LOCHABER CORNWALL INC

CONTINUOUS BELT
IR BELT FURNACE

Model LA-310X
Furnace Computer Upgrade

Owner's Manual

Revision 0

MODEL: LA-310

SERIAL NUMBER: 1303100101

FACTORY ORDER NUMBER: 17-002

Infrared Furnace Setup, Operation, Theory & Troubleshooting Guide

This Owner's Manual contains product information specific to the newly installed equipment and software. In addition, this manual contains information regarding features and options which may or may not be included in your furnace system.

Use this Manual in conjunction with the Continuous Belt IR Furnace Reference Manual

Continuous Belt IR Furnace

Owner's Manual

Rev. 0

Model: LA-310X

Serial Number: 1303100101

Part No. 17-002 - 676-110000-01 CD

Part No. 17-002 - 676-110000-02 Loose Leaf

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For information on parts, service and aftermarket products and reconditioned furnaces and to obtain technical support please contact FurnacePros Aftermarket Services at +1.714.935.0302.

TABLE OF REVISIONS

Rev	Sections	Description	Date
0	All	Initial Release	12/08/2017

INTRODUCTION

The RTC LA-310 furnace is a high quality controlled atmosphere infrared belt furnace designed for industrial production and laboratory continuous infrared thermal processing.

While the furnace is very easy to use, proper control of both the heat and gas flow is essential to achieve exceptional performance of the furnace. Achieving high performance and high yields is attainable with careful adjustment of the software zone PID parameters, belt speed and gas flow controls provided on the furnace. Infrared furnaces are highly responsive to critical temperature settings. With lamps as the primary heat source, the equipment is literally heating with light. The unique gas management system provides an extremely even distribution and well-regulated flow of gas throughout the process chambers.

WHAT IS IN THIS MANUAL

This manual covers upgrade software for computer-controlled models manufactured by RTC and controlled with a programmable logic controller (PLC).This Owner's Manual contains your product information and warranty as well as installation, startup, operating instructions specific to the equipment purchased. In addition, this manual may contain information regarding features and options which may or may not be included in your furnace system. The Owner's Manual is to be used in conjunction with the RTC Owner's Manual, RTC Continuous Belt IR Furnace Reference Manual and Dell Computer Product Information Guide to assure the equipment is installed and operated according to manufacturer's instructions.

Study this manual carefully, particularly regarding proper operation and limitations of the furnace equipment for reliable results and long life. Experience has shown that operators who master the contents of this manual can become expert in understanding the process system capabilities of our infrared furnaces. In doing so, many are able to push the initial process performance envelope and thus achieve higher degrees in both process reliability and throughput than previously anticipated.

Note that throughout this manual the equipment is generally referred to as a furnace. A dryer is a furnace with only the top lamp elements installed or operated.

The manual uses LA-309 and LA-310 interchangeably throughout. *The LA-309 is an updated version of the LA-310 using the same design furnace chamber and cooling section.*

FORMATTING CONVENTIONS

This manual uses the following formatting conventions.

DANGER: This signifies a potential threat to human safety.

Warning: This signifies a potential threat to equipment damage or product loss.

Note: This signifies an important fact that could affect process control.

Examples are shown in italic text.

Bold text words or phrases embedded in this document, are terms with definitions in the glossary.

Bold Underlined text is used for pop-up windows, button descriptions & selector button/box choices.

Cross-references to "Section Titles" are bound with quotes.

(Optional ❐) accessories will be shown in parenthesis with a checkbox. If supplied, please check the box as appropriate.

ABOUT LCI

LCI Furnaces specializes in the manufacture and sales of near infrared (0.5-5.5 µm) wavelength continuous belt dryers, ovens and furnaces worldwide. We provide the highest quality controlled atmosphere infrared thermal processing equipment, parts and service available anywhere.

Should you have a furnace operating question, contact LCI Furnaces or FurnacePros Technical Support.

WHERE TO GET HELP

Corporate Offices & Factory

Address: 675 N Eckhoff St, Ste D, Orange, California 92868 USA
Phone: +1 (714) 935-9781

Technical Support & Service

Department: Aftermarket
e-mail: service@furnacepros.com
Phone: +1 (714) 935-0302

Aftermarket Parts Ordering

Department: Aftermarket
e-mail: parts@furnacepros.com
Phone: +1 (714) 935-0302

Equipment Sales, Upgrades & Factory Reconditioning

Department: Sales & Marketing
e-mail: info@lcifurnaces.com
Phone: +1 (714) 935-0813

Websites

New Furnace Equipment: www.LCIfurnaces.com
Aftermarket Support: www.FurnacePros.com

EQUIPMENT LIST

The following equipment was shipped with the furnace.

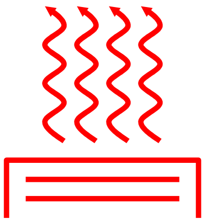
Qty	Unit	Description	Part Number
(1)	ea	ProControl Furnace Software System configured for an LA-310 Furnace and consisting of the following:	17-002
(1)	ea	Furnace Computer, Dell Optiplex 790	5644XR1
(1)	ea	Monitor, Dell Professional 19" LCD Flat Panel	P190S
(1)	ea	Keyboard, USB English, Black	KB-212-B
(1)	ea	Mouse, USB Optical	MS111
(1)	ea	INSTALL KIT, Cable	322-094246-100
(1)	ea	Manual, Software Upgrade	17-002-110000-02
(1)	ea	CD Media, Reinstallation, ProControl™ Furnace software, including - Owner's Manual, P/N 17-007-110000-01 - Reference Manual, P/N 675-110000-01	17-002-110000-01

GENERAL SAFETY GUIDELINES

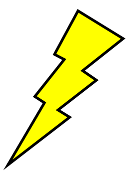
The following set of guidelines is intended to create awareness of potential health and safety hazards.

Normal Good Laboratory Practice

Normal good laboratory practices apply to the operation of IR furnaces. Do not use the space above the furnace as storage. Do not block the cabinet doors preventing the cooling of the electronic equipment inside. Do not operate with side covers off as this will prevent normal cooling of the electronic equipment thus voiding the warranty. Tuck electrical cords out of the way. Do not store flammables in the vicinity of the furnace and especially while operating the furnace with an oxygen atmosphere.

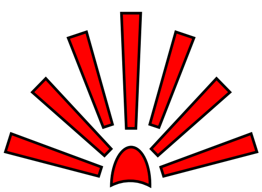


HIGH TEMPERATURES. In general, the operation of any furnace may expose operators or maintenance technicians to the risk of burns. After being processed in an infrared furnace, customer product may still be dangerous to handle. Each owner is responsible for providing a safe work environment and proper training in the handling of material being processed in a furnace.

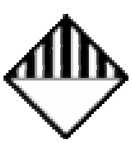


ELECTRICAL SHOCK HAZARD. IR furnaces operate at high voltages. Operation with side covers off constitutes a safety hazard. Ensure that main power is off while side covers are removed.

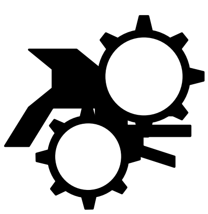
Electrical shock hazards exist for those technicians who service the furnace. High voltages are required to operate the furnace and precautions must be taken to reduce the exposure to these elements. Again, it is the responsibility of the furnace owner to assure that only properly trained service technicians, familiar with high voltage operations be allowed to service the equipment



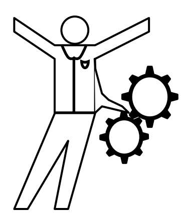
EXPLOSION Explosive dangers may exist in the high temperature process environment of the furnace. If the furnace operates with process gas containing hydrogen, measures must be taken to avoid the dangers of explosion. Furthermore, improper gas flow balance may draw oxygen rich air into the furnace, mixing with effluent gases and material from products, also creating a hazardous environment.



HAZARDOUS MATERIALS. Persons performing maintenance tasks such as replacement of lamps may become exposed to silica fiber compounds. Such tasks should be performed by qualified persons wearing gloves, eye protection and a facemask to prevent inhalation of particulates.

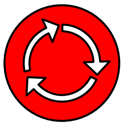


ROTATING EQUIPMENT. Roller dangers exist when working around the conveyor belt of the furnace. Care should be taken not to place hands or garments on or near the belt drive mechanisms when the conveyor system is operating as roller crush may occur. Operators should avoid walking near the open ends of the conveyor belt. Those who must be near the moving parts should wear close fitting clothing.



SAFETY EQUIPMENT

EMO Buttons



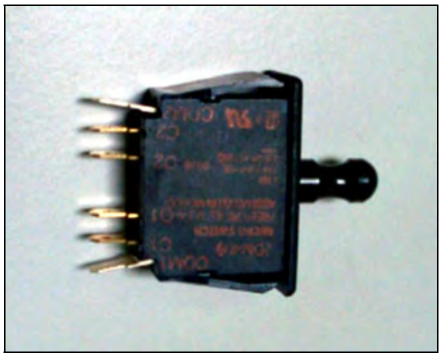
Each infrared furnace is fitted with at least two SEMI S2 compliant Emergency Machine Off buttons (EMO's), one located at each end of the furnace. Each Emergency Machine Off button (EMO) is attached directly to a switch that automatically shuts down all furnace electrical systems. In many cases, process gas flow will remain on after power is shut off.

Locate and insure their proper function prior to regular furnace operation.

Panel Interlock Switches

The furnace is equipped with a number of interlock switches located to prevent operation of the furnace with high voltage access covers out of place. One is located on each of the lower side panels closest to the furnace entrance safeguarding access to the high voltage at the chamber lamps.

Bypass this switch to allow furnace operation with the panels removed. Grasp the protruding switch and pull it out to override the switch (see Figures). Setting the panel switches in bypass mode is useful during SCR calibration and other troubleshooting.



Panel Switches Showing Normal Operation Position

Panel Switch Installed - Bypass Mode Position

DANGER: Bypassing the panel interlock switches increases maintenance personnel exposure to electrical hazards. The user must ensure that any interlock switches placed in override mode are returned to normal operation following any inspection or adjustment..

2.1 Power Controls and Indicators

2.1.1 Power Status Indicators

A. MAIN POWER ON (White Indicator)

This lamp burns continuously whenever power is available to the furnace and the main circuit breaker (optional) is turned on.

B. FURNACE POWER ON (Green Indicator)

This lamp burns continuously when the control circuits are energized, and indicates that power is available to actuate the control circuits.

Figure 2-41 Control Panel showing Furnace Power ON and OFF and Indicator Lights

C. ALARM HORN -Black Audible Alarm

This horn provides audible feedback for furnace system alarm conditions.

D. UCD - Fill, Run & Drain Indicating Lamps – (equipment not active)

Lamps light to indicate status of Ultrasonic Cleaner Dry system. See logic table on drawing 802-101787.

E. USB Ports

One (1) USB 2.0 port is provided on the back left side of the professional computer monitor to connect a jump drive, camera or other device. USB 2.0 ports are also provided on the front of the furnace computer for connecting profiling equipment.

2.1.2 Power Console

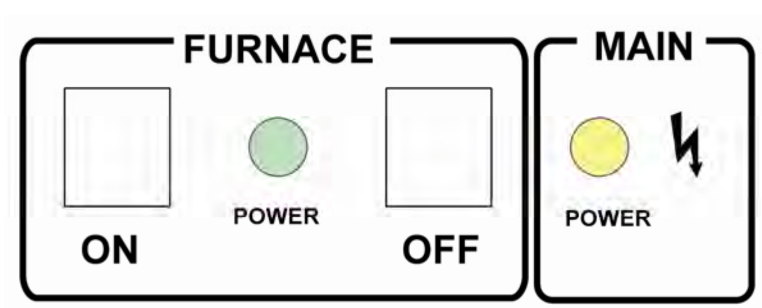


Figure 2-42 Furnace Power Control and Indication

A. MAIN FURNACE POWER

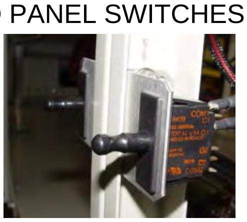
Table 2-1 Main Furnace Power		
MODE	**ON**	**OFF**
MAIN FACILITY BREAKER	Power to TR0 only: 1. MAIN POWER light (white) on 2. PC-S1 and PC-S2 sockets live for PC and monitor	No power to furnace, computer or monitor
3-PHASE INTERLOCK DISCONNECT SWITCH  	Optional lockable switch interlocked with safety panel cover. Switch must be turned OFF to enable removal of lower access panel. When switch is OFF, Power is disconnected from all furnace circuits (except 3-phase power connection to hot side of disconnect switch inside switch enclosure). Padlock switch to assure power remains OFF during maintenance. Switch must be turned to ON to provide power to furnace.	No power to furnace, computer or monitor
3-PHASE CIRCUIT BREAKER DISCONNECT 	Optional lockable circuit breaker furnace disconnect switch. Switch must be turned ON to provide power to furnace.	No power to furnace, computer or monitor
EMO SWITCHES  **Entrance EMO**  **Exit EMO**		Operator activated Emergency Power Off switch located at furnace entrance and exit immediately cuts power to furnace and PLC controller. Computer and monitor stay on. Rotate EMO knob to reset. FURNACE POWER ON button must be pressed to re-introduce power.
EPO PANEL SWITCHES 	For maintenance purposes only, pulling out on all exposed interlock switches will allow operation of the furnace. FURNACE POWER ON button must be pressed to re-introduce power.	If a lower panel is removed, emergency power interlocks will automatically cut power to furnace, including PLC controller. Computer and monitor stay on.

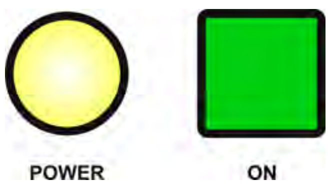
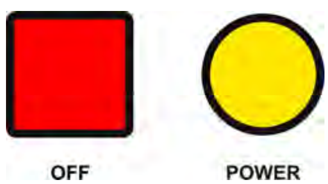
Table 2-1 Main Furnace Power		
MODE	**ON**	**OFF**
MAIN POWER ON 	Lamp illuminates indicating that 3-phase power is connected to the furnace and the main disconnect switch is ON.	No power to furnace, computer or monitor
FURNACE CONTROLS ON  FURNACE CONTROLS OFF 	Power to furnace and furnace PLC controller. Pressing this momentary switch causes the furnace to go through its power up sequence, providing the MAIN POWER lamp is lit and the EMOs (Emergency Power Off switches) and interlocks located in the doors are released. 24 Vac controls active only if EMO and panel interlocks allow: 1. K2 mechanical relay latches up, FURNACE POWER light (green or yellow) on. 2. K6 mechanical relay sends switched 117 Vac power to belt motor, Opto22, gas supply valves, EM, and hour meter. 3. K3 contactor energizes phase transformers TR1, TR2 & TR3; all 117 and 24 Vac power control signals and accessories turn on.	Cuts power to furnace and furnace PLC controller. Pressing the OFF button causes the furnace to begin a timed power shutdown sequence. The heaters are shut down immediately. After Cool-Down (below 100°C), the fans, transport belt, and other functions are shut down. 1. K2 mechanical relay turns off entire control system. 2. K6 mechanical relay turns off. Belt motor, Opto22, gas supply valves, EM, and hour meter stop instantly, unless COOL DOWN clicked on PROCESS screen prior to OFF button being pushed. 3. K3 contactor turns off. All 117 Vac and 24 Vac control signals and accessories stop instantly, unless COOL DOWN clicked on PROCESS screen prior to OFF button being pushed. 4. K1 lamp contactor shuts off, removing power to lamps and edge heaters.
POWER FAILURE		Cuts power to furnace, including computer and monitor.

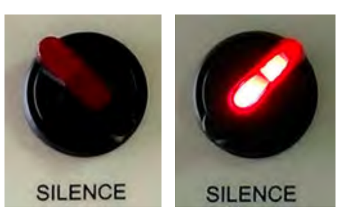
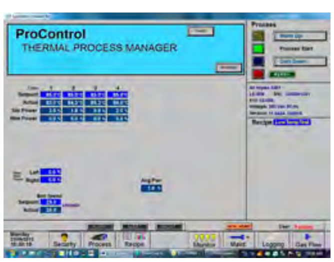
Table 2-2 Special Controls		
MODE	**ON**	**OFF**
SILENCE Switch  **Inactive (OFF)** **Active (ON)** Located on Control Console	When active, Silence switch mutes audible alarms sound. Lights when active to indicate alarms are silenced. Software indicates alarm condition normally by flashing Alert or Alarm button and logs alarm.	DEFAULT. Audible alarms sound normally. Software indicates alarm condition by flashing Alert or Alarm button and logs alarm

Table 2-2 Special Controls

MODE	ON	OFF
LOW PRESURE ALARM Bypass Switch  Service switch - located on left side of the PLC panel	Optional. When in Disable Alarms position, prevents system detection of low pressure condition. Software will NOT detect or log low process gas pressure condition.	DEFAULT. Enable Alarms. Alarms sound normally. Software indicates alarm condition by flashing Alert or Alarm button and logs alarm
CONTROLLER POWER Switch (optional)  Service switch - located on upper left side of PLC panel	DEFAULT. Controls AC power to PCL panel DC power supplies that supply power for Controller and control auxiliaries, including pressure alarms and element monitoring system. ON during all normal furnace operations. Note: RTC furnaces may use a key switch on the 24V/5V power switch and a slide switch on the small PS5 5V power supply.	Useful to cycle or service controller or control system analog and digital I/O devices.

Table 2-3 Software – Furnace Control

SOFTWARE MODE	WARMUP	COOL DOWN
PROCESS SCREEN  	If FURNACE POWER is ON, 1) energizes lamps and edge heaters via K1 lamp contactor, If FURNACE POWER is OFF, no effect	If furnace is in WARM UP or PROCESS READY modes, 1. provides power to K6 mechanical relay and K3 contactor until temperature reading in all zones < 100C; then 2) shuts off K6 and K3 (see FURNACE POWER button OFF), Otherwise no effect

B. COMPUTER POWER

COMPUTER UNSWITCHED (Default). The computer has been wired to be powered from an un-switched power source. The computer and monitor remain ON unless either is individually shut down at the computer or monitor or if Main Power is removed from the furnace. This mode offers the best protection for the computer operating system, files and hard drives. Power to the computer is supplied when Main Power is supplied to the furnace.

The momentary power button on the front of the computer must be pressed to start the computer.

> Note: Pressing the red FURNACE CONTROLS OFF button on the Furnace Console will not cut power to the computer or monitor.

2.2 Starting the Furnace

2.2.1 Main Power Indicator

The MAIN POWER indicator must be lit to make sure facility power is provided to the furnace.

2.2.2 Process Gas Pressure

Assure that clean dry compressed process gas is supplied to the furnace at a minimum of 4.8 bar (70 psig). Compressed gas must be delivered to the furnace walls, exit stack venturi and belt tensioners for proper operation of the furnace. If furnace is supplied with Auto Gas Shutoff feature, process gas will flow when Furnace Power ON is pressed.

2.2.3 Power On/Startup

Follow the steps per the STARTUP table to start the furnace. See section 0 if restarting from Auto Shutdown

Table 2-4 Starting the Furnace

1. Main Power	Verify the white Main Power ON button is lit. Furnace Disconnect switch should be ON, all panels in place and EMO switches reset.
2. Furnace ON	Press Furnace Controls ON button. Green or Yellow Furnace Controls Power light illuminates. Power is provided to the furnace controller.
4. Monitor ON	Press the power button on the monitor if the monitor ON/OFF button is not lit or you do not see the logo screen.
3. Computer ON	If the computer does not start automatically, open the computer enclosure door, press the Computer start button on the tower to start the computer. The computer boots up and the logo screen is displayed. Furnace software starts. Computer and PLC begin to communicate.
5. Start Program **6. Log-In**	Press Furnace program icon to initialize communication with the PLC and start the furnace program. Log in to furnace software. Log-in is only possible when PLC and Computer are communicating. 

CAUTION: Dangerous voltages are now present throughout the electrical systems of the furnace. Make sure that any probes in the furnace are placed on the belt surface only. Probes extending over the sides of the belt may contact high voltage terminals!

2.2.4 Fans

Check that the cabinet cooling exhaust fans, and optional cooling tunnel exterior fans and product cooling fans are turning. If the exhaust for the furnace is located on the bottom of the machine, it is important to have the bottom impeller fan speed greater than or equal to the speed of the top fan to allow the cooling system to work properly.

2.2.5 Screen Menu Bar (located at bottom of screen)

The Screen Menu Bar allows operator to select the desired screen by moving the cursor and clicking on the chosen screen button. Note: Menu bar will vary according to furnace features and user log-in level.

Figure 2-43 Screen Button Menu

2.2.6 Furnace Log-on and Initial Operation

Select "Security" button to access the "Security and User Information" screen.

A. Security and User Information

The Security and User Information screen allows the operator to select access level, log-on or log-off, add or delete users, and modify password and access codes.

B. Access Level

Select Access Level by clicking on the User List, click Log-On and enter the appropriate password and select Ok.

The system is shipped with three (3) access levels, each with its own password. See the Furnace Reference Manual, Chapter 5 Software, for information on managing users and passwords.

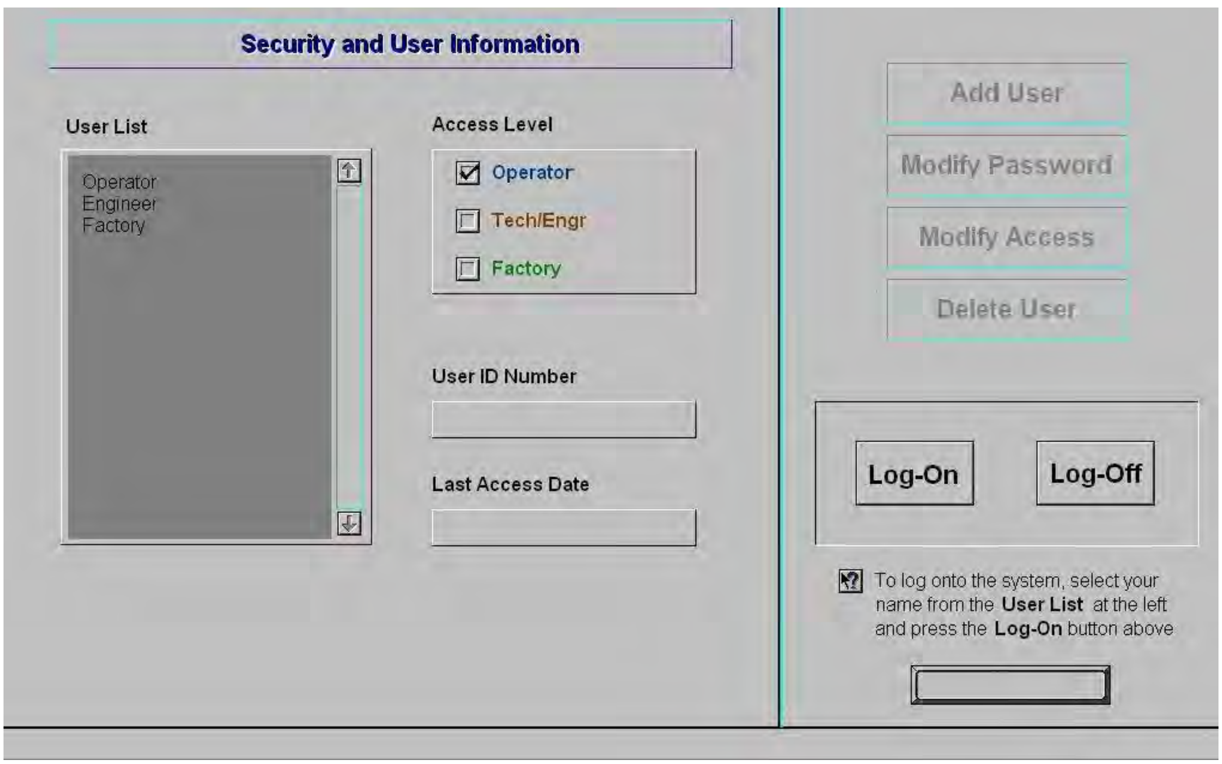


Figure 2-44 Security Screen, Log-on

Access Level 1 password:	1. Operator level, and allows the operator to load and run a recipe and initiate a process. (Initial password is set to "1".)
Access Level 2 password:	2. Tech/Engr level. It allows the Technician or Engineer to do all of the above, as well as changing parameters such as temperature setpoints, power distribution, and belt speed. (Initial password is set to "2".)
Access Level 3	restricted to Manufacturer's personnel only.

NOTE: Before turning off furnace computer, you must "Log-Off" through the Security screen and shut down Windows OS via the START button on the computer Desktop display.

2.2.7 Atmosphere Supply Gas - CDA

A. FURNACE PROCESS GAS SYSTEM

Plant supply process gas must be filtered and regulated to 4.8 bar (70 psi) before the furnace is started to assure consistent clean dry process gas is supplied during furnace operation. An internal gas reservoir with check valve further regulates gas pressure to 15 psi for the belt tensioner.

If the furnace air pressure drops below the set point during operation, the operator should put the furnace into Cool Down. The operator can reset the system to Warm Up when air pressure is again over 70 psig.

Table 2-5 Gas Supply Pressure

Location	Default Setting	
Plant Process Gas Regulator supply to furnace	65-70 psig	4.5-5.0 bar
Furnace Regulator (option not supplied)	- psig	- bar
Low Gas Pressure Alarm Switch	60 psig	4.1 bar

See Section 3 for information calibration and service of the pressurized gas (N_2/CDA) system.

WARNING: The flowmeters on these furnaces are rated at 5 bar (70 psi) maximum. Operating above 70 psi exposes the operator to possible injury.

B. Flow Meter Default Settings

Select the Gas Flow button. The Gas Flow screen will be shown. Open the furnace flowmeter access panel and adjust the gas flow to the default flows indicated on the screen or per process recipe requirements. See Owner's Manual, Engineering section for default settings. See Reference Manual, Chapter 9, Balancing Gas Flow for information on setting the flow meters to balance the system gas flow.

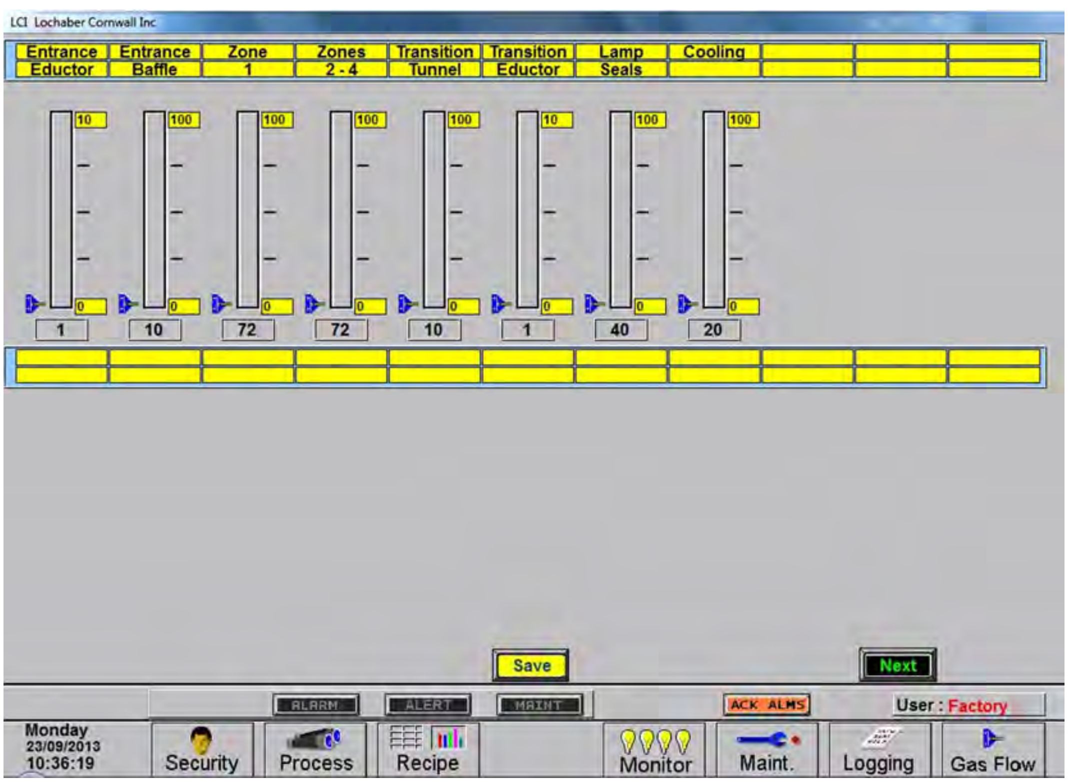


Figure 2-45 Gas Flow Screen

2.2.8 Furnace Process Screen

A. Process screen overview

Select the Process button on the menu bar view the Process screen. The Process screen displays the setpoint temperature, the current recipe, process state and status, transport speed, and other information such as percentage of power to elements and edge heaters. Alarm and alert dialog box also is displayed here along with event status.

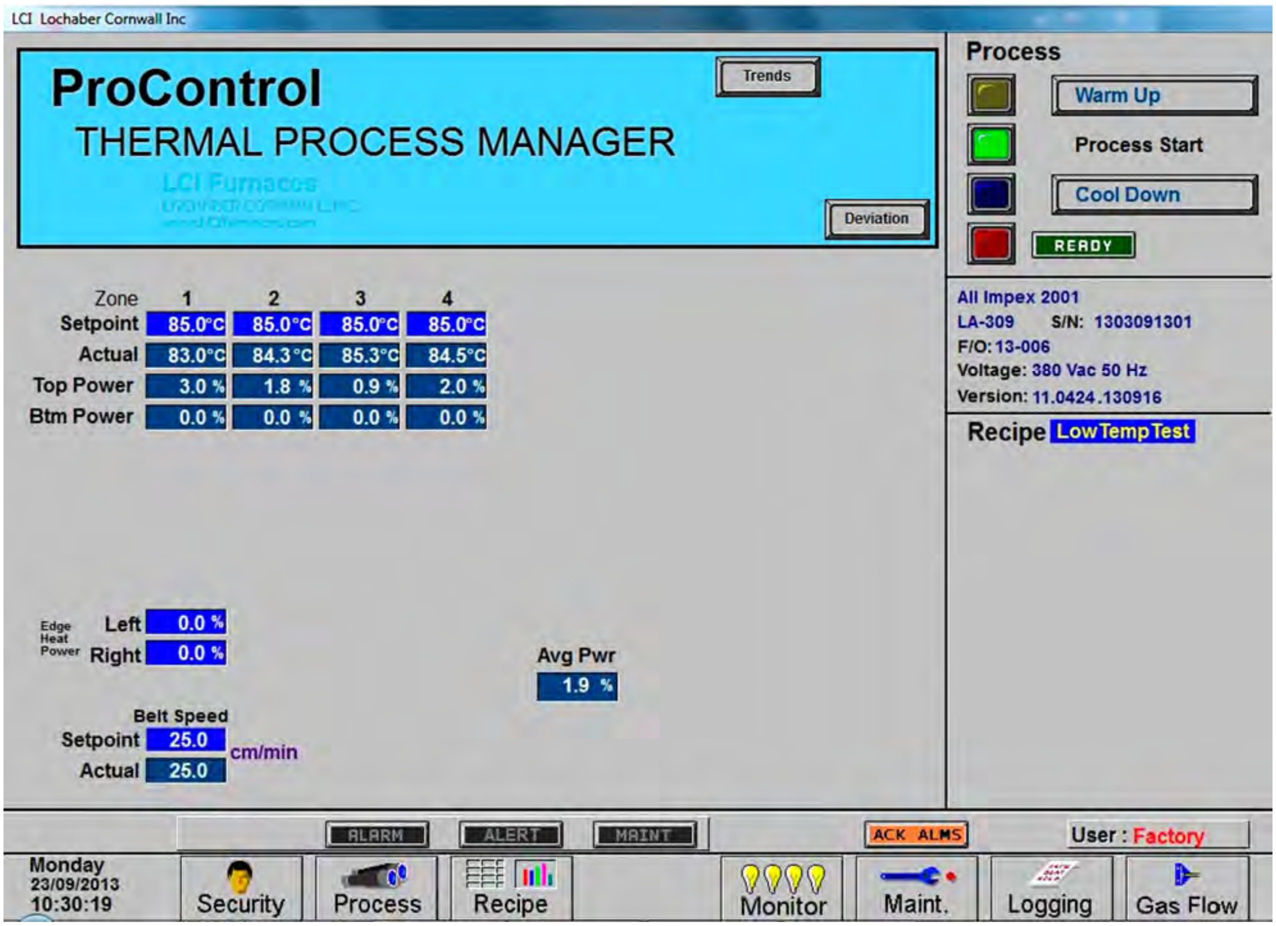


Figure 2-46 Process Screen

B. Zone Setpoint temperature fields

To enter or change zone setpoint temperatures, click on the Setpoint field and enter the new temperature in degrees Celsius.

C. Zone Actual temperature fields

The actual temperature field shows the temperature measured in each zone by the zone thermocouple in degrees Celsius.

D. Top Power / Btm Power fields

The Top and Btm Power fields display the percent power used by each zone by the lamps above and below the belt..

Change any value by clicking on the field and entering a value from 1-100%. For values less than 100% the furnace program will multiply the entered percentage times the resulting PID control value. For example if 50% is entered into the Top Power field for Zone one, when the PID value calculates a value of 3.0% power, the actual power applied and displayed will be 1.5% for that location.

E. Edge Heat Power (option)

If edge heaters are included, enter value (0-100%) to apply linear heat to sides of furnace wall. Since edge heaters only apply the preset amount of heat to their entire length, the lowest acceptable value should be used to achieve even distribution of heat across the belt.

F. Belt Speed fields

Click on the Setpoint field to enter a new belt speed. The Actual Belt Speed field displays the belt speed determined by the motor speed as calibrated.

G. Trends button (option)

If SuperTrends are enabled, the Trends button will open a zone dialog box. Once a zone is selected the SuperTrends will open. See technical note on use of SuperTrends feature.

H. Deviation button

When on the Process Screen, the user can activate the Deviation screen by clicking on the Deviation button. The Temperature Deviation screen will show the deviation of measured temperature from set point for each zone. The vertical bars are green for process ready conditions by zone, and change color independently as the deviation in a given zone changes.

The user can drag the Deviation screen to another location on the Process Screen or close the screen at any time.

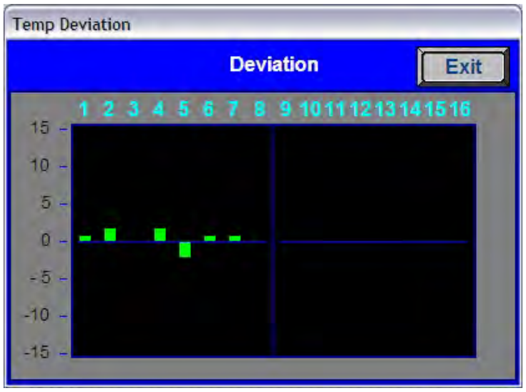


Figure 2-47 Temperature Deviation Screen

I. Avg Pwr field

The Avg Pwr field on the Process screen reflects the calculated actual power being used by the machine. This number is based on the % power applied to each zone and the lamp power of each zone. Edge heaters are not included in the calculation.

J. ALERT & ALARM buttons

Pressing the Alert or Alarm button will open list of current alerts and alarms. ALERTs are notification of an issue or potential problem, while ALARMs indicate a serious problem, shut-down the lamps and/or take the furnace out of the READY state or WARM UP state. After an ALARM has been corrected, the Furnace Controls ON button must be pressed to restart the furnace.

K. ACK ALMS button

Pressing the ACK ALMS button will "Acknowledge" or reset the alarm. If the source of the alarm is still a problem, the ALARM button will continue to blink and the alarm continue to sound.

While the machine is heating, check for alerts and alarms and listen for the alarm buzzer. In particular, check for any exhaust fan failure alarms. Check for failed elements. The effect of an element failure is generally minimal unless two failed elements are adjacent to each other.

> NOTE: Allow the system to stabilize and to enter the PROCESS READY or PROCESS START mode as indicated by a green light on the screen before processing any product.

You must be in "Process Off" condition to exit (indicated by a red light).

L. Process action buttons & indicators

The Process buttons include Warm Up, Process Start, Cool Down and Ready. Press the Warm Up button to introduce power to the heating lamps. The furnace remains in Warm Up until all zones are ±2% of setpoint for over 60 seconds, then the green Process Start indicator and green READY box will lite. Pressing the Cool Down button starts the cool down sequence.

M. Recipe indicator

The Recipe indicator displays the recipe currently in running in the furnace controller.

N. Power Limit Feature (option)

If Power Save is enabled, the power can be limited by a “Maximum power” value entered on the Maintenance/Calibration screen. If this value is set at 0, no power is calculated and no limit is set on the power used by the machine. Any non-zero value will cause the system to calculate the power and limit it to this value.

Default maximum power is set to 100% . When enabled, the total power will then always stay below the number set by the user. Edge heaters are not included in the calculation.

WARNING: A low power limit may prevent the machine from reaching the Process Ready state, since the user value may not be high enough to reach the desired temperature. For example, setting a maximum of 30 kW will most likely not be enough to reach a steady state in a high temperature furnace when trying to go to 900°C. In this case, the machine will just stay in the Warm Up mode.

2.3 Normal Furnace Operation

A. Check for Alarms & Alerts

Check to assure that there are no active alarms or alerts. If needed, move cursor to and click on "ACK ALMS" to clear or silence an alarm/alert in order to proceed with furnace operation. If alarm/alert does not clear, see Troubleshooting in Section 3.

B. Set Process parameters

Verify correct recipe is loaded. If not, click on RECIPE button for the "Recipe" screen (Figure 2-48) or enter desired process parameters including zone set point temperatures, power, edge heater and belt speed by clicking on respective the blue fields and typing the correct values.

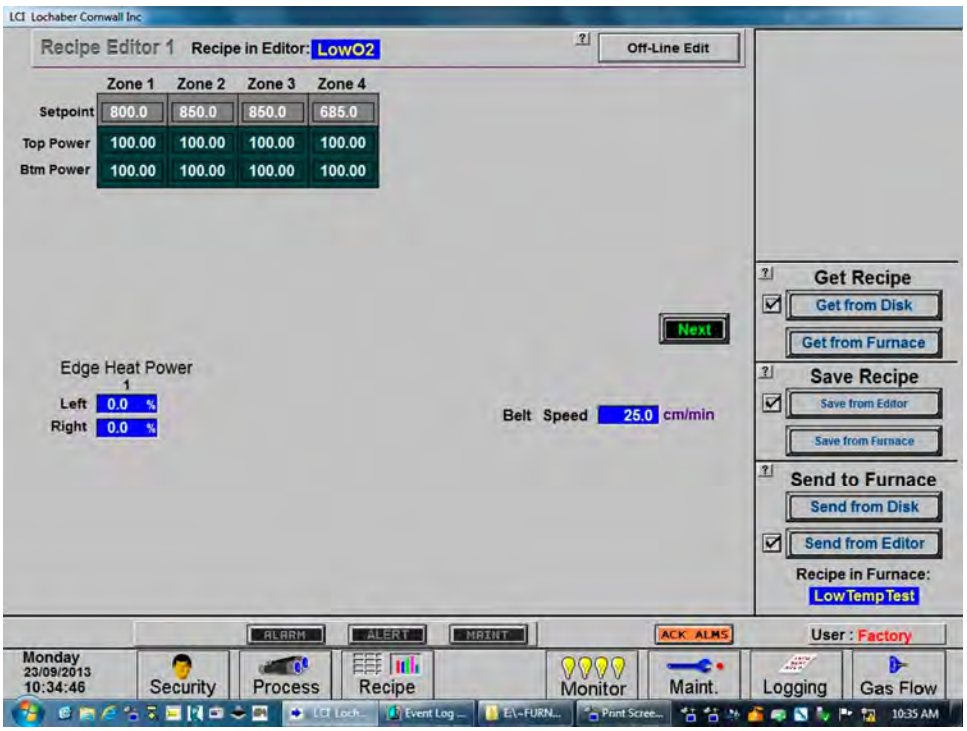


Figure 2-48 Get Recipe Menu and Editor

C. Select WARM UP

In the Process field, select "WARM UP" to initiate the process selected (Figure 2-49). In the "WARM UP" mode, the heating elements are energized. After 20 minutes, check the system for instability or cycling, and correct if necessary.

D. Process Start

When the furnace has stabilized the green Process Start button indicator and the READY box will lite. Product man now be placed on the belt for processing (Figure 2-49).

NOTE: Allow the system to stabilize and to enter the PROCESS READY or PROCESS START mode as indicated by a green light on the screen before processing any product.

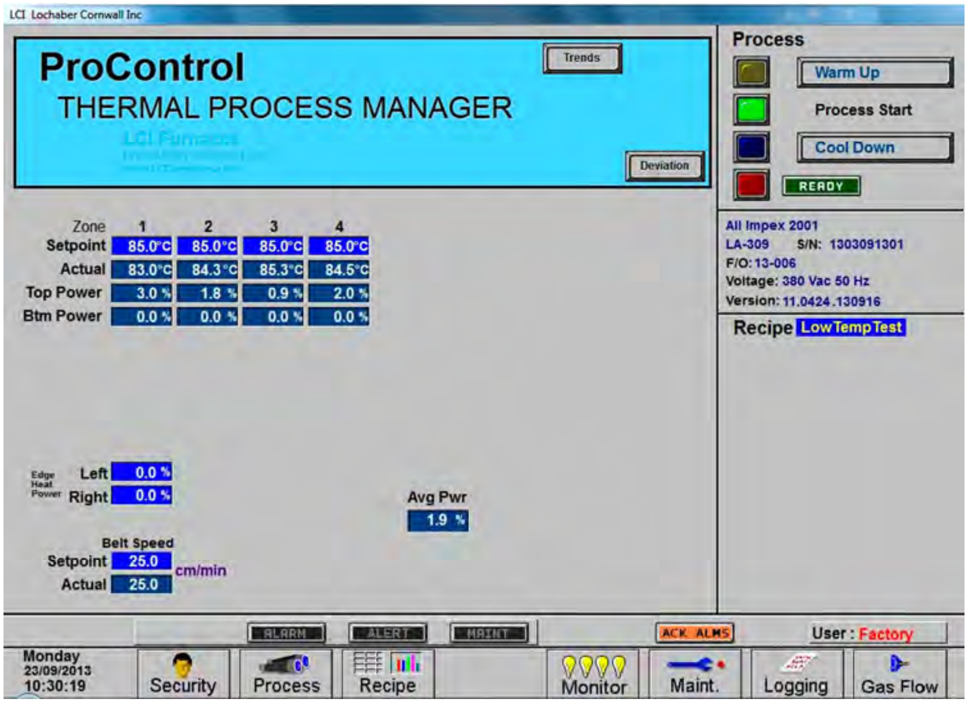


Figure 2-49 Process Start

2.4 Furnace Shut Down

2.4.1 Shut Down Modes

There are five basic levels of shut down on the furnace:

1. EMO – Emergency Off
2. Control System Off
3. Cool Down
4. Auto Shut Down
5. Complete Shut Down

Whenever possible, log out of the furnace program and shutdown the computer using the Windows operating system before pressing the OFF button on the control console. The computer is configured to start automatically when the furnace ON button is pressed on the control console.

2.4.2 EMO Shut Down

For immediate shut down of the furnace:

1. EMO - Press any of the Emergency OFF (EMO) buttons.
2. All systems will immediately shut down, except for furnace computer and monitor.

2.4.3 Furnace Control System Shut Down

For immediate shut down of the furnace:

1. Shut down furnace computer.
2. Press FURNACE POWER OFF button on Control Console .
3. All systems will immediately shut down, except for furnace computer and monitor.

2.4.4 Cool Down

To place the furnace in "standby" mode for quick restart (to load and run new recipe):

1. Using PC mouse, click the COOL DOWN button on the PROCESS screen to remove power from the heating elements. The heating elements turn off immediately. You will hear the K1 lamp power contactor release with a click. The furnace control system will continue to run the belt, cabinet cooling fans, product cooling fans, and keep process gas flowing during COOL DOWN.
2. When all zones are below 100°C, COOL DOWN is complete. The furnace may be left in this condition with belt running and process gas flowing indefinitely. You may manually turn off the process gas flow at this point without causing harm to the furnace, although you must remember to turn it back on prior to restarting the furnace.
3. To restart the furnace (after loading a new recipe or to run the current recipe again), click the WARM UP button on the Process screen , referring to item 5) in the Furnace Operation (Process Screen) section 2.3.

2.4.5 Shut Down Considerations

The furnace should be shut down when more than an hour or two will elapse between production runs. A shutdown conserves energy and prolongs the life of the furnace and elements. Follow the steps in sections 2.4.6 for short duration shutdowns.

The furnace computer is often left running if the furnace is to be down for less than 2-3 days. Leaving the computer on for longer period will not harm the system. However, always shut down the furnace computer using the Windows operating system first before the OFF button on the console is pressed.

2.4.6 Auto Shut Down

Auto Shut Down allows an operator to initiate the shutdown sequence and not have to be present when the furnace completes COOL DOWN to complete the sequence. After Auto Shut Down is complete, the furnace computer remains running, although the rest of the furnace is shut down completely and must be restarted to resume operation (see section 2.4.10).

To initiate the Auto Shut Down sequence while in PROCESS START or WARM UP mode on the PROCESS screen follow steps 1 and 2. If all furnace zones are below 100°C, go to step 2:

AUTO SHUT-DOWN STEPS:

1. Click COOL DOWN on Process screen
2. Press FURNACE POWER OFF button

COOL DOWN. Using the PC mouse, click the COOL DOWN button on the PROCESS screen to remove power from the heating elements. The heating elements turn off immediately. You will hear the K1 lamp power contactor release with a click. The furnace control system will continue to run the belt, cabinet cooling fans, product cooling fans, and keep process gas flowing during COOL DOWN.

You may move to Step 2) at any time after clicking COOL DOWN, or the furnace can be left in this condition without problem. However, until FURNACE POWER OFF is pressed, the belt and auxiliary systems will continue to run even after COOL DOWN is through.

FURNACE POWER OFF. Shut down the Windows computer. Then press the FURNACE POWER OFF button on the control console.

While still in COOL DOWN, the MAIN POWER light remains “on” and the FURNACE POWER OFF button light is “off”. All controls and accessories (belt motor, fans, light tower, etc.) remain “on”. When all zones are below 100°C, COOL DOWN is complete and the control system will stop the belt automatically and shut off any other automatic systems.

When both AUTO SHUT-DOWN steps have been initiated and are complete, the furnace will be completely shut down electrically, except for the furnace computer and monitor. If the furnace is not equipped with Auto Gas Valve Shutdown, the process gas will still be flowing to the furnace until the valve is manually closed. The furnace can be left in this state indefinitely without harm to the furnace. For complete shutdown of the furnace see section 2.4.7.

2.4.7 Complete Shut Down

For complete shutdown of all systems and power to the furnace follow steps 1-5:

1. Click COOL DOWN on Process screen
2. Computer system OFF
3. Press FURNACE POWER OFF button
4. Process Gas OFF
5. Main Power

COOL DOWN. See section 2.4.5, subsection 0.

FURNACE POWER OFF. See section 2.4.5 , subsection 0.

COMPUTER SYSTEM. The computer system is normally left ON between short to medium periods of furnace shut down. However, for Complete Shutdown, before COOL DOWN is finished, exit the Furnace program from the Process or Security screen. Then, click on Windows Start/Shut Down to turn the computer OFF. The computer will Power OFF after the operating system closes all files are closed. The furance controller will continue to operate the cool down mode until all zones are below 100C..

PROCESS GAS. For furnaces equipped with the Auto Gas Shutoff feature, the process gas valves will close after COOL DOWN is finished. For complete shutdown, manually close process gas supply valves, but only after COOL DOWN is complete.

MAIN POWER. The main power is not automatically disconnected from the furnace. If you wish to disconnect the main power to the furnace, wait until steps 1-3 are complete before throwing the facility power breaker.

2.4.8 Turning Off Furnace PC and Monitor

Shutdown of Windows operating system and the furnace computer is only required if you are disconnecting facility power to the furnace.

1. **LOG OFF.** Using the PC mouse, go to the Security screen. Click your user name in the User List and click Log-Off. Clicking on the Exit button will take you out of furnace operation mode when all zones are below 100°C and the belt has stopped.
2. **SHUT DOWN.** From the Windows Desktop, select start, then select Shut Down. The computer will Power OFF after the operating system closes all files.

2.4.9 Exiting a Frozen Furnace Program

1. **EXIT FROZEN PROGRAM.** Using the PC keyboard, press ALT-F4 to exit the active program.
2. This method of closing the furnace program should only be used to exit a frozen program. It will not affect the program running in the furnace Controller. If still in Cool Down, the furnace will continue to run until the Cool Down sequence is complete.

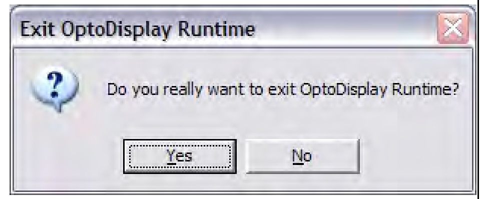
Note: If communication is lost to the PLC LCM4 controller, the furnace program will freeze. To exit any frozen Windows® program, Press Alt-F4 on the keyboard.

2.4.10 Restarting the Furnace after Auto Shut Down

Auto shutdown turns off process gas and the Opto22 PLC after Cool Down. Since the computer remains on, the PLC must be re-initialized. Follow the steps per the RESTART table to start the furnace after Auto shutdown.

Table 2-6 Restarting the Furnace after Auto Shut Down

After Auto Shutdown, the furnace computer left ON, while furnace belt, lamps and all auxiliaries are OFF. In this state the furnace program will not be communicating with the PLC and, therefore, must be closed and reopened after the furnace is restarted to re-establish communication with the furnace.

1. Close Furnace program	Click in the center of the furnace program screen and use Alt-F4 to close the furnace program. Note: Alt-F4 is a Windows command to close the active window. If Alt-F4 does not close the main furnace program, repeat the Alt-F4 command until you see the Exit OptoDisplay Runtime dialog box. Do not restart the furnace program until the furnace is ON. 
2. Main Power	Verify the Main Power ON button is lit. Disconnect switch should be on, all panels in place and EMO switches reset.
3. Furnace ON	Press Furnace Power ON button. Furnace ON light illuminates. **Wait 5 minutes for the Opto22 PLC to sync with the Furnace computer.**
4. Start Furnace Program	Press Furnace program icon to initialize communication with the PLC and start the furnace program. 
5. Log-in	Log in to the furnace software. Log-in is only possible when PLC and Computer are communicating.

CAUTION: Dangerous voltages are now present throughout the electrical systems of the furnace. Make sure that any probes in the furnace are placed on the belt surface only. Probes extending over the sides of the belt may contact high voltage terminals!

2.5 Modifying Control Strategies

2.5.1 Recipe Screen (Off Line Edit)

A. Go to Recipe Screen (Recipe Editor1)

NOTE: When editing this screen the process is not changed.

Level 1 access will allow the operator to inquire, select, and run preset parameters and recipes. Level 2 access will allow the operator to edit and save recipe data.

When initializing the "Load & Run" field, the process screen is updated and the Recipe Setup screen is changed to On Line Edit.

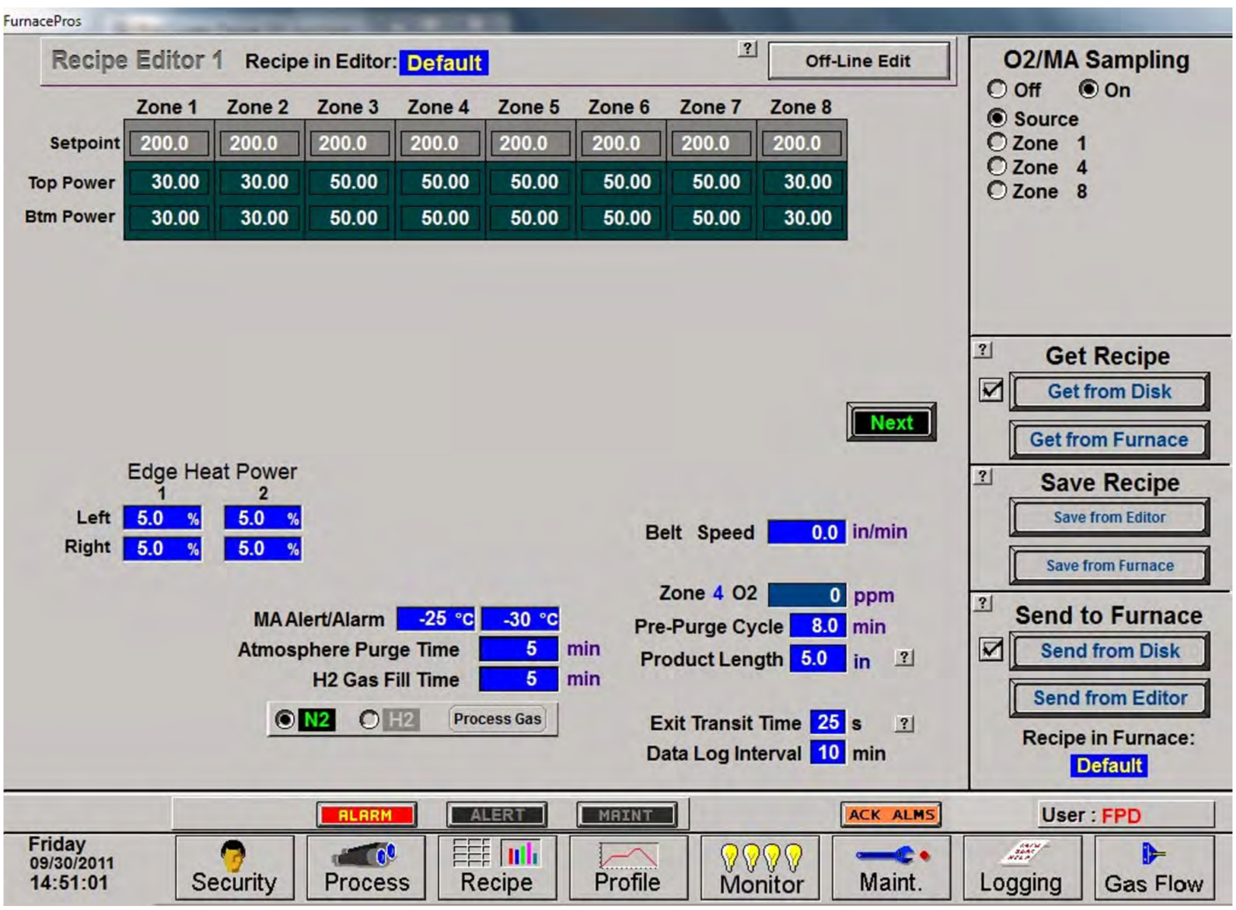


Figure 2-50 Recipe Editor 1

B. Load Recipe (Access Levels 1 and 2)

C. Delete Recipe (Access Level 2)

D. Edit Stored Recipe, Save Stored Recipe (Access Level 2)

NOTE: Do not use this feature on the current recipe while in ready mode and while processing parts.

2.5.2 Changing Recipe Set points (Access Level 2)

A. Change Temperature (Access Level 2)

Place the cursor on the temperature setting to be modified. Type the new setting and press enter from the keyboard.

NOTE: Temperature display is in degrees Celsius.

B. Change Power Distribution (Access Level 2)

1. Heating Element Power distribution

Default value is 100% top and bottom.

Place the cursor on the power distribution setting to be changed. Type in the new setting and press enter from the keyboard. This can be between 0% and 100%.

Power distribution is a scaled percentage of maximum power output to the top and bottom heating elements.

The maximum power is typically set at 1.5 times the actual percentage of power used when the furnace is in the “Ready” mode.

2. Edge Heater Power Distribution (Access Level 2)

The edge heaters are located at the outer edges of the belt and run the entire length of the heated chamber. They can be used to improve the temperature uniformity across the width of the belt. Click on the blue cell to modify the percentage on. The range is 0-100% and can be set in increments of 1%. See the Reference Manual for more on using the edge heaters.

c) Change Transport Speed (Access Level 2)

Place the cursor on the Belt Speed field, click, type in the new value and press enter from the keyboard.

NOTE: Transport speed is displayed in inches per minute or cm/min.

3. O2/MA Sampling (option)

If equipped with an integrated sampling system with oxygen analyzer and/or moisture analyzer, the O2/MA sampling panel will appear in the upper right hand portion of the screen. Select default state of sampling system (ON/OFF) and sampling port (Source, Zone 1,4,8).

If an oxygen analyzer is supplied, enter alarm value for O2 ppm.

If a moisture analyzer is supplied, enter values in degrees Celsius for moisture analyzer and oxygen analyzer alerts and alarms.

4. SMEMA (option)

If equipped with SMEMA product tracking, enter length of product or product carrier in inches. Also enter the amount of time it takes from the time the part leaves the furnace until it reaches the an integrated moisture analyzer, enter values in degrees Celsius for moisture analyzer and oxygen analyzer alerts and alarms. Store in recipe file.

5. Hydrogen/FG Furnace (option)

If equipped as a hydrogen or Forming Gas furnace, you can enter setpoint time for Pre-Purge cycle (min) for the time the gas will take to purge the furnace zones with nitrogen before combustible gas can be started.

2.5.3 PID Zone Tuning

(Access Level 2)

On the recipe screen, "Next" button to view the Recipe Editor 2 screen. Enter new values for Gain, Integral and Derivative and save in recipe file.

Table 2-7 PID Initial Settings	
Parameter	**Initial Values**
Proportional Gain	9
Integral	45
Derivative	0-1

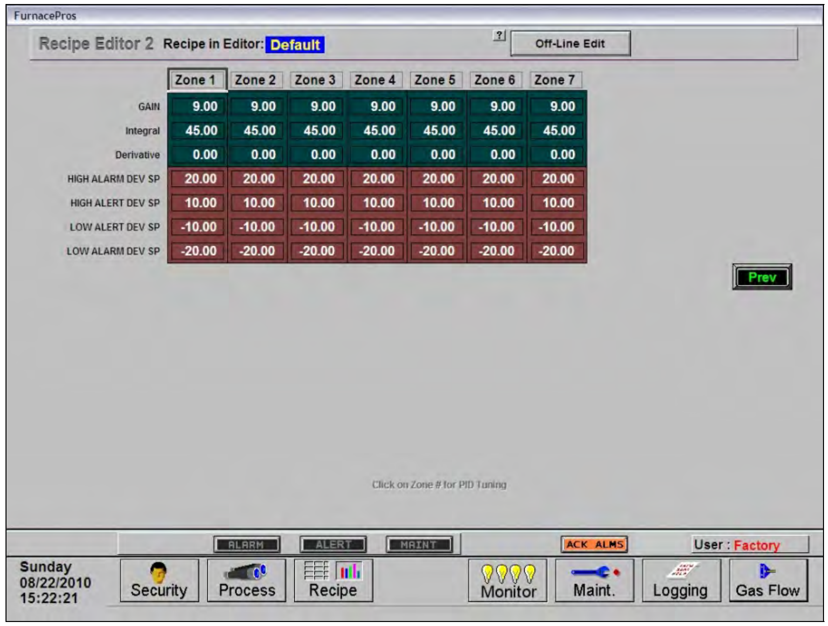


Figure 2-51 Recipe Editor2: Zone PID Parameters

Click on the desired Zone title pushbutton to monitor and Edit Zone PID Settings. A Zone Tuning dialog box (Figure 2-52) will appear with default values for proportional gain, integral, and derivative. Place the cursor on the value to be modified and click. Type the new setting and press enter from the keyboard. See Reference Manual, Chapter 9 for Process Engineering considerations in establishing PID parameters. Also see section 3.14.1 to completely retune a zone.

