

Operating instructions and guidelines for normal startup, operation and shutdown of the furnace. Refer to chapter 1 to view operating instructions for optional equipment.

3.1 Furnace Operation

Daily operation of the furnace requires a routine start up procedure to assure long life of the furnace and to guard against premature failure. In particular, adequate gas flow should ALWAYS be established before turning on the heating elements to protect temperature sensitive components from excessive heat. This furnace is designed to operate effectively between 100-960C. To prolong lamp life, do not operate at zone temperatures above 1000 °C.

3.1.1 Furnace Controls

Furnace operation is controlled from the Furnace Control console (Figure 3-1) and the flowmeters on the Sample System console (Figure 3-2).



Figure 3-1 Furnace Control Console

Furnace zone environment sampling is controlled from the Sample System console and the oxygen analyzer (see Figure 3-2)

3.1.2 Retained Control Settings:

When power is shut off to the furnace control system, these settings are retained:

All zone controller parameters, values and settings (internal to controllers).

The belt speed setting (relies on knob position).

Energized lamp selections (relies on pushbutton position).

Gas flow settings (relies on knob position and supply gas pressure and selection).

The alert/alarm buzzer silenced status (relies on pushbutton position).




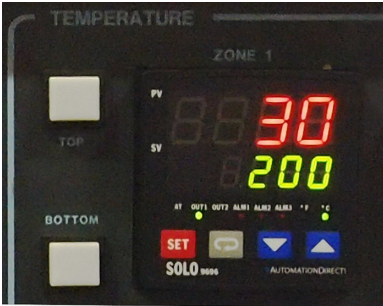





Figure 3-2 Sample System Console & Oxygen Analyzer

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3.1.3 Start Up Procedure (Cold Start – Power OFF, Lamps OFF)



Table 3-1 Cold Start Up	
Action	Comments / Changes
<p>1. Confirm main power is ON</p>	<p>If not on, turn on power to the furnace.</p> <p>Caution: Dangerous voltages and current are now present throughout the control enclosure and on lamp wire connections to the furnace lamps.</p>
<p>2a. Select Aux Gas and Furnace Gas</p> <p>The image shows a control panel titled 'SUPPLY GAS SELECT'. It has two large black lever valves. The left valve is labeled 'AUX GAS VALVE (GAS 1)' and is currently pointing to 'N2'. The right valve is labeled 'FURNACE GAS VALVE (GAS 2)' and is currently pointing to 'SINGLE GAS (GAS 1)'. There are also labels for 'CDA' and 'DUAL GAS (FG)'. Below the valves, there is text: 'IF AUX GAS VALVE=CDA, SET FURNACE GAS VALVE TO SINGLE GAS.' and 'IF AUX GAS VALVE=N2, SET FURNACE GAS VALVE TO SINGLE GAS OR DUAL GAS.'</p>	<p>Turn valve on SUPPLY GAS SELECT console to select N₂ or CDA gas for furnace auxiliaries. Then select SINGLE GAS to direct aux gas to furnace heating chambers and plenums; or select DUAL GAS to direct forming gas to furnace heating chambers and plenums.</p>
<p>2b. Turn on the process gas supply valves for the gases selected in 2a.</p>	<p>Verify that the supply gas pressure at the furnace for the selected gases is set to 70 psig. Adjust regulator pressure as necessary.</p> <p>CAUTION: Do not exceed 70 psig.</p>
<p>2c. Adjust flowmeters to desired flow for the product being fired.</p> <p>The image shows a row of flowmeters for an 'R.T.C. CU-915 INFRARED FURNACE'. From left to right, the flowmeters are: FURNACE VENTURI, ENTRANCE BAFFLE, FURNACE ZONE 1, FURNACE ZONE 2, PLENUM, TRANSITION TUNNEL TOP, TRANSITION TUNNEL BOTTOM, and COOLING. Each flowmeter has a scale in SCFH (Standard Cubic Feet per Hour) and a valve knob for adjustment.</p>	<p>Check each flowmeter and adjust valve knob on each to desired setting. Recheck all since individual level may interact with one another.</p> <p>WARNING: NEVER RUN THIS FURNACE WITHOUT PROCESS GAS. Assure an adequate supply of process gas is available at 70 PSIG at the furnace before energizing the lamps to avoid damaging the furnace chamber, seals, and/or heating elements.</p> <p>WARNING: Set LAMP PLENUMS to minimum 60 SCFH. Set LAMP PLENUMS to min of 80 SCFH or higher for temperatures above 400C.</p>
<p>3. Push white ON button on POWER panel</p> <p>The image shows a control panel with a blue border. It has a white button labeled 'ON' and a red button labeled 'OFF'. The word 'POWER' is printed in blue above the buttons.</p>	<p>Powers up the control system. Wait a few seconds for the zone controllers to initialize and display current zone and setpoint temperatures (Main Screen).</p>

Table 3-1 Cold Start Up

Action	Comments / Changes
<p>5. Confirm desired belt speed.</p>  <p>The image shows a control panel labeled 'TRANSPORT'. It has three indicator lights for 'IPM', 'CPM', and 'FPM'. A digital display shows the number '78' in red. Below the display are 'PAR', up arrow, and down arrow buttons, and a 'red ipm' logo. A large black knob is at the bottom.</p>	<p>Set using the TRANSPORT panel BELT SPEED knob. Turn knob CW to increase belt speed, CCW to decrease speed.</p> <p>Briefly examine the transport system, making sure the belt is operating smoothly.</p> <p>Note: Belt speed units are factory set to inches per minute (IPM).</p>
<p>6. Confirm desired setpoint temperatures</p>  <p>The image shows a control panel labeled 'TEMPERATURE'. It has 'TOP' and 'BOTTOM' pushbuttons. A digital display shows '30' in red (PV) and '200' in green (SV). Below the display are 'SET', 'SOLO', and navigation buttons. The text 'AUTOMATIONDIRECT' is visible at the bottom.</p>	<p>Press controller  or  keys to enter the setpoint temperature (green) for each zone, and Press  key to store the value.</p>
<p>7. Confirm lamps to be energized</p>  <p>The image shows two pushbuttons labeled 'TOP' and 'BOTTOM' on a dark blue panel.</p>	<p>Press TOP and BOTTOM pushbuttons to energize selected lamps and zones on the TEMPERATURE panel.</p> <p>Turns lamps ON.</p> <p>When the lamps first turn on, the SCR “soft start” capability limits the in-rush of current to the cold lamps.</p>
<p>8. Wait for furnace to stabilize</p>  <p>The image shows four temperature controllers arranged in a 2x2 grid. Each controller has a red PV display and a green SV display. The values are: Zone 1 (700 PV, 700 SV), Zone 3 (800 PV, 800 SV), Zone 2 (750 PV, 750 SV), and Zone 4 (850 PV, 850 SV). Each controller has 'SET' and 'SOLO' buttons.</p>	<p>When all controllers indicate zone temperatures (red values) are near setpoint (green values) for at least 5 minutes, the furnace is now ready to process product.</p>

