Asphalt Burner Management System

INSTALLATION AND OPERATIONS MANUAL

WEBSTER COMBUSTION
A Selas Heat Technology Company

The *Better* Burner.

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Webster ABMS Installation and Operations Manual

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1. GENERAL CONSIDERATIONS AND REQUIREMENTS

!!! Before beginning installation and commissioning, read through this manual and all application literature. Also, familiarize yourself with the control circuit components and diagrams.

The information and guidelines contained within this Installation and Operations Manual pertain only to the Webster Combustion Technology, LLC's Asphalt Burner Management System (ABMS) with regards to the installation of the ABMS controller panel and connections made to the panel, as well as the commissioning and the operation of the ABMS controller.

Only QUALIFIED and COMPETENT technicians should attempt to install and commission the ABMS and connected components. Combustion tuning can be dangerous without the proper equipment and knowledge. Do not continue with the installation or commissioning of the ABMS and connected components without comfortable knowledge of the application, equipment, and process requirements.

1.1 INSTALLATION

The ABMS can come as a preassembled panel that is enclosed in a benchtop console or as a preassembled 'drop-in' unit that is custom built to fit . Regardless of which configuration is being installed some planning needs to be completed to ensure a proper installation.

The console has a **minimum space requirement of 26" wide X 18" deep** and although it is only a little over 19" high when the door is closed, it requires an additional 20" above this to accommodate for door clearance **(~40" total height allowance)**. This is the minimum space and does not allow for full extension of the handles that are provided. A total of **36" of width allowance will accommodate for full extension of the handles** on the side of the console.

Place the ABMS console or drop-in panel in a predetermined, prepared location and route conduit/wires to the panel allowing for a clean installation.

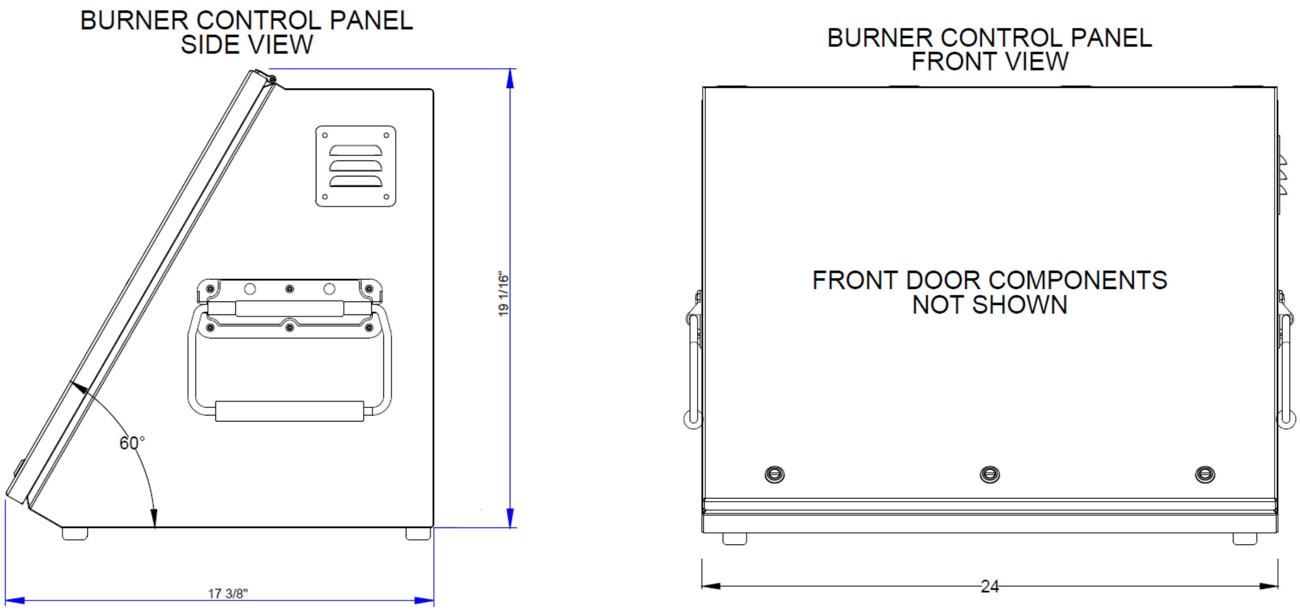
If installing a console or a controls tray (drop-in), be sure to leave plenty of room in front for opening the door/tray and for access to the controls. With a controls tray, ensure enough slack is left in the wiring to allow for extension and retraction of the tray. Protect the wiring from any sharp edges or pinch points to prevent damage to the wiring and controls.

Pay attention to the low voltage sensor wiring and communications wiring with regard to routing, trying to keep the low voltage sensor and communications wiring separated from the higher voltage wires (>50 V), as best as possible.

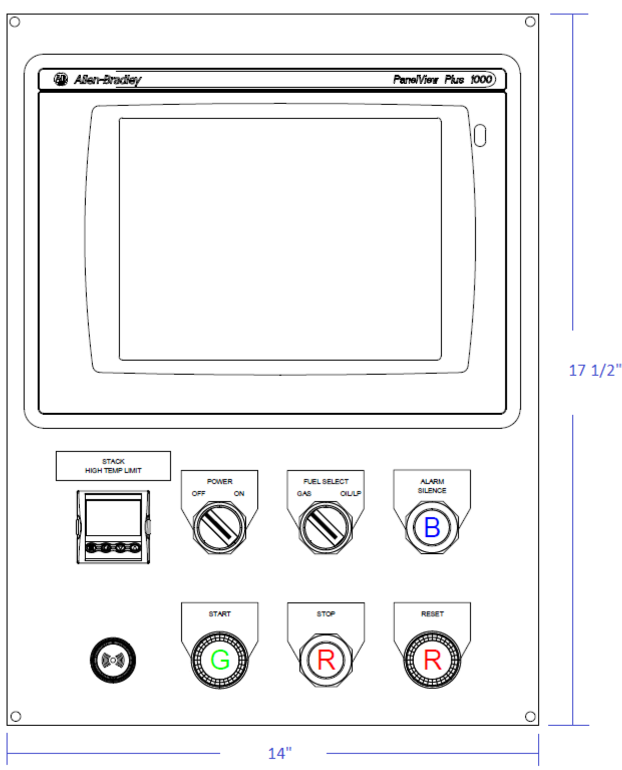
In the case of the preassembled console, the exterior wiring must enter from the sides in certain areas near the bottom of the enclosure. Some room is available higher up the sides, but much care needs to be taken when planning wire entries into this enclosure.

There is no room for wire entries at the back or the bottom of the consolette enclosure.

Drop-in panels are custom fit to each installation and must be installed accordingly.



BENCH TOP CONSOLE



MINIMUM DROP-IN FACE PLATE DIMENSIONS

1.2 POWER SUPPLY AND CONTROL CIRCUIT WIRING

ALL WIRING AND ELECTRICAL CONNECTIONS SHALL BE COMPLIANT WITH THE NEC AND LOCAL ELECTRICAL CODES.

***The ABMS control system DOES NOT include the blower/fan motor starting and motor control components for the combustion blower and the exhaust blower. The ABMS only controls the Combustion Air/Exhaust Damper or the Combustion Air/Exhaust VFD speed command (if enabled). Blower/fan motor starting components, motor contactors and VFDs need to be supplied separately.*

The ABMS requires a clean **120 V / 60 HZ / 1 PH** power supply.

The ABMS control circuit is protected by a 15A midget class fuse however, a protected power supply is required.

The conductors (wires) that supply power to the ABMS shall be a minimum size of **#14 AWG** and be a stranded copper type suited for the application.

All 120 VAC field connected control circuit conductors that connect the ABMS control panel to the burner junction box or components shall be a minimum size #14 AWG, stranded copper of type THHN or equivalent.

All 120 VAC field connected control circuit conductors between the ABMS and the burner junction box or components should be no longer than 300 feet.

Multi-conductor cables may be used in lieu of individual wires if the cables are approved for the application and by the local Authority Having Jurisdiction. If quick connect fittings are used to make field connections, they must be approved for the application and environmental conditions.

The low voltage control and feedback signal conductors, between the ABMS and the burner junction box, shall be shielded cables with stranded wire conductors having a minimum size of **#18 AWG per conductor**. A braided metallic shield is preferred however, the foil screen type will be sufficient if it is a type that contains a bare drain wire within the cable.

Only one end of the shield shall be connected to the indicated grounding location, the grounded end is denoted within the wiring diagram. If the grounded end of the cable is not clearly denoted then, it shall be the end of the cable that terminates in the ABMS control panel that will be connected to the shield ground.

A good earth ground is required, and **ground continuity** MUST BE MAINTAINED between the ABMS control panel and the connected components at the burner, this is referred to as the 'chassis ground', GND or, PE.

> *This control system utilizes 0-5 VDC and 4-20 mADC (24VDC) signal circuits therefore, shielding and grounding is VERY important for maintaining good signal quality; in particular with the utilization of VFD(s).

1.3 TEMPERATURE SENSORS

At a minimum, three (3) **Type-J thermocouple** temperature detectors are required to operate the ABMS properly. These include the Material Temperature, Stack/Baghouse Inlet Temperature, and the Baghouse Outlet Temperature.

The thermocouples need to be wired accordingly, with proper extension wire. The thermocouple wires SHALL NOT be running in the same conduit with higher voltage wiring.

Three (3) more, additional, Type-J thermocouples can be monitored. These auxiliary thermocouples can be individually labeled via settings in the ABMS display. *See Page 5 of the wiring diagram for details.*

1.4 FLAME DETECTORS

One (1) or two (2) flame detectors can be utilized, one for Pilot Flame sighting and one for Main Flame sighting or, one (1) detector can be utilized to view both the Pilot and Main Flame.

The standard flame detector is the **Honeywell C7027 series U.V. detector**. Other flame detection methods can be used (I.R., Self-Checking U.V.) however, other flame detection methods need to be specified when purchasing the ABMS package.

The flame detector(s) need to be wired accordingly. *See Page 1 of the wiring diagram for details.*

The flame detection wiring SHALL NOT be running in the same conduit with higher voltage wiring.

1.5 DRUM (DRAFT) PRESSURE

If Drum Pressure (Draft) control is to be implemented then, a **loop-powered 4-20 mADC pressure transmitter** or transducer needs to be wired to the Draft Transmitter terminals.

The range of the sensor is adjustable at the display however, the default setting is 0-1"wc (4mA @ 0"wc - 20mA @ 1"wc). *See Page 5 of the wiring diagram for details*.

The setting made at the display for the Drum (draft) pressure is a positive value that may represent a negative measurement. Therefore, a setting of "0.15" at the display may represent a drum (draft) pressure of -0.15"wc. This depends on the location of the pressure sensing ports and sensor settings, attention to these parameters when selecting and installing the sensor is important.

Drum (draft) pressure control can be done by a VFD or by a damper, but not both. This is selectable at the display however, with either control method (*VFD or control motor*), the positional feedback of this control element is made via the Draft Pressure reading and NOT the direct position of the damper motor nor the speed of the VFD.

This pressure reading is best to be taken from the drum, generally at the end where the burner is located. The sensing line(s)/port(s) can be in the drum exhaust ducting (stack), baghouse exhaust ducting or taken as a differential across the draft fan if necessary.

1.6 CONTROL ELEMENTS

Make note of the required Control Motors and VFD(s) needed to control all of the elements that are being utilized.

In GAS Firing Mode, up to 5 Control Elements can be utilized…

- 5 control motors (*Fuel, Combustion Air, Register/Spin Vane, Exhaust Damper, Auxiliary*)
- 4 control motors and 1 VFD (*Combustion Fan* or *Exhaust Fan*)
- 3 control motors and 2 VFD(s) *(Combustion Fan* and *Exhaust Fan*)

In OIL/LP Firing Mode, up to 6 Control Elements can be utilized...

- 6 control motors (*Fuel, Atomizing Media, Combustion Air, Register/Spin Vane, Exhaust Damper, Auxiliary*)
- 5 control motors and 1 VFD (*Combustion Fan* or *Exhaust Fan*)
- 4 control motors and 2 VFD(s) (*Combustion Fan* and *Exhaust Fan*)

Typical control elements and (modes in operation)…

*Gas Flow Control Valve (**Fuel 1**)*
*Oil Flow Control Valve (**Fuel 2**)*
*LP/LPG Flow Control Valve (**Fuel 1 or 2**)*
*Atomizing Air Control Valve (**Fuel 2**)*

*Register/Shaping Vanes (**Fuel 1 and 2**)*
*Comb. Air Damper <u>-OR-</u> VFD (**Fuel 1 and 2**)*
*Louver Box/Auxiliary Actuator (**Fuel 1 and 2**)*
*Exhaust Damper <u>-OR-</u> VFD (**Fuel 1 and 2**)*

1.7 VARIABLE FREQUENCY DRIVES

Determination of the Combustion Air and the Drum Pressure control methods must be made in order to select the proper Motor/VFD assignments and, to enable the proper controller outputs.

1.7.1 1st Consideration: *Will the Combustion Air be controlled by a louver box, a VFD or both?*

The wiring of a control motor, or a VFD, that is used to control the Combustion Air element, as well as some controller settings needed to facilitate their use, are dependent on the control method you chose to use.

The Combustion Air element is considered the ‘leading’ element in the combustion correlation profile, the “Combustion Air Damper” and “Combustion Air VFD” cannot be active at the same time since these are the two options given to choose from for the Combustion Air control in the ABMS controller settings; damper motor (Relay) or VFD (Analog), one or the other must be active, but never both.

If you chose a control motor (Relay) then the Combustion Air Damper is the leading element, and the VFD terminals will not function.

If you choose a VFD (Analog) then the Combustion Air VFD is the leading element, and the combustion air motor terminals will not function.

It is possible to use a VFD and a damper/louver box to control the Combustion Air to the burner, in this case the VFD is still the leading element, and the lover box control motor would need to be wired accordingly.

- **DAMPER/LOUVER BOX ONLY:** If the Combustion Air element is to be controlled by a damper/louver box alone then, the control motor for this element will need to be wired to the <u>Combustion Air Damper Motor terminals (6630, 6640)</u>*
- **DAMPER/LOUVER BOX AND A VFD:** If the Combustion Air is to be controlled by a VFD and a damper/louver then, no motor is wired to the Combustion Air Damper Motor terminals. The control motor for the damper/louver will need to be wired to the <u>Louver Box/Auxiliary Motor terminals (6410, 6420)</u>*
- **VFD ONLY:** If the Combustion Air is to be controlled by a VFD alone then, no motor is wired to the Combustion Air Damper Motor terminals and, the Louver Box/Auxiliary Motor functions could still be used for other control purposes, if needed.

**refer to pages 6 and 7 of the wiring diagrams for details.*

The Combustion Air VFD needs to be setup to utilize a 4-20 mADC control signal from the ABMS for speed demand reference, this signal represents 0-100% Demand (Firing Rate). For example: <u>**4 mADC = 18 Hz and 20 mADC = 60 Hz**</u>.

The VFD is required to supply a 4-20 mADC signal back to the ABMS for Combustion Air VFD Position Feedback. This output from the VFD should be scaled to equal the same range as the input above (ex. 15-60 Hz = 4-20 mADC).

The Combustion Air VFD needs to have a relay output to facilitate the VFD ‘Running’ Interlock. This is a 120 VAC powered circuit from the ABMS that requires the relay to close when the VFD is in a running state. If there are no relay outputs available within the VFD then an interposing relay must be used in conjunction with any low voltage digital outputs that are available within the VFD.

There is also a dedicated input to the ABMS from the VFD to indicate a VFD fault. This is also a 120 VAC powered circuit from the ABMS which requires the use of a relay output within the VFD setup to close when the VFD is in a fault condition. This is not a necessary connection however, this allows the ABMS display to alert the operator if the VFD is tripped and requiring attention.

1.7.2 2nd Consideration: *Will the Drum Pressure (Draft) be controlled by a damper/louver or a VFD?*

As with the Combustion Air control element, the wiring of a control motor (*or a VFD*) that is used to control the Draft element (drum pressure), as well as some controller settings needed to facilitate their use, are dependent on the control method you chose to use.

Also, as with the Combustion Air VFD, the use of the Exhaust Damper motor output and the Exhaust VFD output cannot be done at the same time; one or the other must be chosen; damper motor (relay) or VFD (analog).

However, unlike the Combustion Air control, the Draft control utilizes the Draft Pressure for the control feedback. Due to this feature, there are no feedback connections to be made from the Exhaust Damper motor (*or VFD*) to the ABMS.

It is possible to use the relay control method to control a VFD, if the VFD is setup for floating input (3-position step). Since the Draft control uses the Draft Pressure for the feedback, a VFD with a pulse to increase/pulse to decrease application macro can also be used to control the Draft element.

In any method chosen, the Exhaust Damper or VFD needs to be wired accordingly.

- **DAMPER CONTROL:** If this element is to be controlled by a damper/louver then, the control motor for this element needs to be wired to the Exhaust Damper Motor terminals (6750, 6760).

- **VFD CONTROL:** If this element is to be controlled by a VFD then, the control method of the VFD needs to be determined.

  - ***Will the VFD be controlled with a variable linear analog input (4-20 mADC = 0-60 Hz)?***
    If this is the method chosen then, the VFD will need to be connected to the proper terminals in the ABMS (5530, 5540)*

  - ***Will the VFD be controlled with a floating input (discrete up/down modulation through relays)?***
    If this is the method that must be used, then two (2) extra relays will need to be installed to facilitate this (*denoted as 675CR and 676CR)**

  **See pages 6 and 7 of the wiring diagrams for details.*

The Exhaust VFD needs to have a relay output to facilitate the VFD 'Running' Interlock. This is a 120 VAC powered circuit from the ABMS that requires the relay to close when the VFD is in a running state. If there are no relay outputs available within the VFD then an interposing relay must be used in conjunction with any low voltage digital outputs that are available within the VFD.

There is also a dedicated input to the ABMS from the VFD to indicate a VFD fault. This is also a 120 VAC powered circuit from the ABMS which requires the use of a relay output within the VFD setup to close when the VFD is in a fault condition. This is not a necessary connection however, this allows the ABMS display to alert the operator if the VFD is tripped and requiring attention.

These control motors utilize a 120VAC 'Floating' or, '3-position step' control method (*also referred to as Series 60 in Honeywell literature*).

The smaller motors (gas, oil, atomizing air) are all setup for use with the EA57 motor control scheme. That is, closure of the case ground (X) to the drive terminals (2 or 3, *never both*) will cause the motor to move.

The larger motors (register, louver/auxiliary, combustion air damper and exhaust damper) are all setup for use with the EA73 motor control scheme. That is, closure of the ungrounded, hot leg (L1) to the drive terminals (2 or 3, *never both*) will cause the motor to move.

This is a significant difference between the operation of the two different motor series, care must be taken to ensure the servos are of the correct type for the element they are controlling.

These motors also utilize a 100 ohm slide-wire feedback potentiometer. This is used for positional feedback to the ABMS and is powered by a 5 VDC power supply.

If another brand or series of motor is utilized, then they must meet the same operating and feedback criteria as the EA57 and EA73 series control motors.

The Control Motors, couplers and the control elements should be verified for proper configuration, with regards to the direction of rotation and travel limits, before continuing with commissioning.

With retrofits, it is best practice to start by uncoupling all of the control motors from the control elements (*dampers, register, valves, etc.*) before energizing the ABMS panel for the first time. This is done to prevent damage to components if the motors are presumed to be at the 'closed' position when being mounted and coupled.

1.8.1 **Check the rotational direction requirements for each Control Motor:** check this relative to the controlled component, to ensure proper operation of each element. The wiring diagram for a 'Standard' standalone ABMS Panel (*retrofit*) shows the Control Motors wired to open/increase the control element in the CLOCKWISE direction, looking at the shaft end of the EA57/73 control motor.

