FURNACE EQUIPMENT

Description of typical LA-series IR furnace basic thermal process elements, standard hardware and their functions. Your furnace model may and equipment may be different from the illustrations shown in this section.

0.1 Furnace Description

The LA-310 is a computer controlled near-infrared, conveyor belt furnace for laboratory and production

thermal processing in the range of 100-1000 ^{0}C in a controlled atmosphere, free of outside contamination.

Your furnace may be configured for a maximum 600 ^{0}C temperature operation. Process gas may be CDA, N_2

or another inert gas. Dual gas furnaces may use Nitrogen and a second gas such as Forming Gas (pre-mixed N_2/H_2) or another type of reducing gas injected into the heating chamber.

Figure 0-1 Typical Furnace Front Elevation

The LA-310 furnace transports product on a 240 mm (9.5-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-310 furnaces feature a hermetically sealed heating chamber permitting 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-310 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-310 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.

0.2 Furnace Views

Figure 0-2 Typical Furnace Rear Elevation

Figure 0-3 Typical Entrance Elevation

Figure 0-4 Typical Exit Elevation

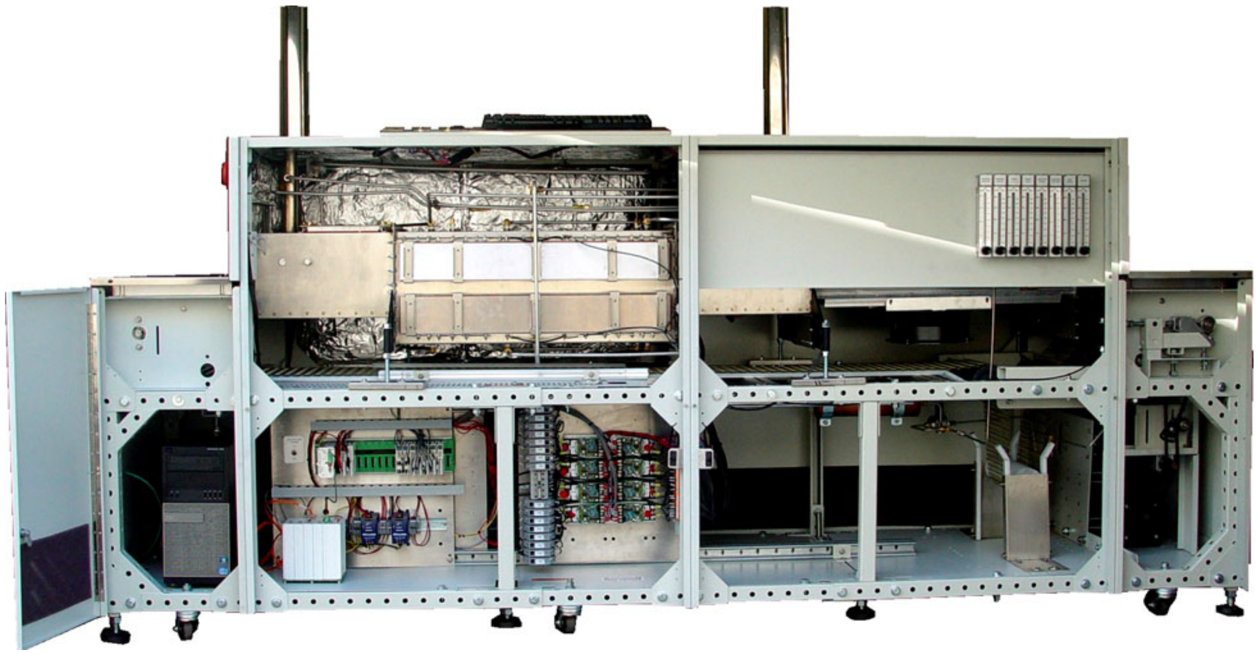

Figure 0-5 Front All Panels Off

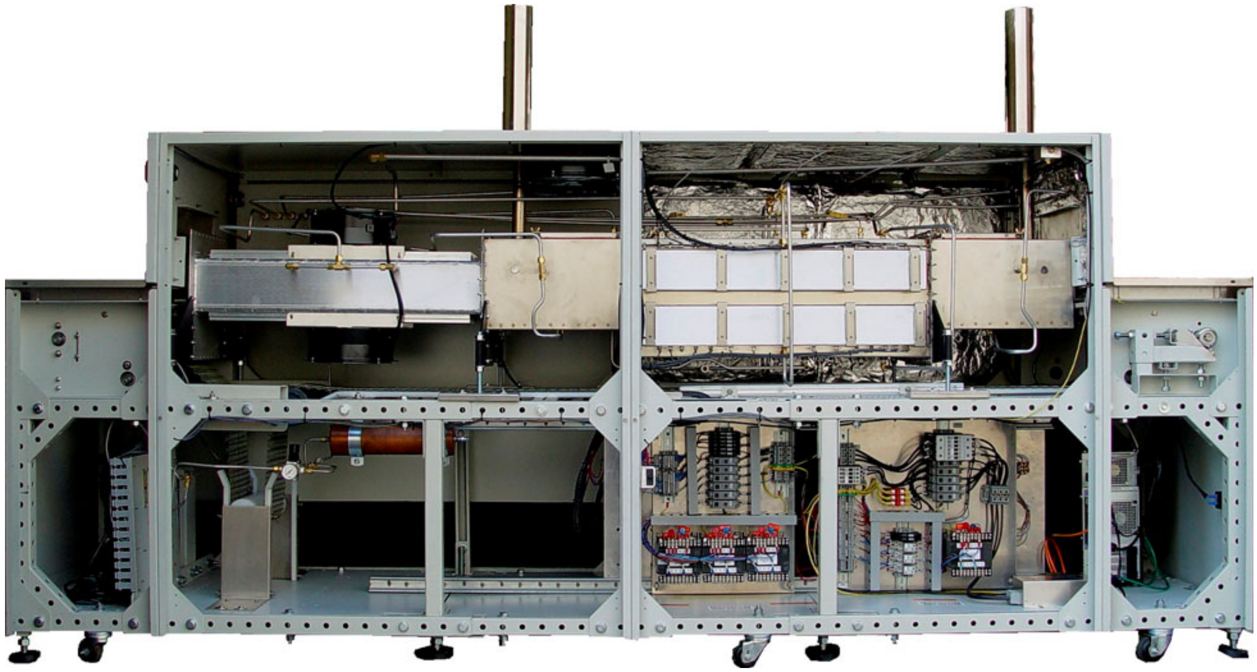

Figure 0-6 Rear All Panels Off

Figure 0-7 Front Entrance LA-309 with Entrance Extension

Figure 0-8 Front Exit LA-309 with Exit Extension
and SENSLAS Product Alert

0.3 Furnace Elements

0.3.1 Furnace Arrangement

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 152 mm (9.5-inch) wide belt driven by an adjustable speed motor. Maximum vertical parts clearance inside the standard furnace is 50 mm (2 inches).