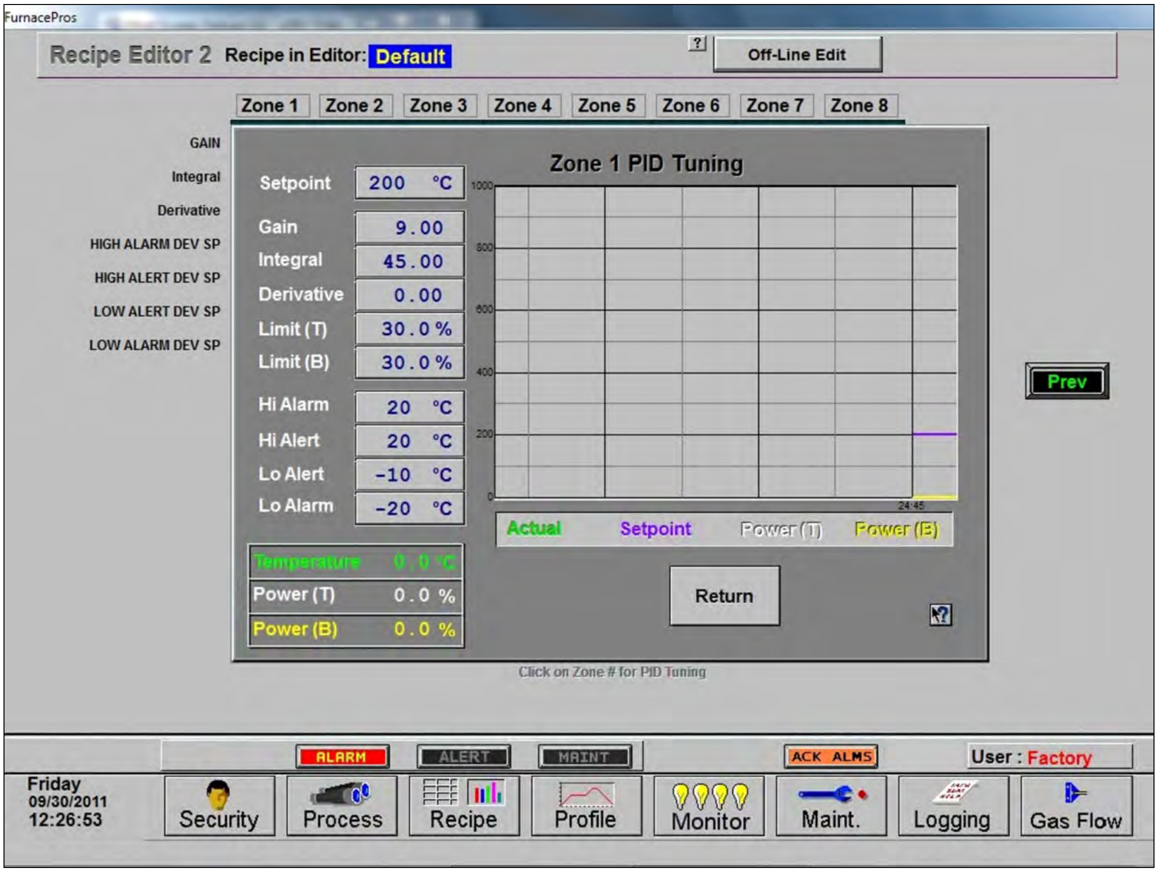


Figure 2-52 Recipe Editor 2: Zone PID Tuning

A. Gain (Proportional)

Gain influences the proportional response of the PID by amplifying the error between set point and actual temperature to establish an output level. The proportional band, in degrees Celsius, is defined as 100 divided by the gain. An increase in the gain reduces the amount of temperature deviation required to turn the heating elements on at full distributed power or decrease it. Too small a value will cause the system to be sluggish in response. Too high a value will cause the system to overshoot and be unstable.

B. Integral

The integral (or Reset) function corrects temperature offset.

C. Derivative

Derivative is a rate function that clamps temperature overshoot/oscillation. The maximum set point for the derivative function should be ¼ of the integral value.

D. Exit

For each Zone PID Tuning popup opened, you will need to click the “Return” button until all are closed. Click “Prev” button to return to Recipe Editor 1 screen.

2.5.4 Store Gas Flow Settings

Record flowmeter settings and store for each recipe using the Gas Flow screen. Enter flowmeter values by clicking on the value in the box below each flowmeter to record new values for the recipe being edited. See section 2.2.7 for more information. If stored with the recipe file, when a recipe is later opened, the operator can verify and adjust the flowmeters to match each recipe.

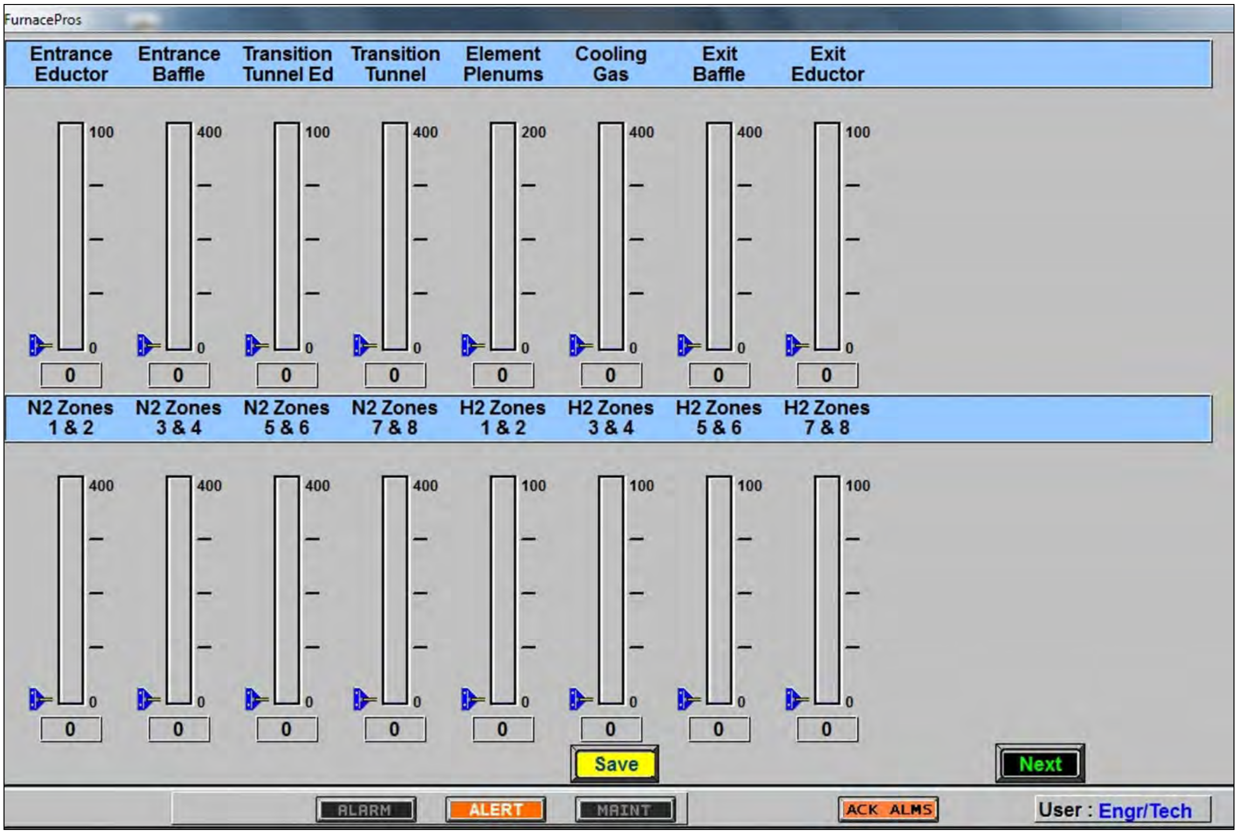


Figure 2-53 Recipe Gas Flow flowmeter settings

2.6 Super Trends

To view current or historical performance by zone:

1. Press the Trends button at the top of the Process screen,
2. Select desired zone to view.

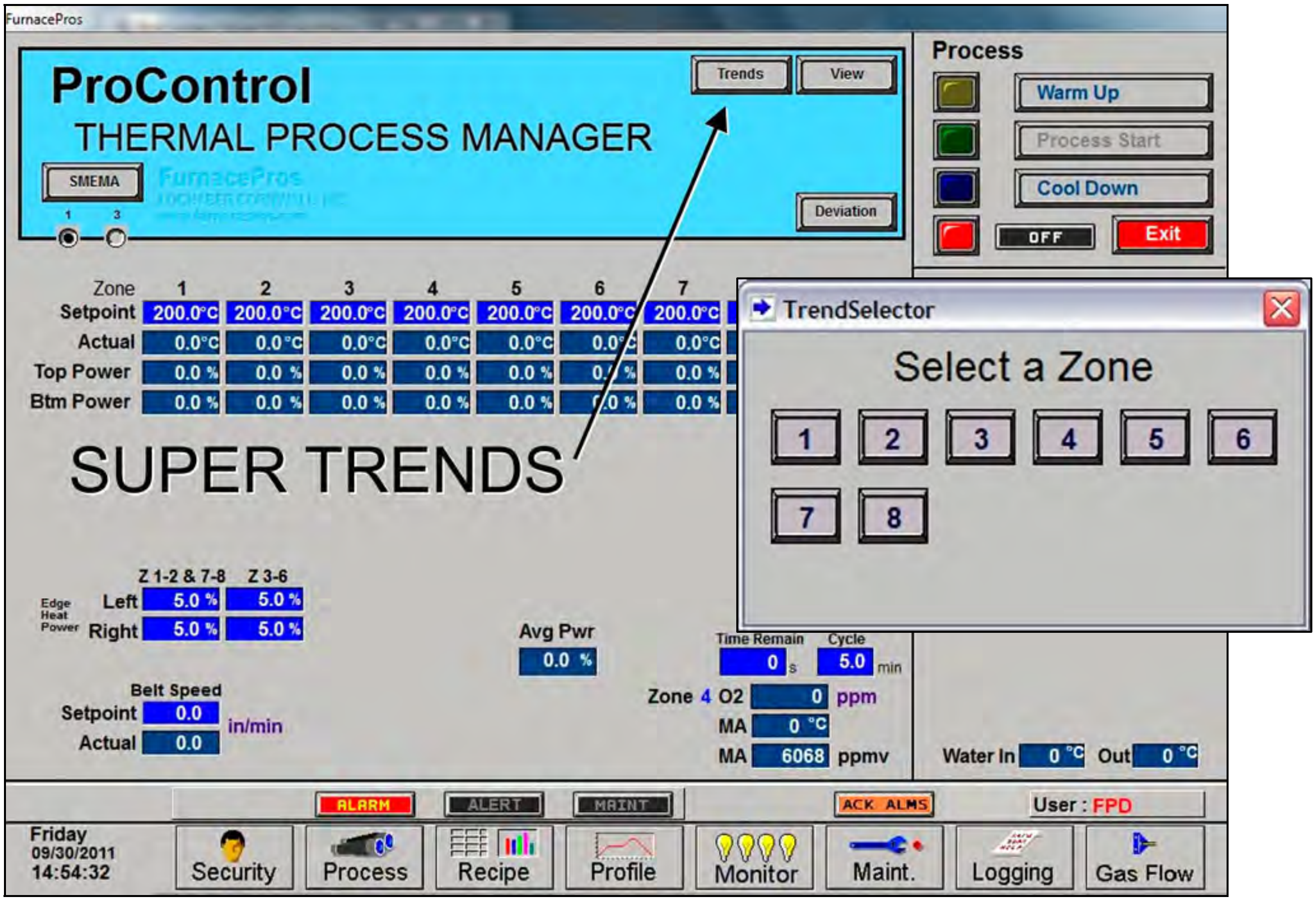


Figure 2-54 Super Trends button with Trend Selector

The Super trends graph appears as in Figure 2-55

Once the trends graph appears you can select the parameter to view. Selecting a specific parameter changes the vertical axis for that parameter. Press the button to change the scale for the selected parameter. (see Figure 2-57). All parameters are shown on the screen at all times, although the scale is adjusted for the selected parameter.

Figure 2-55 Super Trends graph

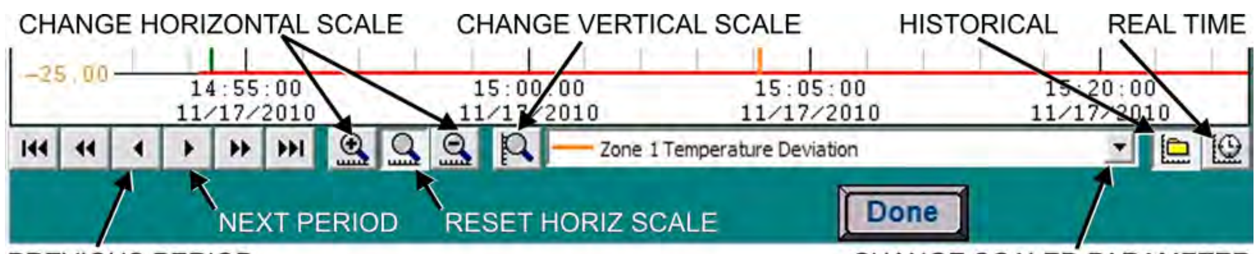
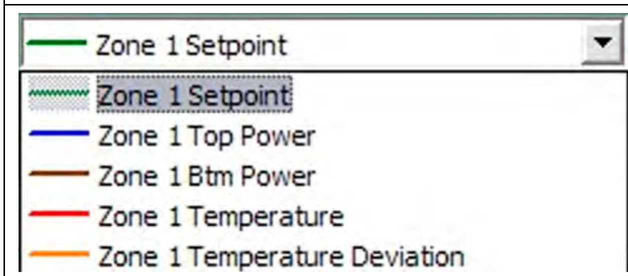


Figure 2-56 Super Trends Menu

Table 2-8 Super Trends Menu Buttons

Button	**Action**
	**Real Time Mode** (default). Shows data currently being recorded for all 5 parameters.
	**Historical Mode**. Opens file from an earlier period. (See Figure 2-18). Activates Previous and Next buttons and Horiz scale buttons.
	**Select Pen**. Select a pen parameter and the vertical scale changes to match its set value
	**Zoom Pen**. Change vertical scale for selected parameter.
	**Zoom Normal**. Resets Horizontal scale to default (30 minutes per screen).
	**Zoom Hour**. Compresses horizontal scale (x-axis) to show more detail (one hour per screen).
	**Zoom Day.** Compresses horizontal scale (x-axis) to show longer time period in one view. (24 hours per screen)
	**Log Forward** (movement varies with Zoom) Zoom Normal: 5 minutes / 30 minutes / End of data Zoom In: 6 minutes / 1 hour / End of data Zoom Out: 30 minutes / 1 day / End of data
	**Log Back** (movement varies with Zoom) Zoom Normal: Start of data / 30 minutes / 5 minutes Zoom In: Start of data / 1 hour / 6 minutes Zoom Out: Start of data / 1 day / 30 minutes

Enter the Historical Log Mode by pressing . The Super Trend Historical Log file popup is shown in Figure 2-18. Once an historical file has been selected, the Zoom and Log Forward/Back buttons can be used to view different time periods of furnace activity.

Figure 2-57 Change Vertical Scale

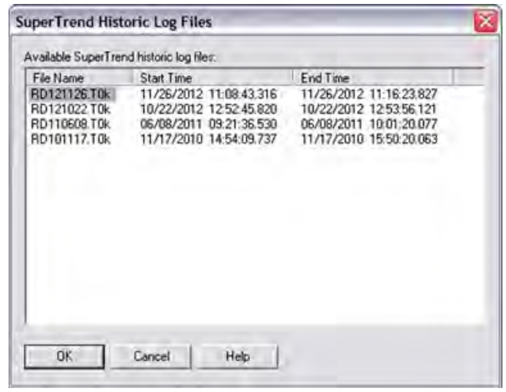


Figure 2-58 Load Historical Trend Data

2.7 Alarm Status (All Access Levels)

This is a display only feature. Any existing alarm conditions, such as transport speed error, are highlighted on the Process screen. To clear or silence an alarm/alert, move the cursor to and click on "Acknowledge Events." See Section 3 SERVICE & MAINTENANCE for further information.

2.8 Data Log/Alarms and Alerts

2.8.1 Occurrence and Timed Logging Control (Access Levels 1 and 2)

Move the cursor to and click on "Logging" to see any occurrence.

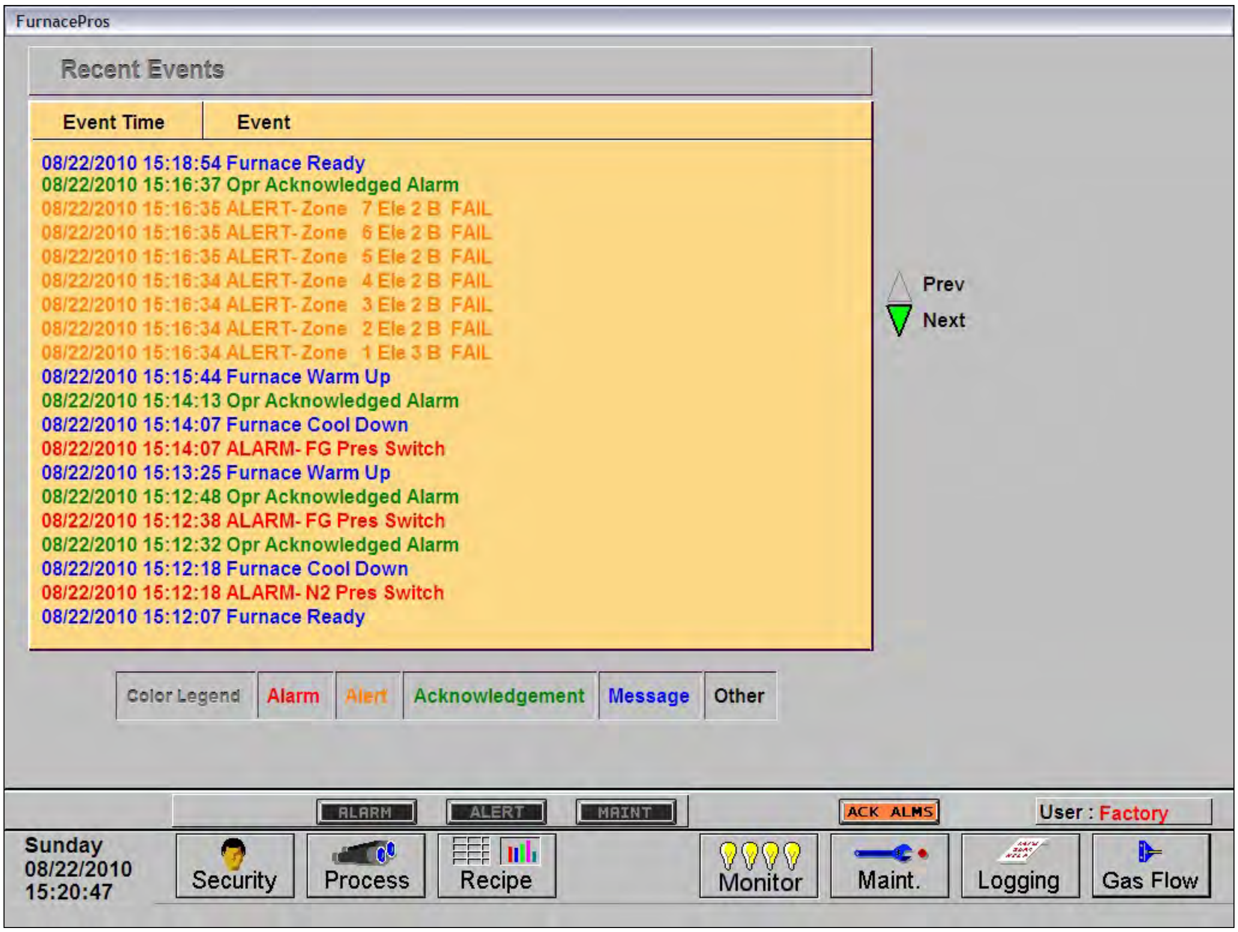


Figure 2-59 Event Logging

2.8.2 IPS Low Gas Pressure Alarms (option not included)

MAKE SURE THE LOW PRESSURE ALARM bypass switch on the PLC panel is in the ENABLE ALARM position. The IPS switch signals can be bypassed for service and testing using the LOW PRESSURE ALARM switch on the PLC panel. However, all alarms should be enabled during normal furnace operation.

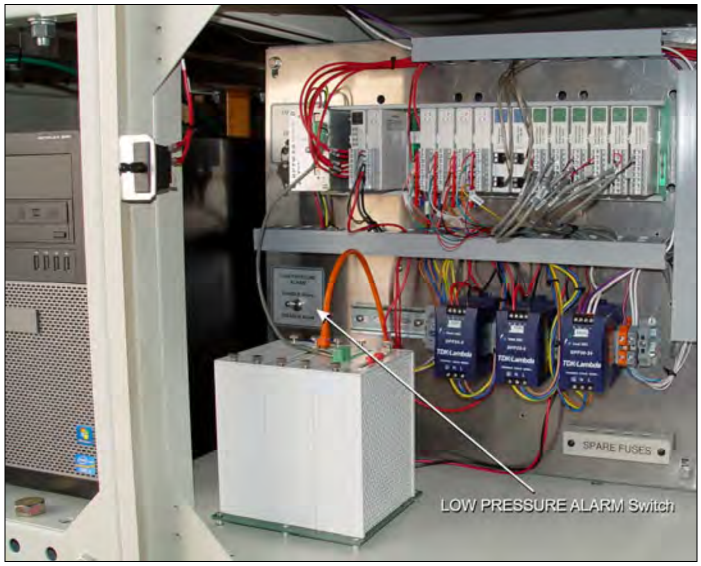


Figure 2-60 Low Pressure Alarm bypass switch location

A Inlet Pressure Switches is installed on each process gas manifold. These switches are normally open. They close when proper pressure is present in the process gas supply lines.

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

Table 2-9 Initial Alarm Settings			
Port	**Manifold**	**Pressure**	
Gas 1	CDA or Nitrogen	55-60 psig	3.8-4 Bar
Gas 2	Nitrogen Forming Gas, or other (Option)	55-60 psig	3.8-4 Bar

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

Figure 2-61 IPS Inlet Pressure Switch

2.8.3 Auto Gas Shutoff (option not included)

This furnace may be equipped with Auto Gas Shutoff. The Auto Gas Shutoff feature consists of solenoid valves on the process gas supply lines integrated with the furnace. These valves open and allow Process Gas to flow when Furnace ON is pressed. This feature is designed to conserve process gas. To shut down the furnace the operator need only put the system into Cool Down and press Furnace OFF. When all furnace zones reach 100°C or lower for at least one minute, the furnace shuts down and the process gas valves close.

The Auto Gas Shutoff valves fail in the closed position.

2.9 Element Monitoring System

The Element Monitoring system consists of a panel of 6-channel circuit boards which detect the location of a failed heating element. The circuit boards monitor the current to the lamps and activate an audible alarm and visible alarm upon sensing an element failure. The display shows the specific location of the lamp or lamp string (multiple lamps wired in series make up a string) containing the failed lamp. The audible alarm alerts the operator immediately if a lamp fails and allows him to discern its location and determine if process results will be appreciably affected.

Access the Monitor screen in the software to view the status of the heating element strings. Communication failure or individual lamp failure of itself will not shut down the process. The process will only shut down if a lamp failure adversely impacts the furnace ability to maintain set point temperatures.

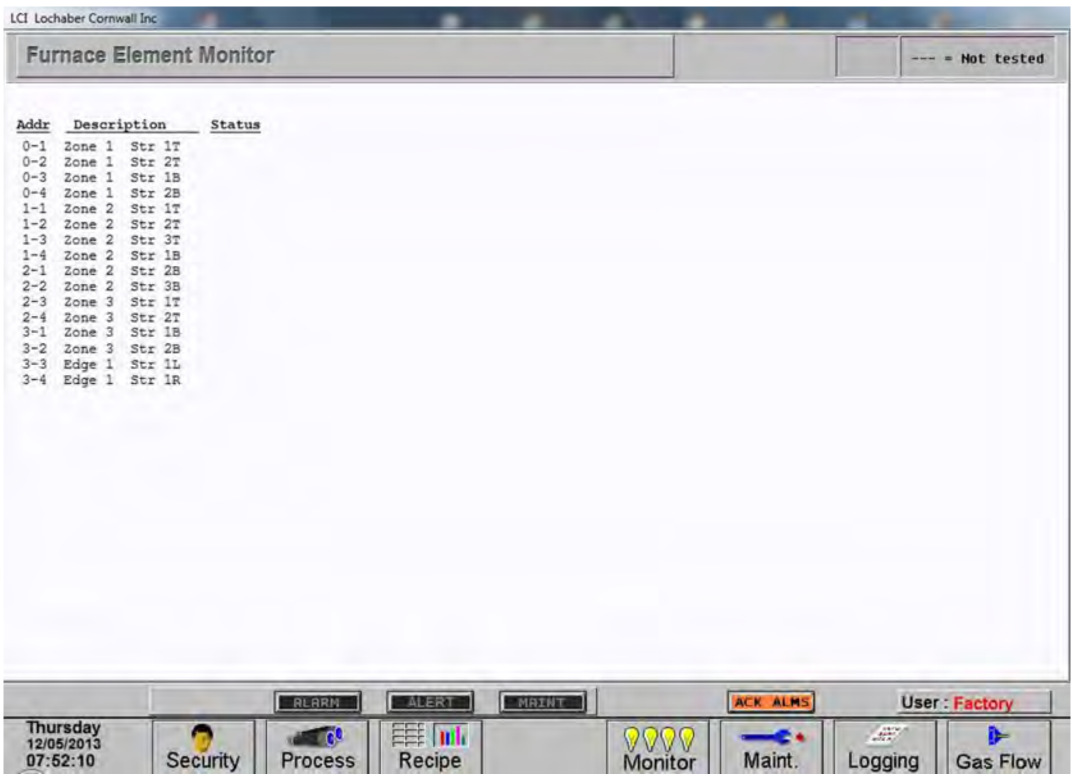


Figure 2-62 Element Monitor screen

2.9.1 EM Signal Polling (2001-2012 furnaces only)

On 2013 furnace models and later, the element monitor signals are collected from a current switch located each serial string. Visual indication of the status of each switch can be seen on the PLC digital modules assigned to the EM strings (see Figure 3-9 Furnace Controller EM I/O modules).

On pre-2013 models, the software polls the element monitor cards via a serial string. The signal sent from each channel can be viewed on the Serial EM Test popup screen (Figure 2-23). Click on the Serial EM Test button to determine if all boards are communicating properly with the PLC controller. Each board contains a dip switch which determines the digital address of a given board and the software checks each board in sequence. Boards are addressed from 0 to nn.

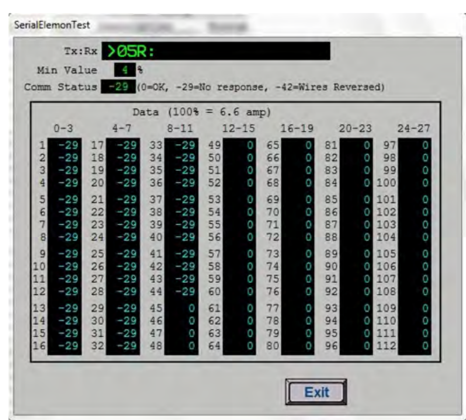


Figure 2-63 EM Serial Test screen

2.10 Over Temperature Alarm

2.10.1 Over Temperature Option (option not included)

The Over Temperature Alarm system consists of 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 near the flowmeter controls.

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

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

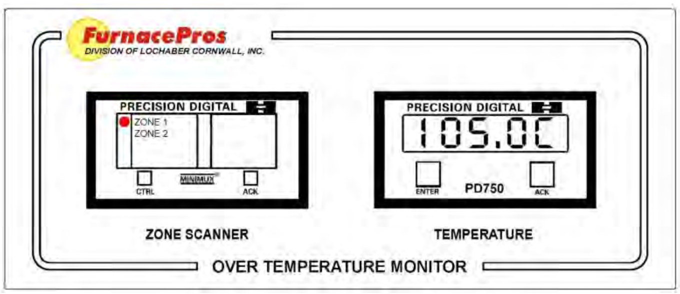


Figure 2-64 Event Logging

2.11 View Alternate Programs

To switch the viewing window between ProControl™ Furnace Process Software and another application (the WinKIC or DataPaq Windows Applications) press and hold down the ALT key, and then press TAB repeatedly. When the title of the desired Windows Application appears, release ALT. The new application will appear in the foreground. Repeat the procedure to return ProControl™ Furnace Process Software to the active window.

2.12 Exit Program in Windows

To exit an active program, click Alt-F4 and the program will either close immediately or present a dialog box asking if you are sure. Click yes to close the program.

2.13 Remote Access

In order to allow for remote diagnostics of in-process furnace operations, a 2nd network interface card (NIC) is provided as well as a modem with communication software. The remote operator, in conjunction with on-site personnel, can simultaneously view the Process screen and have access to input and control features.

Remote access can be accomplished as follows:

- Broadband connection via internet access

2.13.1 Network Connection

To connect furnace to the network:

Wired: Connect a Cat5 or higher TCP/P Cable to the RJ45 port below the entrance of the furnace. Set LAN Connection 2 to receive network signals.

Note LAN Connection 1 must be reserved for the furnace control system.

Wireless: Connect a USB wireless transmitter such as D-Link DWA-140 RangeBooster Wireless-N network adapter to the control console USB port (behind the keyboard). Setup connections to receive network signal.

2.13.2 Remote Diagnostics

A good method of connecting to the furnace remotely is to use the TeamViewer™ internet service for remote diagnostics. See Section 3.8 Remote Access for more information.

2.13.3 Connect Using TeamViewer™

Enable Teamviewer™ by clicking on blue icon on lower right of screen and enable.

Contact factory service tech and indicate system is on-line and available for troubleshooting.

3.1 Service and Maintenance Access

INTERLOCKED PANELS. Interlock switches will cut power to the furnace when the panel is removed or opened. Interlocks are located on the entrance lower panels on both the front and back of the furnace. In addition, the control enclosure rear dropdown door is interlocked. The control enclosure top access plate is not interlocked.

Observe extreme caution when the furnace power is engaged while the access panels are removed. Dangerous levels of AC and DC voltages will be present.

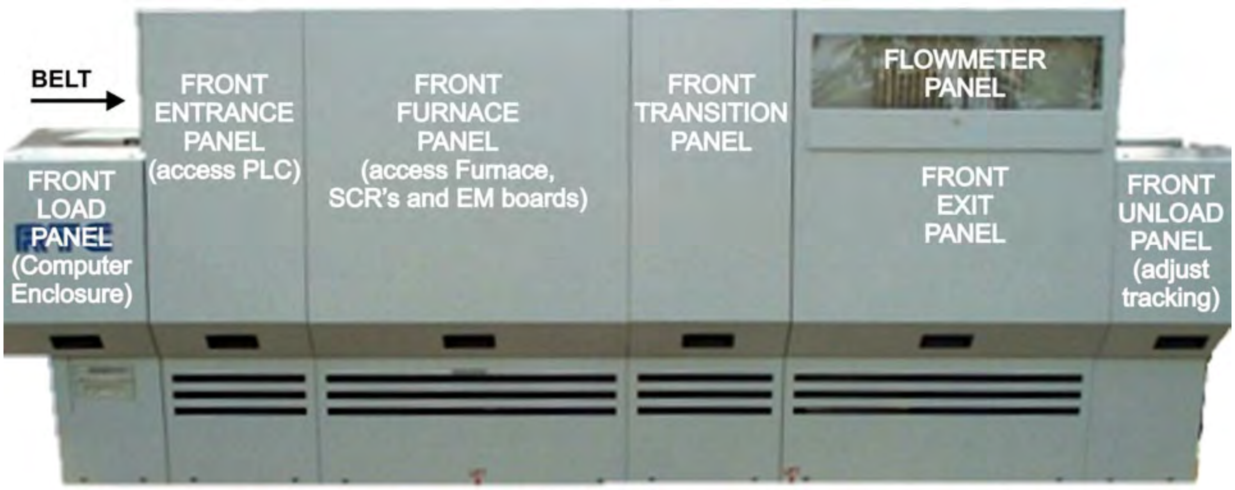


Figure 3-1 Front Access Panels
(Rear Panels - opposite side)

ACCESS PANELS. Gain access to the lower sections of the furnace by lifting and removing the panels (see Figure 3-1) on front and rear of the furnace. Make sure the EPO interlock switches (Figure 1-39) on the two entrance access panels are pulled out if the furnace is to be energized while these panels are off.

COMPUTER ENCLOSURE. To gain access to the computer, lift the Front and/or Rear LOAD Panel.

CONTROL ENCLOSURE. To gain access to programmable control system components and SCR's, remove the Front Furnace Panel.

COOLING SYSTEM. Remove Rear Exit Panel to access cooling system.

LOAD/UNLOAD PANELS. These panels located on either side of the furnace near the entrance and are not interlocked. Remove either panel to gain access to transport drive rollers.

FURNACE DRIVE ENCLOSURE. Remove Front and Rear UNLOAD panels at exit to adjust the belt tracking.

HEATING ELEMENTS. Remove entrance Front and/or Rear Furnace panels near entrance to access lamp elements.

UCD AND CDA FILTERS & REGULATORS (optional). Remove Front and/or Rear UNLOAD panels to access the Ultrasonic Cleaner Dryer tank heater, solenoids, water regulator and CDA filter and regulators if so equipped.

3.2 Electrical Panels

There are 5 main electrical panels in the furnace plus the control console and auxiliary panels for optional items. The panels are located in the furnace in somewhat the same orientation as in Table 3-1 with the belt travelling from Left-to-Right.

Table 3-1 Electrical Panels

• Safety Panel	• PDP or Power Distribution Panel	• MCC or Motor Control Center
• Control Console • PLC Panel	• SCR & EM Panel	• Auxiliary Panels:H2 Systems, Gas Sampling systems, Product Alert systems, etc.

Safety panel – Point where power enters the furnace. Contains main contactor. Located at furnace entrance, back side (Figure 3-2).

PDP or Power Distribution Panel – Distributes power 3 phases. Located next to Safety panel on furnace back side (Figure 3-2).

Control console – Main human interface for controlling power to the furnace. On top of furnace near entrance (Figure 3-5).

PLC panel – Programmable logic controller with I/O (analog and digital input and output modules) for managing signals to and from the furnace systems. Located near furnace entrance on front side (Figure 3-3).

SCR panel – Contains the SCR power controllers, solid state switches and firing boards, that manage power to the lamps using signals from the furnace controller. Located next to PLC panel on front side (Figure 3-3).

EM panel – Element Monitor panel contains current detection devices for determining integrity of lamp heater strings. Located on SCR panel or next to SCR panel (Figure 3-3).

MCC panel – Motor control center. Controls transport motor system. Located at furnace exit (Figure 3-4).

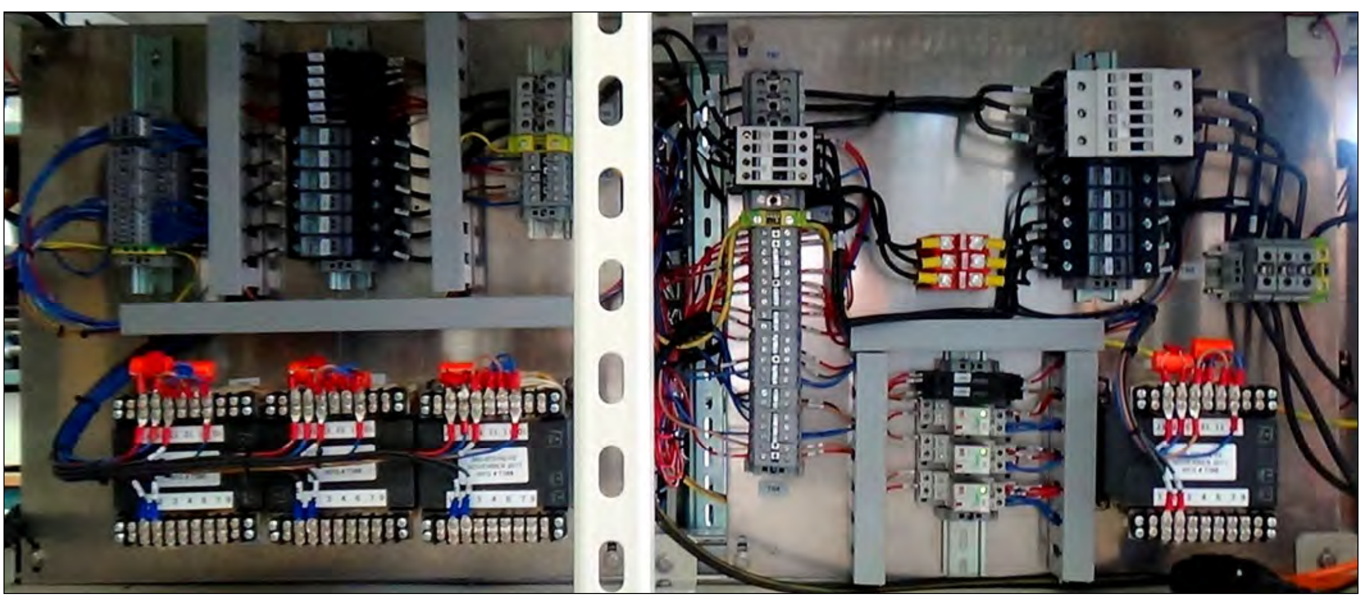


Figure 3-2   Power Distribution and Safety panels

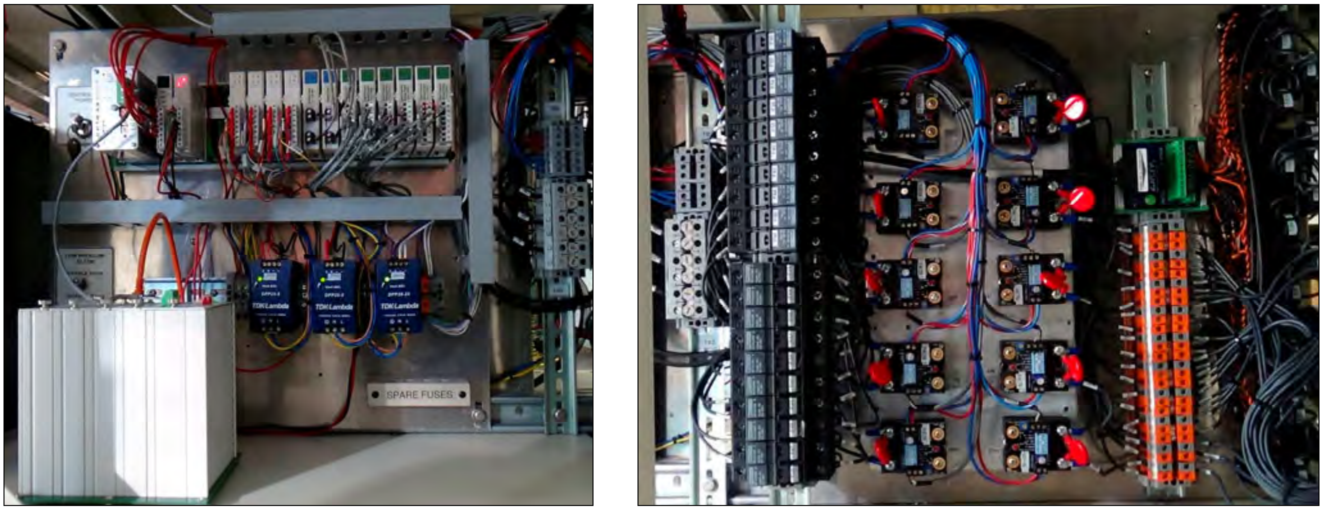


Figure 3-3 PLC panel (L) and SCR/EM panel (R)

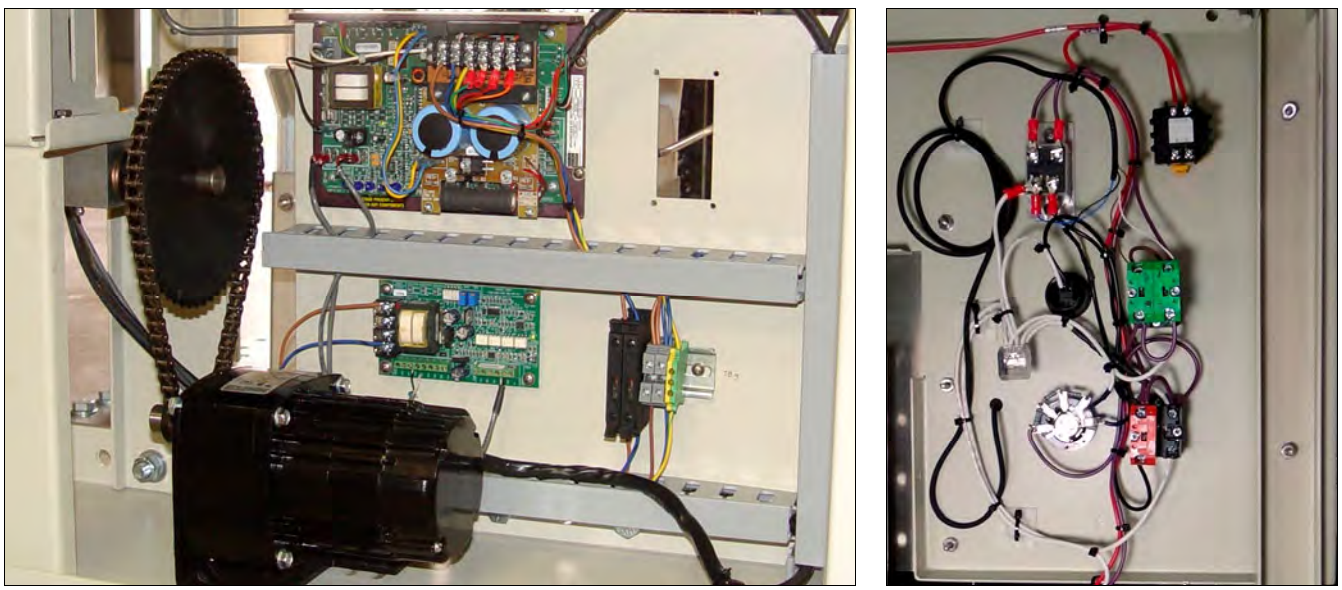


Figure 3-4 MCC or Motor Control panel (L) and SENSLAS Product Alert panel (R)

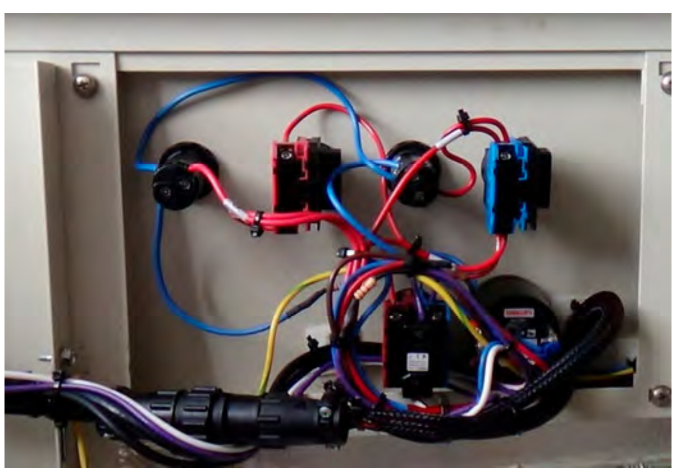


Figure 3-5 Control console (underside)

3.3 Routine Maintenance

3.3.1 General

Generally external cleaning is all that is required. The chambers are not to be touched or removed. If chamber cleaning is required, contact FurnacePros.

WARNING. DO NOT ATTEMPT TO OPEN OR MANUALLY CLEAN THE CHAMBERS OR THE FURNACE MAY BE INOPERABLE DUE TO DAMAGE TO THE INSULATION. Contact the manufacturer if cleaning is required.

3.3.2 Daily Maintenance

Daily maintenance consists of a simple series of functional checks that will alert maintenance personnel to any signs of developing problems. The importance of regularly checking the machine cannot be over stressed to prevent not only damage to the machine, but also loss of productive time and product. Whenever the furnace is started up the failure alarms should be checked for signs of trouble. An intermittent exhaust failure indicates that something is wrong and that the alarm mechanism, system exhaust fan, and possibly exhaust ductwork must be checked and corrected as necessary. Other alarm functions should be monitored, such as the lamp failure indicator, to see if corrective action is required. As the machine is being started, each control and switch should be briefly checked to ensure that all functions are working properly. Any controls that do not respond as expected, or alarms that do not clear should be checked out and corrected before putting the machine into operation.

3.3.3 Monthly Maintenance

Monthly maintenance, in general, means four weeks of operation for one eight-hour shift per day. This period of operation is not an absolute number, and it is possible that some of the tasks are needed more or less often. Experience with the machine and process being performed should dictate the need.

Note: Run a temperature profile, no less often than monthly, on machines that are used for sensitive processes.

On machines that are used for a variety of products, it is advisable to set up a profiling schedule so that each process can be checked periodically. The most sensitive profiles should be checked at least monthly, while less sensitive profiles could be checked every 2-6 months.

3.4 Other Preventive Maintenance

3.4.1 Preventive Maintenance Screen

The Preventive Maintenance Screen is used to list maintenance and their preferred frequency of occurrence. Consult the Reference Manual, Chapter 7 for a description of the use of this screen.

The Remaining Time Status Bar on the Maintenance Screen will provide a graphical representation of the time remaining before maintenance is required. When any Maintenance Item has timed out/reached the maintenance required date, the MAINT status box on the Process Screen will Flash.

As Maintenance Items are completed, click on the appropriate “Completed” pushbutton the Maintenance Screen in order to set a new maintenance required date that is based upon the #days field.

3.4.2 Recommended Maintenance and Frequency

The following table lists furnace equipment and maintenance tasks and recommended intervals. Many of these items are optional equipment and may not be found on your furnace. In many cases visual inspection can determine whether any preventative maintenance is required. Often maintenance intervals are determined by the process and furnace use.

Table 3-2 Recommended Maintenance & Frequency

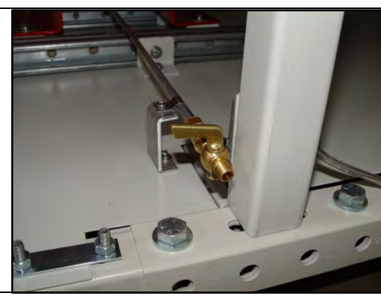
Equipment	Recommended Maintenance	Recommended Interval
Air Filters, Compressed air	Remove the door panel below the flowmeters and replace filter set in the compressed air line to assure furnace receives clean dry air.  	6 months or as required.
Air Filters, Door	Remove the foam sponge air filters from the lower electrical compartment (base doors); clean or replace them. These filters can be washed out with a mild detergent and water, but must be completely dry before being replaced.	Annually, or as required.
Compressed Air Tank (optional)	With air pressure still on the furnace system, remove the door panel below and to the left of the flowmeters. Open the small valve for the air compressor reservoir drain. Purge the tank until the condensate has been removed. 	Monthly or as required.
Battery, PLC	The Opto22 LCM4 controller has a lithium backup battery with a 5-year life cycle, but other factors may affect its service time. Storing the unit with the furnace power off shortens the battery lifespan. The battery will actively back up RAM when the Furnace is OFF. When the battery is near the end of its useful life the BATT LED will turn red. Once the battery begins to fail, the furnace controller will often fail to retain program parameters after power is lost to the controller. Eventually the program may not reset or may fail to load. BATT LED is normally green.	Every 5 years
Belt Shaft Bearings-perm	To gain access to the belt shaft bearings remove the end covers from both ends of the machine. Located at both ends of each belt shaft are permanently-lubricated bearings. These bearings should not be lubricated.	None
Belt Shaft Bearings with grease fittings	Bearings with grease fittings should be lubricated with a general multipurpose bearing grease. Apply enough grease to the bearing block so that excess grease can be visually seen squirting out along the shaft of the device. Wipe off all excess grease that has squirted out to avoid dirt accumulation.	6 months

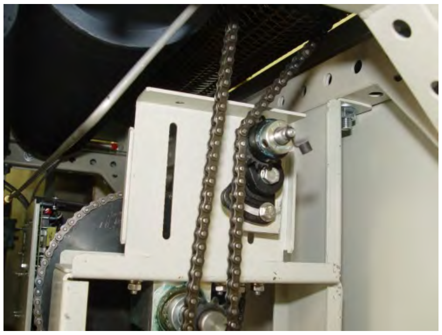
Table 3-2 Recommended Maintenance & Frequency		
Equipment	**Recommended Maintenance**	**Recommended Interval**
Belt Shaft Rollers	The belt shaft rollers should be inspected periodically to make sure that they are centered on their respective shafts. Remove the end covers to gain full access to the belt shaft rollers. If a roller is misaligned, loosen the setscrews that hold the roller onto the shaft and use a rubber mallet to move the roller on its shaft. Use a scale to make sure the rollers are centered to within 0.125 inches on the belt shaft. 	After first 30 days, annually thereafter
Belt Tracking Adjustment	The belt should be checked periodically to make sure that it is tracking through the center of the oven. Belt tracking can be checked visually at the entrance and exit ends of the oven. The belt should be centered between the belt guides at the entrance and exit ends of the oven. If the belt tracks off-center this problem can be rectified by realigning the belt shafts. First, set the belt speed to zero and remove the end covers at the entrance and exit end of the machine to expose the frame ends and the belt shaft bearing mounts at the end of the belt shafts. The following procedure can be used to correct tracking problems at either end of the furnace.  Loosen the belt shaft bearing mount bolts at one end of the furnace (entrance or exit). While facing the end (entrance or exit) of the furnace, use the following procedure. If the belt is tracking to your left, pull the left side of the belt shaft forward and/or move the right side of the belt shaft rearward. If the belt is tracking to your right, pull the right side of the belt shaft forward and/or move the left side of the belt shaft rearward. Repeat this procedure at the other end of the furnace. It is best to make these adjustments in small increments. Adjustments that are too large will cause a belt tracking problem in the other direction. At the exit end of the furnace, the transport motion sensor will also have to be loosened and moved with the belt shaft to maintain engagement with the gear on the belt shaft. Now run the belt at its highest speed and observe how the belt is tracking. Repeat the adjustment procedure until the belt tracking is centered.	Weekly
Chamber	The chamber normally does not require maintenance. If a problem with the chamber is suspected, the manufacturer should be consulted. Because the process gas is inserted through the insulation, the gas flow away from the insulation prevents contamination from building up on the chamber walls. To help reduce flux residue buildup in the chamber, the zones can be set at 400°C and the furnace can be put into a self-cleaning cycle for about an hour to burn out these organic residues.	Process dependent
Cooling Fans	Inspect all system cooling fans and flow switches, for freedom of movement and proper operation.	1 year

Table 3-2 Recommended Maintenance & Frequency

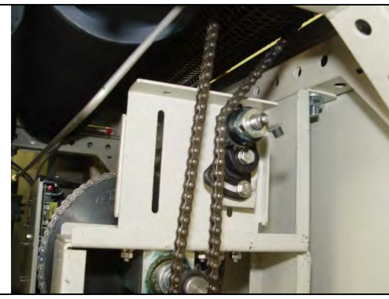
Equipment	Recommended Maintenance	Recommended Interval
Drip Trays	Remove and clean the drip trays, located under the process exhaust stacks. Access to the trays is through the top removable section of the furnace chamber, located above the trays, or at the furnace entrance, behind the cosmetic entrance molding. For procedure on removal and cleaning of the trays, consult the furnace Reference Manual, Section 7.5.1. Depending on the process, if very little buildup is found, cleaning may not be necessary more than once a year.	After the first 6 months of operation, as required thereafter
Drive Chain	The chain drive system is contained in the motor enclosure at the exit end of the oven. Lubricate the drive chain with FurnacePros #100523 chain lube or a commercial quality non-dripping chain lube. 	Every 12 months of operation
Drive Chain Tensioner	The chain tensioner is equipped with a grease fitting for lubrication. The chain tensioner should be lubricated every 6 months with a general multipurpose bearing grease. Apply enough grease to the tensioner so that excess grease can be visually seen squirting out along the shaft of the device. Wipe off all excess grease that has squirted out to avoid dirt accumulation.	6 months
Drive Motor Mounts	The drive motor is contained in the enclosure at the exit end of the oven. The motor mount bolts must be checked periodically and tightened if necessary.	Annually, or as required.
Exhaust Stack	A visual inspection of the stack is recommended along with each drip tray cleaning. 1. With a flashlight, look down the furnace stack. Check the exhaust stacks, after 6 months of operation, for possible buildup of materials generated from firing processes. The stacks should be cleaned, as necessary, with a brush and solvent to remove the buildup. A periodic inspection of the stacks is essential to establish a sensible maintenance cycle, since some processes will require frequent cleaning, and others require none at all. Contact LCI/FurnacePros if new gasket material is required to reattach the stack.	After the first 6 months, and thereafter as required.
Lamp Heating Elements	No maintenance is required for the heating elements other than replacement when one burns out. Note that with low temperature operations, the lifetime of the heating element is in excess of 100,000 hours. It is only at temperatures in the 900°C to 1000°C range that the expected lifetime begins to shorten. Also, the heating elements do not degrade over time. Should failure occur, it will be sudden and catastrophic. Use ohmmeter for best results visual inspection is unreliable. Refer to the Reference Manual for changing heating elements.	Inspect regularly, replace lamps as required.
Lamp Seals	Inspect the lamp seals for loose, cracked or missing packing material. Once the side covers are removed, the lamp seals can be visually inspected.	12 months

Table 3-2 Recommended Maintenance & Frequency		
Equipment	**Recommended Maintenance**	**Recommended Interval**
Sprocket Alignment	The sprockets are contained in the motor enclosure at the exit end of the oven. Visually verify that the sprockets are aligned. Adjust according to the furnace Reference Manual, Chapter 7.	After first 30 days and annually thereafter.
Sprocket Shaft Bearing Block	The sprockets are contained in the motor enclosure at the exit end of the oven. The sprocket shaft bearing block is equipped with a grease fitting for lubrication. The bearing block should be lubricated with a general multipurpose bearing grease. Apply enough grease to the bearing block so that excess grease can be visually seen squirting out along the shaft of the device. Wipe off all excess grease that has squirted out to avoid dirt accumulation.	12 months
Transport Belt Length	Check the length of the transport belt and shorten it if the gravity loop comes within 6 inches of the floor. A properly shortened belt should hang between 2 and 3 inches below the main frame.	Annually, or as required.
Transport Clutch	The clutch should be inspected periodically to insure proper tension on the belt. To adjust, a large hex nut at the chain sprocket end of the drive drum must be tightened until the drum turns. If the drum cannot be stopped by firm pressure with your hands, the clutch is too tight. Do not over tighten the clutch, as it is there for safety reasons.	Annually, or as required

3.5 TROUBLESHOOTING

To troubleshoot, follow all suggested remedies sequentially to determine source of the problem.

3.5.1 No power to furnace

A. The white MAIN POWER light on Control Console is out

1. Check main facility breaker is "on".
2. Check 3-phase disconnect switch mounted on furnace is "on" (Table 2-1).
3. Check EPO panel switches are pulled out or all furnace cover panels are in place (Table 2-1).
4. Check EMO switches are reset (Table 2-1).
5. Check fuse FA (neon light if blown) on Safety Enclosure panel per 802-101770 Power Control schematic.

B. The green or yellow FURNACE POWER light on Control Console is out

1. Check fuses FA & FB (neon light if blown) on Safety Enclosure panel per 802-101770 Power Control schematic.
6. Check K2 (located on Safety Enclosure panel per 802-101770 Power Control schematic) relay neon light "on" when FURNACE POWER ON button pressed.

C. The green or yellow FURNACE POWER light on Control Console is on, but the PLC has no power

1. Check fuse FB (neon light if blown) on Safety Enclosure panel per 802-101770 Power Control schematic.
7. Check Opto22 5 Vdc power supply fuses.
8. Check K6 (located on Safety Enclosure panel per 802-101770 Power Control schematic) relay light "on".
9. See section 3.6.2. items C) and D) below.

D. The green or yellow FURNACE POWER light on Control Console is on, but the belt doesn't move

1. Check K6 (located on Safety Enclosure panel per 802-101770 Power Control schematic) relay light "on".
10. Check that PLC has power.
11. Check fuses MA, MB, MC (neon light if blown) on Motor Control panel and on-board motor fuse on Motor Speed controller per 802-101771 Frame Wiring schematic.
12. See section 3.6.5 below.

3.5.2 Unable to log on:

A. The PLC control system does not have any power

1. Check fuses FA & FB (neon light if blown) on Safety Enclosure panel per 802-101770 Power Control schematic.
13. Check Opto22 5 Vdc power supply fuses.
14. Check the Ethernet cable between the PC and the Opto22 controller at the back of the PC and at the controller. (Ref: Frame Wiring Schematic in Documentation Section)
15. Check the setup of the installed Ethernet card. (Ref: Section 3)

3.5.3 Temperature

A. The furnace has been in "WARM UP" mode for more than 15 minutes.

On the Process screen, the zone temperature does not change. Perform the following procedures sequentially to determine cause.

1. Check K1 lamp contactor (located on Safety Enclosure panel) to be sure it is operational: on the Process screen, click on Cool Down and then click on Warm Up. You should easily hear the “snap” of the contactor points opening and then closing. If not, check:

   - Relay K5 (located on Safety Enclosure panel per 802-101770 Power Control schematic) light “on” when Warm Up mode selected. If not “on”, check fuse FD (neon light if blown), then check fuses F6 and F7 on Power Distribution panel. If K5 is “on” and the fuses are okay, check:

   - K7 Lamp_Power_Cntl relay located on Opto22 panel (Ref: Channel Assignments 802-101570 in Section 5 and PLC Configuration 802-101710 in Section 6) looking for an illuminated LED, indicating an active output.

> NOTE: K7 has diagnostic circuitry by allowing the user to manually control the status of the output

Set @ 3: Automatic (Factory set)

Set @ 2: Off (Bypass)

Set @ 1: Manual On/Off

B. The heat is in a runaway condition and cannot be shut off by changing the setpoint to a lower value.

1. The SCR needs calibration. See Maintenance (“Maint”) screen for details. (Ref: Reference Manual)
2. The SCR has failed and shorted. Replace SCR.

> NOTE: The following are factory typical settings:
>
> | | |
> |---|---|
> | Gain: | 9 |
> | Integral: | 45 |
> | Derivative: | 0 or 1 |

3.5.4 Zone temperature fluctuates.

A. The SCR needs calibration

Calibrate SCR per section Calibrate SCRs3.14.1

B. Improper flowmeter setting(s)

Adjust flowmeters to improve furnace isolation and proper heat transfer. Generally gas flow should either be balanced or moving toward the entrance stack.

C. Adjacent zone temperature differentials are too large

Modify the adjacent temperature zones so setpoint differences are smaller to facilitate a stable furnace.

D. Improper PID setting(s)

See section 0 for initial recommendations. Also see section 3.14.1 to completely retune a zone.

3.5.5 Conveyor System

A. Transport Speed Error.

1. Check K6 (located on Safety Enclosure panel on 802-101770 Power Control schematic) relay light ON.
2. Check that PLC has power.
3. Check fuses MA, MB, MC (neon light if blown) on Motor Control panel and on-board motor fuse on Motor Speed controller per 802-101771 Frame Wiring schematic.
4. Inspect clutch for slippage.
5. Visually inspect for belt jam or snag.
6. Check the input signal on Motor Speed controller board (located in motor box); S1 is common, S2 is speed control. At maximum speed the voltage is approximately 10 Vdc.

