	4-20 mA, 001
T74	Analog In 2 Lo	0.0%	OK
T75	Analog In 2 Hi	100.0%	OK
T76	Analog In 2 Loss	Disabled	OK
T77	Sleep-Wake Sel	Disabled	OK
T78	Sleep Level	10.0%	OK
T79	Sleep Time	0.0 Secs	OK
T80	Wake Level	15.0%	OK
T81	Wake Time	0.0 Secs	OK
T82	Analog Out1 Sel	0	4-20 mA, Hz, 14
T83	Analog Out1 High	100.0%	OK
T84	Analog Out1 Setpt	0.0%	OK
T85	Analog Out2 Sel	1	OK
T86	Analog Out2 High	100.0%	OK
T87	Analog Out2 Setpt	0.0%	OK

Communications

C101	Language	English	OK
C102	Comm Format	RTU 8-N-1	OK
C103	Comm Data Rate	9600	OK
C104	Comm Node Addr	100	4
C105	Comm Loss Action	Fault	003-Continu Last
C106	Comm Loss Time	5.0 Secs	OK
C107	Comm Write Mode	Save	OK

Advanced Program

A141	Purge Frequency	5.0 Hz	OK
A142	Internal Freq	60.00 Hz	OK
A143	Preset Freq 0	0.0 Hz	OK
A144	Preset Freq 1	5.0 Hz	OK
A145	Preset Freq 2	10.0 Hz	OK
A146	Preset Freq 3	20.0 Hz	OK
A147	Accel Time 2	30.00 Secs	OK
A148	Decel Time 2	30.00 Secs	OK
A149	S Curve %	20% Disabled	OK
A150	PID Trim Hi	60.00 Hz	OK
A151	PID Trim Lo	0.0 Hz	OK
A152	PID Ref Sel	PID Disabled	OK
A153	PID Feedback Sel	Analog In 1	OK

A154	PID Prop Gain	1	OK
A155	PID Integ Time	2.0 Secs	OK
A156	PID Diff Rate	0.00	OK
A157	PID Setpoint	0.0%	OK
A158	PID Deadband	0.0%	OK
A159	PID Preload	0.0 Hz	OK
A160	Process Factor	30.0	OK
A161	Not Used		
A162	Not Used		
A163	Auto Restart Tries	0	1
A164	Auto Restart Delay	1.0 Secs	5
A165	Start At Power Up	Disabled	OK
A166	Reverse Disable	Rev Disabled	OK
A167	Flying Start Enable	Disabled	Enabled, 001
A168	PWM Frequency	4.0 kHz	OK
A169	PWM Mode	2-Phase	OK
A170	Boost Select	45.0, VT	OK
A171	Start Boost	2.5%	OK
A172	Break Voltage	25.0%	OK
A173	Break Frequency	15.0 Hz	OK
A174	Maximum Voltage	Rated Volts	OK
A175	Slip Hertz @ FLA	2.0 Hz	OK
A176	DC Brake Time	0.0 Secs	OK
A177	DC Brake Level	Rated Amps x 0.05	OK
A178	DC Brk Time @Strt	0.0 Secs	OK
A179	Current Limit 1	Rated Amps x 1.1	OK
A180	Current Limit 2	Rated Amps x 1.1	OK
A181	Motor OL Select	No Derate	OK
A182	Drive OL Mode	Both-PWM 1st	OK
A183	SW Current Trip	0.0 Disabled	OK
A184	Load Loss Level	0.0 Disabled	OK
A185	Load Loss Time	0 Secs	OK
A186	Stall Fault Time	60 Seconds	OK
A187	Bus Reg Mode	Enabled	OK
A188	Skip Frequency 1	0 Hz	OK
A189	Skip Freq Band 1	0.0 Hz	OK
A190	Skip Frequency 2	0 Hz	OK
A191	Skip Freq Band 2	0.0 Hz	OK
A192	Skip Frequency 3	0 Hz	OK
A193	Skip Freq Band 3	0.0 Hz	OK
A194	Compensation	Electrical	Disable, 000
A195	Reset Meters	Ready/Idle	OK
A196	Testpoint Select	1024	OK
A197	Fault Clear	Ready/Idle	OK
A198	Program Lock	Unlocked	OK
A199	Motor NP Poles	4	2
A200	Motor NP Amps	Drive Rated Amps	Per Motor Nameplate

Advanced Display

d301	Control Source	Read Only
d302	Contrl In Status	Read Only
d303	Comm Status	Read Only
d304	PID Setpnt Displ	0.0%
d305	Analog In 1	0.0%
d306	Analog In 2	0.0%
d307	Fault 1 Code	Read Only
d308	Fault 2 Code	Read Only
d309	Fault 3 Code	Read Only
d310	Fault 1 Time-hr	Read Only
d311	Fault 1 Time-min	Read Only
d312	Fault 2 Time-hr	Read Only
d313	Fault 2 Time-min	Read Only
d314	Fault 3 Time-hr	Read Only
d315	Fault 3 Time-min	Read Only
d316	Elapsed Time-hr	Read Only
d317	Elapsed Time-min	Read Only
d318	Output Powr Fctr	Read Only
d319	Testpoint Data	Read Only
d320	Control SW Ver	Read Only
d321	Drive Type	Read Only
d322	Output Speed	Read Only
d323	Output RPM	Read Only