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3.1.4 Change to a New Profile With a Hot Furnace (Power ON, Lamps ON)




Table 3-2 Changing the Profile	
Action	Comments / Changes
<p>1a. To lower temperature settings, push zone TOP and BOTTOM LAMPS white buttons to de-energize lamps in the zones to be changed.</p> <p>1b. To raise temperatures settings, leave LAMPS energized, go to step 2.</p>	<p>Turns lamps OFF.</p> <p>The red PV zone temperatures will start to fall as the zones cool. The furnace control system will stay on, as will the transport belt, cabinet and cooling fans.</p>
2. Set any new setpoint temperatures	Press controller  or  keys to enter the temperature, and SET key to store the value.
3. Confirm desired belt speed	<p>Set using the TRANSPORT panel BELT SPEED knob.</p> <p>Briefly examine the transport system, making sure the belt is operating smoothly.</p>
4. Set/confirm gas flowmeters	Adjust gas flowmeters on GAS FLOW CONTROL panel for appropriate flow for the product being fired.
5. Wait for zone temperatures to settle	If any lamps were de-energized, monitor zone controllers until all zone PV temperatures (red display) are at, or below, new SV temperatures (green display).
6. Confirm lamps to be energized	<p>If any lamps were de-energized, energize those lamps by pressing TOP and BOTTOM LAMPS buttons.</p> <p>Turns lamps ON.</p> <p>Zone PV temperatures will start to rise as increasing heat is reported by the zone thermocouples. The “soft start” controls will increase power gradually for the first 20 seconds of the warm up to limit the in-rush current to the lamps.</p>
7. If firing in low O2 environment, Select port to be sampled and turn Oxygen analyzer blue switch ON.	Make sure analyzer sample flow is 0.1 to 0.15 LPM. Adjust flow using knob on back of analyzer if necessary.
8. Wait for furnace to stabilize	<p>When all controllers indicate zone temperatures (red values) are near setpoint (green values) for at least 5 minutes, the furnace is now ready to process product.</p> <p>For low oxygen firing, the analyzer must report zone concentrations at acceptable levels before processing can begin.</p>

3.1.5 Place Hot Furnace in Standby Mode (Power ON, Lamps OFF):

Table 3-3 Standby	
Action	Comments / Changes
1. Push LAMPS TOP & BOTTOM buttons OFF.	Furnace will go into COOL DOWN. Lamps turn OFF. The red PV zone temperatures will start to fall as the zones cool. All fans, the transport belt, and the zone controllers stay ON. You can press LAMPS TOP & BOTTOM buttons at any time to cancel COOL DOWN mode.
2a. If furnace is to be restarted in 1 hour or less ...	Turn Oxygen analyzer blue switch OFF. Maintain operational gas flows during short shut down periods to assure rapid stabilization upon start up. Leaves belt, cabinet fans and process gas ON.
2b. If furnace is to be in Standby Mode for more than 1 hour ...	Turn oxygen analyzer blue switch OFF. When all zone temperatures fall below 100 °C, shut off the process gas supply valve (not recommended for very low O2 firing).

The furnace can be left in this mode indefinitely without harm.

3.1.6 Resume Operation From Standby Mode (Power ON, Lamps OFF):

Table 3-4 Resume Operation from Standby	
Action	Comments / Changes
1. Turn on the process gas supply valve. Verify gas pressure is 70 psig.	Adjust gas flowmeters on GAS FLOW CONTROL panel for appropriate flow for the product being fired.
2. Confirm desired setpoint temperatures	Press controller  or  keys to enter the temperature, and  key to store the value.
3. Confirm desired belt speed.	Set using the TRANSPORT panel BELT SPEED knob. Briefly examine the transport system, making sure the belt is operating smoothly.
4. Confirm lamps to be energized	Select TOP & BOTTOM LAMPS buttons ON.
5. If firing in low O2 environment, Select port to be sampled and turn Oxygen analyzer blue switch ON.	Make sure analyzer sample flow is 0.1 to 0.15 LPM. Adjust flow using knob on back of analyzer if necessary.
6. Wait for furnace to stabilize	When all controllers indicate zone temperatures (red values) are near setpoint (green values) for at least 60 seconds, the furnace is now ready to process product. For low oxygen firing, the analyzer must report zone concentrations at acceptable levels before processing can begin.

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3.1.7 Completely Shut Down a Hot Furnace (Power OFF, Lamps OFF):

Table 3-5 Shutdown	
Action	Comments / Changes
1. Push LAMPS TOP & BOTTOM buttons OFF.	Furnace will go into COOL DOWN. Lamps turn OFF. The red PV zone temperatures will start to fall as the zones cool. All fans, the transport belt, and the zone controllers stay ON.
2a. Turn off auxiliaries.	Turn oxygen analyzer blue switch OFF. Maintain gas flows for COOL DOWN. Leaves belt, cabinet fans and process gas ON.
IMPORTANT NOTE: To exit COOL DOWN at any time, push the LAMPS TOP & BOTTOM buttons to turn the lamps ON and resume operation.	
3. When all zones are below 100 °C ...	Push POWER OFF red button. Shut off the process gas supply valve.

3.2 Furnace Alerts & Alarms

3.2.1 With Power ON:



Table 3-6 Alerts & Alarms – Controls ON	
Problem	Comments/Remedies
A zone controller displays no Cont or Err CnPt instead of the process and setpoint temperatures:	The thermocouple or its connection to the controller may be bad. Check the input wiring and the thermocouple (replace if necessary).
A zone controller displays Err Proa instead of the process and setpoint temperatures:	There is an error within the controller. Cycle the power to the controller by pressing the CONTROLS red button to shut down the control system, waiting 10 seconds, then pressing the CONTROLS green button to restart the control system. This should clear the problem and the Main Screen should appear.

3.2.2 With Power ON, Lamps ON:

The buzzer sounds.

Press SILENCE button to silence the buzzer.

Check STATUS panel indicators for source of error.