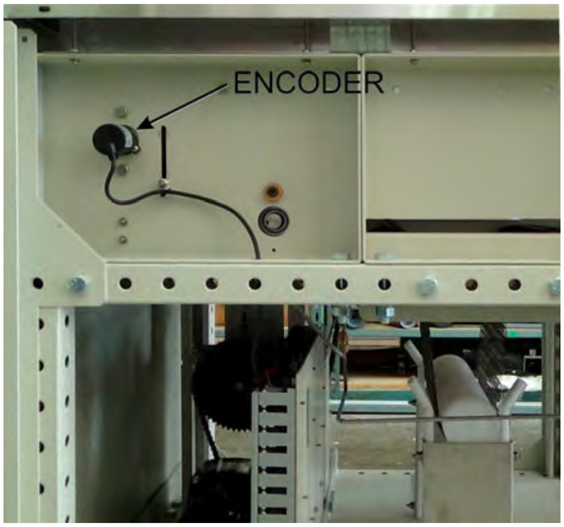


Figure 3-6 Encoder located behind furnace back exit panel

B. Transport Motion Fault.

In addition items in 3.5.5A, the following items should be checked:

1. **Furnaces after 2002.** Check for wear and tear or loosening of the transport motion encoder mounted on the drive roller shaft at the exit end of the furnace.
2. **Furnaces prior to 2002** may have a chopper wheel instead of a rotary encoder. Check to make sure the wheel is still turning and the optical sensor is clean.

3.5.6 Transport System - Jerking or Vibrating of the Belt

See Recommended Maintenance and Frequency table 3.4.1 for transport system alignment and maintenance.

3.5.7 IPS Alarm Bypass

The furnace is equipped with a manual ALARM BYPASS switch for each process gas pressure sensor. The switches are located on the PLC panel. Switch to Alarm Disable to manually close the pressure switch contact and bypass the alarm.

Caution: in the bypass position the software will no longer detect and alarm for low process gas pressure.

IPS Bypass switches are useful for troubleshooting the system when gas pressure is not available.

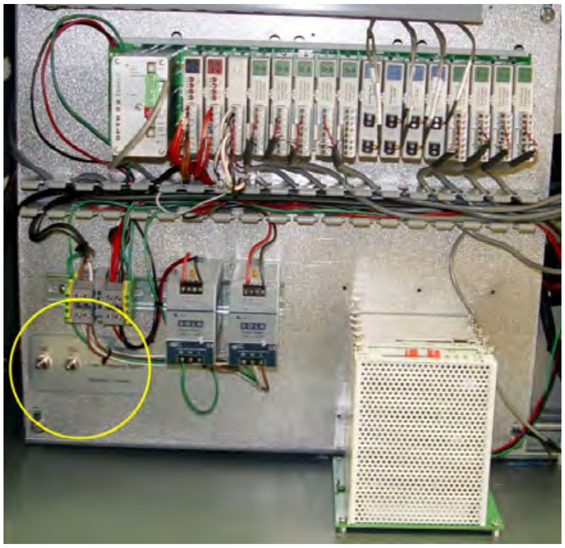


Figure 3-7 IPS Inlet Pressure Switch Location

3.6 Hardware COM Troubleshooting

3.6.1 Controller Communication

The most often seen problem is no communication between the computer and the controller and is characterized by pound signs "######" on the screen where you should have temperature or the date or any type of data.

Check the following things in this order:

Log Event Viewer: Any event happening between the computer and the controller is logged on this screen. You can access it by "ALT-TAB". The following are messages that are displayed:

- the normal message is "Attaching to Scanner"
- then a file download, such as the default recipe file.
- a message relating to the Ethernet card, make sure the coaxial cable is plugged in, and the controller IP address is correct.
- out of memory, switching to low scan mode; there is insufficient memory to run the software. Contact FurnacePros for additional memory.
- Incompatible gml file date/time; the source code has been changed, contact FurnacePros.

PLC: If you have communication, but it looks like some data is frozen, it may be a loss of communication between the PLC controller and the PLC modules. Check the PLC LCM4 controller module to be sure the LED's BATT, LINE AND STAT are green.

- Line "green" indicates 5VDC power status is good.
- BATT "green" indicates CMOS battery status is good.
- STAT "green" indicates the firmware is good.
- The LED's "TX" and "RX" indicate data is communicating between the controller and the modules.

Otherwise use the following table to troubleshoot communication problems:

Table 3-3 PLC Opto22 Troubleshooting Guide

INDICATION	EXPLANATION	REMEDY
LINE LED is off	No Power.	Check fuses FA & FB (neon light if blown) on Safety Enclosure panel per 802-101770 Power Control schematic. Check wiring.
LIINE LED is red or Controller resets.	Power may be out of specification	Check/adjust 5V DC power supply to minimum 5.0 - 5.1 Vdc limits. Do not exceed 5.2 Vdc.
STAT LED is off	Controller is faulty	Call FurnacePros Technical Support.
STAT LED blinks red	Firmware problem	Call FurnacePros Technical Support
BATT LED is red	Backup battery is low	Replace LCM4 controller battery.
RX LED is stuck on	Wiring polarity problem	Call FurnacePros Technical Support.
Controller cannot transmit to PC	Configuration jumpers were changed without cycling power.	Cycle power off/on and retry transmission.
No communication to host PC.	Communication Problems	Check serial port. Check PC IP address (10.192.105.100)
No communication to host PC. RX LED is on, but TX LED is off	Communication Problems	Check controller address (10.192.105.102), baud rate, and ASCII/binary settings.
No communication to host PC. RX and TX LEDs are on	Communication Problems	Try a slower baud rate.
No communication to I/O modules. TX LED is off while trying to communicate.	Communication Problems	Check that I/O port software is configured for correct port. If RX LEDs on I/O modules are off while trying to communicate, check for loose connections, shorts or breakage. IF RX LEDs on I/O are on, check I/O address, baud rate, and protocol setting in software.
Furnace program fails to load with correct parameters, clock is wrong, or furnace controller fails to reset	Backup battery is low (battery has a 5 year life cycle)	Replace LCM4 controller battery.

If you have communication, but some variables appear as “###”, this means the controller does not know what this particular variable is. Check the Event Log viewer for more details.

3.7 Computer Troubleshooting

The Furnace computer is equipped with indicating lights and sound to provide status information and troubleshooting diagnostics. See Figure 1.3.3 for location of lights and ports.

3.7.1 Indicating Lights

The Furnace computer lights provide basic information about the system state..

Table 3-4 Computer Indication Lights	
Controls and Lights - Front of the computer	
Power button (6)	push button
Power light (7)	blinking green — indicates that the computer is in sleep state solid green — indicates that the computer is in power-on state blinking amber — indicates a problem with the system board solid amber — indicates that the system board is unable to initialize
Drive activity light (4)	blinking green — indicates that the computer is reading data from or writing data to the hard drive
Network connectivity light (8)	green — indicates that a good connection exists between the network and the computer off (no light) — indicates that the computer is not detecting a physical connection to the network
Diagnostic lights (5)	four lights. For more information, see Diagnostics.
Controls and Lights - Back of the computer	
Link integrity light on integrated network adapter (7)	green — a good 10 Mbps connection exists between the network and the computer. orange — a good 100 Mbps connection exists between the network and the computer. yellow — a good 1000 Mbps connection exists between the network and the computer. off (no light) — the computer is not detecting a physical connection to the network.
Network activity light on integrated network adapter (6)	yellow light — A blinking yellow light indicates that network activity is present.

3.7.2 Power Button Light Codes

The diagnostic lights give much more information about the system state, but legacy power light states are also supported in your computer. The power light states are shown in following table.

Table 3-5 Computer Power Button Light Codes

Power Light State	Description
Off	Power is off, light is blank.
Blinking Amber	Initial state of light at power up. Indicates system has power, but the POWER_GOOD signal is not yet active. If the **Hard Drive light is off**, it is probable that the power supply needs to be replaced. If the **Hard Drive light on**, it is probable that an onboard regulator or VRM has failed. Look at the diagnostic lights for further information.
Solid Amber	Second state of the light at power up. Indicates the POWER_GOOD signal is active and it is probable that the power supply is fine. Look at the diagnostic lights for further information.
Blinking Green	System is in a low power state, either S1 or S3. Look at the diagnostic lights to determine which state the system is in.
Solid Green	System is in S0 state, the normal power state of a functioning machine. The BIOS will turn the light to this state to indicate it has started fetching op-codes.

3.7.3 Computer Beep Codes

If the monitor cannot display error messages during the POST, the computer may emit a series of beeps that identifies the problem or that can help you identify a faulty component or assembly. The following table lists the beep codes that may be generated during the POST. Most beep codes indicate a fatal error that prevents the computer from completing the boot routine until the indicated condition is corrected.

Table 3-6 Computer Beep Codes

Code	Cause
1-1-2	Microprocessor register failure
1-1-3	NVRAM read/write failure
1-1-4	ROM BIOS checksum failure
1-2-1	Programmable interval timer failure
1-2-2	DMA initialization failure
1-2-3	DMA page register read/write failure
1-3	Video Memory Test failure
1-3-1 through 2-4-4	Memory not being properly identified or used
3-1-1	Slave DMA register failure
3-1-2	Master DMA register failure
3-1-3	Master interrupt mask register failure
3-1-4	Slave interrupt mask register failure
3-2-2	Interrupt vector loading failure
3-2-4	Keyboard Controller Test failure
3-3-1	NVRAM power loss
3-3-2	Invalid NVRAM configuration
3-3-4	Video Memory Test failure
3-4-1	Screen initialization failure
3-4-2	Screen retrace failure
3-4-3	Search for video ROM failure
4-2-1	No timer tick
4-2-2	Shutdown failure
4-2-3	Gate A20 failure
4-2-4	Unexpected interrupt in protected mode
4-3-1	Memory failure above address 0FFFFh
4-3-3	Timer-chip counter 2 failure
4-3-4	Time-of-day clock stopped
4-4-1	Serial or parallel port test failure
4-4-2	Failure to decompress code to shadowed memory
4-4-3	Math-coprocessor test failure

4-4-4	Cache test failure

3.7.4 Computer Diagnostic Lights

To help troubleshoot a problem, your computer has four lights labeled 1, 2, 3, and 4 on the bank panel. When the computer starts normally, the lights flash before turning off. If the computer malfunctions, the sequence of the lights help to identify the problem.

NOTE: After the computer completes POST, all four lights turn off before booting to the operating system.

Table 3-7 Computer Diagnostic Lights

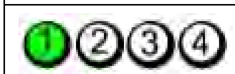
Light Pattern	Problem Description	Suggested Resolution
	The computer is in a normal *off* condition or a possible pre-BIOS failure has occurred. The diagnostic lights are not lit after the computer successfully boots to the operating system.	• Plug the computer into a working electrical outlet. • If the problem persists, contact Dell.
	A possible processor failure has occurred.	• Reseat the processor (see Processor information for your computer). • If the problem persists, contact Dell.
	Memory modules are detected, but a memory failure has occurred.	• If two or more memory modules are installed, remove the modules, then reinstall one module and restart the computer. If the computer starts normally, continue to install additional memory modules (one at a time) until you have identified a faulty module or reinstalled all modules without error. • If available, install working memory of the same type into your computer. • If the problem persists, contact Dell.
	A possible graphics card failure has occurred.	• Reseat any installed graphics cards. • If available, install a working graphics card into your computer. • If the problem persists, contact Dell .
	A possible floppy drive or hard drive failure has occurred.	Reseat all power and data cables.
	A possible USB failure has occurred.	Reinstall all USB devices and check all cable connections.
	No memory modules are detected.	• If two or more memory modules are installed, remove the modules, then reinstall one module and restart the computer. If the computer starts normally, continue to install additional memory modules (one at a time) until you have identified a faulty module or reinstalled all modules without error. • If available, install working memory of the same type into your computer. • If the problem persists, contact Dell.

Table 3-7 Computer Diagnostic Lights		
Light Pattern	**Problem Description**	**Suggested Resolution**
	Memory modules are detected, but a memory configuration or compatibility error has occurred.	• Ensure that no special requirements for memory module/connector placement exist. • Ensure that the memory you are using is supported by your computer (see the "Specifications" section for your computer). • If the problem persists, contact Dell.
	A possible expansion card failure has occurred.	• Determine if a conflict exists by removing an expansion card (not a graphics card) and restarting the computer. • If the problem persists, reinstall the card you removed, then remove a different card and restart the computer. • Repeat this process for each expansion card installed. If the computer starts normally, troubleshoot the last card removed from the computer for resource conflicts. • If the problem persists, contact Dell.
	Another failure has occurred.	• Ensure that all hard drive and optical drive cables are properly connected to the system board . • If there is an error message on the screen identifying a problem with a device (such as the floppy drive or hard drive), check the device to make sure it is functioning properly. • If the operating system is attempting to boot from a device (such as the floppy drive or optical drive), check system setup to ensure the boot sequence is correct for the devices installed on your computer. • If the problem persists, contact Dell.

3.8 Remote Access

In order to allow for remote diagnostics of in-process furnace operations, a 2nd network interface card (NIC) is provided as well as a modem with communication software. The remote operator, in conjunction with on-site personnel, can simultaneously view the Process screen and have access to input and control features.

Remote access can be accomplished as follows:

- Broadband connection via internet access
- Wireless connection via internet access

3.8.1 Connect Using TeamViewer™

A good method of connecting to the furnace remotely is to use the TeamViewer internet service for remote diagnostics:

If the computer is TeamViewer enabled:

Make sure there is an internet connection to the local network connection 2 port.

Click on the blue TeamViewer icon in the menu or next to clock on desktop menu bar.

Provide Your ID and random generated Password to remote user (factory or service tech).

Partner (factory or service tech) must have Remote User ID and TeamViewer password as well as Furnace Computer password, if any to log on the furnace computer from a remote location.

Note: For security, each time TeamViewer is enabled on the Furnace Computer, TeamViewer will generate a new password that must be provided to the remote user.

If the computer is not TeamViewer enabled, contact factory for installation instructions.

3.9 Remote Diagnostics

Enable Teamviewer™ by clicking on blue icon on lower right of screen and enable.

Contact factory service tech and indicate system is on-line and available for troubleshooting

3.10 Element Failure Indication

3.10.1 Furnace Element Monitor screen

Press the Monitor button on the menu bar to view the lamp status. Use this screen to identify whether any lamp string have a problem. The element monitoring system only detects lamp status when lamp current is above a set value (default is 4%) and sometimes may report false failures if the current is too low at the power setting.

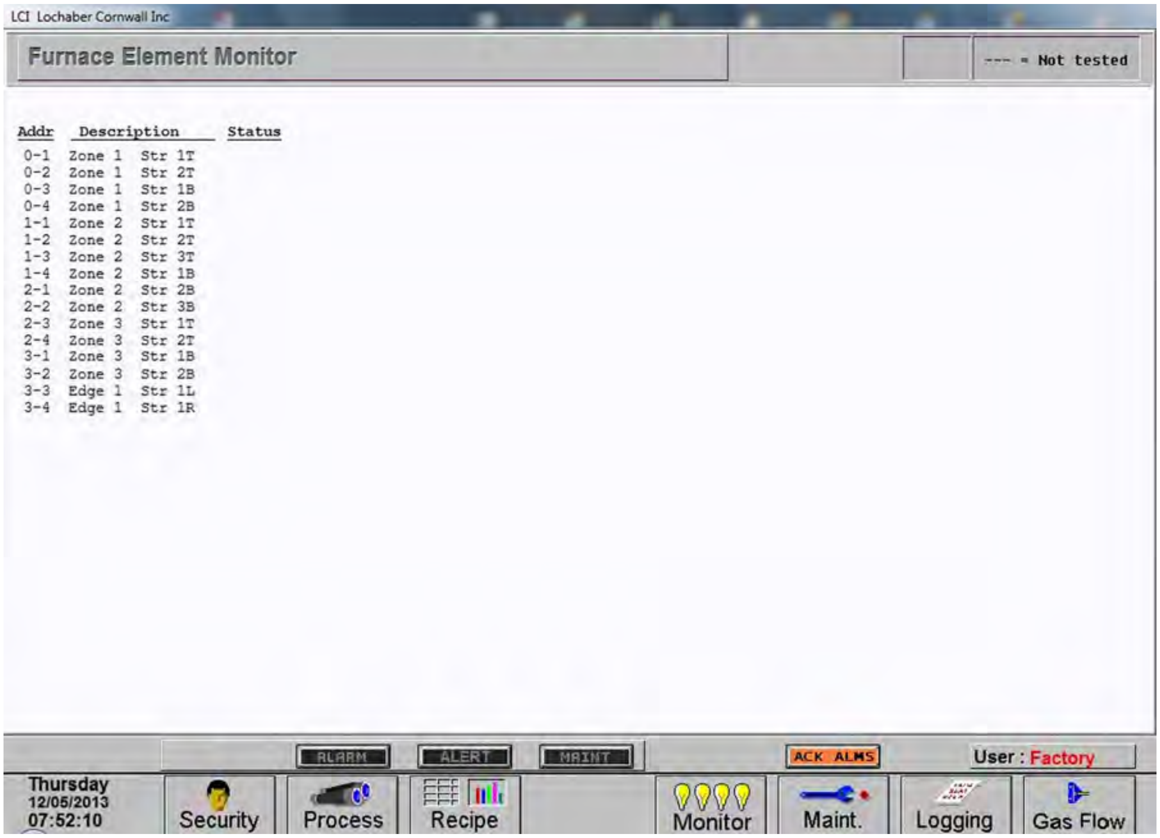


Figure 3-8 Lamp String Failure screen

Table 3-8 shows examples of EM screen readings and their meaning.

Table 3-8 Element Monitor Screen

Addr	Zone	Str# T/B	Status	Description and Location
0	Zone 1	Ele 1T	See Table 3-9	Element monitor 0 detected a possible failed top lamp in Zone 1in the first string from entrance.
1	Zone 1	Ele 2B	See Table 3-9	Element monitor 1 detected a possible failed bottom lamp in Zone 1 in the second string from entrance.
10	Edge 1	Ele 1 L	See Table 3-9	Element monitor 10 detected a possible failed Left Edge heater, in the first pair of edge heaters from the entrance.

Table 3-9 defines the EM screen possible Status values, description and recommended actions.

Table 3-9 Element Monitor Status

Status	Description	Action
- - - -	Not Tested	Lamp %power is too low to test current.
PASSED	Lamp string OK	None
FAIL	Lamp string reports faulty string	If a single string is shown as faulty, check lamp string using procedure in section 3.10.3. If all strings in a zone (top or bottom) are faulty, verify corresponding SCR is operating properly. If four strings fail, verify element monitor board is operating properly.

3.10.1 Discrete Indication (RTC retrofits and new furnaces, 2013 and after)

The Furnace controller contains a channel for each independent string of lamps. When power is applied to the lamps above a minimum value, the controller checks the status of all channels and reports any failures. When the lamps are ON, lights on the controller indicate which strings indicate current is flowing.

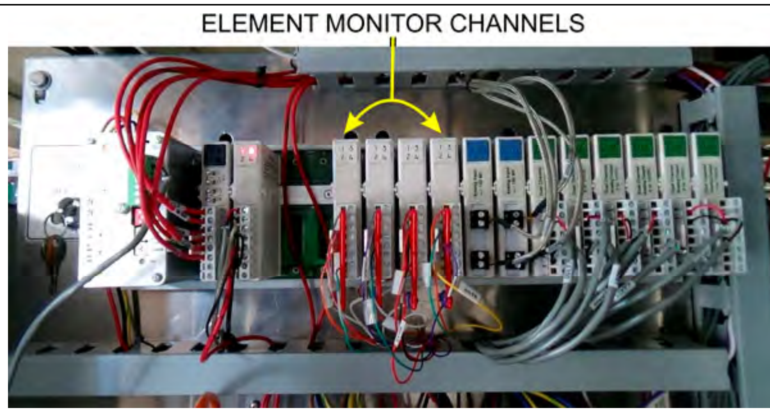


Figure 3-9 Furnace Controller EM I/O modules

3.10.2 Serial Polling (2001-2012 furnaces)

If the system returns a number of nuisance errors, from the monitor screen, you increase the minimum value below which the program will not poll the strings. To change this value, click on Serial EM Test button open the Serial Elemon Test screen (see Figure 3-10). This screen shows real time polling of the signal from the element monitor boards. Enter a higher value in the Min Value % box: Sometimes a value of 15% can provide better results if the system is falsely reporting string failures. The screen will also reveal if there is a wiring error of if there is no response from a polled system.

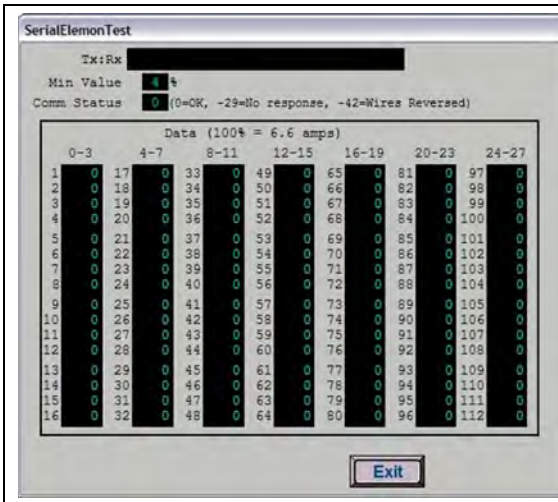


Figure 3-10 Serial Element Monitor Test screen (2001-2012 furnaces)

3.10.3 Heating Element Test Procedure

To simplify troubleshooting, the software displays the lamp strings by zone, top and bottom to indicate possible failures in each serial string of lamps. The furnace element screen displays the specific location of a suspected failed lamp string during operation. For a more reliable check, the user should perform the Testing Lamps process in this section.

Visual inspection of the lamps (either by looking down the entrance of the furnace or by removing the lamp covers) with the power on or off is not reliable. When adjacent lamps are on, reflected light will make a defective element appear okay. If the Testing Lamps process confirms that a string has failed, note the LAMP STRINGS indicator (EleT1, B1, etc.) that was OFF during the test, and use the following procedure to isolate which lamp in that identified string has failed.

This procedure is to be used to test for open heating or failed lamp heating elements.

A. Required Equipment

1. Ohmmeter (or Continuity Tester)

2. 3/8" Box or Open End Wrench

3. Control & Element Wiring Schematic 802-101814

B. Test Procedure

Remove all power from the furnace, and if a UPS or EPS is installed, locate and shut off the unit. Remove all side covers, completely exposing all lamp terminations.

Locate the identified failed string and the lamps in that string using the Element Monitor table (see **Error! Reference source not found.**):

Within each zone, the lowest numbered lamp (Ele 1) is nearest the entrance end of the furnace.

Disconnect one end of each of the 2 to 4 lamps in the suspect string and measure the resistance of each lamp. The resistance of a good lamp is <10 Ω. A higher reading identifies a defective lamp that should be replaced.

Refer to section 3.13.7 Heat Lamp Replacement for lamp replacement instructions.

Once the elements have been completely tested, replace the covers on the furnace. Turn on the EPS/UPS (if so equipped) and power to the furnace. Bring the furnace up to temperature, and, next, run a profile verifying that no leaks occurred around the lamps that were replaced.

The procedure is now complete.

3.10.4 Lamp Replacement

See furnace Reference Manual, Section 7.5.3 Heat Lamp Replacement.

3.11 Troubleshooting Process Problems

3.11.1 Belt speed

Measure the belt speed with a stopwatch. If it differs from the value on the process screen by more than 5% (1 IPM off for each 20 IPM of belt speed), re-calibrate the belt speed. Follow the Belt Speed Calibration procedure in the furnace Reference Manual, Chapter 7.

3.11.2 Resolving zone control issues

The calibration screen can be useful for use in troubleshooting and resolving zone control issues, testing lamps and checking for blown lamp fuses by isolating individual zones.

Zone Control. If heat in any zone increases rapidly into a "runaway" condition even if the zone controller OUT1 LED indicator is dark (the controller output is OFF), but the heat can be stopped by shutting off the affected zone top and bottom switches, the zone SCR probably has failed with a shorted output and needs to be replaced.

If the heat in any zone steadily stays above the setpoint value, but is not in a "runaway" condition, enter zero on the Process Screen for power for the affected zone top and bottom and see if the heat decreases. If it does not, the furnace has a process gas flow problem or the setpoint value in adjacent zones may need to be lowered.

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

3.11.3 Temperature or large power fluctuations

If the temperature is slow to respond to large deviations from setpoint temperature, it may be a problem with the PID settings. If you need to modify a particular zone, see the procedures in section 0. Also see section 3.14.1 to completely retune a zone.

At low temperatures (<100°C) or near the maximum temperature, if there is an unacceptable deviation from setpoint, the SCR may need to be calibrated. If the SCR is out of calibration, most likely it will not be noticeable in the medium range of the temperature. If necessary, calibrate the SCR Calibration using the procedure in section 3-45 Calibrate SCRs.

> NOTE: PID tuning should only be attempted by qualified personnel. Unreasonable PID parameters can stress the components of the system and cause premature failure of some electrical systems.

3.11.4 Unstable zone temperatures

If the temperature fluctuates by more than 5 degrees in less than 20 seconds after you reached ready state, it might be a problem with the PID settings. If you notice unstable behavior in a certain zone, you may need to modify the PID loop parameters for that particular zone. Follow the procedures in section 0 to retune the PID loop parameters. Also see section 3.14.1 to completely retune a zone.

If the SCR is out of calibration, most likely it will not be noticeable in the medium range of the temperature. Only at low temperature (<100°C) or near the maximum temperature, will there be deviation from the setpoint. See the SCR Calibration procedure in the Furnace Reference Manual.

> NOTE: PID tuning should only be attempted by qualified personnel. Unreasonable PID parameters can stress the components of the system and cause premature failure of some electrical systems.

3.11.5 Abnormal sensor behavior

There are numerous sensors (standard and optional) on the furnace, from thermocouple to a board counter, gas analyzer, and so on. If one particular sensor seems to behave erratically, you will need to look into the value reported by the control subsystem.

The errors could be

1. • a temperature with a negative value,
2. • a gas analyzer readout that never changes value,
3. • a board counter that doesn't count.

For the digital sensors, first locate the relay module connected to that sensor on the OPTO panel, using the Channel Assignment configuration sheet. The red LED should toggle every time the sensor changes state. If it doesn't, the problem is with the sensor or the wiring. Most unlikely the relay module itself.

If the relay does toggle, make sure the module is talking to the controller; the TX LED should be flashing.

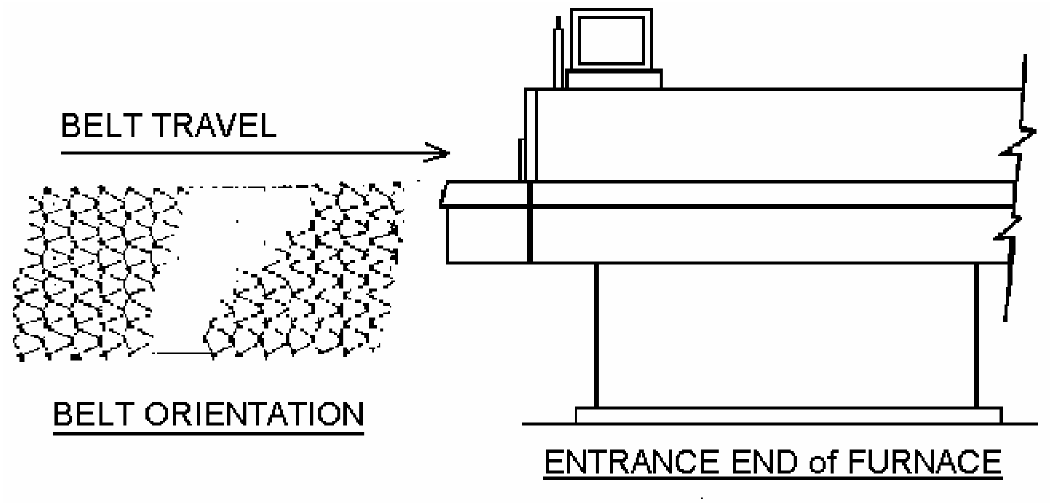
The analog inputs cannot be checked visually.

3.12 SERVICE

3.12.1 Transport Belt Replacement

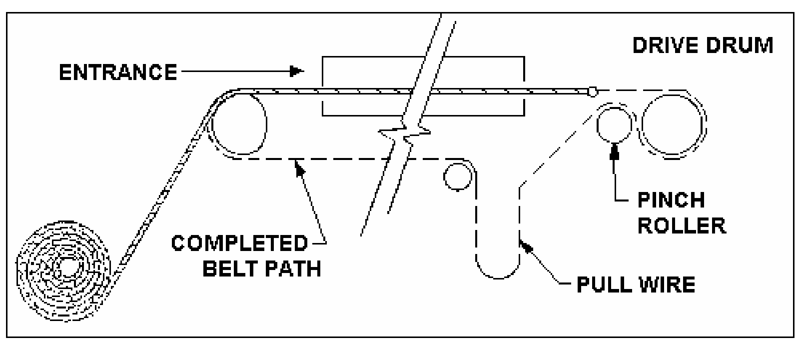
When replacing the transport belt, it will be helpful to have an assistant for the task.

1) Place the rolled up belt at the entrance end of the furnace and orient, as shown in the figure below.



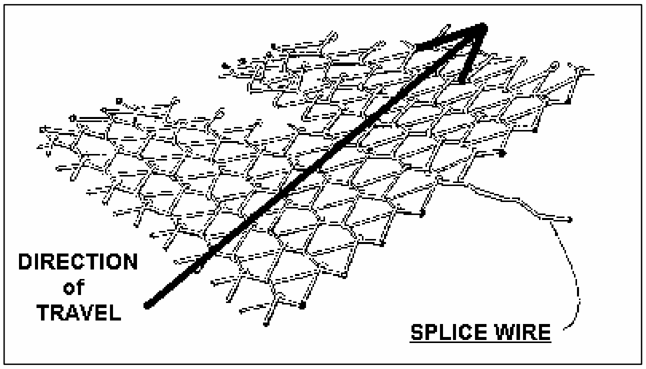
2) Extend a long rod or stick through the furnace chamber, being careful not to damage the lamps or insulation. If possible, use the old belt to draw a pull wire through the chamber during its removal. Securely attach the leading edge of the belt to the rod. Carefully pull the belt through the furnace from the exit end, while an assistant unrolls and guides the belt into the furnace.
3) When the belt has been pulled through the furnace chamber, remove the rod and thread a pull wire through the rollers and drive drum, as shown below. Attach the wire to the leading edge of the belt and pull the belt through.

Figure 3-11 Belt Installation



4) Continue pulling the belt through the drive system using the wire, and then by hand, until the belt path is complete.
5) Splice the belt, as shown below.

Figure 3-12 Inserting the Belt Splice



3.12.2 Drive Train / Belt Alignment

A. Sprocket Alignment

Unscrew the end cover at the exit end of the furnace to reveal the motor and drive mechanism. All sprockets should be perfectly aligned. Adjustments can be made by loosening the setscrews on the sprocket flanges. A straight edge can be useful for this operation.

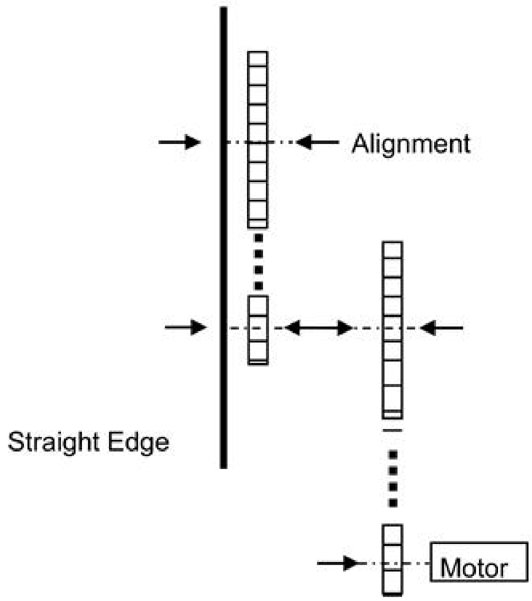


Figure 3-13 Sprocket Alignment

B. Motor Mount Bolts

Motor mount bolts must be checked periodically and tightened if necessary.

C. Sprocket Shaft Bearing Block Bolts

These shafts must be checked periodically. You will need to remove the end side covers to gain access to the bolts.

Sprocket shaft and roller shaft bearings are sealed units requiring no maintenance. The greasing points are redundant.

D. Chain Tension and Drive Chains

The chain tensioner is equipped with a grease fitting for lubrication. Apply sufficient grease to the tensioner so that grease can be seen squirting out along the shaft. Remove excess grease.

If the tensioner is spring loaded, no adjustment is necessary. For other types of tensioners, slacken the mounting bolts and turn the tensioner towards the chain. Tighten the bolts. A correctly tensioned chain can just be lifted from the tensioner sprocket, but cannot be lifted clear of the sprocket teeth.

Drive chains should be lubricated with a non-dripping chain lubricant every 30 days.

E. Belt Roller Alignment

If a roller is misaligned on its shaft, loosen the setscrews that secure the roller on its shaft. Use a rubber mallet to move the roller. Rollers need to be centered within 0.125 inches so you will need a ruler or scale for this operation.

F. Clutch Adjustment

With the motor running, the belt should be stoppable by placing firm pressure on the entrance roller. If the belt can be stopped too easily, tighten the clutch nut. If it cannot be stopped at all, slacken the clutch nut.

G. Belt Tracking

With the belt speed set to different values, stand at the furnace exit or entrance and look along the length of the belt. If the belt appears to be running towards one side, you will need to adjust the tracking using the following steps at the end where the tracking appears off. The illustrations below are of the front exit end of the furnace, but can be applied to the rear entrance adjustment if the entrance belt tracking appears to be off.

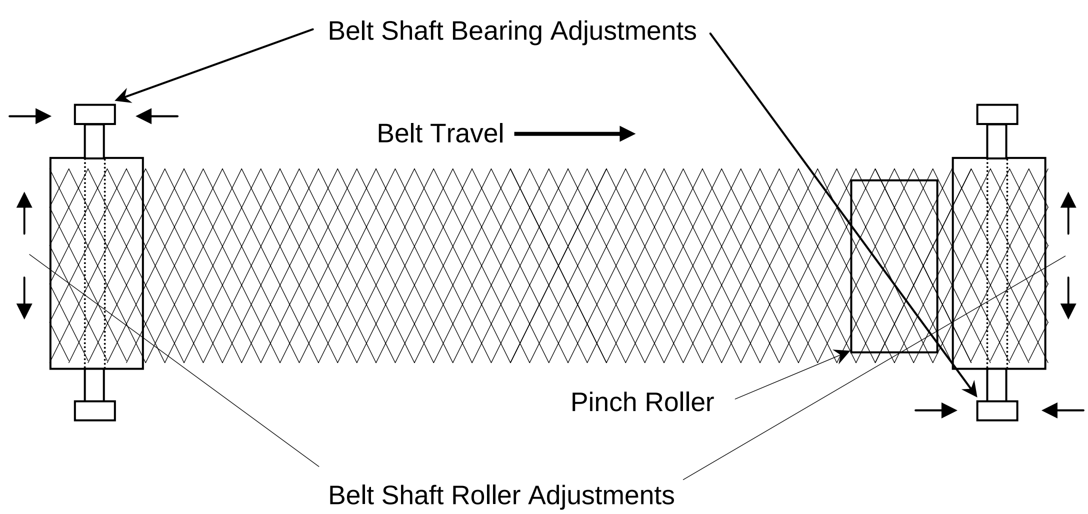


Figure 3-14 Belt Tracking Adjustment Diagram

1. Remove side panel (front side panel at exit shown, similar)

Figure 3-15 Remove Front Exit side Panel

Figure 3-16 Front Exit Side Panel off

2. Adjusting belt alignment

a) Start belt and operate at a slow speed (5 inches/minute, 125 mm/min)

b) Loosen hex nuts (1)

c) Turn hex head Adjusting Screw (2) to align the belt. Turning Adjusting Screw clockwise moves belt away from this side. Turning Adjusting Screw counterclockwise moves belt toward this side. Make small adjustments (1/4 turn) and observe belt tracking. Wait one minute between adjustments to assure the belt tracking is improving.

d) Tighten hex nuts to lock position.

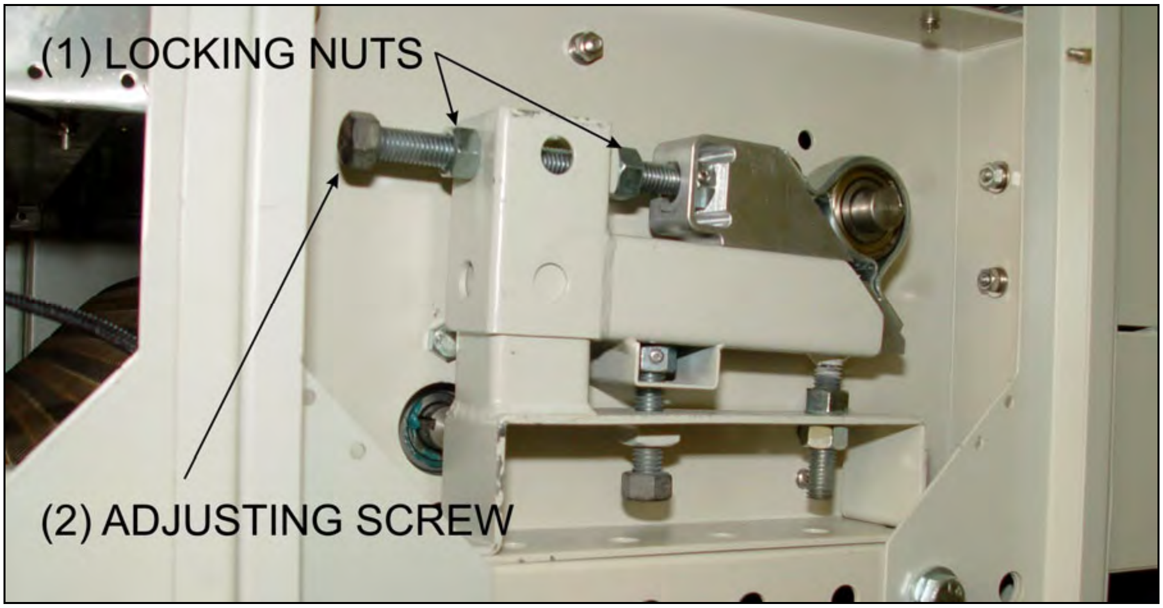


Figure 3-17 Adjust Belt Alignment

3. Replace covers

3.12.3 Drip Tray Cleaning

Drip trays are located in the furnace entrance baffle and transition tunnel baffle sections. Drip trays may collect condensate it the exit gas is not cool enough to keep the exhaust in a gaseous state.

The maintenance period for drip trays depends very much on the processes being run. While some processes require drip trays to be cleaned every month, others processes may barely soil the drip trays.

A. Drip Tray Removal

1 Unscrew and remove the furnace side covers. If necessary, remove the cooling fan assembly.

2. Disconnect the T-pieces that connect the gas supply to the air-rake tubes. The T-pieces must be disconnected at the top and bottom but the connection to the air-rake tube may remain connected.

3. Undo the air-rake retaining nut.

4. Completely remove the air-rake tubes.

5. Undo the butterfly nuts holding the drip-tray inspection cover in place and remove the inspection cover.

6. Remove the drip tray being careful not to damage the attached baffle plates.

B. Clean Drip Tray

1. Insert the drip tray and baffle assembly. Remove the wire.

2. Replace the inspection cover and reattach clamps. After several hours of operation, check the butterfly nuts on the inspection cover, and tighten if necessary.

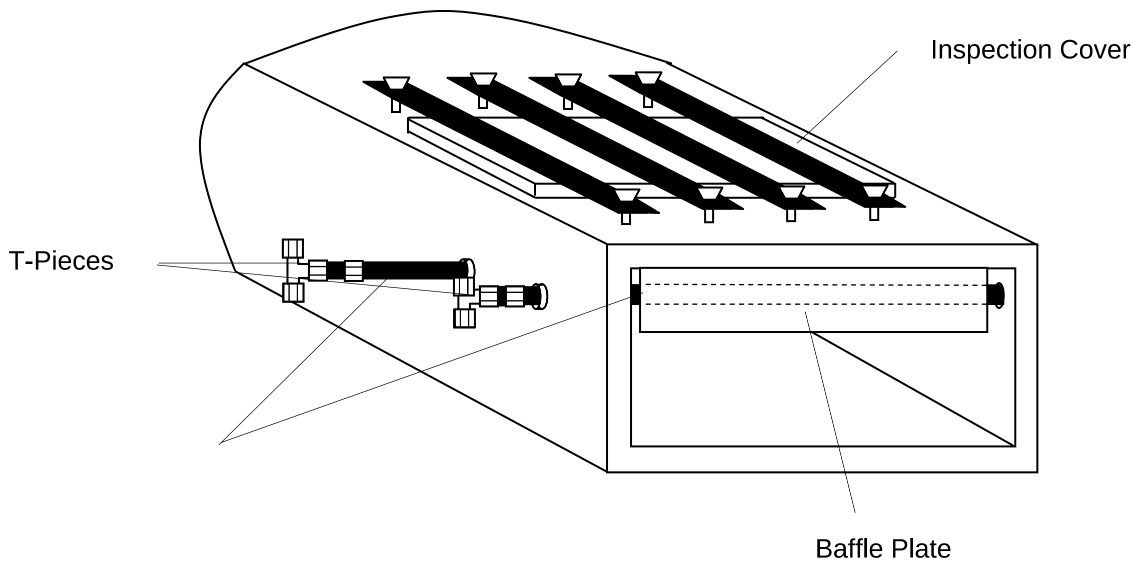


Figure 3-18 Drip Tray Cleaning Diagram

C. Drip Tray Installation

Re-installing the drip tray is easier if the baffle plates are tied flat against the drip tray. This is easily achieved by loosely wrapping a piece of wire around the drip tray and baffle plates.

1. Insert the drip tray and baffle assembly. Remove the wire.

2. Replace the inspection cover and reattach clamps.

3. Reinstall air rakes making sure that they are oriented as before with the notch on the alignment ring facing up, Figure 3-19.

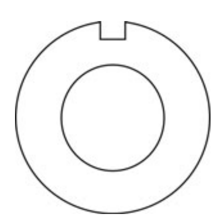


Figure 3-19 Air Rake Alignment Ring

D. Final Check

Run furnace. After several hours of operation, check the butterfly nuts on the inspection cover, and tighten if necessary.

3.13 Control System Installation and Setup

3.13.1 LCM4 Furnace Controller Installation

Connect the various cables between the modules, the controller, the computer and the I/O racks. Newer systems have a surge protector on the network cable between the computer and the controller.

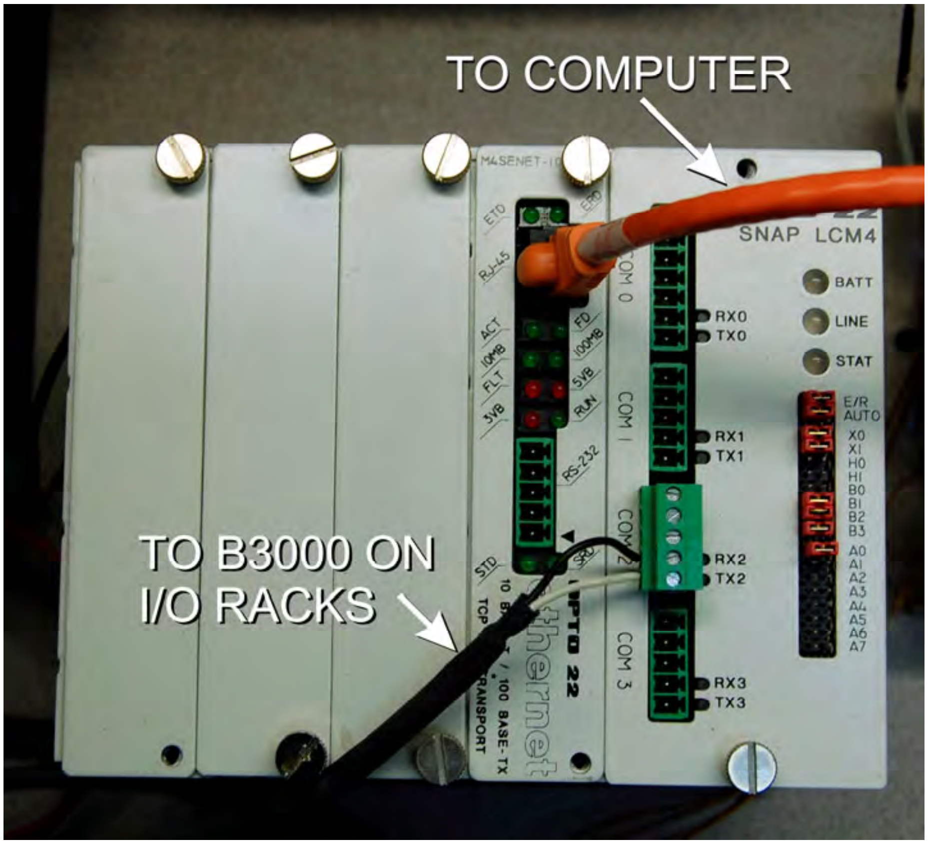


Figure 3-20 Furnace Controller connections

INITIALIZE: Open computer access door and turn ON the computer. When the WINDOWS® logo comes up, hold down the shift key to prevent the MMI from starting, since the controller is not ready yet. If it started, exit using ALT +F4.

The first time the controller is turned on, its memory is empty, and the software has to be downloaded. Double click on the download icon in the furnace group in Windows or the furnace icon on the desktop.

FURNACE SOFTWARE. The furnace icon or menu item will download the kernel (the Operation System for the controller) and the ProControl™ furnace software, and start running it.

You can now start the MMI software by double clicking on the Furnace icon. From now on, startup will be automatic.

You should see the correct date and day in the bottom left corner. If not, go to the Ethernet Installation and troubleshooting section.

LOG-IN. Check the log-in dialog box for one of the 3 proposed users: operator, tech and Factory (FPD). Enter appropriate password for the level selected.

3.13.2 Verify configuration of the external jumpers of the LCM4 Controller

Refer to Section 6, PLC CONFIGURATION drawing for board jumper settings or Figure 3-20.

3.13.3 Windows7® Setup of Furnace Computer Ethernet Connection

a. From the desktop, click on the network icon on the lower right hand side of the screen, Figure 3-21. Click Open Network and Sharing Center, Figure 3-22.

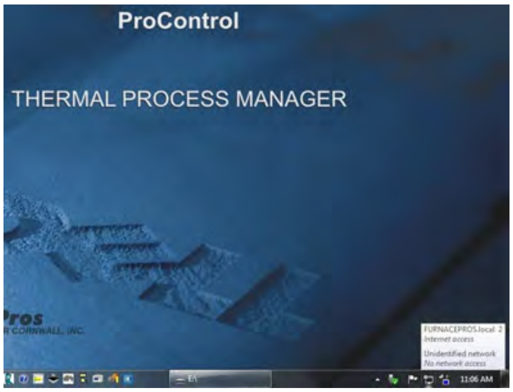


Figure 3-21 Network icon

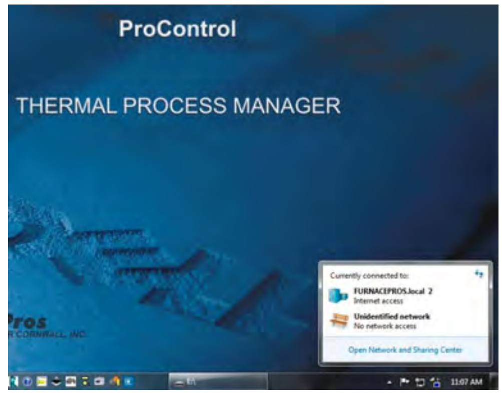


Figure 3-22 Open Network and Sharing Center

b. From Network and Sharing Center click on the connection that corresponds to the furnace network (will say "No network access"), Figure 3-23

c. Select Properties button from the Local Area Connection Status window, Figure 3-24

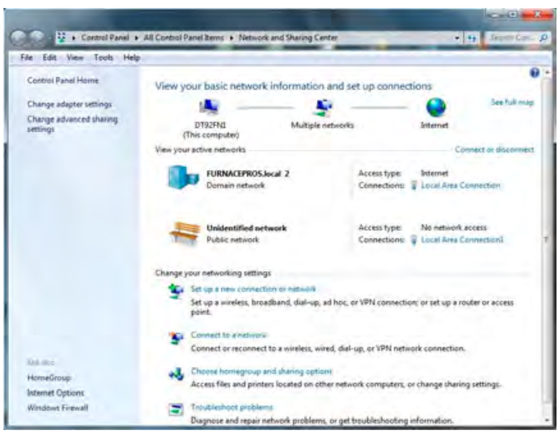


Figure 3-23 Network and Sharing Center

Figure 3-24 Connection Status

d. Select Internet Protocol Version 4 (TCP/IPv4) from the Properties screen, Figure 3-25

e. Enter IP address 10.192.105.100 and subnet mask 255.255.255.0, Figure 3-26

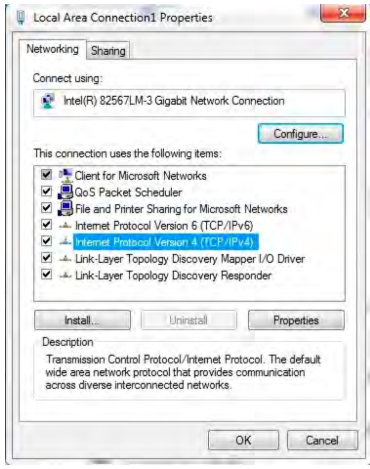


Figure 3-25 Connection Properties

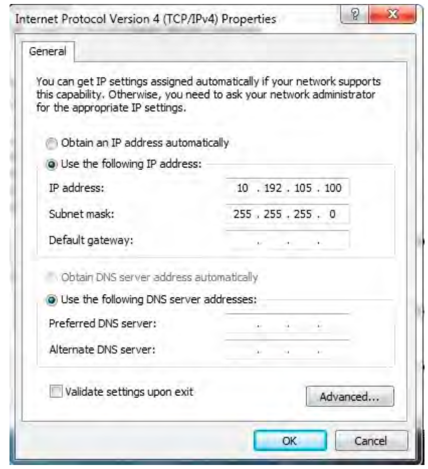


Figure 3-26 TCP/IP Properties

3.13.4 Reset & Assign an IP Address to the Controller's Ethernet Adapter Card.

a. Remove power from the controller chassis box.

b. Remove the controller's Ethernet adapter card from the controller chassis.

Note: Follow standard anti-static dissipative procedures when removing and handling the card.

c. Remove Ethernet and RS-232 connectors

d. Release (4) front panel set screws and (2) covers

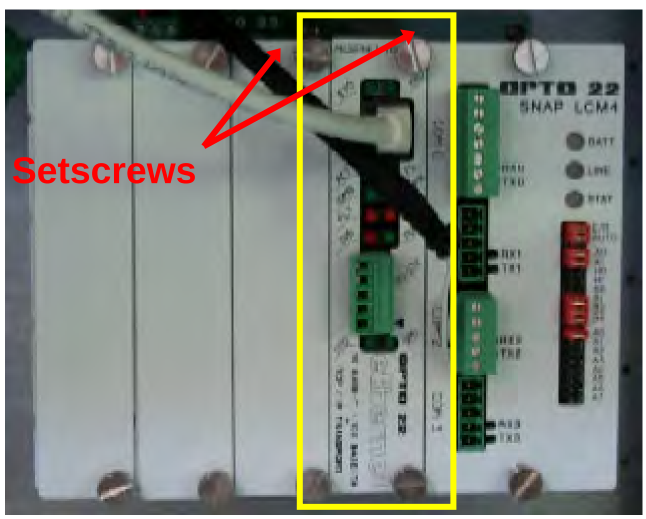


Figure 3-27 Remove Card from chassis. (See figure below)

e. Remove the Ethernet adapter card

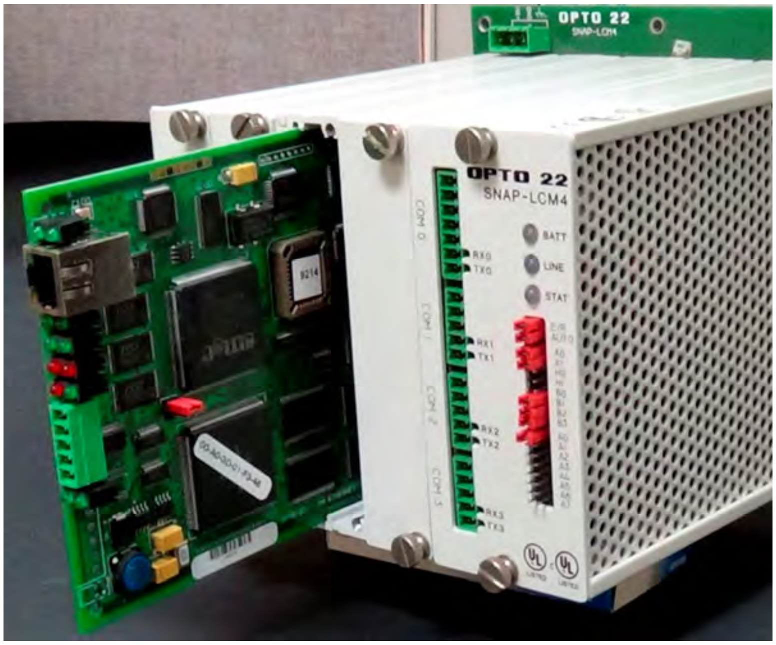


Figure 3-28 Removal of Ethernet Card

f. Move the J7 Jumper to the Module Reset Position as shown in the following pictures.

Figure 3-29 Location of J7 Jumper
J7 in Normal RUN Position

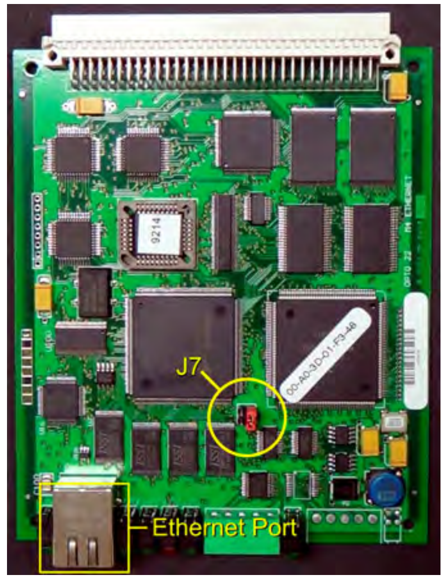


Figure 3-30 J7 Jumper at Module RESET

g. Reinstall the Ethernet adapter card into the Opto22 controller chassis box.

h. Wait for the STD LED on the Ethernet adapter card to stop blinking, and then turn off, or remove power from the system.

Note: The power switch on the PC may need to be initialized.

i. Apply power to the controller system.

Note: This procedure resets the Ethernet Adapter Card to its factory default settings.

j. After removing power from the controller system, again remove the Ethernet Adapter card and restore the J7 Jumper to its original position as shown at right

Figure 3-31 Original J7 Position

k. Reinstall the Ethernet Adapter card into the Opto22 controller chassis box making sure the covers and set screws are in place. Connect the network cable to the Ethernet port on the Ethernet adapter card. Make sure the green I/O connector is connected to COM2 port on the LCM4 (do not connect to the Ethernet card).

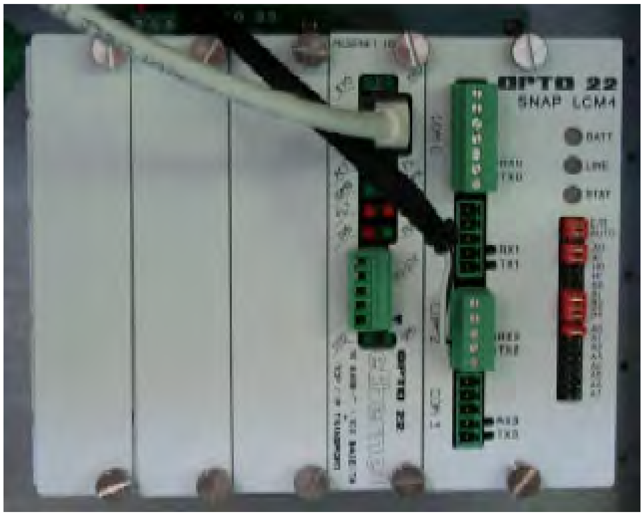


Figure 3-32 LCM4 Controller with Ethernet Adapter (on left)

l. From the Windows© Toolbar, Select <Start/Programs\Opto22\OptoUtil\OptoBootP Utility>

m. On the "OptoBoot Tool" dialog box, click the "Listen" pushbutton located at the upper right.

n. After a few seconds, in the dialog box's data window, a Mac address will be listed followed by 0.0.0.0 IP Address and a ?.?.?.?. Subnet Mask.

   Double Click on the 0.0.0.0 field to assign an IP Address

   Enter "**10.192.105.102**" for the IP Address and "**255.255.255.0**" for the Subnet Mask. Leave the Gateway field **0.0.0.0**.

   Click the "Send" pushbutton to assign the entered address.

   The data window should now be updated to display a "Yes" under the "Sent" Column.

o. Click on "Exit" to leave the OptoBoot tool application.

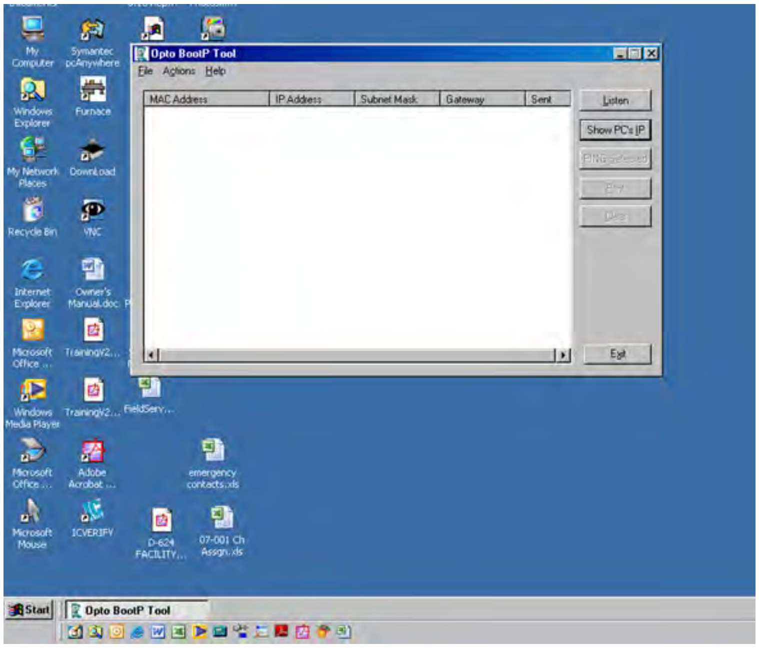


Figure 3-33 OptoBoot Screen

3.13.5 Gas Supply Low Pressure Switch Calibration

The process gas pressure switch is located on the gas supply manifold for each gas supplied.

If a reservoir tank is supplied, the pressure switch is located at or near the compressed air receiver. See drawing 802-101780-01.

A. Alarm Bypass Switch

A switch located near the controller on the PLC Panel allows the low pressure alarm sensor to be bypassed to allow troubleshooting. Assure that the Low Pressure Alarm switch is ENABLED for normal operation.

B. Calibration

To calibrate each switch:

Verify that the Low Pressure Alarm switch is enabled.

Close all flowmeter valves.

Set inlet air pressure to desired set point pressure. Read pressure on gage in Figure 3-34 Enable Low Pressure Alarm switch .

Rotate the Adjusting Wheel: Clockwise to increase the pressure set point, counterclockwise to decrease. You can hear a faint click when the micro switch changes state. Below this point below which the switch will activate the alarm when enabled.

Start the furnace system without power to the lamps. Close the facility process gas valve to the furnace. Open the flowmeter valves and verify that the alarm trips when the pressure drops below the new set point.

Readjust as necessary and retest.