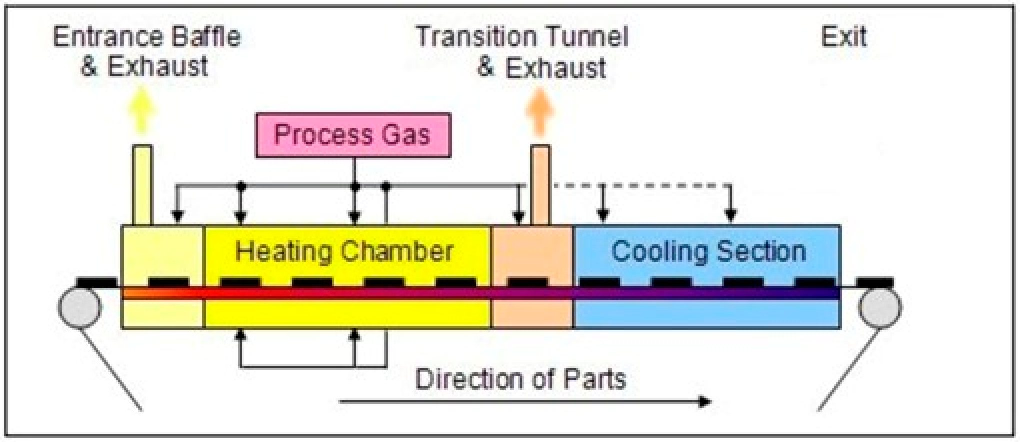

Figure 0-9 Process Sections

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 or 4 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 the PLC which communicates with the furnace computer. The furnace software PID loop algorithms control 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.

0.3.2 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.

0.3.3 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.

0.3.4 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.

0.3.5 Furnace Process Equipment

The furnace process equipment includes an entrance baffle with an eductor equipped exhaust stack, a heating chamber, a transition tunnel with exhaust stack 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 0-10. Together, the individual sections function as a unit to provide a carefully controlled gas atmosphere, precise temperature profile and two-stage controlled atmosphere cooling.

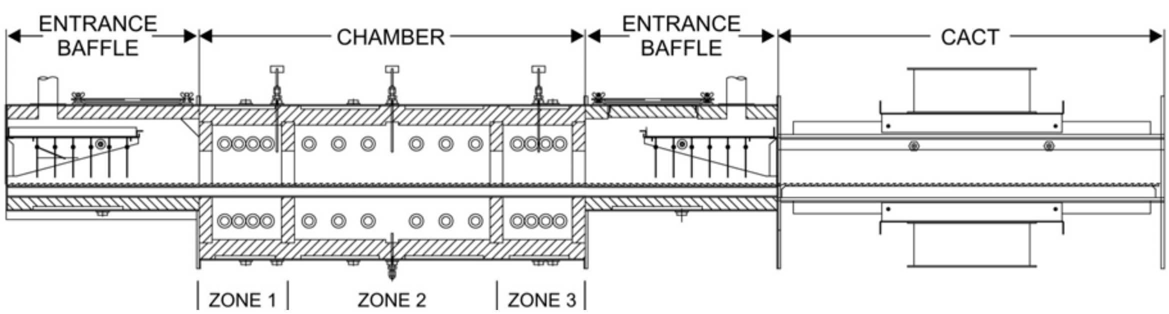

Figure 0-10 3-Zone Furnace Internals

In four zone LA-series X model furnaces zones 2 and 3 have the same number of lamps and spacing as zones 1 & 4. Entire chamber length is 30 inches and it the same for 3-zone and 4-zone furnaces.

0.3.6 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.

0.3.7 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.

0.3.8 Heating 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 0-1 Furnace Arrangement** shows the distribution of lamps and available power in each zone. See 802-101500 Power and Current datasheet in Section 5 for more information of the distribution of lamps and available power in each zone.

Table 0-1 Furnace Arrangement

Zone	Zone Length (mm)	# of Lamps Top / Btm	Lamp Spacing (mm)	Max. Available Zone Power* (W) 208 – 480 Vac	Max. Available Zone Power (W) 208 Vac
1	190	4 / 4	30	2336 - 7200	6800
2	190	4 / 4	30	2336 - 7200	6800
3	190	4 / 4	30	2336 - 7200	6800
4	190	4 / 4	30	2336 - 7200	6800

*Depends on line voltage.

Power Configurations. LA-309X & LA-310X furnaces are wired in high power configuration. In the high power configuration for voltages up to 240 Vac, Zones 1 through 4 are wired with four (4) parallel strings, each consisting of one (1) lamp in series. The high power model is optimized for 500-1000 ^{0}C operation. Lamps within the furnace are arranged as shown in Table 0-2.

Table 0-2 Furnace Lamp Wiring Configuration

Zone	Standard Configuration		Total Number of Lamps
	Strings Top/Btm	Lamps per String Top/Btm	
1	4 / 4	4 / 4	8
2	4 / 4	6 / 6	8
3	4 / 4	4 / 4	8
4	4 / 4	4 / 4	8

Zones. The heating chamber is partitioned into 4 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. Edge heaters can be used to improve the temperature evenness across the belt.