Table 3-7 Alerts & Alarms – Lamps ON	
Problem	Comments / Remedies
ZONE TEMP DEVIATION indicator lamp is ON:	<p>This is an Alert and the furnace will continue operation.</p> <p>Check all zone controllers for an ALM1 LED (red) indicator ON. That zone has experienced a process temperature outside the setpoint temperature +/- the ALM1 limits set in the controller. The factory set ALM1 limits are +/- 10°C.</p> <p>Try to remedy the situation while the furnace continues to run. Remedies include:</p> <p>Do nothing. It may have been a transient anomaly.</p> <p>Check eductor gas flow. You may have to adjust the entrance exhaust eductor flow slightly up or down to pull more or less zone heat towards front of furnace.</p> <p>Check zone gas flows. You may have to increase zone gas flow to increase flow stability through the zone.</p> <p>Change the zone setpoint. A slightly higher or lower temperature might better accommodate temperature fluctuations in this particular profile. Adjust the zone controller setpoint using the  or  keys to enter the temperature, and press SET key to store the value.</p> <p>Autotune the zone PID settings. See 5. Modifying Control Strategies, below.</p> <p>Widen the <i>AL1H</i> and/or <i>AL1L</i> limits set for the zone. See 5. Modifying Control Strategies, below.</p>
GAS PRESSURE LOW indicator lamp is ON:	<p>This is an Alert and the furnace will continue operation.</p> <p>The indicated gas manifold has seen a drop in gas pressure.</p> <p>Remedy the situation while the furnace continues to run by immediately turning on the identified gas supply (or supplies) to the furnace.</p> <p>Note: If the gas supply (or supplies) cannot be restored <u>immediately</u>, push the COOL DOWN button to avoid damage to furnace components.</p> <p>Do not operate furnace with lamps ON until the gas supply can be restored.</p>

When the alert condition is remedied, and the ALM1 LED turns OFF, reset the alarm system buzzer:

1. **Push the SILENCE button.** The audible buzzer is enabled. The buzzer should not sound if all alarms are cleared.
2. Return to normal furnace operation.

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3.2.3 With Power ON, Lamps ON:

Suddenly, main K1 contactor shuts off with an audible click.

ALL Element Monitor display LEDs turn OFF.

PV temperature displays on the zone controllers begin to fall.

All control panel lights remain ON.

This is an Over temperature Alarm.

Problem	Comments/Remedies
OVER TEMPERATURE ALM3 LED is ON:	<p>This is an Alarm and the furnace cannot continue with the Lamps turned ON.</p> <p>Check each zone controller for an ALM3 LED ON to identify zone in which the Over temperature condition occurred and for a PV temperature at or near 1005 °C. That zone has experienced a process temperature higher than the ALM3 limit set in the controller. The factory set ALM3 limit is 1005 °C.</p> <p>Remedy the situation while the furnace cools down. Remedies include:</p> <p>Check eductor gas flow. You may have to adjust the entrance exhaust eductor flow slightly up or down to pull more or less heat towards front of furnace.</p> <p>Check zone gas flow. You may have to increase zone gas flow to increase flow stability through the zone.</p> <p>Change the zone setpoint. A slightly higher temperature might better accommodate temperature fluctuations in this particular profile. Adjust the zone controller setpoint using the , or . keys to enter the temperature, and press ; key to store the value.</p> <p>Tune or Autotune the zone PID settings. See 3.7 MODIFYING CONTROL STRATEGIES.</p> <p>Check affected zone SCR for “output stuck open” failure (i.e. applying full power to lamps with no control input signal). If confirmed, replace zone SCR immediately. See 4.5.3 for more information.</p>

In an Over Temperature condition:

1. Turn OFF all zone lamp switches to allow the furnace to cool via constant gas flow and belt movement.
2. Perform checks in Table 3-8 Over Temperature Alarm to determine root cause or causes.
3. Apply the appropriate remedy or remedies.
4. Identify the zone controller with the ALM3 LED lit and reduce the SV (setpoint temperature) by 100°C from current value.
5. Turn all zone lamp switches ON to allow furnace to heat back up.
6. When affected zone reaches its reduced SV target, gradually raise the reduced SV temperature in 25°C increments, allowing 5 minutes at each temperature step to confirm stable operation continues.
7. Resume furnace operation when furnace is stabilized.

When the alarm condition is remedied, the ALM3 LED on the affected zone turns OFF.

3.3 Energizing Lamps

The ability to turn banks of lamps off and on via the zone TOP and BOTTOM LAMPS buttons allows the user great flexibility in applying energy to each zone. Use just the top lamps in each zone for drying moisture or volatile organic compounds from the top surface of substrates or trays, or curing thermosetting compounds or coatings on wafers or polycarbonate materials. Use both top and bottom lamps in traditional furnace applications. Use just the bottom lamps to emphasize conduction heating of parts from the transport belt and from IR radiation on the bottom of metallic or ceramic parts carriers.

3.3.1 Selecting banks of lamps

Top lamps only, bottom lamps only, both top and bottom lamps, or no lamps at all can be selected in each zone to give the user flexibility in applying energy to each zone. Select which lamps you want to energize either before or after pressing on the Power ON button. To ensure smooth power up to operating temperatures and better PID control, all zones should be below their setpoint temperature before pressing Power ON.

3.3.2 Troubleshooting & resolving zone control issues using Lamp Buttons

Lamp TOP and BOTTOM buttons are also useful for testing lamps (see section **Error! Bookmark not defined.**) and checking for blown lamp fuses (see Table 4-3 Troubleshooting Power).

If heat in any zone increases rapidly into a “runaway” condition even if the zone controller OUT1 LED indicator is dark (the controller output is OFF), the heat can be stopped by shutting off the affected zone Top and Bottom pushbutton switches. In this event, the zone SCR most likely has failed with an *output stuck open fault* and needs to be replaced.

If the heat in any zone steadily stays above the SV (green temperature setpoint value), but is not in a *runaway* condition, shut off the affected zone top and bottom switches and see if the heat decreases. If it does not, the furnace has a process gas flow problem or the SV in adjacent zones may need to be lowered.

3.4 Gas Flow Control

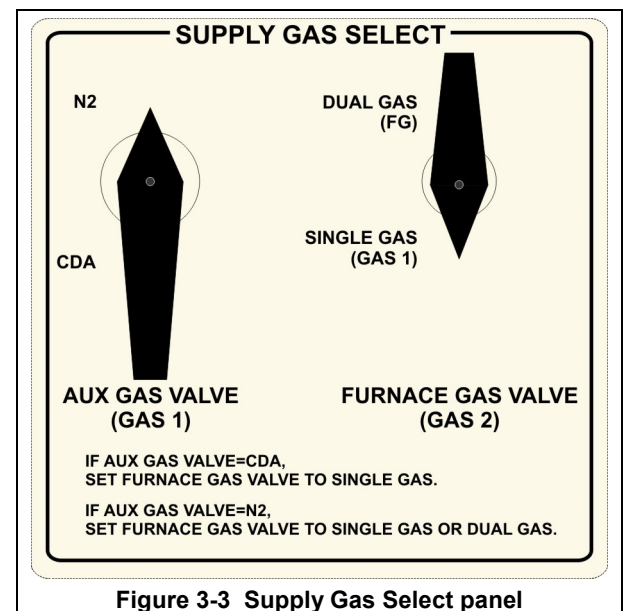
3.4.1 Selecting Process Gases

Three gases can be connected to this furnace, normally CDA (clean dry compressed air), N₂ (nitrogen) and FG (Forming Gas).

