Chapter 1

FURNACE EQUIPMENT

Description of the LA-309P IR furnace basic thermal process elements, standard hardware and their functions. Refer to Chapter 6 for optional equipment description and operation.

1.1 Furnace Description

The LA-309P is a 1000 ^{0}C compact, near-infrared, conveyor belt furnace for laboratory and general purpose thermal processing in a controlled atmosphere, free of outside contamination. Process gas may be CDA, N_2 or another inert gas. Dual gas furnaces may use Nitrogen and a reducing gas such as Forming Gas (pre-mixed N_2/H_2) or another type of process gas introduced into the heating chamber.

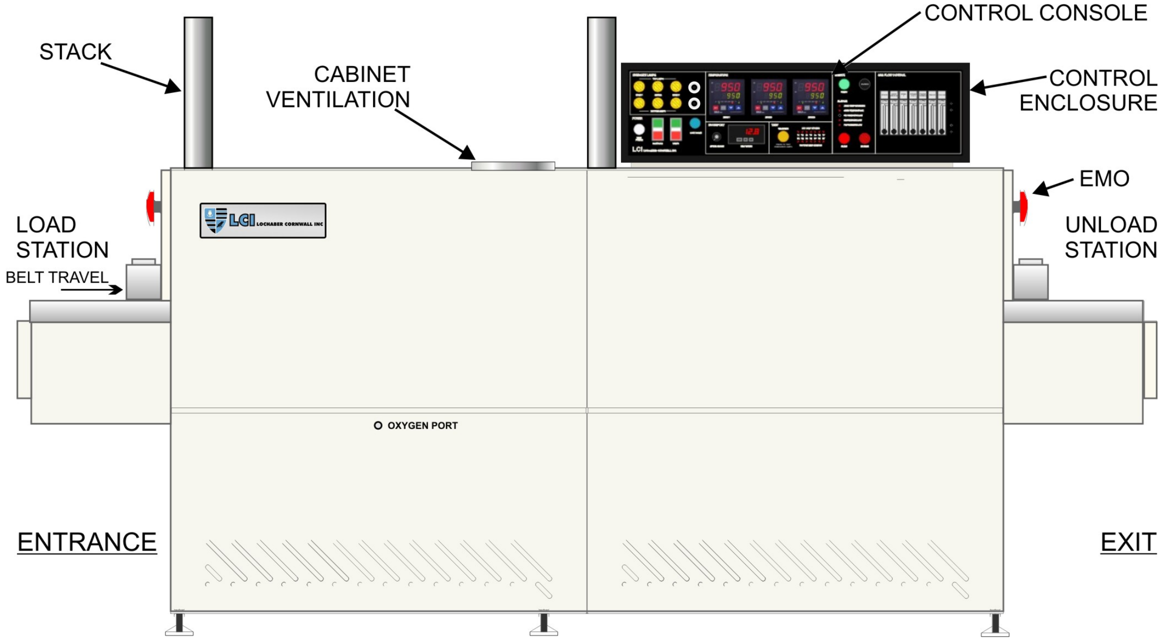
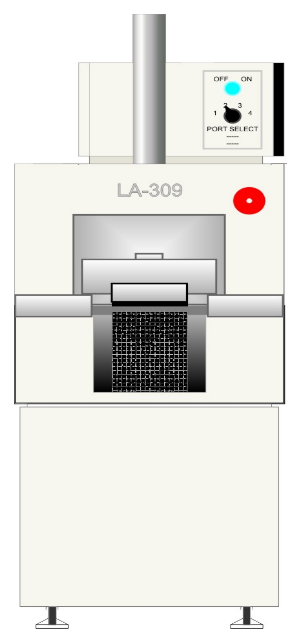


Figure 1-1 Furnace Front Elevation



The LA-309P furnace transports product on a moving 240 mm (9½ -inch) wide belt. In the standard design the chamber clearance above the belt is 50 mm (2 inches). Optionally the furnace can be ordered with 25 mm (1-inch) or 100 mm (4-inch) vertical clearance above belt. LA-309P furnaces feature a hermetically sealed heating chamber permitting atmospheric control of the furnace chamber process environment. Baffle sections before and after the heating section contain curtains that hang down to just above the belt to further isolate the furnace chamber from the room atmosphere and from the cooling section.

The LA-309P can process substrates, wafers, PCBs, metal, ceramic, glass or polycarbonate parts for electronic package sealing, thermo-setting polymer curing, reflow soldering, copper and hybrid/thick film firing, brazing, annealing, brazing, tempering and metal sintering applications, or almost any kind of general thermal processing requiring precision temperature control in a controlled atmosphere environment.

The LA-309P can also be used for precise curing of coatings on optical lenses, advanced thin film crystalline silicon, cadmium telluride (CdTe alloys) and certain copper indium diselenide (CIS-alloys) as well as many dental lab and production applications.

1.2 Furnace Views

Figure 1-2 Furnace Front Elevation

Figure 1-3 Entrance Elevation

Figure 1-4 Exit Elevation
(with CDA Mixing & SENSLAS)

Figure 1-5 Rear Elevation

Figure 1-6 Top Front View with optional Entrance Hood and OSS control

1.3 Thermal Process Elements

During furnace operation, parts are carried from the load station through the heating and cooling sections of the furnace to the unload station on a 240 mm (9½-inch) wide belt driven by an adjustable speed motor. Maximum vertical parts clearance inside the standard furnace is 50 mm (2 inches).

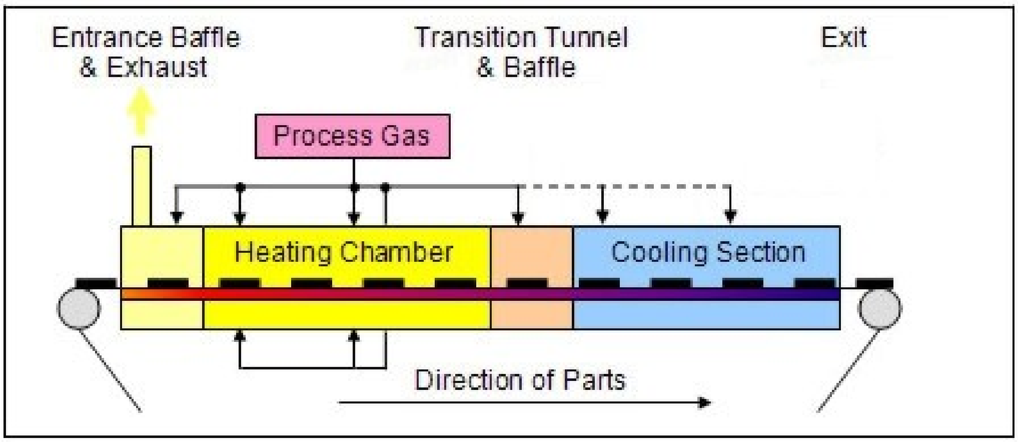


Figure 1-7 Process Sections

Process atmosphere is controlled much like a clean room: pressurized gas is pushed through the heating chamber insulated walls providing pre-heated, laminar flow for a uniform, stable atmosphere.