Notes

A170 If motor pulsates , can decrease VT ,3

Appendix B - Procedure to Load Program and Set Up PanelView Plus HMI

1. Copy the **Rockwell Software** folder from its location on the server to a compactflash card that you use to load standard Panelviews. There should be nothing else on the card but this folder.
2. Power up the PV+ and insert compact flash card into slot provided.
3. Touch **Terminal Settings [F4]**.
4. From Terminal Settings, select **File Management**.
5. Select **Copy Files**.
6. Select **Copy Applications**.
7. Using the **Source [F1]** button, select External Storage 1 (the green bullet should move down to that selection). Use the up/down buttons to select the application you want to load and then press the **Destination [F2]** button.
8. From the Copy Applications Destination screen, the green bullet should be on **Internal Storage**. If it's not it should be. Press the **Copy [F2]** button.
9. After the file is copied you should be back in the **Copy Applications** screen. Press **Cancel [F8].**
10. You should now be on the **Copy Files** screen. Press **Close [8].**
11. You should now be on the File Management screen. Press **Close [F8].**
12. You should now be back on the Terminal Settings screen. Select **Networks and Communications**.
13. From the Networks and Communications screen select **Network Connections**.
14. From the Network Connections screen select **Network Adaptors**.
15. From The Network Adaptors screen press **IP Address [F2]**.
16. From the IP Address screen select Use **DHCP [F4]**. The green bullet should be in the No position and the IP Address [F1] button should be black.
17. Press **IP Address [F1]** and enter the IP address with the keypad provided. The IWT100 IP addressing scheme for the PV+ is 192.168.1.181 thru 192.168.1.188 for boilers 1 thru 8.
18. Press **Subnet Mask [F2]** and enter 255.255.255.000
19. Press **Gateway [F3]** and enter 192.168.1.1
20. After entering IP Address, Subnet, and Gateway, press the **Ok [F7].**
21. From the **Adapters** screen press **Ok [F7]**.
22. From **Network Adaptors** screen press **Close [F8].**
23. From the **Network Connections** screen press **Close [F8]**.
24. From the **Network and Cnnections** screen press **Close [F8].**
25. From the **Terminal Setting** screen press Close [F8].
26. You should now be on the **FactoryTalk View ME Station** screen. Press **Load Application [F1].**
27. Load the application from Internal Storage by pressing the Load [F2] button.
28. You should back on the **FactoryTalk View ME Station** screen. Press **Terminal Settings [F4]**.
29. Select **Startup Options** and then select **FactoryTalk View ME Station Startup**.
30. Using the **On Startup [F1]** button, put the green bullet to **Run Current Application.** Then press **Ok [F7].**
31. You should now be on the **Startup Options** screen. **Press Close [F8].**
32. You should now be on the **Terminal Settings** screen. Press **Close [F8]**.

You should now be on the **FactoryTalk View ME Station** screen. Press **Run Application [F2].**

Appendix C — Setting Actuator Stroke

Remove fuse for the feedback power supply. Remove the three feedback wires from the feedback potentiometer terminals 5, 6, & 7.

Figure D-1

⚠ Warning

An actuator with its cover removed presents a risk of electrical shock. *120 VAC power is present at terminals 2 & 3.*

Place a multimeter between terminals 5-6 on the actuator. Set the meter to read ohms.

From the Hawk 5000 display menu, Press <Calibrate Actuators> (you must be logged in as “Service” or “Factory”). On the Actuator Selection screen, press the <Calibrate> button for the appropriate actuator.