Either of the first two gases can be supplied to all AUX gas flowmeters by turning the AUX GAS VALVE on the SUPPLY GAS SELECT panel to N₂ or CDA.

Turning the FURNACE GAS VALVE to the SINGLE GAS position supplies the selected AUX gas to the FURNACE flowmeters (Zone 1, Zone 2-4 and Lamp Plenums) as well.

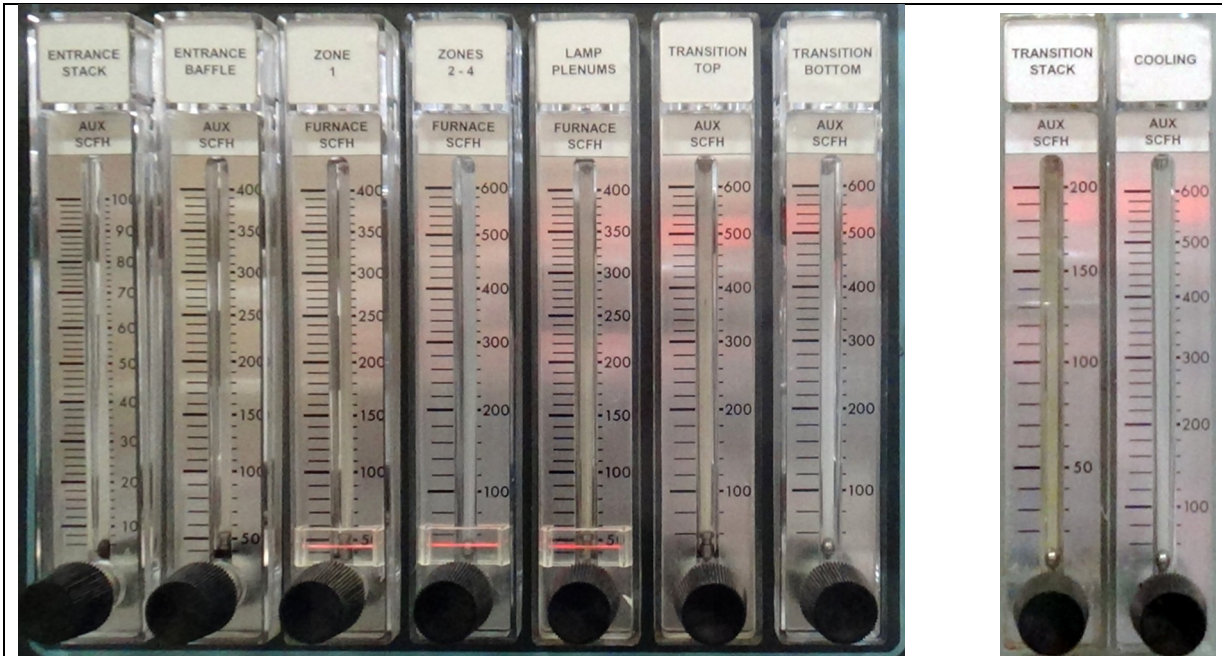
When the FURNACE GAS VALVE is turned to the DUAL GAS position. The third gas (FG) is supplied instead to the FURNACE flowmeters (Zone 1, Zones 2-4, and Lamp Plenums). This position is typically used for very low O₂ firing.



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3.4.2 Adjusting Flowmeters

The process gas flowmeters are located on the Control Console. The flowmeters control process gas flow to the furnace elements as labeled. See section 2.12 or section 5 for recommended initial settings. See sections for 8.5 through 8.5.7 for process engineering calculations.



**Figure 3-4 Process Gas Control Flowmeters
(3-Gas, Dual Mode configuration shown)**

Turn the black flowmeter needle valve knob counterclockwise to increase gas flow and clockwise to decrease gas flow or close the valve completely.

Note: The STATUS ALARMS only report on LOW SUPPLY GAS PRESSURE to the gas manifolds. If the supply gas pressure is adequate, the alarms will NOT indicate absence of sufficient gas flow to the furnace elements even if the flowmeter valves are completely closed. Make sure flowmeters are set to provide adequate flow for the temperature profile being run.

3.4.3 Indicator Flags

Small plastic indicator flags may have been provided with the furnace to indicate preferred settings.

1. Press the indicator flag into place in front of scale with the red line on the back side next to the scale.
2. Slide the flag from the bottom of the top of the scale and back again 3 or 4 times to remove the mold release agent which is present on the flowmeter.
3. Slide the pointer flag to the desired location and place in service.

3.5 Monitoring Oxygen Level

To monitor the oxygen level in a furnace zone:

1. Start furnace.
2. On Sample System console, turn PORT SELECT switch to sample port S using Port Select switch.
3. Turn Analyzer ON switch to energize system and start analyzer.
4. Run furnace until system stabilizes.
5. Turn PORT SELECT switch to the sample port, 1, 2 or 3, to be sampled for analysis of O₂ content.

Turn PORT SELECT switch back to S before shutdown to prevent starting O₂ system before furnace is dry.

3.6 ALARM STATUS

During an alarm/alert condition, the problem alarm/alert button remains lit. Any existing alarm/alert condition such as low gas pressure, can be heard and/or viewed as shown in Table 3-9. To silence an alarm/alert, press the SILENCE button and work to correct or clear the alarm condition. Allow the system to stabilize as indicated by all temperature controllers at or close to setpoint and ALM1 is OFF on all temperature controllers. See Section 4 SERVICE & MAINTENANCE for further information.

Note: ALERTS are conditions that deviate from product recipe parameters or normal operating parameters and may damage product being processed. ALARMS are harmful conditions that can damage the equipment or can cause personal injury.

A. Silence button

Pressing the Silence button will only disable the buzzer. If the source of the alarm/alert is still a problem, the problem corresponding alarm/alert indicator will remain lit although the buzzer will not sound.

While the machine is heating, check for alerts and alarms and listen for the alarm buzzer. In particular, check for any exhaust process gas failure alarms.

Check for failed elements. The effect of an element failure is generally minimal unless two failed elements are adjacent to each other.