Zones. The heating chamber is divided into 3 zones separated by insulating dividers so that adjacent zones can maintain different setpoint temperatures, if required. Control starts with K-type thermocouples in each zone quickly sensing changing conditions and feeding these signals to individual digital PID controllers for each zone. The PID loop controllers drive arrays of IR quartz heating lamps inside the heating chamber so as to maintain the desired temperature setpoint in each zone.

Product cooling is by radiant cooling and CDA or N2 gas convective cooling in an enclosed tunnel, with exterior fan heat removal.

1.4 Heat Transfer Methods

Transfer of heat in the furnace is by three different methods: Radiation, Convection and Conduction. In order of their contribution to heating the product, these methods are:

A. Radiation

The furnace lamps emit infrared electromagnetic waves which, when striking and absorbed by product on the belt, cause its temperature to rise. "Heat lamps" and microwave ovens work in a similar manner and it is also the way the sun heats the Earth. The infrared radiation does not directly heat the process gas within the furnace.

B. Convection

During operation, lamp radiation heats the chamber top, bottom and side wall insulation. As the process gas enters the furnace through the porous ceramic insulation, it is heated to near the setpoint temperature of the zone. This flow of heated gas transfers heat to the product on the belt. Hair dryers and home forced air heating function in the same fashion.

C. Conduction

Lamp radiation heats the transport belt which becomes a heat source for the product supported on the belt. Electric stoves and hot plates heat in this way.

1.5 Controlled Atmosphere

LCI furnaces are equipped with the ability to supply constant streams of a supplied process gas. This feature allows the user to reduce product oxidation or contamination, remove process effluents or reduce other potentially negative effects of ambient air at high temperatures.

A controlled atmosphere also helps establish higher consistency in thermal processes. When a product travels through the process section, slight changes in the atmospheric conditions in a non-controlled atmosphere environment can affect the stability and consistency of the product temperature profile.

1.6 Hermetically Sealed Systems

For most furnace systems, the lamps ends are enclosed in plenums. Gas fed to the plenums keeps the lamps cool and prolongs the life of the lamp and improves lamp IR performance. Balancing the furnace gas inflows and outflows enables the furnace to maintain a hermetic seal. While not air-tight, a hermetic seal resists the mixing of the outside atmosphere with the furnace atmosphere by maintaining a higher pressure inside the furnace chamber.

1.7 Furnace Process Equipment

The furnace process equipment includes an entrance baffle with an eductor equipped exhaust stack, a heating chamber, a transition tunnel between the heating and cooling sections, and a closed atmosphere cooling tunnel, configured for 50mm (2-inch) product height (PH2) and arranged as shown in Figure 1-8 (see Chapter 6, PH1 and PH4, for optional product height choices). Together, the individual sections function together to provide a carefully controlled gas atmosphere, precise temperature profile and two-stage controlled atmosphere cooling.

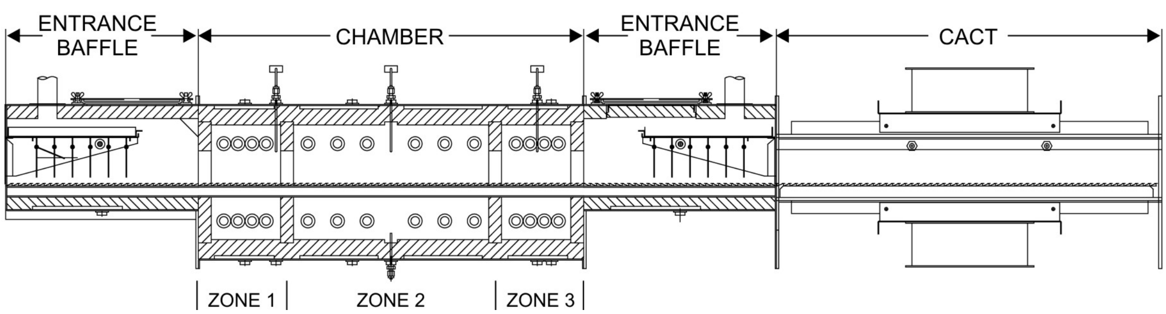


Figure 1-8 Furnace Internals

1.8 Load Station (LOAD)

Located immediately before the furnace entrance, the Load station consists of two (2) horizontal stainless steel surfaces 370 mm (14.5 inches) long x 206 mm (8.125 inches) wide positioned on either side of the belt. The Load station provides a convenient area for handling product and for holding profiling equipment. Extensions in multiples of 380 mm (15 inches) can be added to increase the length of the Load station.

1.9 Entrance Baffle & Exhaust Stack (BE)

The entrance baffle isolates the heating section from the ambient air outside the furnace entrance. It is housed in a welded stainless steel shell lined with ceramic fiber insulation. An N_2 or CDA gas curtain with a series of hanging stainless steel baffle plates serves to act as a thermal barrier as well as purge the baffle and help prevent ambient air from entering the furnace. Owner can stipulate baffle clearance of 6 mm to 40 mm (0.25 to 1.5 inches) above the belt (or eliminate entirely). Adjust gas flow to the ENTR BAFFLE flowmeter to isolate Zone 1 from room atmosphere.

A venturi-assisted exhaust stack, or “eductor”, draws furnace gases out of the furnace. Before exhausting via the stack, the process gas passes over a removable drip tray to collect exhaust condensation and prevent it from falling into the baffle section and contaminating the product. The eductor pulls 10-15 times its process gas flow from the furnace. Adjust gas flow to the ENTR STACK flowmeter to balance the furnace gas outflow with the gas inflow.

1.10 Chamber

The furnace chamber is similar in construction to the entrance baffle and is usually hermetically sealed with plenum covers over the lamp ends. Inside this section, arrays of tungsten filament quartz heating lamp tubes located above and below the belt, generate intense near-wave (sometimes called "short-wave") infrared light with a color temperature of 2500 K (peak wave length of 1.16 µm). These lamps are very efficient heaters with very fast response times, producing up to 900 W per lamp at full power and capable of heating the furnace chamber to a state of equilibrium within minutes.

Lamp Arrangement. The lamps are arranged symmetrically above and below the belt. The top and bottom lamps may be used independently or together to configure the best possible heat transfer mode for each individual process. **Table 1-1 Furnace Arrangement** shows the distribution of lamps and available power in each zone.