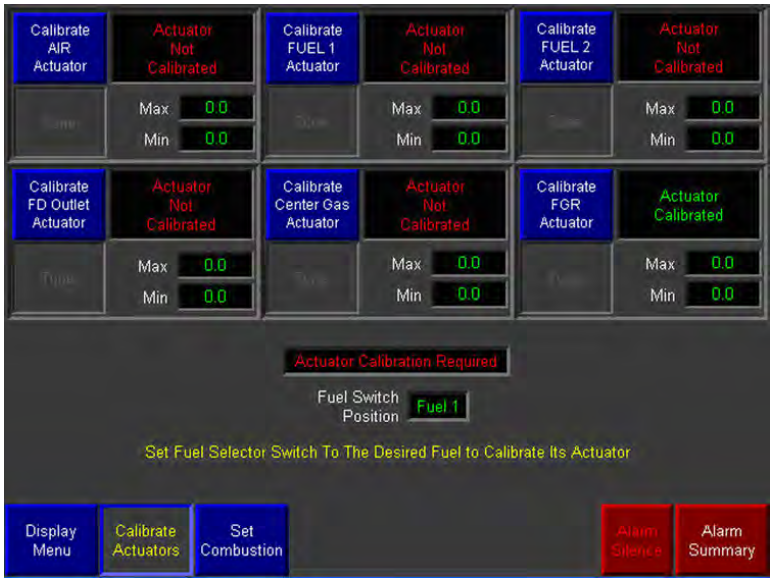


Figure D-2 Actuator Selection Screen

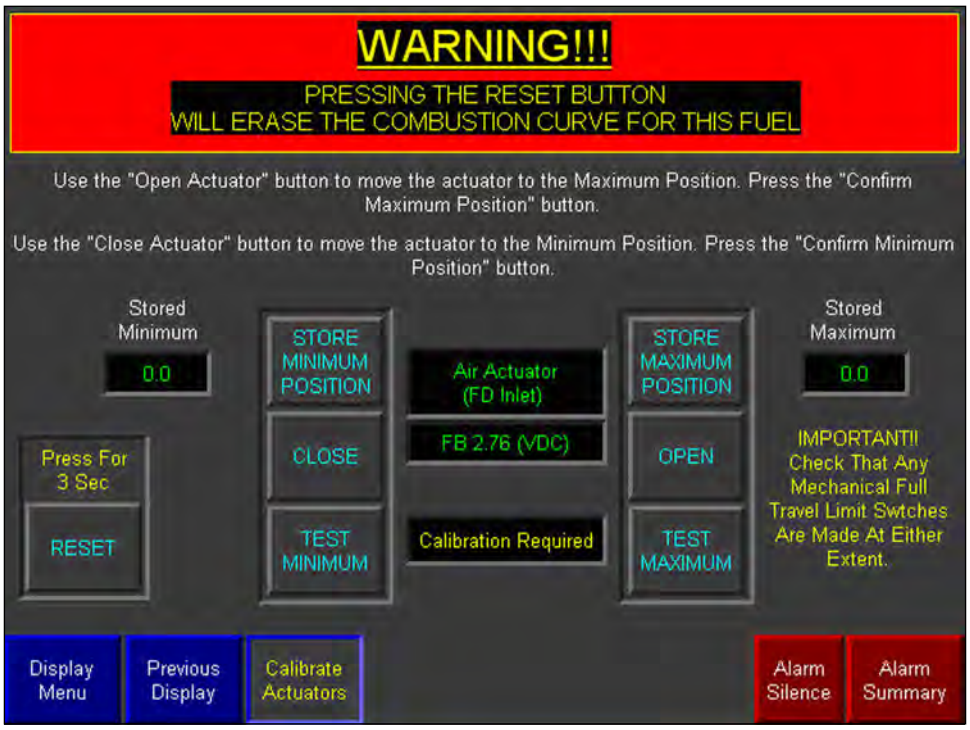


Figure D-3 Actuator Commissioning Screen

Use the actuator commissioning screen to drive the actuator to the closed position.

Adjust switch until meter reads 1666 ohms +/- 50 ohms. You may need to use the commissioning screen <Open> and <Close> buttons to verify the setting.

If the actuator will not close far enough to read the desired ohms, rotate cam switch (the one furthest from the potentiometer) counterclockwise (looking from the potentiometer side) with the white knurled adjuster so that actuator will continue to turn.