B. Alarms

Table 3-9 Alarms and Indication			
Name	Type	Description	Indicator, Display
Temperature Deviation	Alert	High or Low temperature after setpoint is reached. Separate high and low deviation can be set for each zone in corresponding SOLO zone temperature controller.	Buzzer, TEMP DEV lamp on STATUS panel, ALM1 LED on SOLO controller turns ON. Resets automatically when condition is clear.
Low Gas Pressure	Alarm	Low gas 1 or gas 2 pressure. Factory set at 55 psig.	Buzzer, GAS LOW lamp on STATUS panel turns ON. Resets automatically when condition is clear. Operator should immediately shut off all power to lamps until condition is cleared.
Oxygen Level High 1	Alert	Oxygen level sampled above maximum setpoint. Setpoint can be entered in oxygen analyzer.	Buzzer, O2 HIGH lamp on STATUS panel turns ON. ALARM 1 LED on oxygen analyzer turns ON. Resets automatically when condition is clear.
Oxygen Level High 2	Alert	Oxygen level sampled above maximum setpoint. Setpoint can be entered in oxygen analyzer.	ALARM 2 LED on oxygen analyzer turns ON. Resets automatically when condition is clear.
Over temperature	Alarm	Zone temperature above maximum. Factory set to 1005°C	Immediate power shut off to all lamps, all Element Monitor LEDs go dark. ALM3 output on SOLO Temperature Controller turns ON. Resets automatically when condition is clear.
Zone x Lamp Fail	Alert	Lamp String Failure in specified Zone.	LED on ELEMENT MONITOR panel goes dark. Resets automatically when condition is clear.
O2 Level (analog)	Alert	Oxygen level measured in furnace. Program 3 rd party data collection software to alert when readings are above setpoint	Analog output on oxygen analyzer only. Available for independent data collection and alert triggers.

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3.6.2 IPS Low Gas Pressure Alarms

An Inlet Pressure Switch is installed on the GAS 2 process gas manifold. These switches are normally open when gas is disconnected from the furnace. They close when proper pressure is present in the process gas supply line(s).

The current switches are set to open when pressure falls below set points in the following table:

Table 3-10 Initial Alarm Settings			
Port	Manifold	Pressure	
Gas 1	CDA and Nitrogen	55-60 psig	3.8-4 Bar
Gas 2	Forming Gas, or other (Option)	55-60 psig	3.8-4 Bar

The pressure switch set points can be adjusted manually. Locate the switch in the process gas supply line. To increase the set point turn the wheel clockwise. Turn the top of the switch counter clockwise to decrease the pressure set point so the alarm will not occur until the pressure drops to a lower point. See section 4.8.6 for instructions on adjustment and calibration.



Figure 3-5 IPS Inlet Pressure Switch

3.6.3 Over Temperature Option (option not supplied)

The Over Temperature Alarm system consists of redundant zone thermocouples, a scanner/annunciator and digital panel meter hardware integrated into the furnace control system. The scanner/annunciator and digital panel meter are mounted on top of the furnace near the flowmeter controls.

NORMAL OPERATION. The system scans each zone and passes a temperature signal to the digital panel meter. The operator can view the temperature on the panel meter and the respective zone being monitored will be indicated on the scanner.

ALARM. If the temperature in any zone reaches the alarm set point, an alarm will sound in the scanner/annunciator and the furnace will go into Cool Down, the heating elements will be shut off by the controller. To silence the alarm, press ACK on the scanner/annunciator. The furnace cannot be restarted until the zone temperature drops below the alarm set point.

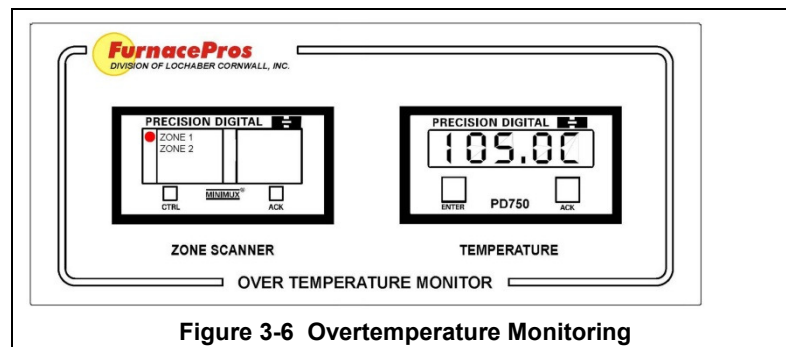


Figure 3-6 Overtemperature Monitoring

3.6.4 Element Monitoring System

The Element Monitoring system consists of single channel circuit boards installed on each string which detect the location of a failed heating element. The circuit boards monitor the current to the lamp string and activate an audible alarm and visible alarm upon sensing an element failure. The display shows the specific location of the lamp or lamp string (multiple lamps wired in series make up a string) containing the failed lamp. The audible alarm alerts the operator immediately if a lamp fails and allows him to discern its location and determine if process results will be appreciably affected.

View the ELEMENT MONITOR screen to view the status of the heating element strings. LED indicator failure or individual lamp failure of itself will trigger an audible alert or alarm. The process will only alarm if a lamp failure adversely impacts the furnace ability to maintain set point temperatures.