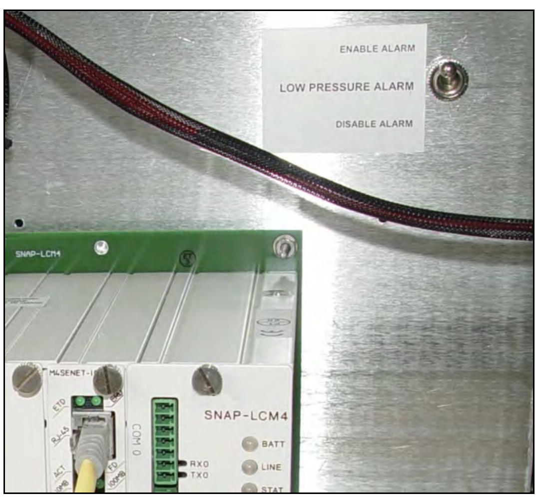


Figure 3-34 Enable Low Pressure Alarm switch

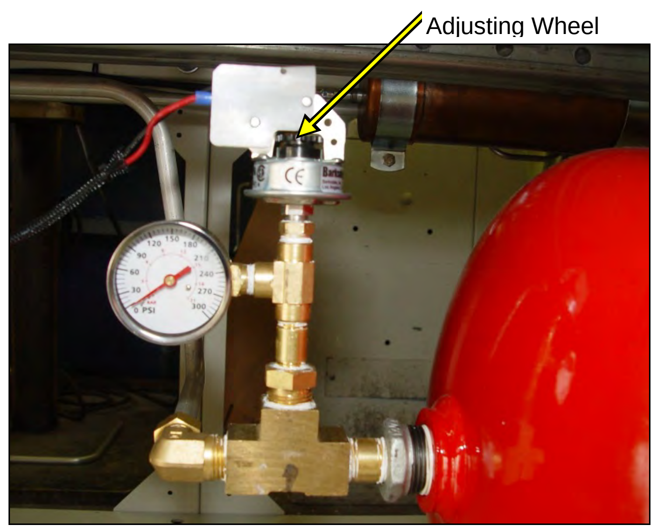


Figure 3-35 Air Pressure sensor

3.13.6 Replacing SCR Control Modules

A. SCR REMOVAL

To remove the entire SCR assembly, disconnect the 10Vdc and the 24 Vac wire pairs. Unscrew the Line and Load wires. If you are only replacing the firing board, remove the (2) firing board screws. If you are removing the entire assembly, remove the (2) SCR Mounting screws. See **Figure 3-36 SCR installed**

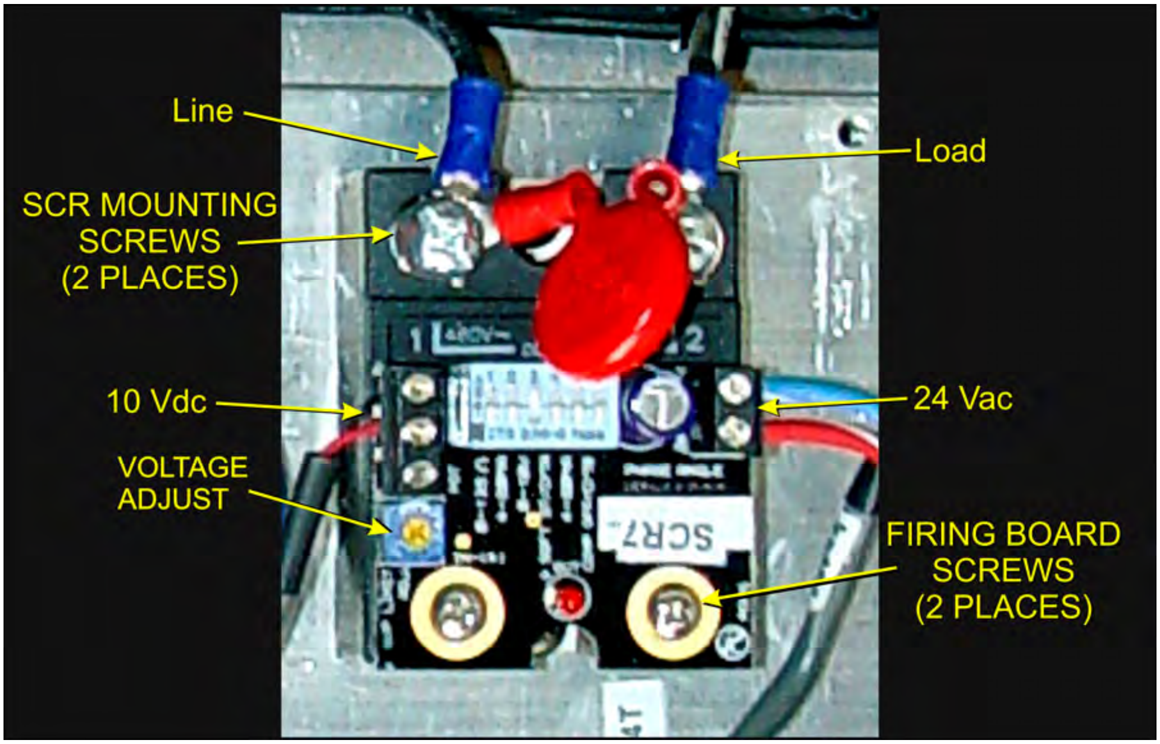


Figure 3-36 SCR installed

B. SCR INSTALLATION

Install an entire SCR assembly, by first checking that thermal paste is applied to the back of the SCR and the heat sink (aluminum plate) in the location where is will be mounted. Screw the assembly to the heat sink. Connect the 10 Vdc control wires, the 24 Vac control voltage wires and the Line and Load wires with red capacitor in place. Make sure the dip switch is set as shown in Table 3-12 . Then follow the procedure on page 3-45, section **3.14.1 Calibrate SCRs** to calibrate the SCR.

Table 3-10 SCR Firing Board DIP Switch Settings

Dip Switch	1	2	3	4	5	6
Position	OFF	OFF	ON	OFF	OFF	OFF

3.13.7 Heat Lamp Replacement

A. Tools Required:

Table 3-11 Tools needed for replacing Lamps	
(2) 3/8 in. open ended wrenches	Replacement Kaowool packing material
Allen wrench	Lint free cloth or protective gloves
Flashlight	

B. Handling Heating Lamps

Warning: Whenever handling furnace heat lamps, special care must be taken not to touch the surface of the lamp. Leftover salt from handling the lamps can cause hot spots which can reduce lamp performance or cause failure.

If the cleanliness of a heat lamp is suspect, clean the lamp with isopropyl alcohol and wipe with a lint-free cloth prior to use.

C. Lamp Removal

All power should be removed from the furnace before replacing lamps.

1. If Plenum covers are supplied, remove the setscrews securing the plenum clamps and carefully remove plenum covers. Care must be taken not to damage the rubber seal between the plenum chamber and the chamber cover.
16. Short one lamp from each zone to the furnace frame to remove any charge residing in the lamps.
17. Taking care not to disturb the ceramic insulating blocks, use one of the 3/8" wrenches to hold the base nut while you loosen the fastening nut.

Warning: If the furnace is equipped with the hermetic seal (Option ❒), any cracks to the insulating block will result in furnace chamber leaks and should be replaced if broken.

18. Disconnect the element lead from the insulating terminal block. Repeat this step for the opposite side.
19. Remove lamp and old packing material.

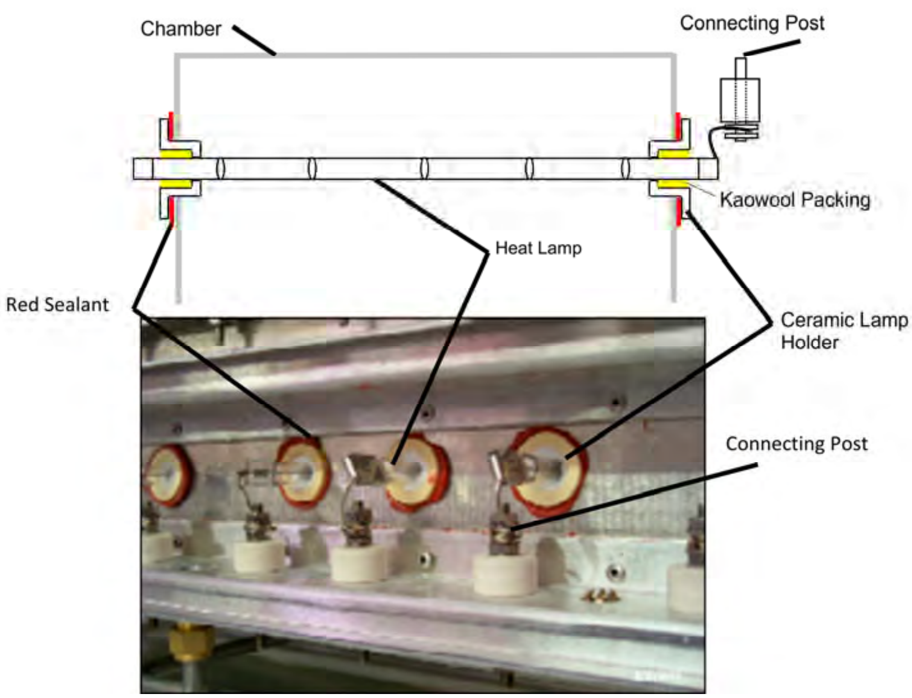


Figure 3-37 Lamp Replacement
Cross-section Across-the-Belt Diagram (top), End View Picture (bottom)

D. Lamp Installation

1. Make sure the red sealant securing the ceramic lamp holder is intact. Unsealed ceramic lamp holders may be resealed with Kaowool packing.
2. Using a lint free cloth or protective gloves, remove the lamp from its carton being very careful not to touch the glass with bare hands.
3. Straighten the connecting lead on one end of a new lamp and slide it into place. You may need the flashlight to locate the opposite side's ceramic holder. Once the lead appears from the ceramic holder, you may carefully pull the lamp through the furnace chamber.

   If threading the lamp is difficult. Thread a dowel or stiff wire through the furnace. Tape the lead to the dowel or wire and then pull the lamp into position.

5. Pack the ceramic holders on both sides with the Kaowool packing material.
6. Center the lamp to ±1/32-in. (±0.8-mm) and recheck the packing.
7. Wrap the connection leads around the connection terminals in the same direction as the nut will be tightened. Use two wrenches, as you did when removing the connection, to ensure the connection post is not disturbed.
8. Cut off excess connection wire.
9. Replace plenum covers being careful not to damage the rubber seal.

3.14 Calibration

Consult the Reference Manual Section 7.3 for most calibration procedures.

3.14.1 Calibrate SCRs

Follow the calibration procedure described in section 7.3 of the Reference Manual.

Calibration of the SCRs is usually necessary only if an SCR or SCR controller is replaced. Good maintenance practice, however, is to check SCR calibration every 6 months or so, or if the furnace seems to be slower than usual to reach operating temperature.

This calibration procedure will require use of an RMS responding voltmeter/multimeter and a thin blade screwdriver, and will require that the access cover to the control enclosure be opened.

3.14.2 PID tuning

PID parameters can be varied for each zone. Typical initial values for PID parameters in high temperature applications are shown in Table 3-12. Alternate values can be used for a low temperature application to provide more constant application if IR energy. Use the SuperTrends screen to evaluate performance in each zone for you process.

Table 3-12 Typical PID Initial Factory Settings

Symbol	Parameter	Initial Value	Alt Initial Value
P	Proportional Gain	9	18
I	Integral	45	45
D	Derivative	0	1

See Furnace Reference manual for theory and description of PID Tuning.

If you notice unstable behavior in a certain zone, use the following procedure to retune the PID:

NOTE: This procedure should only be attempted by qualified personnel. Unreasonable PID parameters can stress the components of the system and cause premature failure of some electrical systems.

First go the Process screen an open the Super Trends chart for the zone to be tuned (see section 2.6 Super Trends). Go to the recipe screen and select the PID tuning for the zone of interest. Write down the values of Gain and Integral before you start changing them! If all else fails, you can return to the factory default.

Set the integral to the maximum possible value (180), the Derivative to 0 and the Gain to 1. Wait until the temperature stabilizes. Increase the Gain by 10%. Repeat until the temperature starts oscillating. Always wait for at least 5 oscillations before changing any parameters again. The temperature will be oscillating at a value BELOW the setpoint. This is normal. The temperature will be anywhere between 5° and 50°C below the setpoint.

Now set the Integral to the period of previous oscillations (usually between 5 and 15 seconds). Round up to the nearest integer. The temperature will slowly drift to a new value. Reduce the Integral term for faster convergence.

At that point, the system may start oscillating again. Decrease the Gain by an additional 10% until stable.

If the heating process inside the chamber is a first order process with very little lag time. This means that the PID does not need a Derivative value to operate (D = 0).

Oscillations are caused by gain too high, integral too short, or rate too long. Never set rate to more than one-fourth of integral time. Sluggish response is caused by gain too low, integral too long, or rate too short.

The PID values will work over a rather wide range of temperature. However, on a High Temperature furnace, the PID might require tuning for the low range of temperature, around 200°C, and different set of parameters above 500°C. The machines are set up for one set of PID parameters at the factory. For furnace fine tuning, it is the responsibility of owner's process engineer to determine the final settings.

3.14.3 Belt Speed Measurement

The belt speed has been calibrated at the factory. The actual belt speed can be verified by the following procedure.

Tools Required: Tape Measure & Stop Watch.

❶ Measure the distance from the furnace entrance gate to the exit gate.

❷ Set the belt to the desired speed. (Set belt to the maximum speed if you plan to reprogram the Belt Speed Display meter.).

❸ Place an object on the belt to act as a marker

❹ Start the timer as the marker enters the entrance gate.

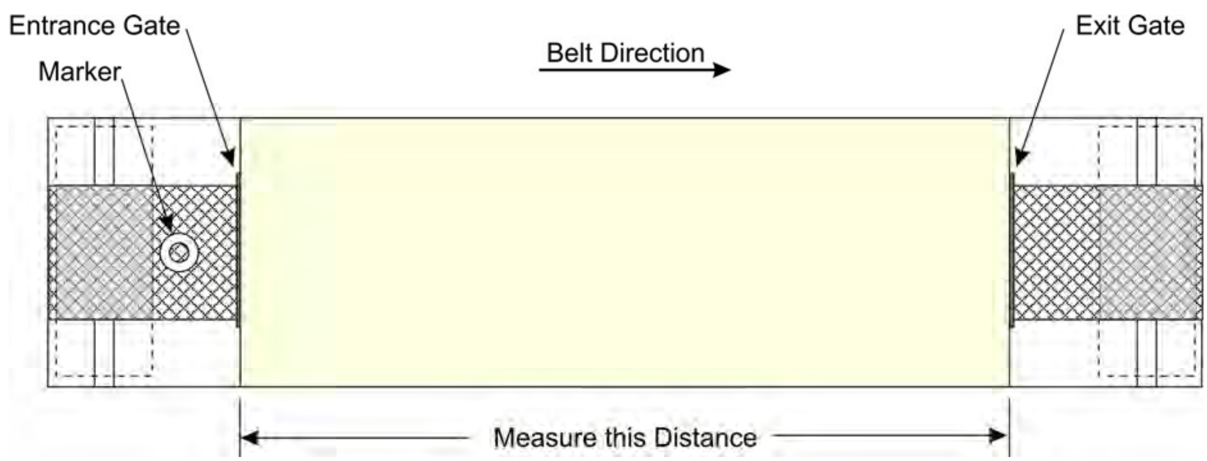


Figure 3-38 Belt Speed Calibration Diagram

❺ When the marker on the belt reaches the exit belt tray, stop the timer. Record the time in seconds.

CALCULATE ACTUAL BELT SPEED:

Convert the measured distance from **step** ❶ above to inches.

Convert the time from **step** ❺ to minutes.

Compute the actual belt speed according to the following equation:

$$\textbf{Speed} = \frac{\textbf{Distance (in.)}}{\textbf{Time (min.)}}$$

3.14.4 Belt speed Calibration

Go to the calibration screen. Check the box 50% output. Using a stopwatch, time the belt speed over a known distance, and calculate the actual belt speed. Enter the number in the Actual speed field. Un-check the 50% output box. See Reference Manual Chapter 7.3 for more detail.

3.14.5 Thermocouples

The thermocouples are pre-calibrated. They do not require any additional calibration.

3.14.6 IPS - Low Gas Pressure Switch Calibration (optional equipment-not installed)

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

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

Table 3-13 Initial Alarm Settings

Port	Manifold	Pressure	
Gas 1	CDA or Nitrogen	55-60 psig	3.8-4 Bar
Gas 2	Nitrogen Forming Gas, or other (Option)	55-60 psig	3.8-4 Bar

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

Figure 3-39 IPS Inlet Pressure Switch

A. Gas Supply Low Pressure Switch Calibration

The process gas pressure switch is located on the gas supply manifold for each gas supplied.

If a reservoir tank is supplied, the pressure switch is located at or near the compressed air receiver. See drawing 802-101780-01.

B. Calibration

To calibrate each switch:

1) Verify that the Low Pressure Alarm switch is enabled.
2) Close all flowmeter valves.
3) Set inlet air pressure to desired set point pressure. Read pressure on supply gage.
4) Rotate the Adjusting Wheel: Clockwise to increase the pressure set point, counterclockwise to decrease. You can hear a faint click when the micro switch changes state. Below this point below which the switch will activate the alarm when enabled.7
5) Start the furnace system without power to the lamps. Close the facility process gas valve to the furnace. Open the flowmeter valves and verify that the alarm trips when the pressure drops below the new set point.
6) Readjust as necessary and retest.

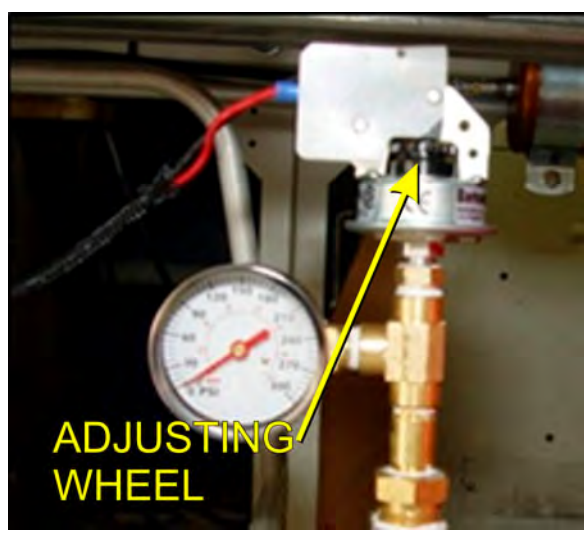


Figure 3-40 Air Pressure sensor

7)

3.15 Over Temperature Alarm Setpoints

The optional independent Over Temperature Alarm system is typically factory set to 950°C for each zone. The system consists of a microprocessor-based eight channel analog input scanner/multiplexer and annunciator that provides automatic switching for multi-point display and alarm of the furnace zone temperatures. Signals received from redundant type K thermocouples in each zone of the furnace are scanned and alternately displayed on the digital temperature panel meter mounted below the Main Control Console of the furnace. See drawing 802-101915-03 Over Temperature Monitor wiring schematic.

DIGITAL PANEL METER SCALE (F or C). F or C can be switched to indicate Fahrenheit or Celsius.

1. Press ENTER, when F or C appears press ENTER again.

2. The meter will display F or C alternatively. Press ENTER when desired character is flashing. Meter will then return to indication mode and display the temperature in either Fahrenheit or Celsius.

DIGITAL PANEL METER ALARM SET AND RESET PROGRAMMING. The panel meter alarm set and reset point is performed in the ALAr5 routine.

1. To enter the ALAr5 routine, press ENTER and when ALAr5 appears, press ENTER again. This starts a scan of the system set and reset points. The scan sequence begins with a flashing display of alarm #1 set point. The "1" LED and "S" LED are illuminated to indicate the meter is flashing alarm #1 set point value.

2. All digits flash for 3 seconds. If this is the desired display for this alarm point, press ENTER. Pressing ENTER completes this alarm point programming. Proceed to step 8 for next alarm point programming.

If this is not the desired display, wait for the first digit to flash. It will flash for 3 seconds before it starts to scroll.

3. If the first flashing digit is OK, press ENTER before it starts to scroll to accept it, the next digit flashes – go to step 6. If not OK, wait for first digit to scroll.

4. When the first digit is OK, press ENTER and the next digit flashes for 3 seconds before it starts to scroll.

5. If the flashing digit is OK, press ENTER before it scrolls. If not OK, wait for digit to scroll

6. When digit is OK, press ENTER. Program remaining digits in same fashion.

7. When the last digit is OK, press ENTER. The entire display flashes for 3 seconds. Press ENTER if OK to complete alarm point programming and proceed to step 8. If not OK, wait, first digit flashes. Repeat steps 3-8. When an alarm set or reset point has been programmed the scan moves to the next alarm set or reset point. To program the remaining alarm set and reset points, repeat steps 2-8.

SCANNER/ANNUNCIATOR. The scanner/annunciator is programmed for scanning and alarm functions using the CTRL button and a four-position DIP switch (S1). The CTRL button is used to set the dwell time for each channel (if using internal scanning) and DIP switch S1 is used to program the following:

Table 3-14 Over Temperature Alarm Switches

S1 Switch	Function
S1-1	Sequence A or F2A alarm operation (if needed)
S1-2	Stopping-on-alarm or continuous scan-on-alarm (if needed)
S1-3	Internal or external scanning
S1-4	RUN or SETUP mode

The scanner/annunciator's front cover is held in place by 6 latches that snap into notches on the cover. To remove the cover grasp it firmly on its top and bottom edges and pull it forward. The latch plate remains around the case. DIP switch S1 is located below the right bank of LEDs.

PROGRAMING DWELL TIME (INTERNAL SCAN ONLY). The default dwell time is four seconds per channel. It can be adjusted for any time between 0.6 and 30 seconds per channel. A channel can be disabled from the scan sequence by programming that channel's dwell time for less than 0.5 seconds during setup.

To program a dwell time for other than the four second default or to disable a channel:

1. Set the switch S1-4 to the SETUP (off/up) position.
2. Unit will beep and channel 1 will illuminate, indicating it is ready to be programmed.
3. Dwell times are programmed with the CTRL button, either
    a) Press and release CTRL button within 0.5 seconds to disable a selected channel,
    b) Press and release CTRL button after the 0.5 second beep to program channel for minimum dwell time, or
    c) Press and hold CTRL button for desired length of dwell time up to 30 seconds maximum.
4. After the CTRL button is released the unit will beep and go to the next channel.
5. Program the remaining channels in a similar fashion.
6. When the dwell times for all eight channels have been programmed, a red LED will light up next to channels that have been disabled (default: channels 4-8 are disabled).
7. To make sure the dwell times have been programmed as desired, set switch S1-4 back to the RUN (on/down) position and scanner will begin scanning.
8. To make any corrections to the dwell times, set switch S1-4 back to the SETUP (off/up) position and press the ACK button to advance to the desired channel.
9. When the dwell times have been programmed as desired set switch S1-4 to the RUN (on/down) position.

SPECIFICATIONS

LCI Furnaces DIVISION OF LOCHABER CORNWALL INC	EQUIPMENT SPECIFICATIONS	DOC NBR: 17-002 - 802-101401		R2
		MODEL: RTC LA-310	CUSTOMER: Microsemi (Phil)	
CONTINUOUS BELT IR FURNACE		SERIAL NBR: 1303100101	SHT 1 OF 1	PRNT 12/08/17

Equipment Model

Model	Base Equipment	Control Zones	Furnace Heated Length	Nominal Furnace Belt Width
RTC LA-310	Continuous Belt Controlled Atmosphere Furnace	4	30 in 762 mm	10.0 in 254 mm

Equipment Arrangement

Phase	Process	Max	Length		Process Gas	Temperature (typ)
Phase 1	IR Furnace, 4 Zones	1000 °C	30 in	762 mm	CDA	450-950 C
Phase 2	Transition Tunnel		15 in	381 mm	CDA	450-750 C
	Gas Convective Cooling, Exterior Fan Heat Removal		30 in	762 mm	CDA	35-450 C

Process Sections

Function	Name	Location	Length		Process Gas	Temperature (typ)
Product Load	Load Table Extension	Entrance unload ext	15 in	381 mm	none	ambient
	Load Station	Entrance load area	15 in	381 mm	none	ambient
IR Furnace	ENTRANCE BAFFLE/ENTRANCE STAC	Entrance barrier	15 in	381 mm	CDA	665 °C
	ZONE 1	Heating chamber 1	7.5 in	191 mm	CDA	865 °C
	ZONE 2	Heating chamber 1	7.5 in	191 mm	CDA	890 °C
	ZONE 3	Heating chamber 1	7.5 in	191 mm	CDA	890 °C
	ZONE 4	Heating chamber 1	7.5 in	191 mm	CDA	870 °C
Cooling	TRANSITION TUNNEL	Transition tunnel Ed	15 in	381 mm	CDA	770 °C
	COOLING TUNNEL	Cooling section	30 in	762 mm	CDA	425 °C
Product Unload	Unload Station	Exit station	15 in	381 mm	none	ambient
	Unload Table Extension				none	ambient
	Frame Adjustment		1 in	25 mm		
	Total		136.0 in	3454 mm		

Process Gas

	Actual Conditons		Typical		Typical (Low O2)		Max (all flowmeters open)	
Furnace Replenishment Rate			2.0 rep/min		2.3 rep/min		8.7 rep/min	
	Temp °C	Press psi	Min Flow scfh	Min Flow sL/m	Typical scfh	Typical sL/m	Max Compressor scfh	sL/m
CDA Supply	21	70	209	98. 8	236	111	1,829	863
TOTAL PROCESS GAS			209	99	236	111	1,829	863

Exhaust Gas

	Temp °C	Press in H_2O	Min Flow scfh	Min Flow sL/m	Typical scfh	Typical sL/m	Maximum Exhaust scfh	sL/m
CDA & none mix	200	6	105	49	136	64	3,226	3 226

Cabinet Ventilation

Cabinet Ventilation Fans	Flowrate	1100 cfm	1870 m3/h
(vent to room or exhaust system)	Temperature	<86°F	<30°C

Transport System

Belt width	9.5 in 241.3 mm	Belt Edge Heater(s): 30-inch, pair
Belt type	Balanced spiral weave	
Product height	2 in (50.8 mm) above belt level.	Baffle plate clearance: 0.5" above belt
Belt speed range	1-20 ipm	25-500 mm/m
Conveyor height	36.0 in +/- 1.5 in adjustable	914.4 mm +/-38.1 mm adjustable

Electrical System

Voltage required	208 Vac, 50 Hz, 3 Ph
Maximum power required	29.1 kW, 80.8 A
Typical (operating) power required	14.9 kW, 41.2 A

Materials of Construction

Heating Chamber	Aluminum, aircraft	Cooling	Aluminum, aircraft	Belt	Nichrome V, 80%Ni,20%Cr, <1% Fe
Baffle & Eductor	Aluminum, aircraft	Belt support	Quartz rod, Quartz tube	Frame	Steel, 2-prt urethane or powder coated
Heating element	Quartz, near infrared	Belt Return	UHMW-PE	Cover Panels	18GA Steel, urethane or powder coated

Furnace Dimensions

		Length	Width	Height (floor to stack)	Furnace Sect	Coolg Sectn	Weight
Furnace, English	Net	133 in	44 in	66 in +/- 1.5 in	1600 LB		1600 LB
Furnace, Metric	Net	3.38 m	1.10 m	1.68 m +/- 0.04 mm	726 kg		730 kg

Standard Conditions	Pressure	14.7 psia	101.3 kPa	Temperature	70 °F	21 °C

LCI LOCHABER CORNWALL INC

COMPUTER CERTIFICATE

JOB OR LOCATION	17-002 (fo 32672)		
CUSTOMER OR USER	Microsemi (Philippines), RGL for		
FURNACE MODEL	RTC LA-310	FURNACE SERIAL NUMBER	1303100101
Model	OPTIPLEX 790		
SERVICE TAG	5644XR1		
EXPRESS SERVICE CODE	11253657565		
OS	WINDOWS 10 PRO 32-bit	PROD	QLF-00572
PRODUCT KEY	PD8FD - NDR7R - YXCCQ - BW4RM - CWF9F		
COMPUTER NAME	5644XR1	Local Area Connection IP	10.192.105.100
LOGIN	Furnace1	SUBNET	255.255.255.0
PASSWORD	NONE	DNS server	10.192.105.1
		Gateway	None
DEVICE	LCM4	IP	10.192.105.102
INTERFACE	M4SENET-100	SUBNET	255.255.255.0
MAC	00:A0:3D:01:F4:88	GATEWAY	none

Temporarily disable Local Connection 2 before using OptoBootP to address M4SENET-100 card.

SOFTWARE	PROCONTROL	ED	13.1218.171208
FACTORY PRODUCT KEY	operator: 1 engineer: b 2		
Teamviewer	358 780 850	COMPUTER NAME	
		ACCESS CODE:	17002microsemi
WARRANTY:	REMOTE SUPPORT	EXPIRES:	3/1/2018

BY: JMC *James McClark* DATE: 1-Dec-17

The power to do more

Dell™ OptiPlex™ 790 desktop

The OptiPlex 790 flexible desktop solution is designed for advanced performance and efficient collaboration. It enables business-class control that helps ensure IT saves time and money and the remote management technology also helps simplify systems management and protect your data. Dell OptiPlex 790 is available in four different chassis sizes that blend seamlessly into office environments and respect our planet.

Flexible and environmentally conscious design

The completely redesigned form factors are amongst the smallest within their categories. The mini-tower, desktop and small form factor chassis have been optimized to help maximize desk space and ensure the systems integrate seamlessly in virtually any office environment. The Dell OptiPlex 790 also shares the same visual identity as OptiPlex 990 and 390 to offer a more consistent look across the OptiPlex portfolio and two All-in-One stands enable deployment as a single device with up to 24" displays. Accessibility and serviceability are easy thanks to the convenient side-latch mechanism which makes access to key system components for upgrades and services fast and easy. The form-factor flexibility has also been designed with our planet in mind. The systems all have a minimum of 10% post-consumed recycled plastic enclosure and offer 90% efficient power supplies option. Starting with OptiPlex small form factor Dell also provides recyclable packaging. By using post-consumed recycled plastic content in the chassis of more models, the new generation of OptiPlex is Dell's most environmentally responsible commercial desktop offering.

Advanced performance and productivity

The OptiPlex 790 delivers great performance and features nearly the same performance as OptiPlex 990 which is the most powerful OptiPlex ever. Enable your workforce with cutting-edge productivity tools such as the advanced 2nd generation Intel® Core™ i7 processor featuring generous high-speed memory options and support for up to four simultaneous video displays across small-form factor, desktop and minitower chassis with dual PCI-express slots. The OptiPlex 790 also supports flexible desktop virtualization deployment models to help users get up and running fast and have their data centrally stored to avoid downtime. OptiPlex 790 supported virtualization solutions range from virtual remote desktop control to on-demand desktop streaming or client hosted virtualization.

Business-class control

The OptiPlex 790 is equipped with Intel Standard Management technology enabling efficient remote system management that helps managing many systems simultaneously; along with the Dell Data Protection security capabilities such as one-touch preset compliance policy templates, flexible encryption and single solution for system disk as well as removable medias that work in your unique environment. A business-class range of security and management options which allows security and remote control configurations to meet large organizations unique needs and challenges. Dell KACE system management appliances are fully-compatible with the OptiPlex 790 desktops enabling easy deployment of remote manageability and maintenance simplification. The OptiPlex technological assets are backed with proven professional IT services and support worldwide, ranging from deployment to maintenance or web solutions to help IT to simplify their daily tasks. The OptiPlex platform commitment to stability, long-lifecycle and managed transitions also help ensure IT to save time and money.

Dell OptiPlex 790

designed to deliver advanced productivity and business-class control to help IT save time and money.

OptiPlex 790 Technical Specifications					
Processors[1]	Intel® 2nd Generation Core™ i7, i5, i3 Processors.				
Chipset	Intel® Q65 Express Chipset				
Operating System Options	Microsoft® Windows 7® Home Basic (32/ 64 bit),Microsoft® Windows 7® Home Premium (32/64 bit), Microsoft® Windows 7® Professional (32/64 bit), Microsoft® Windows 7® Ultimate (32/64 bit) Windows Vista® Home Basic SP2 (32/64 bit), Windows Vista® Business SP2 (32/64 bit), Windows Vista® Ultimate SP2 (32 bit) Ubuntu® Linux (select countries); FreeDOS for N-series				
Video[2]	Integrated Intel® HD Graphics 2000 [with iCore Dual/Quad core class CPU-GPU combo]; optional 1GB AMD RADEON HD 6450; optional 512MB AMD RADEON HD 6350				
Memory[3]	Up to four DIMM slots; Non-ECC dual-channel 1333MHz DDR3 SDRAM, up to 16GB				
Networking	Integrated Intel® 82579LM Ethernet LAN 10/100/1000; optional Broadcom® NetXtreme® 10/100/1000 PCIe card; optional Dell Wireless 1520 PCIe (MT, DT, SFF); optional half-mini PCIe (USFF) WLAN card (802.11n)				
I/O Ports	10 External USB 2.0 ports and 1 Internal USB 2.0 (MT & DT only);1 Serial; 1 RJ-45; 1 VGA; 1 DisplayPort; 2 PS/2; 2 Line-in (stereo/microphone), 2 Line-out (headphone/speaker), optional Parallel/2nd Serial PCIe card (MT), optional 2nd Serial PCIe card (DT & SFF), optional 1394a PCI card (MT & DT, available from middle May 2011); optional USB 3.0 PCIe card				
Removable Media Options	DVD+/-RW; DVD-ROM; Dell 19 in 1 Media Card Reader (MT & DT only)				
Hard Drives[4] Options	3.5" Hard Drives: up to 1TB 7200 RPM SATA 3.0Gb/s; 2.5" Hard Drives: up to 500GB 7200 RPM SATA 3.0GB/s; 500GB Hybrid; 320GB 7200 RPM Opal SED, 128GB Solid State Drive Supports Dell's Flexible Computing Solution diskless option				
Chassis		Minitower (MT)	Desktop (DT)	Small Form Factor (SFF)	Ultra Small Form Factor (USFF)
	Dimensions (H x W x D) Inches/(cm)	14.2 x 6.9 x 16.4 / (36.0 x 17.5 x 41.7)	14.2 x 4.0 x 16.1 / (36.0 x 10.2 x 41.0)	11.4 x 3.7 x 12.3 / (29.0 x 9.3 x 31.2)	9.3 x 2.6 x 9.4 / (23.7 x 6.5 x 24)
	Min. Weight (lbs/ kg)	19.55/8.87	16.67/7.56	12.57/5.7	7.20 / 3.27
	Number of Bays	2 internal 3.5" 2 external 5.25"	1 internal 3.5" 1 external 5.25"	1 internal 3.5" 1 external 5.25" (slimline)	1 internal 2.5" 1 external 5.25" (slimline)
	Expansion Slots	1 full height PCIe x16 1 full height PCIe x16 (wired x 4) 1 full height PCIe x1 1 full height PCI	1 half height PCIe x16 1 half height PCIe x16 (wired x 4) 1 half height PCIe x1 1 half height PCI	1 half height PCIe x16 1 half height PCIe x16 (wired x 4)	1 miniPCIe connector
	Power Supply[5] Unit (PSU)	Standard 265W PSU or optional 265W up to 90% Efficient PSU; Energy Star 5.0 compliant, Active PFC	Standard 250W PSU or optional 250W up to 90% Efficient PSU; Energy Star 5.0 compliant, Active PFC	Standard 240W PSU or optional 240W up to 90% Efficient PSU; Energy Star 5.0 compliant, Active PFC	200W up to 90% Efficient PSU, ENERGY STAR® 5.0 compliant, Active PFC
Peripherals Options	Monitors: Dell Entry Standard and Widescreen Flat Panel Analog: Dell E170S, E190S, E1709W, E1910, E1911, E2011H, E2210H, E2211H, E2311H Dell Professional Digital Standard and Widescreen Flat Panel: Dell P170S, P190S, P1911, P2011H, P2210, P2211H, P2311H, P2411H Dell UltraSharp Digital Standard and Widescreen Flat Panel, Adjustable Stand: Dell 2007FP, U2211H, U2311H, U2410, U2711, U3011				
	Keyboards: Dell USB Entry Keyboard, Dell Multimedia Pro Keyboard, Dell Smartcard Keyboard				
	Mouse: Dell USB Optical Mouse, Dell Laser Mouse				
	Audio Speakers: Internal Dell Business audio speaker, Dell AX210 2.0 and AY410 2.1 Desktop Speakers; Dell AX510 and AX510PA Sound Bar Speakers				
Security	Trusted Platform Module[6] (TPM) 1.2, Dell Data Protection / Access, Chassis lock slot support, optional Chassis Intrusion Switch, Setup/BIOS Password, I/O Interface Security, optional Smart Card keyboards, Intel® Trusted Execution Technology, BIOS support for optional Computrace[7]				
Systems Management Options[8]	Intel® Standard Manageability; No Out of Band Systems Management				
Environmental, Ergonomic, & Regulatory Standards	Environmental Standards (eco-labels): Energy Star 5.0, EPEAT Registered (see epeat.net for registration status by country), CECP, TCO, WEEE, Japan Energy Law, Japan Green PC, South Korea Eco-label, EU RoHS, China RoHS, Blue Angel Other Environmental Options: Dell Energy Smart settings; Carbon Off-set Program; System Recycle (Asset Recovery Service)				
Warranty	Limited Hardware Warranty[9]; Standard 3-year Next Business Day On Site Service after Remote Diagnosis[10] (3-3-3); Optional 3-year Dell ProSupport™ for IT; 4 year and 5 year service and support options[11]				

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***Important Information: Remote Diagnosis is determination by online/phone technician of cause of issue; may involve customer access to inside of system and multiple or extended sessions. If issue is covered by Limited Hardware Warranty and not resolved remotely, technician and/or part will be dispatched, usually within 1 business day following completion of Remote Diagnosis. Availability varies.**
Other conditions apply. For copy of Ltd Hardware Warranty, write Dell USA LP, Attn: Warranties, One Dell Way, Round Rock, TX 78682 or see www.dell.com/warranty.

1. Offering may vary by region.
2. System Memory and Graphics: Significant system memory may be used to support graphics, depending on system memory size and other factors.
3. 4GB or Greater System Memory Capability: A 64-bit operating system is required to support 4GB or more of system memory.
4. Hard Drive: GB means 1 billion bytes and TB equals 1 trillion bytes; actual capacity varies with preloaded material and operating environment and will be less.
5. PSU: This form factor utilizes a more efficient Active Power Factor Correction (APFC) power supply. Dell recommends only Universal Power Supplies (UPS) based on Sine Wave output for APFC PSUs, not an approximation of a Sine Wave, Square Wave, or quasi-Square Wave (see UPS technical specifications). If you have questions please contact the manufacturer to confirm the output type.
6. TPM: TPM is not available in all regions.
7. Computrace: Not a Dell offer. Certain conditions apply. For full details, see terms and conditions at www.lojackforlaptops.com.
8. Systems Management Options:
   - Intel® Standard Manageability - Fully enabled at point of purchase, the Intel Standard Management option is a subset of the AMT features. ISM is not upgradeable to vPro technology post-purchase.
   - No Out-of-Band Systems Management - This option entirely removes Intel out of band systems (OOB) management features. The system can still support in band management. OOB management support through AMT cannot be upgraded post-purchase.
9. Limited Hardware Warranty: For copy of Ltd Hardware Warranty, write Dell USA LP, Attn: Warranties, One Dell Way, Round Rock, TX 78682 or see www.dell.com/warranty.
10. Next Business Day Onsite Service after Remote Diagnosis: Remote Diagnosis is determination by online/phone technician of cause of issue; may involve customer access to inside of system and multiple or extended sessions. If issue is covered by Limited Hardware Warranty (www.dell.com/warranty) and not resolved remotely, technician and/or part will be dispatched, usually within 1 business day following completion of Remote Diagnosis. Availability varies. Other conditions apply.
11. Dell Services: Availability and terms of Dell Services vary by region. For more information, visit www.dell.com/servicedescriptions.
12. OptiPlex 990 small form factor (coming in May in US, UK and Japan) is brominated flame retardant free (BFR-free) and polyvinyl chloride free (PVC-free); meeting the definition of BFR-/PVC-free as set forth in the iNEMI Position Statement on the 'Definition of Low-Halogen Electronics (BFR-/CFR-/PVC-free)'. Plastic parts contain less than 1,000 ppm (0.1%) of bromine (if the Br source is from BFRs) and less than 1,000 ppm (0.1%) of chlorine (if the Cl source is from CFRs or PVC or PVC copolymers). All printed circuit board (PCB) and substrate laminates contain bromine/chlorine total less than 1,500 ppm (0.15%) with a maximum chlorine of 900 ppm (0.09%) and maximum bromine being 900 ppm (0.09%).

OptiPlex 790

The power to do more

radiant Technology Corporation
1335 S. Acacia Ave.
Fullerton, California 92831-5315

Furnace Channel Assignments

Customer: **Cielo Communications, Inc.**

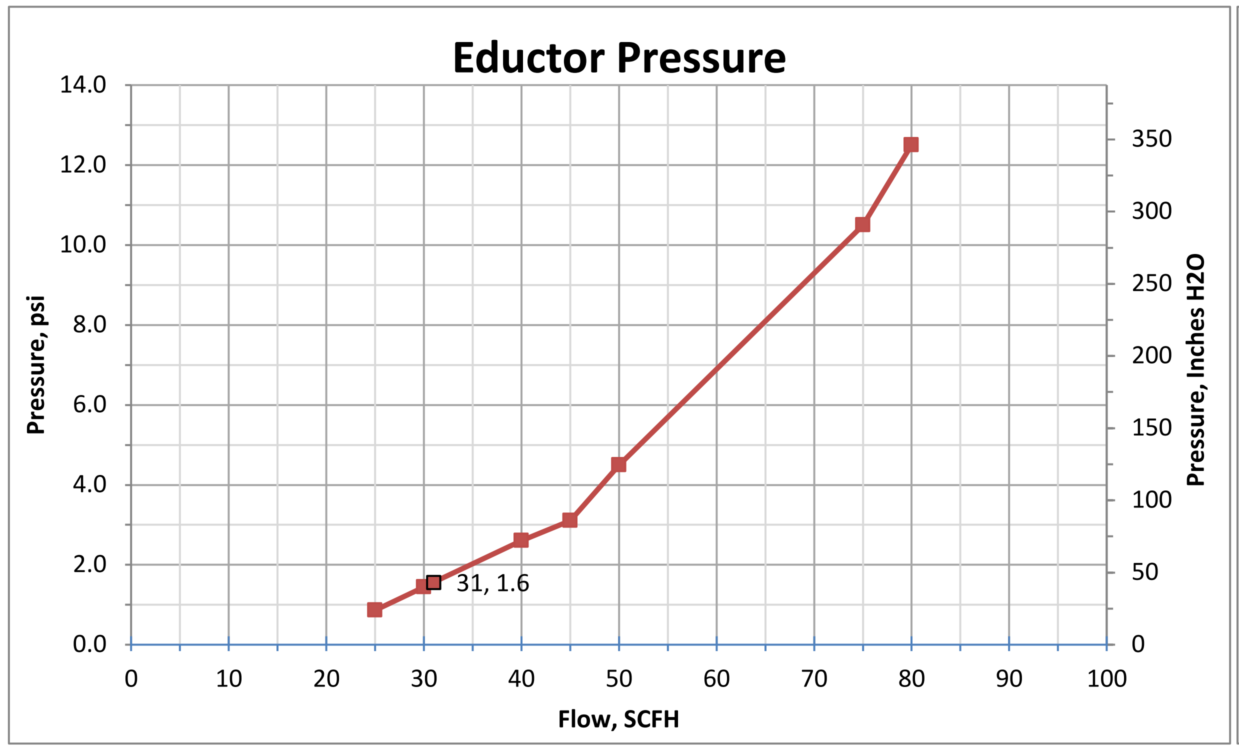
LAYOUT

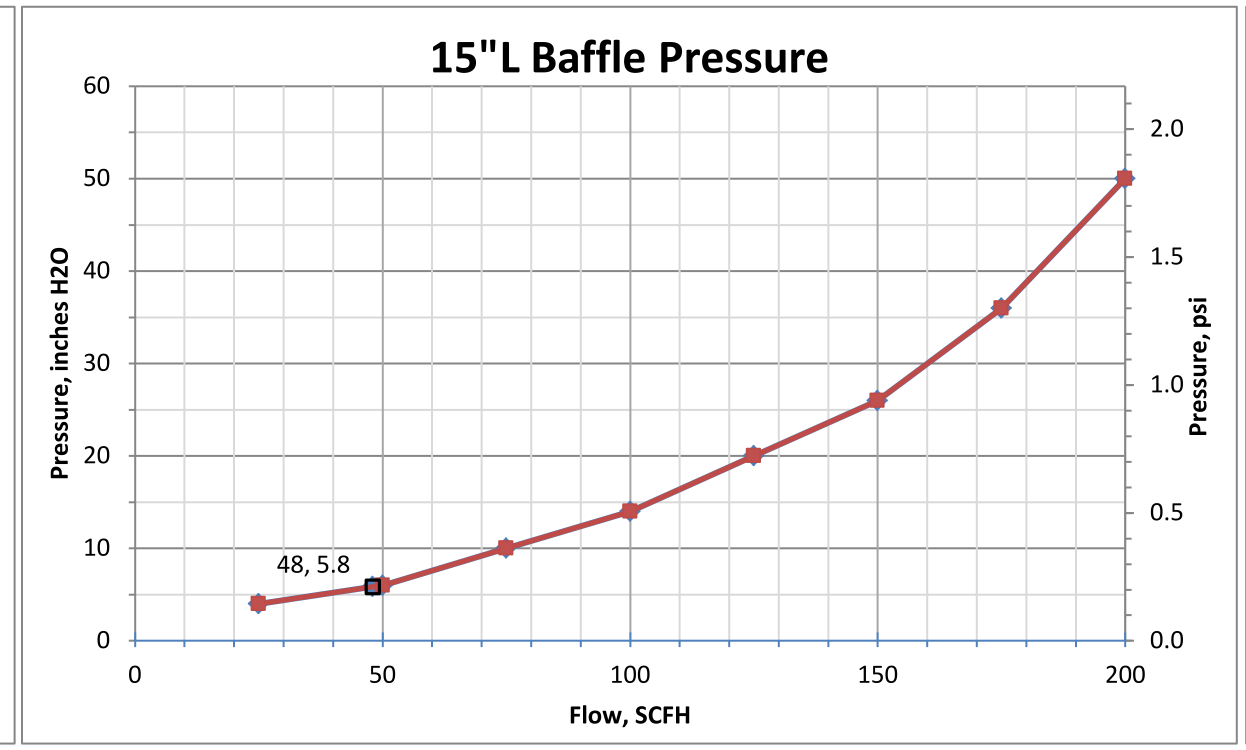
Addr	Power Supply	322-092210-01	Addr	Controller	322-092246-01
2	Analog1	322-092212-01		Analog1_Expansion	322-092226-01
1	Digital1	322-092213-01	4	EleMon1_01_TO_16	322-092226-02 322-092246-02

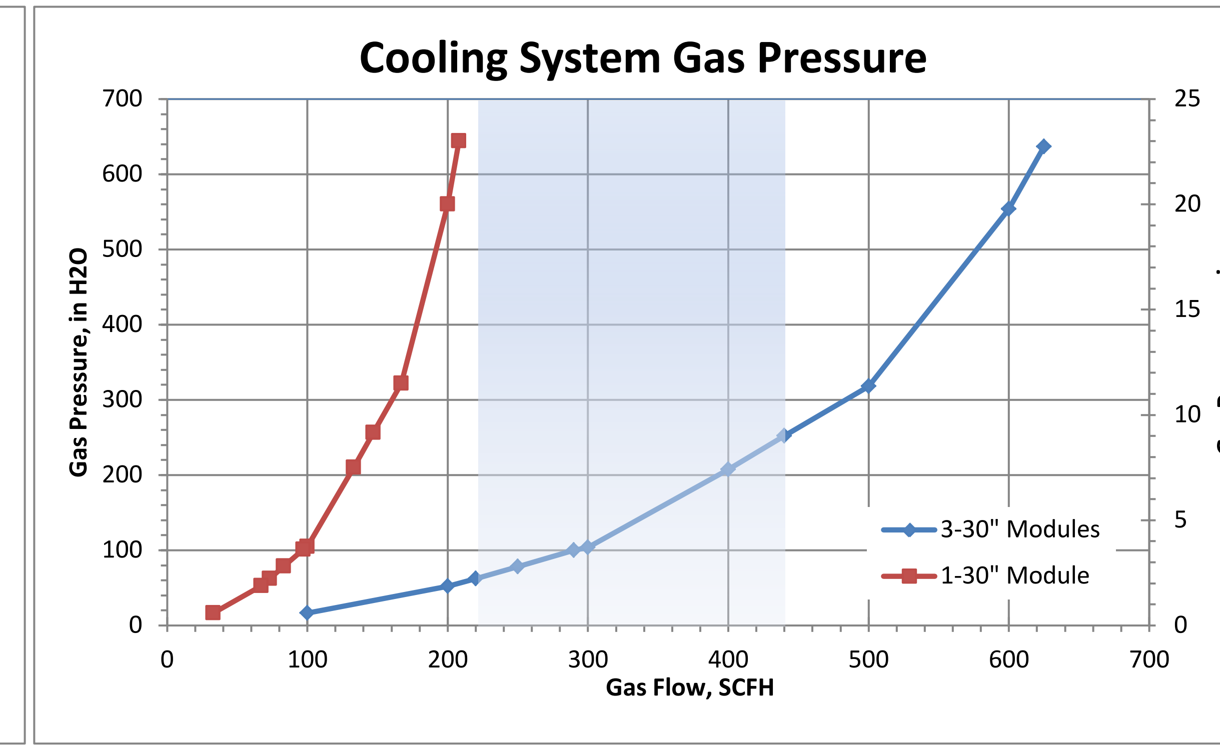
Factory Order: **32672**
Date: **24-Apr-00**
Model Number: **LA310**
Serial Number: **1303100101**
Power: **208vac, 60hz**

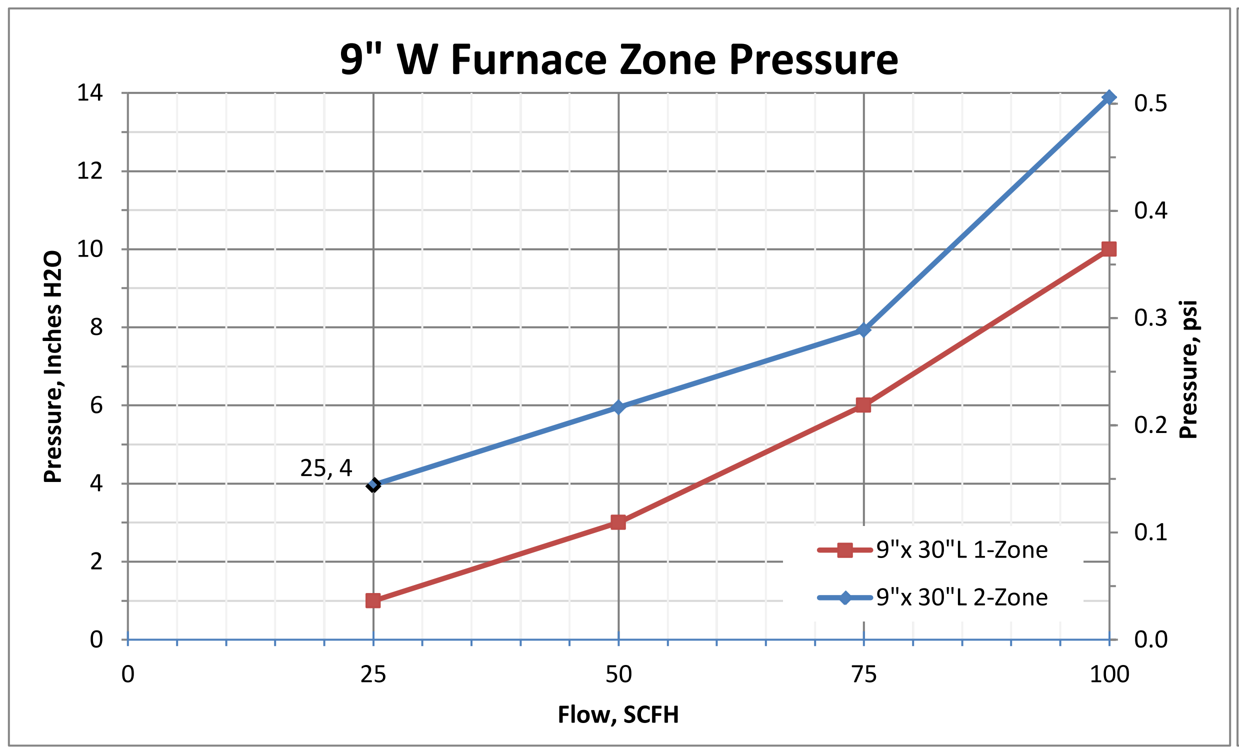
BELT SPEED 2-20 IPM

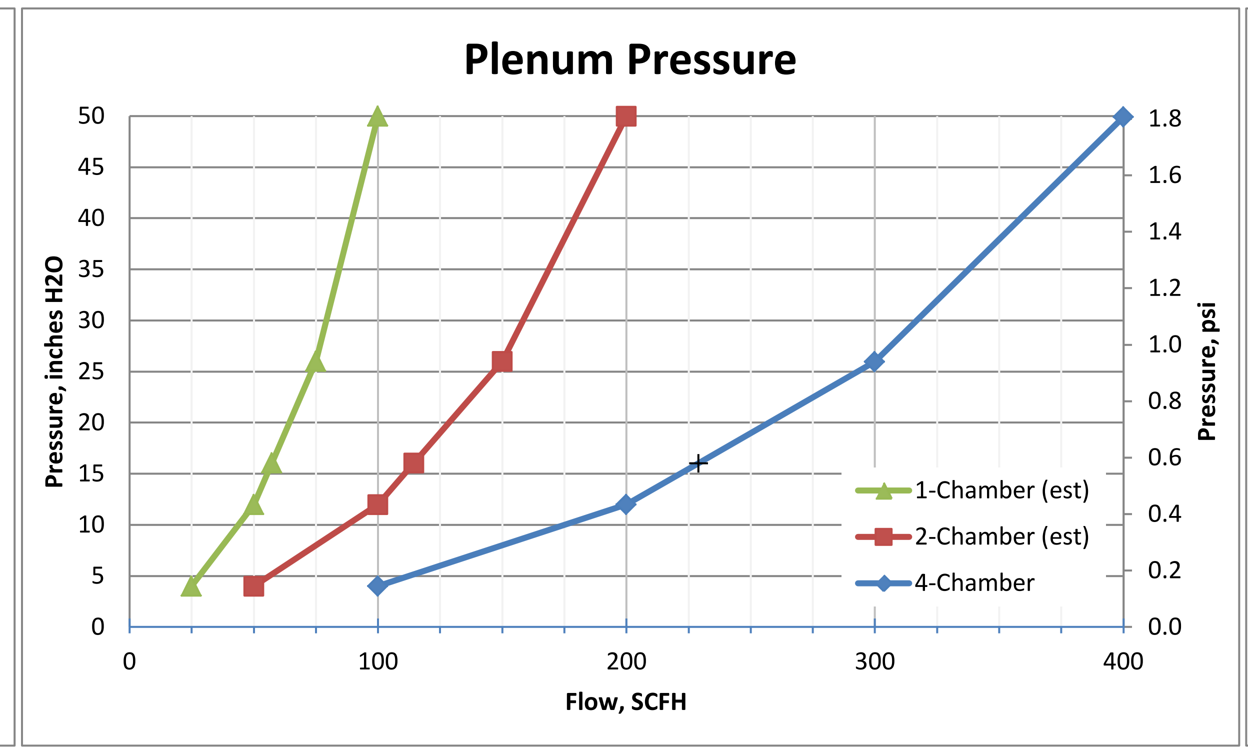
Chn	Signal	Part Number	Module Description	Model Number	Signal Description
	Analog1				
0	TEMPERATURE_ZONE_1_K	322-092204-01	Type K analog input	G4AD8-K	KA103 Thermocouple Inputs TC1
1	TEMPERATURE_ZONE_2_K	322-092204-01	Type K analog input	G4AD8-K	KA203 Thermocouple Inputs TC2
2	TEMPERATURE_ZONE_3_K	322-092204-01	Type K analog input	G4AD8-K	KA303 Thermocouple Inputs TC3
3	TEMPERATURE_ZONE_4_K	322-092204-01	Type K analog input	G4AD8-K	KA403 Thermocouple Inputs TC4
4	ZONE_1_TOP	322-092201-01	Analog dc out 0-5v	G4DA4	KA100 Top SCR Signal Control
5	ZONE_1_BOTTOM	322-092201-01	Analog dc out 0-5v	G4DA4	KA101 Bot SCR Signal Control
6	ZONE_2_TOP	322-092201-01	Analog dc out 0-5v	G4DA4	KA200 Top SCR Signal Control
7	ZONE_2_BOTTOM	322-092201-01	Analog dc out 0-5v	G4DA4	KA201 Bot SCR Signal Control
8	ZONE_3_TOP	322-092201-01	Analog dc out 0-5v	G4DA4	KA300 Top SCR Signal Control
9	ZONE_3_BOTTOM	322-092201-01	Analog dc out 0-5v	G4DA4	KA301 Bot SCR Signal Control
10	ZONE_4_TOP	322-092201-01	Analog dc out 0-5v	G4DA4	KA400 Top SCR Signal Control
11	ZONE_4_BOTTOM	322-092201-01	Analog dc out 0-5v	G4DA4	KA401 Bot SCR Signal Control
12	RIGHT_EDGE_HEAT1	322-092201-01	Analog dc out 0-5v	G4DA4	KA111 Edge Heat 1 Left SCR Signal Control
13	LEFT_EDGE_HEAT1	322-092201-01	Analog dc out 0-5v	G4DA4	KA112 Edge Heat 1 Right SCR Signal Control
14	BELT_SPEED_OUTPUT	322-092203-01	Analog Out 0-10vdc	G4DA5	KA2 Motor Speed Control Signal
15	O2_INPUT	322-092216-01	Analog DC in 0 - 10vdc	G4AD7	KA4 02 sensor reading, Ref: 802-101773
	Digital1				
0	MAIN_POWER_LATCH	322-092200-01	Digital AC Out 12-140vac	G40AC5MA	K4 Delay Power OFF, Ref: 802-101770
1	LAMP_POWER_CTRL	322-092200-01	Digital AC Out 12-140vac	G40AC5MA	K7 Process Power On, Ref: 802-101770
2	SPEED_FEEDBACK	322-092207-01	Digital In 2.5-16v	G41IDC5K	K11 Transport Motor Tach Feedback, Ref: 802-101771
3	TRANSPORT_MOTION_FAULT	322-092207-01	Digital In 2.5-16v	G41IDC5K	K8 Transport Motion Sensor, Ref: 802-101771
4	ALARM_HORN	322-092227-01	Digital DC Out 5-60vdc	G40DC5MA	K14 Alarm Horn, Ref: 802-101772
5	RED_LAMP	322-092200-01	Digital AC Out 12-140vac	G40AC5MA	K15 Light Tower Control, Ref: 802-101775
6	YEL_LAMP	322-092200-01	Digital AC Out 12-140vac	G40AC5MA	K16 Light Tower Control, Ref: 802-101775
7	GRN_LAMP	322-092200-01	Digital AC Out 12-140vac	G40AC5MA	K17 Light Tower Control, Ref: 802-101775
8	O2_SRC	322-092200-01	Digital AC Out 12-140vac	G40AC5MA	K20-MA/O2 Source Control, Ref: 802-101773
9	O2_SAMPLE_1	322-092200-01	Digital AC Out 12-140vac	G40AC5MA	K21 MA/O2 Sample Control, Ref: 802-101773
10	O2_SAMPLE_2	322-092200-01	Digital AC Out 12-140vac	G40AC5MA	K22 MA/O2 Sample Control, Ref: 802-101773
11	O2_SAMPLE_3	322-092200-01	Digital AC Out 12-140vac	G40AC5MA	K23 MA/O2 Sample Control, Ref: 802-101773
12	O2_POWER	322-092200-01	Digital AC Out 12-140vac	G40AC5MA	K24 MA/O2 Power On/Off, Ref: 802-101773
13	Not Used				
14	Not Used				
15	Not Used				
	EleMon1_01_TO_16				
0	EM01	322-092207-02	10-32 vac/vdc digital input	Snap-IDC5	-| Input 1 of 4, Elem. Mon Z1-1-T
1	EM02	322-092207-02	10-32 vac/vdc digital input	Snap-IDC5	| Input 2 of 4, Elem. Mon Z1-1-B
2	EM03	322-092207-02	10-32 vac/vdc digital input	Snap-IDC5	| Input 3 of 4, Elem. Mon Z2-1-T
3	EM04	322-092207-02	10-32 vac/vdc digital input	Snap-IDC5	-| Input 4 of 4, Elem. Mon Z2-1-B
4	EM05	322-092207-02	10-32 vac/vdc digital input	Snap-IDC5	-| Input 1 of 4, Elem. Mon Z3-1-T
5	EM06	322-092207-02	10-32 vac/vdc digital input	Snap-IDC5	| Input 2 of 4, Elem. Mon Z3-1-B
6	EM07	322-092207-02	10-32 vac/vdc digital input	Snap-IDC5	| Input 3 of 4, Elem. Mon Z4-1-T
7	EM08	322-092207-02	10-32 vac/vdc digital input	Snap-IDC5	-| Input 4 of 4, Elem. Mon Z4-1-B
8	EM09	322-092207-02	10-32 vac/vdc digital input	Snap-IDC5	-| Input 1 of 4, Elem. Mon EH1-L
9	EM10	322-092207-02	10-32 vac/vdc digital input	Snap-IDC5	| Input 2 of 4, Elem. Mon EH1-R

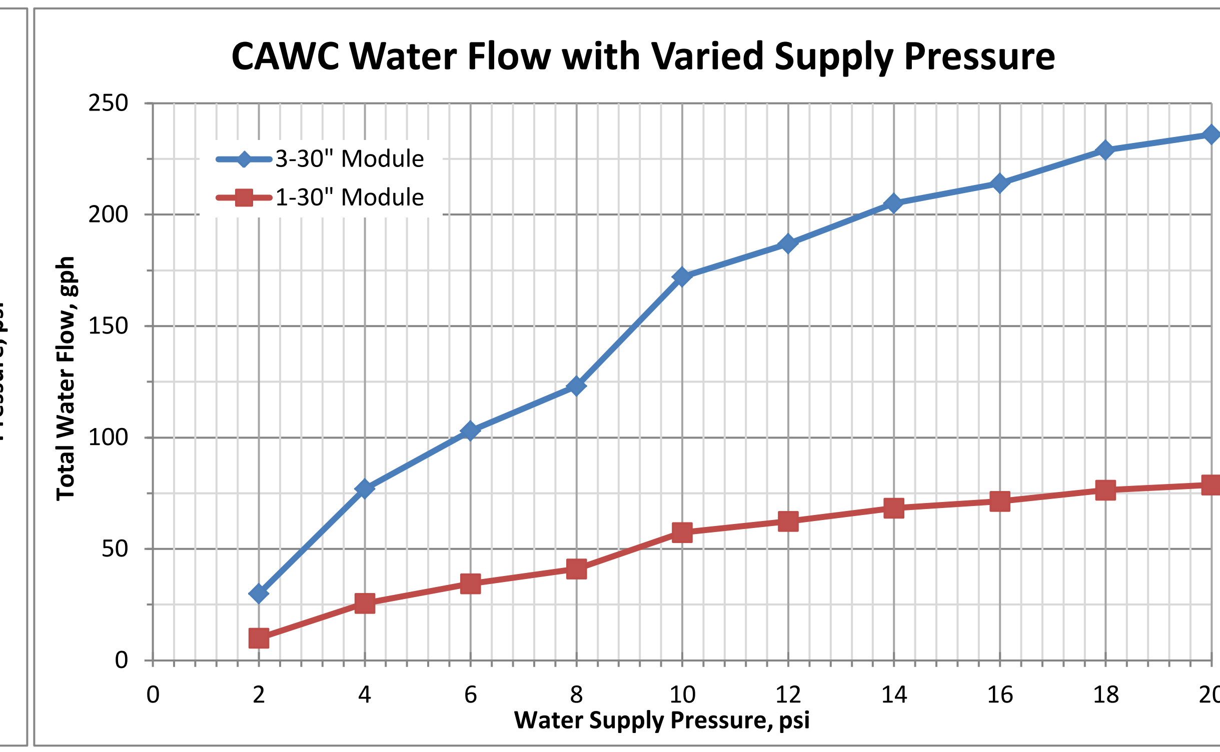












NOTES:

PROCESS GAS TO PLENUMS, EDUCTORS, CHAMBERS, BAFFLES & CAWC

For each gas element tested, the flow was varied and the pressure drop determined by temporary installation of a test pressure gage. Pressures were recorded at each flow.