ABMS packaged systems provided with Webster Combustion Technology, LLC burners will show the control motors wired 'as built' in the relative wiring diagrams.

**The motor drive wires, and the position feedback wires, can be swapped at the motors or the burner junction box to change the rotational direction of the motors if needed*.

1.8.2 **Check to ensure freedom-of-movement for each control element:** make sure no binding is observed throughout the entire range of motion of the element (*damper, valve, linkage*). Make sure there is no excessive force required to move the control element. The controlled component should be able to move before reaching any mechanical limit without binding.

If a control element cannot move a full 90 degrees, then an end limit switch should be utilized to limit the stroke of the control motor. The EA57/73 motors have an adjustable position limit switch that can be used to help prevent a motor from moving outside of an acceptable range.

1.8.3 **Ensure all Control Motors are wired correctly:** leave the motors uncoupled from the controlled components.

When the ABMS is ready to be powered and the control motor setup is ready to be done this will allow for verification of the rotational direction and travel limits without concern for over travel or moving the control elements in the wrong direction.

After the wiring and movement has been verified to be correct the couplers may be tightened. Do not perform motor feedback calibration until all of the elements are firmly coupled.

1.9 PURGE/IGNITION POSITION INTERLOCKS

Determination of which mechanical Positional Proving Switches are to be utilized needs to be done to ensure that the positional proving requirements, relative to the control scheme, are implemented.

At a minimum, all Combustion Air related control elements will open during the Pre-Purge phase to meet the purging requirements. The Purge Position is proven via an external mechanical limit switch on each element that 'proves' the control element is at this commanded position.

The Fuel Control Valves, generally, stay closed during Pre-Purge and do not require purge position proving. The positional feedback in the control motors will still monitor the position and alert the operator if the control motor is not in position.

All of the control elements, including the Fuel CVs are to be proven to be at their commanded Ignition Position. This is done with a separate external mechanical limit switch on each element.

The Atomizing Air Valve, generally, does not require these position proving switches due to the use of the Atomizing Air Pressure Switch to 'prove' that atomizing air is available. As with all the other motors, the positional feedback from the Atomizing Air control motor will still alert the operator to a position fault.

In a 'Standard' standalone ABMS panel, all of the generally required position proving switches are accounted for; <u>if any are not used then a jumper must be installed at the terminals to bypass the unused limits.</u> *See Page 3 of the wiring diagram for details.*

These mechanical limit switches will need to be set up to close the contacts of the switch when the controlled element is at the commanded position, the mechanical operation of these switches needs to ensure this fail-safe function.

1.10 FUEL VALVE INTERLOCKS

The Main Fuel Shutoff Valves (Gas, Oil and LP), generally, have Proof-of-Closure limit switches that are integral to the valve actuators. These switches 'prove' that the fuel valves are closed during any phase in which the fuel valves are not to be energized.

If the burner only fires a single fuel or, <u>if any of the fuel trains do not incorporate POC limits then, jumpers will need to be installed at the terminals to bypass the unused POCs</u>. At a minimum, any gaseous fuel train should have proof-of-closure limits implemented; it is recommended that all fuel trains incorporate POCs.

**Fuel valve POC requirements vary depending on location and the Authority Having Jurisdiction, check with local authorities to ensure compliance is maintained*.

The POCs need to be wired accordingly, *see Page 3 of the wiring diagram for details*.

1.11 SAFETY LIMITS

Determination of which safety limits are to be implemented needs to be done to ensure that all safety devices are accounted for. Each fuel train will have supervisory limits that monitor the pressures and temperatures of the fuel, the atomizing air supply piping will have a pressure proving limit, as well.

The Combustion Air Proving Switch, Combustion Air VFD/Motor Starter ITLK, Exhaust Air Proving Switch, Exhaust VFD/Motor Starter ITLK and an additional User Auxiliary Limit are also included in this safety limit 'chain'.

**Fuel train and other safety requirements vary depending on location and the Authority Having Jurisdiction, check with local authorities to ensure compliance is maintained*.

The standalone ABMS panel incorporates all of the generally required safety limits, <u>if any of these limits are not used then a jumper will need to be installed at the terminals of any unused safety limit.</u> *See Page 1 of the wiring diagram for details.*

1.12 OTHER WIRING NOTES

The Main Fuel Valves, Pilot Fuel Valves and the Ignition Transformer all need to be wired accordingly.

The standard ABMS stand-alone wiring diagram will show the option for a Pilot Select Switch. This is a standard for ABMS panels supplied with a Webster HDRA burner and allows for the selection between Natural Gas and Propane pilot gas supply at the burner junction box.

If the Pilot Select option is not utilized, then the switch can be omitted, and the pilot train will be connected to terminal 1532. *See page 1 of the wiring diagram.*

2. PANEL CHECKOUT

2.1 STATIC CHECKOUT

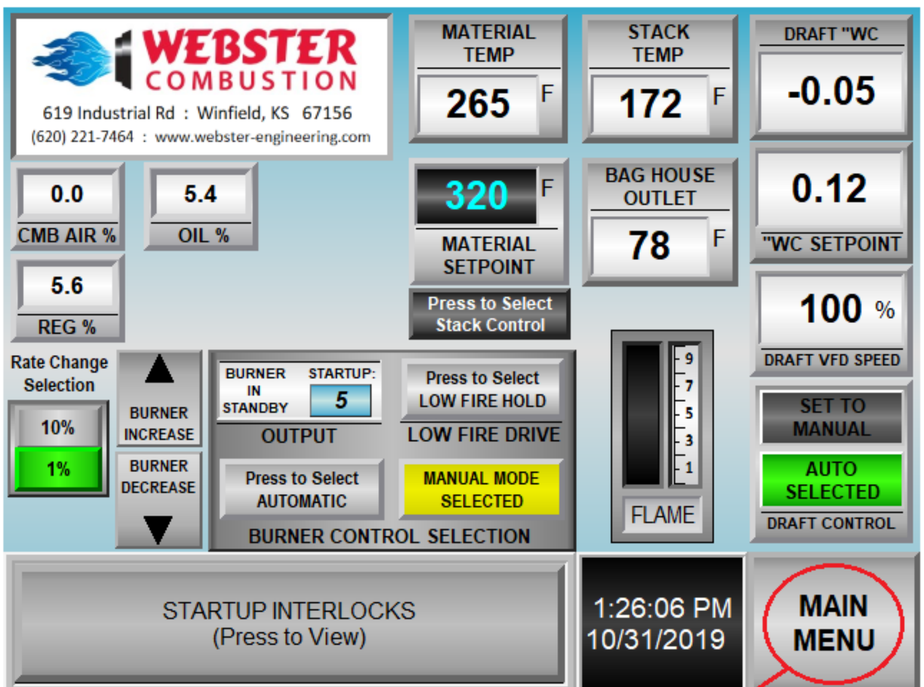
!!! Before applying power to the panel, perform a general static circuit analysis of the control system !!!

Check for ground continuity, short-circuit potentials, limit chain function and any other static checkout that can be done.

Check to ensure the available power supply meets the requirements of the panel (120Vac/60Hz, protected, with a good ground).

Apply power to the panel, the HMI will take a minute to boot. There may be a fault present due to the motors not being calibrated, if this occurs just silence the alarm by pressing the “Alarm Silence” pushbutton.

The Main Operations screen will be the initial screen that is visible once the HMI has completed the booting process, the controls and the HMI are energized by turning the “POWER” switch to the “ON” position.



Press this button to access the Main Menu

2.2 LIVE CHECKOUT

Check for voltage potential at the panel ground, ensuring that proper control voltages are present at each power supply fuse; there are three (3) fuses…

101FB is a 15A midget class fuse for protecting the entire control panel; there should be 120 Vac between terminals 1040 and 1041. Also, 120 Vac between 1040 and the ground should be observed; <u>there should be no voltage potential between 1041 and the ground.</u>

230FB is a 2A 5x20mm fuse for protecting the 24 Vdc I/O and supply circuit; there should be 24 Vdc between terminals 2400 (+) and 2401 (-). The power supply unit has a trim pot that can be used to adjust the voltage if required.

268FB is a 2A 5X20mm fuse for protecting the 5 Vdc motor position feedback circuit; there should be 5Vdc between terminals 2700 (+) and 2701 (-). The power supply unit has a trim pot that can be used to adjust the voltage if required.

Check to ensure that power is only measured at expected terminals; investigate any anomalies.

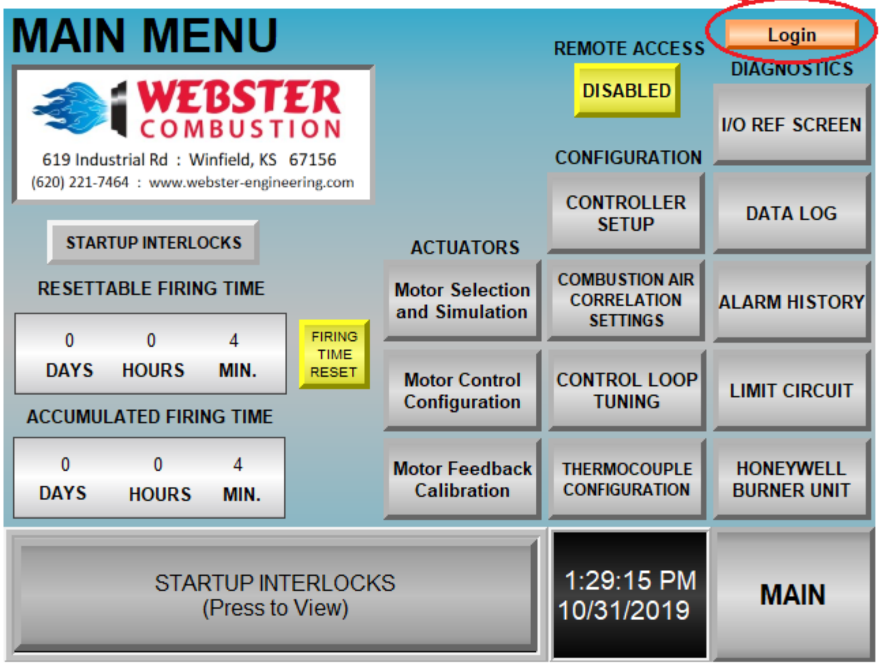
Before continuing it is a good practice to open and close the Data Log screen, opening this screen ensures that the data logging has started. It is also good practice to go through and open all of the screens one by one.

The benefit in doing this is that it preloads and starts the data updating of each screen. When each screen is opened for the first time after a reboot it takes a brief moment to update all of the data points. Then, when you change to a new screen the data will already be updated.

3. CONTROL MOTOR/VFD SETUP AND CALIBRATION

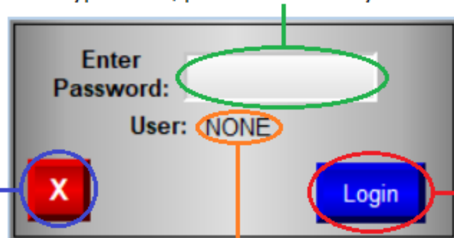
3.1 **LOG IN** by entering the Main Menu screen of the HMI and pressing the **Login** button in the upper right corner of the Main Menu screen; enter **4858** for the Engineer passcode.

Press this button to access the Log In popup



Press the Numeric Entery panel to access a numeric keypad popup. Enter the passcode with the keypad then, press the enter key.

Press the **X** button to escape from and close the Login popup.



Press the **Login** button to apply the passcode. The **Login** will change to **Logout** when a passcode is active; pressing the **Logout** button will cancel the passcode and set the User to NONE.

The User name will change if the passcode is accepted.

3.2 **SETUP THE CONTROL SCHEME** by first selecting the Control Motors and VFDs that will be used. Unique ID or names can be given to each motor in the Motor Selection screen.

The Combustion Air MUST be enabled in the Motor Selection screen to operate the system, at a minimum. Then, the Damper or VFD control method is chosen in the Motor Configuration screen.

The Exhaust Air MUST be enabled to allow for any drum pressure (draft) control or measurement. Then, the damper or VFD control method is chosen in the Motor Configuration screen.

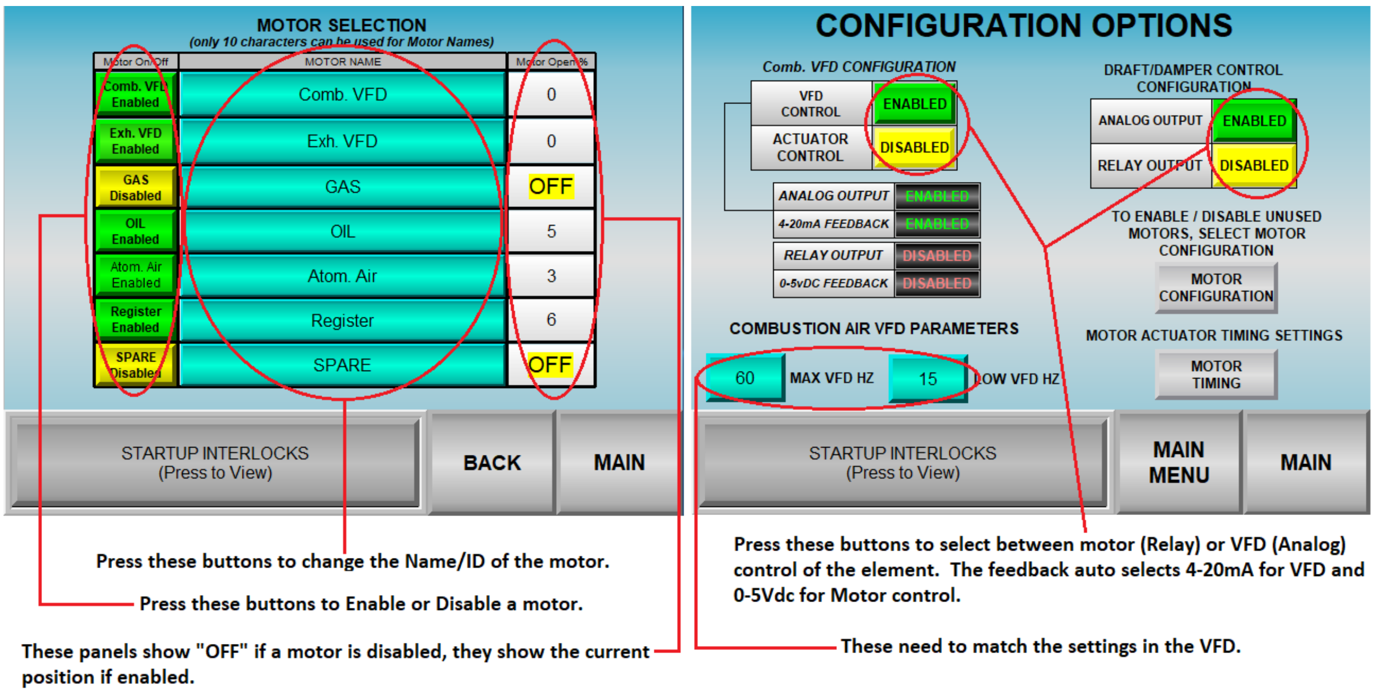
The VFDs must be set to accept a 4-20mA speed reference; this must represent 0-100% of the VFD speed range (*ex. 4-20mA = 18-60Hz*). The Analog Output from the Combustion Air VFD to the ABMS (*for speed feedback*) should be set to represent 0-100% of this speed range, as well.

The ABMS controller does not require any feedback from the Exhaust VFD since the Drum Pressure (Draft) is used for the exhaust setpoint and feedback.

The LOW VFD HZ and MAX VFD HZ is used with certain VFDs that cannot be scaled accordingly or easily. With these drives the output scaling is 0-100% of the parameter the output it is representing, if the VFD you are using will not allow for proper scaling of the output channel then these parameters can be used to help.

For example: if the VFD is setup to run at 15HZ with a 4mADC input and at 60HZ with a 20mADC input but, the Analog Output of the VFD can only be selected to represent 0-60HZ in 4-20mADC then the LOW VFD HZ will need to be set at 15HZ. This setting is used to allow the PLC to recalculate the zero position relative to this offset.

Essentially, the PLC is looking for the speed demand signal and the feedback signal to be similar, within the set dead band.



<u>3.3</u> CALIBRATE THE CONTROL MOTORS/VFD POSITION FEEDBACK

Begin by entering the Motor Calibration screen. The left side of the Motor Calibration screen displays the enabled control motors, as well as, the live position feedback, motor fault indicators, 'within dead band' indicator and the dead band setting for each enabled motor.

If a calibration fault or a position fault occurs then, the associated fault indicator will turn RED.

When the control motor is at position, within the set dead band, the "DB" indicator turns GREEN.

<u>3.3.1</u> Ensure all of the required motors are enabled before starting the calibration process. To begin the calibration process, you must be logged in as ENGINEER then, press the "ZERO" button on the lower right side of the screen. The motors/Combustion Air VFD will move to their full closed/low speed position.

Once all of the motor/VFD positions are stable and, the control motors/VFD are verified to be in the closed/low speed position, press the "SPAN" button. This will save the motor position raw feedback signals in the PLC then, drive all of the motors/Combustion Air VFD to their full open/high speed position.

Once all of the position indications are stable and the motors/VFD are observed to be at their fully open/high speed position, press the "OFF" button. This will save the feedback signals in the PLC then, drive the motors/VFD to their Low Fire/Standby position.

3.3.2 The "MINIMUM SPAN" setting represents the amount of *raw* signal change, between the calibrated closed/low speed position and the calibrated opened/high speed position, which must be observed to determine that the motor has enough usable range of motion to satisfy operating requirements. This is a 'binary count' value, a setting of 13,500 represents roughly 80% of the available feedback span.

If a motor/VFD does not move this amount between 0 and 100% then, a "Motor Calibration Fault" will be indicated.

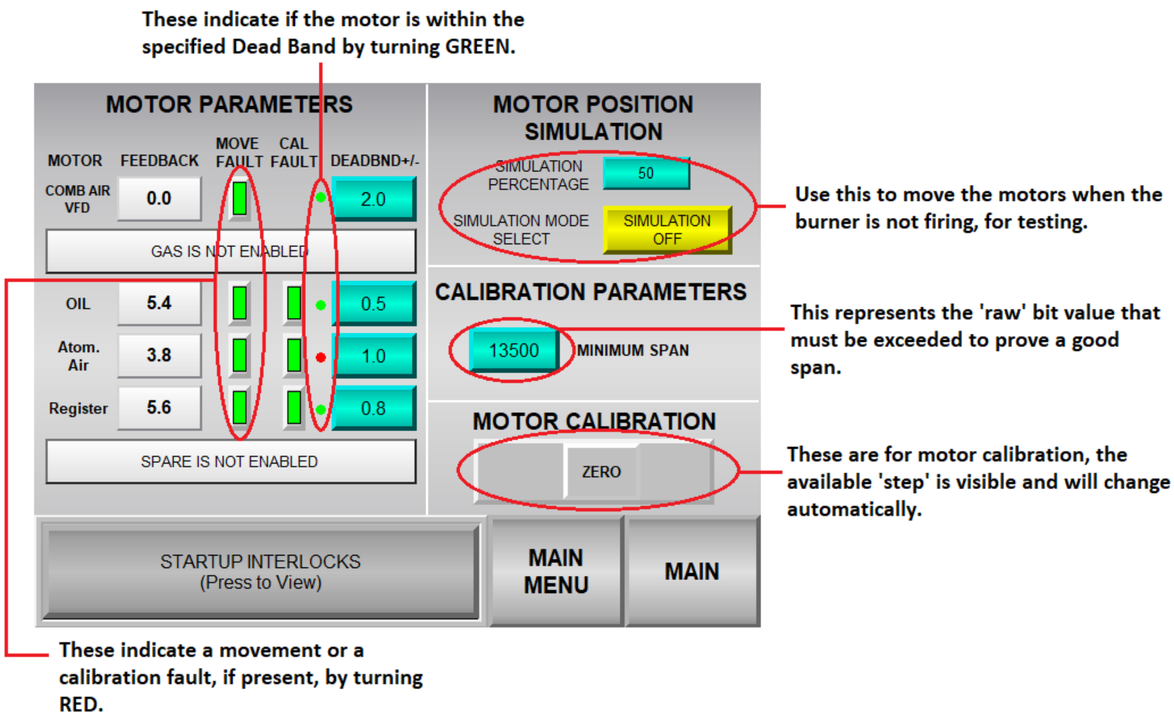
If a motor is not 'seen' to have moved more than 3% after a continuous drive command of 10 seconds, then a "Motor Move Fault" will be indicated.