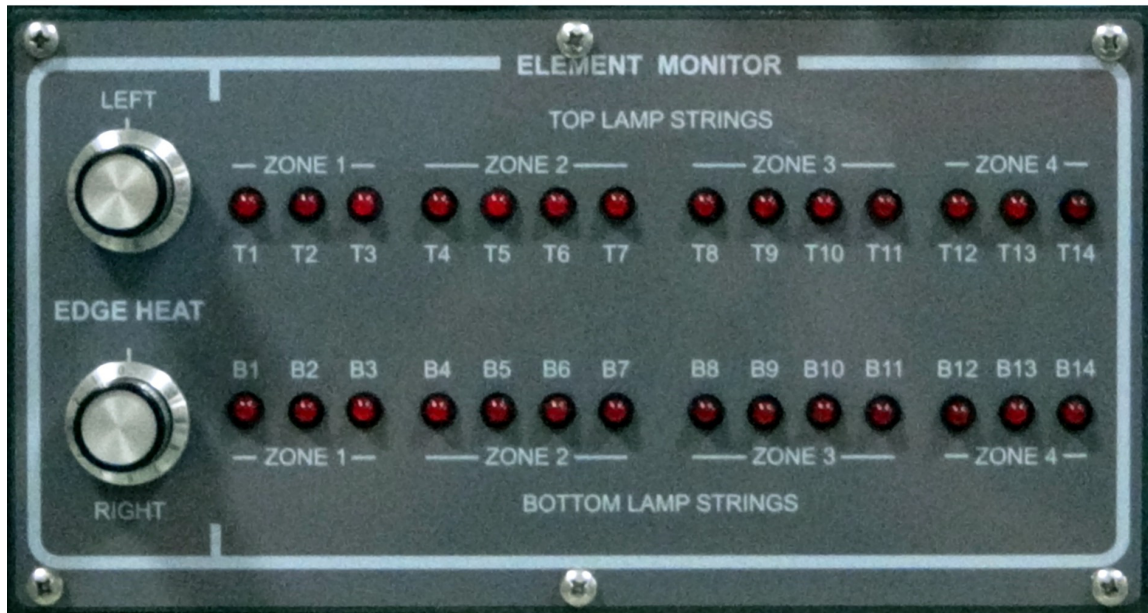


Figure 3-7 Element Monitor panel OFF

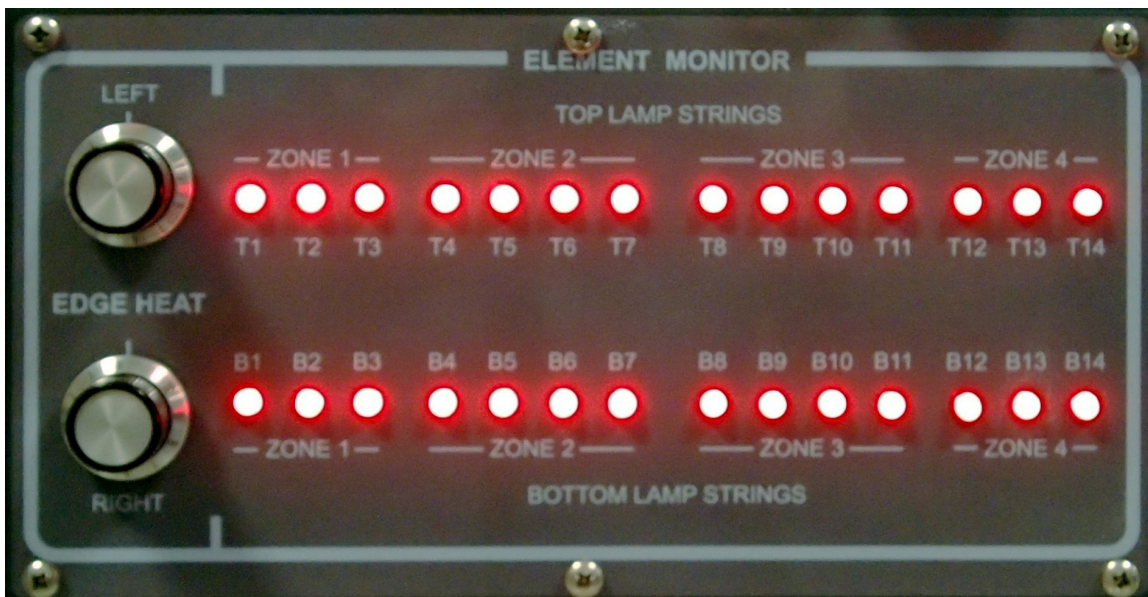


Figure 3-8 Element Monitor panel ON

Section 3




3.7 MODIFYING CONTROL STRATEGIES

The remainder of section 3 contains instructions for changing furnace operating parameters, alert and alarm levels. Includes steps and values for re-entering factory default settings.




3.8 Modifying Zone Controllers

Each of the zone controllers in the furnace have been preset for PID operation and tuned for four operating levels. During furnace operation, the controller will automatically select the appropriate PID control loop parameters to use based on the current zone setpoint temperature.

In addition, values for temperature deviation alerts (± 10 °C), an over temperature alarm (1005 °C), and the READY lamp have been preset at the factory. However, during normal operation of a well-balanced furnace, $\pm 1-2$ °C should be expected.


For most applications and users, these settings provide excellent control and process protection. Therefore, the furnace has arrived preset with all controller key pad operation disabled except for changing the zone setpoint temperature using the ,  and  keys.

3.8.1 Changing the Zone Setpoint Temperature

Adjust the zone controller setpoint using the  or  keys to enter the temperature, and press  key to store the value. The controller output will change immediately after the value is stored. To apply all temperature changes at the same time, press LAMPS OFF button, make and set changes on the zone controllers, then press LAMPS ON button. The SCR “soft start” will limit current in-rush and the temperature changes will proceed smoothly together.














3.8.2 Unlocking and Re-locking Controller Keys

If you need to change any of the controller settings (other than the setpoint temperature), you first must unlock access to the key programming pads.

To unlock the key pad: press  and  keys at the same time. All keys now function.

To relock the key pad from the Main Screen:

Press the  key to access Operation Mode Parameters, and continue:

Parameter (PV display)	Value (SV display)	Action
		Press the  key repeatedly until  appears.
		Press  or  keys to select Lock Mode:  The Lock feature is disabled.  All key pad operation is ignored.  All key pad operation is ignored except for  or  keys for changing SV. This is the factory default setting. Press  button to select choice, then press  again to return to the Main Screen

3.8.3 Changing Temperature Deviation Alert Limits

From the Main Screen:

Table 3-12 Changing Temperature Deviation Alert Limits		
Parameter (PV display)	Value (SV display)	Action
		Press the key repeatedly until AL H appears.
AL H	10	<p>Sets the high limit for the temperature deviation alert. Alert is activated when PV temp reaches SV temp and then will trigger ON if PV temp rises above SV temp + AL H</p> <p>Press and keys to change this setting. Press SET key to store new value.</p> <p>Press key for next parameter.</p> <p>Press SET twice to return to the Main Screen.</p>
AL L	10	<p>Sets the low limit for the temperature deviation alert. Alert is activated when PV temp reaches SV temp and then will trigger ON if PV temp fall below SV temp - AL L</p> <p>Press , , SET, keys as above.</p>

3.8.4 Changing Over temperature Alarm Limit

Changing this alarm will remove the factory setting of 1005 °C. This upper limit acts to shut down the furnace in the event of an erratic zone or shorted output SCR causing thermal runaway above the 1000 °C furnace design maximum.

While changing this value is not recommended, the advanced user may wish to set this lower than 1005 °C for use in monitoring a peak temperature limit on one of their thermal processes.