Table 1-1 Furnace Arrangement – Standard and High Power Configurations

Zone	Length (mm)	# of Lamps Top / Btm	Lamp Spacing (mm)	Standard 380-480 Vac Max. Available Zone Power (W)*	High Power 380-480 Vac Max. Available Zone Power (W)*
1	190	4 / 4	30	5900-7200	5900-7200
2	380	6 / 6	58	4700-6800	8900- 10800
3	190	4 / 4	30	5900-7200	5900-7200

*Depends on line voltage; 380 Vac, select lower end of range; 480, select upper end of range.

Standard & High Power Configurations. LA-309P furnaces are wired with 12 top and 12 bottom lamp strings. An optional high power LA-309P is configured with 14 top and 14 bottom lamp strings. In the standard 380-480 Vac configuration Zones 1 and 3 are wired with two (2) parallel strings, each consisting of two (2) lamps. Zone 2 is wired with three (3) parallel strings, each string consisting of three (3) lamps in series. High power models differ only in Zone 2 which is wired with three (3) parallel strings, each string consisting of two (2) lamps in series. Either model will perform well throughout the design temperature range of the furnace (100-1000 ^{0}C), the standard model is optimized for 100-960 ^{0}C operation with low to moderate mass and belt speeds, while the high power model is optimized for 100-960 ^{0}C operation for product with higher mass and at higher belt speeds. Lamps within the furnace are arranged as shown in Table 1-2.

Table 1-2 Furnace Lamps Wiring Configuration

Zone	Standard Configuration		High Power Configuration		Total Number of Lamps
	Strings Top / Btm	Lamps per String Top / Btm	Strings Top / Btm	Lamps per String Top / Btm	
1	2 / 2	2 / 2	2 / 2	2 / 2	8
2	2 / 2	3 / 3	3 / 3	2 / 2	12
3	2 / 2	2 / 2	2 / 2	2 / 2	8

Zones. The heating chamber is partitioned into 3 separate zones using ceramic fiber dividers. The dividers are designed with the smallest possible opening consistent with the parts clearance specifications. This partitioning assures very high thermal isolation between zones. Although the heating profile across the belt is extremely uniform, heat losses through the furnace side walls and at the belt edge supports produce a temperature drop near the edges of the transport belt. Away from the extreme edges of the belt, overall temperature uniformity across the belt is normally better than ±5 ^{0}C.

Temperature Measurement. Inside the furnace chamber, at the top center of each zone a type K thermocouple measures the temperature in that zone and provides feedback to each respective zone PID controller to determine the amount of power necessary to maintain setpoint temperatures. However useful these thermocouples are for controlling the temperature in each zone, the actual part is exposed to three heat transfer methods. As with any furnace, the most accurate way to determine what temperature product on the belt actually sees from these three methods of heating is to profile the furnace with a thermocouple placed directly on the product surface.

Chamber Process Gas. Process gas (CDA, N_2 , FG or other gas) is introduced through the top and bottom of the chamber via zone flowmeters and through the sides via the plenums. Chamber top and bottom process gas is preheated before reaching the furnace interior by allowing it to permeate through the hot porous ceramic fiber insulation. This method of gas distribution improves furnace IR behavior and helps keep the furnace interior clean.

Zones: Adjust ZONE 1 and ZONES 2&3 flowmeters to keep the lamps on as long as possible and to control the process atmosphere.

Plenums: Process gas (CDA, N_2 , FG or other gas) is introduced into the chamber sides via 4 plenums, two on each side of the chamber, one top and one bottom. The process gas passes around the lamps into the chamber through high temperature fiber seals surrounding the lamp diameter as it passes through the chamber insulation. This gas serves to cool the ends of the lamps to prolong lamp life and also prevents the chamber atmosphere from leaking out of the furnace. Control gas to the sides of the chamber via the LAMP SEALS flowmeter. Maintain at least 20 Lpm flow to the LAMP SEALS to prevent damage to the lamps. Increase LAMP SEALS gas flow 4 Lpm for each 100°C the furnace is operated above 400°C to prolong lamp life.

1.11 Transition Tunnel with Stack (TTSE)

The transition tunnel separates the furnace chamber from the closed atmosphere cooling tunnel. The transition tunnel is constructed using the same materials as the furnace section to minimize thermal stresses to the product caused by excessive cooling rates. Convective gas cooling of product is produced by the controlled flow of process gas into this tunnel via gas rakes. Hanging stainless steel baffle plates act as a thermal barrier and help contain the furnace heating and cooling atmospheres in their respective sections. Owner can stipulate baffle clearance of 6 mm to 40 mm (0.25 to 1.5 inches) above the belt (or eliminate entirely). Adjust TRANS TUNNEL flowmeter to control product initial temperature drop and to isolate the furnace atmosphere from the cooling section.

A venturi-assisted exhaust stack, or “eductor”, draws furnace gases out of the furnace. Before exhausting via the stack, the process gas passes over a removable drip tray to collect exhaust condensation and prevent it from falling into the baffle section and contaminating the product. The eductor pulls 10-15 times its process gas flow from the furnace. Adjust gas flow to the TRANS STACK flowmeter to balance the furnace gas outflow with the gas inflow.

1.12 Cooling Tunnel (CACT)

The closed atmosphere cooling tunnel (CACT) is a 76 mm (30 inch) long high efficiency heat exchanger that reduces the temperature of the product on the belt as it passes through. It is constructed of extruded aluminum heat sink material and is not insulated. Inside, a carefully controlled atmosphere of CDA or N2 gas is maintained to cool the product to a safe temperature. Fans mounted on the exterior of the CACT transfer heat to the air inside of the furnace cabinet. This cabinet air is then exhausted by cabinet fan through an opening in the furnace top cover into the room or for removal by facility exhaust ducting.

To inhibit drafts and ambient air from entering the CACT, a hanging stainless steel baffle plate is mounted directly to the CACT exit. Adjust gas flow using the COOLING flowmeter to isolate the transition tunnel from room atmosphere and to control product cooling rate. For operation of the furnace above 300 C assure that the COOLING flowmeter allow at least 12 Lpm gas flow. Increase COOLING flow at least 4 Lpm or more for each 100°C Zone 3 is operated above 200°C to prevent overheating the CACT cooling chamber.

1.13 Unload Station (UNLOAD)

Located immediately after the furnace cooling section exit, the Unload station consists of two (2) horizontal stainless steel surfaces 370 mm (14.5 inches) long x 206 mm (8.125 inches) wide positioned on either side of the belt. The Unload station provides a convenient area for handling and inspection product exiting the furnace and for product removal. Extensions in multiples of 380 mm (15 inches) can be added to increase the length of the Unload station.

1.14 Console Controls & Indicators

1.14.1 Control Console

Interface with the furnace is via the Control Console (Figure 1-9) mounted over the cooling section of the furnace. The Control Console is divided into 7 logical panels: Power panel, Energize Lamps panel, Temperature panel, Transport panel, Test panel, Status panel and Gas Flow Control panel. The Control Console is used to communicate with the programmable logic controller (PLC), housed within the Control Enclosure, that controls furnace operation.