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 preheated before reaching the furnace interior by allowing it to permeate through the hot porous ceramic fiber insulation. This method of gas distribution does not affect the temperature profile 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 (40 cfh) flow to the LAMP SEALS to prevent damage to the lamps. Increase LAMP SEALS gas flow 4 Lpm (78 scfh) for each 100°C the furnace is operated above 400°C to prolong lamp life.

0.3.9 Transition Tunnel (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 (or EXHAUST STACK) flowmeter to balance the furnace gas outflow with the gas inflow.

0.3.10 Closed Atmosphere 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 (25 scfh) gas flow. Increase COOLING flow at least 4 Lpm (8 scfh) or more for each 100°C Zone 4 is operated above 200°C to prevent overheating the CACT cooling chamber.

0.3.11 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 0-11).

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:

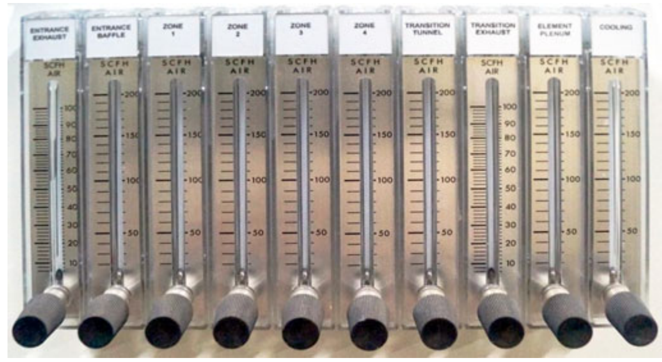

Figure 0-11 Gas Flowmeters

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. Excessively high settings can force outside air into the furnace.

C. ZONES 1, 2, 3 and 4

Zone 1 - 4 flowmeters control process gas flow to each respective 7.5-inch long furnace heating zone. For standard CDA firing, flowmeters should be set to provide just enough flow to drive lamps on continuously. Zone flows are generally higher for Nitrogen, Forming Gas or other special atmospheric firing.

D. TRANS TUNNEL

Controls flow to the transition tunnel isolating the heating chamber and cooling chamber from one another. Excessively high flows can force gas into the furnace heating chamber and affect performance.

E. TRANS (EXIT) 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).

F. LAMP SEALS (PLENUMS)

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 500 °C or below, set the SEALS flowmeter to at least 20 L/min (40 scfh).**
- **When operating above 500 °C, increase flow a minimum of 4 L/min (8 scfh) for each 100 °C the furnace is operated above 500 °C.**

G. 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 (20 scfh) up to 250°C in Zone 3 +4 L/min (8 scfh) per 100C above 250C to protect CACT or higher to suit process parts cooling requirements.**

0.3.12 Control System

This control system is comprised of a programmable logic controller (PLC) and an computer interface (HMI) described in greater detail in Section 2.

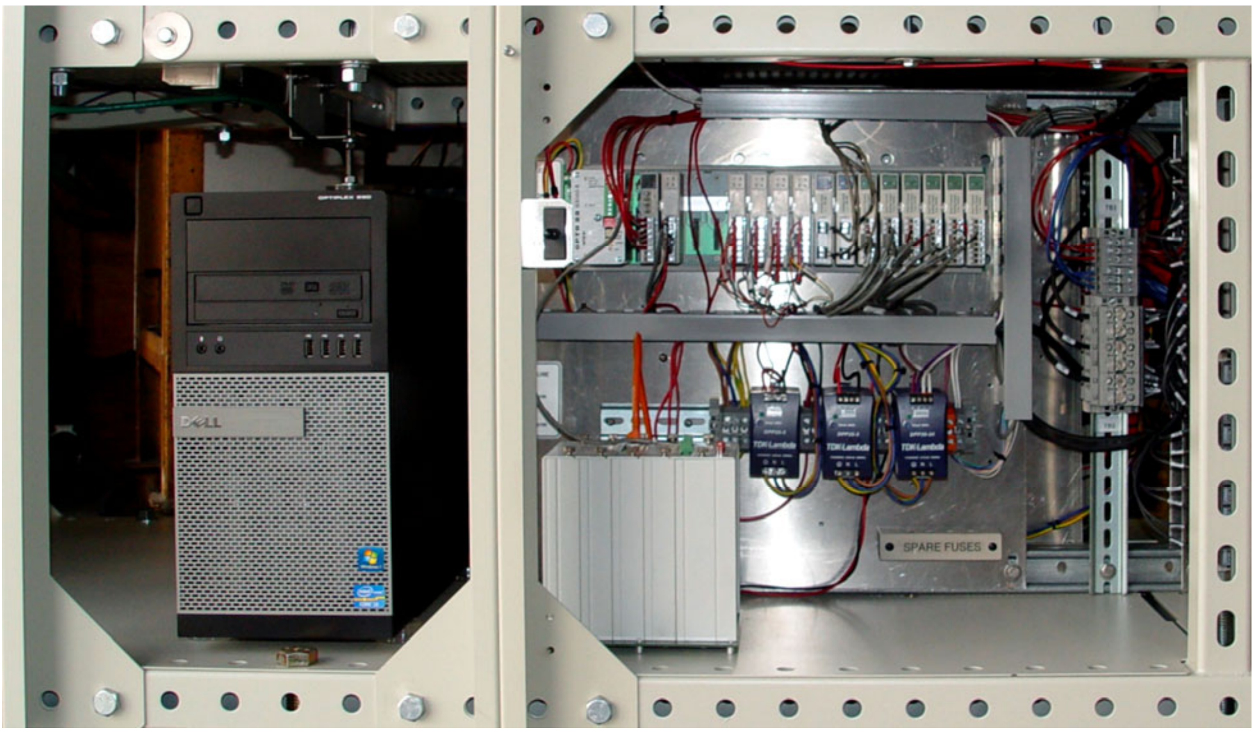

Figure 0-12 Furnace Computer and PLC Controller

0.4 Auxiliary Equipment

0.4.1 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.

Cooling System Fans. The CACT cooling tunnel is cooled by fans mounted outside the top and bottom of the tunnel. Cabinet air is forced over the cooling tunnel to remove heat transferred from the tunnel interior. This air is evacuated via the cabinet fan.