From the Main Screen:

Table 3-13 Changing Over temperature Alarm Limit		
Parameter (PV display)	Value (SV display)	Action
		Press the key repeatedly until AL 3H appears.
AL 3H	1005	<p>Sets the limit for the over temperature alarm. Alarm is activated when PV temp rises above AL 3H.</p> <p>The factory default setting is 1005 °C to prevent damage to the lamps. The advanced user may wish to set this lower than 1005 °C for use in monitoring a peak temperature limit on one of their thermal processes.</p> <p>When this alarm is triggered, the lamps will shut off.</p> <p>Press and keys to change this setting. Press SET key to store new value.</p> <p>Press key for next parameter.</p> <p>Press SET twice to return to the Main Screen.</p>

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3.8.5 Changing READY Light Limits (Option, not included)

From the Main Screen:

Table 3-14 Changing READY Light Limits		
Parameter (PV display)	Value (SV display)	Action
		Press the  key repeatedly until RL2H appears.
RL2H	10	<p>Sets the high limit for the READY light.</p> <p>READY will turn ON when the PV temp is within the range of SV temp – RL2L and SV temp + RL2H.</p> <p>The READY light limits are different from the temperature deviation limits.</p> <p>Press  and  keys to change this setting.</p> <p>Press SET key to store new value.</p> <p>Press  key for next parameter.</p> <p>Press SET twice to return to the Main Screen.</p>
RL2L	10	<p>Sets the low limit for the READY green light.</p> <p>READY will turn ON when the PV temp is within the range of SV temp – RL2L and SV temp + RL2H.</p> <p>Note: the READY light limits are different from the temperature deviation limits. The READY green light will turn on only after the furnace is within limits on all 3 zones for a 2-minute period free of alerts or alarms.</p> <p>Press   SET  keys as above.</p>

3.9 Controller PID Tuning

The temperature controllers PID loop parameters are preset at the factory. Before making changes, the user should read and understand sections 3.9 through 3.13. In any case, factory preset values can always be restored, if necessary (see section **3.13 Restoring Factory Presets**).

3.9.1 Factory Preset Zone Controller Settings

Quite often a thermal process will change its characteristics notably as it heats up. For this reason, each zone controller can automatically select the most useful PID control loop parameters closest to the desired setpoint temperature entered by the user.

Each zone controller in this furnace can store 4 groups of PID parameter values identified as **PLd0**, **PLd1**, **PLd2** and **PLd3**. Within each group, the following PID parameters can be stored, shown in this table with their factory default values:

Table 3-15 Factory PID Settings								
Zone 1	Group 0		Group 1		Group 2		Group 3	
PID Group Label (read only)	Pid0	250	Pid1	450	Pid2	650	Pid3	850
Setpoint Target	Sv0	250	Sv1	450	Sv2	650	Sv3	850
Proportion Band	P0	50	P1	110	P2	95	P3	95
Integral Time	I0	8	I1	6	I2	10	I3	10
Derivative Time	D0	1	D1	2	D2	2	D3	3
Integral Offset	ioF0	10	ioF1	9	ioF2	50	ioF3	70

Zone 2	Group 0		Group 1		Group 2		Group 3	
PID Group Label (read only)	Pid0	250	Pid1	450	Pid2	650	Pid3	850
Setpoint Target	Sv0	250	Sv1	450	Sv2	650	Sv3	850
Proportion Band	P0	50	P1	50	P2	75	P3	70
Integral Time	I0	8	I1	8	I2	8	I3	8
Derivative Time	D0	3	D1	2	D2	2	D3	3
Integral Offset	ioF0	8	ioF1	35	ioF2	50	ioF3	70

Zone 3	Group 0		Group 1		Group 2		Group 3	
PID Group Label (read only)	Pid0	250	Pid1	450	Pid2	650	Pid3	850
Setpoint Target	Sv0	250	Sv1	450	Sv2	650	Sv3	850
Proportion Band	P0	40	P1	50	P2	75	P3	85
Integral Time	I0	8	I1	8	I2	8	I3	8
Derivative Time	D0	3	D1	2	D2	2	D3	3
Integral Offset	ioF0	8	ioF1	35	ioF2	50	ioF3	70

Zone 4	Group 0		Group 1		Group 2		Group 3	
PID Group Label (read only)	Pid0	250	Pid1	450	Pid2	650	Pid3	850
Setpoint Target	Sv0	250	Sv1	450	Sv2	650	Sv3	850
Proportion Band	P0	110	P1	125	P2	100	P3	85
Integral Time	I0	8	I1	10	I2	12	I3	10
Derivative Time	D0	2	D1	3	D2	3	D3	3
Integral Offset	ioF0	4.5	ioF1	20	ioF2	50	ioF3	70

The active group of PID values in use for a particular controller can be either manually selected by the user (**PLd0** – **PLd3**) or automatically selected by the controller (**PLd4**) based on the Setpoint Target closest to the controller setpoint temperature. The factory has pre-tuned the furnace in each zone for 250 °C, 450 °C, 650 °C and 850 °C and has preset automatic selection in each zone. For most applications, these preset values provide excellent control.

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3.9.2 Viewing and Changing a PID Parameter Group

From the Main Screen, press the **SET** key:

Table 3-16 View & Change PID Parameter Group		
Parameter (PV display)	Value (SV display)	Action
Pl	OFF	Ignore, press ↩ key for next parameter
PIdn	For PID0-3: nnn For PID4: Auto	PV displays currently active PID Group PIdn and its target setpoint temperature nnn : PId0 is PID Group 0 PId1 is PID Group 1 PId2 is PID Group 2 PId3 is PID Group 3 PId4 is PID Group Auto Select Press ▼ and ▲ key to select active PID group. Press SET , then ↩ key to view/edit PID group. Press SET twice to return to the Main Screen.
Sn	nnn	Target setpoint temperature for selected active PID Group PIdn . Press ▼ and ▲ keys to change this setting. Press SET key to store new value. Press ↩ key for next parameter. Press SET twice to return to the Main Screen.
Pn	nnn.n	Proportion band for selected active PID Group PIdn . Press ▼ ▲ SET ↩ keys as above.
In	nnn	Integral time (in seconds) for selected active PID Group PIdn . Press ▼ ▲ SET ↩ keys as above.
dn	nnn	Derivative time (in seconds) for selected active PID Group PIdn . Press ▼ ▲ SET ↩ keys as above.
IoF	nnn	Integral offset for selected active PID Group PIdn . This parameter will improve the speed that the PV reaches the SV on furnace startup. Press ▼ ▲ SET ↩ keys as above.
Ignore all other parameters beyond this point. Press SET to return to Main Screen.		

3.9.3 Zone Auto Tuning

Auto Tuning a zone replaces the active PID Group control parameters stored in the zone controller with new values. You can Auto Tune 1, 2 or 3 zones at the same time using this procedure.

Before starting the Auto Tuning process on the furnace,

- POWER button should be ON.
- LAMPS TOP and BOTTOM buttons should be OFF.
- Set desired setpoint temperature in each zone controller.
- Set the desired belt speed.