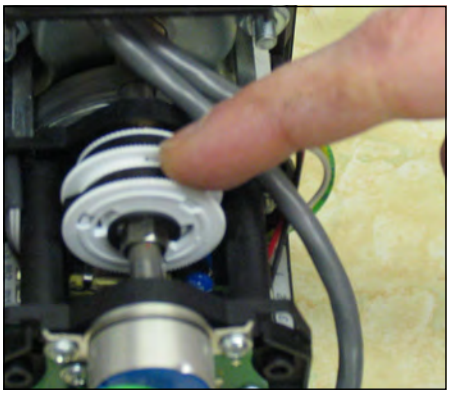


Figure D-4 Adjust Switch

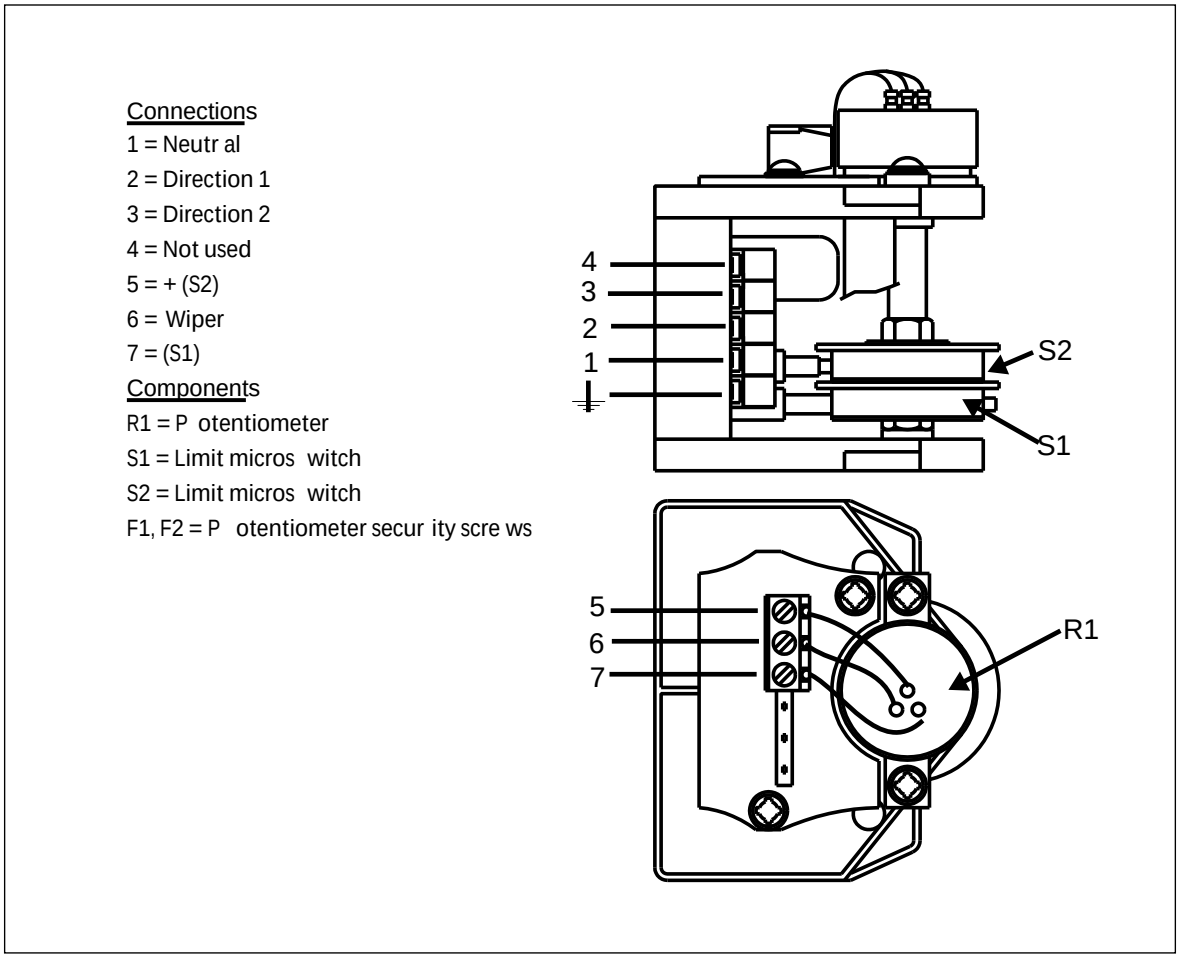


Figure D-5 Actuator Stop Adjustments

After the closed position has been set, use the commissioning screen <Open> button to set the cam switch closest to the potentiometer until the open position reading on the ohm meter is 3333 ohms +/- 50 ohms.

Verify both positions by running the actuator between the closed and open positions and monitoring the ohm meter.

Remove the ohm meter and reattach the feedback wires onto terminals 5,6,& 7.

Continue procedure with the next actuator.

When all the actuators are stroked, replace the fuse for the feedback power supply. The feedback voltage on the Hawk 5000 screen should read approximately 4.4 volts at the closed position and 7.5 volts at the open position.

Appendix D – Hawk 5000 START/ STOP Sequence

To understand fully the sequence of operation, please refer to the following documentation:

- Hawk 5000 Wiring Diagrams
- CB-120E Burner Management Control Manual
- Hawk 5000 Manual

Please note that all terminal numbers that are referenced below are on the wiring base of the Burner Management Control, unless otherwise noted.
A constant 120 VAC should be available to the L1-L2 terminals of the wiring base of the Burner Management Control.

Control Panel Primary Components:

- Combustion Control System (CCS) Programmable Logic Controller (PLC)
- Burner Management Control

Control Panel Operators and Indicators:

- Burner STOP/ RESET Pushbutton PB-112A
- Burner START Pushbutton PB-112B
- Burner START pilot light PL-112
- E-Stop Pushbutton PB-112C
- Atomizing Media Selector Switch
- Fuel Selector Switch H-200
- Proof of Closure Test Pushbutton
- Forced Draft Fan H-O-A Switch HS-217
- Low Water Alarm Light L-308
- High Water Alarm Light L-313
- Alarm Light L-511

Boiler Start Sequence – Firing Natural Gas (Fuel Selector in Gas Position)

1. Press Burner START pushbutton PB-112B. Burner START relay CR-112 will energize if the following conditions are met:
   - Burner Management Control Lockout relay CR-223 is de-energized.
   - E-Stop pushbutton PB-112C not engaged.
   - FD Fan Current Sensing Relays CSR-1,2,3 are de-energized.
2. Energizing CR-112 will apply power to Burner Management Control terminal 3 if the following conditions are met:
   - Recycle Limit relay CR-502 energized.
   - Main Fuel block valves are proved closed (Burner Management Control circuit L1-13 closed).