After all of the motors have been calibrated, the motors can be installed and coupled to the controlled components.

3.3.3 The motors/control elements can be moved to any position if the Simulation Mode is selected. This is done by pressing the "Simulation Mode" button on the upper right side of the screen (*you must be logged in and the burner must be off*). The motors will move to the position that is set with the numeric entry button above the Simulation Mode button.

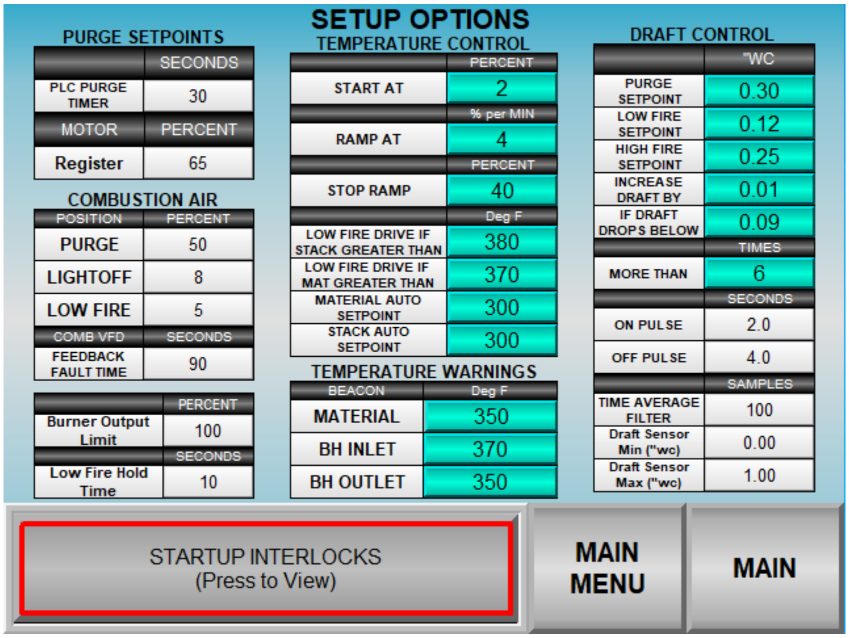
This function can be used to check the movement of the coupled motors and the control elements, and to ensure proper operation.

Press the Simulation Mode button again to exit from the Simulation Mode.



4. CONTROLLER CONFIGURATION

4.1 **SETUP THE CONTROLLER CONFIGURATION** by entering the Controller Setup screen; from here most of the controller system set points can be changed. These settings include the following…



The Blue numeric entry panels represent unlocked settings, the White numeric display panels represent locked settings, you must be logged in to adjust the White panels. A Red rectangle around the "Startup Interlocks" button indicates that a safety limit is not satisfied…press this panel to view the Startup Interlocks Quick View popup.

4.1.1 PURGE SETPOINTS

PLC PURGE TIME: This is the time (in seconds) that the blower will run with the air related control elements at their 'Purge Position' set points during the initial purging period. This is a separate time setting than a 'HBCU' purge time that would be integral to certain Burner Control Units. The ABMS utilizes the Honeywell RM7800 series burner controllers; some versions have a separate purge time that occurs after the initial purge and the ignition sequence is started. The base ABMS version does not require a separate 'HBCU' purge sequence.

REGISTER MOTOR PURGE POSITION: This setting represents the position that the Register/Spin Vane Motor will move to during the initial purging phase. If the motor name/ID is changed in the Motor Selection screen then, the given name/ID will appear here.

4.1.2 COMBUSTION AIR SETTINGS

PURGE: This is the position/output that the Combustion Air Motor/VFD will move to during the initial purging phase. If the VFD and the Louver Box is used then, the Louver Box will also move to this position during the initial purging phase.

LIGHTOFF: This is the position/output that the Combustion Air Motor/VFD will move to after the initial purging phase is completed; this position will be held until the Main Flame Stabilization Period has expired.

FEEDBACK FAULT TIME: This setting represents the amount of time that the PLC will wait for the Combustion Air VFD (*if enabled*) to reach its commanded speed. If the VFD does not reach the commanded speed after this time has elapsed then, the burner will shut down and initiate a "Combustion Air Feedback Fault". This should be set to 5 seconds longer than the Accel/Decel Time that is set in the VFD. (ex. If the VFD Accel and Decel is set for 45 seconds; set the Fault Feedback Time for 50 seconds)

BURNER OUTPUT LIMIT: This setting represents the maximum allowable firing rate, relative to the profile setup.

LOW FIRE HOLD TIME: This setting represents the Main Flame Stabilization Period. The burner will hold at Low Fire after the ignition period has elapsed to allow the main flame to become established and stable before modulation begins.

4.1.3 AUTO RAMP SETPOINTS

START AT: This setting represents the output demand that the burner will start at if the Auto Ramp function is enabled after an initial start or subsequent restart.

RAMP AT: This setting represents the amount of output change that will occur every minute when the Auto Ramp is enabled after an initial start or subsequent restart.

STOP RAMP: This setting represents the output rate that will automatically disable the Auto Ramp function if the Auto Ramp function has been enabled; once the burner reaches this demand value it will move to the output demand that is determined by the PID algorithm, if "Automatic Control" is selected. If "Manual Control" is selected then, the output demand will hold at this setting until the operator selects a different demand setting.

The Auto Ramp function can be disabled before startup if the operator chooses to warm the unit manually. The Auto Ramp function can also be disabled at any point during the warming process, after the initial startup has been initiated.

4.1.4 LOW FIRE DRIVE SETPOINTS

LOW FIRE DRIVE IF STACK GREATER THAN: If the Stack/Baghouse Inlet temperature exceeds the value entered here, the burner will automatically drive to low fire. The burner will return to the output demand it was at before this action was initiated, once the Stack/Baghouse Inlet temperature is reduced by 20 degrees F.

LOW FIRE DRIVE IF MATERIAL GREATER THAN: If the Material temperature exceeds the value entered here, the burner will automatically drive to low fire. The burner will return to the output demand it was at before this action was initiated, once the Material temperature is reduced by 20 degrees F.

MATERIAL AUTO SETPOINT: This setting represents the temperature the Material will be controlled to maintain while in Automatic Material Modulation Mode.

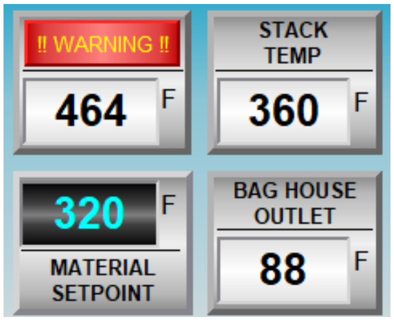
STACK AUTO SETPOINT: This is the temperature the Stack/Baghouse Inlet will be maintained at while in Automatic Stack Modulation Mode.

4.1.5 TEMPERATURE WARNING SETPOINTS

MATERIAL: This setting represents the temperature, at which, the warning beacon will appear on top of the Material Temperature Indication Panel that is in the Main Operations screen.

BH INLET: This setting represents the temperature, at which, the warning beacon will appear on top of the Stack/Baghouse Inlet Temperature Indication panel.

BH OUTLET: This setting represents the temperature, at which, the warning beacon will appear on top of the Baghouse Outlet Temperature Indication panel.



These warning beacons are only a visual warning indicating that the temperatures are approaching critical levels, if these temperatures continue to increase, the burner will automatically drive to Low Fire, trip the High Limit device or could cause critical damage to the Baghouse filters.

4.1.6 DRAFT CONTROL SETPOINTS

PURGE SETPOINT: This value represents the pressure that the drum will be held at during the initial purging phase, the setting is a positive number that represents a negative pressure (*i.e., a set value of 0.12 = -0.12"wc*).

LOW FIRE SETPOINT: This value represents the pressure the drum will be held at when the burner is in the ignition phase or, when the burner is firing, and the output demand is at Low Fire (0%). Again, the setting is a positive number that represents a negative pressure.

HIGH FIRE SETPOINT: This value represents the pressure that the drum will be held at when the burner is firing, and the output demand is at High Fire (100%). Again, the setting is a positive number that represents a negative pressure.

The drum pressure setpoint will change linearly between these two settings from 0%-100% demand (*i.e., if the Low Fire setting is 0.10 and the High Fire setting is 0.20 then, at 50% demand the setting will be 0.15)*.

INCREASE DRAFT BY: This setting represents the amount that the draft setpoint will increment if the Drum Pressure continues to drop below the **IF DRAFT DROPS BELOW** setting. However, it will only do this if the drum pressure does this over the **MORE THAN** amount of occurrence.

ON PULSE: This setting represents the amount of time, in seconds, that the exhaust damper or VFD will increase or decrease when the Relay control method is chosen for draft control and, the drum pressure is not at setpoint.

OFF PULSE: This setting represents the amount of 'pause' time, in seconds, when the exhaust damper or VFD is increasing or decreasing when the Relay control method is chosen.

If the exhaust damper/VFD needs to open to decrease the drum pressure then the damper/VFD will move for the ON PULSE time then pause for the OFF PULSE time, then repeat…until the drum pressure is at setpoint, if the Relay control method is selected.

TIME AVERAGE FILTER: This setting represents the amount of Drum Pressure (Draft) measurement samples are used to create an average readout, if the reading is erratic this setting can be increased.

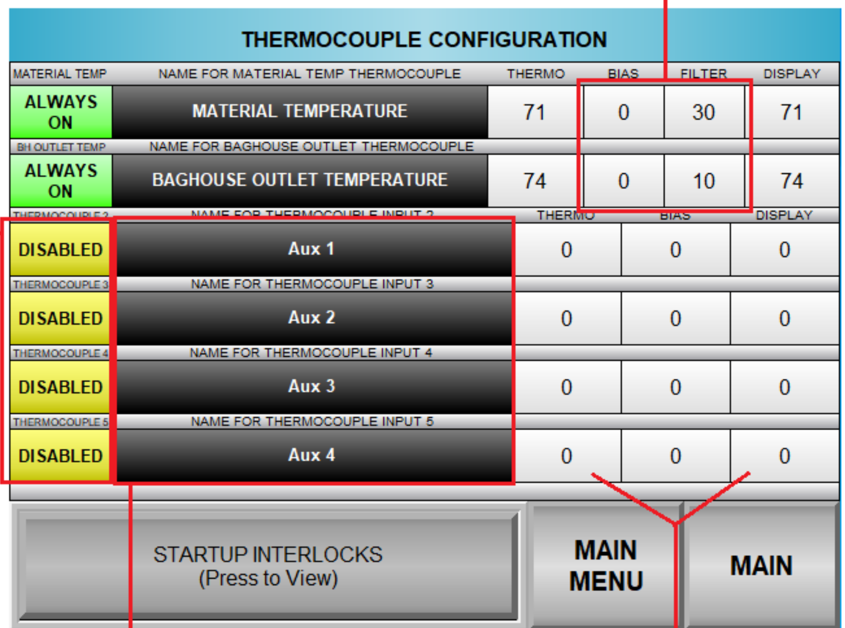
DRAFT SENSOR MINIMUM: This setting should be set to represent the minimum range of the Drum Pressure (Draft) sensor, this setting is in inches of water column ("wc) and is generally 0; some sensors may have a (-) value.

DRAFT SENSOR MAXIMUM: This setting should be set to represent the 'span' or 'range' of the Drum Pressure (Draft) sensor, this setting is in inches of water column ("wc); the maximum allowable range is 50"wc.

4.2 SETUP ANY EXTRA THERMOCOUPLES

Use these buttons to enable or disable the spare thermocouple inputs.

The 'FILTER' tabs are used for buffering any erratic readouts from these thermocouples. This is represented as "number of samples" used for the moving average, the range is 10-200 samples.



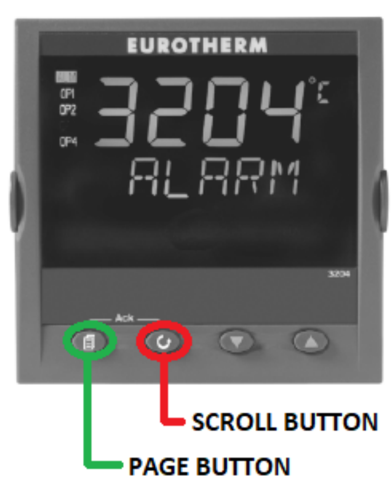
You must be logged in as ENGINEER to enable adjustment of the BIAS and FILTER settings.

Press the thermocouple NAME to set a unique name or ID for the spare thermocouple inputs, such as: AC Oil Temperature, Fuel Temperature, Silo Temperature, etc. These readouts can only be viewed from this screen.

The 'THERMO' tabs display the raw temperature, before the filters or bias is applied. The 'DISPLAY' tab shows what the final displayed temperature will be. Bias tabs are used to calibrate the final displayed temperature to compensate for any inaccuracies in the readout. Bias range is -50 to +50 degrees F.

4.3 SETUP AND RESET THE HIGH STACK TEMPERATURE LIMIT

The Exhaust High Temperature Limit (EHTL) device is a Eurotherm 3216i controller, the setpoint for the High Stack Temperature is made at this device. The following is a basic description of the device setting and lockout reset.



The **Page** button is used to move through the available Menu Pages. The available Menu Pages vary depending on the access level that is currently enabled. To change the High Stack Temperature setpoint you must access User Level 2.

The **Scroll** button is used to 'scroll' within the Menu Pages, in order to view and select configuration parameters.

Use the 'Up' and 'Down' buttons to adjust the parameter values.

To acknowledge and, reset an alarm state, press the **Page** and **Scroll** buttons together, simultaneously.

4.3.1 **CHANGING THE HIGH STACK TEMPERATURE SETPOINT** requires the operator to access User Level 2, follow the steps below to access Level 2.

Operator Level 2

Level 2 provides access to additional parameters. It is protected by a security code.

To Enter Level 2

1. From any display press and hold .
2. After a few seconds the display will show:-

3. Release .
   (If no button is pressed for 45 seconds the display returns to the HOME display)
4. Press or to choose LEu 2 (Level 2)

5. After 2 seconds the display will show:-

6. Press or to enter the pass code. Default = '2'

7. If an incorrect code is entered the indicator reverts to Level 1.

Then press the **Page** button, over and over, until “A1 High” is in the lower display. From here, you can adjust the setpoint; press the **Scroll** or **Page** buttons to accept the change.

4.3.2 **TO RETURN TO THE MAIN OPERATORS PAGE** you will need to place the control back to User Level 1, to do this press and hold the **Page** button until “GOTO” is in the lower display; use the arrow keys to change the upper display to **Lev 1** then, press the **Scroll** button. *No access code is required when moving to lower access levels.*

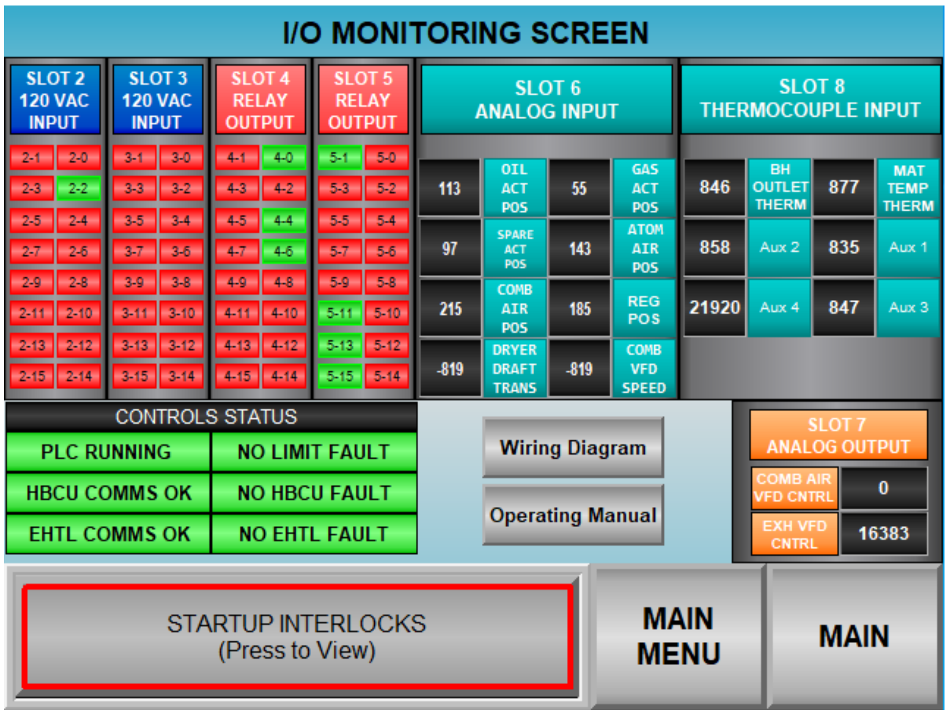
5. EXPLANATION OF SCREENS AND DATA

OTHER SCREENS: AVAILABLE INFORMATION AND NAVIGATION

There are a few other screens that have not yet been mentioned however, these screens offer numerous ways to monitor the operations and conditions of the system components. Knowing what information is available and noting observations over time, will help the operator to develop an understanding of the nominal operating conditions.

Being able to understand the information available will also aid in troubleshooting any system operation anomalies or faults that may be encountered. The information available can greatly reduce troubleshooting time and therefore, reduce downtime, if the operator knows how to properly interpret and utilize this information.

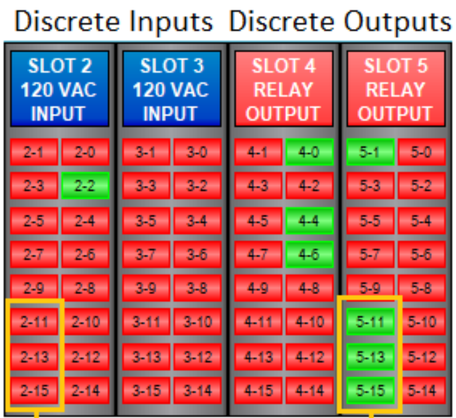
5.1 I/O STATUS SCREEN



The I/O Status screen can be accessed by pressing the **I/O REF SCREEN** button that is within the **MAIN MENU**. From this screen you can monitor the status of all of the input and output modules, as well as monitor the communications status between the PLC, the Honeywell Burner Control Unit (HBCU) and the Exhaust High Temperature Limit (EHTL).

You can also see if there are any current system faults that are being recognized by the PLC.

As an added benefit to the operator, the wiring diagram and the Basic Operations Manual are available for viewing on the display.



RED: For Inputs = No input detected. For Outputs = Not energized, no output.

GREEN: For Inputs = Input is detected. For Outputs = Energized, output given.

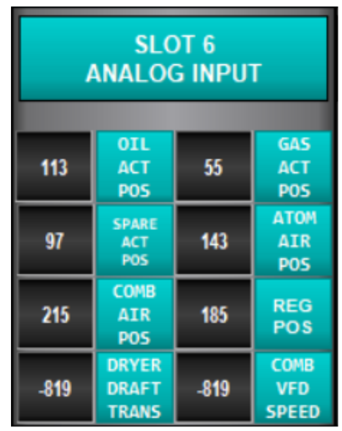
The Discrete (On/Off) Inputs and Outputs can be monitored via the graphics shown here.