Figure 1-9 LA-309P Control Console

1.14.2 POWER Panel

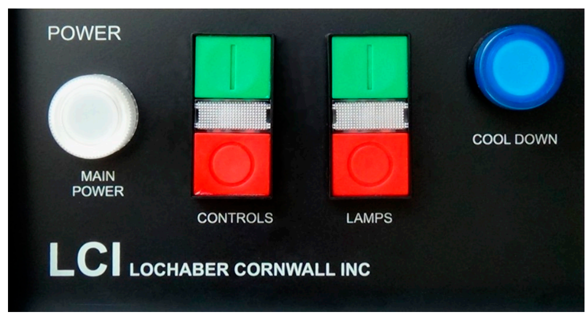


Figure 1-10 Power control panel

A. MAIN POWER lamp

Indicates connected power. When this WHITE light is ON, the furnace is connected to the power line.

B. CONTROLS pushbuttons with indicator

Switches power to the furnace control system.

Pressing the green switch applies power to the furnace controls, belt motor and cooling fans.

Pressing the red switch shuts off power to the furnace and acts electrically in the same way as pushing an EMO button.

Between the switches is an indicator light that stays ON while the control system is ON.

C. LAMPS pushbuttons with indicator

Switches power to selected heating elements. These buttons work only when CONTROLS indicator is ON.

Pressing the green switch applies power to the lamps.

Pressing the red switch shuts off power to the lamps.

Between the switches is an indicator light that stays ON while the lamps are ON.

D. COOL DOWN pushbutton with lamp

Starts Cool Down cycle. Pressing this button begins a controlled cool down sequence. The furnace lamps shut down immediately, but the Cool Down circuit keeps the zone controllers, transport belt and cooling fans ON to help cool the furnace until one of these conditions occurs:

1. All zones cool to below 100°C
2. 120 minutes have passed
3. The operator pushes the red CLEAR pushbutton on the STATUS panel.

While in COOL DOWN, the blue indicator in the pushbutton remains lit until the Cool Down condition is met, then the blue light turns OFF.

COOL DOWN can be cancelled using the CLEAR button on the Status panel.

Cool Down – Auto Shut Down. After starting COOL DOWN, if the operator then presses the red CONTROLS button, the cooling cycle will continue as above, except that after the cooling cycle is complete, all controls, displays, the PLC and the furnace shuts off completely.

1. Auto Shut Down mode may be **cancelled** at any time by first pressing the CONTROLS pushbutton ON and then pressing the CLEAR pushbutton on the Status panel.

2. In an **emergency** during Auto Shut Down mode, pressing any EMO button shuts off the PLC and the furnace completely.

1.14.3 ENERGIZE LAMPS Panel

A. Zone Selector Switches with Lamps

Each switch turns the respective top or bottom heating elements in the designated zone ON or OFF. When a switch is turned CW, those elements are selected to be ON and the switch light turns ON. Turning a lighted switch CCW turns those elements OFF.

Selected zones remain selected even when furnace power is OFF.

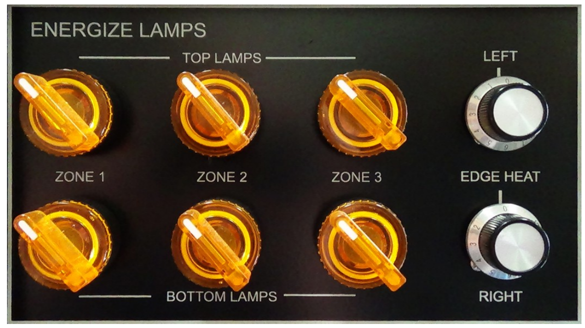


Figure 1-11 Energize Lamps control panel

NOTE: Change zone selection only with LAMPS OFF to maximize zone selection switch life.

B. Edge Heater Switched Controls

Each Edge Heat switch turns the respective left or right heating element ON or OFF. Rotating the switch clockwise increases power to the edge heater, clockwise decreases power. Turn full counter clockwise to click to full OFF when not in use.

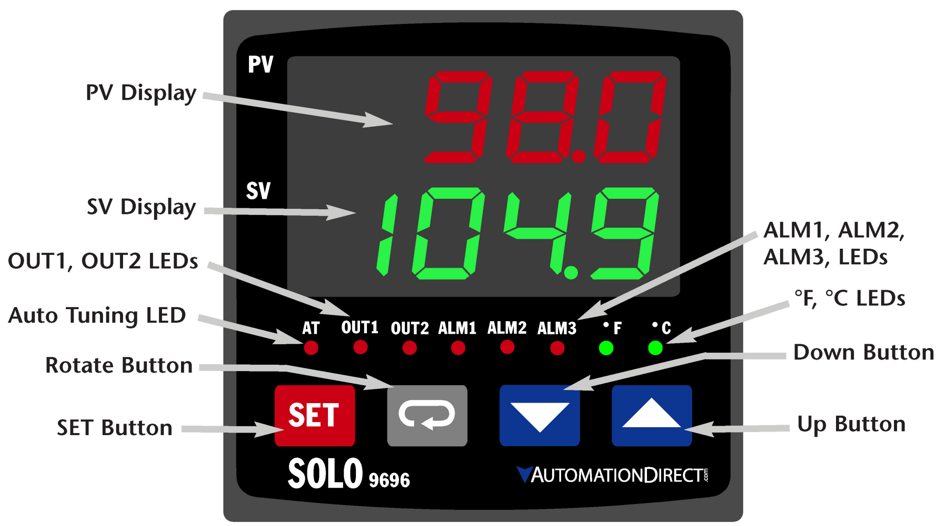
Note: Edge Heat should be used sparingly to add heat to product at the left and/or right sides of the belt. Increasingly higher levels of Edge Heat can reduce the ability of the zone controllers to properly control and stabilize the furnace.

1.14.4 TEMPERATURE Panel

Controls Zone Temperature. Independent control of each furnace zone is provided by type K sensing thermocouples, located above the belt in each zone, coupled to digital temperature controllers that regulate the power output of the lamps and sense alarm or alert conditions in each zone. The behavior of the furnace zone heating elements is controlled via these sophisticated PID temperature controllers (Figure 1-12).

Figure 1-12 Zone Temperature Controllers

Each zone controller is a digital single-loop PID controller with loop Autotune and three alarm functions. The controller's closed loop temperature control system uses K-type thermocouples for feedback. For each zone, four individual PID models are independently optimized to provide excellent furnace performance throughout the 100-960°C operating range of the furnace. The zone controllers automatically select the PID control model closest to the target setpoint. Zone temperature controller indicators and controls are illustrated in Figure 1-13.