3. With power applied to terminal 3, the following running interlocks must be satisfied to close Burner Management Control running interlock circuit 3-P:
    - Aux Low Water Cutoff (ALWCO)
    - Low Water Cutoff #1 (LWCO-1)
    - Low Water Cutoff #2 (LWCO-2)
    - Low Gas Pressure Switch (LGPS)
    - High Gas Pressure Switch (HGPS)
    - High Steam Pressure Cutoff switch (HSP)
    - High High Steam Pressure Cutoff switch (HHSP)
    - High Furnace Pressure switch (BPES)
    - Non-Recycle Limit Relay CR-504 energized (NRLR)
    - Combustion Air Pressure Switch closed (CAPS)
4. With power applied to Burner Management Control terminal 3 and running interlock circuit 3-P closed, Burner Management Control terminal M is turned on and energizes Blower Motor START relay CR-218. CR-218 turns on the blower motor. The Outlet damper is commanded open prior to purge.
5. With power applied to terminal M, Burner Management Control terminal X will turn on and apply power to PLC input 2:1 (go to PURGE command). The PLC then outputs the purge signal to the combustion air damper actuator.
6. The Burner Management Control purge timer will start when Burner Management Control circuit M-8 is made (High Fire Proven). The following conditions must be met to close circuit M-8:
    - PLC detects combustion air damper and boiler outlet damper are in the purge position and energizes PLC output 3:4, which energizes High Fire Proven relay CR-506.
    - Proof Purge Air Pressure switch (PAPS) is closed.
7. When the Burner Management Control purge timer times out (30 secs.), Burner Management Control terminal X opens and terminal 12 closes, applying power to PLC input 2:14 (go to LOW FIRE command). The PLC then outputs low fire signals to the combustion air damper and fuel valve actuator. The Outlet damper remains open.
8. Burner Management Control terminal 5 (Pilot Trial for Ignition) will turn on when Burner Management Control circuit M-D is made (Low Fire Proven). The following condition must be met to close circuit M-D:
9. PLC detects all actuators are in their low fire positions and turns on PLC output 3:3. Output 3:3 energizes Low Fire Proven relay CR-505 the contacts of which close Burner Management Control circuit M-8.
10. When Burner Management Control terminal 5 is turned on power will be applied to CR-224, the ignition transformer, gas pilot valves GPV-1 and GPV-2, and the gas pilot vent valve GPVV. If the Low Pilot Gas Pressure Switch opens during the Pilot Trial for Ignition, the burner will shutdown and alarm. If the switch opens at any other time, the condition will only be alarmed. This will allow the operator the opportunity to correct the condition before another light-off sequence is required if the burner is already firing.
11. When the flame scanner detects sufficient pilot flame intensity to prove pilot, Burner Management Control terminal 7 is turned on (Main Trial for Ignition) applying power to CR-227, main gas valves MGV-1 and MGV-2, and to the main gas valve vent valve MGVV.
12. When the flame scanner detects sufficient flame intensity to prove main flame, Burner Management Control terminal 5 is turned off de-energizing the pilot valves and the normally open pilot vent valve.
13. If sufficient flame intensity is proven for 10 seconds, Burner Management Control terminal 12 (Low Fire) is turned off and terminal 11 (Release to Modulate) is turned on. The outlet damper begins automatic

control to maintain the boiler draft set point. Terminal 11 then powers PLC input 2:2 which releases the boiler from low fire hold to control pressure on set point.

Boiler Start Sequence – Firing #2 Oil (Fuel Selector in Oil Position)

1. Turn the Atomizing Media switch to “Local” or “Plant Air” and open/close the appropriate atomizing air supply valves. If “Local” is selected, install the boiler air pump belt. Verify that oil is at the proper pressure in the main supply loop and open the oil supply & return valves.
2. Check that the burner oil gun is in place and that the oil gun interlock switch is made.
3. Press Burner START pushbutton PB-112B. Burner START relay CR-112 will energize if the following conditions are met:
   - Burner Management Control Lockout relay CR-223 is de-energized.
   - E-Stop pushbutton PB-112C not engaged.
   - FD Fan Current Sensing Relays CSR-1,2,3 are de-energized.
4. Energizing CR-112 will apply power to Burner Management Control terminal 3 if the following conditions are met:
   - Recycle Limit relay CR-502 energized.
   - Main Fuel block valves are proved closed (Burner Management Control circuit L1-13 closed).
5. With power applied to terminal 3, the following running interlocks must be satisfied to close Burner Management Control running interlock circuit 3-P:
   - Aux Low Water Cutoff (ALWCO)
   - Low Water Cutoff #1 (LWCO-1)
   - Low Water Cutoff #2 (LWCO-2)
   - Atomizing Air Pressure Switch A (AAPS-A)
   - Atomizing Air Pressure Switch B (AAPS-B)
   - Low Oil Pressure Switch (LOPS)
   - High Oil Pressure Switch (HOPS)
   - Oil Gun Inserted position Switch (ODS) CR-117 energized
   - High Steam Pressure Cutoff switch (HSP)
   - High High Steam Pressure Cutoff switch (HHSP)
   - High Furnace Pressure Switch (BPES)
   - Non-Recycle Limit Relay CR-504 energized (NRLR)
   - Combustion Air Pressure Switch closed (CAPS)
6. With power applied to Burner Management Control terminal 3 and running interlock circuit 3-P closed, Burner Management Control terminal M is turned on and energizes Blower Motor START relay CR-218. CR-218 turns on the blower motor. If “Plant Air” is selected, the Plant Air Solenoid Valve (PASV) will also be energized. The Outlet damper is commanded open prior to purge.
7. With power applied to terminal M, Burner Management Control terminal X will turn on and apply power to PLC input 2:1 (go to PURGE command). The PLC then outputs the purge signal to the combustion air damper actuator.
8. The Burner Management Control purge timer will start when Burner Management Control circuit M-8 is made (High Fire Proven). The following conditions must be met to close circuit M-8:

- PLC detects combustion air damper is in its purge position and energizes PLC output 3:4, which energizes High Fire Proven relay CR-506.
- Proof Purge Air Pressure switch (PAPS) is closed.
- Outlet damper is proven to be in the open position.