0.4.2 Low Pressure Alarms (IPS) – not included.

If supplied, 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 0-3 for Gas 1 and Gas 2.

Figure 0-13 Pressure Switch

Table 0-3 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	Nitrogen, Forming Gas or other (Dual Gas option only)	55-60 psi	3.8-4.1 Bar
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.

0.4.3 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 This arrangement allows two production furnaces to be easily operated by a single person.

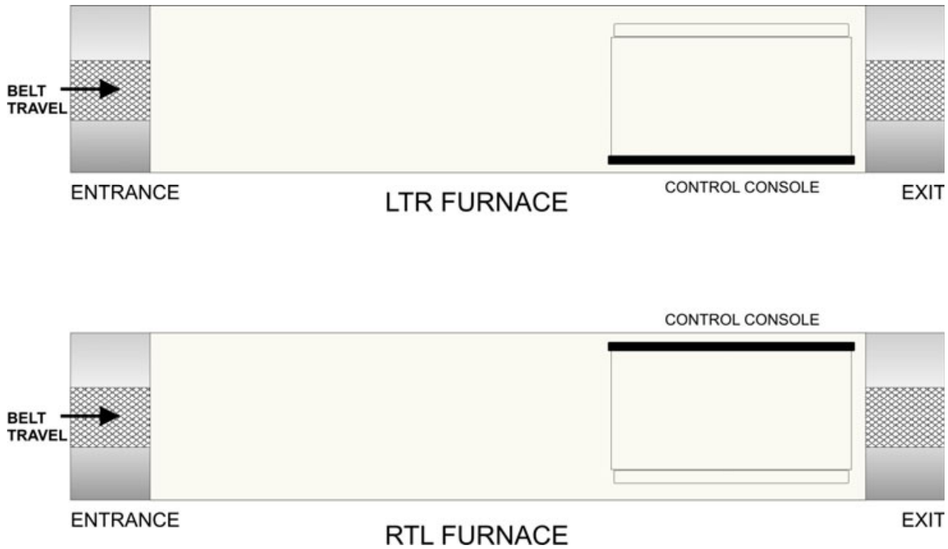

Figure 0-14 Direction of Belt Travel

0.4.4 Transport Belt

The standard conveyor belt is of stainless steel. For high temperature applications (>450°C) the conveyor belt is a close weave Nichrome-V belt manufactured from high temperature wire comprised of 80% nickel and 20% chromium. This belt offers fast heat-up times, more uniform operating temperatures and excellent mechanical stability. This belt exhibits minimum shrinkage, growth, sag or distortion in use.

0.4.5 Transport Drive Motor

The transport drive motor assembly is typically mounted near the exit of the process section. Depending upon belt width, product mass, product number and belt speed, the motor-sprocket may appear different than the example shown in Figure 0-15 Transport Drive Motor.

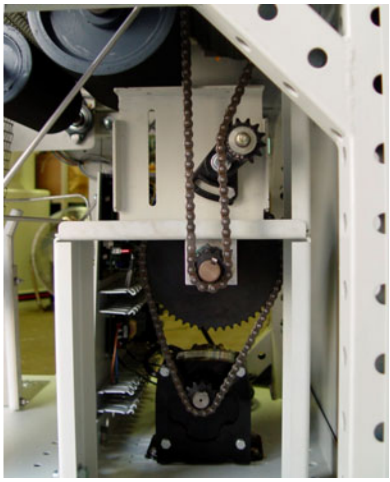

Figure 0-15 Transport Drive Motor

0.4.6 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.

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

0.5 Optional Equipment

Features and operation of the most common LA-309 equipment options that may have been included with the furnace or added later. See Table 0-4 for a summary of featured options. Items in bold were supplied on the furnace.

Table 0-4 Summary of Advanced Features & Options					
AFR	Air filter/trap regulator	DGO	Dual gas operation	**PH2**	**50 mm chamber height**
AR10	Gas Reservoir	GSM	Supply gas mixing system	RTL	Right to Left Belt Travel
Belt Speed	Alternate belt speed	HO/NHM	H_2 operation N_2/H2 mixing	**RAID**	**Furnace Computer with mirroring drives**
CB-3	**3-phase circuit breaker**	LFI	Line Interference Filter	**SENSLAS**	**Laser product alert system**
CE	CE mark	MA	Moisture analyzer	SSP	Sample ports
CXE15	**Load station extension**	OA	Oxygen Analyzer	UCD	Ultrasonic belt cleaner
CXX15	**Unload station extension**	OSS	Gas sampling system	UPS	Uninterruptable Power Supply

0.5.1 Air Filter Regulator (AFR option ❒, not included)

High volume compressed air filter, moisture trap and pressure regulator to assure supply compressed air is clean, dry and at the proper pressure before entering the furnace. If this option is not selected, customer must assure that an adequate supply of clean dry compressed gas not exceeding 5 bar (70 psig) is connected to the furnace.

0.5.2 Gas Reservoir (AR10 option ❒, not included)

Pressure vessel for compressed air or nitrogen, 30-56 L (8-15 gal). Acts as a local reservoir to reduce process gas pressure fluctuations. Also can assure that in the event of process gas supply failure, an adequate supply of compressed gas is available to purge furnace of volatile or toxic gases.

Consists of an ASME tank, plumbing, pressure relief valve and drain.

0.5.3 Circuit Breaker (CB-3 option ❒, not incl)

A three phase circuit breaker can be installed in an enclosure on the top of the furnace for convenient shutoff of the furnace when not in use. (Figure 0-16). On three phase systems, the standard single phase circuit breaker switch is omitted.

Figure 0-16 3-Phase Circuit Breaker (Option)

0.5.4 European Certification (CE option ❐, not supplied)

A strict implementation of CE requirements is followed according to the following documents:

Council Directive 2004.108/EC (EMC)

Council Directive 2006/42/EC (MSD)

Council Directive 2006/95/EC (LVD)

Figure 0-17 CE Mark

Compliance with all safety relevant provisions referring to:

Controls
Protection against mechanical hazards
Required characteristics of guard and protection devices
Protection against other hazards such as electrical, fire, noise and vibration

The following supplemental options must also be added to achieve the standard:

Operation Manual for European Union (included)
Circuit Breaker (must purchase CB-3 option separately)
Line Filter (included)

0.5.5 Load Extension (CXE15 option ❐, not included)

Increases standard 368 mm (14.5-inch) stainless steel Load station at the entrance of the furnace in 380 mm (15-inch) increments. Useful if a longer product load area is needed. (Similar to Figure 0-18)

Increases furnace length by a like amount.