PV Display: process value or parameter type	**ALM1-ALM3:** alert/alarm LEDs, light when ON
SV Display: setpoint or parameter value	**ºF, ºC:** temperature units selected. Default is °C
AT: flashes when Autotuning operation is ON	**SET:** press to select mode or set parameter value
OUT1: lights when control output is ON	**ROTATE:** selects next parameter within a mode
ALM1-ALM3: alert/alarm LEDs, light when ON	**DOWN:** press to decrease displayed SV values
ºF, ºC: temperature units selected. Default is °C	**UP:** press to increase displayed SV values

Figure 1-13 Temperature Controller Indicators and Control Buttons

1.14.5 TRANSPORT Panel

Figure 1-14 Transport Panel

A. SPEED ADJUST Knob

Sets belt speed setpoint. The Transport Speed Adjust knob enters the belt speed setpoint. CW rotation increases speed, CCW rotation decreases speed setpoint. Fine tuning is possible with roughly 10 turns between minimum and maximum speed.

B. CALIBRATE light indicator

The Calibrate indicator light illuminates whenever the SPEED ADJUST knob is being turned or the SPEED ADJUST system is in MANUAL MODE.

C. BELT SPEED Indicator

Displays belt speed. The digital display meter shows belt speed in inches per minute (ipm), millimeters per minute (mm/m), centimeters per minute (cm/min), or other custom units of rate.

The PAR, ▼ and ▲ are only used to change the display parameters and are normally disabled during furnace operation.

D. SPEED ADJUSTMENT & CONTROL

Normal operation. During normal operation, the belt speed is automatically controlled by the furnace controller to a setpoint determined by the user. Turn the SPEED ADJUST knob to set or change the belt speed setpoint to a value above the furnace specification minimum speed. Stop turning when the desired setpoint appears in the BELT SPEED display. During adjustment, the CALIBRATE light turns ON indicating the setpoint is being changed (Figure 1-15). The BELT SPEED display is updated every 3 seconds, so there is a short delay in seeing the effect of your adjustment. Release the knob and after 10 seconds, the currently displayed belt speed will be stored as the new setpoint and the CALIBRATE light will turn OFF.

During the next 60 seconds or so, the BELT SPEED display will fluctuate as the controller refines its control of the belt motor's speed to the new setpoint. (Note: before again adjusting the knob, allow the controller some time to properly settle the belt motor at the new speed.) Once the lock is established, that belt speed setpoint will be maintained by closed-loop (feedback) control until the user turns the SPEED ADJUST knob, initiates MANUAL MODE, or presses the CONTROLS OFF pushbutton.

On furnace restart, the furnace automatically resumes normal operation at the stored belt speed setpoint. As noted in normal operation above, allow 60-90 seconds for the belt control system to settle at the stored speed.

Manual mode. In MANUAL MODE, the belt speed lock (feedback control) is disabled and the SPEED ADJUST knob input directly controls the belt speed (feed-forward control). To enable MANUAL MODE, press and hold the CALIBRATE pushbutton for 3 seconds, and then release. Both the CALIBRATE and CLEAR light indicators will illuminate and remain lit until MANUAL MODE is cancelled. As in normal operation, adjust belt speed using the SPEED ADJUST knob; the BELT SPEED display is updated every 3 seconds, so there is a short delay in seeing the effect of your adjustment. The belt speed may fluctuate slightly or drift over time in this mode.

To cancel MANUAL MODE, press the CLEAR pushbutton on the control console and you will return to normal operation (feedback control) as described above. The belt speed displayed at the moment the CLEAR pushbutton is pressed will be stored as the new belt speed setpoint to a value above the furnace specification minimum speed. The MANUAL MODE is useful for calibrating or servicing the belt transport system, or as an alternate way to set your desired belt speed.

Speed Adjustment - Best Practice: Setting Belt Speed using Manual Mode. To set belt speed, some users prefer to place the furnace in manual mode first. To use this method:

1. Press and hold CALIBRATE pushbutton for **at least** 3 seconds; (Note: holding pushbutton for less than 3 seconds will initiate the SCR calibration process with rapidly rising zone temperatures. If this happens, immediately press the CLEAR pushbutton on the Status panel to cancel the SCR calibration process.)
2. Adjust belt speed using the SPEED ADJUST knob until belt speed displays your desired speed; Keep in mind the 3-second delay in belt speed display update; it may take several iterations of this delay interval until the display settles at the value you selected.
3. Press CLEAR pushbutton.

CALIBRATION light stays ON until controller locks on the new speed setting. Belt speed will oscillate slightly for a moment until it begins controlling to the new setpoint.

1.14.6 TEST Panel

A. CALIBRATE pushbutton

Starts lamp string test and calibrate SCR cycles. Whenever the LAMPS button is ON, 25% power is applied directly to the lamps selected on the ENERGIZE LAMPS panel, allowing a reliable check for failed lamps using TOP and BOTTOM LAMP STRING indicators, or to adjust the SCR line voltage settings during SCR maintenance.

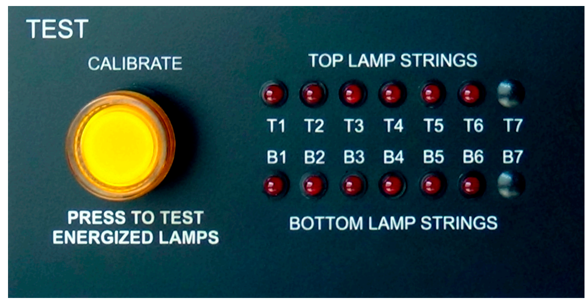


Figure 1-15 Test Panel

The CALIBRATE mode ends automatically after 2 minutes. Pressing the CLEAR button ends the CALIBRATE mode immediately. Lamp (SCR) control is then returned to the zone controllers.

B. TOP LAMP STRINGS and BOTTOM LAMP STRINGS indicators

Failed lamp indicator displays lamp string current flow. A lamp "string" is 2 or 3 IR heating lamps wired in series to maximize each lamp's efficiency. Whenever the LAMPS button is ON and current is flowing to the energized zone, corresponding furnace TOP lamp strings T1 through T7 above the belt, and BOTTOM lamp strings B1 through B7 below the belt are continuously monitored for lamp failure. Strings T1/B1 are closest to the furnace entrance, and T7/B7 are closest to the exit. See Figure 1-16 (for a Standard furnace) or Figure 1-17 (for High Power furnace) for correlation of lamp strings to zones.

During normal operation, if an indicator is lit, the lamps in the string are fine. If unlit, the commanded power may be too low or OFF for an accurate assessment (a condition most likely during actual operation of the furnace); one of the lamps in that string may have failed; or the string may not be in the group of lamps selected on the ENERGIZE LAMPS panel. For a more definitive assessment, use the CALIBRATE mode to check the lamps before running product in the furnace or during maintenance checks.