CAWC COOLING WATER

For the water cooling section, all 6 water flowmeters were opened full and the pressure varied from 2-20 psig.
Flows were recorded for each flow meter at each pressure setting and then summed for total water flow through the CAWC as a function of inlet pressure.
Tests on the CAWC were run as follows:

1) Furnace operating with last zone at approx. 450-460C. CAWC COOLING AIR turned off. Cooling water set to 8 psig. CAWC cooling water varied from 0 to 60 gph (1 gpm).
Temperature profiles of the furnace were run at each of 5 Total Water Flow settings. Inlet & outlet water temp recorded
2) Furnace operating with last zone at approx. 450-460C. Cooling water set to 8 psig, Total Water Flow set to 48 gph (8 gph in each of 6 CAWC chambers).
CAWC COOLING AIR increased from 0 to 400 scfh. Temperature profiles of the furnace were run at each of 6 water flow settings.

Data suggests the furnace cooling system be operated with 40 to 60 gph Total Water Flow through the CAWC and improve cooling performance by running the CAWC cooling gas at 200-300 SCFH.

REV	DESCRIPTION	BY	DATE

APPROVALS		DATE
DWN	JMC	6/11/11
CHK'D	SBARBER	6/15/11
ENGR	JMC	6/22/11
PM	JMC	7/28/11

LCI Furnaces
DIVISION OF LOCHABER CORNWALL INC
675 N ECKHOFF STREET STE D
ORANGE, CALIFORNIA 92868 USA
(714) 935-0302 www.furnacepros.com

TITLE: IR FURNACE PRESSURE AND FLOW CHARACTERISTICS

JOB	DOCUMENT NUMBER	REV
STD	802-101470	0

SIZE:	PRNT:	SN:	SHEET	OF
B	11/28/12	ALL	1	1

Section 5
ENGINEERING

LCI Furnaces DIVISION OF LOCHABER CORNWALL INC	DATA SHEET	DOC NBR: 17-002	802-101501	R0
	IR FURNACE SYSTEM POWER & CURRENT	MODEL: RTC LA-310	APVL SLB	12/8/17
		SERIAL NBR: 1303100101	CONF: JMC	12/8/17
Customer: Microsemi (Phil)		PRINT: 12/08/17	SHT 1	of 1

INPUT TABLE	Entry OK? VALID	
Enter Line Voltage: (208,220,380,400,415,440,480)	208 Vac	TRUE
Limit Lamps to Max Rating? (Y/N)	Y	TRUE
Line Frequency (50/60)	50 Hz	TRUE
Number of Phases:	3 Φ	TRUE
Lamp Length (6, 9, 15, 24, 36)	10 inches	TRUE
Typical Operating %	50 %	TRUE

SUMMARY OF RESULTS	
Max Power:	29.1 kW
Max Current:	80.7 A
Typical Power:	14.8 kW
Typical Current:	41.1 A

HARDWARE	
Lamps: 32	SCRs: 10
EMs: 9	TCs: 4
Nbr strings 32	
Nbr Lamps in 10" zone: 6	AOV-25: 5
	AITM: 2

CONFIGURATION	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9	Zone 10	Zone 11	Zone 12	Totals
Length (6.6,7.5,10,14.3,15,20,30) in.	7.5	7.5	7.5	7.5									30 in.
Length Entry OK?	TRUE	TRUE	TRUE	TRUE									
(F)urn., Furn. (1) SCR-Zn, (D)ryer	F	F	F	F									4
Zone Type OK?	TRUE	TRUE	TRUE	TRUE									
No. Lamps in Series/String (1-5)	1	1	1	1									
Lamps/String OK?	TRUE	TRUE	TRUE	TRUE									
No. Lamps in Top/Bottom Power	4/4 F	4/4 F	4/4 F	4/4 F									Plenum: 120
SCR PHASE Zone Entry OK?	VALID	VALID	VALID	VALID									Lamp Balance (kW)
Top Lamp Phase (1/2/3):	1	2	3	1									
Bottom Lamp Phase (1/2/3):	1	2	3	1									Phase 1: 13.6
SCR POWER													Phase 2: 6.8
Rated Lamp Voltage	216	216	216	216									Phase 3: 6.8
Max. Lamp Wired Voltage	208	208	208	208									
50% Power SCR Cal Span Setting	**147**	**147**	**147**	**147**									<-- Vrms
Max. Lamp Wired Power (W)	849	849	849	849									
No. Strings per SCR	4	4	4	4									
Max. Current per String (A)	4.1	4.1	4.1	4.1									
No. Lamps in Zone	8	8	8	8									32
No. SCRs in Zone	2	2	2	2									8
No. Strings in Furnace Zones	8	8	8	8									32
Nbr. Furnace Element Monitors:													8
Top Lamp Power (kW)	3.4	3.4	3.4	3.4									
Bottom Lamp Power (kW)	3.4	3.4	3.4	3.4									
Total Power/Zone (kW)	6.8	6.8	6.8	6.8									27.2
Current Required Top SCR (A)	16.3	16.3	16.3	16.3									
Current Required Bottom SCR (A)	16.3	16.3	16.3	16.3									
Color Temp (K) (nominal: 2500K)	**2465**	**2465**	**2465**	**2465**									
Peak Wavelength (μm)	**1.18**	**1.18**	**1.18**	**1.18**									
Estimated Lamp Life (hrs)	11769 hr	11769 hr	11769 hr	11769 hr									
Lumen Output vs. Rated (%)	89	89	89	89									

Furnace Total	Number of Item?	Voltage (Vac)	Current (Amps)	Power (kW) Max	Typical	Phase Assigned	
Lamps	32	208	as above	27.2	13.6	as above	
PC, Monitor	1	117	1.3	0.2	0.2	1	
Belt, Opto22, EM	1	117	2.1	0.2	0.2	1	
UC (Pump & Gen)		117	10.0				
UC (Tank Heater)		117	8.4				
UCD (Blower)		117	2.0				
UCD (Heater)		208	6.9				
Edg Htr 1 Length	30	208	6.6	1.4	0.7	3	OK
Edg Htr 2 Length							
Edg Htr 3 Length							
Cabinet Vent Fan 10"	2	117	0.3	0.1	0.1	1	OK
CACT Fans 10"	2	117	0.3	0.1	0.1	1	OK
CACT Fans 4"		117	0.16				
Control Box Fans 4"		117	0.16				
Prod Cooling fans		117	0.16				
			Furnace Totals:	29.1	14.8		

Other Items
10" Cabinet or CACT Fans, 117 Vac, 0.30/029 A for 50/60 Hz
4" Box (Muffin) Fans, product cooling, 117 Vac, 0.16 A
Cross-flow Fans, product cooling, 230 Vac, 1.27 A max
Lower Cabinet Blowers (Impellers), 230 Vac, 0.72 A max
H2 Igniters, 120 Vac, 5 A   24 Vdc PS, 120 Vac, 2 A
No more than 8 SCRs/phase per TRx xfmr 24 Vac secondary
TR1: 4   TR2: 2   TR3: 4
Max Curr/EH1 SCR: 3.3 A   63 ohms
Max Curr/EH2 SCR:
Max Curr/EH3 SCR:
Cabinet/CACT/Control Box Fans: 1.2 A

	PHASE BALANCING			TOTAL
PHASE	1	2	3	ALL
LAMP PWR, kW	13.6	6.8	6.8	27.2
EH/OTHER	0.5	0.0	0.7	1.2
TOTAL	14.1	6.8	7.5	28.4

LCI Furnaces DIVISION OF LOCHABER CORNWALL INC	FLOWMETER SETTINGS	DOC NBR: 17-002 -	802-101460-01		R0
Customer: Microsemi (Phil)		MODEL: RTC LA-310	DWN:	SLB	08/25/11
		SERIAL NBR: 1303100101	APVL:	JMC	12/07/17
		PRINT: 08Dec17	PM:	JMC	12/09/17

PROCESS GAS

GAS1	CDA	Clean Dry Air	cfh
GAS2	none	none	

SETTINGS FOR SINGLE GAS MODEL

Replenish Rate is the number of times/minute that the furnace (or a section of the furnace) evacuates its gas

Replenish Rate	Furnace or Section Replenishes/Hour	Time to Refresh Furnace or Section
1 times/minute	60 times/hour	60 seconds
2 times/minute	120 times/hour	30 seconds
3 times/minute	180 times/hour	20 seconds
4 times/minute	240 times/hour	15 seconds

Different sections of the furnace can be replenished at different rates, if required

Flowmeters graduated in: scfh (lg=RMC flowmeters, sm=small RMA flowmeters)

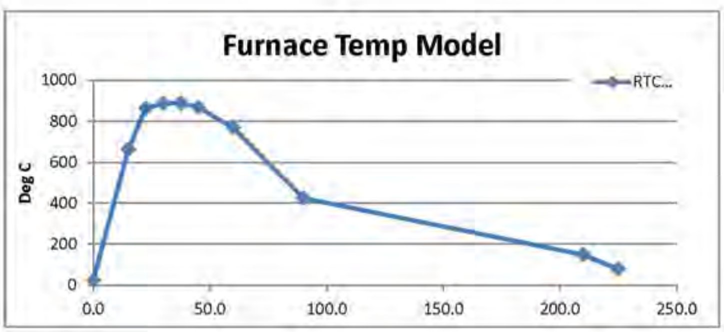
BALANCE

100	scfh difference	=> Positive pressure in furnace to purge O2	
100	scfh grad	44.8%	incr (decr) of inflows over outflows

No.		Location	Label	Temps	Metered Gas	Flowmeter Size cfh	1 per Minute Replenish Rate Flow Setting scfh grad	Desired Replenish Rate per Minute (3)	Initial Flowmeter Setting scfh grad	Initial Flowmeter Setting scfh grad
1	BESE	Entrance barrier	ENTRANCE BAFFLE		CDA	200	15	2	20	20
2	Z1	Heating chamber 1	ZONE 1	865	CDA	200	15	3	20	20
3	Z2	Heating chamber 1	ZONE 2	890	CDA	200	15	3	20	20
4	Z3	Heating chamber 1	ZONE 3	890	CDA	200	15	3	20	20
5	Z4	Heating chamber 1	ZONE 4	870	CDA	200	15	3	20	20
6	TTSE	Transition tunnel Ed	TRANSITION TUNNEL		CDA	200	15	2	20	20
7	CACT	Cooling section	COOLING TUNNEL		CDA	200	34	2	45	45
8	HC	Heat chamber sides	LAMP SEALS		CDA	200	38	2	50	50

EXHAUST

No.		Location	Label	Metered Gas	Flowmeter Size cfh	distr %	scfh grad	scfh grad
9	EEBE	Entrance stack	ENTRANCE STACK	CDA	100	60%	4.9	4.9
10	EETT	Transition tunnel	TRANSITION TUNNEL STACK	CDA	100	40%	3.3	3.3
						100%		



Furnace Balance	scfh	scfh
Gas Inflow to furnace	223.1	223.1
Gas to Eductors	8.2	8.2
Total Gas Required	231.3	231.3
- Stack Exhaust Flow	131.3	131.3
Net inflow	100	100.0
	cu ft	L
Furnace internal volume	3.8	108.4

PROCESS GAS SUPPLY REQUIREMENTS			Temp °C	Press psi	Gas	scfh	scfh
1	Gas 1	All	21	70	CDA	231.3	231.3
2	Gas 2		21	70	none	0.0	0.0
			STP = 21C, 1 atm		Total	231.3	231.3

LCI Furnaces DIVISION OF LOCHABER CORNWALL INC	FLOWMETER SETTINGS	DOC NBR: 17-002 -	802-101460-02	R0
Customer: Microsemi (Phil)		MODEL: RTC LA-310	DWN: SLB	08/25/11
		SERIAL NBR: 1303100101	APVL: JMC	12/08/17
		PRINT: 08Dec17	PM: JMC	12/08/17

PROCESS GAS

GAS1	N2	Nitrogen	cfh
GAS2	none	none	

SETTINGS FOR LOW O2 (<10 ppmv): SINGLE GAS

Replenish Rate is the number of times/minute that the furnace (or a section of the furnace) evacutes its gas

Replenish Rate	Furnace or Section Replenishes/Hour	Time to Refresh Furnace or Section
1 times/minute	60 times/hour	60 seconds
2 times/minute	120 times/hour	30 seconds
3 times/minute	180 times/hour	20 seconds
4 times/minute	240 times/hour	15 seconds

Different sections of the furnace can be replenished at different rates, if required

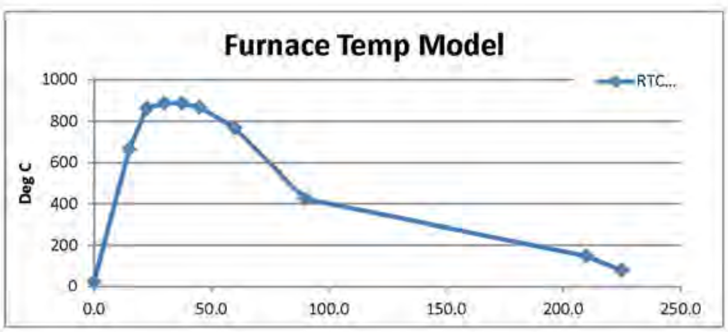
Flowmeters graduated in: scfh (lg=RMC flowmeters, sm=small RMA flowmeters) **1 per Minute** 8

BALANCE

200	scfh difference	=> Positive pressure in furnace to purge O2	
200	scfh grad	53.8%	incr (decr) of inflows over outflows

No.		Location	Label		Metered Gas	Flowmeter Size L/m	Replenish Rate Flow Setting sL/m grad	Desired Replenish Rate per Minute	Initial Flowmeter Setting scfh grad	Initial Flowmeter Setting sL/m grad
1	BESE	Entrance barrier	ENTRANCE BAFFLE		N2	200	15	2	20	20
2	Z1	Heating chamber 1	ZONE 1	865	N2	200	56	12	76	76
3	Z2	Heating chamber 1	ZONE 2	890	N2	200	37	8	51	51
4	Z3	Heating chamber 1	ZONE 3	890	N2	200	37	8	51	51
5	Z4	Heating chamber 1	ZONE 4	870	N2	200	38	8	51	51
6	TTSE	Transition tunnel Ed	TRANSITION TUNNEL		N2	200	15	2	21	21
7	CACT	Cooling section	COOLING TUNNEL		N2	200	34	2	46	46
8	HC	Heat chamber sides	LAMP SEALS		N2	200	37	2	50	50

	EXHAUST					distr %	scfh grad	scfh grad
7	EEBE	Entrance stack	ENTRANCE STACK	N2	100	50%	5.7	5.7
8	EETT	Transition tunnel	TRANSITION TUNNEL STACK	N2	100	50%	5.7	5.7
						100%		



Furnace Balance	scfh	scfh
Gas Inflow to furnace	372.0	372.0
Gas to Eductors	11.5	11.5
Total Gas Required	383.4	383.4
- Stack Exhaust Flow	183.4	183.4
Net inflow	200	200.0
	cu ft	L
Furnace internal volume	3.8	108.4

PROCESS GAS SUPPLY REQUIREMENTS			Temp C	Press psi	Gas	scfh	scfh
1	Gas 1	All	21	70	CDA	390.1	390.1
2	Gas 2		21	70	none	0.0	0.0
			STP = 21C, 1 atm		Total	390.1	390.1

DRAWINGS & SCHEMATICS

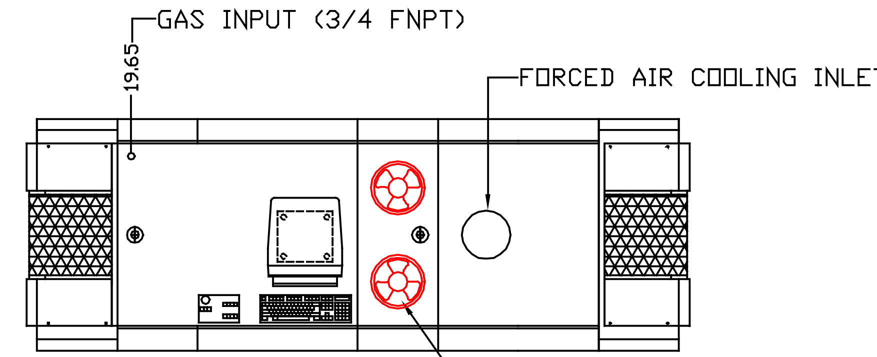
Job/Master	Drawing Nbr.	Title
RTC	3672-803-092435	FURNACE INSTALLATION, LA-310
RTC	803-091734-04	CHAMBER ARRANGEMENT, 4 ZONE
RTC	110-091769-80	TRANSPORT DRIVE GEAR MODULE ASSY
RTC	802-101770-01	POWER CONTROL SCH
RTC	802-101771	FRAME WIRING SCHEMATIC
RTC	802-101843	MOTOR SPEED CONTROL
RTC	802-101772	SIGNAL CONTROL WIRING
RTC	802-101773	OXYGEN ANALYZER
RTC	802-101775	LIGHT TOWER
RTC	802-101835	ELEMENT WIRING (2 SHT)
RTC	802-101905	OPTO22 JUMPER SETTINGS WITH EM

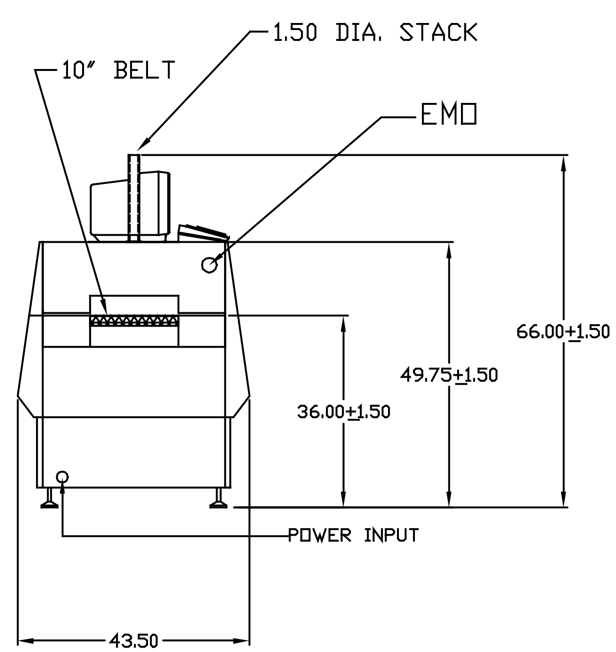
6.1 Furnace Arrangement LA-310X

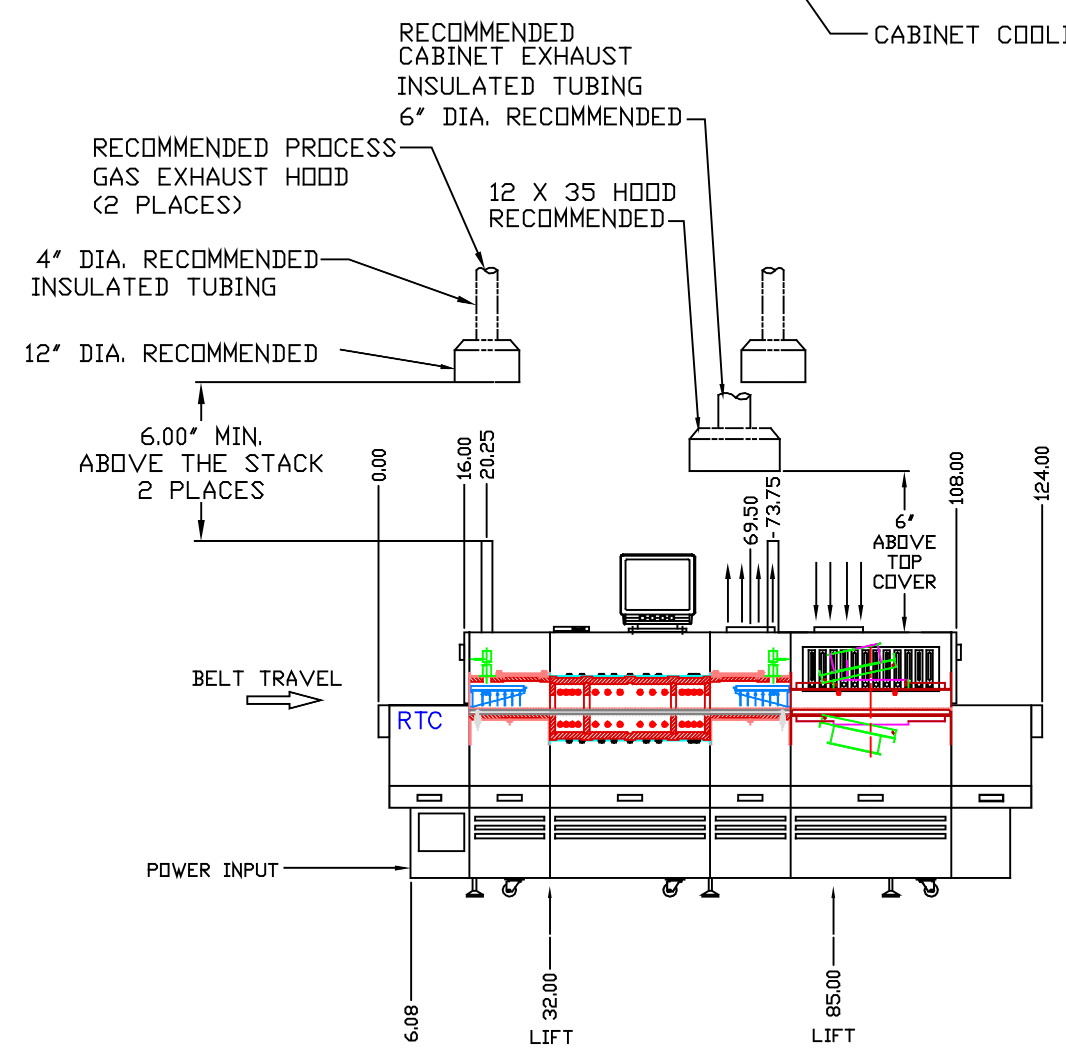
VOLTAGE		208 V	480 V	380 V
PEAK POWER CONSUMPTION		16 KW	22 KW	22 KW
MAX. CURRENT (UNBALANCED)		38 A	26 A	33 A
GAS CONSUMPTION (MAX)	NITROGEN	1800 SCFH W/ALL FLOWMETERS @100%		
NITROGEN/FORMING GAS		70 PSIG REGULATED PRESSURE		
PROCESS EXHAUST	AVERAGE	650 CFH		
	MAX	300° C		
CABINET EXHAUST	MAX	1000 CFM		
	MAX	40° C		

REVISIONS				
REV	DESCRIPTION	EO#	DATE	ASSIGNED
A	NEW RELEASE	32672	7/2/01	JM
B	CHANGED COOLING TOP COVER	40341	8/28/03	DP

210 SHOWN FOR 10"B, 2"TH





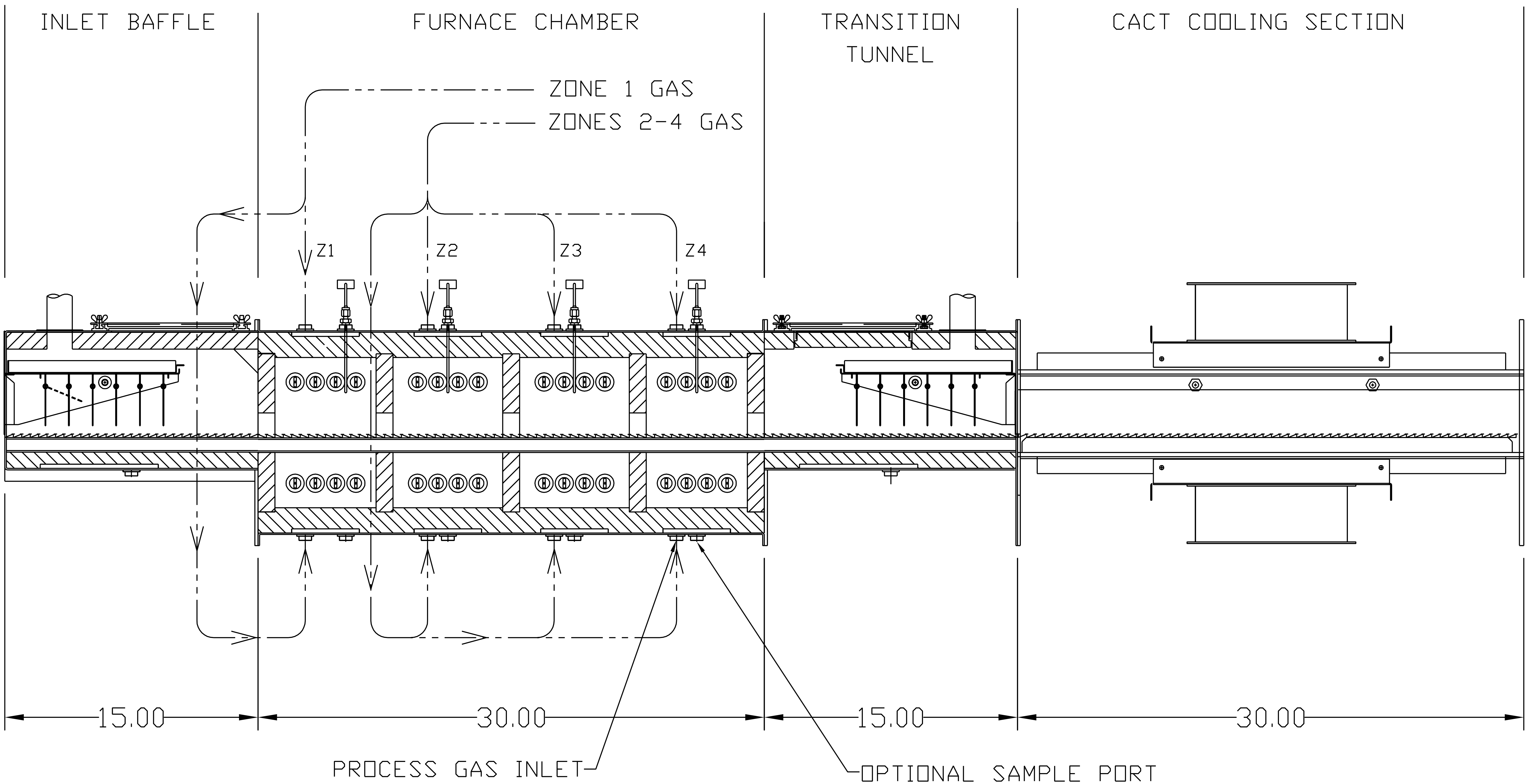


NOTES, UNLESS OTHERWISE SPECIFIED:

1. FOR COMPLETE INSTALLATION INSTRUCTIONS CONSULT FURNACE OPERATING MANUAL.
2. CONVEYOR HEIGHT IS ADJUSTABLE UP AND DOWN 1.5" FROM STATED 36.00".
3. 1/2" CLEARANCE BELT TO BAFFLE.
4. DIMENSIONS SHOWN FOR INSTALLATION REFERENCE ONLY (+ 1/2).
5. MAX PARTS HEIGHT 2 INCHES.

		PART NUMBER	DESCRIPTION	MATERIAL/STOCK SIZE
CONFIG.	32672	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: DECIMALS .XX ± .03 .XXX ± .010 ANGLES XX±.5° XX.X±.2° FRACTIONS X/X±1/32	CONTACT NO.	radiant technology corp. 1340 N. Jefferson St. Anaheim, California 92807
NEXT ASSY	USED ON	MATERIAL	APPROVALS / DATE	TITLE: INSTALLATION DWG LA-310
		FINISH	DRAWN: DANNY PHAN 8/28/03	SIZE: A
			CHECKED	FSCM NO.
			ISSUED	DWG. NO. 803-92435-XXX
APPLICATION		DO NOT SCALE DRAWING		REV. B
				SCALE NONE · SHEET 1 OF 1

6.2 Chamber Arrangement – 4Z



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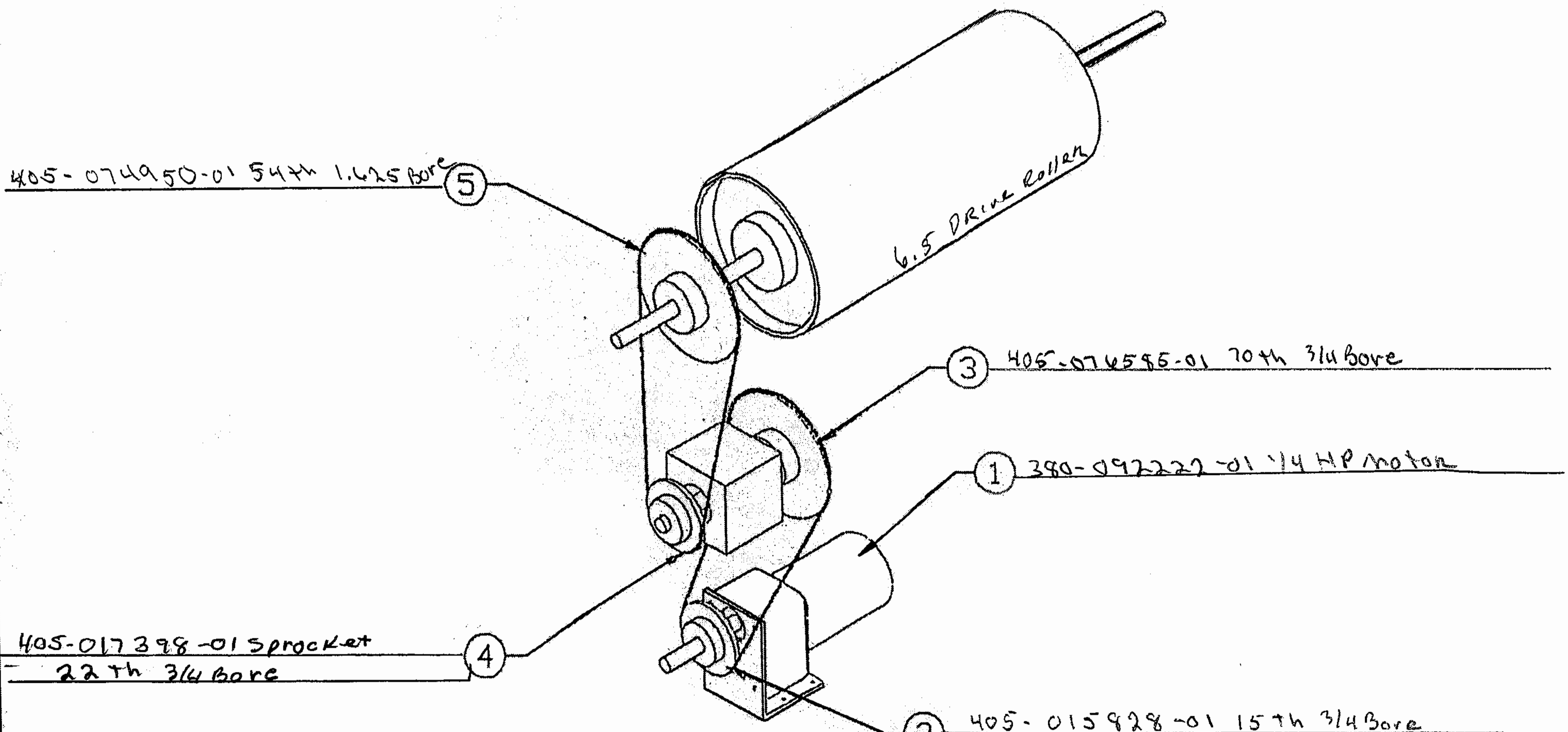
	MATERIAL	DRAWN C ROODE	10/29/12	TITLE CHAMBER ARRANGEMENT 4 ZONE LA-309
	FINISH	CHECKED		
		ISSUED		SIZE / JOB NO. STD / DWG. NO. 803-091734-04 / REV. -
	DO NOT SCALE DRAWING			SCALE NONE / SHEET 1 OF 1

6.3 Drive Gear Module Assy

REV	DESCRIPTION	DATE	APPROVED



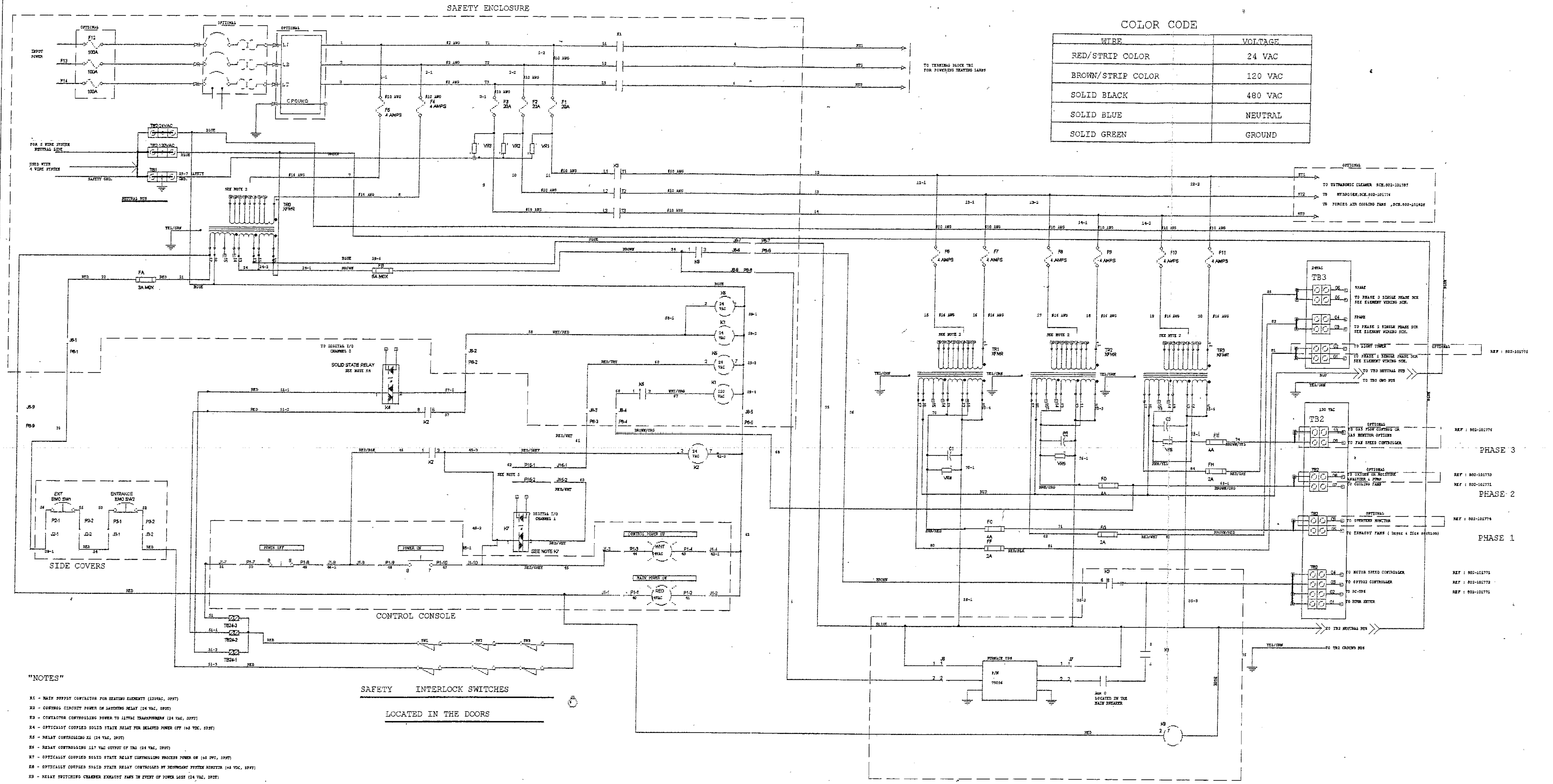
2. SEE B/M FOR ACTUAL PARTS USED.

1. DWG TO SHOW LOCATION OF SPROCKETS ONLY.

NOTE: UNLESS OTHERWISE SPECIFIED

MATERIAL SEE B/M		RTC
FINISH N/A		
DO NOT SCALE DRAWING	CONTRACT	TITLE GEAR MODULE ASS'Y REFERENCE DWG.
	DRAWN	
DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED TOLERANCES ARE:	CHECKED	SIZE A / DWG NO. / REV A
DECIMALS .XX±.03 .XXX±.010 ANGLES ±.05	RELEASED	
	FILE	SCALE NONE / DATE 5/1/97 / SHEET 1/1

6.2 Power Control Sch



COLOR CODE

WIRE	VOLTAGE
RED/STRIP COLOR	24 VAC
BROWN/STRIP COLOR	120 VAC
SOLID BLACK	480 VAC
SOLID BLUE	NEUTRAL
SOLID GREEN	GROUND

"NOTES"

K1 - MAIN SUPPLY CONTACTOR FOR HEATING ELEMENTS (120VAC, 3PST)

K2 - CONTROL CIRCUIT POWER ON LATCHING RELAY (24 VAC, DPDT)

K3 - CONTACTOR CONTROLLING POWER TO 117VAC TRANSFORMERS (24 VAC, 3PST)

K4 - OPTICALLY COUPLED SOLID STATE RELAY FOR DELAYED POWER OFF (+5 VDC, SPST)

K5 - RELAY CONTROLLING K1 (24 VAC, DPDT)

K6 - RELAY CONTROLLING 117 VAC OUTPUT OF TR0 (24 VAC, DPDT)

K7 - OPTICALLY COUPLED SOLID STATE RELAY CONTROLLING PROCESS POWER ON (+5 DVC, SPST)

K8 - OPTICALLY COUPLED SOLID STATE RELAY CONTROLLED BY REDUNDANT SYSTEM MONITOR (+5 VDC, SPST)

K9 - RELAY SWITCHING CHAMBER EXHAUST FANS IN EVENT OF POWER LOSS (24 VAC, DPDT)

1. FOR INPUT VOLTAGE OF 380VAC OR GREATER, CB1, CB3, CB4, CB5 ARE 4 AMP.
   FOR INPUT VOLTAGE OF 277VAC OR LESS, CB1, CB3, CB4, CB5 ARE 5 AMP.
2. CONNECT TAP ACCORDING TO LINE VOLTAGE.

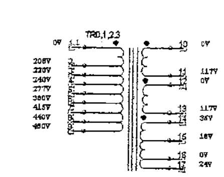
PIN #	VOLTAGE
2	208
3	220
4	240
5	277
6	380
7	415
8	440
9	480

3. ALL COMPONENTS EXCEPT AS NOTED ARE LOCATED ON THE POWER DISTRIBUTION PANEL.
4. ALL WIRES #18 AWG EXCEPT WHERE NOTED.
5. CONNECTOR P15 IS REPLACED WHEN THE OVER TEMP OPTION IS INSTALLED.
   SEE THE OVER TEMP.MONITOR WIRING SCHEMATIC FOR DETAILS.

P/N101677

6. SWITCH LABEL STARTS FROM SW1. TOTAL # OF SWITCHES IS DIFFERENT FROM ONE MACHINE TO THE OTHER ONE.

TRANSFORMER FOR REF. ONLY



APPROVALS	DATE
DRAWN ALEX REY	5/25/99
CHECKED	
ISSUED	

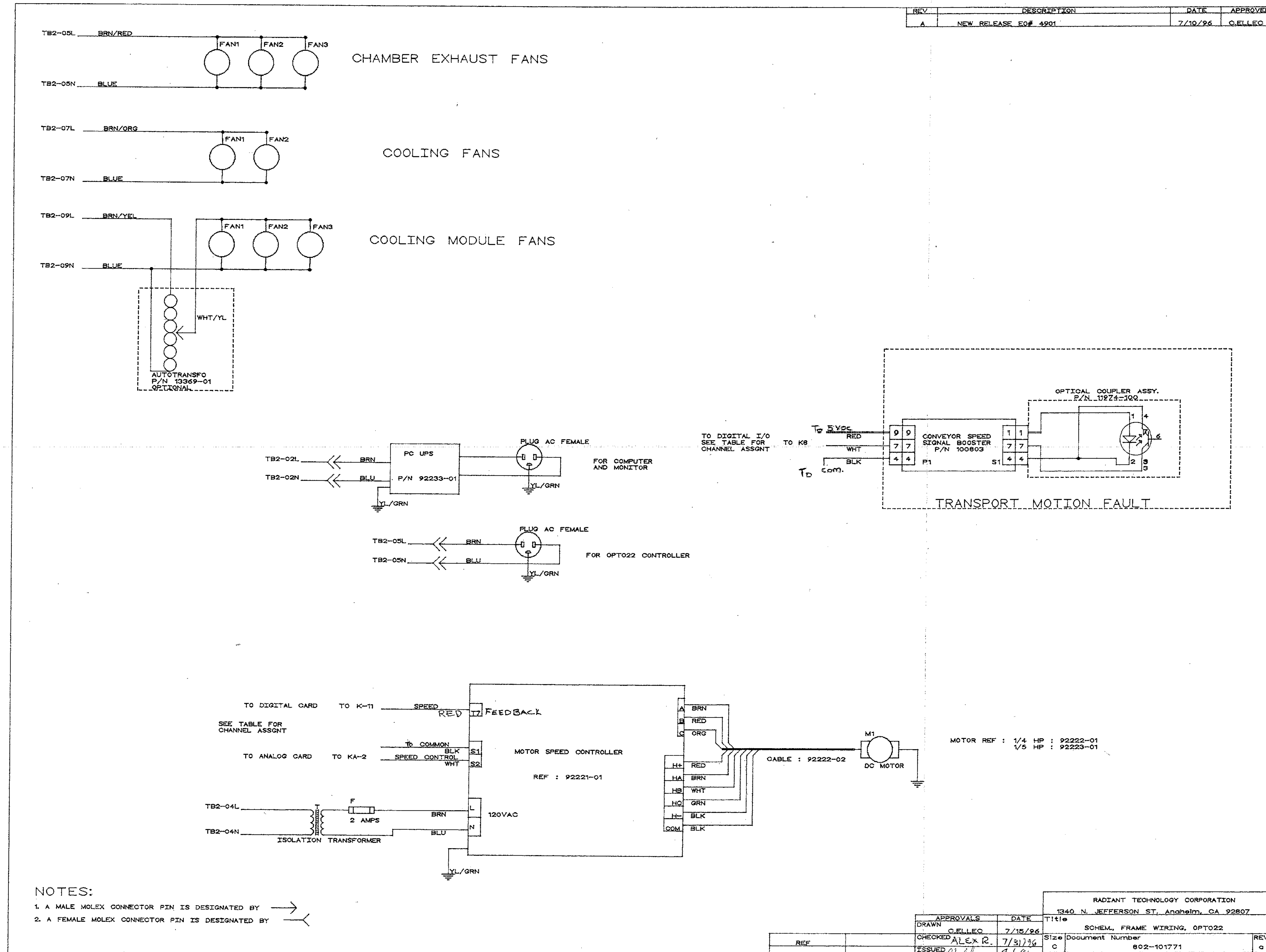
RADIANT TECHNOLOGY CORPORATION
1340 N. JEFFERSON ST., ANAHEIM, CA 92807

Title: SCHEM., POWER CONTROL OPTO22

Size: D | Document Number: 802-101770-01 | Rev: B

Date: Monday, May 24, 1999 | Sheet 1 of 1

6.3 Frame Wiring Sch

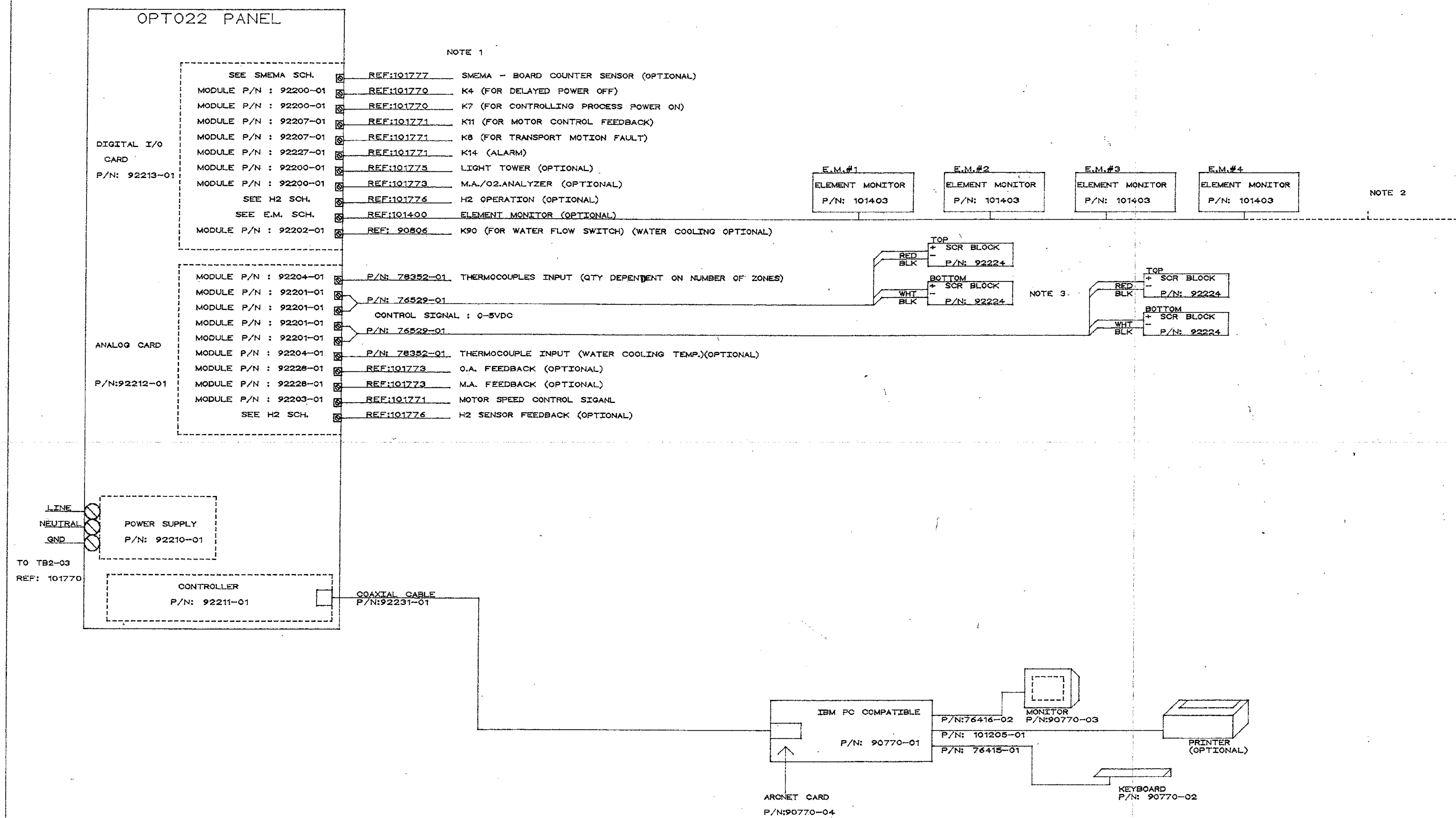


REV | DESCRIPTION | DATE | APPROVED
A | NEW RELEASE EO# 4901 | 7/10/96 | C.ELLEC
TB2-05L BRN/RED
FAN1 FAN2 FAN3
CHAMBER EXHAUST FANS
TB2-05N BLUE
TB2-07L BRN/ORG
FAN1 FAN2
COOLING FANS
TB2-07N BLUE
TB2-09L BRN/YEL
FAN1 FAN2 FAN3
COOLING MODULE FANS
TB2-09N BLUE
WHT/YL
AUTOTRANSFO P/N 13369-01 OPTIONAL
OPTICAL COUPLER ASSY. P/N 13874-100
TO DIGITAL I/O SEE TABLE FOR CHANNEL ASSGNT
TO K8
To 5VDC
RED
WHT
BLK
To com.
P1
CONVEYOR SPEED SIGNAL BOOSTER P/N 100803
S1
TRANSPORT MOTION FAULT
TB2-02L BRN
TB2-02N BLU
PC UPS
P/N 92233-01
YL/GRN
PLUG AC FEMALE
FOR COMPUTER AND MONITOR
YL/GRN
TB2-05L BRN
TB2-05N BLU
PLUG AC FEMALE
FOR OPTO22 CONTROLLER
YL/GRN
TO DIGITAL CARD TO K-11 SPEED
RED FEEDBACK
SEE TABLE FOR CHANNEL ASSGNT
TO COMMON
TO ANALOG CARD TO KA-2 SPEED CONTROL
BLK
WHT
S1
S2
MOTOR SPEED CONTROLLER
REF : 92221-01
A BRN
B RED
C ORG
H+ RED
HA BRN
HB WHT
HC GRN
H- BLK
COM BLK
CABLE : 92222-02
M1
DC MOTOR
MOTOR REF : 1/4 HP : 92222-01
1/5 HP : 92223-01
TB2-04L
TB2-04N
ISOLATION TRANSFORMER
F
2 AMPS
BRN
BLU
L
N
120VAC
YL/GRN
NOTES:
1. A MALE MOLEX CONNECTOR PIN IS DESIGNATED BY →
2. A FEMALE MOLEX CONNECTOR PIN IS DESIGNATED BY ≺
REF
APPROVALS DATE
DRAWN C.ELLEC 7/15/96
CHECKED ALEX R. 7/31/96
ISSUED 8-1-96
RADIANT TECHNOLOGY CORPORATION
1340 N. JEFFERSON ST. Anaheim, CA 92807
Title SCHEM., FRAME WIRING, OPTO22
Size C Document Number 802-101771 REV a
Date: July 31, 1996 Sheet 1 of 1

MASTER

6.4 Signal **Control** Wiring

REV	DESCRIPTION	DATE	APPROVED
A	NEW RELEASE EO# 4912	9/3/96	C.ELLEC



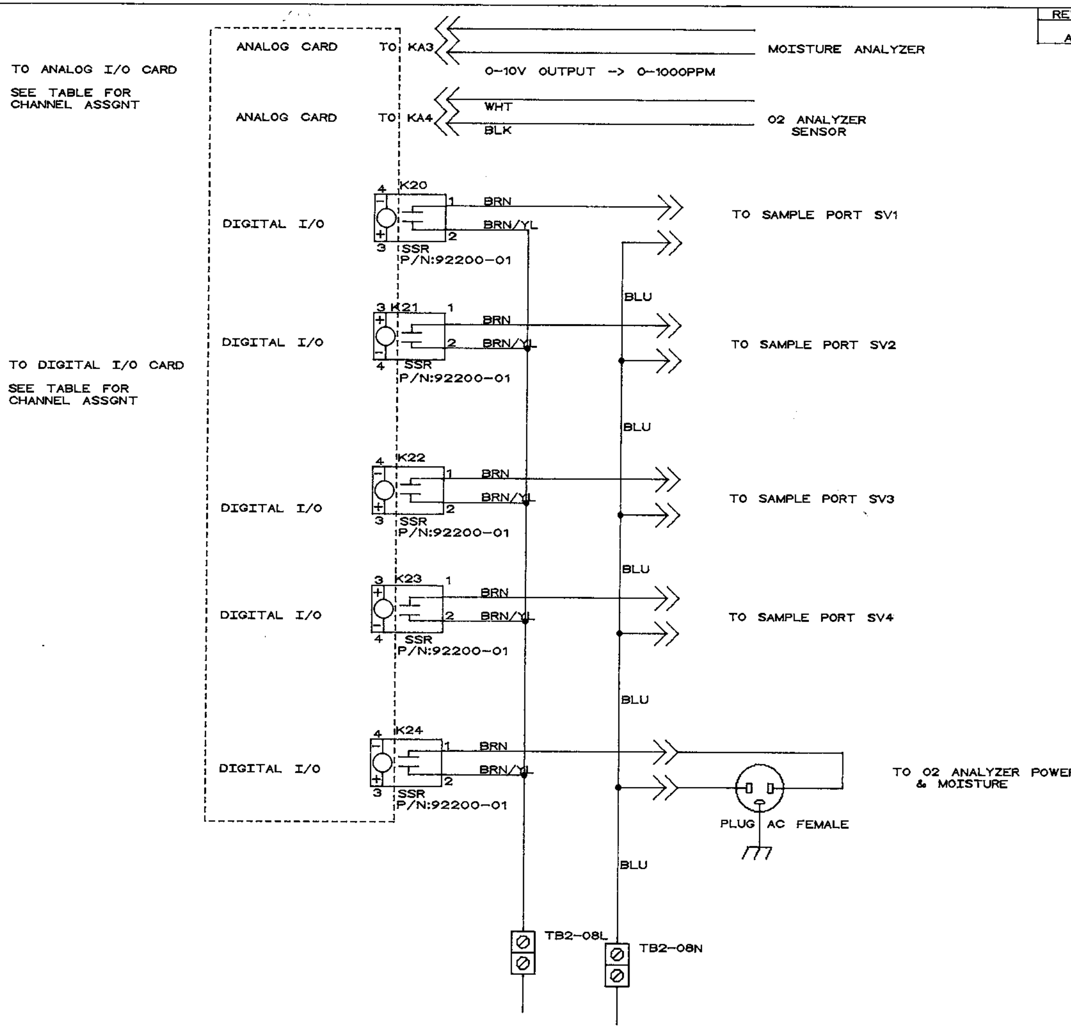
NOTES : 1 - SEE TABLE FOR CHANNEL ASSIGNEMENT
2 - SEE ELEMENT WIRING SCH. FOR NUMBER OF E.M. BOARDS
3 - SEE ELEMENT WIRING SCH. FOR NUMBER OF SCR BOARDS

MASTER

9-4-96

RADIANT TECHNOLOGY CORP. ANAHEIM, CA		
Title: SCH. SIGNAL CONTROL WIRING OPTO22		
Size: C	Document Number: 802-101772	REV: A
Date: September 4, 1996	Sheet	of