0.5.6 Unload Extension (CXX15 option ❐, not included)

Increases standard 368 mm (14.5-inch) stainless steel Unload station length at the exit of the furnace in 380 mm (15-inch) increments. Used for product inspection or to provide a longer period for product removal.

Increases furnace length by a like amount.

Figure 0-18 LA-309 Unload station with CXX15

0.5.7 Dual Gas (DGO option ❐, not included)

Dual gas systems can allow more expensive specialty gas to be introduced into the furnace chamber while another gas can be provided to all furnace auxiliaries.

A. DGO Equipment

Includes separate manifold for supply of a different gas to the furnace heating zones. Gas 1 can be CDA or nitrogen supplied to eductors, entrance baffle, transition tunnel, lamp seals, and the cooling system. Gas 2 is usually nitrogen, forming gas or other specialty gas. The flowmeters may be in a different array to accommodate grouping of zone flowmeters for Gas 2 supply.

An alarm will sound if either Gas 1 or Gas 2 supply is low in pressure. The Control Console Status panel will have an indicating light for each gas area of the furnace.

Figure 0-19 Control Enclosure showing Dual Process Gas Connection

B. DGO Operation

A furnace plumbed for dual gas is operated in much the same was as a single gas furnace.

1. Operators must assure that gas is flowing from both supply sources.
2. Dual gas systems have a second alert lamp for Gas 2.
3. Typical systems will have nitrogen gas supplied for Gas 1 and forming gas supplied for Gas 2.

0.5.8 H2/N2 Mixing (HO/NHM option ❐, not included)

Hydrogen/nitrogen mixing allows hydrogen and nitrogen to be introduced separately into the furnace gas mixing system where it is blended before being introduced into the furnace heating chamber.

A. HO/HNM Equipment

Hydrogen/nitrogen mixing requires the addition of a special gas mixing console and combustible gas sensors at key points on the furnace as well as additional flow and pressure sensors to assure the hydrogen introduced in an oxygen free furnace environment. Exhaust stack ignitors are also added to harmlessly flame any free hydrogen that maybe evacuated from the furnace.

B. HO/HNM Operation

Use of Hydrogen (H2) in the heating chamber requires special furnace owner safety considerations including:

1. Furnace installation ensuring proper ventilation and safe source gases,
2. Special warm up and cool down procedures must be followed.
3. Gas flow balance is critical to the safety of all personnel working near an infrared furnace operating with hydrogen process gas. Escaping hydrogen gas, or the admission of oxygenated gas into the process section is extremely hazardous.

These three elements ensure that no additional H2 gas is allowed into the furnace and that the remaining H2 is diluted and removed as quickly as possible.

Separate operating instructions will be provided for the HO/NHM option.

0.5.9 Supply Gas Mixing (GSM option ❒, not included)

The GSM system option allows for rapid switching between two gas sources to the furnace heating zones. The GSM system provides pressure regulation of two gas sources at pressures within the range 100-3500 psig down to a furnace operating pressure of 70 psig.

Supply Gas 1 is typically nitrogen (N2) or air (CDA) and plumbed to all furnace areas including inlet baffle, stack eductor, transition tunnel and cooling section as well as through the Gas 1 flowmeter to the furnace heating zones.

Supply Gas 2 is typically nitrogen (N2) or forming gas (FG) and plumbed through the Gas 2 flowmeter to the furnace heating zones.

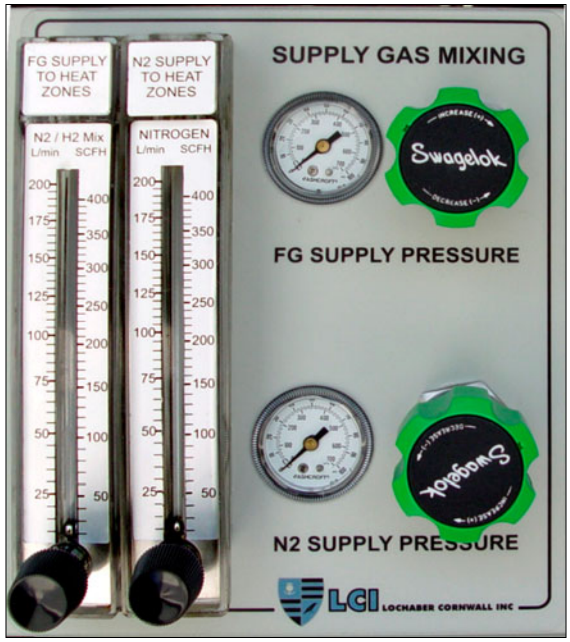

Figure 0-20 Supply Gas Mixing System Control Panel

A. GSM Equipment

The GSM system includes two (2) high flow 0-3500 psig pressure regulators each with a 0-100 psi pressure gauge and flowmeter. Users can adjust for 100% forming gas to the furnace for critical reducing operations and later quickly switch to nitrogen to conserve higher cost specialty gas. User can also adjust flowmeters to increase amount of nitrogen in the forming gas mix (Figure 0-20).

The system can be ordered with alternate pressure ranges.

B. GSM Operation

To operate the furnace with Gas1 only (nitrogen):

1. Adjust Gas1 pressure.
2. Open Gas1 flowmeter and adjust Gas1 pressure to 70 psig.
3. Close Gas2 flowmeter.

To operate with Gas2 (forming gas) to furnace zones, Gas 1 to furnace auxiliaries:

1. Adjust Gas2 pressure.
2. Open Gas2 flowmeter and adjust Gas2 pressure to 70 psig.
3. Close Gas1 flowmeter.

To operate with both Gas1 and Gas2 to furnace zones, Gas 1 to furnace auxiliaries:

1. Adjust Gas1 and Gas2 pressure.
2. Open Gas1 flowmeter and adjust Gas1 pressure to 70 psig.
3. Open Gas2 flowmeter and adjust Gas2 pressure to 70 psig.
4. Adjust Gas1 and Gas2 flowmeters to achieve volume percent balance of gas entering the furnace chamber. Both should read the same pressure to assure even mixing.