9. When the Burner Management Control purge timer times out Burner Management Control terminal X opens and terminal 12 closes, applying power to PLC input 2:14 (go to LOW FIRE command). The PLC then outputs low fire signals to the combustion air damper and fuel valve actuator. The outlet damper remains open.
10. Burner Management Control terminal 5 (Pilot Trial for Ignition) will turn on when Burner Management Control circuit M-D is made (Low Fire Proven). The following condition must be met to close circuit M-D:
    - PLC detects all actuators are in their low fire positions and turns on PLC output 3:3. Output 3:3 energizes Low Fire Proven relay CR-505 the contacts of which close Burner Management Control circuit M-8.
11. When Burner Management Control terminal 5 is turned on power will be applied to CR-224, the ignition transformer, to gas pilot valves GPV-1 and GPV-2, and the gas pilot vent valve GPVV. If the Low Pilot Gas Pressure Switch (LPGPS) opens during the Pilot Trial for Ignition, the burner will shutdown and alarm. If the switch opens at any other time, the condition will be alarmed but the burner will remain firing. This will allow the operator the opportunity to correct the condition before another light-off sequence is required.
12. When the flame scanner detects sufficient pilot flame intensity to prove pilot, Burner Management Control terminal 7 is turned on (Main Trial for Ignition) applying power to main gas valves OV-1 and OV-2.
13. When the flame scanner detects sufficient flame intensity to prove main flame, Burner Management Control terminal 5 is turned off shutting of the pilot valves and opening the pilot vent valve.
14. If sufficient flame intensity is proven for 10 seconds, Burner Management Control terminal 12 (Low Fire) is turned off and terminal 11 (Release to Modulate) is turned on. The outlet damper begins automatic control of the boiler draft set point. Terminal 11 then powers PLC input 2:2 which releases the boiler from low fire hold to control pressure on set point.

Boiler Stop Sequence – Both Fuels

1. Press Burner STOP pushbutton PB-112A. Burner START relay CR-112 will de-energize, removing power from Burner Management Control terminal 3.
2. With power off of terminal 3, Burner Management Control terminal 7 is turned off closing the main fuel valves. The outlet damper is commanded open during the entire post purge sequence.
3. Power remains on Burner Management Control terminal M during the post-purge period (15 sec.). When post purge is complete, terminal M is turned off, stopping the combustion air blower motor and de-energizing the Plant Air Solenoid Valve if it has been selected. The outlet damper is commanded to the closed position once post purge has been completed.

Lockouts

When a safety shutdown occurs, the flame safeguard will lockout and the alarm will be displayed on HMI. The non-volatile memory of the flame safeguard will remember the status of the control even if a power failure occurs. The Burner Management Control is reset by pressing the “Burner Stop/Reset” button on the boiler control panel door.

IMPORTANT – The cause for the lockout should always be determined and investigated prior to resetting the flame safeguard.

Safety Shutdowns:

1. If the running interlock circuit does not close (3-P), the control will lockout and the blower motor will be de-energized. If the interlock circuit opens during a start-up or firing period, all fuel valves will be de-energized and the control will lockout.
2. If pilot flame is not detected during the 10 seconds trial for ignition period the pilot valve and ignition transformer will be de-energized and the control will lockout on safety.
3. If main flame is not detected at the end of the main flame trial for ignition period, all fuel valves will be de-energized and the control will lockout on safety.
4. If the main flame fails during firing cycle, all fuel valves will be de-energized within 4 seconds after loss of flame signal and the control will lockout on safety.
   A flame seen at an improper time will cause a lockout.
5. If the proven high fire circuit (M-8) has not closed after a (10) minute “Hold” period at the start of pre-purge, the control will lockout.
6. If the low fire circuit (M-D) has not closed after a (10) minute “Hold” period at the end of pre-purge, the control will lockout.
7. If the fuel valve end switch or proof of closure switch connected to terminal 13 opens during stand-by or purge, the control will lockout.
8. The following conditions will cause opening of NRLR:
   - Feedback voltage position signal for air actuator or fuel actuator is below 90% of the minimum position set during actuator commissioning
   - Feedback voltage position signal for air actuator or fuel actuator is above 110% of the maximum position set during actuator commissioning
   - During run period deviation between commanded and actual actuator (fuel or air) position exceed 5% on high fire and 1% for low fire for 20 seconds
   - With actuators in the other than minimum or maximum position, allowable deviation is interpolated between 1 and 5%.
   - Boiler stack temperature is above the high stack temperature shutdown set point.