Lamp Strings by Zone. LEDs that should be lit for each zone are indicated in Figure 1-16 and Figure 1-17. In each zone, all TOP and all BOTTOM LEDs, if energized, should be lit at the same time. If only one LED in a zone does not light it indicates the lamp string may contain a failed lamp or loose wire.

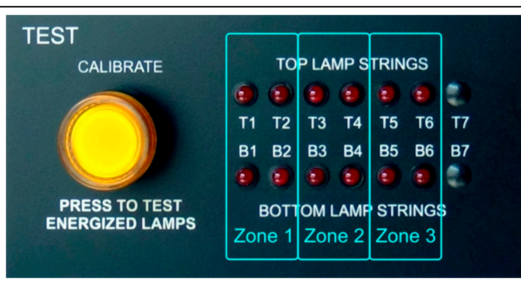


Figure 1-16 Zone Lamp Strings, Standard

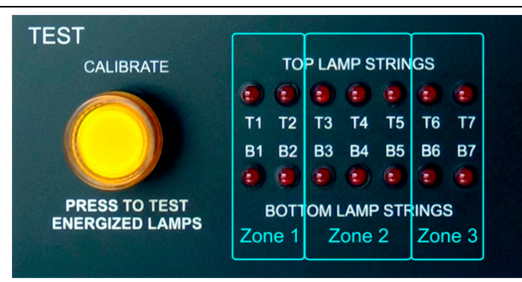


Figure 1-17 Zone Lamp Strings, High Power

1.14.7 STATUS Panel

Figure 1-18 Status Panel and Alarm Controls

A. READY lamp

Indicates the furnace is ready to process parts. After all zones have heated to their SV setpoint values and the controllers have reported all PV process temperatures as within process ready limits for 2 minutes, the process READY light (green) on the STATUS panel will turn ON.

B. BUZZER

Audible warning. Broadcasts with an audible signal of any alert or alarm condition.

C. ALARMS

Indicates the condition that caused an alert or alarm. An alert condition will only produce an audible and visual warning. An alarm condition will produce an audible and visual warning and immediately shut off the lamps. Any alert or alarm condition will shut off the READY Lamp. LED indicators stay lit until CLEAR is pressed.

D. ZONE TEMP DEVIATION alert indicator

Lights when a zone has experienced a process temperature outside the setpoint temperature (ALM1) limits set in the zone controller. Factory setting is +/- 10°C.

E. OVER TEMPERATURE alarm indicator

Lights when a zone has experienced a process temperature higher than the maximum limit (ALM2) set in the zone controller and the lamps have been turned OFF. Factory setting is 1005 °C.

F. AIR PRESSURE LOW alert indicator (optional)

Lights when the CDA (clean, dry air) gas manifold has insufficient gas pressure, effecting operation. Factory setting is 55-60 psi.

G. N2 PRESSURE LOW alert indicator (optional)

The N2 (nitrogen) gas manifold has insufficient gas pressure, effecting operation. Factory setting is 55-60 psi.

H. FG PRESSURE LOW alert indicator (optional)

On dual Gas Systems only, this lamp indicates the furnace chamber manifold has insufficient FG (forming gas, H2/N2 mix) pressure.

If system is equipped with GSM (Supply Gas Mixing system), this alarm indicates the furnace manifold gas selected at the GSM is low, effecting operation. Factory setting is 55-60 psi.

I. CLEAR pushbutton with lamp

Indicates and clears alerts and alarms; also halts CALIBRATE and COOL DOWN modes, and stores presently displayed belt speed in PLC memory when belt speed Manual Mode is selected. This red lamp lights with any alert or alarm condition or any condition that can be cleared (including Calibrate and Cool Down cycles). Press the button to:

1. Clear all alerts and alarms, and will
2. Immediately cancel the CALIBRATE or COOL DOWN function, if active.

Continuing alert and alarm conditions will re-light the lamp, however, so it is best to correct the cause of the alert or alarm condition before pressing the CLEAR button.

J. SILENCE switch with red lamp

Silences buzzer. Turn the SILENCE switch CW to silence the buzzer. This will also turn the SILENCE red lamp ON as a reminder to the operator that the buzzer is disabled.

Silencing alerts is useful when changing setpoint temperatures, calibrating the SCRs, or auto tuning a zone.

Turning the lighted SILENCE switch CCW will enable the audible buzzer and turn the SILENCE lamp OFF.

1.14.8 GAS FLOW CONTROL Panel

Indicates and controls Process Gas flow. Atmosphere control is adjusted manually using needle valve variable rate flowmeters which control gas flow to the various parts of the furnace and out the exhaust stack in order to achieve overall gas flow balance within the furnace. Flowmeters are graduated in liters per minute (Figure 1-19).

Each flowmeter is identified with a label as to specific function and is adjustable from zero flow to full scale by means of a needle valve control knob. Turning this knob CW decreases flow; CCW increases flow. Flow is read on the graduated scale at the mid-point of the bead. Standard flowmeters include:

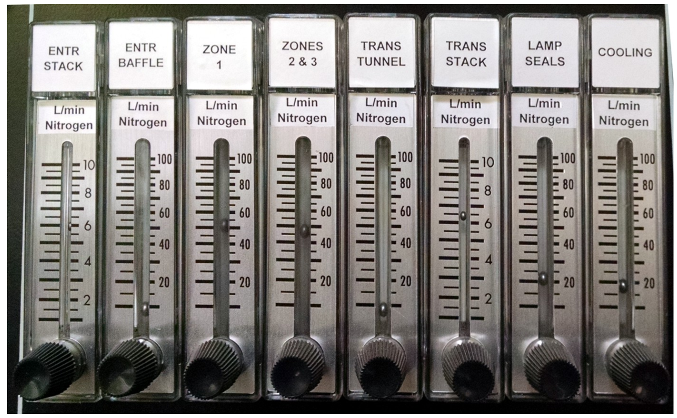


Figure 1-19 Gas Flowmeters

A. ENTR STACK

Controls flow to the entrance exhaust stack venturi. Stack flow has the capacity to exhaust from the furnace atmosphere a volume 15 times the flow setting (for example, 5 L/m Stack flow removes 75 L/m of furnace atmosphere).

B. ENTR BAFFLE

Controls flow to the entrance baffle isolating the furnace from room air.

C. ZONE 1

Controls flow to furnace chamber zone 1.

D. ZONES 2 & 3

Controls flow to furnace chamber zones 2 and 3.

E. TRANS TUNNEL

Controls flow to the transition tunnel isolating the heating chamber and cooling chamber from one another.

F. TRANS STACK

Controls flow to the transition tunnel exhaust stack venturi. Stack flow has the capacity to exhaust from the furnace atmosphere a volume 15 times the flow setting (for example, 5 L/m Stack flow removes 75 L/m of furnace atmosphere).

G. LAMP SEALS

Controls flow to the sealed lamp plenum boxes on each side of the furnace heating chamber.