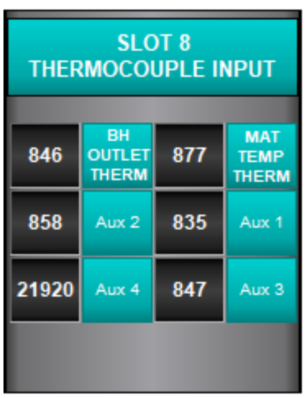
You can observe the live 'state' of the input/output by observing the indicators color, Green = Power Present, Red = Power Not Present.

The number in the icons represent the module's slot number and the channel number (i.e., 5-11= Module in Slot #5, channel 11).

If there is a module fault, or a failure to connect to the module, all of the indicators will be greyed out, if this is observed the module and PLC needs to be checked.

The Analog Inputs can be viewed from this panel, it indicates that the AI module is located in slot #6.

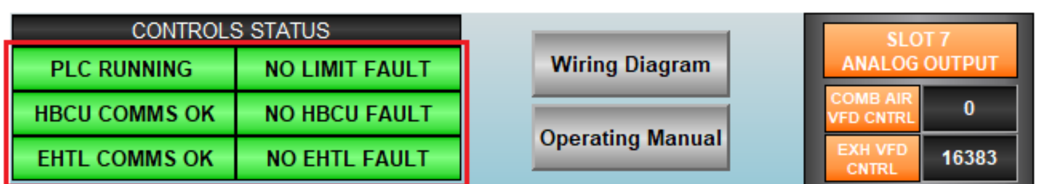




The Thermocouple Inputs from the TC module, located in slot #8, can be viewed from this panel.

The numerical values represented in the AI panel are 'raw' binary count values. The top 6 are positional feedback signals from the control motors, these are 0-5Vdc. The bottom 2 are signals from the Draft Sensor and the feedback from the Combustion Air VFD, these are 4-20mA.

The TC input values are in Degrees F, with no decimal point. For example, 846 = 84.6 F…21920 = 2,192.0 F.



These panels indicate status.
GREEN = Condition is Good, No Fault
RED = Unsatisfactory Condition, Fault

These panels display the Analog Output to the VFDs;
0 = 4 mA (0%)
16383 = 20 mA (100%)

ONBOARD WIRING DIAGRAM AND OPERATING MANUAL

Pressing the "Wiring Diagram" or "Operating Manual" buttons located in the IO monitor screen will open a PDF viewer and the selected document will be viewable and navigable.

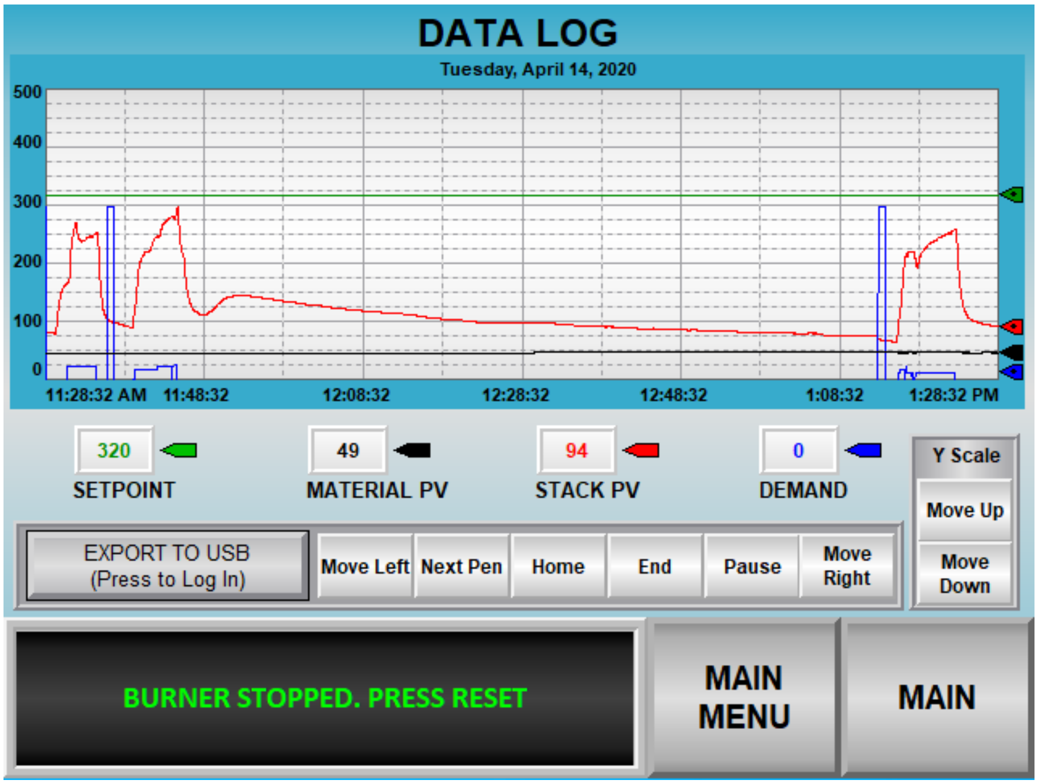
You can change to the next page by swiping your finger from right to left, or the previous page by swiping from left to right. Double tapping the screen will allow you to zoom in and out.

To close the document just press the X (*Screen Close*) button in the upper right hand corner.

5.2 DATALOG SCREEN

The Datalog screen displays a graphical representation of the Material Temperature Set Point, Material Temperature, Stack (*baghouse inlet*) Temperature and the Firing Rate Demand along a historical trend. The trend is recorded to the USB stick that is provided with and installed in the back of the display.

The trends can be viewed from the display by using the navigation buttons and, the trends can be exported to the USB stick and downloaded to a PC for viewing with file viewer software.



Move Left: Pressing this button will scroll the trend to the right, to view older data. If you keep the button depressed the screen will continue to scroll.

Next Pen: Changes the scale of the graph (Y-axis) to represent the channel of the same color. For example, the scale is Black when representing the Material PV pen, Blue for the Demand.

Home: This will bring the trend to the first record in the current trend history. Every time you export data to the USB a new trend history is started.

End: This will bring the trend back to the current, most resent, record in the trend history.

Pause: This button will stop the trend auto-scroll so you can evaluate a portion of the trend without the graph advancing, press any of the movement buttons to un-pause the graph.

Move Right: Pressing this button will scroll the trend to the left, to view newer data. If you keep the button depressed the screen will continue to scroll.

Move Up: This will raise the upper end of the currently selected pen's scale, zooming out of the trend for that particular pen.

Move Down: This will lower the upper end of the currently selected pen's scale, zooming in to the trend for that particular pen.

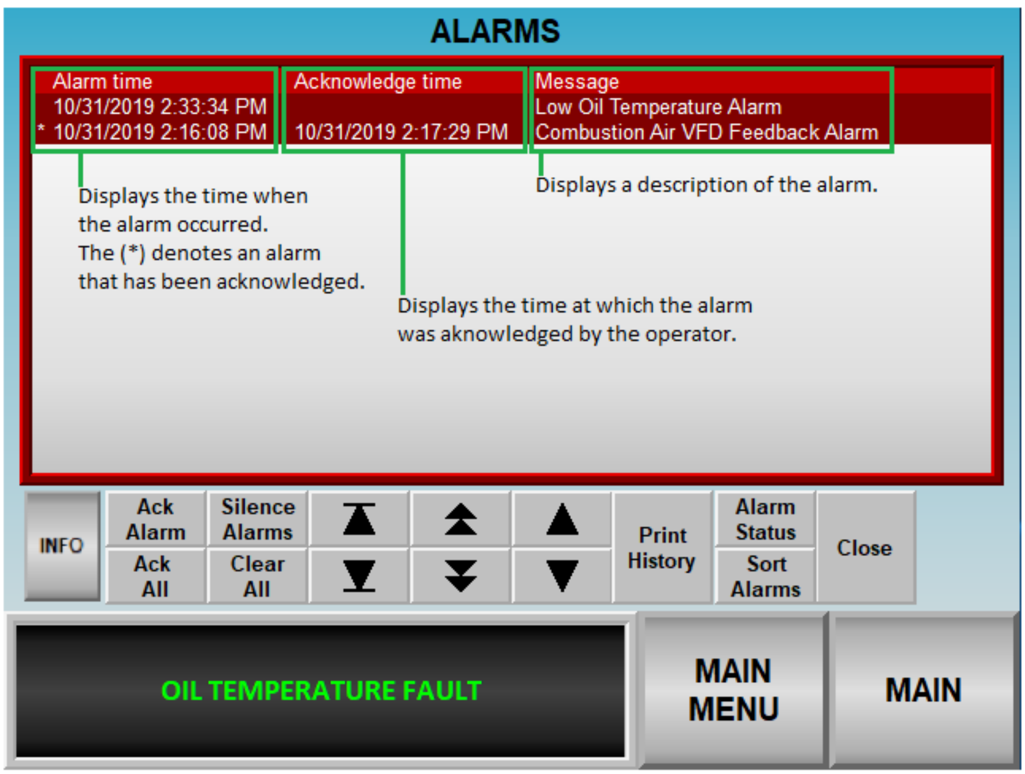
EXPORT DATA LOG TO USB: Pressing this button will bring up another popup window that will ask you to confirm that you want to shut the runtime application down and export the trend to the USB. Once the display shows the Display Configuration Screen the USB can be removed to download to a PC. Then, place the USB back in the display and select “Run Application” to start the runtime program which will return you to the Main screen after a reboot.

****Doing this will not shut the PLC or the Burner off and the burner will run just as it was before the export, all safeties are still functioning. However, it is better to do this when the burner is NOT firing since you will not be able to view data until the display program restarts.*

5.3 ALARM HISTORY SCREEN

The Alarm History screen records any of the critical faults or, any limits opening at any time when the burner is in operation, this includes the Pre-Purge, Ignition and Firing phases. Any faults or limits that open during the Standby phase will not be logged in this history however, the alarm or limit will be annunciated via the message bar at the bottom of all of the screens.

This is done so the alarm log will not be overpopulated with nuisance faults or trips during setup, calibration, or testing. The alarm horn and lamp will still be energized, and the alarm will need to be silenced/reset in all phases, even in Standby.



INFO: Pressing this button will open a pop-up window that will display a Diagnostics Log that is generated by the HMI, the messages here relate to display operating system or communication errors.

Arrow Buttons: Pressing these buttons will allow you to scroll up and down, one entry at a time or, one page at a time or, jump to the most recent or the oldest entry in the log.

Ack Alarm: Pressing this button will acknowledge the selected entry.

Ack All: Pressing this button will acknowledge all of the unacknowledged entries.

Silence Alarms: Silences the audible alarm in the display, if available. This does not silence the alarm horn in the panel, you must press the Alarm Silence pushbutton on the panel to do this.

Clear All: Pressing this button will erase all of the current history and clear the log.

Alarm Status: This button will bring a pop-up screen that will show the currently selected entry in a different format.

Sort Alarms: Pressing this button will rotate the log from latest entry on top to earliest entry on top.

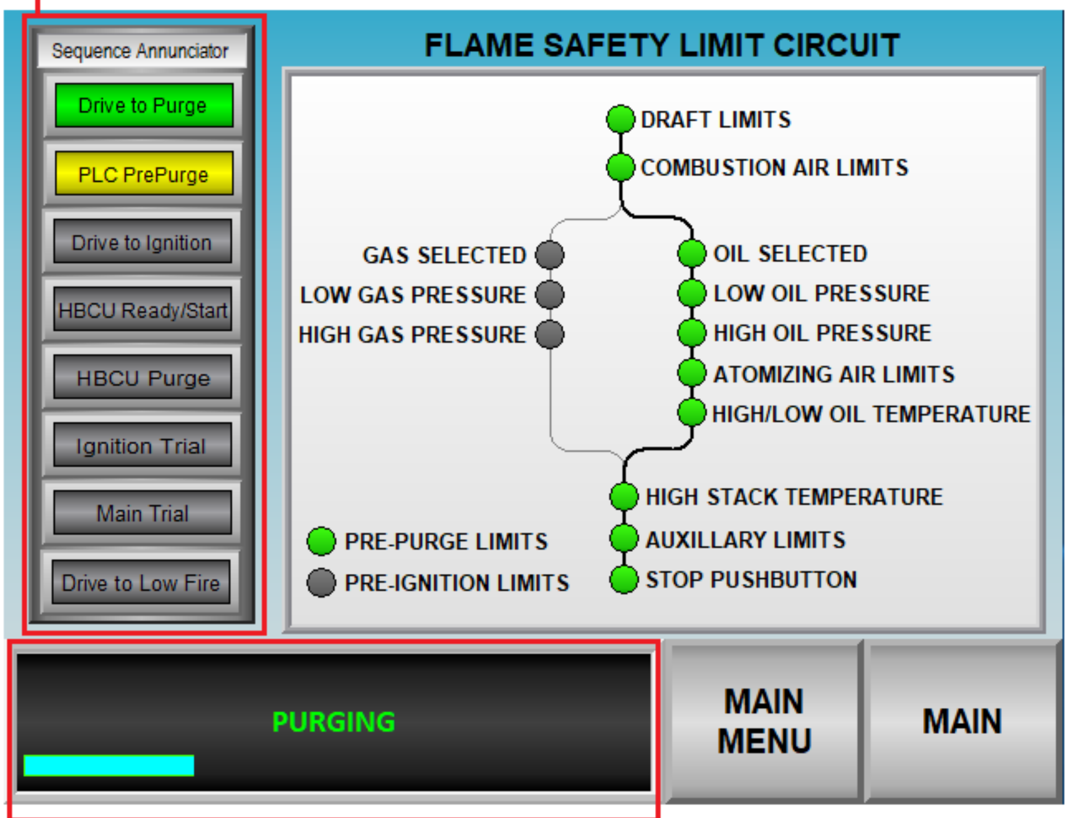
Close: This button will close the Alarm History Log and return you to the screen that was active when the alarm occurred. You can alco close the log by pressing the MAIN or MAIN MENU buttons, which will return you to those selected screens.

5.4 LIMIT CIRCUIT SCREEN

This screen is accessed by pressing the LIMIT CIRCUIT button in the MAIN MENU screen. From this screen you can monitor each individual flame safety limit in the circuit. The graphical representation is identical to the wiring scheme.

The operator can also monitor the phase sequencing to know which step the controller is in at all times. If a fault condition exists, the operator can use this data to help aid in troubleshooting by knowing which phase the faults are occurring in.

The Sequence Annunciator indicators will turn YELLOW to indicate that the controller is waiting for conditions to be satisfied before the indicated phase can begin.
They will turn GREEN when the conditions have been met and the controller is currently in the indicated phase. They will stay green if the phase is completed and the next sequence indicator will turn YELLOW to indicate the controller is trying to enter the next phase.



The local message display will indicate which limit has opened and will also indicate the phase it is in, in all screens.
There is also a progress bar that indicates the purge time progression, during the initial purge.

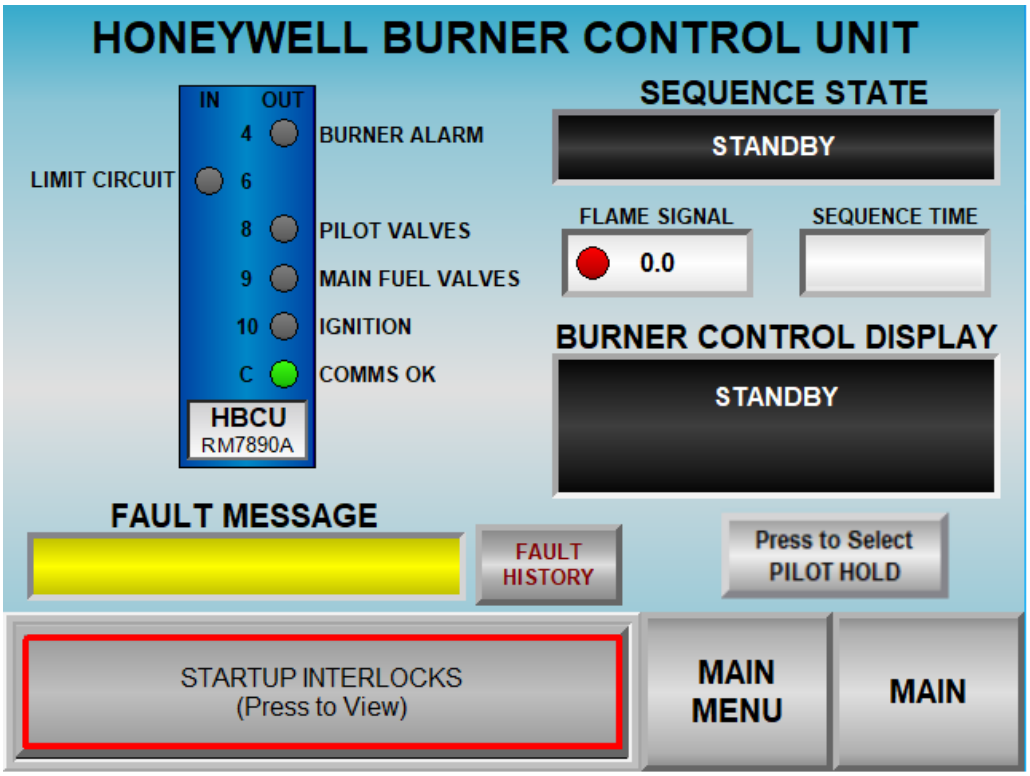
The Limit Circuit is a First-Out arrangement, the first lamp out is the unsatisfied limit.

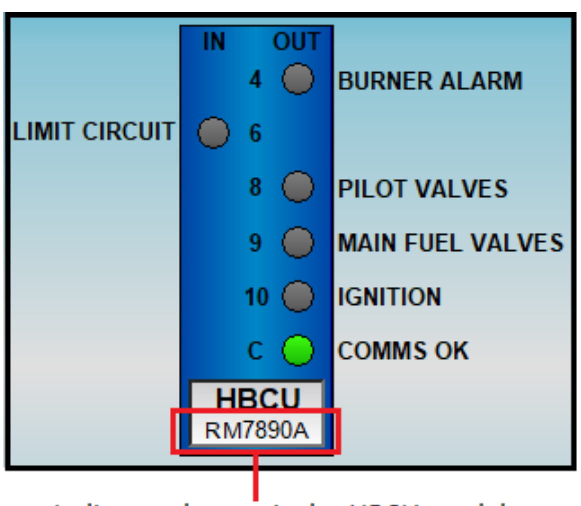
5.5 BURNER CONTROL UNIT SCREEN

This screen can be accessed by pushing the HONEYWELL BURNER CONTROL button in the MAIN MENU screen. From here you can monitor the status of the HBCU (flame safeguard) and recall the fault history stored within the HBCU.

There is button for placing the burner in a “Pilot Hold” state. When activated, this will pause the burner in the Pilot Ignition phase with only the pilot gas valve being energized after flame has been proven. Deselect the Pilot Hold to resume main flame ignition. This function is useful for pilot flame adjustment and ‘sighting’ of the flame sensor.

The flame signal can also be monitored here as the live, raw value seen in the flame safeguard. There is an indicator next to the flame signal that easily relays Bad (RED), Poor (YELLOW) and Good (GREEN) flame signal strength.