For each controller involved in the Auto Tuning process, select the active PID Group and the target temperature to be changed using Auto Tune. **Caution: Auto tune will replace all factory default values for the zone.**

From the Main Screen, press the **SET** key:

Table 3-17 Zone Auto Tuning		
Parameter (PV display)	Value (SV display)	Action
At	OFF	Ignore, press ↩ key for next parameter
PIdn	For PID0-3: nnn For PID4: Auto *	PV displays currently active PID Group PIdn and its target setpoint temperature nnn : PId0 is PID Group 0 PId1 is PID Group 1 PId2 is PID Group 2 PId3 is PID Group 3 PId4 is PID Group Auto Select* * <u>Note</u> : For Auto Tune, select the active PID Group from among PId0 – PId3 only. Press ▼ and ▲ key to select PID group. Press SET key to make PID group active. Press ↩ key to change the target setpoint temperature. Press SET twice to return to the Main Screen.
Sn	nnn	Target setpoint temperature for selected active PID Group PIdn . Press ▼ ▲ SET ↩ key to change target temperature. Press SET key to store target temperature. Press SET again to return to the Main Screen

When back to the Controller Main Screen and ready to start, push LAMP TOP and BOTTOM buttons to turn the lamps ON and start heating the furnace.

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At any point while the current process temperature (red PV display) is still below the setpoint temperature (green SV display) on the controller, press **SET** key once on the controller to prepare to Autotune the PID loop and proceed as follows:

Parameter (PV display)	Value (SV display)	Action
AT	OFF	Press ▲ key to select on Press ▼ key to select OFF Press SET to start or stop the Autotuning process.
	on	Auto Tuning activated. Controller AT indicator turns on , and the process begins when the process temperature in zone reaches the setpoint temperature. After Auto Tuning is complete, this value returns to OFF , the new PIDn values are stored and normal zone control resumes using those values.
	OFF	Auto Tuning deactivated. If this value is selected during the Auto Tuning process, the controller stops the Auto Tuning process immediately and does not change any PID values.
AT	on	At any time with Auto Tuning activated, you may press SET to return to the Main Screen while the Auto Tuning process continues. When the controller AT indicator LED turns OFF, Auto Tuning is complete.

These new PID values are stored in the controller permanently in the active PID group, unless they are changed by another Auto Tuning process or by manual change via the controller buttons.

Verify all Zone Temperature Controller have reached setpoint for at least 5 minutes.

Return to normal furnace operation, if desired.

Note that the Auto Tuning process will not start until the process temperature reaches the setpoint temperature; if the process temperature is at or above the setpoint temperature, Auto Tuning will never start.

To restore factory default settings, follow the steps in 3.9.2 to manually enter the values found in the tables in 3.9.1.

CAUTION: While controller Autotuning may achieve stable temperatures in each zone, it often does not make best use of the infrared energy. Manually tuning zones can achieve better results by observing the ELEMENT MONITOR panel and changing PID parameters to minimize the amount of time zones are not firing.

3.10 Automatic PID Group Selection

By selecting PID4 as the active PID Group, the controller will choose automatically the PID0, PID1, PID2 or PID3 group with the target setpoint value closest to the controller setpoint temperature entered by the furnace operator. This mode is factory set as the default mode.

If there are 2 or more PID Groups that have target setpoint values equally close to the setpoint temperature, the controller uses the lowest number PID Group (e.g. if PID Groups 0 -3 have the same target setpoint value, the controller uses PID0 parameters for control).


3.11 Manual PID Group Selection

The user can select PID0, PID1, PID2 or PID3 Group as the active PID group for any controller. See 3.9.2 Viewing and Changing a PID Parameter Group for details. For advanced users only.

3.12 Viewing Controller Output Level

The controllers supply a 0-10 Vdc output control signal to the SCRs to regulate lamp power. To view the controller output level in percent:

From the Main Screen

Table 3-19 View Temperature Controller Output Level		
Parameter (PV display)	Value (SV display)	Action
		Press the  key repeatedly until OUT 1 appears.
OUT 1	000.0	This parameter is a “read -only” display of the controller output over a 0.0 - 100.0% range. Use it to confirm controller output level. Press SET twice to return to the Main Screen.

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3.13 Restoring Factory Presets

Zone controllers can be restored to their factory settings by entering and storing the data in the Value column of Table 3-20 and Table 3-21:

3.13.1 Restoring Factory Initial Settings

From the Main Screen:





























Table 3-20 Restore Temperature Controller Factory Settings		
Parameter (PV display)	Value (SV display)	Comments
		Press the SET key and hold for 3 seconds to enter the Initial Setting mode. For each Parameter below: Press ▼ and ▲ keys to change the value. Press SET key to store new value. Press ↩ key for next parameter. Press SET twice to return to the Main Screen.
TnPt	2	T/C type K (-200 – 1300 °C)
EPUn	0	Temperature units
EP-H	1005	Highest temperature
EP-L	0	Lowest temperature
Ctrl	PID	PID control
S-HC	HEAT	Output 1 configuration
ALR1	0	Alarm 1 type (temp dev)
ALR2	4	Alarm 2 type (ready)
ALR3	6	Alarm 3 type (overtemp)
SALA	OFF	System Alarm feature disabled
CO5H	on	Allows changes via RS-485 port
C-SL	RTU	Modbus RTU protocol
C-no		Not used
BPS	9600	Baud rate
LEN	8	Bit length
Prty	EVEN	Parity
Stop	1	Stop bit
		Press SET twice to return to the Main Screen.

3.13.2 Restoring Factory Zone PID Settings

See 3.9.1 for factory zone controller settings. Follow the steps in section 3.9.2 Viewing and Changing a PID Parameter Group to manually re-enter the settings in Table 3-15 Factory PID Settings.

3.13.3 Restoring Factory Operation Settings

From the Main Screen:

Table 3-21 Restore Temperature Controller Factory Operation Settings		
Parameter (PV display)	Value (SV display)	Comments
		Press the  key to enter the Operation mode. For each Parameter: Press  and  keys to change the value. Press  key to store new value. Press  key for next parameter. Press  twice to return to the Main Screen.
		Controller run
		Display format (no decimal point)
		Alarm 1 high
		Alarm 1 low
		Alarm 2 high (option, not included)
		Alarm 2 low (option, not included)
		Alarm 3 high
		Lock mode (allows only   &  key entry)
		Setting is read-only and cannot be changed. Press  to return to the Main Screen.

3.14 Changing Belt Speed Range

The CU-915 furnace is equipped with two transport drive motors to facilitate low and medium belt speeds. The furnace was shipped with the medium belt speed motor installed, and the low speed motor mounted on the electrical pedestal as a spare.

3.14.1 To change the belt speed range:

1. Disconnect power and data cables to current transport drive motor.
2. Remove current transport drive motor by loosening its bolts and removing its chain
3. Un-bolt the alternate motor from its storage location and bolt in place of the original motor. Install its chain.
4. Connect power and data cables to new transport drive motor.
5. Mount the spare motor in the storage location for later use. Store chain.
6. Calibrate belt and enter new parameters for Rt-Inp and Rt-diSP in the speed indicator. See detailed instructions for calibrating the belt speed on the datasheet labeled RATE METER PARAMETERS in Section 5.