REV	DESCRIPTION	DATE	APPROVED
A	NEW RELEASE E.O. 4901	7/11/96	C.ELLEC

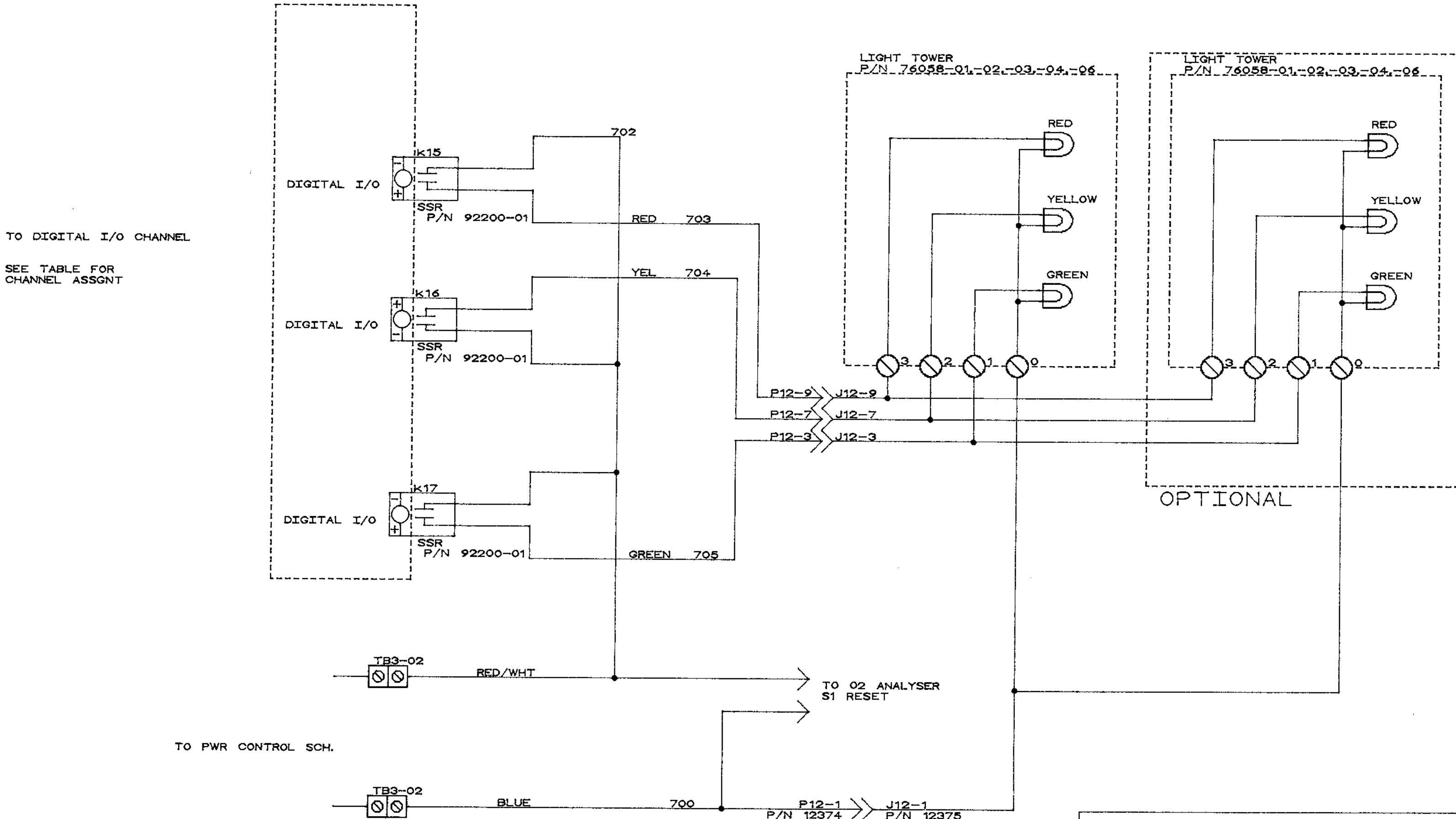


RADIANT TECHNOLOGY CORPORATION
1340 N. JEFFERSON
ANAHEIM, CA. 92807

APPROVALS	DATE
DRAWN C.ELLEC	7/11/96
CHECKED ALEX 2.6?	7/18/96

Title		
MA/02 ANALYSER WIRING - OPTO22 CONTROL		
Size	Document Number	REV
B	802-101773	A
Date: July 15, 1996	Sheet 1 of 1	

REV	DESCRIPTION	DATE	APPROVED
A	NEW RELEASE E.O. 4901	7/11/96	C.ELLEC



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ANAHEIM, CA. 92807

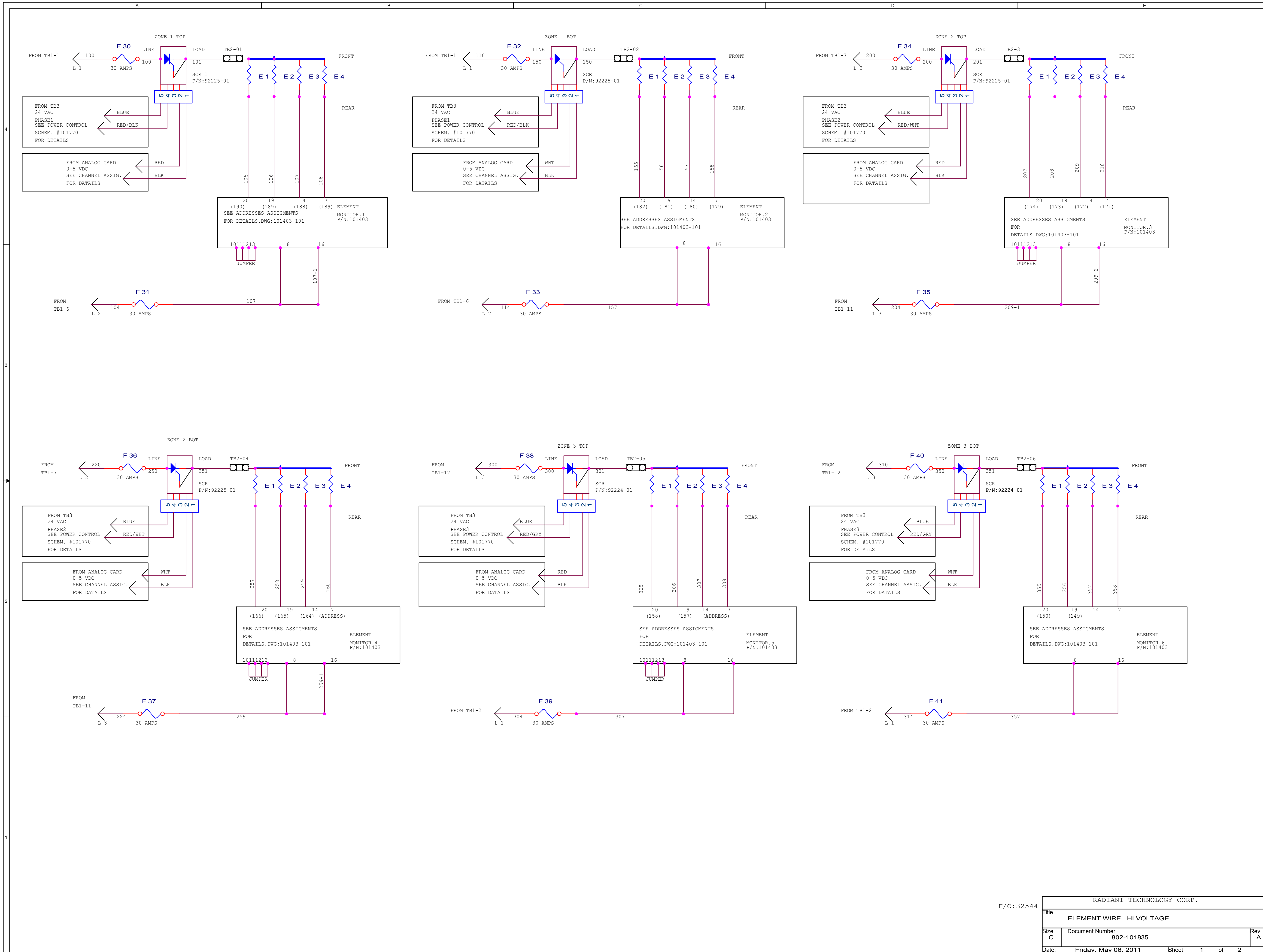
APPROVALS	DATE
DRAWN C.ELLEC	7/11/96
CHECKED ALEX REY	7/18/96

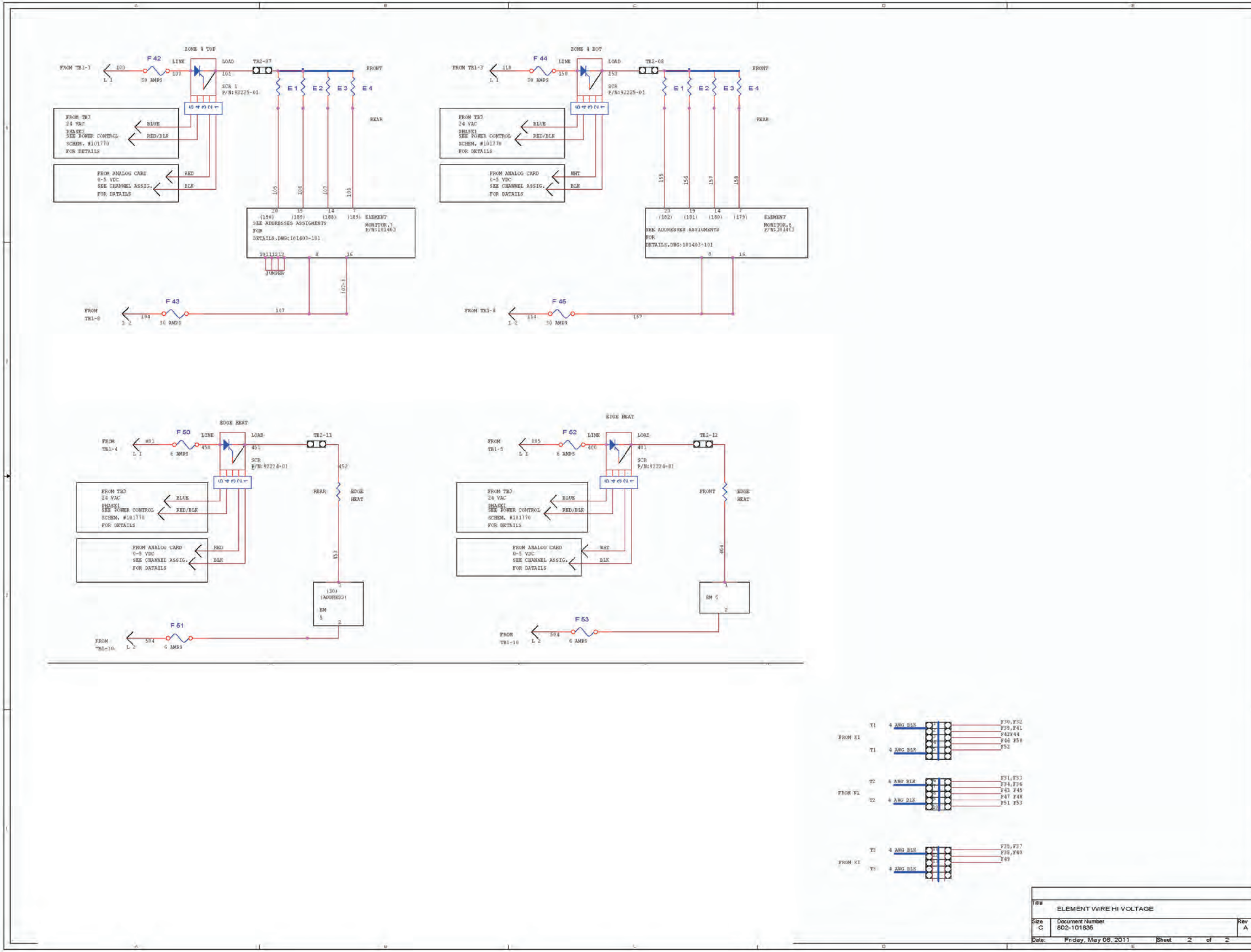
Title: LIGHT TOWER OPTO22 CONTROL

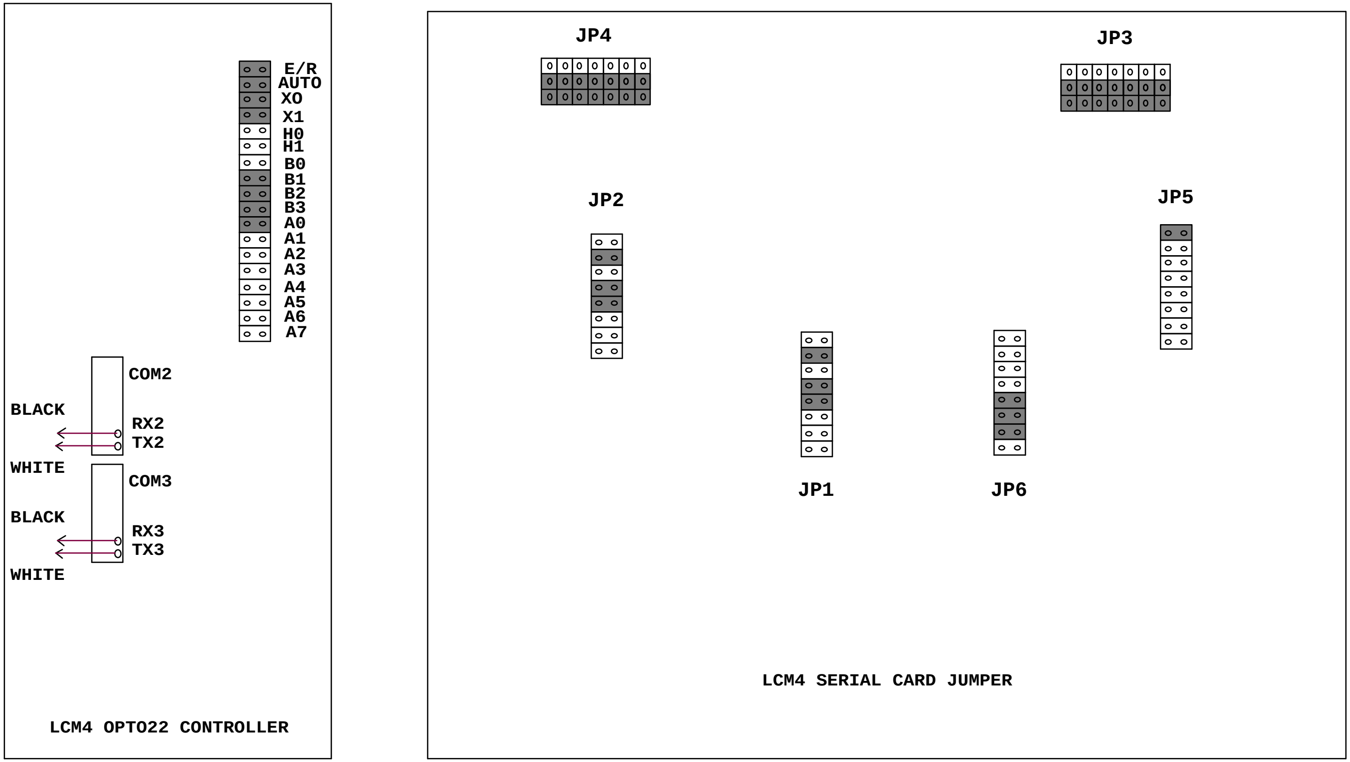
Size	Document Number	REV
B	802-101775	A

Date: July 15, 1996 Sheet 1 of 1

6.7 Element Wiring


ZONE 1 TOP
FROM TB1-1
L 1
F 30
30 AMPS
LINE
LOAD
TB2-01
FRONT
E 1
E 2
E 3
E 4
REAR
SCR 1
P/N:92225-01
FROM TB3
24 VAC
PHASE1
SEE POWER CONTROL
SCHEM. #101770
FOR DETAILS
BLUE
RED/BLK
FROM ANALOG CARD
0-5 VDC
SEE CHANNEL ASSIG.
FOR DATAILS
RED
BLK
SEE ADDRESSES ASSIGMENTS
FOR DETAILS.DWG:101403-101
ELEMENT
MONITOR.1
P/N:101403
JUMPER
FROM TB1-6
L 2
F 31
30 AMPS
ZONE 1 BOT
F 32
TB2-02
MONITOR.2
FROM TB1-6
F 33
ZONE 2 TOP
FROM TB1-7
F 34
TB2-3
PHASE2
RED/WHT
MONITOR.3
FROM TB1-11
L 3
F 35
ZONE 2 BOT
F 36
TB2-04
WHT
MONITOR.4
F 37
ZONE 3 TOP
FROM TB1-12
F 38
TB2-05
P/N:92224-01
PHASE3
RED/GRY
MONITOR.5
FROM TB1-2
F 39
ZONE 3 BOT
F 40
TB2-06
MONITOR.6
F 41
F/O:32544
RADIANT TECHNOLOGY CORP.
Title
ELEMENT WIRE HI VOLTAGE
Size C
Document Number
802-101835
Rev A
Date: Friday, May 06, 2011
Sheet 1 of 2


ZONE 4 TOP
FROM TB1-7
F 42
30 AMPS
LINE
LOAD
SCR 1
P/N:92225-01
TB2-07
E 1
E 2
E 3
E 4
FRONT
REAR
FROM TB3
24 VAC
PHASE1
SEE POWER CONTROL
SCHEM. #101770
FOR DETAILS
BLUE
RED/BLK
FROM ANALOG CARD
0-5 VDC
SEE CHANNEL ASSIG.
FOR DETAILS
RED
BLK
ELEMENT
MONITOR 7
P/N:101403
SEE ADDRESSES ASSIGMENTS
FOR
DETAILS.DWG:101403-101
JUMPER
F 43
30 AMPS
FROM TB1-8
ZONE 4 BOT
F 44
F 45
TB2-08
ELEMENT
MONITOR 8
P/N:101403
WHT
EDGE HEAT
F 50
6 AMPS
FROM TB1-4
TB2-11
SCR
P/N:92224-01
REAR
EDGE HEAT
(20)
(ADDRESS)
EM
F 51
FROM TB1-10
F 52
FROM TB1-5
TB2-12
FRONT
EM 6
F 53
FROM K1
4 AWG BLK
Title
ELEMENT WIRE HI VOLTAGE
Size
C
Document Number
802-101835
Rev
A
Date: Friday, May 06, 2011
Sheet 2 of 2



JUMPER PLACEMENT(TYPICAL)

NO JUMPER (TYPICAL)

COM2 COMMUNICATION TO BRICKS
COM3 COMMUNICATION TO ELEMENT MONITOR BOARDS

Title	LCM44 JUMPER SETTINGS
Size: A	Document Number: 802-101905 — Rev: A
Date: Saturday, May 14, 2005	Sheet 1 of 1

7.1 IR Furnace Process

The infrared furnace continuously processes product on a moving belt. Each product moves through the same areas and is exposed to the same process elements. The furnace process sections are shown in Figure 7-1.

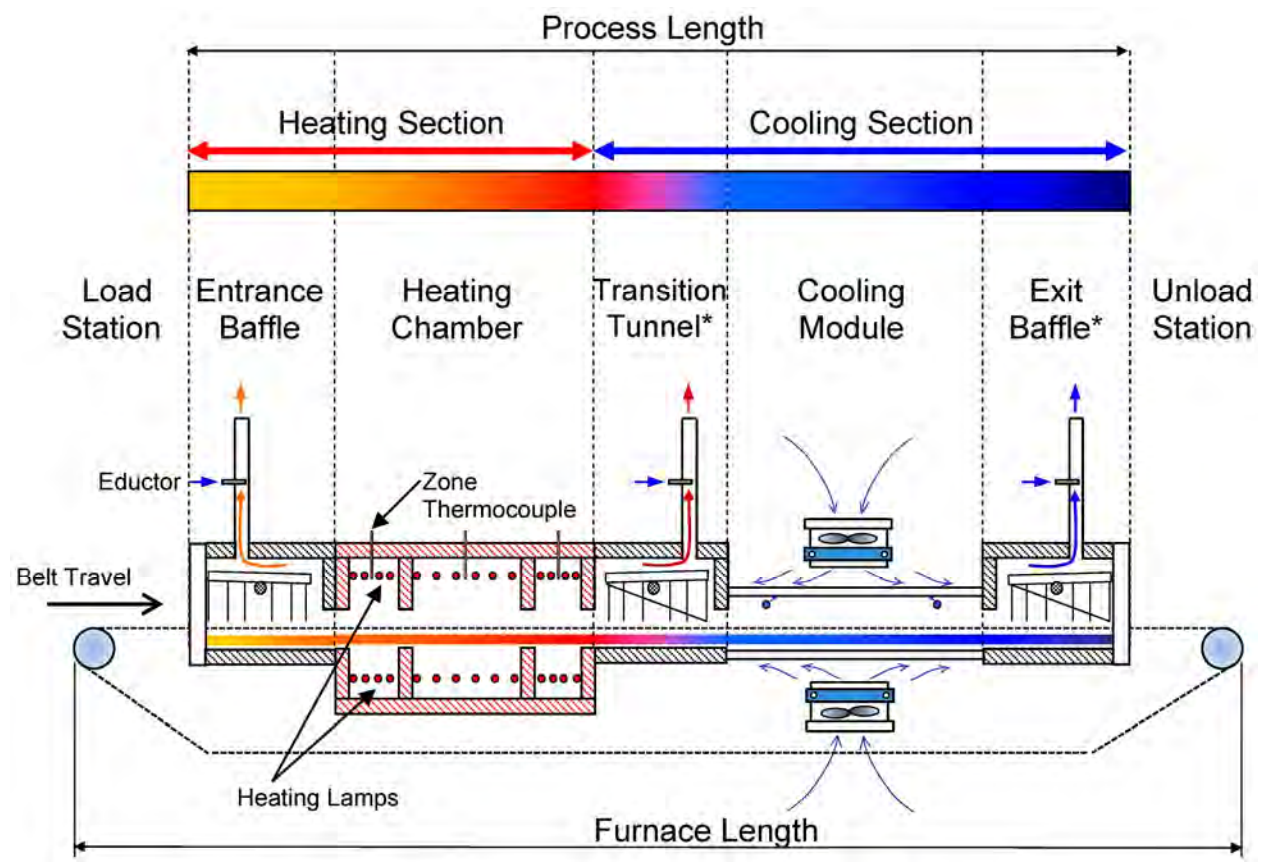


Figure 7-1 IR Furnace Process Sections

*Furnace configurations vary. Some furnaces are not equipped with a stack on the Transition Tunnel or an Exit Baffle.

Continuous IR Processing is generally characterized by rapid ramping rates, ability to vary temperatures greatly from zone to zone and consistent processing performance in a controlled atmosphere. Establishing an acceptable profile and stabilizing the furnace are key to successful thermal processing. This is done by managing the following:

- Zone Temperatures
- Belt Speed
- Process Gas inflow
- Balancing the Gas flow using exhaust venturi flow
- PID Loop and Zone Power adjustments

7.1.1 Zone Temperatures

Set zone temperature controllers so that the furnace can easily achieve the required temperatures in each heating zone.

7.1.2 Belt Speed

If the profile temperatures are acceptable, but the period it too long or short, vary the belt speed to achieve the required retention time. Increasing belt speed reduces process time, reducing belt speed increased time at temperature. Adjusting belt speed will also affect ramping time. Be careful to keep belt speed low enough to assure the product has adequate time to cool before it reached the exit belt roller.

7.1.3 Process Gas Inflow

Process gas introduced into the furnace through the chamber walls serves to keep the lamps ON and thereby improving process control. Too much gas will force lamps ON and use more power than may be necessary. Too little gas with allow the lamps to shut OFF. While the furnace is coasting, it is out of control and may result in uneven results.

The process gas flow can be adjusted to replenish the gas in each zone by multiples of the volume of that zone. Replenish rates for normal processing are 1-2x. If processing requires very low moisture and/or oxygen concentrations below 20 ppmv, higher replenish rates in the zones may be required to achieve good results. See section **7.5 Gas Flow** through **7.5.8 Process Gas Flow Guidelines** for detailed information of gas flow replenish rates and balancing the furnace.

7.1.4 Balancing the Gas Flow

One the process gas inflows are set, the exhaust stacks must be adjusted for the type of environment desired. If the process being run required very low moisture and/or oxygen concentrations, the furnace atmosphere should be positive (internal pressure higher than the pressure of the room). To establish a positive atmosphere in the furnace, sum the inflows, subtract excess gas amount (typically 50-200 Lpm) and divide 15 to determine the stack exhaust flow settings.

If the process may give off volatile or poisonous gas, set the furnace to neutral or negative atmosphere (furnace internal pressure lower than room atmospheric pressure). To achieve a negative atmosphere, sum the inflows, add excess gas amount (typically 50-200 Lpm), and divide by 15 to determine the stack exhaust flow settings.

The furnace eductors are designed to extract the process gas from the furnace and cooling section internals at approximately 15 times the flow to the stack eductor. For example to extract 250 Lpm from the furnace via the stack, set the stack flow to 17 (250/15 = 16.67). See section **3.4** Error! Reference source not found. for recommended initial settings. See sections for 8.5 through 8.8 for process engineering considerations.

7.1.5 PID and Zone Power

While the furnace PID settings are preset at the factory, sometimes a process requires adjustment of these parameters to achieve desired results. In addition on computer controlled furnaces, adjusting the zone power settings can dampen furnace performance. Increasing zone power will increase furnace responsiveness.

In furnace with independent zone controllers, the Autotune feature can aid in optimizing zone controller performance. See section Error! Reference source not found. Error! Reference source not found. and **7.4 PID Tuning** for more details.

7.2 Furnace Construction

The heating chamber technology allows for rapid heat-up and cool-down times. Stable temperatures of up to 1000ºC can often be reached in less than 20 minutes. Radiant heating allows for rapid startups and profile changes and system stabilization.

The heating chambers consist of an outer metallic shell fabricated from either aluminum or stainless steel, lined with a refractory-ceramic-fiber (RCF) insulation. Controlled atmosphere heated sections allow process gas to pass through the RCF insulation.

7.2.1 Modules

The furnace is constructed from a number of basic modules which make up the furnace length.

For example, the standard LA-310 is comprised of 7 modules

Module 1 – Loading Station

Module 2 – Entrance Baffle

Module 3 – 3-Zone Heating Chamber Module

Module 4 – Transition Tunnel

Module 5 – Controlled Atmosphere Cooling Module

Module 6 – Unloading Station

In some applications, longer cooling sections are required. Additional controlled atmosphere cooling modules, a water cooling system, or a forced air cooling module after the exit baffle may be added.

Another application may call for a longer heating section with an additional 4-Zone heating chamber module.

Every furnace heating chamber is constructed with 30-in. (76-cm) modules. Depending upon application requirements, the furnace can be configured for any size up to 16 zones. Each furnace is a custom arrangement from standard design modules, the layout and overall design is completed prior to the start of fabrication.

7.2.2 Throat

The throat of the furnace describes the maximum height of any product allowable through the process section. Depending upon configuration, throat clearance can range from 0.75 to 4 inches. The throat height has a significant impact on the thermal process profile as gas flow between chambers is significantly increased as the throat is increased.

Warning: Feeding items trough the furnace that exceed the throat clearance will damage furnace zone separators and may reduce furnace performance.

7.3 Heating Chamber Design

7.3.1 Zones

The heating chambers are divided into individually controlled **zones**. Each 30" chamber module can be divided into 1, 2, 3 or 4 zones. If the furnace requires more than 4 zones, additional heating chamber modules must be added. The zone configuration of your furnace depends on the type of processes your furnace will be running and is part of the project furnace design specification.

7.3.2 Infrared Heating Chamber

The chamber is insulated with a porous material and if the furnace is used in a controlled atmosphere application, pressurized process-gas entering **plenums** at the top and bottom diffuses through the porous insulation and enters the process area. The gas enters in high volume and with low velocity. As the gas diffuses, it becomes heated to the bulk temperature of the zone.

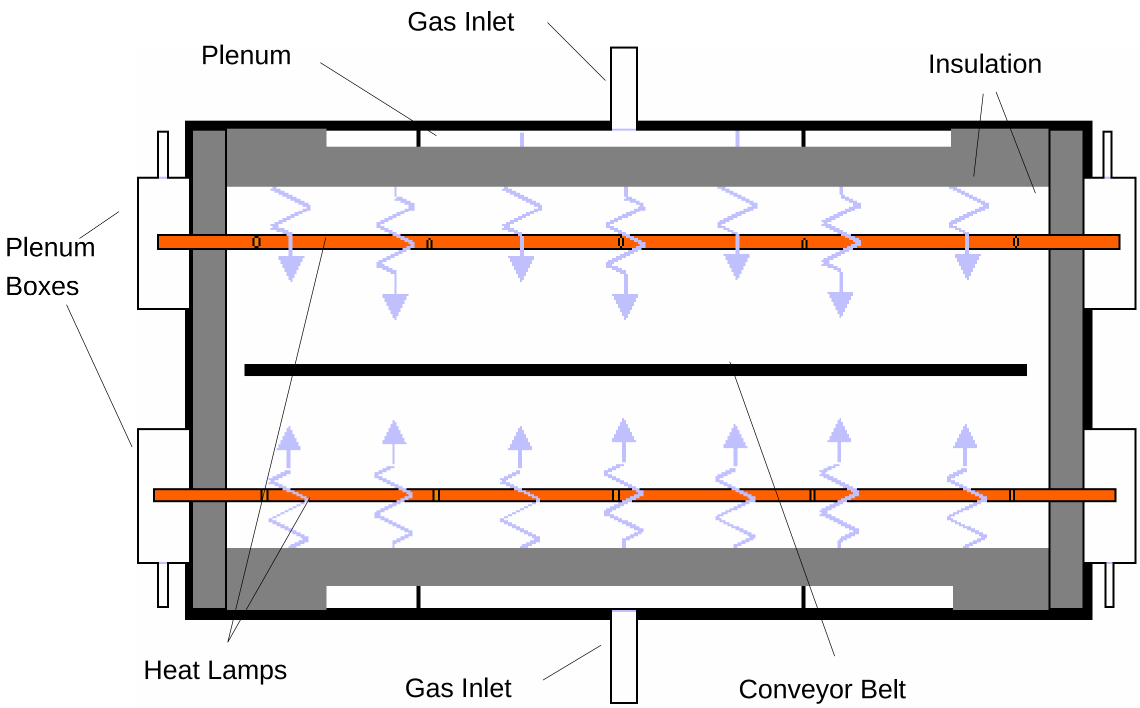


Figure 7-2 Heating Chamber Construction. End view

Plenum boxes may be specified and included as part of the hermetic seal option, which allows a light positive pressure to be applied to the ends of the heat lamps forming a highly controlled atmosphere condition.

Correctly balancing the airflow contributes greatly to the cleanliness of the chamber. When properly balanced, a high volume gas-flow is present from both top and bottom of the chamber. Effluents released from your product are swept along the centerline of the chamber to the exhaust ports, and do not rise to contact the upper surfaces or fall to contaminate lower surfaces.

Incoming process gas introduced through a large displacement area provides rapid purge times and low contamination levels. Typically, a process environment atmosphere of less than 10 parts Oxygen in 1,000,000 parts Nitrogen (<10ppm O2) can be achieved within about 10 minutes. Rapid purge times also allow for quick process environment replenishments as well as fast cool-down times.

7.3.3 Energy Type for Applications

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

7.3.4 Placement

Lamp configuration within each zone is determined to achieve optimal power consumption based on the type of processes specified by the owner operator. Heat lamps can be packed closely together where high temperatures need to be reached quickly. For Holding Zones where rapid rises to high temperatures are not required, lamps are usually spaced further apart.

7.3.5 Wiring

Heating lamps are wired differently for each furnace. The actual amount of power available to each lamp is based upon the heat lamp wiring configuration and the AC input voltage. Lamps may be wired in parallel providing the highest available power to the individual lamp or in series, splitting the power with other lamps. Most systems are wired in a series-parallel configuration to optimize the use of available voltage and minimize current flow. Refer to the wiring diagram in the Operating Manual for heat lamp wiring details for a specific furnace.

7.4 PID Tuning Concepts

When the furnace is in operation, the power supplied to the lamps is under constant control. A special performance control is used to maintain consistent zone temperatures by adjusting the current allowed to reach the heat lamps. The control is referred to as a PID control loop. The name PID stands for **P**roportional + **I**ntegral + **D**erivative and represents the three terms used in the control loop.

When PID tuning, any changes that are made are sent directly to the controller modifying the way the controller responds to deviations from setpoint. Tuning the furnace allows the engineer to precisely control the temperature profile inside the furnace.

A complete understanding of how a PID loop works and how to tune it will greatly benefit the owner operator and product results.

In general, the PID equation takes on the following form:

$$\mathrm{CO} = G \cdot \left\{ (S - T) + \frac{1}{I}\int_{0}^{1\,\mathrm{sec}} T \cdot dt + D \cdot \frac{dT}{dt} \right\}$$

Where:

$T = \text{Temperature}$

$t = \text{Time}$

$G = \text{Gain Term Value}$

$S = \text{Setpoint Temperature}$

$I = \text{Integral Term Value}$

$D = \text{Derivative Term Value}$

The output from the three terms, the proportional, the integral and the derivative terms are summed to calculate the output of the PID controller. The following paragraphs review and explain the three components of the PID equation.

7.4.1 Gain

The proportional band is adjusted according to the following equation

PB °C = 100 °C / Gain

The higher the gain, the narrower the proportional band; the lower the gain, the wider the proportional band.

The gain value multiplies the difference between the setpoint and actual temperature. The difference between these two values is referred to as the **error.** (This does not mean that anything is wrong). The error is measured continuously, about once a second. When this difference is large, power to the heat lamps will be increased, or decreased, accordingly. When the error is small, power to the heat lamps will be maintained at present levels. Gain values greater than 1 amplify the controller's response to error (differences between temperature and setpoint).

Setting the gain too high will result in temperature over and under shoots. It is possible that the temperature will never reach a stable state. The temperature might oscillate around the setpoint.

Setting the gain too low will result in a slow response to temperature changes. The furnace will take longer to reach operating temperatures and will be slower to recover from temperature drops as the product soaks up heat.

> Note: Since the gain value is a multiplier, it should not be set to zero.

Default values for gain vary for each zone and temperature setpoint range. Gain is typically set at default values from **40** to **95** for most applications.

7.4.2 Integral

With only gain operating, and no value set for integral and derivative, the controller acts somewhat like a thermostat. When the difference between temperature and setpoint (error) is zero, power to the heat lamps is maintained at current levels. When the temperature drops below the setpoint, power is increased until the temperature returns to the setpoint. This PID setting results in an operating condition where the measured temperature is often inappropriately far from the temperature setpoint.

The integral value is used to rapidly converge on the set point.

The **integral value** refers to the integer value entered in the recipe screen. The **integral term** is calculated automatically by the controller. The integral value multiplies the integral term.

The Integral term in the PID equation represents the average error (temperature difference) over a time interval of about one second and is updated continuously, accumulating error as a function of time.

The integral product (**integral value** multiplied by **integral term**) is added to the error. This integral product can make a significant difference to the PID control output signal especially if the current error is small.

Think of it this way: The difference between temperature and setpoint at any given time could be zero, but the average difference between temperature and setpoint over the length of time represented by the integral term is never likely to be zero. With an integral value of zero, power will be maintained at its current level even though the temperature is about to decrease. With an integral value greater than zero, multiplying the integral term, power will be increased slightly and the impending temperature drop will be not be as profound.

With a Gain and an Integral value entered in a recipe, the PID equation will always be adjusting the controller's output unless the both the **current difference** and **average difference** between temperature and setpoint is zero.

Larger integral values generate smaller responses from the controller. A value of 1, for instance, will use the entire average difference between temperature and setpoint for the correction value. A value of 2 will use half the average difference for the calculation. Entering very large integer values will have the same effect as entering zero.

Default values for integral vary for each zone and temperature setpoint range. Integral is typically set at default values from **8** to **15** for most applications.

7.4.3 Derivative

The derivative term of the PID equation is a value representing the rate of change of the temperature setpoint deviation. If, for example, the temperature deviation is accelerating away from the setpoint, the derivative term attempts to predict what the deviation will be some short time in the future. This behavior allows the derivative to sense a change in load early and attempt to counteract its effect ahead of time.

Suppose, for example, that the zone temperature is deviating downwards from the setpoint at 10°C/second. At the next measurement, the temperature is deviating downwards at a rate of 20°C/second. The derivative term will sense this acceleration away from the setpoint and counteract it by increasing the PID signal to the controller. The larger the derivative value entered in the recipe screen, the larger the correction.

A zero value may be appropriate for many processes with constant furnace loading (a continuous stream of similar parts entering the furnace).

For processes where furnace loading is uneven, such as when parts arrive from screen printers or non-buffered processes in an automated line, a non-zero derivative term may help the furnace respond more quickly when parts suddenly enter the heating zones.

Care must be taken when entering derivative terms higher than 4 due to the fast response of the IR furnace.

Detecting an accelerating deviation from setpoint requires at least three temperature measurements. Therefore, at least two seconds elapse before a correction can be made. Heat lamps are very responsive and very little amplification is needed to correct the lamp output. The derivative can show a downwards accelerating temperature deviation even though the temperature may have started increasing. This condition can result in an over correction.

Even when furnace loading is fairly constant, Derivative can vary for each zone and temperature setpoint range. Derivative is typically set at default values of **1** to **3** for most applications.

7.5 Gas Flow

7.5.1 Gas Flow Basics

The most important factor in creating a safe and efficient process environment is gas-flow balance. The volume of process gas entering the system should be equal to the volume of exhaust gas leaving the system.

Gas flow entering the oven is controlled by **flow meters**. The flow meter arrangement is different for every furnace. A flow meter can be installed to supply gas for each individual zone or for various combinations of zones.

All furnaces are equipped with gas power exhausts. Compressed gas (usually air or nitrogen) is forced through a small hole in a small tube creating a venturi effect inside the exhaust stack. The forced high-speed gas flow drags the furnace atmosphere out with it. To regulate the rate of exhaust, each venturi is supplied by its own flow meter.

Correct gas flow through the venturi is a critical factor in achieving stable temperature profiles. For this reason, exhaust stacks cannot be connected to facilities ducting. Changes in facilities-ducting pressure would change exhaust pressure that would in turn change the gas flow within the furnace. The condition will lead to alterations in the thermal process profile.

Disruptions in gas flow in the process section can be caused by the following influencers:

- Close proximity of doors
- Close proximity fans
- Placing a furnace through a wall between rooms
- Attaching facility exhaust ducts directly to the furnace exhaust stack

7.5.2 Process Gas

Various forms of process gas can be utilized inside furnaces. Users may want to operate a pure N_2, O_2 or H_2 environment. Others will only need clean dry air (CDA). Whatever the case, the furnace can be factory configured in different ways to meet specific requirements. The following are some possible process gases.

7.5.3 Nitrogen

Many processes require the process environment be free, or almost free, of oxygen as the products would either burn or oxidize. Removing oxygen involves forcing the oxygen out by pumping in another gas. A relatively inert gas such as nitrogen is normally used for this purpose.

7.5.4 Forming Gas

Forming gas is the term used to describe any mixture of N_2 and H_2 gas. Without the Hydrogen option, only non-combustible gas can be used safely with the LA-310.

7.5.5 Hydrogen

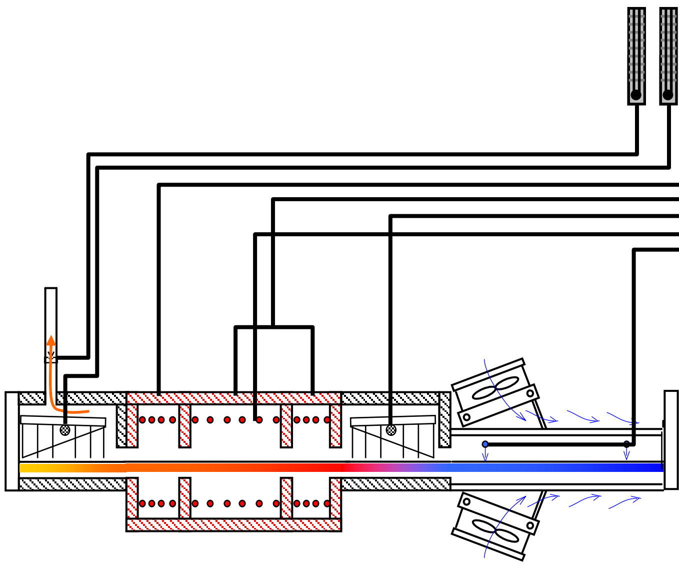
Other gases having a beneficial effect on a process can also be introduced into the process environment. Hydrogen, for example, is commonly used in reflow soldering processes to facilitate solder flow. Without the Hydrogen option, only non-combustible gas can be used safely with the LA-310.

All processes with concentrations of H_2 higher than 4% mass percent require all H_2 automated safety features. When the concentration of H_2 gas required for the process falls below 4%, H_2 levels will not reach an explosive concentration inside a furnace.

7.5.6 Creating an Optimum Process Environment

To establish a process environment, the engineer will need to start with the number of times the air surrounding the product will need to be replenished. This figure depends very much on the process requirements and costs. Some processes give off large quantities of volatiles that will need to be removed, requiring higher gas flow rates than other, cleaner processes. The cost of the process gas will also need to be taken into account, as quick replenishment times will use significant volumes of gas. For new processes, it may be safest to start with a high gas flow rate that can be adjusted downwards until the test product stops coming out clean.

The first step in calculating the flow rates will be to calculate the internal volume of the furnace chamber and multiply the answer by the number of times per hour that the atmosphere needs replenishing. The result is the total gas flow per hour for the chamber.



- Entrance Eductor
- Entrance Baffle
- Zone 1
- Zone 2-3
- Transition Baffle
- Lamp Seals
- Cooling Section

A. Calculate the Internal Volume of an LA-310 Furnace

Example 1:

The process engineer determines the thermal process replenish time is 30 seconds.

Given: *Replenishment Requirement: 30 seconds / replenish*
Belt Width: 6 in.

Process Section Dimensions *(Not including Open Air cooling modules)*
The better the estimate of internal volume, the less tuning required.

	L (cm)	*W (cm)*	*H (cm)*	*V (cm^3)*
Entrance Baffle	*38*	*17.8*	*15.2*	*10 324*
Zone 1	*19*	*17.8*	*22.9*	*7 8743*
Zone 2	*38*	*17.8*	*22.9*	*15 486*
Zone 3	*19*	*17.8*	*22.9*	*7 743*
Trans Tunnel	*38*	*17.8*	*15.2*	*10 324*
Cooling	*76*	*17.8*	*15.2*	*20 648*
Lamp Seals	*305*	*2.5*	*5.1*	*3 933*
Total Internal Volume				*72 267*

B. Calculate Replenish Rate

Convert furnace Volume from cubic centimeters to liters:

72 267 ~~cm~~^{3} / 1000 ~~cm~~^{3}/L

= 72 L / replenish

Convert to L/min

1 minute = 60 seconds

60 ~~seconds~~/min / (30 ~~seconds~~ / replenish) = 2.0 replenishes / min

(2.0 ~~replenishes~~ / min) x (100 L / ~~replenish~~) = 144 L / min

Balancing Gas Flow, Q = 144 L/min (actual liters per minute)

From these calculations you can balance the furnace environment with a total gas flow of 1,444 L/min.

Note: although the above result is not true Lpm, it can be used to balance the furnace. The flowmeter scales are labeled in Lpm, but are not corrected for actual conditions. To calculate true Lpm, convert using Boyles law:

Correct for temperature and pressure to convert from CFH to standard cubic feet per hour (SCFH), assuming the inside of the furnace is at 1 atmosphere:

$$\text{sLpm} = \text{aLpm} \text{ x } \frac{(\text{Std Temperatur e x Actual Pressure})}{(\text{Act Temperatur e x Std Pressure})}$$

Actual Furnace Temperature, T1 = 38C + 273 = 311 K

Actual Pressure, P1 = 0 kPa + 101.3 kPa = 101.3 kPa

Standard Temperature, Ts = 21C + 273 = 294 K

Standard Pressure, Ps = 101.3 kPa

$$\text{sLpm} = 144 \text{ x } \frac{(294 \text{ K x } 101.3 \text{ kPa})}{(311 \text{ K x } 101.3 \text{ kPa})}$$

True Standard Gas Flow, Q_s = 137 sLpm (21C, 101.3 kPa)

Standard liters per minute can be used to determine plant compressed air requirements.

7.5.7 Balancing Gas Flow

Once the total gas flow has been determined for the process, the process engineer can then determine the balance of the gas flow.

Balanced gas flow means that the same volume of gas enters the chamber as exits.

❶ First to determine the quantity of gas that should be introduced to the each heating chamber: Divide the Balancing Gas Flow among each of the heating chamber zones and baffles for which the furnace has control.

❷ To determine the total gas flow to the eductors, first subtract the volume excess gas flow (flow to exit from entrance and exit openings) and then divide the result by 15. The approximate volume of air drawn out by the venturi created by the eductor is 15 times the flow rate.

❸ Divide the total eductor gas flow among the available eductors.

❹ The sum of the eductor gas flow and the Balancing Gas Flow is the gas consumed by the furnace.

Refer to Example 2 example shown on the following page.

Note: A balanced gas flow does not guarantee the best or most economical environment for your process. After following this procedure, gas flow may still need adjusting to achieve an optimum and safe environment.

A. Calculate the Balancing Flow

Example 2:

Given: *Desired Excess Gas Flow = 100 Lpm*

Balancing Gas Flow = 144 Lpm (from Example 1)

Gas Entering Zones

Entrance Baffle		20	Lpm	
Zones 1		20	Lpm	
Zones 2 & 3		30	Lpm	
Transition Tunnel		15	Lpm	❶
Lamp Seals		20	Lpm	
Cooling	+	20	Lpm	
Balancing Gas Flow in =		125	Lpm	
- Excess Gas Flow =		80	Lpm	
Evacuation Gas Flow =		45	Lpm	❷
Eductor Flow Divider	÷	15		
Total Eductor Gas Flow =		*3*	*Lpm*	
Entrance Stack Eductor		1.5	Lpm	❸
Transition Stack Eductor		1.5	Lpm	

Gas Consumption

Total Gas Flow in	125	Lpm	
Eductor Gas Flow	3	Lpm	
Total Gas Consumption =	128	Lpm	← ❹

This method provides a good starting point for balancing the gas flow in your furnace. It is, however, an approximate method so additional tuning will be required.

7.5.8 Process Gas Flow Guidelines

The following are guidelines for some common processes performed in furnaces.

1. If faster cooling is required – increase flow to the entrance eductor while reducing flow to the transition or exit eductor. This will prevent hot air from the heating chamber from carrying over into the cooling section.
2. For equilibrium profiles – set the flow to the zones at about the same rate. This will assist in keeping a steady flow of process gas around the product during heating.
3. For peaked or non-equilibrium profiles (i.e. solder reflow or solar cell firing) – increase flow to the middle zones and reduce flow at the beginning and ending zones, also increase flow to cooling sections. This will help the product achieve high temperature under IR radiation and allow for quick cooling.

4. In a long steady peak profile – increase flow to exit or transition eductor while reducing flow to the entrance eductor. This will draw the air to the end of the heating chamber using convection heating to assist in raising the product to its final temperature.

THERMAL PROCESSING THEORY

8.1 Infrared Waves

Infrared waves form part of the electromagnetic spectrum. Electromagnetic waves with wavelengths from 0.78 μm to 1000 μm are called infrared waves. You are already familiar with electromagnetic waves of different wavelengths. Microwaves, X-rays, radio waves and visible light are all electromagnetic waves. Infrared waves produced inside the furnace lie predominately in the near and medium infrared range with wavelengths ranging between 0.5 and 3.0-μm.

When using infrared lamps, higher heat-lamp temperatures emit higher radiant energy. This elevated energy translates to a shorter electromagnetic wavelength of emitted IR radiation. While the IR waves of a heat lamp come from a continuous range of wavelengths, the **dominant wavelength** (λ_{dom}) as given by Plank's distribution principle is the wavelength transmitted with the highest occurrence. So for a given temperature, only one λ_{dom} exits. See Figure 8-1 below.

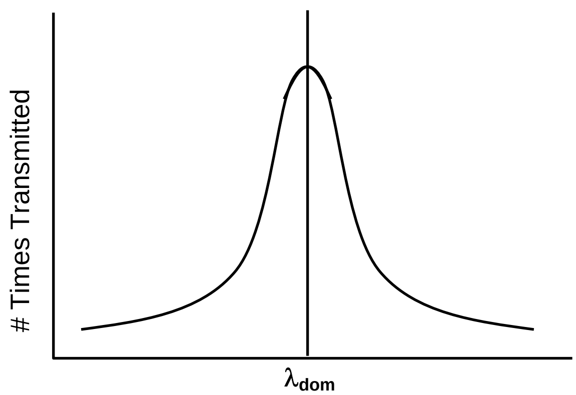


Figure 8-1 Dominant Wavelength Graph

The relationship between heat-lamp filament temperature **T** and λ_{dom} is given by the fixed relationship:

$$\lambda_{dom}\ \mu m = \frac{2897\ \mu m \cdot K}{\mathbf{T}\ K}$$

To convert from degrees Celsius (°C) to Kelvin (K) add 273 to the Celsius temperature value.

For example:

At 1000°C the respective material dominant wavelength is:

$$\mathbf{T} = 1000°C + 273$$
$$\mathbf{T} = 1273\ K$$

Substituting back into the given equation:

$$\lambda_{dom} = 2897\ \mu m \cdot \cancel{K} / 1273\ \cancel{K}$$
$$\lambda_{dom} = 2.28\ \mu m$$

8.2 Infrared Heating

Infrared (IR) heating is electromagnetic radiation emitted from the surface of IR lamps or emitters. Thermal radiation is generated when heat from the movement of charged particles within atoms is converted to electromagnetic radiation. In the furnace, radiant heating from IR lamps provides heat directly to objects without first heating the surrounding air. IR waves excite molecules within a substance (product) thus generating heat, but pass generally undisturbed through the surrounding atmosphere. Other substances such as glass, ceramics and some organic materials are also transparent to IR waves. Objects suspended in these media can, therefore, be heated directly by IR waves without directly heating the supporting media.

Not all heating in the furnaces occurs via direct IR radiation. The belt and air inside the furnace are heated via the IR lamps. Also edge heaters (resistance heaters installed along the furnace length) can introduce heat into the furnace. Your product also acquires heat from the edge heaters, conveyor belt and surrounding heated gas in the chamber via **conduction**.

The amount of direct heating via IR radiation is determined by three factors:

1) The level of IR radiation emitted from the heat lamps.
2) The amount of IR absorbed by a product.
3) The level of edge heat introduced into the furnace

If you know the **resonant frequency** of a particular substance, matching the furnace dominant wavelength the product resonant frequency ensures maximum energy transfer via IR radiation. In most cases, rapid product heating can be achieved more efficiently through frequency matching rather than with temperature increases.

8.2.1 Advantages of IR Heating

Heating via conduction and convection operates by transferring heat to object surfaces. Heat is then transferred from the surface to the layers beneath. Heat transfer, however, is not uniform, causing temperature differences and unequal expansion across an object. The unequal expansion due to the uneven heating is called thermal stress and can cause objects to fracture called thermal shock.

IR radiation heats molecules below an object's surface and allows for more uniform heat distribution than can be provided by conduction and convection heating alone.

Rapid heat up time is also achieved with IR technology due to the high energy-transfer rate of IR waves. The speed of conduction and convection heating is proportional to the temperature difference between the object and heating environment, whereas the speed of IR heating is proportional to the difference between the fourth powers of the object and environment temperatures.

For example:

Suppose the temperatures of an object were 100ºC.

If a convection heating furnace were heated to 500ºC, the proportional difference would be

500 - 100 = 400

If an IR furnace were heated to 500ºC, the proportional difference would be

$$500^4 - 100^4 = 6.25\ e^{10} - 1.00\ e^{8} = 6.24e^{10}$$

Other factors such as the emissivity of objects are taken into account when calculating energy transfer rates.

8.3 Thermal Process

The **thermal process** is the idealized process description for a particular product as it passes through the process section, including the product temperature profile and process environment. When establishing the thermal process, a consistent temperature profile is just as important as establishing the correct process environment.

Each dissimilar product that passes through a continuous belt Infrared furnace will likely utilize a different thermal process. Engineering design and empirical testing are the best methods of achieving the best thermal process.

8.4 Temperature Profiling

The proper thermal process is usually verified by performing a temperature profile. A temperature profile represents multiple temperature measurements taken at close intervals over a period of time through the length of the furnace. Product passing through the furnace go through a set of temperatures known as a temperature profile.

Notice in Figure 8-2 that the green horizontal lines define the setpoint temperatures, yet the thermocouple readings do not reach the actual setpoint temperature inside each zone. Also notice that the product peak temperature may be achieved well inside the cooling section.

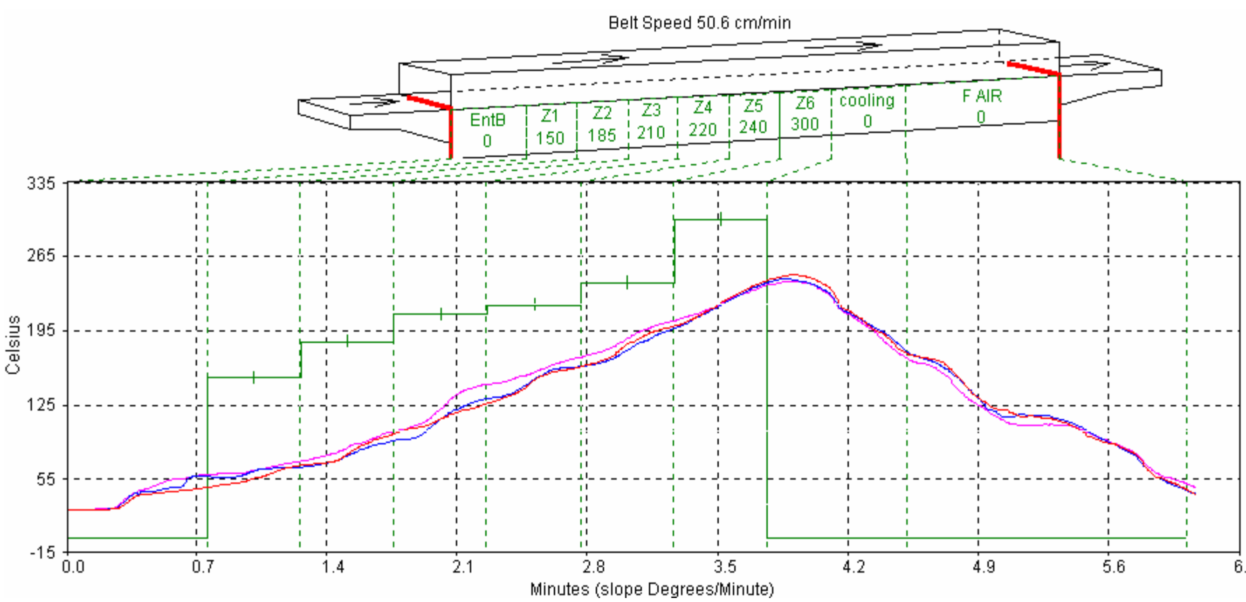


Figure 8-2 Temperature Profile

The temperature profile will be affected by the product material, mass and process gas. For example, a furnace with a controlled atmosphere cooling module installed can cool the product while in a pure nitrogen gas environment. The same temperature profile could be achieved with a forced-air cooling module, but could subject the product to a potentially hazardous oxidizing environment at elevated temperatures.

Prior to shipment, all furnaces undergo a temperature profile test. In this test, typically one or three (on furnaces with 15-inch or wider belt) thermocouples are sent through the furnace located on sample product on the conveyor belt at the center and, if three are used, one each side. All furnace zones are programmed to produce the furnace owner's prescribed setpoint temperature and allowed to reach steady state. The thermocouple readings are expected to remain within 5% of one another. While this test is performed at the factory, it should also be performed at startup and periodically thereafter to assure that the desired temperature profile can be maintained.

8.4.1 Profiling Responsibilities

The process engineer must set the furnace process parameters to achieve the desired temperature profile with the product. To do this, the engineer must have an idea of the process cycle of the product and the important process parameters and limitations. Looking again at the temperature profile from Figure 8-2, six zones are visible labeled Z1 – Z6. Depending upon the configuration of the furnace, fewer or more zones may be present. Standard and high power LA-310 models are 3-zone furnaces. Initially, temperature profiles must be recorded from temperatures measured inside the furnace.

8.4.2 Profile Specification

In general, the temperature profile is defined by a combination of the following parameters:

a. Heating Rate: The rate of increase of temperature from room temperature.

b. Dwell/Hold Time: The time the product remains above a certain temperature or range of temperatures.

c. Second Heating Rate: The rate of increase of temperature from the temperature reached during the hold time (if required).

d. Second Hold Time: Dwell/Hold time for 2nd heating (if required).

e. Peak Temperature: The maximum temperature reached with a +/- range and time at peak.

f. Cooling Rate: The rate of decrease of temperature to a lower/critical temperature.

g. Product Exit Temperature: As required.

If across the belt temperature distribution is a critical factor, use of three thermocouples attached in a similar fashion in the same line across the belt can reveal the temperature stratification during furnace processing.

If the parts are of great thickness as in a brass forging part, two thermocouples can be used to measure the temperature differences at different locations on the sample part.

For production work, the required specification must be achievable at a single speed setpoint within the specified furnace speed range. In general, the speed range depends on the factory gearing for the size and type of furnace and the specified requirements. Many sets of belt speeds and temperature settings can meet a given set of profile specifications. Furthermore, higher belt speeds can result in greater temperature deviations and lower consistency from the desired temperature profile. Also higher speeds shortens the cooling retention time and the parts may exit the furnace too hot.

8.4.3 Basic Profiling Variables

The two most influential and basic variables in setting up a temperature profile are:

- Retention Time: The time required to pass through the process section. Retention time in influenced by belt speed and zone temperature setpoints.
- Temperature Setpoints: Determines the energy level in each zone.

The combination of the time-temperature exposure of the product determines the temperature profile. The temperature settings in each zone set the heating rate and hold times of the product.

A third and less influential factor in the temperature profile is:

- Flow Meter Settings: Controls the rate of gas flow through the process section. Can influence heating and cooling rates and furnace IR stability.

If the furnace is equipped for a controlled atmosphere, this will be an important factor to consider. Gas flow and flow meter settings is addressed in detail in Sections 7.1.3 and 7.1.4.

8.4.4 Types of Profiles

In most processes, two kinds of temperature profiles exist:

Equilibrium (flat) profile applications:

- -Annealing
- -Brazing
- -Die-attachment processes
- -Drying/Curing of polymeric products
- -Glass or metal/solder sealing of IC packages
- -Hybrid thick film and PTF firing

Non-Equilibrium (peaked/spiked) profile applications:

- -Cerdip lead-frame attachment
- -Solar cell firing processes
- -Solder reflow attachment

Most microelectronic and semiconductor thermal processes fall into one of the above categories, or some combination of the two. Set the furnace parameters according to the type of process that will be used with the furnace.

Examples of the two fundamental types of profiles are illustrated in Figure 8-3 and Figure 8-4.

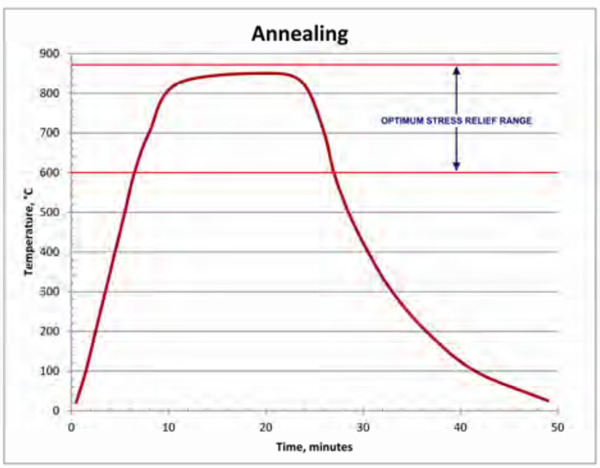


Figure 8-3 Equilibrium Profile

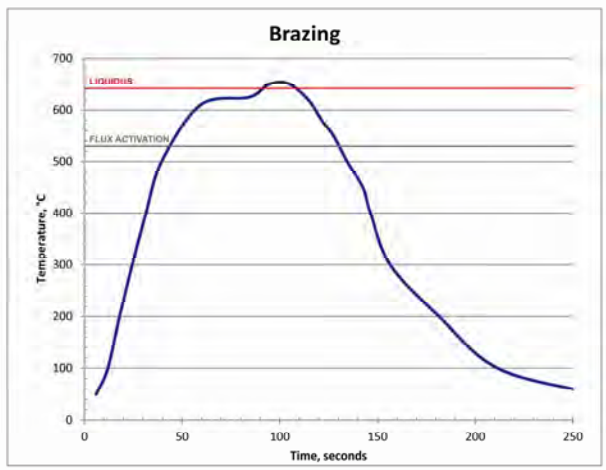


Figure 8-4 Non-equilibrium profile

8.4.5 Profiling Apparatus

A typical setup for profiling an infrared furnace is depicted on an LA-306 in Figure 8-5 and includes a computer and data logger positioned at the entrance of the furnace. For profiling, a type K thermocouple is placed on the surface of a part or representative sample which can be placed on the belt or in a parts boat. The thermocouple is plugged into a data logger connected to the computer. Figure 8-6 shows a close-up of a high speed high temperature type K thermocouple, a wire basket or parts boat, and a DataPaq Q18 data logger. As the part travels through the furnace, the computer graphs the temperature as a function of time and distance traveled.