Indicates the particular HBCU model

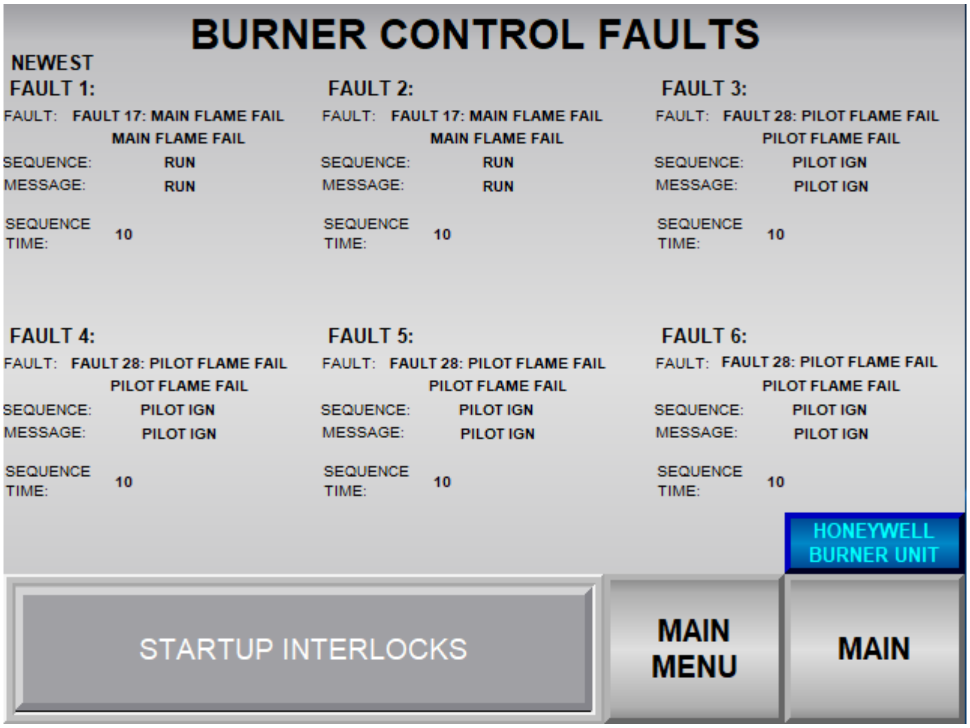
The HBCU detail displays and indicates the Flame Safety Limit (Call for Heat) input and all of the HBCU direct outputs.

The indicators will turn GREEN if the input (120VAC) is detected or, if an output (120VAC) is energized.

The numbers next to the indicators represent the actual terminal numbers on the subbase of the HBCU unit itself.

There is also an indicator to show that the MODBUS communications to the PLC are working.

You can access the HBCU internal fault history by pressing the FAULT HISTORY button next to the FAULT MESSAGE display window.



This is the HBCU internal fault history.

This historical log stores the 6 most recent faults related to the operation of the HBCU, with FAULT 1 being the most recent.

You can return to the HBCU detail screen by pressing the blue HONEYWELL BURNER UNIT button.

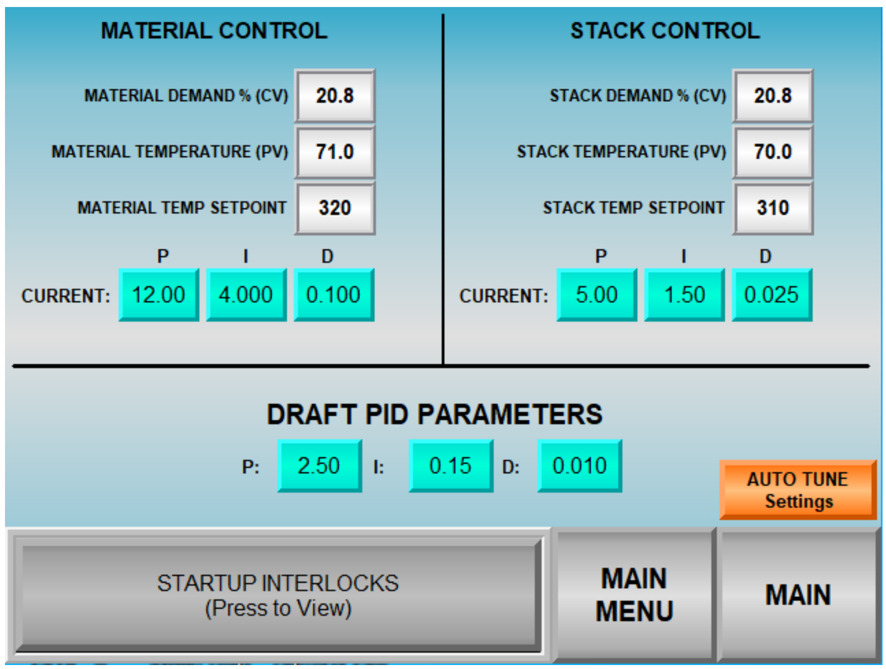
5.6 CONTROL LOOP TUNING SCREEN

This screen can be accessed by pressing the CONTROL LOOP TUNING button on the MAIN MENU screen. From here the operator can view the control loop tuning parameters (PID) and adjust them if needed.

The ABMS has **3** individual control PID loops: The Material temperature control algorithm, Stack temperature control algorithm and the Drum pressure (draft) control algorithm. All 3 of these loops have completely independent parameters that need to be set properly to allow for optimum control of the burner firing rate and drum pressure.

The ability to perform an Auto Tune of the PID parameters for the 'Material' and the 'Stack' temperature control algorithms is provided to aid in the initial process *tuning*, if needed.

See section 8 of this manual for a detailed explanation of the control loop tuning options that are available.

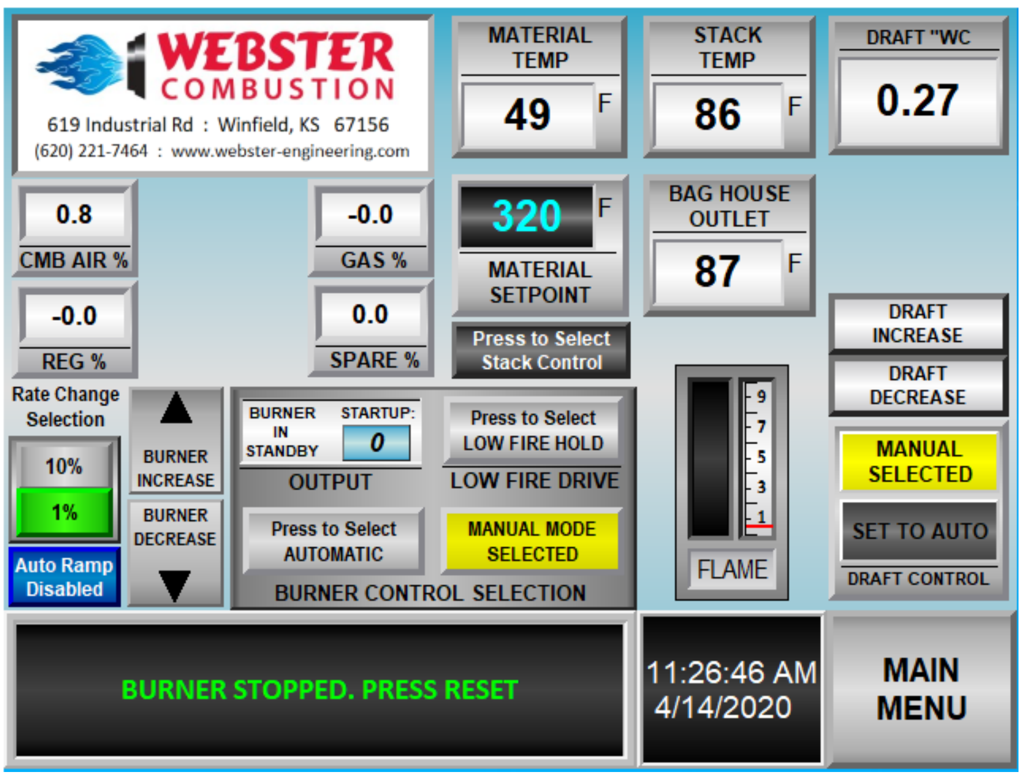


6. MAIN SCREEN OPERATIONS

This 'Main Screen' is where all of the main operations of the burner are performed.

From this screen the operator can…

- view the Material, Stack and Baghouse Outlet temperatures
- view and adjust the Material or Stack Temperature Setpoints
- choose to modulate based on Material or Stack temperature
- choose to manually control the Burner Firing Rate
- view the Drum (Draft) pressure
- view and adjust the Drum (Draft) Pressure Setpoint
- choose to manually control the Drum (Draft) Pressure
- choose to use or ignore the Auto Ramp-Warming function
- set the startup Low Fire position
- force a Low Fire Hold status
- view the control motor positions
- view the Flame Signal Strength
- view the sequence status/controller phase
- view fault messaging
- view system time and date
- go to the main settings menu



6.1 TEMPERATURE CONTROL MODE SELECTION AND SETPOINT

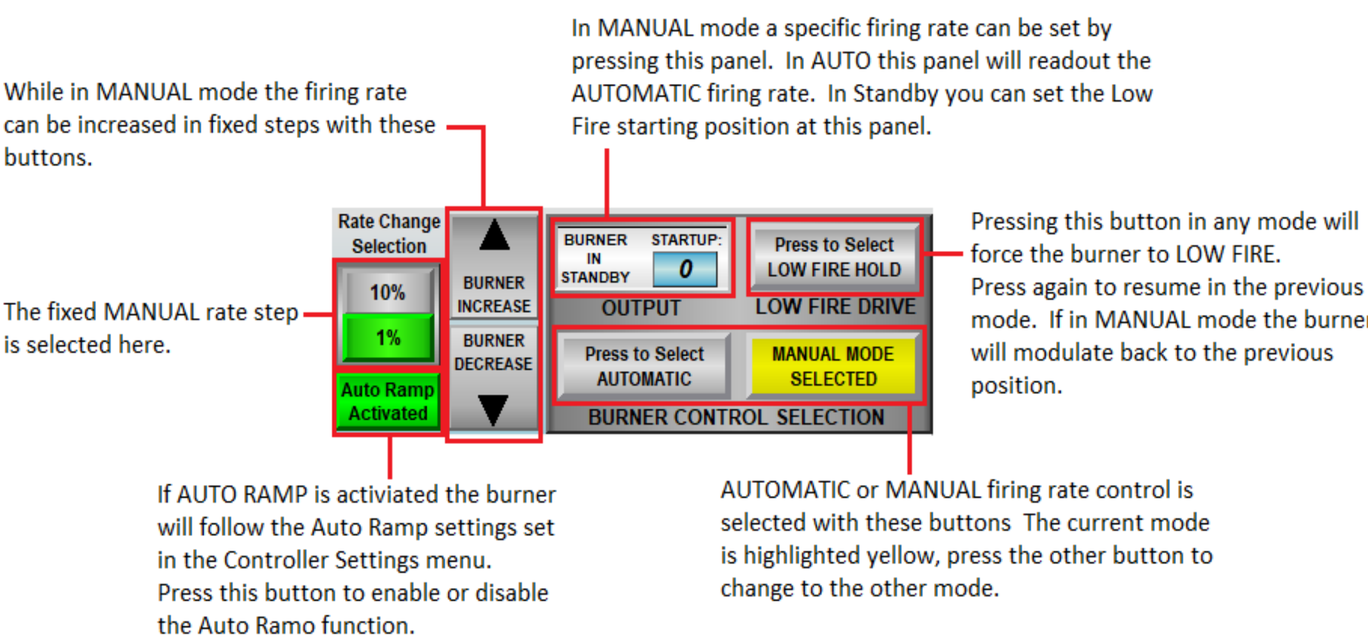
The option to use the MATERIAL temperature or the STACK temperature as the source to justify the automatic fire rate modulation is selected with the button that is located under the Material/Stack Temperature Setpoint panel.

When the Material temperature is the current selection then the text "MATERIAL SETPOINT" appears in the setpoint panel and the text of the pushbutton will state "Press to Select Stack Control". Pressing this button will change the Temperature Control Mode to Stack and the text in the setpoint panel will change to "STACK SETPOINT", the button will now state "Press to Select Material Control"; the indicated setpoint is for the selected control source.

Pressing the setpoint panel digits (blue) will open a numerical entry panel, from here you can adjust the setpoint of the current temperature mode (*setpoints can also be adjusted in the Controller Setup menu*).

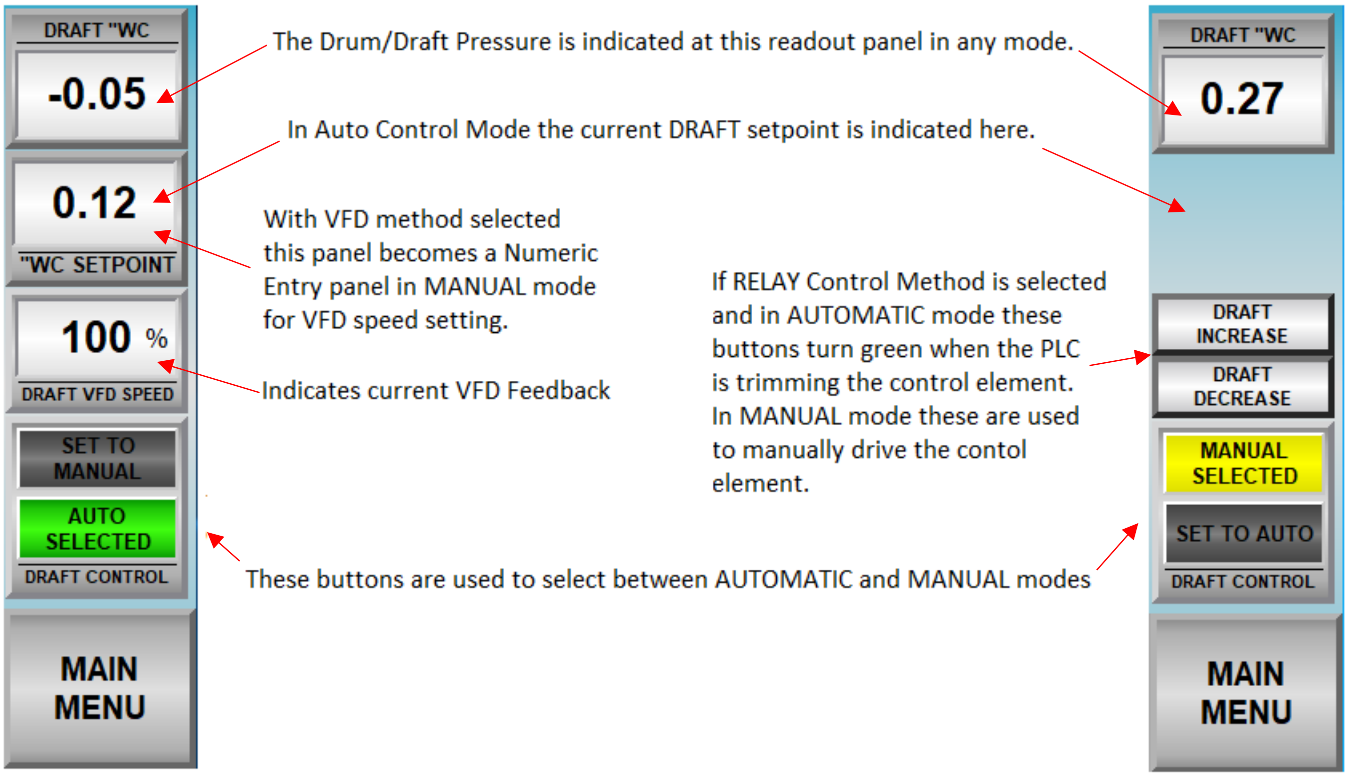
6.2 FIRE RATE CONTROL (DEMAND) SELECTION AND SETPOINT

The option to run the burner in the AUTOMATIC fire rate control mode, the MANUAL fire rate control mode or the forced LOW FIRE HOLD mode are all done with the buttons within the Fire Rate Control panel.



6.3 DRAFT CONTROL MODE AND SETPOINT

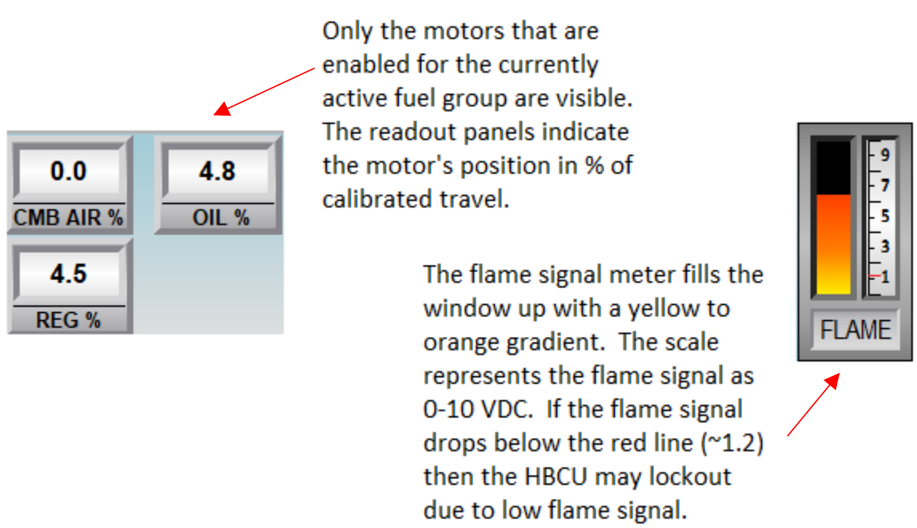
The AUTOMATIC or MANUAL operation of the Drum/Draft pressure control element can be done from the Draft Control panel. There are two different Draft Control panels, the one that is visible depends on the Control Method selected in the Motor Configuration menu.



VFD METHOD SELECTED **RELAY METHOD SELECTED**

6.4 MOTOR POSITION AND FLAME SIGNAL INDICATION

The currently active servo motors are visible on the Main screen and will change depending on the Fuel group selected. If a position fault or calibration fault occurs with a motor, that motor's position readout panel will turn RED, and a message will show up in the message bar.



7. COMBUSTION PROFILE SETTINGS

The Combustion Profile setup in the ABMS is quite simple. The profile is set by entering 12 position values for each control element, except for the Combustion Air Motor/VFD, for every 10% step in the load demand profile.

The load Demand is representative of the burner firing rate and has a range of 0-100%. The Combustion Air Motor/VFD (*which ever method is selected*) follows this 0-100% demand profile relative to 0-100% of the Combustion Air control element's calibrated, range…that is the reason there are no adjustments to be made in the Combustion Correlation Settings menus for the Combustion Air element. The only position settings to be made for this element are the Purge, Light Off and Low Fire positions; found in the Controller Settings menu.

There are a couple of guidelines that must be known to understand how the Correlation settings function.

1st: The ABMS must be placed in Manual Rate Control to properly perform combustion tuning.

2nd: The positions of the motors must always increase as the demand increases along the profile.

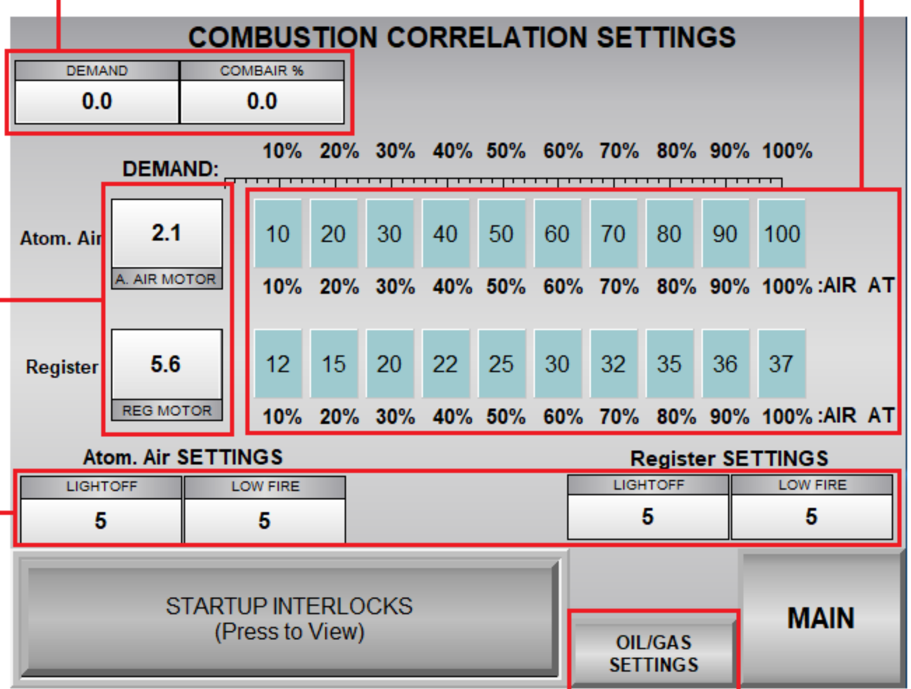
3rd: There must be a minimum of 1% movement from one demand step to the next.