> NOTE: Note: Each GSM flowmeter is sized to accommodate full flow to all zones through the furnace. Consequently when the individual zone flowmeters on the Control Console are at low settings, the flow through the larger Gas1 and Gas2 flowmeters may appear to near zero if the sum of the flow is near the minimum operating range of the flowmeter (minimum is 10% of full flow).

0.5.10 Line Filter (LFI option ❒, not included)

An AC power line interference filter reduces the potential electrical interference generated by SCRs and motor controls within the furnace. Compliant with IEC 60950. This option is included on furnaces with the European CE option.

0.5.11 Moisture Analyzer (MA option ❒, not included)

For processes that are sensitive to moisture, a moisture analyzer can provide status of monitored zones.

The moisture analyzer can be connected to any one sample port (with SSP option) or can used with a 3-port sample system (OSS option).

Figure 0-21 MM510 Moisture Analyzer

A. MA Equipment

The brand of moisture analyzer can generally be specified by the owner. A high quality choice, the MM510 electrolytic moisture analyzer is designed for precise measurement of moisture in gas over a wide range (0.1 ppm to 1000 ppm with ± 5% accuracy). The analyzer is configured with an internal sample pump. The sample systems are manufactured using stainless steel throughout with 1/8-inch tube connections on the sample line. Sample flow is 0.05-0.5 L/min (50-500 cc/minute) controlled.

MM510 Sensor. The phosphorus pentoxide moisture sensor consists of a dual platinum winding formed around a quartz tube about 8 cm long. A constant voltage is applied across the windings and the current monitored. The moisture in the sample gas stream causes the resistance of the platinum coil to change. The change in resistance results in a change in measured current providing an absolute measure of the moisture contained in the process sample gas. Unlike aluminum oxide sensors, the phosphorus pentoxide sensor does not require annual factory calibration.

B. MA Operation

The model of moisture analyzer selected will be factory set for your application.

1. Startup of the furnace will start the moisture sampling if the analyzer is left enabled by the operator.
2. A switch on the back of the analyzer allows shutoff of the analyzer while the furnace is running, if desired.
3. Sample line flow is controlled by the valve knob on the back of the analyzer Adjust to 0.15 L/min.

0.5.12 Oxygen Analyzer (OA option ❒, not included)

An oxygen analyzer can assure furnace settings result in a low oxygen environment in the furnace chamber during operation.

Figure 0-22 EC913 Oxygen analyzer

The brand of moisture analyzer can generally be specified by the owner. A high quality choice, the EC913 process oxygen analyzer uses an electrochemical RACE™ cell for accurate measurement of oxygen (measuring range: 0.1 ppm-30% at ± 2%) and features microprocessor controlled functions, large auto-ranging LED display, and fast response. To avoid interference, indicate if hydrogen gas will be present.

The analyzer is fitted with an integral sample pump downstream of the sensor. The sample Out valve on the back of the analyzer is used for flow control and is adjustable from 0.05-0.5 L/min (50-500 cc/min) sample rate (default is 0.1 to 0.15 L/min).

On furnaces, the oxygen analyzer is usually mounted inside the furnace cabinet enclosure. The analyzer is integrated with the furnace control system. The oxygen concentration is displayed on the computer screen. Alerts and alarms are set in the process recipe on the computer.

Figure 0-23 shows the O2/MA Sample system control panel. The oxygen concentration for the selected zone is shown on the Process screen.