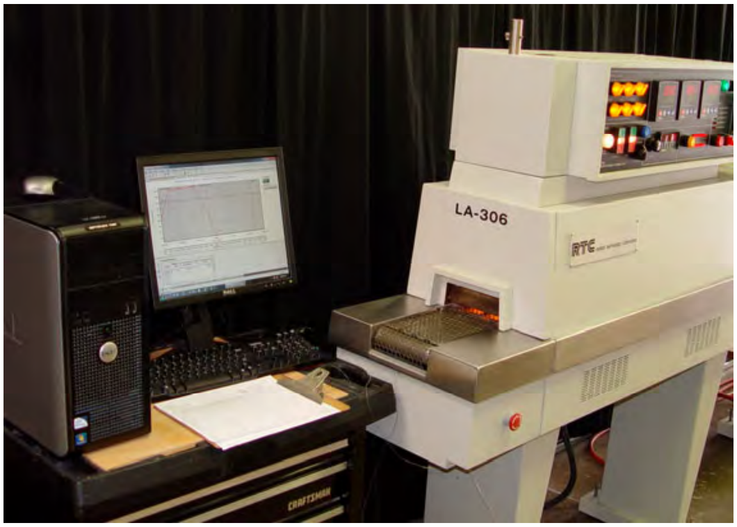


Figure 8-5 Temperature Profiling Apparatus

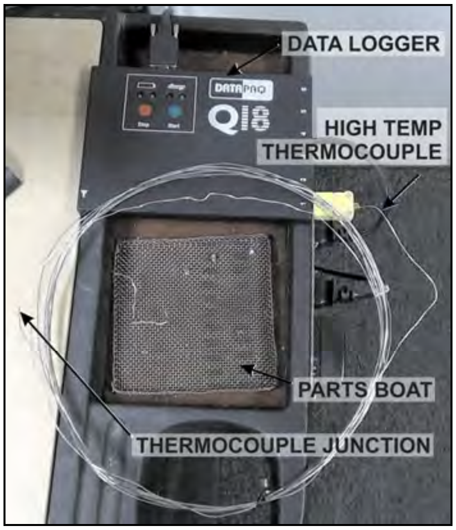


Figure 8-6 Data Logger

To produce a temperature profile, the following components are needed:

- Thermocouple
- Data Logger
- Sample part
- Computer

A. Thermocouple Wires

- K-Type thermocouples are recommended.

Depending upon operational temperatures, use a properly rated thermocouple for accurate readings. For temperatures above 300ºC, we recommends the use of ultra-thin high speed type K thermocouples. Make sure exterior sheath is grounded to furnace frame.

Use one thermocouple for centerline profiling or three for across-the-belt profiling.

B. Data Loggers

A data logger or temperature data collection device. Examples are:

- Chart recorder
- DATAPAQ data logger (Q18 or similar)
- KIC temperature profiling kit
- MOLE/SuperMOLE data logger

Figure 8-6 shows a DataPaq Q18 six-channel data logger with one high temperature thermocouple attached to channel 1.

Another data collection method involves sending a data logger down the belt inside an insulated enclosure. A short thermocouple is connected to the data logger through a sealed opening in the enclosure. The data logger collects the data for later transfer to a computer for graphing and analysis.

C. Sample Part

The part can be an actual production part, or something of similar material, mass, size and shape. The closer the sample is to an actual production part, the more representative the results will be. If parts boats or carriers are to be used in production, use a similar boat for the test. Figure 8-7 and Figure 8-8 depict different samples with high temperature thermocouples in position.

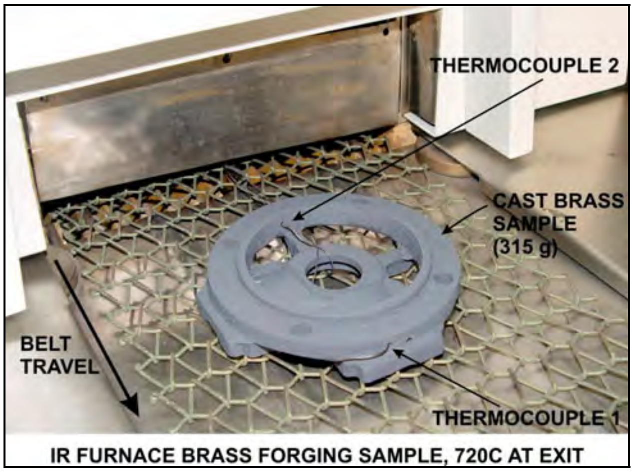


Figure 8-7 Brass Forging Sample With 2 thermocouples

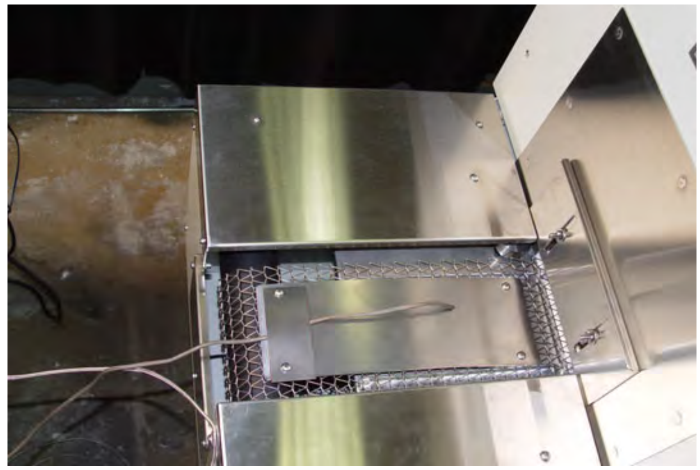


Figure 8-8 Metal Plate Sample with Wire Sheath Type K Thermocouple

8.4.6 Profiling Procedure

A. Operate furnace to steady state or READY.

B. Connect the thermocouple to the part and place on Load table.

1. Below temperatures of 300ºC, the thermocouple can be taped with Kapton tape to a test specimen. Repeat testing may require new tape for accurate results.

2. Above 300ºC, the thermocouple sensor can be cemented onto a test specimen if direct contract is not otherwise possible. In cases where the product of interest is not readily available, the thermocouple may be placed inside a small length of ceramic tube called a bead or other piece of material similar in shape and mass to the actual product.

C. For real time viewing, ready profiling software on the computer.

D. Place sample on belt. As thermocouple junction in the part passes furnace entrance, start data logger (click on start button on computer screen).

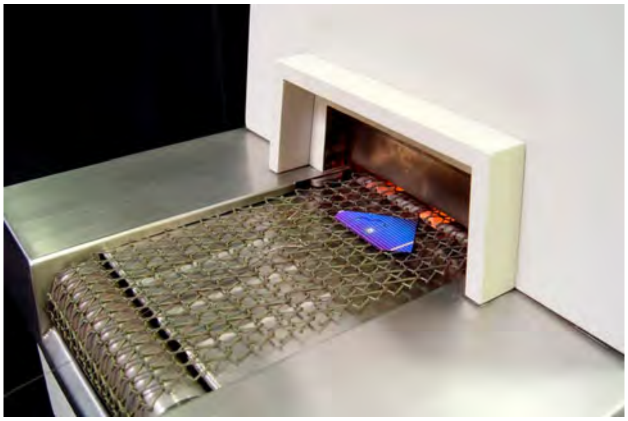


Figure 8-9 Silicon Wafer Entering Furnace

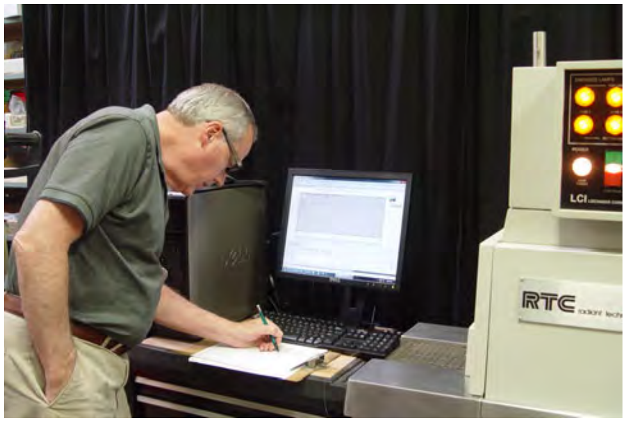


Figure 8-10 Recording Setpoints

E. Place sample on belt. As part passes furnace entrance (Figure 8-9), start data logger.

F. Record temperature setpoints and process gas flowmeter setpoints in a log (Figure 8-10)

G. As thermocouple junction passes exit of furnace, stop data logger.

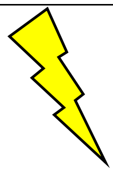
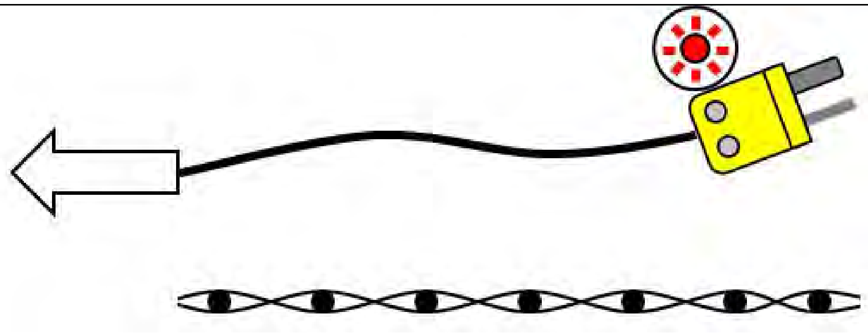
Note: If the start and the stop times coincide with the furnace entrance and exit, the actual belt speed can be verified in the profiling software and graph.

Figure 8-11 Brass forging sample exiting furnace

Figure 8-12 Sample plate exiting furnace

8.4.7 Safety Tips

	DANGER: When using metal shielded thermocouple wires inside a furnace, electrostatic energy may collect on the wires. Properly ground the shielding material to the furnace chamber by wrapping a wire around the sheath and attaching one end to an unpainted portion of the furnace cabinet.
DANGER:	**Extreme caution must be taken when pulling thermocouple wires through the process section. Connectors may bounce inside the chamber and break a lamp exposing the handler to high voltage and current, which could cause serious injury or death.**

8.4.8 Equilibrium Profile Settings

For equilibrium profiles (flat temperatures profiles), set a belt speed that will result in at least a 6-10 minute dwell time inside the heating chamber. The following table shows some belt speeds for various heating chamber lengths.

Table 8-1 Equilibrium Belt Speed Recommendations

Heating Chamber Length		Dwell Time			
		6 minutes		10 minutes	
(inches)	(cm)	(in/min)	(cm/min)	(in./min)	(cm/min)
30	76	5	12.7	3	7.6
60	152	10	25.4	6	15.2
90	229	15	38.1	9	22.9
120	304	20	50.8	12	30.4

For across-the-belt temperature profiles, set the belt speed to a minimum. The slow rate of the conveyor belt will result in a larger number of recorded temperature readings. A slower rate increases the resolution of the temperature profile and can reveal more information about temperature uniformity and consistency.

Set all zone temperatures to the desired peak temperature plus 5ºC.

If edge heaters are installed, a setpoint of 30% power is a good starting point. Also, for edge heat, allow a few minutes to pass between setting adjustments, as the nickel chromium edge heat wires do not respond as quickly as the IR heat lamps.

If faster heating rate is desired with a longer dwell time at the peak temperature, increase **the** first 1-2 zone temperature setpoints by about 10-20% of the peak temperature. The heating rate will be higher at the start, while the remaining zones will maintain the temperature of the product at the peak temperature.

A slow belt speed will allow the temperature to reach the peak temperature within the first 1-2 zones. The rest of the heating chamber will hold the temperature for the remainder of the profile.

- Record the temperature and observe the results.

If the desired temperature and hold time is not achieved, begin tuning the belt speed and zone setpoint temperature variables. The following are some guidelines:

For faster initial heating rates, try one of the following:

- Lower the belt speed
- Raise the first 1-2 zone temperature setpoints

For slower initial heating rates:

- Raise the belt speed
- Lower the first 1-2 zone temperature setpoints

For faster belt speeds:

- Raise the belt speed 5%
- Increase zone 1-2 setpoint temperatures by 7%

For slower belt speeds:

- Lower the belt speed 5%
- Decrease zone 1-2 setpoint temperatures by 7%
- Record a new temperature profile

Go back and retune as necessary until the desired temperature profile is achieved.

8.4.9 Profiling Results – Typical Curves

Following are examples of actual profiles run at the factory on different machines with product samples for a wide range of applications. Figures 9-13, 9-15 and 9-16 were performed on LCI LA-306 models. Figures 9-14, 9-17 and 9-18 were performed on LCI retrofitted RTC LA-306 furnaces. LA-309P performance will be similar.

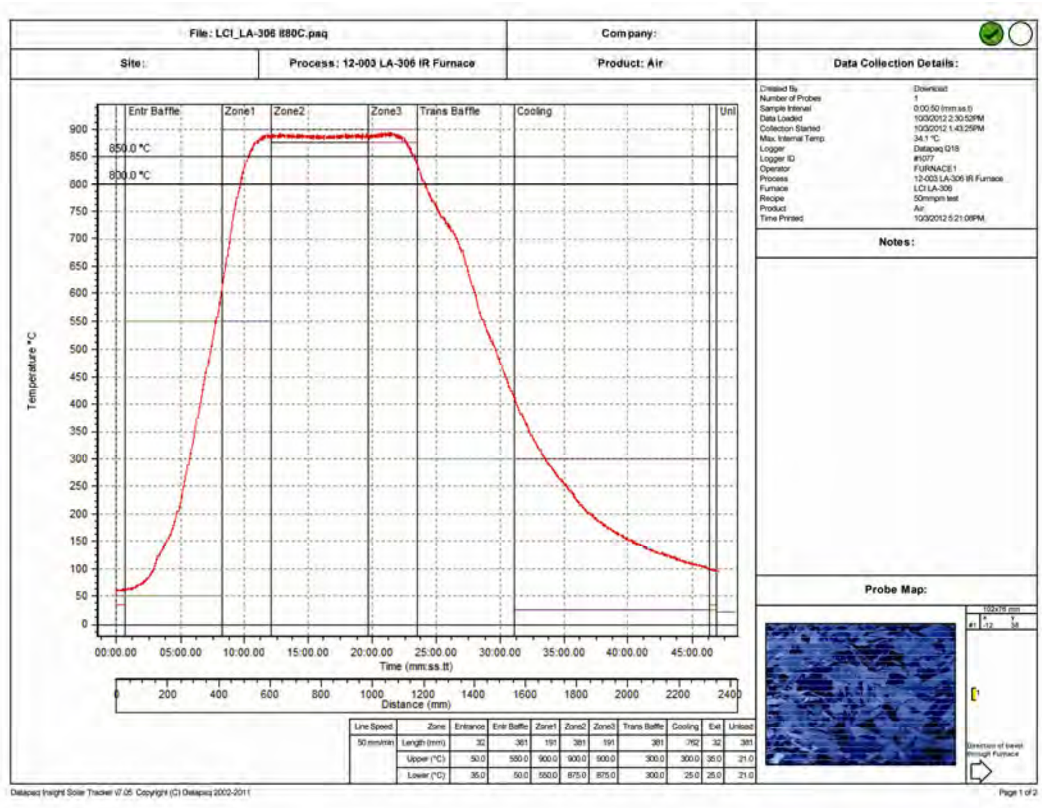


Figure 8-13 880 °C Annealing profile

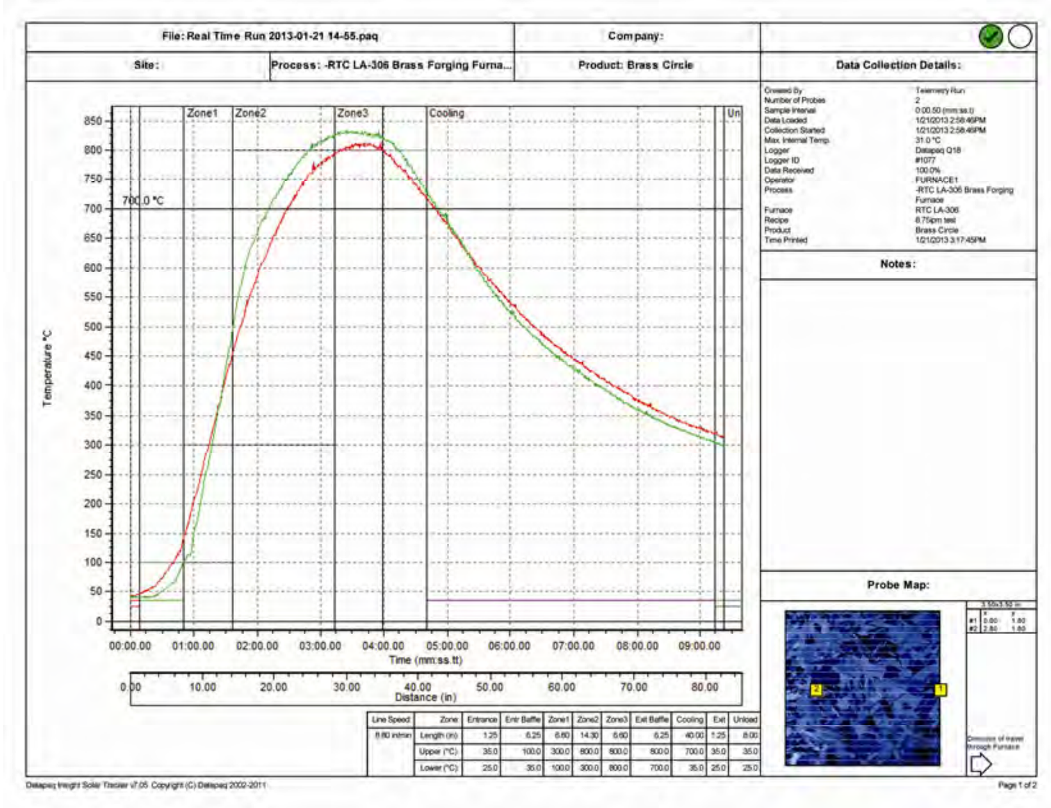


Figure 8-14 880 °C Brass Forging profile

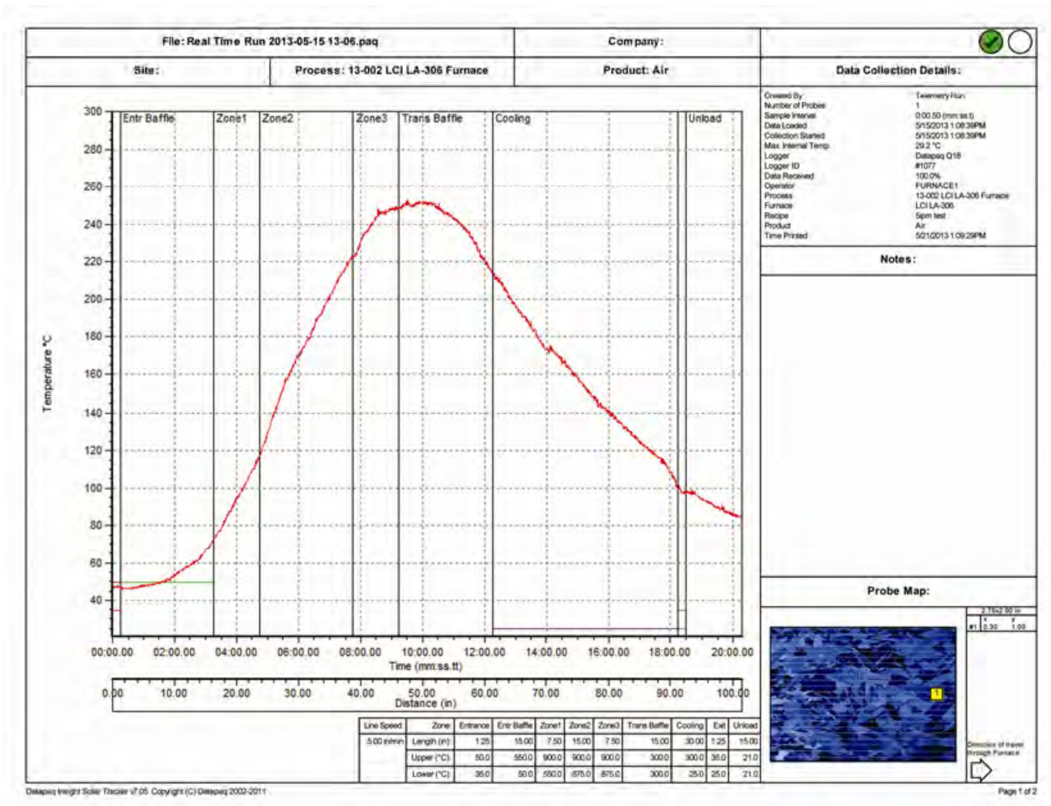


Figure 8-15 250 °C Curing Profile

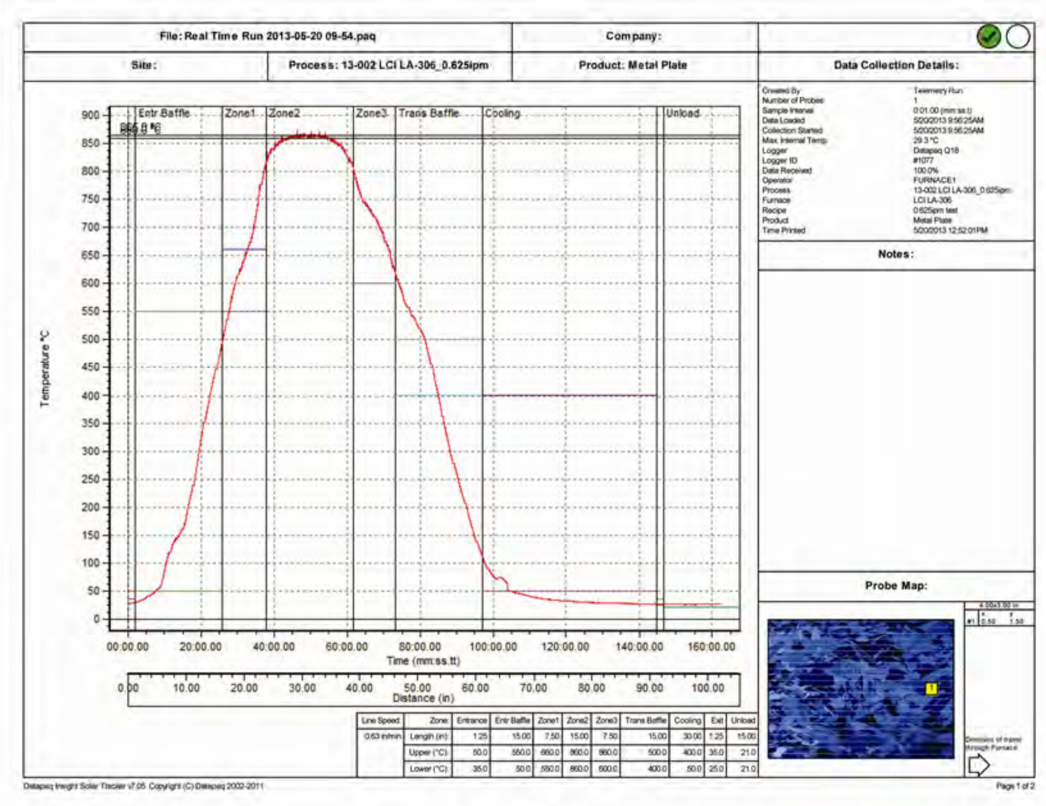


Figure 8-16 860 °C Thick Film profile

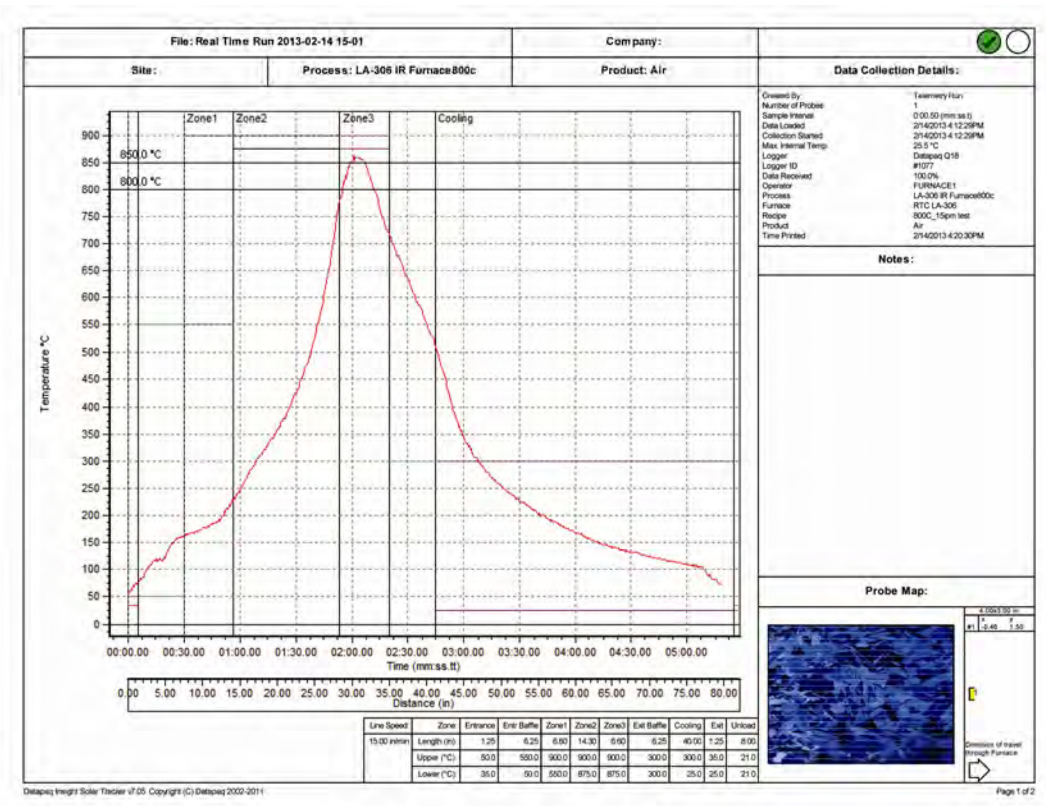


Figure 8-17 860 °C Spike profile

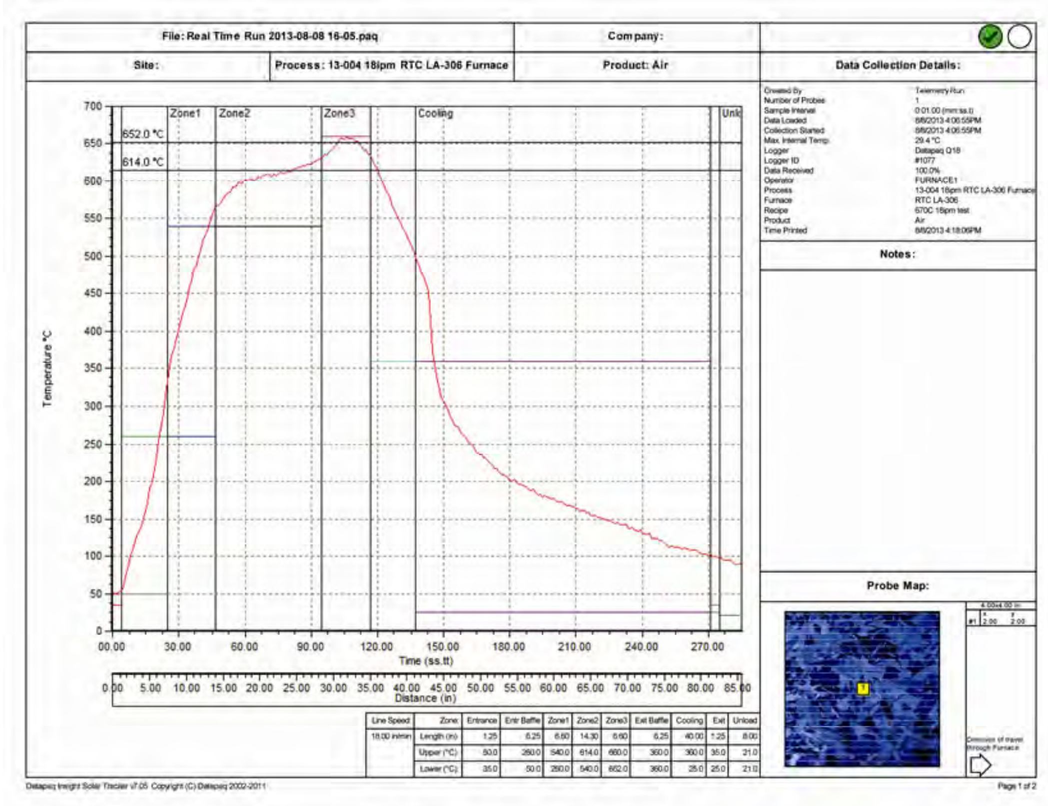


Figure 8-18 652 °C 1205 Brazing profile

Section 9

TECHNICAL NOTES

1.0 SCOPE

1.1 Instructions for the installation of the Model 3984 Isolated Interface Module on an existing furnace with a Bodine Electric drive motor and Model 3911 Motor Speed Board.

2.0 EQUIPMENT AFFECTED

2.1 Motor Speed Board Model 3911

2.2 Isolated Interface Module Model 3984

3.0 ADJUST MOTOR SPEED BOARD MODEL 3911

3.1 Start furnace. On Furnace program Process Screen, set belt speed to zero.

3.2 Using a nonconductive adjustment tool, adjust the each of the pots at the top of the motor speed board:

3.2.1 Set zero. Turn Min pot to full counter clockwise (CCW). Adjust clockwise (CW) until motor starts. Turn CCW until motor stops.

3.2.2 Set Max pot full CW and turn back ¼ turn.

3.2.3 Set Acceleration at between full CCW and midpoint.

3.2.4 Set Deceleration at between full CCW and midpoint.

3.2.5 Set Torque to full CW, adjust slightly CCW.

3.3 For reference, the pots to be adjusted are located from left to right as in the following table.

3911 POTS	MAX	MIN	ACCEL	DECEL	TORQ
Preferred Settings:	just CCW from Full CW	turn CW until motor stops	midway bet CCW and midpoint	midway bet CCW and midpoint	just CCW from Full CW

4.0 INSTALL 3984 ISOLATED INTERFACE MODULE

4.1 Inspect 3984 Board and verify that DS1 dip switches are all in OFF positions.

4.2 Make sure furnace is DISCONNECTED from facility power.

4.3 Remove panels to enable access to drive motor at the exit end of the furnace.

4.4 Using the supplied Mounting Template for the 3984 Isolated Interface Module, mark for 4 holes. Drill using 4 mm (5/32 inch) drill bit. In a convenient place on the motor control panel. (see Figure 1)

4.5 Mount the 3984 Isolated Interface Module using the supplied #8 machine screw fasteners.

Figure 1 Motor control Panel Layout

4.6 Disconnect the spade wire connections from S1 and S2 on the 3911 Motor Speed board.

4.7 Take these same wires and Plug black S1 into ICOM and white S2 into VIN1 connectors on the 3984 Isolated Interface Module. (see Figure 1)

4.8 Plug connectors coming from the VOUT & COM on the 3984 Isolated Interface Module black S1 and white S2 wires into the 3911 Motor Speed board spade connectors labeled S1 and S2 respectively.

4.9 Connect power (see Figure 2). Loosen screws on the 3911 Motor Speed board terminal block marked L and N. Slip the brown power wire terminal into the L screw then tighten. Slip the blue wire terminal into the N screw then tighten. Snap the two fuse blocks onto the DIN rail next to the existing fuse block.

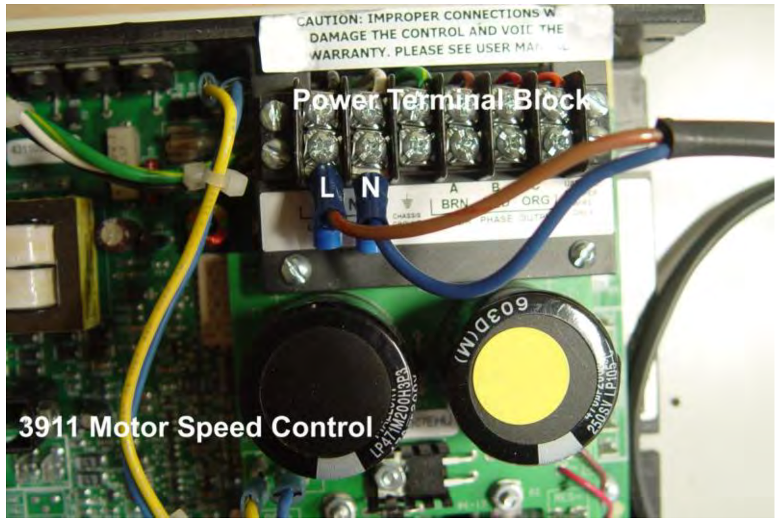


Figure 2 Power connect from 3984 module

5.0 CALIBRATE ISOLATED INTERFACE MODULE MODEL 3984

5.1 Set zero. Using a small flat screwdriver and a DC Voltmeter + on VOUT and – on COM, turn the Min pot CCW until motor stops and Voltmeter reads 0.120 to 0.130. If DC Volts will not go under 0.200 re-adjust MIN pot on the 3911 board until the Volts drop to 0.120-0.130. Adjust 3984 min pot CW until motor starts again. Turn 3984 min pot CCW again until motor stops and DC volts are within range.

5.2 Go to Furnace Calibration screen and click Transport Belt 1 Calibration checkbox to "Set 50% output to calibrate".

5.3 Adjust Max pot until voltage across Vout and Com equals 5.0 Vdc.

5.4 For reference, the pots to be adjusted are labeled Min and Max as in the following table.

3984 POTS	MIN	MAX
Field Adjustment	turn CW until motor stops	3984 $V_{out\text{-}com}$ = 5 Vdc or 3911 $V_{S1\text{-}S2}$ = 5.0 Vdc

6.0 REPLACE FURNACE PANELS

6.1 Replace all panels and fasteners.

7.0 CALIBRATE BELT SPEED

7.1 Use standard procedure for belt speed calibration.

1.0 SCOPE

1.1 Instructions for the setup and installation of the SNAP-LCM4 Controller on an IR furnace.

2.0 EQUIPMENT AFFECTED

2.1 Snap LCM4 Furnace controller

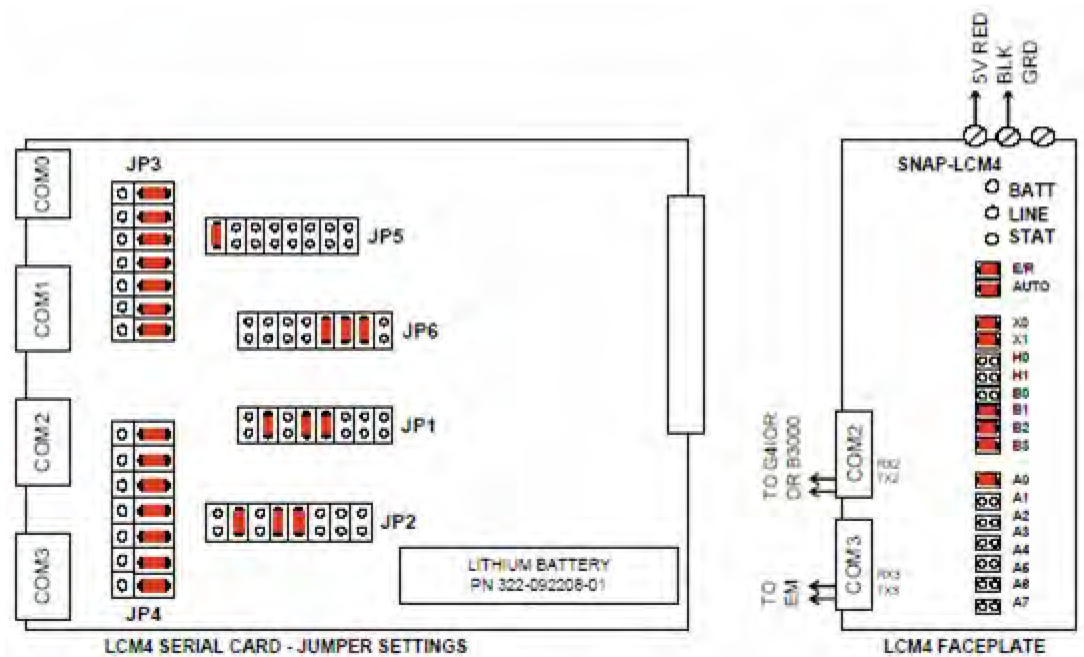
2.2 Power Supply, 5 Vdc

3.0 CONFIGURATION

3.1 Remove blank plate and install M4SENET-100 Ethernet card in any empty slot of the LCM4 controller

3.2 Remove serial card and verify that the jumper settings are as below. Replace serial card.

3.3 Verify jumper settings on LCM4 Faceplate.



4.0 INSTALLATION

4.1 Mount LCM4 horizontally or vertically in a secure location close to 5 Vdc power supply.

4.2 Connect LCM4 to a dedicated 5 Vdc power supply. Supply voltage should be maintained at between 5.1 Vdc -5.2 Vdc.

4.3 Connect the supplied tantalum capacitor across the 5 Vdc and Common terminals of the power supply dedicated to the LCM4 Controller.

CAUTION: The power supply used for the SNAP-LCM4 should not be used to supply any other equipment. Field devices must not be supplied by the same power supply used for the controller, as the optical isolation of the I/O modules would be bypassed and the voltage fluctuations to the controller might cause controller resets.

4.4 Connect cable from G4IOR interface or B3000 or B3000-B brain to COM2.

4.5 If equipped with a serial element monitoring system (EM), connect EM cable to COM3.

4.6 Connect Ethernet TCP/IP cable to M4SENET-100 card if so equipped.

5.0 BATTERY

5.1 The Opto22 LCM4 controller has a lithium backup battery with a 5-year life cycle, but other factors may affect its service time. Storing the unit with the furnace power off shortens the battery lifespan. The battery will actively back up RAM when the Furnace is OFF. When the battery is near the end of its useful life the BATT LED will turn red. Once the battery begins to fail, the furnace controller will often fail to retain program parameters after power is lost to the controller. Eventually the program may not reset or may fail to load. BATT LED is normally green.

5.2 If the battery fails replace with part number 322-092208-01.

6.0 TROUBLESHOOTING

Use the following table to troubleshoot Opto22 PLC communication problems:

Table 6-1 PLC Opto22 Troubleshooting Guide

INDICATION	EXPLANATION	REMEDY
LINE LED is off	No Power.	Check wiring.
LIINE LED is red or Controller resets.	Power may be out of specification	Check the power supply for 5V DC power.
STAT LED is off	Controller is faulty	Call FurnacePros Technical Support.
STAT LED blinks red	Firmware problem	Call FurnacePros Technical Support
BATT LED is red	Backup battery is low	Replace LCM4 controller battery.
RX LED is stuck on	Wiring polarity problem	Call FurnacePros Technical Support.
Controller cannot transmit to PC	Configuration jumpers were changed without cycling power.	Cycle power off/on and retry transmission.
No communication to host PC.	Communication Problems	Check serial port. Check PC IP address (10.192.105.100)
No communication to host PC. RX LED is on, but TX LED is off	Communication Problems	Check controller address (10.192.105.102), baud rate, and ASCII/binary settings.
No communication to host PC. RX and TX LEDs are on	Communication Problems	Try a slower baud rate.
No communication to I/O modules. TX LED is off while trying to communicate.	Communication Problems	Check that I/O port software is configured for correct port. If RX LEDs on I/O modules are off while trying to communicate, check for loose connections, shorts or breakage. IF RX LEDs on I/O are on, check I/O address, baud rate, and protocol setting in software.
Furnace program fails to load with correct parameters, clock is wrong, or furnace controller fails to reset	Backup battery is low (battery has a 5 year life cycle)	Replace LCM4 controller battery.

1.0 Scope

Programmable Logic Control (PLC) devices require specific voltage ranges to assure stable operation. This note provides guidelines for acceptable voltage ranges

2.0 Recommended Voltages

This following table lists preferred and acceptable ranges for select PLC devices. If power supply is adjustable, adjust to Preferred Voltage or slightly above Preferred Voltage. If power supply is not adjustable (PS5), verify the output voltage is within range. If not, replace power supply.

Table 2.1 Power Requirements

Device	Preferred Voltage	Acceptable Range
PAC-S1	24 Vdc	8-24 Vdc (1.24 A to 0.42 A)
LCM4 Controller	5.1 Vdc	5.1 to 5.2 Vdc at 2.0 A max
G432LC	5 Vdc	4.9 to 5.1 Vdc @ 2A
G432LCSX Classic Controller	5 Vdc	4.9 to 5.1 Vdc @ 2A
PAC-SB1	5.1 Vdc	5.0-5.2 Vdc @ 750 mA
B3000-B Brain	5.1 Vdc	5.1 to 5.2 Vdc at 750 mA max
B3000 Brain	5.1 Vdc	5.0 to 5.1 Vdc at 1.0 A max
G4D16R Brick	24 Vdc	23.9 to 24.1 Vdc @ 250 mA
G4A8R	24 Vdc	23.9 to 24.1 Vdc @ 180 mA
G4D32R	24 Vdc	23.5 to 24.5 Vdc @ 220 mA
G4D16R Brick	24 Vdc	23.9 to 24.1 Vdc @ 250 mA

1.0 Scope

This instruction covers installation of the capacitor on an RTC, GBT or FurnacePros furnace power supply. Stable clean power is required for IR furnace programmable logic control (PLC) equipment. Power supplies should include a properly sized capacitor to reduce noise in the dc output.

2.0 Capacitor

Parameter	5 V Power Supplies	24 V Power Supplies
Part Number	310-100637-05	310-100637-24
Size	6.3-10 V, 10 µF	25 V, 10µF
Type	Tantalum	Tantalum
Lead	Solid	Solid

Typical tantalum capacitor showing polarity, positive (+) is on left

3.0 Power Supply with Terminals

If you are installing a B3000-B or B-3000 rack or an LCM4 to a power supply equipped with terminals, install capacitor across dc positive and negative terminals at power supply, Capacitor must be installed with positive (+) lead connected to de positive terminal. Do not install across ground.

4.0 Power Supply with Leads

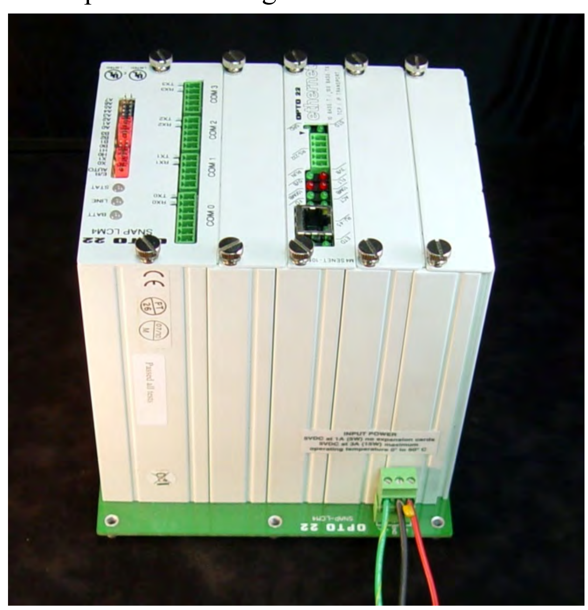
If you are installing a B3000-B or B3000 rack or an LCM4 to a power supply like a PS5 that is equipped with leads (output wires) instead of terminals, install capacitor across dc positive and negative terminals as close as possible to power supply. User terminal blocks if multiple devices are to be installed.

4.1 Single Device

If only one device such as an LCM4 is to be connected to power supply, connection capacitor across positive and negative terminals at LDM4 or other device. Capacitor must be installed with positive (+) lead connected to Vdc positive terminal on device. Do not install across ground.

4.2 Multiple Devices

If multiple devices are to be connected to power supply, use of terminal blocks is recommended. Wire power supply to terminal blocks with capacitor connected across dc positive and negative terminal blocks. Capacitor must be installed with positive (+) lead connected to Vdc positive terminal block. Do not install across ground. Wire devices to terminal blocks.



Tantalum capacitor showing polarity
Positive (+) is on the right

1.0 SCOPE

1.1 Instructions for calibrating the conveyor belt on an RTC Radiant Technology, GreenBridge Technology, or LCI infrared furnace.

2.0 TOOLS REQUIRED

2.1 Tape Measure

2.2 Stop Watch

2.3 Small Object to ride on belt

3.0 PROCEDURE

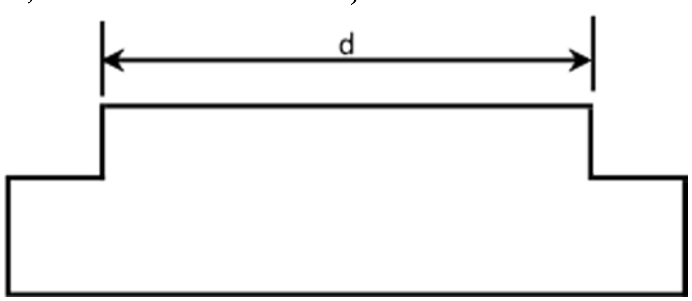
3.1 The belt speed is calibrated by first placing the furnace in the calibrate mode and after measuring the amount of time it takes for an object to travel from the entrance of the furnace to the exit, the speed is calculated and entered on the calibration screen.

Belt speed = distance / time

s = d / t

4.0 DISTANCE MEASUREMENT

4.1 Note the belt speed units on the process screen (in/min, cm/min or mm/min). Measure the distance from the face of the inlet to the outlet of the furnace in the distance units shown on the process screen for belt speed (inches, centimeters or millimeters).



Example: distance s = 315 ¼ inches

s = 315.25 inches

5.0 FURNACE CALIBRATION SCREEN

5.1 Start furnace normally.

5.2 In the furnace software, access the Calibration screen as follows:

1. To access the Calibration Screen, go the **Maintenance** Screen.

2. Click on the **Calibrate** button:

3. The following pop-up window will appear.

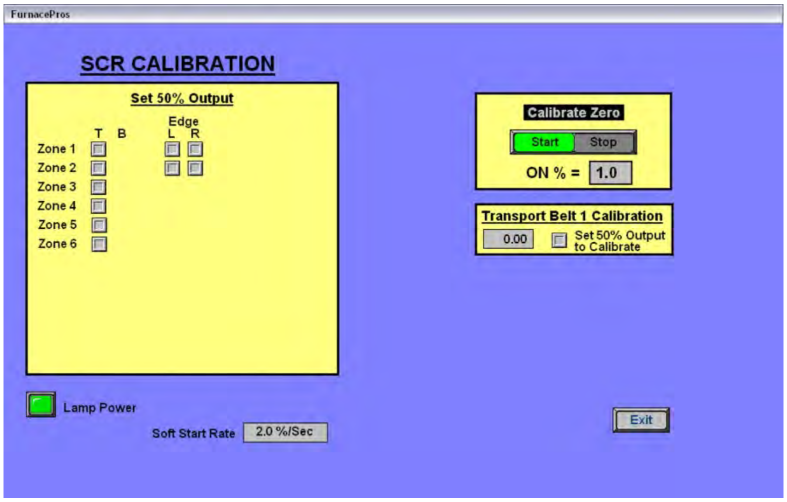


Figure 5.2.1 Calibration pop-up window

6.0 PROCEDURE

6.1 In the **Transport Belt Calibration** window, click on ***Set 50% Output to Calibrate***.

6.2 Place an object on the belt at the entrance of the furnace.

6.3 As the trailing edge of the object passes into the furnace start the stop watch timer.

6.4 As the object exits the furnace, stop the timer as the trailing edge of the object passes out of the furnace.

6.5 Convert the time from minutes and seconds to minutes as in the following example:

t = 15 minutes 24 seconds = 15 +24/60 minutes = 15.40 minutes

6.6 Divide the distance by the time to determine the speed.

Example: s = d / t

s = 315.25 in / 15.4 min = 20.4708 in/min

6.7 Enter the newly calculated speed in the **Transport Belt Calibration** box

6.8 Uncheck the ***Set 50% Output to Calibrate box***.

6.9 Belt speed calibration is complete.

7.0 BELT SPEED CALIBRATION

Distance, inches, decimal	d	
Time, min-sec	t	
Time, minutes, decimal	t	
Speed, inches per minute	s=d/t	

1.0 Application

All LCI and RTC infrared closed atmosphere belt furnaces.

2.0 Scope

To provide the process engineer with guidelines for understanding the primary factors and considerations in adjusting the furnace to achieve a specific result.

3.0 Responsibility

It is the process engineer's responsibility to identify the performance required for each process and/or product. The process engineer must then determine the Furnace Settings required to produce consistently satisfactory process results. The Furnace Settings are recorded as a Recipe for that process so that Operators can produce results that are consistent and repeatable.

4.0 Procedure

Tuning the furnace involves the following steps.

1. Identify the Process Specification required for the product.
2. Determine initial Furnace Settings.
3. Run temperature profiles on product samples in a representative load using a thermal profiler.
4. Analyze product for acceptance.
5. Review profile curve and adjust Furnace Settings, if necessary.
6. Re-run parts profiles (steps 3-5) until an acceptable and repeatable result is achieved.
7. Record Furnace Settings as a Recipe for production Operators.

5.0 Process Specification

The Process Specification defines time and temperature factors and other atmospheric conditions that will process the product in the manner required. Primary process parameters include the following:

Temperature bandwidth durations. Product temperatures and residence times for each specified phase of the process. Units are degrees Celsius and minutes (or seconds).

Rise rates. Heating rate or temperature increase per unit of time. Units are degrees Celsius per minute (or seconds).

Decline rates. Cooling rate or temperature decline per unit of time. Units are degrees Celsius per minute (or seconds).

Oxygen levels. Processes which require an oxygen-free atmosphere may stipulate low oxygen levels. Units are parts per million by volume. Typical values are (20 ppmv, 100 ppmv or 300 ppmv). Some furnaces may be equipped with continuous monitoring systems to provide real time feedback. A cost effective approach to managing O2 levels can be to employ an analyzer to determine the initial flowmeter settings. Once the flowmeters are adjusted and provided the supply of process gas and pressure are maintained, the Operator can be assured of consistent results.

Moisture levels. Processes which require an oxygen-free may also stipulate maximum moisture levels in the heating chamber. The furnace may be equipped with equipment to sample and display moisture content in real time.

6.0 Process Specification Examples

Following are examples of typical profiles for a number of IR furnace applications.

Profile 1 – Solder Seal

- Nitrogen atmosphere with less than 20ppm O2 levels
- 100˚C to 310˚C in 6 minutes +/- 1 minute
- Maximum temperature not to exceed 330˚C
- Temperature to exceed 305 ˚C for 1.5 to 2.5 minutes
- Temperature to fall from 300˚C to 240˚C in 2.5 minutes or less

Profile 2 – Glass Seal

- Air atmosphere
- 100 ˚C to 400 ˚C in 6 minutes +/- 1 minute
- Maintain 420 to 440 ˚C for 9 minutes +/- 1.5 minute
- Maximum temperature, 430 to 440 ˚C
- Temperature to fall from 400 to 250 ˚C in 2.5 minutes

Profile 3 – PCB Reflow

- Air atmosphere – see profile detail below.

Profile Feature	Pb-Free Assembly
Preheat/Soak Temperature Min (T_{smin}) Temperature Max (T_{smax}) Time (t_s) from (T_{smin} to T_{smax})	 150 ˚C 200 ˚C 60-120 seconds
Ramp-up rate (T_L to T_p)	3 ˚C/second max.
Liquidus temperature (T_L) Time (t_L) maintained above T_L	217 ˚C 60-150 seconds
Peak package body temperature (T_p)	T_p = 260 +/- 5
Time (t_p) within 5˚C of the specified classification temperature (T_c).	30 seconds
Ramp-down rate (T_p toT_L)	6 ˚C/second max.
Time 25 ˚C to peak temperature	8 minutes max.

7.0 Furnace Settings

The primary Furnace Settings include temperature, gas flow and belt speed.

1. **Temperature.** Infrared furnace equipment temperature setpoints are determined through profiling the furnace. Secondary parameters include EDGE HEAT%, % POWER and PID parameters. Adjustment of these secondary parameters can improve operational consistency.

   CAUTION: INFRARED FURNACE TEMPERATURE SETPOINTS AND READINGS DO NOT REPRESENT THE ACTUAL TEMPERATURE OF THE FURNCE OR OF THE PRODUCT, BUT CAN SERVE AS A RELIABLE, REPEATABLE GUIDE IN THE OPERATION OF THE FURNCE ONCE TUNING IS COMPLETE FOR A GIVEN RECIPE.

2. **Gas Flow.** Gas flow settings can have multiple rolls in furnace tuning. Initial considerations may include control of oxygen an moisture levels in low O2 firing. Additional adjustments can move heat forward or toward the exit to change the temperature profile. Finally, often a stream of gas is necessary to stabilize furnace performance by assuring the lamps are always energized during production runs.

3. **Belt Speed.** Belt speed in closed loop systems can be used to provide a reliable and accurate representation of product residence time or time in each segment of the process. Small adjustments in belt speed can be used to increase or decrease time at temperature results in an otherwise good profile.

8.0 TEMPERATURE CONSIDERATIONS

Infrared furnaces have a thermocouple in each zone which provides feedback to the control system. Furnace systems do not measure the temperature of the product. The furnace thermocouples do provide some indication of zone temperatures; their primary function is to supply feedback so the control system can make necessary adjustments in power provided to the IR heating elements. **Therefore, the process engineer must determine the temperature setpoints for the furnace zones that will produce the required Process Parameters.**

As Product moves through each heating zone it absorbs infrared energy supplied by the zones. The product temperature can continue to increase in temperature even if successive furnace zones are set to the same temperature.

9.0 RECIPE ADJUSTMENTS

Once the initial settings have been entered and initial profile has been run, the Process Engineer must make adjustments to the furnace settings and tune the furnace to improve the result. This is an iterative process that is best completed when the end result is clearly stipulated and the deficiencies in the current results are carefully identified.

In tuning the furnace it is imperative that the settings and results are recorded for each test or Run. After a number of runs are made, the results can be compared along with the settings used to produce those results.

Each successive test run should incorporate only small changes, usually to a single parameter. For example, do not change gas flow and zone temperature setpoints all at the same time because it will be difficult to determine which adjustment improved or degraded performance. Also multiple adjustments may influence the result in a conflicting manner.

CHANGE RAMP RATE: Increase or decrease Zone 1 temperature to change the heating rate. The initial zone is often used to introduce energy to the part to get the part up to temperature rapidly. Zone 1 temperature setpoint maybe 50 to 200 C or more above the temperature expected in Zone 1 to assure a rapid rise rate.

INCREASE RESIDENCE TIME. To increase the time at temperature you can:

1. Increase temperature setpoint in the zone (introduces more energy in the problem zone), and/or
2. Increase temperature setpoint in the previous zone (introduces energy to the part earlier);
3. Increase temperature setpoint in the next zone (introduces energy to the part longer);
4. Increase gas flow to the zone (can cause lamps to stay on longer adding energy to the part)
5. Decrease belt speed (increased time part is exposed to energy applied in each zone).

If the profile shape is acceptable, but the part needs more residence time, decrease the belt speed by a small amount.

If the profile shape is acceptable, but the part needs more residence time, increase the temperature of the previous zone temperature by a small amount to achieve a faster rise time and earlier maximum temperature. Also you may be able to increase the temperature in the following zone to slightly delay the start of cooling phase.

If the profile shape is acceptable, but the maximum temperature is too low, increase the temperature setpoint of that zone.

LAST ZONE CONSIDERATIONS. The last furnace zone is often set a little higher than the previous zone to assure adequate energy is available to offset the effects of the transition tunnel and cooling sections. Alternately if peak residence time is already more than adequate and/or a slower or more controlled initial cooling rate is desired, lower the last zone below the previous zone to slow the rate of product cooling.

EDGE HEATERS. Use edge heaters to adjust for temperature variation across the belt. Make EH increases small to avoid reducing IR energy introduced via the lamps.

10.0 Using Multiple Furnaces for a Single Process

The specification for a given process describes the requirements to successfully process each part. These requirements are in terms of time, duration and atmosphere. Sometimes additional requirements can include temperature rise time and cooling rates. Additional requirements may be defined for the characteristics required of the processed part itself. The specification for the characteristics of the final processed part take precedent over all other considerations. If the processed part does not meet its requirements, the process parameters may be incorrect and have to be adjusted to assure a quality-assured result.

Each piece of equipment must be adjusted to produce the specified result. The settings on an IR furnace include zone temperature settings, gas flow rates, belt speed. Advanced settings include settings for PID parameters and applied power. Because of differences in hardware no two furnaces will have the same settings to achieve the desired result.

Differences in hardware include:

- Electronics – device tolerances vary
- Insulation - porosity, surface condition varies.
- Thermocouples and other sensing devices -performance varies within tolerance.

Differences in hardware due to age include:

- Electronics - newer devices are truer to original design, variations in both tolerances and sensitivity.
- Insulation – age affects porosity and surface condition.
- Thermocouples – age affects sensitivity and accuracy.
- Computer – newer operating systems, software and I/O respond differently to input data.

While two different pieces of equipment, even from the same manufacturer, can produce the same result, each piece of equipment must be tuned for its specific age, electronics and processing chambers.

….

1. Application

All LCI and RTC infrared closed atmosphere belt furnaces.

2. Scope

To provide the process engineer with guidelines for adjusting the furnace to run a desired thermal process using zone setpoint temperatures, a balanced process gas flow, appropriate zone control settings and alarm/alert levels on an operating, but empty furnace. If a heating zone is not under control in an empty furnace, it will not be under control when you try to run product.

3. Responsibility

It is the process engineer's responsibility to identify the performance required for each process and/or product. The process engineer must then determine the Furnace Settings required for consistently satisfactory process results. The Furnace Settings are recorded as a Recipe for that process so that Operators can produce results that are consistent and repeatable.

4. Summary Procedure

Tuning the furnace involves the following steps. See TEC-620 for assistance with steps marked "*".

- Identify the Process Specification required for the product. *
- Determine initial Furnace Settings. *
- Repeat the next 3 steps until an acceptable and repeatable result is achieved:
  - ✓ Run temperature profiles on product samples in a representative load using a thermal profiler.
  - ✓ Analyze product for acceptance.
  - ✓ Review profile curve and adjust Furnace Settings, if necessary. *
- Record Furnace Settings as a Recipe for production Operators. *

5. Tuning Your Furnace

A. Know Your Furnace.

Refer to your furnace documentation & drawings for details.

1. Confirm proper voltage, as shown on furnace nameplate, is connected.
2. Keep in mind that lengths of RTC and LCI furnace zones may vary.
3. Number of lamps/zone varies by zone length; more lamps mean more power in the zone.
4. Understand the sources of heat in an IR furnace are different from a convection furnace:
   a) 60-70% direct IR from the lamps.
   b) 20-30% convection via process gas heated while passing through furnace insulation.
   c) 10-20% conduction from belt and edge heaters (if present).
   d) Different materials may absorb IR energy at different rates.
   e) Parts hidden from direct IR are heated indirectly by convection and conduction.
5. Gas control flowmeters may supply process gas to more than 1 zone; check flowmeter labels.