4th: The Lightoff positions can be higher or lower than the Low Fire positions.

The 'Demand' represents the current Firing Rate Demand. The 'COMBAIR%' represents the current selected Combustion Air Controlling element's position feedback.

The position a motor should be in, relative to the Combustion Air Position, is set in these numeric entry panels. You must be logged in to make any changes to these settings.

The current position of the motors are shown here.



The Lightoff and Low Fire positions for the motors are set in these numeric entry panels. The Lightoff positions can be higher or lower than the Low Fire positions but, the Low Fire positions should be lower than the 10% settings.

These buttons change between the available motor setting pages, if the Louver Box/Axilliary servo motor is not enabled, the button is not visible (*as in picture above*).

7.1 COMBUSTION PROFILE DETAIL

A correlation position setting can be made before moving to that DEMAND rate, while the burner is firing or with the burner off.

When the position setting is changed in the panel that is at the current DEMAND rate, or if the actual DEMAND rate is between two of the 10% step panels, the motor will move after the new setpoint has been entered. This is due to the interpolation routine in the ABMS logic.

The combustion profile in the ABMS is set through an interpolation table that is generated as the correlation settings are made during the combustion tuning.

These positions are set for Lightoff, Low Fire and for every 10% step in the firing rate (*DEMAND*). The position the motors must be in when at a rate that lies between two of these points is interpolated by a linear calculation using the values of the point lower and the point higher in the correlation settings.

For example, if the setting of the Register Motor is 20% (*position*) for a firing rate of 30% (*DEMAND*) and the position of the motor is set at 30% (*position*) for a firing rate of 40% (*DEMAND*) then, the motor will be commanded to 25% (*position*) when the firing rate is at 35% (*DEMAND*). If the firing rate were at 32% (*DEMAND*) the motor would be commanded to 22% (*position*).

Therefore, if the burner is running and firing at a rate of 35% and the point for the 30% or, the point for the 40% DEMAND rate is changed then, the motor will move to the newly calculated setpoint after the new setting has been entered.

7.2 TYPICAL COMBUSTION PROFILE COMMISSIONING – PREPARATION AND PRESETS

!!! ONLY QUALIFIED TECHNICIANS SHALL ATTEMPT TO PERFORM COMBUSTION PROFILE SETUP AND TUNING !!!

All burner and application data needs to be available and should be studied before commissioning is started. In particular the burner's expected gas supply volumes and pressures, gas manifold pressure, any fuel oil data, nozzle pressures for fuel and atomizing air, required fuel and air supply volumes and pressures, drum/draft pressures.

Some other critical data to gather would be controller setpoint related. What will be the material/stack temperature and draft pressure setpoints? What are the required limits setpoints for the temperatures and pressures? What are abnormal values for these that need to be avoided while commissioning?

It is important to install all measuring devices that will be needed to facilitate burner combustion tuning BEFORE moving forward with any adjustments. At a minimum, this should include the following…

- **Gauges and Manometers** to monitor and record the fuel and air pressures (*gas supply pressure, regulated gas pressure, burner gas manifold pressure, burner fan differential pressure/housing pressure, drum/draft pressure, oil supply pressure/temperature, atomizing air supply pressure, burner oil nozzle pressures (air/fuel*).
- **Combustion Flue Gas Analyzer** with O2 and CO cells as a minimum. NOx and SOx cells may be required depending on local environmental codes.
- **Amp Clamp Meter** to measure the Combustion Fan Motor current.

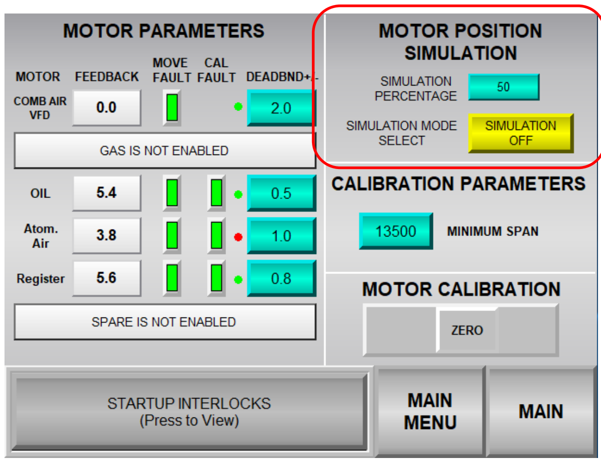
The Draft control element, Draft Sensor readings, the Draft control PID parameters and the Draft control settings should be checked before continuing with the combustion tuning; this is done with the Manual operating mode of the Draft control on the Main Screen. These should be verified to be operating correctly before continuing since the Draft Fan will need to be operational while tuning.

If this is the first startup and initial tuning, then verify that all of the fans and pumps needed to operate the burner are rotating in the proper direction. Also, ensure that all of the control elements have been properly set, calibrated, and verified to operate properly throughout the entire movable range of the element. *See Section 1.8 of this manual.*

Before beginning the live fire tuning, the correlation settings that make up the combustion profile can be 'preset' to make the tuning easier and to maintain safe combustion when moving to the next correlation point.

To do this some trial will need to be done to find the best preliminary Lightoff positions by visually checking each element and moving the motors to observe the positional feedback from the motors when they are at a visually verified safe preliminary ignition position.

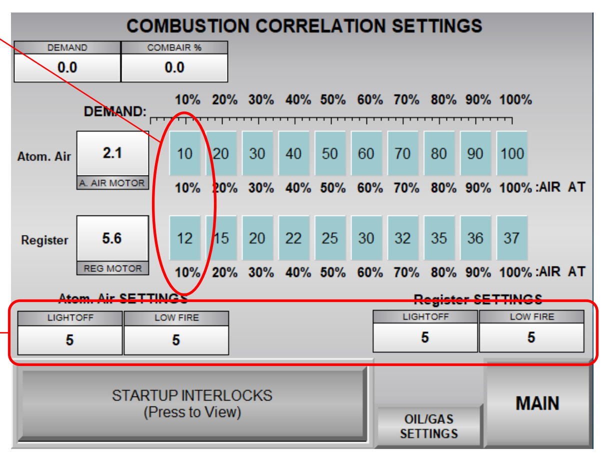
This can be done by enabling the Simulation Mode found in the Motor Calibration menu (*you must be logged in and the burner must not be stopped*).



*****If the Combustion Air VFD is enabled it must be running to operate in Simulation Mode.*****

With the simulation mode active, set the simulation percentage rate to 10%.

Now, you can use the 10% correlation setpoint panels in the Combustion Correlation Settings screens to move the motors to find where you want each control element to be positioned at light off, relative to the physical position of the elements.



Since the Combustion Air element is the controlling lead (*damper or VFD*) its position will be at 10% of the calibrated span (*due to the Simulation Demand Percentage being set at 10%*).

REMINDER*:* *the position of the Combustion Air element should always be equal to the DEMAND, or there is a feedback calibration issue that needs to be resolved.*

Therefore, if you are using a Combustion Air **DAMPER** (*Relay Motor Control Mode-no VFD*) and need to find the position you want to start the Combustion Air Damper at then you will have to adjust the Simulation Percentage set point to move the Combustion Air element (*generally you would do this one last*).

After finding the physical positions you want to start at, place these values in the Lightoff, Low Fire and in the 10% correlation setpoint panels (*the Lightoff and Low Fire settings for the Combustion Air are in the Controller Setup screen*). This will cause the burner to remain in the Lightoff position when it transitions to Low Fire and when you make your first move to the 10% rate while firing.

Next, preset all of the following points to 1% above the previous point. For example, if you find you want to start with the Gas control motor at 5% and the Register at 10%...then set the Lightoff, Low Fire and 10% correlation points for those motors to these settings. Then, set the 20% correlation point for the Gas to 6%, the 30% correlation point to 7% and so on…same with any other servo motors that are enabled.

While firing, as you make settings to the points (*moving up in rate*) the next point will automatically reset itself 1% higher and all of the following points will do the same. This procedure is done to prevent uncontrolled, unverified, movement of the motors when moving to the next point during initial combustion tuning.

When all settings have been made disable the Simulation Mode from the Motor Feedback Calibration screen.

The burner can now be fired, and some trial will have to be done to find the proper Lightoff positions for each element to ensure a proper, stable ignition of the pilot and main flames.

7.3 TYPICAL COMBUSTION PROFILE COMMISSIONING – LIVE FIRE TUNING

Before starting the combustion tuning process: place the burner in MANUAL FIRING RATE MODE, set the Startup Demand to 0% and disable the Auto Ramp feature; this is all done from the Main Operations screen. Also, it may be beneficial to place the control in PILOT HOLD MODE until your Lightoff position is established, this is done from the Honeywell Burner Unit screen.

Press the green START pushbutton when you are ready to proceed. The elements will move to the PURGE position and the PLC Purge Timer will begin to run when all elements and control motors are at their purge positions.

After the PLC Purge is complete the elements will move to the Lightoff positions, once the elements and control motors are at their Lightoff positions the HMI will inform you that it is ready to start the HBCU; press the green START pushbutton to begin the Ignition Trial phase.

With the PILOT HOLD enabled the Main Fuel Valves will NOT energize, this will give you freedom to adjust the pilot gas pressures, sight the flame sensor (*if possible*), and adjust the Lightoff positions of the elements.

When Lightoff looks good disable the PILOT HOLD; the Main Fuel Valves will open and the ABMS controller will enter the Main Flame Establishing phase for a few seconds. If the flame maintains retention and flame signals are good the controller will enter the Burner On phase. Now, you can adjust the Low Fire positions of the elements…remember that the Low Fire positions can be higher or lower than the Lightoff positions.

When moving the elements to work toward the next point in the combustion profile, move each one only a little at a time. Generally, you would lead with the air over the fuel in small steps, if there are issues with the flame signal dropping out while moving the air up then you may find leading with the fuel is better. Ensure that the burner is not going too rich by making smalls steps and monitoring your Combustion Flue Gas Analyzer.

With a good Low Fire established, enter all of the current control motor positions in the 10% correlation settings panels for each element, this will keep the burner at the Low Fire position when moving the demand to 10%.

REMINDER: *You will not have any correlation settings that will be made for the Combustion Air control element, it follows the demand %.*

Now, go to the Main Operations screen and change the DEMAND to 10%. You may now go back to each element and move them up slowly to the positions they need to be to represent 10% of the firing range. *You will notice that the other correlation setting panels will readjust themselves to stay 1% higher than the previous panel if the presetting was done as previously mentioned.*

When you are ready to tune the 20% position settings remember to make sure that the 20% correlation settings are not set too far away from the 10% position settings that you have just entered. You can always set the next positions correlations settings to just 1% above the previous position so that the burner does not move when changing the demand to the next position.

Go to the Main Operations screen and change the Demand to 20% when ready to move forward and repeat this procedure all the way up to 100%.

When all positions have been setup, run the burner back down the firing range by changing the Demand in 10% increments; this is done to ensure stability and repeatability. Then, move up and back down in 20% increments to ensure stability when making larger changes in rate.

The combustion profile tuning is now complete. Some fine tuning can be done at any point in the profile if needed. It may be beneficial to stop the burner and relight to ensure proper Ignition and Low Fire transition.

To finalize the commissioning of the burner the P.I.D. settings for the control loops may need to be adjusted to get stable automatic operation of the Material, Stack and Draft control loops, this is done from the Control Loop Tuning screen.

8. CONTROL LOOP TUNING

The ABMS controller utilizes up to 3 individually tunable process control loops to control the burner firing rate and the draft (*when setup for VFD draft control*) if the Automatic Firing Rate Control mode or the Automatic Draft Control mode is selected.

The VFD draft control mode can modulate the Draft Fan VFD referencing the Draft Pressure sensor. This control method utilizes an independently adjustable control loop. The P.I.D. parameters can be adjusted manually from the Control Loop Tuning screen.

The burner can modulate the firing rate automatically referencing either the Material Temperature sensor or the Stack Temperature sensor. Each of these control methods utilize separate control loops that are independently adjustable manually or an auto-tune algorithm can be used to estimate the P.I.D. parameter values.

8.1 CONTROL LOOP TUNING DETAIL

Control loop tuning requires some knowledge of **P**roportional, **I**ntegral and **D**erivative (P.I.D.) action terms with regard to how these parameters influence the final output from the controller to the controlled element.

The elements referred to in this section would be the DEMAND (*firing rate*) and the Draft Control VFD Speed command.

With regards to the burner firing rate modulation, these parameters affect how the DEMAND setpoint changes relative to the difference between the Material or Stack Temperature (*depending on mode*) and the current Temperature Setpoint. They also dictate how the DEMAND setpoint changes relative to how quickly the temperature is changing.

P.I.D. tuning is finding the settings for these three parameters that provide the best reaction and control of the output, known as the control variable (CV). This control calculation is made relative to the changes in what you are measuring, known as the process variable (PV), when compared to the setpoint variable (SP).

The difference between the SP and the PV is known as the error signal (*Err*), the error signal is represented as a percentage of the input span, which is (-)40 – 600 (640) in the ABMS logic. The ABMS control scheme calculates this error signal as SP-PV, therefore *Err* is a positive value when the PV is below the SP.

For example: a setpoint of 300 F = 53.125% of span, if the PV = 295 F that would be 52.344% of span, therefore *Err* would = 0.781% of span.

Some of the P.I.D. terms use *Err* for the calculation; some use the PV. The ABMS reacts to these terms in the following manner…

PROPORTIONAL TERM (K_P): This term refers to the 'throttling range' of the output. Basically, this represents the output value (CV) that will be present relative to the deviation from setpoint, excluding any other parameter's influence. This term uses *Err* for output calculation.

INTEGRAL TERM (K_I): This term refers to the reaction of the output relative to the time and direction of the PV deviation from the setpoint. Output is added or subtracted based on this setting when *Err* is either positive or negative.

DERIVATIVE TERM (K_D): This term refers to the reaction of the output relative to the direction and the amount of change in the PV% from one scan cycle to the next. Output is added or subtracted based on this setting whenever the PV is changing.

Some basic guidelines for P.I.D. tuning are relevant with any control system; some manufacturers react differently with the same values used for these parameters, but the reaction criteria are still fairly similar.

P-value (*Proportional Gain)*: With this parameter a lower value will produce a minor change in the control variable when the *Err* changes. Whereas a higher value will produce larger changes in the CV with the same change in the *Err*. This calculation is represented as $CV_{calc} = K_P \times (Err_n - Err_{n-1})$.

For example: If the SP = 300 and the P-value = 10 and the burner was running with the CV = 0 at PV = 300 then the CV = 7.81% if the PV were to change to 295 (*Err = 0.78125%*).

If the SP = 300 and the P-value = 2 and the burner was running with the CV = 0 at PV = 300 then the CV = 1.44% with the same change in PV to 295.

**This would be this reaction if the I-value and the D-value both = 0.*

I-value (*Integral Reset)*: With this parameter a lower value will produce a smaller change in the CV for every scan cycle the PV is deviating from the SP, whereas a higher setting will produce larger changes in the CV. There is an inherent dead band that is used to prevent the CV from constantly changing when it is near the SP, this dead band is +/- 0.2% of the SP.

There is also an algorithm that prevents this term from adding or subtracting CV when the CV limits have been reached, this is known as Integral Wind Up Prevention, and it stops integral action if the CV is at < 0% or > 100%. This calculation is represented as $CV_{calc} = (K_I/60 \times Err \times Delta_t)$ where $Delta_t$ = the scan time between samples in seconds).

For Example: Using the values as in the previous example (SP = 300 and the PV = 295), if the I-value is set to 0.25 then the Integral term will add 0.0016% to the CV for every sample period that the PV = 295.

If the I-value = 2.5 then the Integral term will add 0.1628% to the CV for every sample period that the PV = 295.

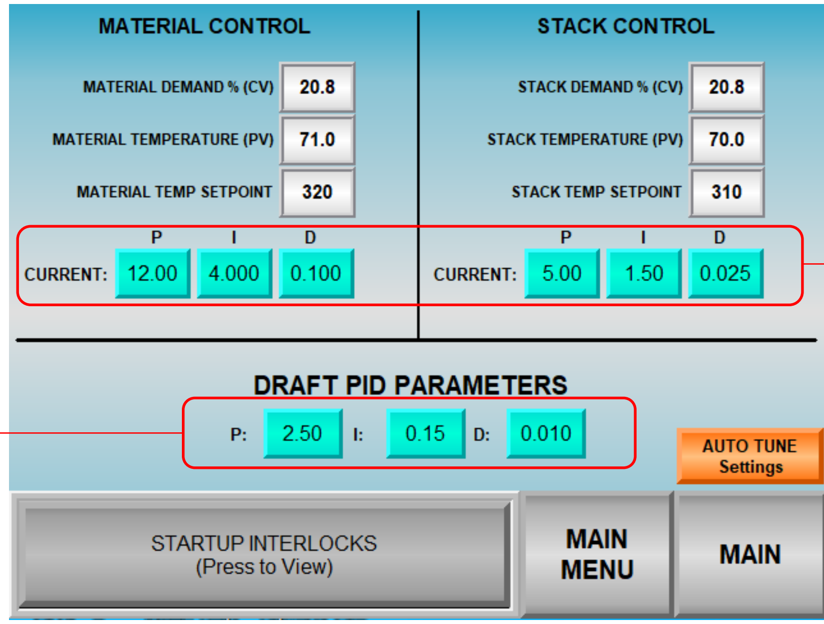
D-value (*Derivative Rate*): With this parameter a lower value will produce a smaller change in the CV when the PV is changing, whereas a higher value can produce a substantial change to CV with the same relative change in the PV. This value is generally very low, more than ¼ lower than the I-value. This parameter can cause CV oscillation if set too high however, this term uses the change in the PV% instead of the *Err* to help smooth any Derivative term spikes. This calculation is represented as $CV_{calc} = ((60 \times K_D) \times (PV\%_n - (2 \times PV\%_{n-1}) + PV\%_{n-2}) / Delta_t)$.

For example: If the PV is changing between sample periods the Derivative term will add or subtract CV, if the PV does not change Derivative action is not made.

If the D-value = 0.2 and the PV changes from 300 to 295 the CV will be increased by 0.192%. However, if the PV continues to drop to 290 in the next sample period the CV will increase by 37.488%. It is particularly important not to set this value too high or large Derivative spikes will occur.

With the ABMS, the D-value is used as an Anticipatory Pre-load to help prevent overshoot and undershoot in Material or Stack temperatures when a gap in material, or moisture fluctuations are experienced in long drums. This is generally due to the lengthy recovery time from heat input to the material and sensing at the thermocouple.

Below is the main Control Loop Tuning screen, from here you can manually adjust the P.I.D. parameter values and observe the reaction of the output (CV) relative to the PV changes of the Material or Stack Temperature Control modes…settings can be made live-on-the-fly however, you must be logged in to make any changes.