For furnaces equipped with a SEALS flowmeter, to prevent damage to the element seals and avoid premature lamp failure:

- **When operating at 400 °C or below, set the SEALS flowmeter to at least 20 L/min.**
- **When operating above 400 °C, increase flow a minimum of 4 L/min for each 100 °C the furnace is operated above 400 °C.**

H. COOLING

Controls flow to the CACT closed atmosphere cooling tunnel gas rakes.

For furnaces equipped with a CACT flowmeter, to prevent damage to the aluminum heat exchanger:

- **When operating at 200 °C or below, set the COOLING to suit process parts cooling requirements.**
- **When operating above 200 °C, set COOLING to a minimum of 12 L/m up to 200°C in Zone 3 +4 L/min per 100C above 200C to protect CACT or higher to suit process parts cooling requirements.**

1.15 Programmable Logic Controller (PLC)

The furnace is controlled by a programmable logic controller or PLC. The PLC is a compact expandable high speed microcomputer. Basic input and output functions (I/O) are managed by the PLC including alert and alarm signals, sensors and ready status. The PLC on each furnace may vary according to installed features and options.

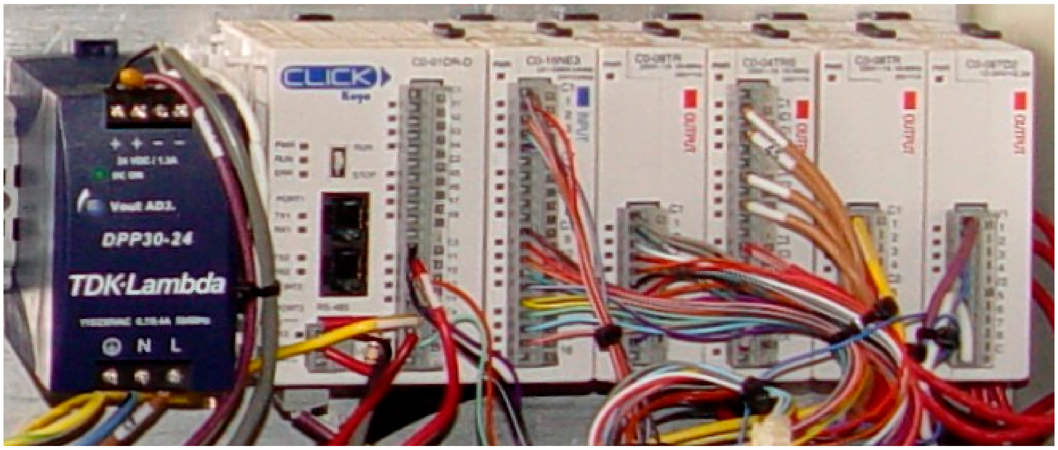


Figure 1-20 PLC and Power Supply

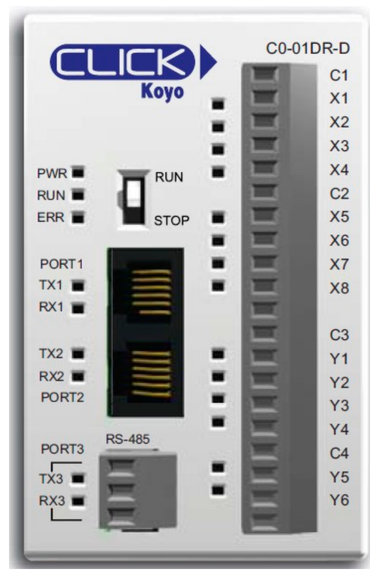


Figure 1-21 PLC CPU

The PLC generally consists of a CPU module and a number of digital and analog input and output modules. The CPU is the central processing unit or controller and contains the furnace program. The input modules receive signals from the furnace indicating its operating state. After processing the input information, the CPU sends instructions to the furnace via the output modules causing the ready light to come on or an alarm to sound. The PLC contains non-volatile FLASH ROM memory to store the factory installed program.

The CPU Contains Status indicators, communication ports and a PLC mode switch. See Section 7.6.2 for information on using the status lights in troubleshooting.

The PLC mode switch must always be in the RUN position to operate the furnace.

Port 1 is an RS-232C programming port.

The PLC (and the furnace) operates only when the CONTROLS pushbutton is ON. Pressing any EMO button or pressing the CONTROLS pushbutton OFF shuts off the PLC and the furnace.

1.16 Furnace Auxiliary Equipment

1.16.1 Cabinet Fans

Cabinet Fan. The furnace is equipped with one (1) 10-inch diameter fan mounted on the underside of the top of the furnace cabinet. This fan exhausts heat emitted from the outside of the furnace chamber and cooling tunnel into the room or customer installed exhaust system.

Enclosure Fan. The control enclosure is cooled by fan(s) mounted under the enclosure. These fans pull cool air from the room into the enclosure through vents in the enclosure base. The air is forced into ports in the back panel, across heat sinks where SCR's are mounted, and exhausts out of the top of the rear door panel.

Cooling System Fans. The exterior of the CACT cooling tunnel is cooled by fans mounted on the top and bottom of the tunnel. Cabinet air forced over the cooling tunnel removes heat conducted from the tunnel interior. This air is evacuated via the cabinet fan.

1.16.2 Low Pressure Alarms (IPS)

Figure 1-22 Pressure Switch

Gas Supply Pressure Switches are installed on the process gas manifolds. These switches are normally closed. They open when proper pressure is present in the process gas supply lines.

The pressure switches are factory set to open when pressure falls below the pressure set points in Table 1-3 for Gas 1 and Gas 2.

Table 1-3 Initial Pressure Alarm Settings

Manifold	Process Gas	Pressure Set Points	
Gas 1	Nitrogen or CDA	55-60 psi	3.8-4.1 Bar
Gas 2	CDA, Nitrogen, Forming Gas or other (Dual Gas option only)	55-60 psi	3.8-4.1 Bar
Gas 2	CDA, Nitrogen, Forming Gas or other (CDA Mixing option only)	none	none
Gas 2	Hydrogen (H_2 option only)	55-60 psi	3.8-4.1 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.

1.16.3 Belt Travel (LTR)

Standard direction for belt travel is from left to right when facing the furnace Control Console. As an option, the furnace can be configured for right to left operation (See section 6.18 for LTR and RLT plan view).

1.16.4 Transport Belt

The standard LA-309P standard conveyor belt is designed for high temperature applications. The belt is a close weave design manufactured from high temperature Nichrome-V wire, comprised of 80% nickel and 20% chromium. This belt offers fast heat-up times, more uniform operating temperatures and excellent mechanical stability. It also exhibits minimum shrinkage, growth, sag or distortion in use.

For some low temperature applications (under 500 °C) a 316 stainless steel belt may be requested at a lower cost.

1.16.5 Transport Drive

A. Major Components

The major transport drive components are listed in Table 1-4 .