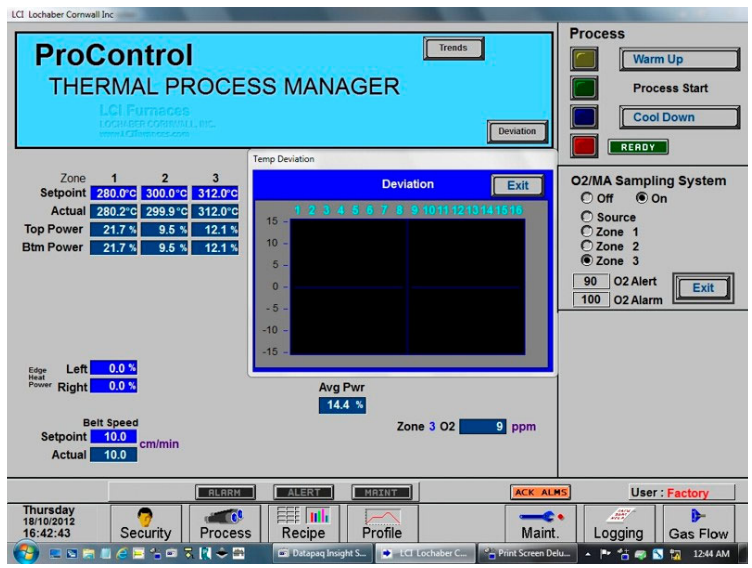

Figure 0-23 O2 ppmv on Process screen

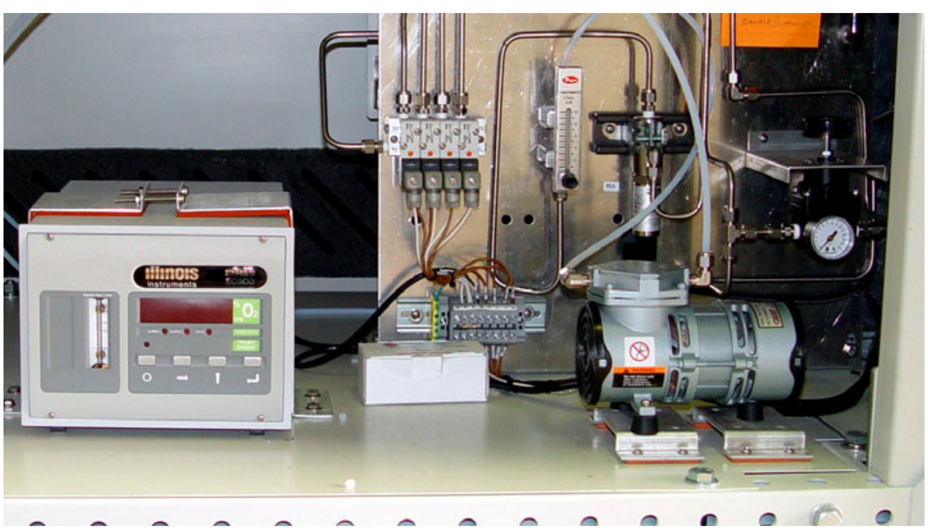

Figure 0-24 Oxygen analyzer next to OSS sample system

0.5.13 Sample System (OSS option ❒, not included)

The OSS option provides user selection of any one of 3 furnace ports or the source gas (nitrogen) to a sample gas line to the gas analyzer equipment (typically moisture and/or oxygen analyzer).

Figure 0-25 Sample System control panel (shown with Supply Gas Mixing System)

A. OSS Equipment

This system consists of electrical controls and piping of a 4-port manifold to a source gas and 3 sample ports. The sample ports are located on the bottom of each furnace chamber zone. The Source is piped from Gas1 (or the nitrogen source) through a pressure regulator adjusted to 35 mbar (0.5 psig) and connected to port 1 on the manifold.

B. Analyzer Initial Setup (with OSS)

1. Enable analyzer by turning Power Switch on back of analyzer (Figure 0-26) to ON position.

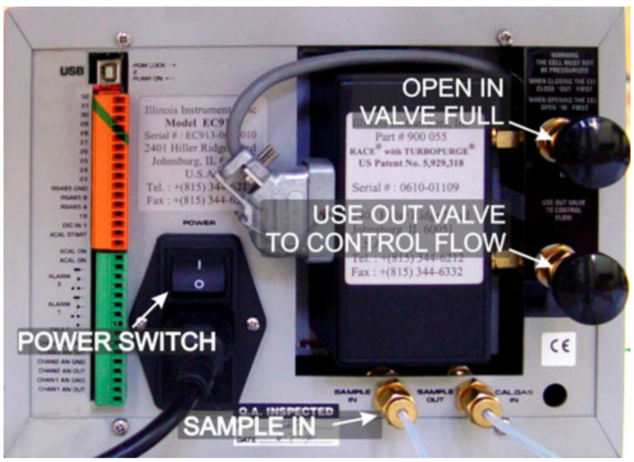

Figure 0-26 EC913 Oxygen Analyzer Rear Controls

2. Open IN valve full CCW (on back of analyzer, (Figure 0-26).

> **Note A: In this configuration, analyzer will start and stop with the OA radial ON/OFF buttons in the furnace software.**

C. OA Operation (with OSS)

1. Start furnace and furnace software.
2. On the Process screen:
   - select sample port,
   - press OA/MA Sample System ON to energize system and start analyzer.
3. During initial startup, adjust OUT valve until Sample Flow flowmeter on front of analyzer reads 0.1-0.15 L/min (Figure 0-26). On subsequent startups, the flow rate does generally not need to be adjusted.

> **Note A: When the sample line is dry, accurate readings can be obtained within minutes. If the sample line contains moisture, it may take from 20 minutes or longer. Moisture may be purged from the sample line by disconnecting the line from the analyzer and using a dry gas (nitrogen) to flush the line. Be careful to keep the pressure under 2.5 bar (35 psig) to avoid disconnecting the sample line from the furnace.**
>
> **Note B: When nitrogen is connected to Gas 1, Port Select S will sample the source nitrogen. Ports 1, 2 and 3 sample the respective furnace zones.**

D. Shut Down Analyzer (with OSS)

If the analyzer is to be out of service for a period of time, further isolate the cell to prolong its life.

1. If system is not equipped with a check valve on the Sample OUT line, close OUT valve on back of analyzer (to isolate cell).
2. If analyzer is disconnected from the OSS, Close IN valve on back of analyzer (to isolate cell).

> **Note A: Analyzer valves can be left in open position while connected to the LA-309/LA-310 as the sample port manifold will isolate the analyzer cell from gas flow when the system is off.**
>
> **Note B: To prolong cell life, limit sampling of air.**

0.6 Product Alert

The SENSLAS system alerts operators when product exits the furnace. For longer processes, operators can perform other tasks in the same work area and respond when product appears at the furnace Unload station (Figure 0-27).

Figure 0-27 SENSLAS System

0.6.1 SENSLAS Equipment
(SENSLAS option ❐, not included)

This system consists of a laser sensor and audible chime with volume control. The SENSLAS system is conveniently controlled at vertical face of the furnace exit. The sensor is mounted on an adjustable bracket approximately 74-90 mm (3-3.5 inches) from the furnace exit (Figure 0-29).

Figure 0-28 SENSLAS Control Panel

0.6.2 SENSLAS Operation

Easy to operate, the operator turns the system on using a lighted switch. Each time product passes under the sensor, the Clear button lights and a gentle audible chime continues to sound until the Clear button is pressed. Turning a four position selector switch changes the volume of the chime from quiet to loud. To disable the system, the ON/OFF switch is turned counter-clockwise (Figure 0-28).

1. Turn the SENSLAS Off/On clockwise.
2. Place hand under laser sensor and adjust the volume selector (1=low, 4=high) to desired sound level.
3. When parts pass under sensor, chime will sound and clear button lights until reset.
4. Press CLEAR button to reset chime.

When enabled, the system can be switched on and off at the furnace Control Console when either of the CONTROLS buttons is pressed.

