Chapter 5

MODIFYING CONTROL STRATEGIES

Instructions for changing furnace operating parameters, alert and alarm levels. Includes steps and values for re-entering factory default settings. Refer to chapter 6 for optional equipment.

5.1 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, ±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 SET keys.

5.1.1 Changing the Zone Setpoint Temperature

Adjust the zone controller setpoint using the ▼ or ▲ keys to enter the temperature, and press SET 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.

5.1.2 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 SET 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:

Table 5-1 Unlock/Lock Temperature Controller Keys

Parameter (PV display)	Value (SV display)	Action
		Press the ↩ key repeatedly until LoC appears.
LoC	oFF	Press ▼ or ▲ keys to select Lock Mode: oFF The Lock feature is disabled. Lo C1 All key pad operation is ignored. Lo C2 All key pad operation is ignored except for ▼ or ▲ keys for changing SV. This is the factory default setting. Press SET button to select choice, then press SET again to return to the Main Screen

5.1.3 Changing Temperature Deviation Alert Limits

From the Main Screen:

Table 5-2 Changing Temperature Deviation Alert Limits		
Parameter (PV display)	**Value (SV display)**	**Action**
		Press the ↻ key repeatedly until AL 1H appears.
AL 1H	10	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 1H 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.
AL 1L	10	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 1L Press ▼ ▲ SET ↻ keys as above.

5.1.4 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 5-3 Changing Over temperature Alarm Limit		
Parameter (PV display)	**Value (SV display)**	**Action**
		Press the ↻ key repeatedly until AL2H appears.
AL2H	1005	Sets the limit for the over temperature alarm. Alarm is activated when PV temp rises above AL2H. **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. When this alarm is triggered, the lamps will shut off. 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.

5.1.5 Changing READY Light Limits

From the Main Screen:

Table 5-4 Changing READY Light Limits

Parameter (PV display)	Value (SV display)	Action
		Press the ↵ key repeatedly until AL3H appears.
AL3H	10	Sets the high limit for the READY light. READY will turn ON when the PV temp is within the range of SV temp – AL3L and SV temp + AL3H. The READY light limits are different from the temperature deviation limits. 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.
AL3L	10	Sets the low limit for the READY green light. READY will turn ON when the PV temp is within the range of SV temp – AL3L and SV temp + AL3H. **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. Press ▼ ▲ SET ↵ keys as above.

5.2 Controller PID Tuning

The temperature controllers PID loop parameters are preset at the factory. Before making changes, the user should read and understand section 5.6.1 below. In any case, factory preset values can always be restored, if necessary (see section **5.6 Restoring Factory Presets**).

5.2.1 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 PId0, PId1, PId2 and PId3. Within each group, the PID parameters shown in Table 5-5 can be stored.

Table 5-5 Factory Default Zone Controller PID Parameters

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	Su0	250	Su1	450	Su2	650	Su3	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	50

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	Su0	250	Su1	450	Su2	650	Su3	850
Proportion Band	P0	50	P1	40	P2	75	P3	70
Integral Time	I0	8	I1	8	I2	8	I3	8
Derivative Time	d0	1	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	Su0	250	Su1	450	Su2	650	Su3	850
Proportion Band	P0	110	P1	110	P2	100	P3	120
Integral Time	I0	8	I1	6	I2	12	I3	6
Derivative Time	d0	2	d1	2	d2	3	d3	3
Integral Offset	IoF0	4.5	IoF1	9	IoF2	50	IoF3	40

The active group of PID values in use for a particular controller can be either manually selected by the user (PId0 – PId3) or automatically selected by the controller (PId4) 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.

5.2.2 Viewing and Changing a PID Parameter Group

From the Main Screen, press the SET key:

Table 5-6 View & Change PID Parameter Group

Parameter (PV display)	Value (SV display)	Action
AL	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.
Sun	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.		

5.2.3 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,

- CONTROLS should be ON.
- LAMPS should be OFF.
- Set desired setpoint temperature in each zone controller.
- Select the lamps to be energized.
- 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 5-7 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* * Note: 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.
Sun	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 LAMPS green button to turn the lamps ON and start heating the furnace.

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:

Table 5-8 Start/Stop Autotune Process

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 the green READY lamp is on and then 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 5.2.2 to manually enter the values found in the tables in 5.2.1

5.3 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).

5.4 Manual PID Group Selection

The user can select PID0, PID1, PID2 or PID3 Group as the active PID group for any controller. See 5.2.2 Viewing and Changing a PID Parameter Group for details. For advanced users only.

5.5 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 5-9 View Temperature Controller Output Level

Parameter (PV display)	Value (SV display)	Action
		Press the ↻ key repeatedly until out 1 appears.
out 1	nnn.n	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.

5.6 Restoring Factory Presets

Zone controllers can be restored to their factory settings by entering and storing the data in the Value column of Table 5-10 and Table 5-11:

5.6.1 Restoring Factory Initial Settings

From the Main Screen:

Table 5-10 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.
InPt	K	T/C type K (-200 to 1300 °C)
tPUn	C	Temperature units
tP-H	1005	Highest temperature
tP-L	0	Lowest temperature
CtrL	PId	PID control
o-HC	HEAt	Output 1 configuration
ALA1	8	Alarm 1 type
ALA2	6	Alarm 2 type
ALA3	4	Alarm 3 type
SALA	oFF	System Alarm feature disabled
CoSH	on	Allows changes via RS-485 port
C-SL	rtU	Modbus RTU protocol
C-no	11 12 13	Network address for Zone 1 controller, or Network address for Zone 2 controller, or Network address for Zone 3 controller
bPS	9600	Baud rate
LEn	8	Bit length
PrtY	EvEn	Parity
StoP	1	Stop bit Press SET twice to return to the Main Screen.

5.6.2 Restoring Factory Zone PID Settings

See 5.2.1 for factory zone controller settings. Follow the steps in section 5.2.2 Viewing and Changing a PID Parameter Group to manually re-enter these settings.

5.6.3 Restoring Factory Operation Settings

From the Main Screen:

Table 5-11 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 SET key to store new value. Press ↵ key for next parameter. Press SET twice to return to the Main Screen.
r-S	run	Controller run
SP	0	Display format (no decimal point)
AL1H	10	Alarm 1 high
AL1L	10	Alarm 1 low
AL2H	1005	Alarm 2 high
AL3H	10	Alarm 3 high
AL3L	10	Alarm 3 low
LoC	LOC2	Lock mode (allows only ▼ ▲ & SET key entry)
out1	000.0	Setting is read-only and cannot be changed. Press SET to return to the Main Screen.