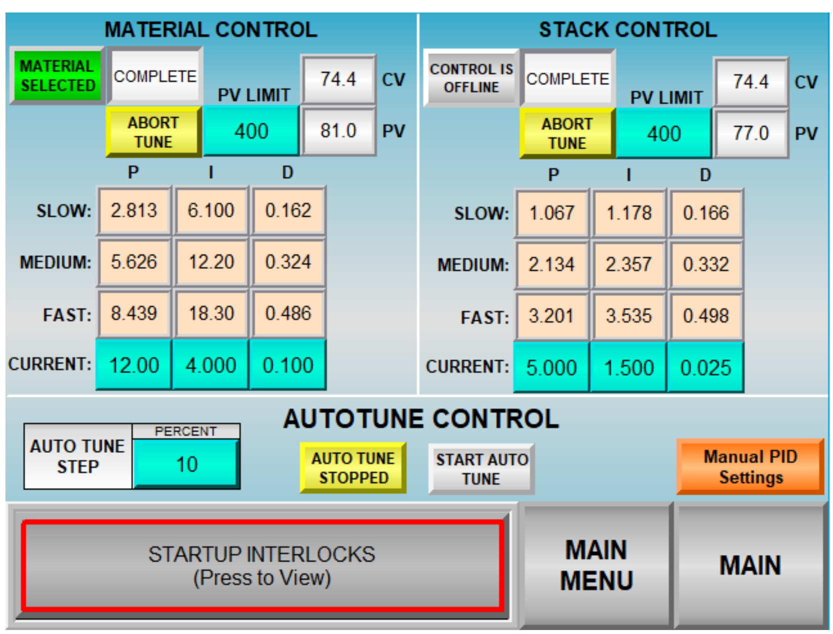


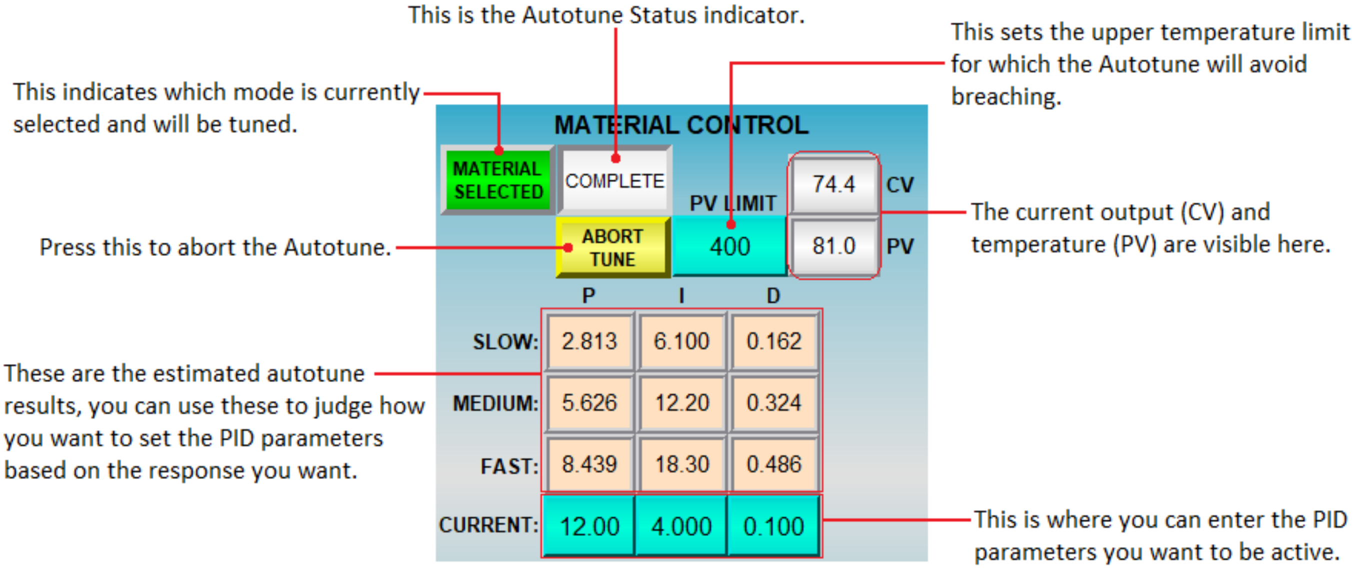
To observe how changes made to the Draft PID Parameters are affecting the Draft Control you will need to switch to the Main Screen and watch the Draft VFD Speed relative to the Draft Pressure readings from there.

Pressing the AUTO TUNE Settings button will bring you to the Material/Stack Temperature Control Autotune screen.

8.2 CONTROL LOOP AUTOTUNE DETAIL

Below is the Material and Stack Temperature Control Loop Autotune screen. From here you can run an automatic autotune on either the Material or Stack control depending on which control mode is selected. You must be logged in to access this screen AND the burner must be in Manual Modulation Mode for Autotune to be enabled.





Material/Stack Mode Selection: You can press these buttons to select between the Material or Stack temperature Autotune Mode. In the above example the Material Mode is selected, pressing this button in the Stack Control panel will switch to Stack Control mode and the indicator will change to green in the Stack Control panel.

Autotune Status: the Autotune Status indicator at the top of the Material/Stack Temperature panels will indicate the current phase of the Autotune process.

READY: This indicates that all criteria are satisfied, Autotune has never been performed and Autotune can be started.

BUSY: This indicates that the Autotune is in progress and currently trying to acquire data.

COMPLETE: This indicates that a successful Autotune has been done and data has been acquired.

ABORT TUNE: Press this button to abort (stop) an Autotune process if unsatisfactory burner operation is being observed.

PV LIMIT: This sets the upper temperature limit that the Autotune will try to avoid breaching by automatically aborting the Autotune process. Set this high enough to allow Autotune to work but low enough to prevent damage to the baghouse filters or sensors.

CV: This is a live indication of the current modulation output of the burner controlled by the Autotune process.

PV: This is a live indication of the current temperature. No matter the mode selected both Material and Stack Control panels will show the live current relative temperatures and burner output.

AUTOTUNE DATA: These panels show the results of the Autotune process once completed. They are grouped into three ranges of system response.

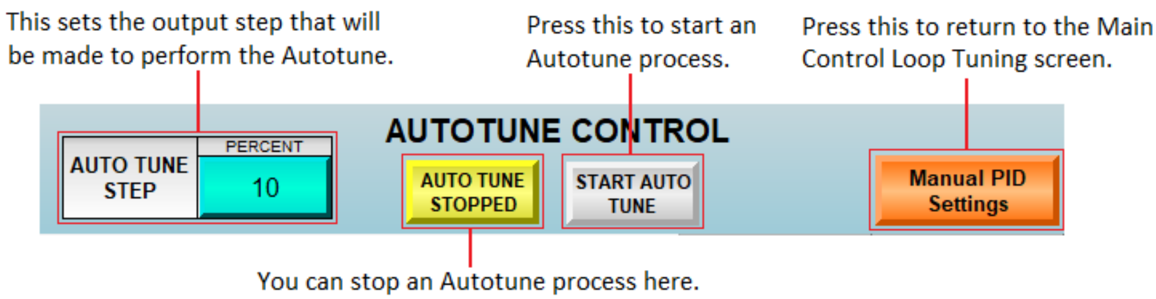
SLOW: These are estimated values that could be used for a 'slower' response to temperature fluctuations for slower reacting systems with long residence times.

MEDIUM: These are estimated values that can be used for 'normal' response to fluctuations. Generally used as a starting point or for systems with medium length drums that do not have long residence times.

FAST: These are estimated values that can be used for systems that need to react quickly to the temperature fluctuations, such as in short drums with short residence times.

These values are estimates and are there for the commissioning technician to use as guidelines, they are not placed into active use.

CURRENT: This is where the commissioning technician can enter the active PID parameter values to use for initial tuning. The Autotune values may be correct or close, it is generally required to perform some manual 'fine' tuning to get the system response to line out for best automatic operation.



*Stopping and Aborting the Autotune have the same effect, however Aborting may erase previous data.

AUTO TUNE STEP: This sets the amount of the ramp step that the Autotune process will make to perform the Autotune procedure. If the manual output is set for 20% and the AUTO TUNE STEP is set for 20% then, the burner will ramp up to 40% during the ramp phase of the Autotune process and back down to 20% when completed.

START AUTO TUNE: Pressing this button will start the Autotune process for the selected control mode, the button will change to green and state, "AUTO TUNE STARTED".

AUTO TUNE STOPPED: When the Autotune is started this button will change to gray and state, "STOP AUTO TUNE", the Autotune process can be stopped if this button is pressed when the Autotune is in process.

8.3 AUTOTUNE PROCESS DETAIL

When an Autotune process is started the Autotune Status panel will state, "BUSY" and the burner output will change from the currently set manual demand setpoint and move up in rate by the value set in the AUTO TUNE STEP setpoint panel. The burner will continue to fire at this rate until the temperature begins to level out or if an internal integrating calculation decides that the temperature will continue to increase.

During this Ramp Phase the Autotune process is gathering data points used to estimate the PID parameter values. After the Autotune decides it has acquired enough data points (*within a preset Autotune Time Period*) the output will return to the manual demand setpoint that was set before starting the Autotune.

At this time, the Autotune Status panel will state, "COMPLETE" if the Autotune was successful and the estimated Slow, Medium, and Fast parameter values are shown in the relative panels.

If the Autotune is manually aborted or there was an error and the Autotune automatically aborted the Autotune Status panel will state, "READY" and another Autotune may be attempted.

Reasons for the Autotune to automatically abort are generally due to a 'noisy' PV signal, PV limits being breached or the temperature taking too long change or to settle. If any changes are made to the manual demand output, switched to automatic control or changes made to the thermocouple bias settings the Autotune process will be aborted.

TIPS FOR A SUCCESSFUL AUTOTUNE

1. Select which control mode you want to Autotune before starting the Autotune process. Ensure the firing rate control is set for MANUAL mode and set the Manual Demand Rate where you want to start the Autotune. This should be 10%-20% rate and material should be moving through the drum to absorb the heat input.
2. Do not start an Autotune process unless the temperature has stabilized and is not ‘bouncing’ around too much.
3. Do not use an Auto Tune Step value less than 10, use a range high enough to get good data but not too high to cause a sharp rise in the temperature. Generally, 20-40 are good values to use depending on the material flow.
4. If the temperature is ‘bouncing’ too much then an investigation in the sensor, sensor wiring, and shielding/grounding needs to be done. The Material Thermocouple input has a filter that can be adjusted in the Thermocouple Configuration screen. The Stack Temperature input is supplied through the High Stack Temperature Limit control (Eurotherm 3216i), the filter time for this input is made within the Eurotherm controller parameters.

APPENDIX A: SYSTEM MESSAGES AND FAULTS

Following is a list of the available System Messages that can be displayed in the Local Message Display located in the lower left corner of all of the screens.

DISPLAYED MESSAGE	CONDITIONS FOR MESSAGE	POSSIBLE RESOLUTIONS/ACTIONS
BURNER STOPPED-PRESS RESET	The burner has been stopped by actuation of the STOP pushbutton.	Press the RESET pushbutton to reset the ABMS control.
READY TO START	All limits are satisfied, and the burner is ready to start.	Press the START pushbutton to begin the startup process.
MOTORS MOVING TO PRE-PURGE POSITIONS	The control motors are moving to their commanded pre-purge positions.	
CHECK PRE-PURGE LIMITS	The motors have reached their commanded pre-purge positions but, a mechanical pre-purge limit is not closed.	Check all of the gas and oil/LP safety shutoff valve proof-of-closure switches and all mechanical purge position limit switches and wiring.
PURGING	All control motors are at their commanded pre-purge positions and all pre-purge limits are satisfied; the burner is purging.	The purge time can be set in the Controller Setup screen.
MOTORS MOVING TO IGNITION POSITIONS	The control motors are moving to their commanded ignition positions.	
CHECK PRE-IGNITION LIMITS	The motors have reached their commanded ignition positions but, a mechanical pre-ignition limit is not closed.	Check all of the gas and oil/LP safety shutoff valve proof-of-closure switches and all mechanical ignition position limit switches and wiring.
PRESS START TO BEGIN IGNITION SEQUENCE	The control motors are at their commanded ignition positions and all pre-ignition limits are satisfied; the burner is ready to ignite.	Press the START pushbutton to begin the ignition sequence.
IGNITING PILOT	Pilot ignition trial is in process.	
PILOT HOLD ACTIVE	Pilot hold is currently activated.	Deselect the Pilot Hold in the Honeywell Burner Unit screen to advance to Main Flame Ignition.
MAIN FLAME IGNITION	Pilot flame has been proven; main flame ignition trial is in process.	
MAIN FLAME STABILIZATION-LOW FIRE HOLD	Pilot has been shut off and the control motors are moving to their commanded Low Fire positions; the sequence will pause for the duration of the Low Fire Hold Time.	The Low Fire Hold Time can be set in the Controller Setup screen.
BURNER RUNNING	Ignition sequence was successful, the burner is now in the RUN state.	
LOW FIRE SELECTED	Low Fire Hold has been selected in the Main Operations screen.	Deselect the Low Fire Hold in the Main Operations screen to allow burner to modulate.

DISPLAYED MESSAGE	CONDITIONS FOR MESSAGE	POSSIBLE RESOLUTIONS/ACTIONS
HIGH MATERIAL TEMPERATURE: LOW FIRE HOLD	The material temperature has breached the 'Low Fire Drive If Mat Greater Than' setpoint and the ABMS is forcing a Low Fire Hold state; burner modulation will be set to Low Fire.	The burner will automatically return to the previous firing rate demand once the material temperature drops 20 degrees below the 'Low Fire Drive If Mat Greater Than' setpoint. The Low Fire Drive If Mat Greater Than setting can be adjusted in the Controller Setup screen. Ensure adequate material flow for the fire rate DEMAND setting. If running in Manual Modulation Mode, reduce the firing rate DEMAND setpoint. Check that the fuel control element has not become uncoupled. Check the fuel delivery pressure.
HIGH STACK TEMPERATURE: LOW FIRE HOLD	The material temperature has breached the 'Low Fire Drive If Stack Greater Than' setpoint and the ABMS is forcing a Low Fire Hold state; burner modulation will be set to Low Fire.	The burner will automatically return to the previous firing rate demand once the stack temperature drops 20 degrees below the 'Low Fire Drive If Stack Greater Than' setpoint. The Low Fire Drive If Stack Greater Than setting can be adjusted in the Controller Setup screen. Ensure adequate material flow for the fire rate DEMAND setting. Ensure adequate draft is available. If running in Manual Modulation Mode, reduce the firing rate DEMAND setpoint. Check that the fuel control element has not become uncoupled. Check the fuel delivery pressure.
NOT ALLOWED WHILE BURNER IS RUNNING	A function was selected that cannot be performed while the burner is firing. This can be Motor Calibration or Simulation Mode selection.	Stop the burner to perform the desired process.
ZEROING	Motor Calibration is in process, control motors and Combustion Air VFD (*if enabled*) are moving to their closed/low speed positions.	After all feedback is stable at the closed/low speed positions the SPAN button may be pressed to continue the calibration process.

DISPLAYED MESSAGE	CONDITIONS FOR MESSAGE	POSSIBLE RESOLUTIONS/ACTIONS
SPANNING	Motor Calibration is in process, control motors and Combustion Air VFD (*if enabled*) are moving to their open/high speed positions.	After all feedback is stable at the open/high speed positions the OFF button may be pressed to complete the calibration process.
CONTROL MOTOR CALIBRATION REQUIRED	One or more of the enabled control motors is not calibrated or, the calibrated span is not wide enough.	Check the Motor Feedback Calibration screen to see which motor(s) are showing a Cal Fault. Ensure control motors and elements are not binding. Perform a control motor feedback calibration. The control motors must span higher than the Minimum Span setting in the Motor Feedback Calibration screen.
SIMULATION MODE ACTIVE	The Simulation Mode has been activated in the Motor Feedback Calibration screen.	The control motors can be moved while the burner is not firing when the Simulation Mode is active, the Combustion Air VFD must be running if selected. Deselect the Simulation Mode to enable burner operation.
FLAME DETECTED OUT OF SEQUENCE	There is a flame signal present during a phase when no signal is expected.	Check for faulty flame sensor. Ensure the flame sensor wiring is NOT ran in the same conduit as higher voltage wiring (>50 VAC). Check for line noise or interference that could be causing a false flame signal. Ensure that the flame sensor is not seeing another UV source such as excess sunlight. Check that there is not a flame present due to a leaking Pilot Fuel Valve or Main Fuel Valve.
FLAME RELAY RESET REQUIRED	The Honeywell flame safety controller (HBCU) is in a fault state and needs to be reset.	Go to the Honeywell Burner Unit screen to access the HBCU fault code and fault history to see why the HBCU is in the fault state. Press the RESET pushbutton to reset the HBCU.
EXHAUST AIR LIMITS FAULT	The exhaust air (draft) limits are not satisfied.	Ensure that the draft fan is running and there is adequate exhaust air flow. Check the Exhaust Air Proving limits.

DISPLAYED MESSAGE	CONDITIONS FOR MESSAGE	POSSIBLE RESOLUTIONS/ACTIONS
COMBUSTION AIR LIMITS FAULT	The combustion air limits are not satisfied.	Ensure that the combustion air fan is running and there is adequate combustion air flow. Check the Combustion Air Proving limits.
LOW GAS PRESSURE	The low gas pressure limit is not satisfied.	Check that adequate gas supply pressure is available. Check the Low Gas Pressure Switch, reset the switch if it a manual reset type. Check the wiring for the low gas pressure limit.
HIGH GAS PRESSURE	The high gas pressure limit is not satisfied.	Check the gas supply pressure, ensure it is not too high. Check the High Gas Pressure Switch, reset the switch if it a manual reset type. Check the wiring for the high gas pressure limit.
LOW OIL or LP PRESSURE	The low oil/LP pressure limit is not satisfied.	Check that adequate fuel supply pressure is available. Check the Low Oil/LP Pressure Switch, reset the switch if it a manual reset type. Check the wiring for the low oil/LP pressure limit.
HIGH OIL or LP PRESSURE	The high oil/LP pressure limit is not satisfied.	Check the fuel supply pressure, ensure it is not too high. Check the High Oil/LP Pressure Switch, reset the switch if it a manual reset type. Check the wiring for the high oil/LP pressure limit.
ATOMIZING AIR LIMITS FAULT	The atomizing air limit(s) is not satisfied.	Ensure the Atomizing Air Compressor is running. Ensure adequate atomizing air supply pressure and flow. Check the Atomizing Air Pressure Switch and wiring.
OIL TEMPERATURE FAULT	The fuel oil temperature limits are not satisfied.	Ensure the fuel oil heater is operational and the fuel oil is at an adequate temperature. Check the Low and High Oil Temperature Switches and wiring.

DISPLAYED MESSAGE	**CONDITIONS FOR MESSAGE**	**POSSIBLE RESOLUTIONS/ACTIONS**
HIGH STACK TEMPERATURE	The exhaust high stack temperature limit is not satisfied, the Eurotherm 3216i controller is tripped out.	Reset the Eurotherm 3216i High Stack Limit controller. Check the stack (baghouse inlet) thermocouple and wiring. Ensure adequate exhaust (draft) air flow.
AUXILIARY LIMIT FAULT	The auxiliary limit(s) is not satisfied.	Check any limits that are wired in the Auxiliary Limits circuit. Check the wiring of the auxiliary limits. Reset the devices if any of these are manual reset type.
DRAFT VFD FAULT	The draft fan VFD is in a fault state.	Check the draft fan VFD and wiring, reset the VFD if tripped out.
COMBUSTION AIR VFD FAULT	The combustion air VFD is in a fault state.	Check the combustion air VFD and wiring, reset the VFD if tripped out.
COMBUSTION AIR VFD FEEDBACK FAULT	The feedback from the combustion air VFD is not matching the speed command signal.	Ensure that the combustion air VFD is running. Check the parameter settings of the combustion air VFD to ensure the feedback is set for 4-20mA and represents the same range as the speed command input (*see section 3.2 of this manual for more information*) Check the wiring to the combustion air VFD.
GAS CONTROL MOTOR FAULT OIL CONTROL MOTOR FAULT ATOMIZING AIR CONTROL MOTOR FAULT SPARE CONTROL MOTOR FAULT (LOUVER BOX) REGISTER CONTROL MOTOR FAULT COMBUSTION AIR CONTROL MOTOR FAULT	The specified control motor failed to move more that 3% after a continuous drive command of 10 seconds.	Check that the control motor and element is not binding. Check the wiring to the control motor. Check the feedback potentiometer in the control motor. Check the control motor drive relays in the ABMS control panel. Check the control motor power supply fuse.