Appendix E - Hawk 5000 I/O List

Discrete I/O

Slot	Ch	Type	Description
2	0	DI	Comb Air Blower Running
2	1	DI	Purge Command
2	2	DI	Release For Modulation Command
2	3	DI	Actuators At Low Fire
2	4	DI	Actuators At High Fire
2	5	DI	Ready To Start/ Limits Closed
2	6	DI	External Start Interlock Proven
2	7	DI	ALFCO
2	8	DI	Pilot Terminal Energized
2	9	DI	Main Fuel Terminal Energized
2	10	DI	Fuel 1 Selected
2	11	DI	Fuel 2 Selected
2	12	DI	Burner Control Common Alarm
2	13	DI	Low Water Cutoff
2	14	DI	Boiler Outlet Damper Open Limit Switch
2	15	DI	Burner START Relay Energized
Slot	**Ch**	**Type**	**Description**
3	0	DO	Energize Recycle Limit Relay
3	1	DO	Start External Device
3	2	DO	Energize Non-Recycle Limit Relay
3	3	DO	Low Fire Proven
3	4	DO	High Fire Proven
3	5	DO	Remote START Command
3	6	DO	Alarm Horn Relay
3	7	DO	Remote STOP Command
Slot	**Ch**	**Type**	**Description**
4	0	DO	High Water Cutoff
4	1	DI	O2 Analyzer Ready Status
4	2	DI	VSD Bypass Switch
4	3	DI	High-High Steam Pressure Switch
4	4	DI	ALWCO Switch
4	5	DI	Low Gas Pressure / Low Oil Temp Switch
4	6	DI	High Gas Press / High Oil Temp Switch
4	7	DI	Low Oil Press Switch
4	8	DI	High Oil Press Switch
4	9	DI	Atomizing Media Flow And Press Switches
4	10	DI	Low Water Alarm
4	11	DI	Comb Air Pressure Switch
4	12	DI	High Water Alarm
4	13	DI	High Stack (Furnace) Press Switch
4	14	DI	Low Inst Air Press Switch
4	15	DI	Oil Gun Position Limit Switch
Slot	**Ch**	**Type**	**Description**
5	0	DO	OPEN Air Damper Actuator
5	1	DO	CLOSE Air Damper Actuator
5	2	DO	OPEN Fuel 1 Actuator

5	3	DO	CLOSE Fuel 1 Actuator
5	4	DO	OPEN Fuel 2 Actuator
5	5	DO	CLOSE Fuel 2 Actuator
5	6	DO	OPEN FGR Damper Actuator
5	7	DO	CLOSE FGR Damper Actuator
5	8	DO	OPEN 2nd Air Damper Actuator
5	9	DO	CLOSE 2nd Air Damper Actuator
5	10	DO	OPEN 2nd Fuel 1 Actuator
5	11	DO	CLOSE 2nd Fuel 1 Actuator
5	12	DO	Reserved
5	13	DO	Reserved
5	14	DO	Reserved
5	15	DO	Reserved

Slot 2 – Standard
Slot 3 – Standard
Slot 4 – Standard
Slot 5 – Optional (required in Pulse Positioning systems)

Analog I/O

Slot	Ch	Type	Description
6	0	AI	Drum Pressure
6	1	AI	Drum Level
6	2	AI	Stack Temperature
6	3	AI	Steam Header Pressure/ Remote Modulation Signal
6	4	AI	Steam Flow
6	5	AI	Mud Drum Shell Temperature
6	6	AI	VSD speed Feedback
6	7	AI	Flue Gas O2
Slot	**Ch**	**Type**	**Description**
7	0	AI	Fuel 1 Flow (or User Defined)
7	1	AI	Fuel 2 Flow (or User Defined)
7	2	AI	Stack Draft (or User Defined)
7	3	AI	Feedwater Flow (or User Defined)
7	4	AI	Economizer Outlet Flue Gas Temperature (or User Defined)
7	5	AI	Economizer Inlet Feedwater Temperature (or User Defined)
7	6	AI	Economizer Outlet Feedwater Temperature (or User Defined)
7	7	AI	Combustion Air Temperature (or User Defined)
Slot	**Ch**	**Type**	**Description**
8	0	AO	Feedwater Valve Control Output
8	1	AO	VSD Speed Reference Control Output
8	2	AO	Economizer Bypass Damper/ Jackshaft Actuator Control Output
8	3	AO	Boiler Outlet Damper Control Output
Slot	**Ch**	**Type**	**Description**
9	0	AI	Air Damper Actuator Position Feedback
9	1	AI	Fuel 1 Actuator Position Feedback
9	2	AI	Fuel 2 Actuator Position Feedback
9	3	AI	FGR Damper Actuator Position Feedback
9	4	AI	2nd Air Damper Actuator Position Feedback
9	5	AI	2nd Fuel 1 Actuator Reserved
9	6	AI	Reserved
9	7	AI	Reserved
Slot	**Ch**	**Type**	**Description**
10	0	AO	Air Damper Actuator Control Output
10	1	AO	Fuel 1 Actuator Control Output
10	2	AO	Fuel 2 Actuator Control Output
10	3	AO	FGR Damper Actuator Control Output
10	4	AO	2nd Air Damper Actuator Control Output
10	5	AO	2nd Fuel 1 Actuator Control Output
10	6	AO	Reserved
10	7	AO	Reserved

Slot 6 – Standard module
Slot 7 – Optional module (required for Stack Draft control, 3-Element Drum Level control)
Slot 8 – Optional module (required for Drum Level control, VSD Speed control, Econ Bypass control, Single-Point systems, Stack Draft control)
Slot 9 – Optional (required for Parallel Combustion control systems, not required in Single-Point systems)
Slot 10 – Optional (required in Current Positioning systems)