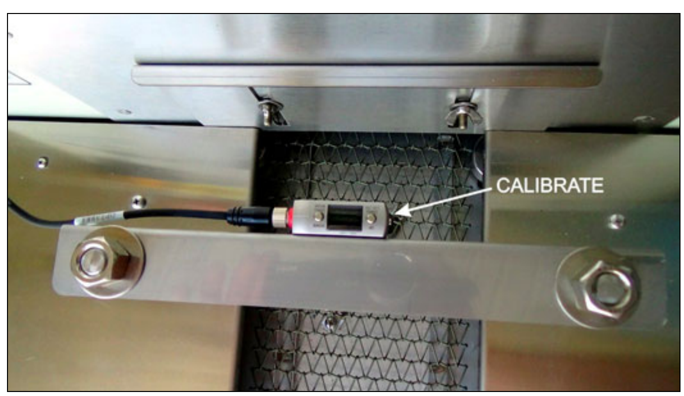

Figure 0-29 Calibrate Sensor

0.6.3 Sensor Calibration

The sensor can be calibrated using two objects: a sample of the product (foreground) and a thin flat sheet of metal or other material (background).

1. Turn on the SENSLAS system.
2. Set the belt at a slow speed (125-250 mm/min (5-10 ipm).
3. Place the two objects in line just before the laser sensor with background object on the center of the belt first immediately followed by the foreground object.
4. As the background object passes under the laser beam, press calibrate button on the side of the sensor for less than 1 second Figure 0-29.

5. As the foreground object passes under the sensor press the button again for less than 1 second.

The sensor is now calibrated to sense objects between the height of the background and the foreground.

0.6.4 Sample Ports (SSP option ❒, not included)

This option includes control enclosure port connection to one or more of the sample ports located on the underside of each zone. Allows connection of an oxygen analyzer, moisture analyzer or other gas analyzer. Must be used with a sample pump (not included). Port connections are be located under chamber . Figure 0-30 shows a typical port location on a chamber. Note: The chamber is fitted so that even if this option is not included at the time of manufacture, sample ports can be added later, if required.

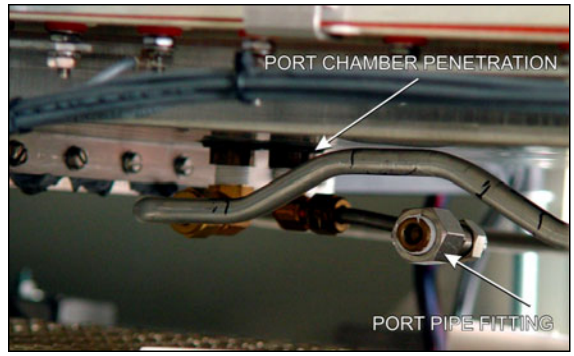

Figure 0-30 Sample Port Chamber Penetration

0.6.5 Independent Over Temperature Alarm Operation (option ❒, not included)

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

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.

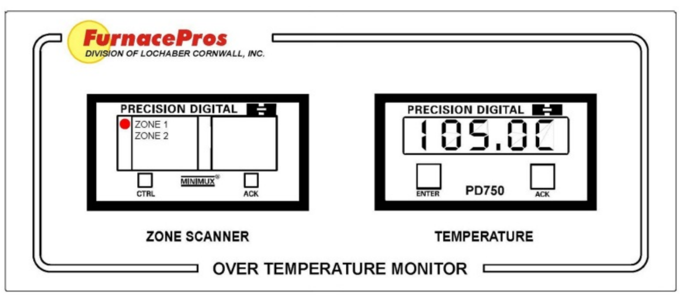

Figure 0-31 Over Temperature Monitor

0.6.6 Cabinet Temperature (option ◙, included)

A secondary thermocouple is attached near the center of the heating chamber between the chamber and the outside panel. The sensor is attached to and indicator to allow the user to monitor the cabinet temperature, which can reveal possible cabinet fan failure, or blocked air inlets or exits.

0.6.7 Low or High Belt Speed (standard belt speed, 0-20 ipm)

Standard belt speed is 5-500 mm/min. Alternate belt speeds can be offered increasing or decreasing the current min/max belt speed. Special conveyor belt speeds require changes to motor speed, power and gearing for this option.

0.6.8 Ultrasonic Cleaner/Dryer (UCD option ❒, existing, not connected)

The ultrasonic belt cleaning system removes contamination that accumulates on the belt during normal furnace operation. This system includes an ultrasonic tank, belt dryer and timer system to enable automatic cleaning of the belt. A fan-driven air blow-off removes water droplets and can be provided with an optional heater to further drive moisture from the belt. The belt is drawn through an ultrasonic tank that is automatically filled and drained by a timer and control circuitry. The cleaning/drying of the belt takes place when the furnace is off-line. This option requires connection to facility water source and water drain.

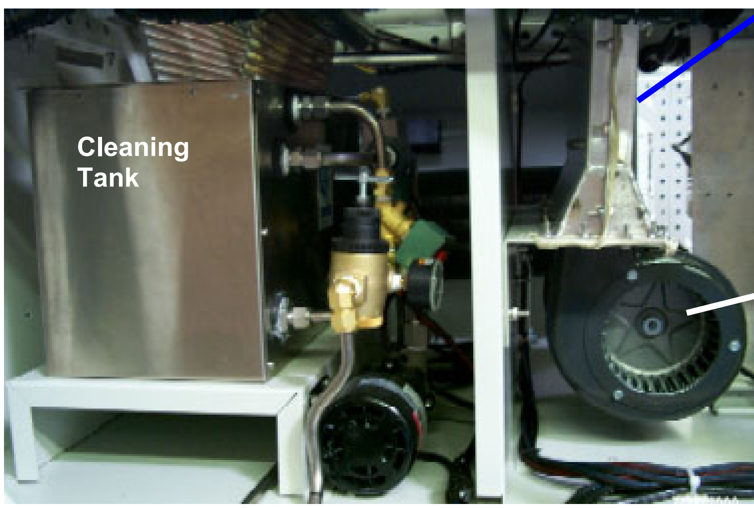

Figure 0-32 Ultrasonic Cleaner installation

0.6.9 UPS (option ❒, not included)

This option adds an uninterruptable power supply to keep the belt, fans, and control system running for at least twenty minutes during a power outage. The transport belt continues to run at set speed which minimizes product loss during brief power failures. The unit automatically switches from standby to process start upon restoring power, whether provided by generator backup or city power.