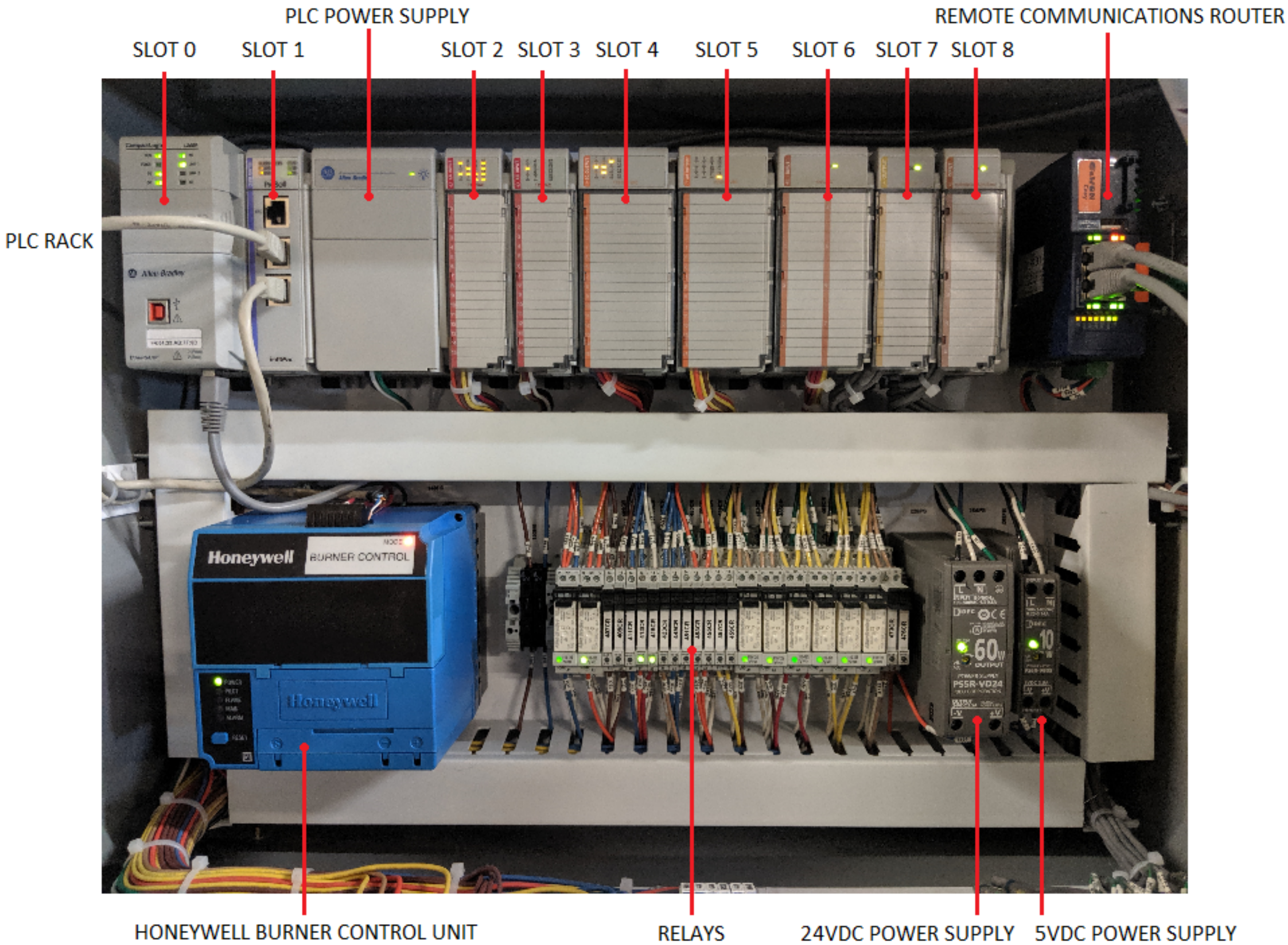
APPENDIX B: PLC RACK MODULES AND CHANNEL ASSIGNMENT

Below is a list of the PLC rack modules, their positions on the rack, the channel assignments for the modules and the channel details such as signal type and range.

RACK SLOT: CHANNEL NUMBER	CHANNEL ASSIGNMENT	MODULE/CHANNEL DETAILS
1769-L30ER CompactLogix 5370 Rack Slot: 0	**Controller Module**	**Allen-Bradley-v24.11**
MVI69-MCM Rack Slot: 1	**MODBUS Communications Module**	**Prosoft**
1769-IA16 Rack Slot: 2	**16 point 120VAC Input Module**	**Allen-Bradley**
Local:2:I.Data.0	Oil/LP Select	120 VAC
Local:2:I.Data.1	Start Pushbutton	120 VAC
Local:2:I.Data.2	Stop Pushbutton	120 VAC
Local:2:I.Data.3	Alarm Silence Pushbutton	120 VAC
Local:2:I.Data.4	Reset Pushbutton	120 VAC
Local:2:I.Data.5	Exhaust Air Limits	120 VAC
Local:2:I.Data.6	Combustion Air Limits	120 VAC
Local:2:I.Data.7	Flame On/Burner In Operation	120 VAC
Local:2:I.Data.8	Low Gas Pressure Switch	120 VAC
Local:2:I.Data.9	High Gas Pressure Switch	120 VAC
Local:2:I.Data.10	Low Oil/LP Pressure Switch	120 VAC
Local:2:I.Data.11	High Oil/LP Pressure Switch	120 VAC
Local:2:I.Data.12	Atomizing Air Limits	120 VAC
Local:2:I.Data.13	Oil Temperature Limits	120 VAC
Local:2:I.Data.14	High Stack Temperature Limit	120 VAC
Local:2:I.Data.15	Auxiliary Limits	120 VAC
1769-IA16 Rack Slot: 3	**16 point 120VAC Input Module**	**Allen-Bradley**
Local:3:I.Data.0	Pre-Purge Limits	120 VAC
Local:3:I.Data.1	Pre-Ignition Limits	120 VAC
Local:3:I.Data.2	Combustion Air VFD Fault	120 VAC
Local:3:I.Data.3	Exhaust Fan VFD Fault	120 VAC
Local:3:I.Data.4	Honeywell Burner Unit Alarm	120 VAC
1769-OA16 Rack Slot: 4	**16 point 120VAC Output Module**	**Allen-Bradley**
Local:4:O.Data.0	Gas Selected	120 VAC
Local:4:O.Data.1	Oil/LP Selected	120 VAC
Local:4:O.Data.2	Flame Safety Enable	120 VAC
Local:4:O.Data.3	Pilot Enable	120 VAC
Local:4:O.Data.4	Main Gas Enable	120 VAC
Local:4:O.Data.5	Main Oil/LP Enable	120 VAC
Local:4:O.Data.6	Pilot Scanner Enable	120 VAC

1769-OA16 **Rack Slot: 4**	**16 point 120VAC Output Module**	**Allen-Bradley**
Local:4:O.Data.7	Alarm Horn	120 VAC
Local:4:O.Data.8	Start Lamp	120 VAC
Local:4:O.Data.9	Reset Lamp	120 VAC
Local:4:O.Data.10	Internet Access Enable	120 VAC
1769-OA16 **Rack Slot: 5**	**16 point 120VAC Output Module**	**Allen-Bradley**
Local:5:O.Data.0	Gas Motor Increase	120 VAC
Local:5:O.Data.1	Gas Motor Decrease	120 VAC
Local:5:O.Data.2	Oil/LP Motor Increase	120 VAC
Local:5:O.Data.3	Oil/LP Motor Decrease	120 VAC
Local:5:O.Data.4	Atomizing Air Motor Increase	120 VAC
Local:5:O.Data.5	Atomizing Air Motor Decrease	120 VAC
Local:5:O.Data.6	Spare (Louver Box) Motor Increase	120 VAC
Local:5:O.Data.7	Spare (Louver Box) Motor Decrease	120 VAC
Local:5:O.Data.8	Register Motor Increase	120 VAC
Local:5:O.Data.9	Register Motor Decrease	120 VAC
Local:5:O.Data.10	Combustion Air Motor Increase	120 VAC
Local:5:O.Data.11	Combustion Air Motor Decrease	120 VAC
Local:5:O.Data.12	Exhaust Damper Motor Increase	120 VAC
Local:5:O.Data.13	Exhaust Damper Motor Decrease	120 VAC
1769-IF8 **Rack Slot: 6**	**8 channel Current/Voltage Analog Output Module**	**Allen-Bradley**
Local:6:I.Ch0Data	Gas Motor Position Feedback	0-5 VDC
Local:6:I.Ch1Data	Oil/LP Motor Position Feedback	0-5 VDC
Local:6:I.Ch2Data	Atomizing Air Motor Position Feedback	0-5 VDC
Local:6:I.Ch3Data	Spare (Louver Box) Motor Position Feedback	0-5 VDC
Local:6:I.Ch4Data	Register Motor Position Feedback	0-5 VDC
Local:6:I.Ch5Data	Combustion Air Motor Position Feedback	0-5 VDC
Local:6:I.Ch6Data	Combustion Air VFD Speed Feedback	4-20 mADC
Local:6:I.Ch7Data	Draft Pressure Transmitter	4-20 mADC
1769-OF4CI **Rack Slot: 7**	**4 channel Single Ended Current Analog Output Module**	**Allen-Bradley**
Local:7:O.Ch0Data	Combustion Air VFD Speed Command	4-20 mADC
Local:7:O.Ch1Data	Exhaust Fan VFD Speed Command	4-20 mADC
1769-IT6 **Rack Slot: 8**	**6 channel Thermocouple Input Module**	**Allen-Bradley**
Local:8:I.Ch0Data	Material Temperature Thermocouple	Type-J t/c
Local:8:I.Ch1Data	Baghouse Outlet Temperature Thermocouple	Type-J t/c

1769-IT6 Rack Slot: 8	6 channel Thermocouple Input Module	Allen-Bradley
Local:8:I.Ch2Data	Auxiliary t/c (configurable)	Type-J t/c
Local:8:I.Ch3Data	Auxiliary t/c (configurable)	Type-J t/c
Local:8:I.Ch4Data	Auxiliary t/c (configurable)	Type-J t/c
Local:8:I.Ch5Data	Auxiliary t/c (configurable)	Type-J t/c



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WEBSTER COMBUSTION TECHNOLOGY LLC.
STANDARD TERMS AND CONDITIONS

EXCLUSION OF OTHER TERMS
This constitutes an offer on behalf of Webster Combustion Technology LLC. (the Company) to sell the goods described in the quotation/acknowledgment (the Equipment) exclusively on the terms and conditions stated in the body of the quotation/acknowledgment and in these Standard Terms and Conditions. Acceptance of this proposal by the buyer (the Buyer) is hereby limited to these Terms and Conditions, whether stated in the Buyer's purchase order form or elsewhere shall be applicable to the transaction unless specifically agreed to in a separately written and signed letter by an officer of the Company at its headquarters in Winfield, Kansas, USA.

LIMITATIONS ON QUOTATION
Unless otherwise stated in the quotation, the quotation will remain open for acceptance for a period of thirty days after the date issued, at which time it will automatically expire unless extended by a signed, written letter issued by the Company from its headquarters in Winfield, Kansas, USA.

EQUIPMENT SELECTION
The selection of sizes, types, capacities, and specifications of Equipment purchased by the Buyer's specific application shall be the sole responsibility of the Buyer and/or the Buyer's representative or consultant.

PRICES
Unless otherwise stated in the quotation/acknowledgment, prices are F.O.B. Winfield, Kansas, USA, exclusive of freight, storage, installation, and local delivery charges, if any.

TAXES
In addition to the purchase price, Buyer shall be liable for all government taxes and/or charges in respect to the purchase and/or sale contemplated herein or hereunder (except taxes on or measured by net income on the Company) including those which the Company may be required to pay.

Buyer agrees to pay, indemnify, and hold harmless the Company for and against all liabilities, expenses, and damages in respect of any claim, action, or suit, proceeding, assessment, demand, and/or judgment arising in any manner from Buyer's failure or refusal to pay any government taxes and/or charges that are the responsibility of Buyer (whether pursuant to these Standard Terms and Conditions or otherwise).

Buyer further agrees that the Company may, in good faith, compromise and settle any claim, action, suit, proceeding, assessment, and/or demand upon the Company on account or by reason or refusal of Buyer to pay any government taxes and/or charges that are the responsibility of Buyer (whether pursuant to these Standard Terms and Conditions or otherwise).

PAYMENT
Unless otherwise stated in the quotation/acknowledgment, Buyer shall pay the full purchase price within thirty days after the date of shipment as evidenced by the Company's invoice. Beginning thirty days after the date of shipment, Buyer shall pay a late payment charge equal to the lesser of (a) One and One-half (1.5%) percent per month, which is an annual rate of eighteen (18%) percent and (b) the maximum amount allowable under applicable law, on any unpaid portion of the purchase price.

DELINQUENT ACCOUNT COLLECTION EXPENSES
In the event that Buyer fails to timely make any or all payments due to the Company, and in the event the Company incurs any expenses arising from the collection of Buyer's delinquent account, Buyer hereby agrees to pay, in addition to all other fees and charges, any collection expenses incurred by the Company. Collection expenses shall include the Company's fees for independent collection agencies, reasonable attorney's fees, costs of court, and other charges directly related to the collection of Buyer's account.

RETENTION OF TITLE; SECURITY INTEREST
The Company shall retain title to the Equipment, any replacements thereof, and any additions thereto, for purposes of security and title shall not pass to Buyer until the purchase price of all sums due under any order resulting from this quotation are fully paid. Buyer shall execute a financing statement (if requested by the Company) and other documents necessary to enable the Company to perfect its security interest in the Equipment. When Buyer has made all the payments called for herein including taxes and has fully complied with the other provisions of this quotation/acknowledgment, the Company shall immediately deliver to the buyer appropriate document evidencing the transfer of title and terminating the security interest.

SERVICE
Where the Company has agreed to provide a factory trained technician, the technician will assist the Buyer in the initial start-up of Equipment and the initial instruction of the Buyer's employees in the operation of the Equipment, and such services shall be supplied Monday through Friday, legal holidays excepted, 8 a.m. through 5 p.m. inclusive. Starting and/or field service shall not be supplied by the Company on days or at times other than those provided herein unless the Company agrees to do so in writing on Buyer's request, in which case the Buyer shall pay the Company the applicable overtime rate for the services. The Company shall not be responsible for any delays in start-up due to Buyer's failure to have Equipment completely installed and ready for operation, and provided with fuel, power, exhaust, coal, and other necessary connections, or failure to provide Seller with sufficient advance notice to meet Buyer's schedule. Buyer agrees to pay the Company for any added expenses it incurs as a result of Buyer's failure to have Equipment ready for start-up. Prices which include starting service of multi-unit installations are based upon this

SHIPMENT
Any shipping date shown in the body of the quotation/acknowledgment represents the Company's reasonable estimate on the date issued, and is not binding. The Company shall not incur any liability of any kind for failure to ship on any particular date unless a firm shipping date has been expressly agreed to by an officer of the Company in a separately signed written letter. Risk of all loss passes to Buyer when the Equipment is placed in possession of a common carrier. Claims against the carrier shall be the responsibility of the Buyer. Claims against the Company for patent defects, errors, or shortages must be made in writing to the Company within thirty days of receipt of the Equipment or such claims shall be deemed to have been waived.

CANCELLATION AND DELAYS
Subsequent to the date an order from Buyer has been acknowledged by the Company, Buyer may not change or cancel the order in whole or part, without the Company's written approval. When equipment has not yet become work in progress, the Company may condition its approval on a change upon a price change to reflect the Company's prevailing prices at the time of such change. If Buyer requests a delay in shipment after the Equipment has become work in progress, the Company may place the Equipment in storage at Buyer's risk and expense, and transfer to storage shall be deemed delivery for all purposes, including invoicing and payments. Cancellations approved by the Company may be conditioned on Buyer's payment of cost incurred by the Company prior to such approval, including engineering, tooling, material, labor, burden, profit, and commission and similar expense in connection with the order canceled.

WARRANTY MATTERS AND EXCLUSION OF IMPLIED WARRANTIES
The following warranty applies: All Products manufactured by the Company are warranted to be free from defects in material and workmanship under normal use and service for a period of eighteen months from the date of shipment or twelve months from the date of start-up, whichever should occur first. Products which are purchased by the Company and resold without further processing by the Company are not covered by the Company's warranty. The Company shall pass to the Buyer whatever warranty the Company receives on such products. The Company will repair or replace, at its option, its products which prove to be defective within the warranty period, F.O.B. the factory. The Company's warranty shall be voided by any abuse, misuse, or neglect of the products by use not in accordance with the Company's published instructions. The remedies for any failure of the Company's product to meet warranty specified herein shall be those remedies herein and no others, those remedies being exclusive remedies as a condition of sale irrespective of the theory upon which any claim might be based, including negligence, breach of contract or strict liability. IN ALL EVENTS, THE COMPANY WILL NOT BE LIABLE FOR AND WILL NOT REIMBURSE ANY LABOR, MATERIAL, OR OTHER REPAIR CHARGES INCURRED BY ANYONE OTHER THAN THE COMPANY ON ANY WARRANTY EQUIPMENT, UNLESS SUCH CHARGES HAVE BEEN SPECIFICALLY AUTHORIZED IN ADVANCE IN WRITING, BY THE COMPANY. THIS PARAGRAPH CONTAINS THE COMPANY'S SOLE WARRANTY.THE COMPANY MAKES NO IMPLIED WARRANTY, AND THERE IS NO IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE.

DAMAGE LIMITATION
Under no circumstances shall the Company be liable for any loss of profits, down time, or any incidental, consequential, special, punitive, exemplary, enhanced, or indirect damages of any kind with respect to its products or the transaction by which its products are sold. IN NO EVENT SHALL THE COMPANY'S AGGREGATE LIABILITY ARISING OUT OF OR RELATED TO THE EQUIPMENT OR THE TRANSACTION BY WHICH THE EQUIPMENT IS SOLD, WHETHER ARISING OUT OF OR RELATED TO BREACH OF CONTRACT, TORT (INCLUDING NEGLIGENCE), OR OTHERWISE, EXCEED THE TOTAL OF THE AMOUNTS PAID TO THE COMPANY WITH RESPECT TO SUCH EQUIPMENT.

EXCUSE
In no event shall the Company be liable for any loss or damage resulting from any delay or failure in shipment or other failure, loss or damage that is the proximate result of any act of government authority, revolution, riot, civil disorder or disturbance, act of enemies, delay or default in transportation, inability to obtain materials or facilities from normal sources of fire, flood, act of God, or any cause not within the reasonable control of the Company, whether of the class of causes enumerated or otherwise. Without limiting the generality of the foregoing, the Company may, without causing a breach or incurring liability, allocate goods which are in short supply irrespective of the reasons therefore among customers in any manner which the Company in its sole discretion deems advisable. If an event occurs that is beyond the control of the Company's performance and causes its cost of production to increase because of the delay, the Company may pass such increase on to the Buyer.

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