Appendix F - Hawk 5000 Alarm List

Alarm Message
Input Bad Quality - Drum Pressure
Input Bad Quality - Drum Level
Input Bad Quality - Stack Temperature
Input Bad Quality - Steam Header Pressure
Input Bad Quality - Steam Flow
Input Bad Quality - Mud Drum Shell Temperature
Input Bad Quality - VSD Speed Feedback
Input Bad Quality - Flue Gas O2
Input Bad Quality - Fuel 1 Flow
Input Bad Quality - Fuel 2 Flow
Input Bad Quality - Main Gas Pressure
Input Bad Quality - Feedwater Flow
Input Bad Quality - Econ Outlet Flue Gas Temperature
Input Bad Quality - Econ Inlet Feedwater Temperature
Input Bad Quality - Econ Outlet Feedwater Temperature
Input Bad Quality - Combustion Air Temperature
Input Bad Quality - Air Actuator Position Feedback
Input Bad Quality -Fuel 1 Actuator Position Feedback
Input Bad Quality - Fuel 2 Actuator Position Feedback
Input Bad Quality - FGR Actuator Position Feedback
Input Bad Quality - 2nd Air Damper Actuator Position Feedback
Input Bad Quality - 2nd Fuel 1 Actuator Position Feedback
Input Bad Quality - Reserved
Input Bad Quality - Reserved
HAlarm - Drum Pressure HIGH (Xmtr)
HAlarm - Drum Level HIGH (Xmtr)
HAlarm - Stack Temp HIGH (Xmtr)
HAlarm – Steam Header Pressure HIGH (Xmtr)
HAlarm - Steam Flow HIGH (Xmtr)
HAlarm - Mud Drum Shell Temp HIGH (Xmtr)
HAlarm - VSD Speed Feedback HIGH (Xmtr)
HAlarm - Flue Gas O2 HIGH (Xmtr)
HAlarm - Fuel 1 Flow HIGH (Xmtr)
HAlarm - Fuel 2 Flow HIGH (Xmtr)
HAlarm - Stack Draft Pressure HIGH (Xmtr)
HAlarm - Feedwater Flow HIGH (Xmtr)
HAlarm - Econ Outlet Flue Gas Temperature HIGH (Xmtr)
HAlarm - Econ Inlet Feedwater Temperature HIGH (Xmtr)
HAlarm - Econ Outlet Feedwater Temperature HIGH (Xmtr)
HAlarm - Combustion Air Temperature HIGH (Xmtr)
HHAlarm - Stack Temp HIGH-HIGH SHUTDOWN (Xmtr)
HAlarm - High Water Cutoff (Contact)
HAlarm - High Gas Pressure (Contact)
HAlarm - High Oil Temperature (Contact)
HAlarm - High Oil Pressure (Contact)
HAlarm - High Water Alarm (Contact)
HHAlarm - High-High Furnace Press SHUTDOWN (Contact)
LAlarm - Drum Press LOW (Xmtr)
LAlarm - Drum Level LOW (Xmtr)
LAlarm - Stack Temp LOW (Xmtr)
LAlarm - Steam Header Pressure LOW (xmtr)
LAlarm - Steam Flow LOW (Xmtr)
LAlarm - Mud Drum Shell Temp LOW (Xmtr)
LAlarm - VSD Speed Feedback LOW
LAlarm - Flow Gas O2 LOW (Xmtr)

LAlarm - Fuel 1 Flow LOW (Xmtr)
LAlarm - Fuel 2 Flow LOW (Xmtr)
LAlarm - Stack Draft Pressure LOW (Xmtr)
LAlarm - Feedwater Flow LOW (Xmtr)
LAlarm - Econ Outlet Flue Gas Temperature LOW (Xmtr)
LAlarm - Econ Inlet Feedwater Temperature LOW (Xmtr)
LAlarm - Econ Outlet Feedwater Temperature LOW (Xmtr)
LAlarm - Combustion Air Temperature LOW (Xmtr)
LAlarm - Low Water Cutoff (Contact)
LAlarm - Aux Low Water Cutoff (Contact)
LAlarm - Low Gas Press (Contact)
LAlarm - Low Oil Temp (Contact)
LAlarm - Low Oil Press (Contact)
LAlarm - Low Water Alarm (Contact)
LAlarm - Low Comb Air Press (Contact)
LAlarm - Low Inst Air Press (Contact)
LLAlarm - Flow Gas O2 LOW-LOW SHUTDOWN
Burner Control Alarm (Contact)
O2 Analyzer In Warm-up Mode (Contact)
Low Atomizing Media (Contact)
Oil Gun Position Switch Not Made (Contact)
Recycle Limit Relay (RLR) Fault
Non-Recycle Limit Relay (NRLR) Fault
Air Actuator Out Of Position Alarm
Fuel 1 Actuator Out Of Position Alarm
Fuel 2 Actuator Out Of Position Alarm
FGR Actuator Out Of Position Alarm
Air Actuator Feedback Outside Calibrated Range
Fuel 1 Actuator Feedback Outside Calibrated Range
Fuel 2 Actuator Feedback Outside Calibrated Range
FGR Actuator Feedback Outside Calibrated Range
External Start Interlock Not Closed Alarm
VSD Speed Reference / Control Output Deviation Alarm
VSD Fault Alarm
Modbus Communication Error
I/O Module ## Fault Detected Alarm
Burner Control Fault Alarm
High Limit Cutoff Alarm
CPU Battery Not Detected Or In Need Of Replacement Alarm
No Fuel Selected
Ethernet Communication Link FAULT - Master
Major Option Selection Not Complete
Boiler Outlet Damper Failed To Open Alarm