Table 1-4 Transport Drive Components

Item	Brand	Model	Drive RPM	HP	Torque, (in-LB)	Motor RPM	Gear Ratio	Belt Speed (ipm)
Controller	**Minarik**	**PCM21010A**	**-**	**1/20-1/8**	**-**	**-**	**-**	**-**
Motor	**Bison**	**011-336-2082**	**22**	**1/8**	**300**	**1760**	**81.8:1**	**4.0 – 14**
Encoder	**Automation Direct**	**TRD-NH30-RZWD**	**-**	**4.75-30 Vdc**	**-**	**30 ppr**	**-**	**-**

B. Motor Controller

The motor speed is controlled by a variable speed SCR drive controller. When operated in the Manual Mode the motor controller uses the control panel-mounted potentiometer to scale output voltage to the motor. In the Normal (or automatic) Mode the PLC averages the pulse counts from the encoder and modifies the signal to the motor controller to maintain motor speed using a PID loop.

The motor controller is designed for 90 Vdc motor operation. The Motor controller is mounted in the furnace Control Enclosure. See Figure 1-23.

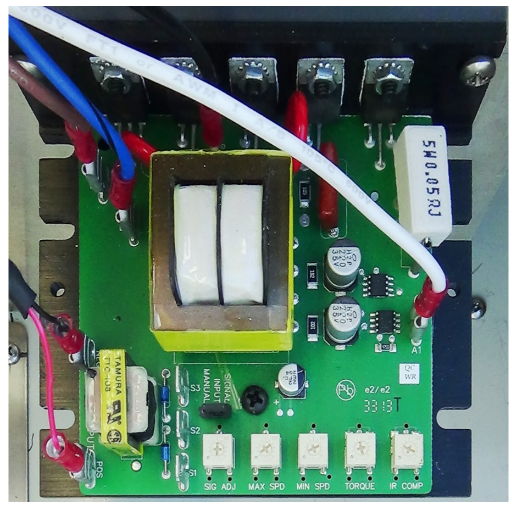


Figure 1-23 Motor Controller

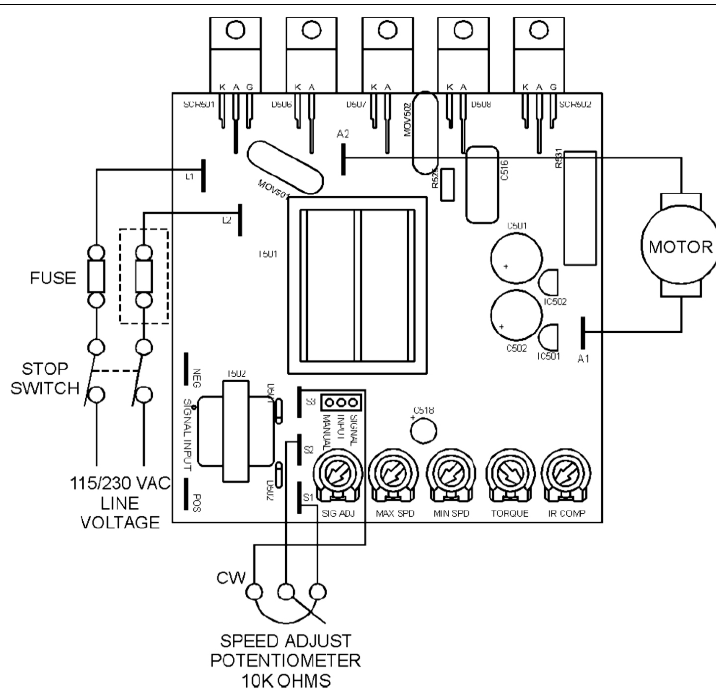
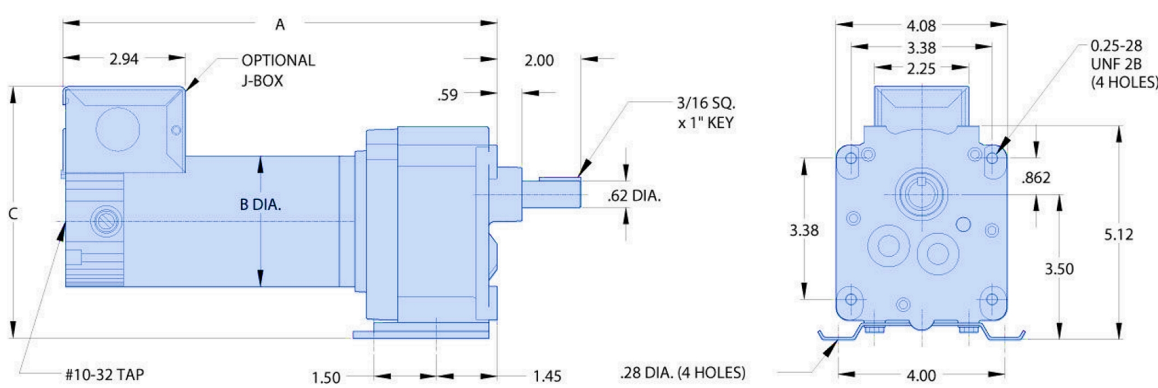


Figure 1-24 PCM21010A Motor Controller

C. Transport Drive Motor

The transport drive motor is a 1/8 HP TENV Brushless parallel shaft DC gearmotor and encoder assembly. The transport motor assembly is mounted in an enclosure at the exit end of the furnace. Drive chain and motor sprocket sized to provide the desired belt speed range shown in Table 1-4. The motor is shown in Figure 1-25 and Figure 1-26.

Figure 1-25 Drive Motor



HP	A	B	C
1/20	8.53	2.58	5.60
1/8	10.34	3.13	6.02
1/4	12.27	3.38	6.23

Figure 1-26 Transport Drive DC Motor

D. Speed Encoder

The motor is equipped with a 30 pulse per revolution dual channel 5-30 Vdc push-pull encoder (Figure 1-27). One channel is connected to the rate meter to report the belt speed, the other to the PLC to lock in the belt speed.

Figure 1-27 Encoder

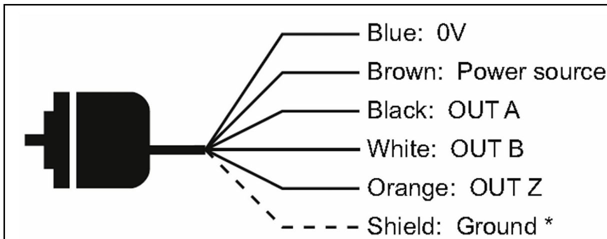


Figure 1-28 Encoder Connections

1.16.6 Universal Transformers

All primary transformers used in the furnace are manufactured specifically for our furnaces. These transformers are 50/60 Hz multi-tap and can be configured to operate the furnace at most commonly available voltages worldwide.