6. Locate eductors (exhaust stacks) for flow balancing; each stack can exhaust 15x its flowmeter setting of process gas volume. Pairs of eductors control gas flow within the furnace by setting one eductor flowmeter higher/lower/same compared with the other eductor. Furnaces with a single eductor at the entrance can pull process gas forward toward the entrance at a higher/lower rate depending on its flowmeter setting.

7. Check zone control thermocouple (t/c) height: it should be the same in each zone. Replace oxidized t/c when required to maintain proper zone temperatures.

8. Determine presence/absence of under-belt edge heaters; use caution when using:

   a) Edge heaters are ***not regulated*** by the zone PID control settings.

   b) They generate constant belt edge conduction heat/unit length; amount of added heat ***varies with zone length***.

   c) Settings higher than 15% ***may affect accuracy*** of zone PID control.

9. Make sure zone SCR controllers are set properly, if adjustments are available. Some controllers require manual "zero" (minimizes SCR power leakage) and/or "span" adjustments (limits maximum voltage applied to lamps); other controllers have no adjustments.

10. Locate quartz rods/tubes supporting the belt within the furnace chamber. These supports absorb heat from the bottom lamps and belt, causing local cooling of the belt immediately above the supports. This affects only parts placed directly on the belt (i.e. not in carriers).

Note: Run parts on belt in lanes ***between*** the belt support rods/tubes.

11. No two furnaces are exactly alike, even if they have the same model number. Most furnaces are built by hand as custom assemblies, with continuous small changes due to "constant improvement" programs within the various furnace manufacturers.

Note: The "same model" furnace may need different zone PID, gas flow, edge heat and/or belt speed settings for optimal tuning to meet the process specification.

12. Don't confuse ***display resolution*** with ***display accuracy*** when tuning a furnace. K-type thermocouples are accurate of only about 2% of reading and drift over time with use.

Note: A display of 305.3C means only that the actual value may be about 305C ± 2-3C.

B. Best Control

For best control, the IR lamps must remain ON at all times with constant process gas flow into and out of the furnace. If the lamps are cycling ON/OFF during processing, the furnace is not in control and not processing parts continuously with infrared radiation (heat in the zone is varying).

C. Thermal Profile

Set up a temperature profile using the Recipe Screen. This will allow you to easily save your work to the system hard drive and to access the controls and alarm/alert settings for each zone. Remember to save your work often.

1. Start with an empty furnace, the belt running, and the default gas flowmeter settings.

2. Make sure the furnace gas inflow/outflow is balanced.

3. Enter desired zone setpoint temperatures, and click on WARM UP. Observe the results of setpoint changes on the Process Screen.

4. Conditions that cause problems:

   a) Large setpoint temperature differences between adjacent zones.

   b) Setting the next zone much cooler than the preceding zone.

5. To remedy these problems:

   a) Minimize the difference in setpoints and/or reduce belt speed. Observe the results on the Process Screen.

   b) Control direction of heated gas flow in the furnace by changing exhaust eductor flows (see Section D, below).

D. Balance Gas Flow

A balanced gas flow means the same volume of gas that enters the furnace chambers exits the furnace chambers, helping ensure furnace control stability.

1. Gas flow in any zone must carry away heat when that zone's lamps are off.

2. Be aware that adjacent zones may contribute heat to the affected zone via gas flow.

3. When the zone lamps are OFF and the actual zone temperature stays the same or rises, the zone is not under control.

4. To remedy this condition, try the following adjustments either singly or in combination while observing the results on the Process Screen. Keep in mind that a properly balanced furnace will meet the criteria in item 3, above.

   a) Confirm that the SCR(s) controlling the zone have properly set "Zero" trim pots as per Section A.9, above.

   b) Raise affected zone setpoint temperature so that control of the actual zone temperature depends only on the power delivered to its lamps.

   c) Lower adjacent zone setpoint temperatures to remove excess heat transfer to the affected zone.

   d) Increase gas flowmeter settings to affected zone (more gas gets rid of heat).

   e) Control direction of gas flow in furnace (toward nearest exhaust, toward entrance, toward exit) by changing exhaust eductor flows. Make these changes in small increments, say 3-5%, keeping in mind the 15:1 effect of the exhaust eductors.

      (1) A higher entrance exhaust flow vs. the transition tunnel/exit exhaust flow will pull gas flow toward the entrance of the furnace. Effects include:

         (a) Added heat to zones near the entrance for maximum ramp up in temperature.

         (b) Any zone setpoint that is much cooler than the preceding zone.

         (c) Faster initial cooling in cooling section.

      (2) Conversely, a higher transition tunnel/exit exhaust flow will pull flow toward the exit of the furnace. Principal effect:

         (a) Pulling heat away from entrance may allow higher temperatures to be maintained with less power in zones nearer to the furnace exit.

      (3) Remember to keep the total furnace gas inflow/outflow in balance when you make any gas flow adjustments.

f) Get in the habit of storing your gas flow settings on the Gas Flow screen with each recipe so that they will be available for operator adjustment when the recipe is recalled from storage.

E. Stability

While the default zone PID control settings entered at the factory may be sufficient for most profiles, the furnace allows fine tuning of these settings, if needed. This tuning should be performed only if Sections C & D above are completed.

1. Observe the effect of your changes on the Trends screen for the selected zone and correct PID settings as required. Allow enough time (2-3 minutes) to let the zone controls settle.

2. What happens when "Gain" is adjusted:

   a) The higher the number, the bigger the amount of correction. If gain is too big, the actual temperature will oscillate above/below the setpoint. Reduce gain until the actual temperature settles quickly onto the setpoint temperature with little overshoot.

   b) **Never set gain to 0!** On RTC furnaces, typical settings are 6-30. Factory default is 9.

3. What happens when "Integral" is adjusted:

   a) The smaller the number, the quicker the correction is applied.

   b) **Never set integral to 0!** On RTC furnaces, typical settings are 25-90. Factory default is 45.

4. What happens when "Derivative" adjusted:

   a) Derivative acts on the "rate of change" of the temperature deviation and gives an anticipatory response. May be set to 0 (Derivative has no effect) for a continuous stream of similar parts entering a zone. A setting of 1 or 2 may help a furnace zone respond more quickly to an uneven flow of parts.

   b) On RTC furnaces, typical settings are 0-2; use with caution as the **IR lamps in the furnace respond quickly**. Factory default is 0.

Note: Zone control settings for this recipe are stored with the recipe when it is saved. These control settings load when the recipe loads: there is no involvement required by the operator.

F. Process Alerts and Alarms. Set up alert and alarm levels.

1. Be smart about alerts and alarms

   a) Always leave the audible horn ON . If you are getting Alerts, check temperature settings, observed deviation from setpoint, rate of recovery from the alert and current power to the lamps for the affected zone on the Process screen. Alerts are giving you and your process people valuable information -- they are not nuisances.

   b) On RTC furnaces with PLC control, use the Deviation window on the Process screen to review Alert and Alarm levels for each zone. A furnace under control will show short, green bars or no bars at all in each zone.

   c) Avoid unnecessary furnace shutdowns due to brief temperature deviations (due to uneven furnace loading, etc.). Once in the process READY mode, the control system will shut off the lamps and enter COOL DOWN whenever any zone actual temperature reaches its Alarm limit. Increasing the Alarm limits for sensitive zones from their default setting of ± 20C to ± 30C can make a big difference; the same is true for Alerts.

G. Examples of Zone Control

Analysis on An RTC or LCI furnace with PLC control.

1. Process In Control

a) On the Process screen, issues with zones out of control can be spotted quickly via the Deviations window. Use the Trends display assess the zone behavior and to identify a solution.

b) Table 5-1 is a Trends display of a **zone under control**. Here the zone gas flow is being replenished at an appropriate rate and the lamps are on continuously adding energy to the entering gas and belt. The furnace was placed briefly in COOL DOWN mode, then returned to WARM UP to check the control response.

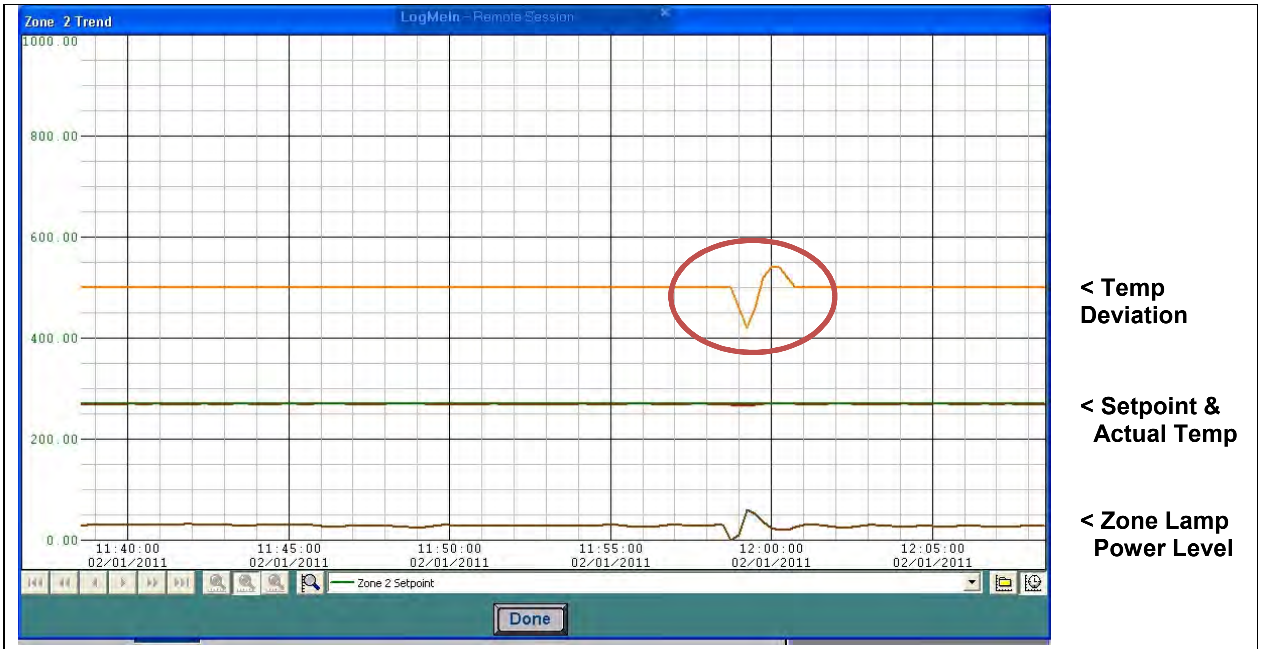


Table 5-1

Observation: This is a stable zone with a balanced gas flow. Note the smooth response in the Temp Deviation trace (circled) to the COOL DOWN command followed by the WARM UP command.

Recommendation: No further adjustment required.

2. Process Needs Adjustment

a) Table 5-2 is a Trends display of Zone 1 out of control due to **gas flow imbalance**. Here the entrance exhaust eductor flow is higher than the transition tunnel exhaust eductor flow causing a net flow of gas toward the entrance of the furnace. This flow is dragging heat from the hotter Zone 2 (setpoint 270C) into Zone 1 (setpoint 210C) on its way to the entrance exhaust stack. Even with the lamps in Zone 1 off, heated gas is entering Zone 2, raising Zone 1 actual temperatures.

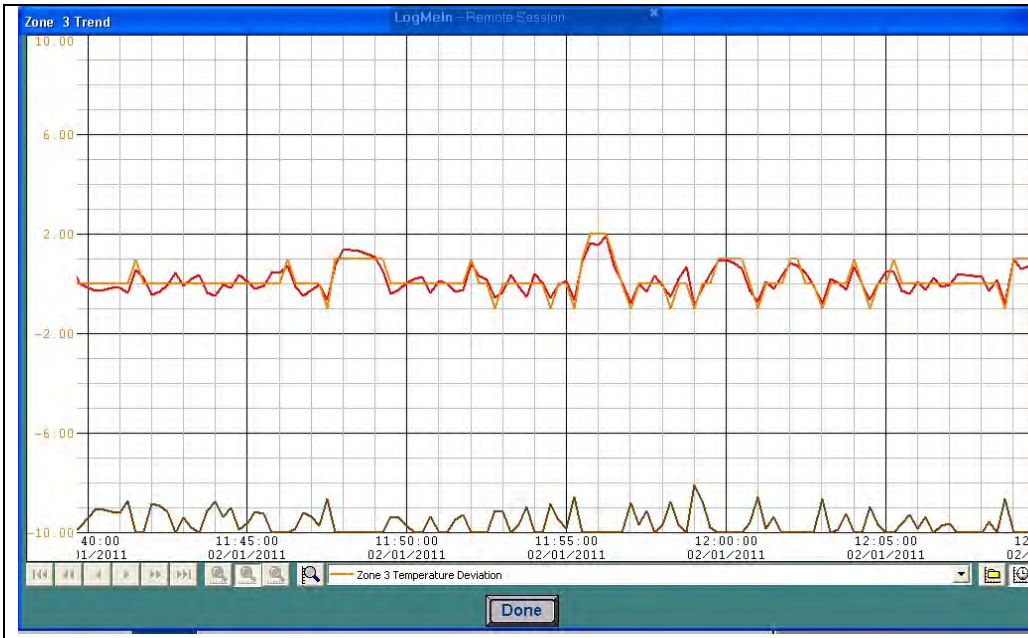
Table 5-2

Observation: Temperature deviation (difference between setpoint and actual) from -2C to + 14C observed. Lamps are on (circled areas, bottom trace) only when deviation is below 0C. During 10 minutes lamps are off, temperature rises due to gas entering from Zone 2.

Recommendation: raise transition exhaust eductor flow (while reducing entrance exhaust eductor flow) to move heated gas toward exit end of furnace. Lamps in both zones will add appropriate heat as required and the zones will be under control.

3. Effect of Changing PID Settings

a) Table 5-3 is a Trends display of the effect of a **change to the control PID settings** in a zone.



< Temp Deviation

< Zone Lamp Power Level

Table 5-3

Observation: Temperature deviations of ± 5C (difference between setpoint and actual) were observed.

Recommendation: by increasing the gain setting from 9 to 18, and reducing the integral setting from 45 to 30, larger and faster corrections reduced temperature deviations in this zone from ±5C to mostly ± 1C.

Additional recommendation: To further improve stability, add slightly more gas flow into the zone or adjust the exhaust eductors at either end of the furnace section to move more heated process gas out of the zone (see 5.D. Balance Gas Flow above).

1.0 Scope

This instruction covers the SuperTrend chart functions supplied as an integral part of the furnace software on many RTC, GBT and LCI infrared furnaces. SuperTrend charts can provide valuable data for fine tuning furnace performance as well as troubleshooting furnace behavior.

2.0 Description

SuperTrend charts present detailed real time charting of five parameters on a zone by zone basis. The charted parameters include:

Setpoint – Zone temperature setpoint, degrees C.

Top Power – Actual power (as percent) supplied to top lamps in zone.

Bottom Power – Actual power (as percent) supplied to bottom lamps in zone.

Temperature – Temperature measured by zone thermocouple, degrees C.

Temperature Deviation – difference between zone setpoint and measured temperatures, degrees C.

The default Real Time SuperTrend screen is shown below:

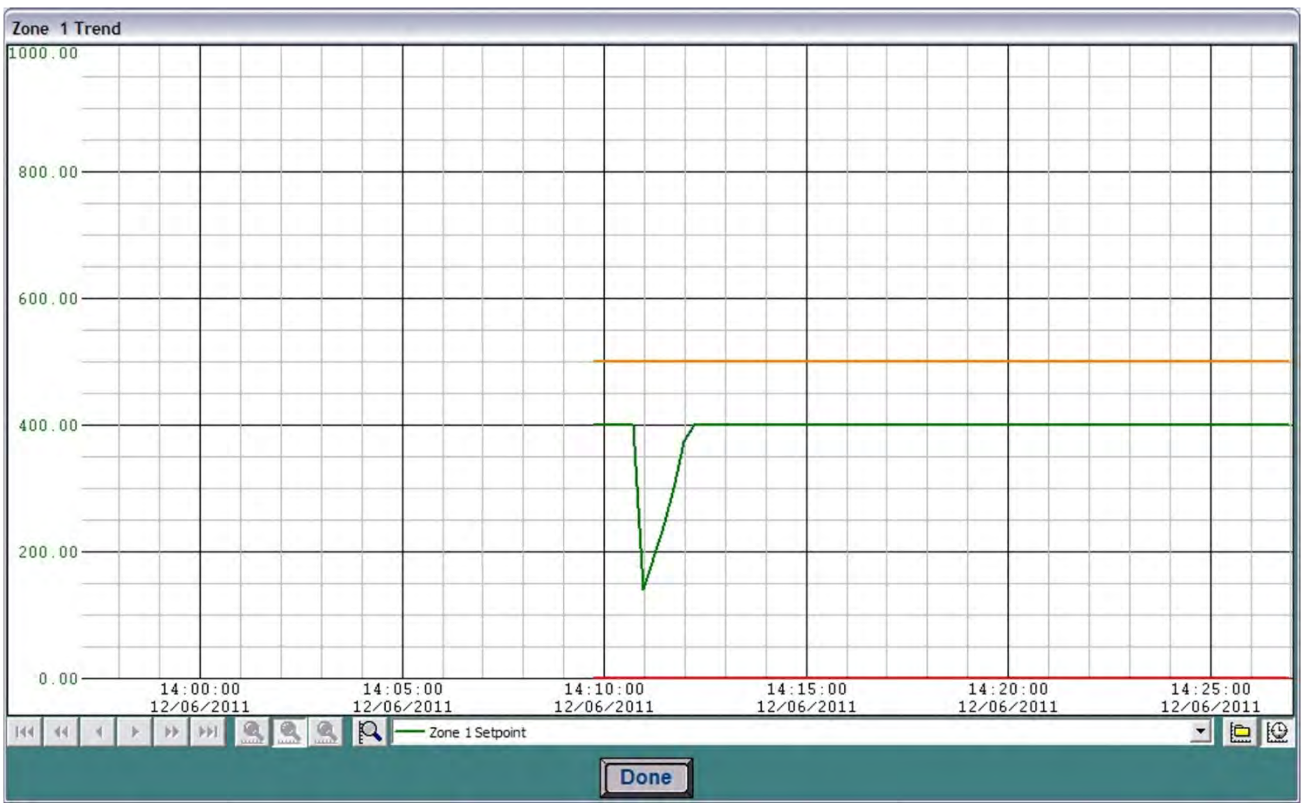


Figure 2.1SuperTrend Real Time Screen

All charts are stored in files on the furnace computer in c:\RTC\Trendlogs directory and can be accessed from the SuperTrend screens.

While these screens allow the viewer to make many changes to the way the data is viewed, the SuperTrending function does not make any changes to the acutal data. Vertical scale changes may be stored as new defaults, however, they can be changed at any time and do not affect the actual stored data.

3.0 Accessing SuperTrend Charts

If the SuperTrend Chart feature is activated, you will see the Trends button on the Process screen.

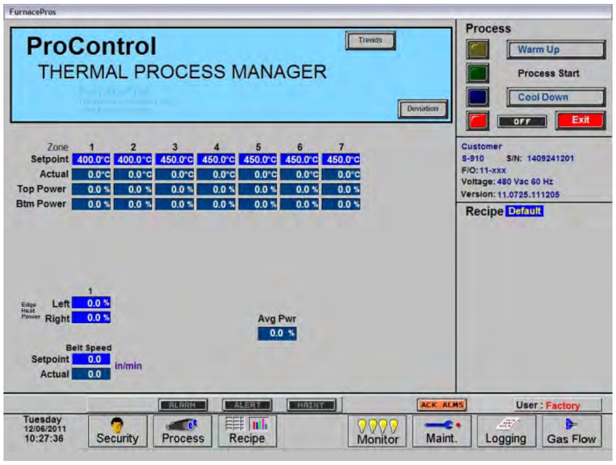


Figure 3.1 Process Screen with Trends button

Press the trends button to see the zone selector popup.

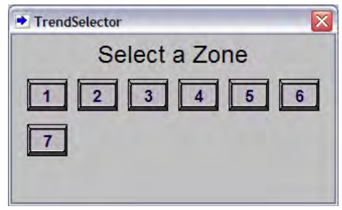


Figure 3.2 Trend Selector popup

3.1 Real Time Charts

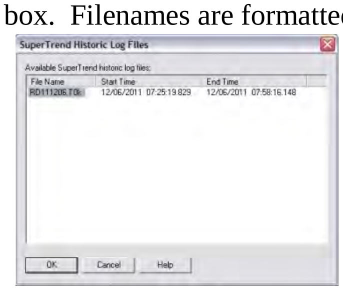
Select the number of the zone you wish to view and the real time Chart for that zone will appear. All five charted parameters are shown. Make a selection from the dropdown menu to view the vertical scale that matches the selected parameter. The vertical scales are user adjustable.
The horizontal scale shows a 30 minute duration in real time mode.

Figure 3.3 SuperTrend Real Time Screen

Click on the Real Time button  to return to real time view.

3.2 Historical Charts

Click on the  button to open the SuperTrend Historical Log Files dialog box. Filenames are formatted as RDyymmdd. File start times and end times are shown. Select the file and click OK to view.



The historical file will be loaded and additional menu bar viewing features will be enabled.

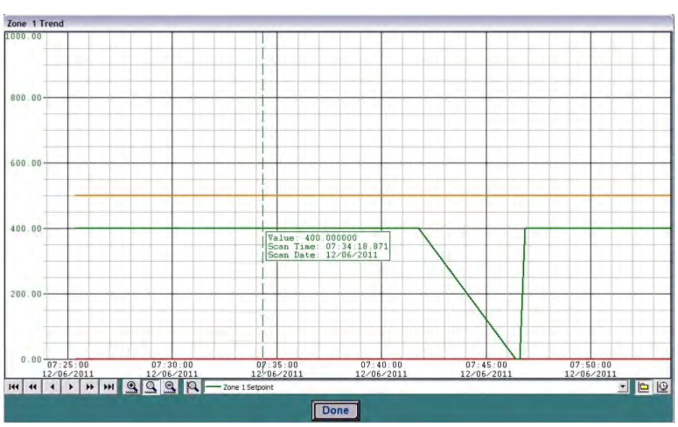


Figure 3.4 SuperTrend Historical Log Screen

Clicking on the face of the screen will reveal the value of the selected setpoint at that time on the chart as shown in Figure 3.4.

Click on the Real Time button  to return to real time view.

4.0 SuperTrends Menu Bar

The menu bar allows users to select and change views of real time and historical log files. In the Real Time mode users can change the vertical scaling to increase or decrease chart resolution. In the Historical Log mode users can also compress and expand the horizontal time scale and move forward and back to view data stored at different times in the file.

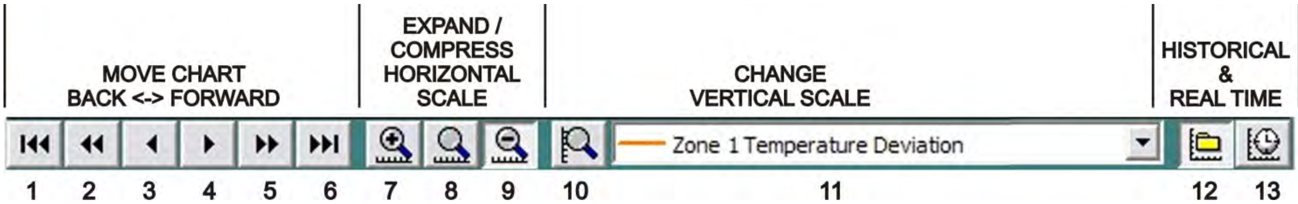


Table 4-1 SuperTrend Charts menu bar			
1	Move to beginning of file	8	Reset horizontal time scale to 30 minutes
2	Move 30 minutes back in file	9	Compress time scale (more time shown)
3	Move 5 minutes back in file	10	Change vertical scale selected in 11
4	Move 5 minutes ahead in file	11	Dropdown to select vertical scale to show
5	Move 30 minutes ahead in file	12	Select historical log file
6	Move forward to end of file	13	Return to view real time chart
7	Expand time scale (less time shown)		

4.1 Changing Parameters

Use the dropdown (Table 4-1, item 11) to change the vertical scale shown. Note when changing parameters, the vertical axis numbers change to correspond to the parameter selected. However, since all 5 parameters are continuously tracked, their relative size and each scale remains the same until its parameter scale is changed.

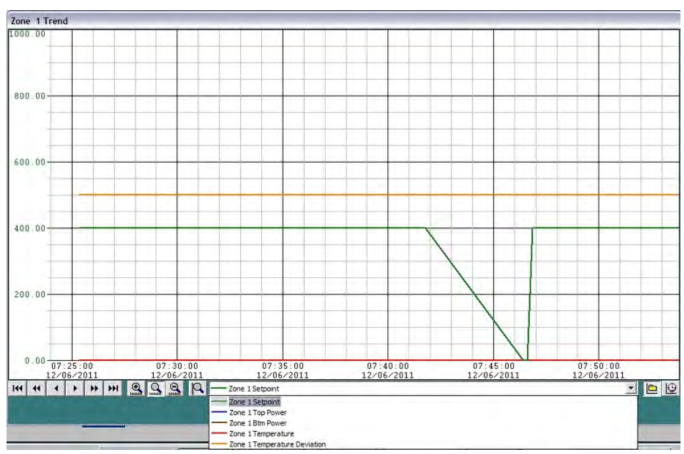


Figure 4.1 Change Parameter Scale

4.2 Changing a Parameter's Scale

Expanding the scale of a parameter allows the viewer to see more of the data that might be out of range. Conversely reducing the scale shows greater detail. For example default scale for Temperature deviation is typically set to +/-25C. After the furnace is setup and stable, the user can reduce the scale to +/-10C or +/- 5C to exaggerate the temperature deviation and allow for finer tuning.

Parameter scales are stored for each zone. So if Zone 1 Temperature scale is changed to 0-200C, Zone 2 Temperature scale will remain at 0-1000C until changed. Each file when opened will be viewed with the current parameter scale settings

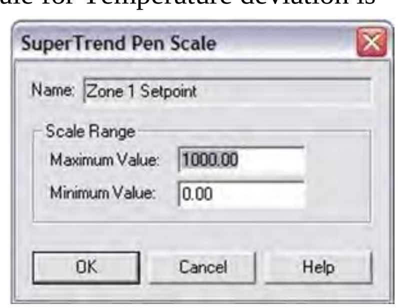


Figure 4.2 Change Vertical Scale popup

4.3 Changing the Time Viewed and Time Scale

In the Historical Log Mode additional views are enabled. Clicking on the forward and back buttons (Table 4-1, buttons 1 through 6) presents the earliest data in the selected file to the last data in the file.

To expand the time scale to see more detail in less time, press the  button (Figure 4.5).

To compress the time scale and see a longer period in one screen, press the  button (Figure 4.3)

To reset the scale to 30 minutes press the  button (Figure 4.4)

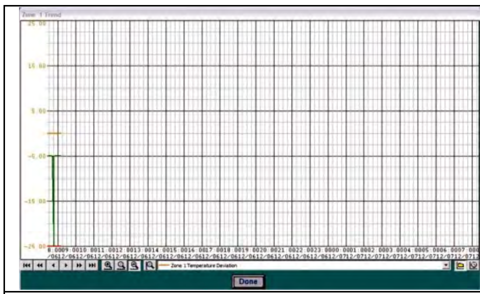


Figure 4.3 Compressed time scale

Figure 4.4 Default time scale (30 min)

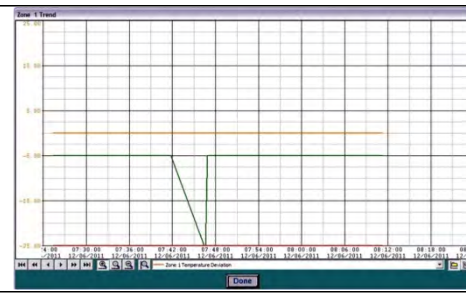


Figure 4.5 Expanded time scale

1.0 Scope

This instruction covers use of furnace software to save process control recipes.

2.0 Recipe Editor

The Recipe Editor is a worksheet for creating a new recipe or making changes to an existing recipe. When the Recipe Editor is off-line, changes to the recipe only exist on the worksheet and do not affect furnace operation nor are they stored on the furnace computer.

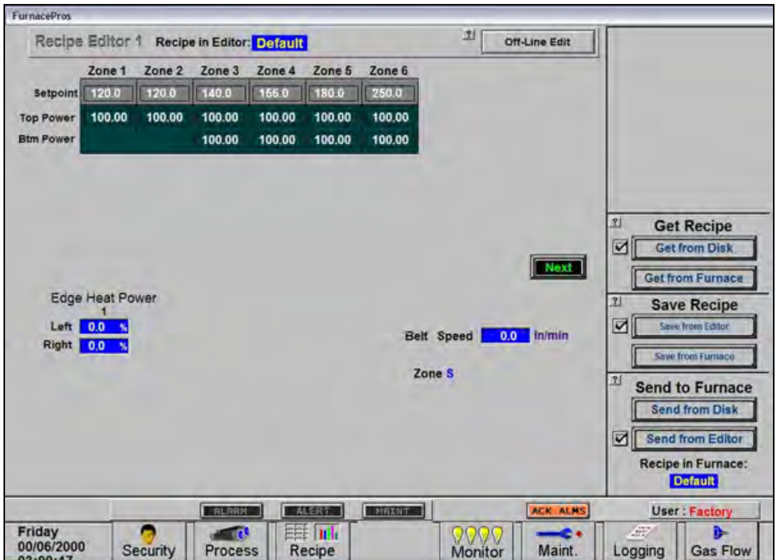


Fig 3-1 Recipe Editor with a recipe named Default

3.0 Recipe Name vs. Recipe File Name

The Recipe Name is a user defined name given to each recipe during the Recipe Save process. The Recipe Name is often the same as the recipe file name (without the .rcp extension). However, it is possible to save a number of recipes with the same Recipe Name but different recipe file names which can cause confusion.

The example in this document starts with a recipe named Default in the editor and in the furnace. The Recipe in Editor name is at the top of the screen in the title bar. The name of the recipe running in the furnace is shown in the lower right hand corner of the Recipe Editor screen.

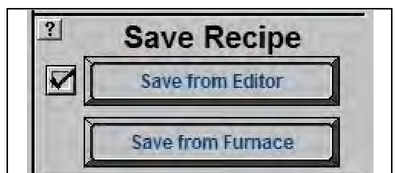


Fig 4-1 Save from Editor button

4.0 Save Recipe – Save from Editor

To save a recipe that is currently viewed in the editor, select the Save from Furnace button in the save Recipe box on Recipe Editor 1.

The Save Recipe dialog will appear (Fig 4-2a). Change the recipe name to a new name (e.g. NewRecipeName) as in Figure 4-2b.

Click on Save to R: button.

The Select Destination File For Upload dialog box will appear (Fig 4-3a).

Enter the new file name in place of the asterisk (*) and press OK (Fig 4-3b). The file will be saved in the R:\ directory with the new recipe name and with the new file name (RecipeName.rcp) as an rcp file.

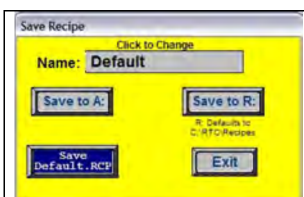


Fig 4-2a Safe Recipe

Fig 4-2b Enter new recipe name

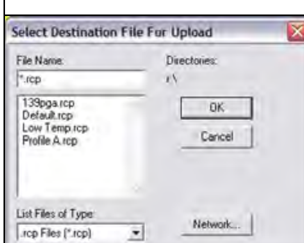


Fig 4-3a Save to R:

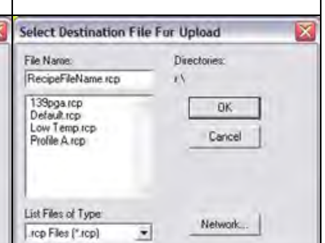


Fig 4-3b Enter new file name

5.0 Apply the new Recipe

After the recipe in the editor has been saved, the Recipe Editor screen will show the name of the new recipe in the title bar at the top of the screen (NewRecipeName in fig 5-1). Note that the lower right hand corner will still show the name of the recipe running in the furnace (Default in fig 5-1)

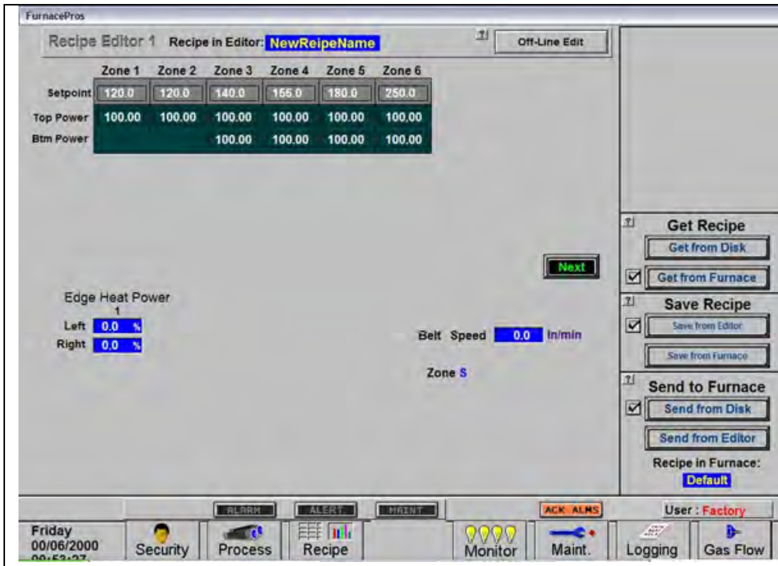


Fig 5-1 Recipe in Furnace different from Recipe in Editor

The recipe in the Recipe Editor must be sent to the furnace in order for it to be used.

To send the recipe in the editor to the furnace, click on Send from editor button in Send to Furnace box (Fig 5-2).

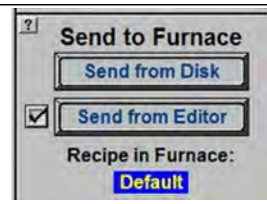


Fig 5-2 Send Recipe in Editor to Furnace

The Recipe Editor screen will now appear similar to fig 5-3. The name of the Recipe in Furnace has changed to the name in the editor as shown in the lower right of the screen in fig 5-3.

Go to the Process screen and verify that the correct recipe values are running in the furnace.

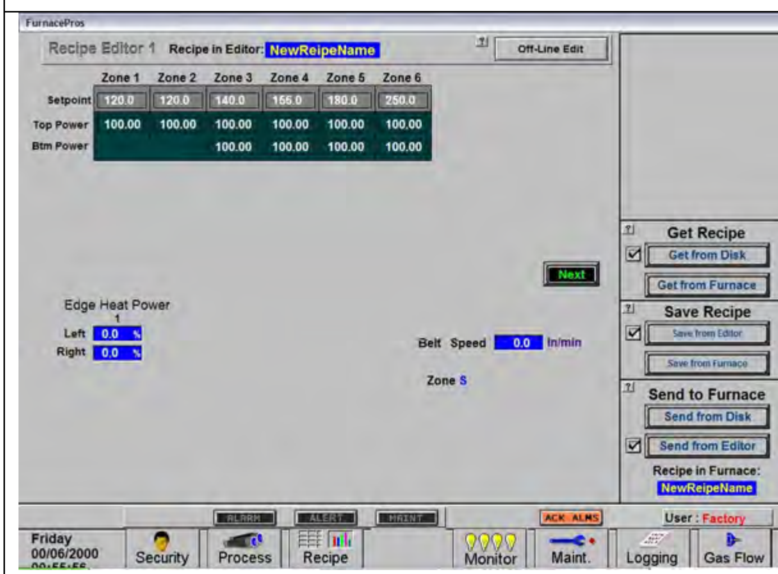


Fig 5-3 Recipe in Furnace sent from Editor

APPENDIX

10.1 Dell Optiplex 790

DELL™

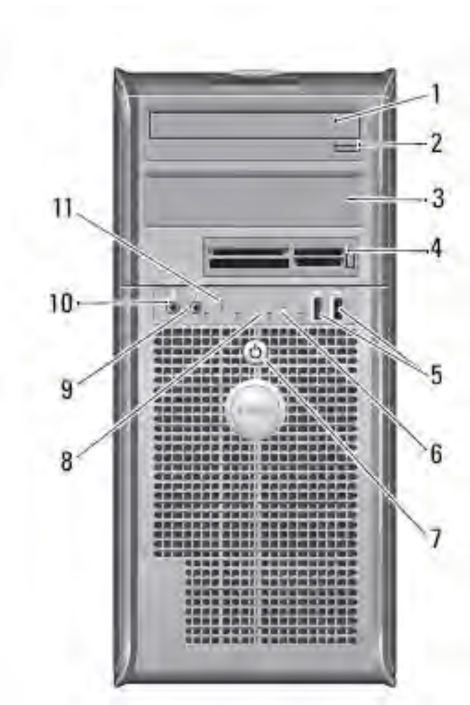
OPTIPLEX™ 780

TECHNICAL GUIDEBOOK

INSIDE THE OPTIPLEX 780

TABLE OF CONTENTS

MINI TOWER COMPUTER (MT) VIEW



FRONT VIEW

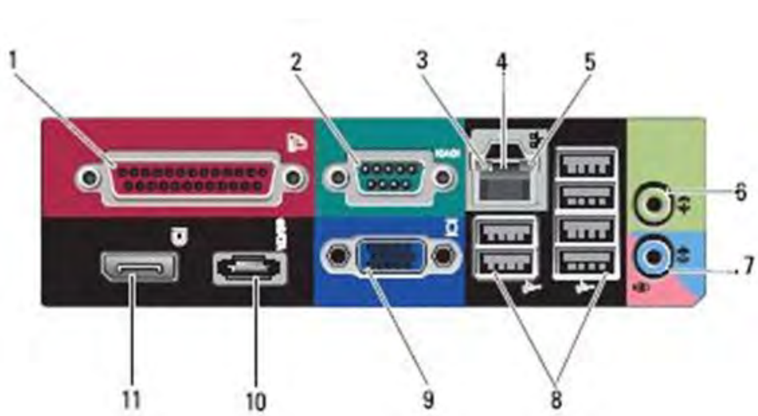
1	Optical Drive (optional)	7	Power Button, Power Light
2	Optical Drive Eject Button	8	Diagnostic Lights (4)
3	Optical Drive Bay	9	Headphone Connector
4	Media Card Reader (optional)	10	Microphone Connector
5	USB 2.0 Connectors (2)	11	Network Connectivity Light
6	Hard Drive Activity Light		

BACK VIEW

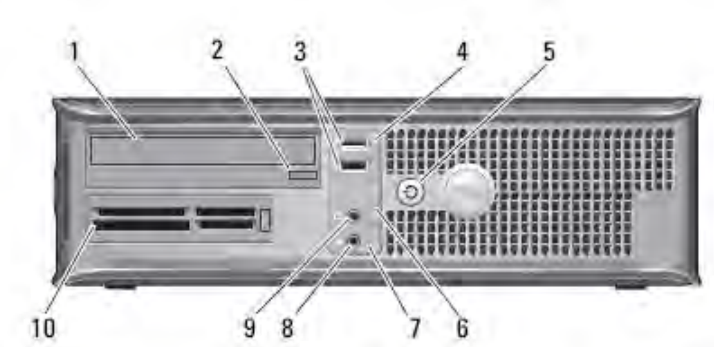
1	Power Connector	4	Power-Supply Vent
2	Back-Panel Connectors	5	Chassis Lock Loop
3	Expansion Card Slots (4)	6	Cover Release Latch

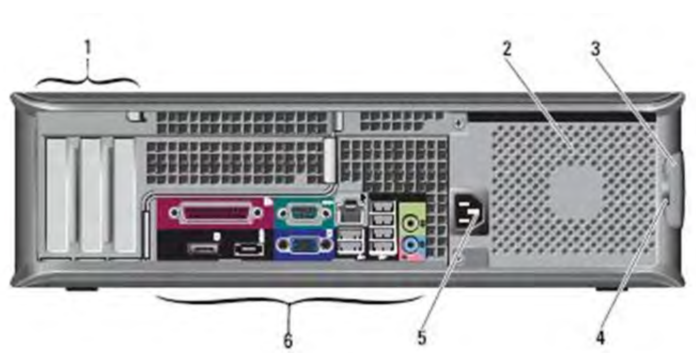
BACK PANEL CONNECTORS

1	Parallel Connector	7	Line-in Connector
2	Serial Connector	8	USB 2.0 Connectors (6)
3	Link Integrity Light	9	VGA Video Connector
4	Network Connector	10	eSATA Connector
5	Network Activity Light	11	DisplayPort Connector
6	Line-out Connector		



DESKTOP COMPUTER (DT) VIEW

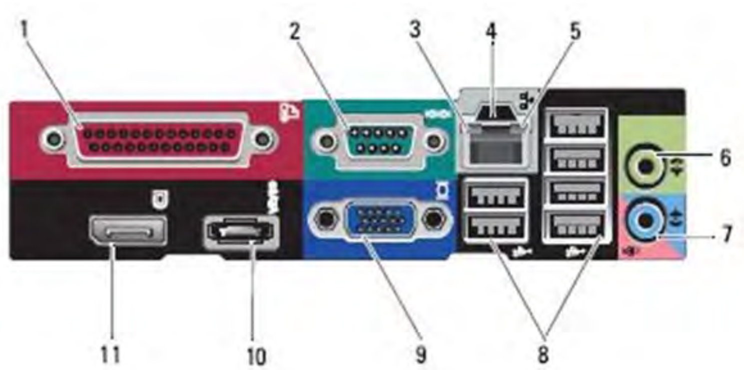




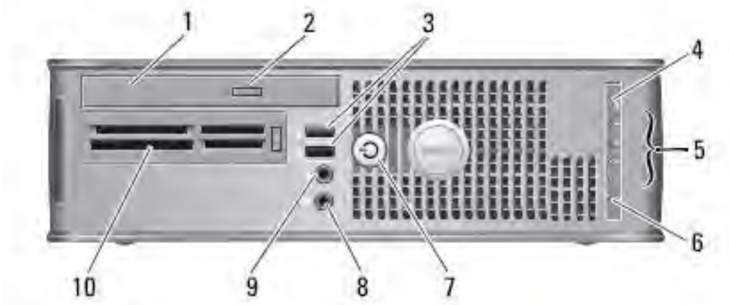
FRONT VIEW			
1	Optical Drive (optional)	7	Network Connectivity Light
2	Optical Drive Eject Button	8	Microphone Connector
3	USB 2.0 Connectors (2)	9	Headphone Connector
4	Hard Drive Activity Light	10	Media Card Reader (optional)
5	Power Button, Power Light		
6	Diagnostic Lights (4)		

BACK VIEW			
1	Expansion Card Slots (3)	4	Chassis Lock Loop
2	Air Vent	5	Power Connector
3	Cover Release Latch	6	Back-Panel Connectors

BACK PANEL CONNECTORS			
1	Parallel Connector	7	Line-in Connector
2	Serial Connector	8	USB 2.0 Connectors (6)
3	Link Integrity Light	9	VGA Video Connector
4	Network Connector	10	eSATA Connector
5	Network Activity Light	11	DisplayPort Connector
6	Line-out Connector		



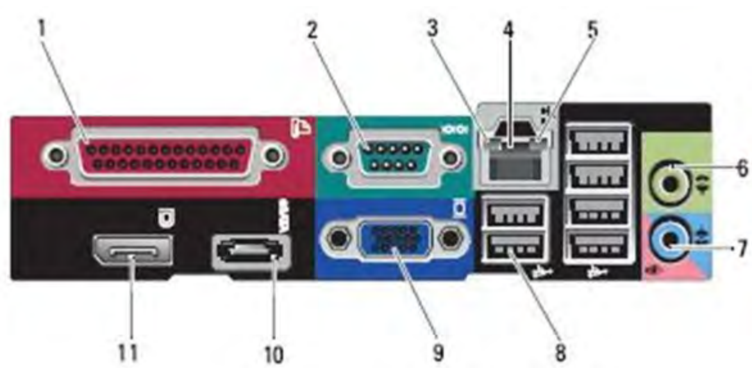
SMALL FORM FACTOR COMPUTER (SFF) VIEW



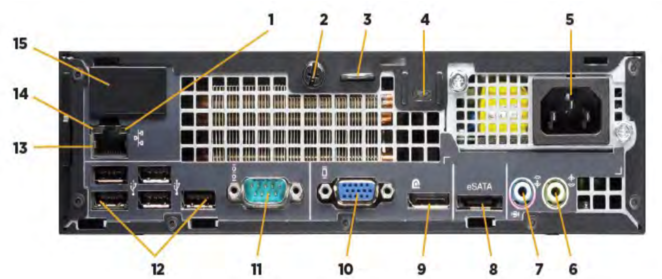
FRONT VIEW			
1	Optical Drive (optional)	7	Power Button, Power Light
2	Optical Drive Eject Button	8	Microphone Connector
3	USB 2.0 Connectors (2)	9	Headphone Connector
4	Network Connectivity Light	10	Media Card Reader (optional)
5	Diagnostic Lights (4)		
6	Hard Drive Activity Light		

BACK VIEW			
1	Chassis Lock Loop	4	Back-Panel Connectors
2	Cover Release Latch	5	Expansion Card Slots (2)
3	Power Connector		

BACK PANEL CONNECTORS			
1	Parallel Connector	7	Line-in Connector
2	Serial Connector	8	USB 2.0 Connectors (6)
3	Link Integrity Light	9	VGA Video Connector
4	Network Connector	10	eSATA Connector
5	Network Activity Light	11	DisplayPort Connector
6	Line-out Connector		



ULTRA SMALL FORM FACTOR COMPUTER (USFF) VIEW



FRONT VIEW			
1	Optical Drive	7	Headphone Connector
2	Power Button, Power Light	8	Microphone Connector
3	Drive Activity Light	9	USB Connector 2.0 (2)
4	Diagnostic Lights (4)		
5	Network Connectivity Light		
6	WiFi Activity Light (optional)		

BACK VIEW			
1	Network Activity Light	9	Display Port Connector
2	Captive Thumbscrew	10	VGA Video Connector
3	Padlock Ring	11	Serial Connector
4	Security Cable Slot	12	USB Connector 2.0 (5)
5	Power Connector	13	Network Connector
6	Line-Out Connector	14	Link Integrity Light
7	Line-in/ Microphone Connector	15	WiFi Antenna (optional)
8	eSATA Connector		

MARKETING SYSTEM CONFIGURATIONS

NOTE: Offerings may vary by region. For more information regarding the configuration of your computer, click Start>Help and Support and select the option to view information about your computer.

OPERATING SYSTEM

NOTE: One of the following Operating Systems will be preinstalled.

	MT	DT	SFF	USFF
Windows 7® operating system (available in Q4 2009)	Microsoft® Windows 7® Basic; Microsoft® Windows 7® Professional (64 and 32 bit); Microsoft® Windows 7® Ultimate			
Windows Vista® operating system	Windows Vista® Business SP1 (32 bit), Windows Vista® Home Basic SP1 (32 bit), Windows Vista® Business SP1 (32 bit) via Windows 7 Professional Downgrade Rights, Windows Vista® Ultimate SP1 (32 bit) via Windows 7 Ultimate Downgrade Rights,			
Windows XP® operating system	Windows**®** XP Professional SP3 via Windows Vista® Business or Ultimate Downgrade Rights (32 bit), Windows**®** XP Professional SP3 via Microsoft® Windows 7® Professional or Microsoft® Windows 7® Ultimate Downgrade Rights (32 bit)			
Other	FreeDOS for (N-series), Ubuntu® Linux (China only)			
OS Media Support	X	X	X	X

CHIPSET

	MT	DT	SFF	USFF
Chipset	Intel Q45 Express Chipset w/ICH10DO			
Non-volatile memory on chipset				
BIOS Configuration SPI (Serial Peripheral Interface)	64Mbit (8MB) located at SPI_FLASH on chipset			
TPM 1.2 Security Device (Trusted Platform Module)[1]	16KB located at TPM1.2 on chipset			
TCM (Trusted Computing Module)	Available in China only			
Non-TPM	Available in select countries			
NIC EEPROM	LOM configuration contained within SPI_FLASH – no dedicated LOM EEPROM			

PROCESSOR

NOTE: Global Standard Products (GSP) are a subset of Dell's relationship products that are managed for availability and synchronized transitions on a worldwide basis. They ensure the same platform is available for purchase globally. This allows customers to reduce the number of configurations managed on a worldwide basis, thereby reducing their costs. They also enable companies to implement global IT standards by locking in specific product configurations worldwide. The following GSP processors identified below will be made available to Dell customers.

NOTE: Processor numbers are not a measure of performance.
NOTE: Processor availability subject to change and may vary by region/country.

	MT	DT	SFF	USFF
Intel® Core™ 2 Quad Processors				
Intel® Core™ 2 Quad Q9650/3.00GHz, 12M, 1333FSB	X-GSP	X-GSP	X-GSP	
Intel® Core™ 2 Quad Q9550/2.83GHz, 12M, 1333FSB	X-GSP	X-GSP	X-GSP	
Intel® Core™ 2 Quad Q9400/2.66GHz, 6M, 1333FSB	X-GSP	X-GSP	X-GSP	
Intel® Core™ 2 Quad Q8400/2.66GHz, 4M, 1333FSB	X	X	X	
Intel® Core™ 2 Quad Q8300/2.50GHz, 4M, 1333FSB	X	X	X	
Intel® Core™ 2 Duo and Pentium® Dual Core Processors				
Intel® Core™ 2 Duo E8600/3.33GHz, 6M, 1333FSB	X-GSP	X-GSP	X-GSP	X-GSP
Intel® Core™ 2 Duo E8500/3.16GHz, 6M, 1333FSB	X-GSP	X-GSP	X-GSP	X-GSP
Intel® Core™ 2 Duo E8400/3.0GHz, 6M, 1333FSB	X-GSP	X-GSP	X-GSP	X-GSP
Intel® Core™ 2 Duo E7600/3.06GHz, 3M, 1066FSB	X	X	X	X
Intel® Core™ 2 Duo E7500/2.93GHz, 3M, 1066FSB	X	X	X	X
Intel® Pentium® Dual-Core E6300/2.8GHz, 2M, 1066FSB	X	X	X	X
Intel® Pentium® Dual-Core E5400/2.7GHz, 2M, 800FSB	X	X	X	X
Intel® Pentium® Dual-Core E5300/2.60GHz, 2M, 800FSB	X	X	X	X
Intel® Celeron® Processors				
Intel® Celeron® Dual-Core 3300/2.50GHz, 1M, 800FSB	X	X	X	X
Intel® Celeron® Dual-Core 3200/2.40GHz, 1M, 800FSB	X	X	X	X
Intel® Celeron® Dual-Core 1600/2.40GHz, 512K, 800FSB	X	X	X	X
Intel® Celeron® Dual-Core 1500/2.20GHz, 512K, 800FSB	X	X	X	X
Intel® Celeron® 450/2.20GHz, 512K, 800FSB	X	X	X	X

ADVANCED SYSTEM MANAGEABILITY MODES

NOTE: Hardware management mode options allow you to select the right systems management feature support for your enterprise. Dell's innovative approach to scalable remote client management offers you a choice of built-in hardware management capabilities across platform offerings.

The latest generation of Intel® vPro™ technology provides the capability to manage your install base of systems regardless of the power state or hardware functionality of the system.

This functionality allows IT to address many issues remotely rather than having to physically visit systems.

The OptiPlex 780 supports Intel® vPro™ technology and Intel® Standard Manageability which supports the following features:

Asset reporting and inventory capabilities, Remote troubleshooting and repair, Client System Isolation, Remote patching/ updating

Intel® vPro™ technology adds these additional features:

Client initialed "Fast Call for Help"/ beyond firewall systems management capability, Microsoft NAP support, Hardened security monitoring, Support for the latest generation of Intel® Core™ 2 Processors

-Intel vPro Technology Enabled: This option enables full vPro out of band functionality. Requires a vPro processor.
-Intel vPro Technology Disabled: This option disables vPro technology but allows for the later enablement of vPro as desired. Requires a vPro processor
-Intel Standard Manageability: This option delivers a portion of basic out of band capabilities (see above)
-No Out of Band Systems Management: This option does not support out of band management. Cannot be enabled after point of sale.

	MT	DT	SFF	USFF
Intel® vPro Technology Enabled* (iAMT 5.x)	X	X	X	X
Intel® vPro Technology DIsabled * (iAMT 5.x)	X	X	X	X
Intel® Standard Manageability *	X	X	X	X
No Out-of-Band Systems Management	X	X	X	X

*The functionality described above requires an appropriate software management console

MEMORY

Memory modules should be installed in pairs of matched memory size, speed, and technology. If the memory modules are not installed in matched pairs, a slight reduction in performance may occur.

	MT	DT	SFF	USFF
Type: DDR3 Synch DRAM Non-ECC Memory	1066MHz			
DIMM Slots	4	4	4	2
DIMM Capacities	Up to 2GB	Up to 2GB	Up to 2GB	Up to 2GB
Minimum Memory	1GB	1GB	1GB	1GB
Maximum System Memory (uses 2GB DIMMS)	8GB[1]	8GB[1]	8GB[1]	4GB
1066MHz Memory configurations				
8GB[1] DDR2 Non-ECC SDRAM, 1066MHz, (4 DIMM)	X	X	X	
4GB[1] DDR2 Non-ECC SDRAM, 1066MHz, (4 DIMM)	X	X	X	
4GB[1] DDR2 Non-ECC SDRAM, 1066MHz, (2 DIMM)	X	X	X	X
3GB DDR2 Non-ECC SDRAM, 1066MHz, (3 DIMM)	X	X	X	
3GB DDR2 Non-ECC SDRAM, 1066MHz, (2 DIMM)	X	X	X	X
2GB DDR2 Non-ECC SDRAM, 1066MHz, (2 DIMM)	X	X	X	X
2GB DDR2 Non-ECC SDRAM, 1066MHz, (1 DIMM)	X	X	X	X
1GB DDR2 Non-ECC SDRAM, 1066MHz, (1 DIMM)	X	X	X	X

[1] The total amount of available memory will be less than 4GB. The amount less depends on the actual system configuration. To fully utilize 4GB or more of memory requires a 64-bit enabled processor and 64-bit operating system.

DRIVES AND REMOVABLE STORAGE

	MT	DT	SFF	USFF
Bays:				
3.5-inch bay (External 19-1 Media Card Reader)	1	1	1 (slim-line)	
5.25-inch bay (External Optical)	2	1	1 (slim-line)	
Hard Drives Supported (Internal and External)	2	2	2	1
Optical Drives Supported	2	1	1	1
Interface:				
SATA	4	3	3	2
3.5" Hard Drives:				
160GB[1] SATA 10K RPM HDD	X	X	X	
80GB[1] SATA 10K RPM HDD	X	X	X	
500GB[1] SATA 7200 RPM HDD	X	X	X	
320GB[1] SATA 7200 RPM HDD	X	X	X	
250GB[1] SATA 7200 RPM HDD	X	X	X	
160GB[1] SATA 7200 RPM HDD	X	X	X	
2.5" Hard Drives:				
320GB[1] SATA 7200 RPM HDD				X
250GB[1] SATA 7200 RPM HDD (available in Q4 2009)	X	X	X	X
160GB[1] SATA 7200 RPM HDD	X	X	X	X
160GB[1] SATA Full Disk Encryption HDD	X	X	X	X
64GB[1] SATA Solid State Drive	X	X	X	X
128GB[1] SATA Solid State Drive				X
RAID 1 Data Protection: (includes two matching capacity/speed hard drives)				
160GB[1] SATA 10K RPM HDD (3.5")	X			
80GB[1] SATA 10K RPM HDD (3.5")	X			
500GB[1] SATA 7200 RPM HDD (3.5")	X			
320GB[1] SATA 7200 RPM HDD (3.5")	X			
250GB[1] SATA 7200 RPM HDD (3.5")	X			
160GB[1] SATA 7200 RPM HDD (3.5")	X			
250GB[1] SATA 7200 RPM HDD (2.5")	X	X	X	
160GB[1] SATA 7200 RPM HDD (2.5")	X	X	X	

DRIVES AND REMOVABLE STORAGE

	MT	DT	SFF	USFF
RAID 0 Performance: (includes two matching capacity/speed hard drives)				
320GB[1] SATA 10K RPM HDD (3.5")	X			
160GB[1] SATA 10K RPM HDD (3.5")	X			
1TB[1] SATA 7200 RPM HDD (3.5")	X			
640GB[1] SATA 7200 RPM HDD (3.5")	X			
500GB[1] SATA 7200 RPM HDD (3.5")	X			
320GB[1] SATA 7200 RPM HDD (3.5")	X			
500GB[1] SATA 7200 RPM HDD (2.5")	X	X	X	
320GB[1] SATA 7200 RPM HDD (2.5")	X	X	X	
Optical Drive: (SFF/USFF require slim-line optical drive)				
DVD+/-RW[2]	SATA 1.5Gbit/s	SATA 1.5Gbit/s	SATA 1.5Gbit/s	SATA 1.5Gbit/s
DVD-ROM[3]	SATA 1.5Gbit/s	SATA 1.5Gbit/s	SATA 1.5Gbit/s	SATA 1.5Gbit/s
Media Card Reader:				
Dell 19 in 1 Media Card Reader	480Mb/s			

1 For hard drives, GB means 1 billion bytes; actual capacity varies with preloaded material and operating environment and will be less.

2 Discs burned with this drive may not be compatible with some existing drives and players; using DVD+R media provides maximum compatibility.

3 DVD-ROM drives may have write-capable hardware that has been disabled via firmware modifications.

SYSTEM BOARD CONNECTORS

NOTE: See Detailed Engineering Specifications for maximum card dimensions.

	MT	DT	SFF	USFF
PCI Slot(s): number of	2	2	1	
PCIe x16 Slot: number of	1	1	1	
PCIe x1 Slot: number of	1	0	0	
Flexbay	1	1	1	
Serial ATA (SATA)	4	3	3	2

GRAPHICS/VIDEO CONTROLLER

NOTE: MT supports full height card, DT supports low profile card or full height card with optional riser. SFF supports low profile card.

	MT	DT	SFF	USFF
Integrated Intel GMA 4500	Integrated on system board			
Enhanced Graphic/Video Options				
DVI (Digital) Adapter Card	Optional card			
256MB ATI RADEON HD 3450 Graphics with dual DVI or VGA and S-Video Out (adapters convert to dual DVI or dual VGA)	Optional card			
256MB ATI RADEON HD 3470 Graphics with Dual DP (adapters convert to dual DVI or dual VGA)	Optional card			
256MB nVidia GeForce 9300 GE with dual DVI or VGA and S-Video Out (adapters convert to dual DVI or dual VGA)	Optional card			
NVIDIA Quadro NVS 420 (available in Q4 2009)	Optional card			

EXTERNAL PORTS/CONNECTORS

NOTE: MT supports full height card, DT supports low profile card or full height card with optional riser. SFF supports low profile card.

See chassis diagrams section for port/connector locations	MT	DT	SFF	USFF
USB 2.0	2 Front, 6 Rear, 1 Internal			2 Front, 5 Rear
Serial	1 rear, second port optional via card			1 Rear
eSATA	1 Rear			1 Rear
Parallel	1 Rear			
Network Connector (RJ-45)	1 Rear			
PS/2	Optional via add-in card			
1394 Controller	Optional via add-in card			
Video:				
VGA	1 Rear			
DVI-I	Optional via add-in card			
DisplayPort	1 Rear			
Audio:				
Line in for microphone	1 Front			
Line in for microphone or stereo	1 Rear			
Line out for headphones or speakers	1 Front, 1 Rear			
Risers: (replaces 1 PCI slot and 1 PCIe slot on DT system board)				
Combo full height riser with 1 PCI and 1 PCIe connector		X		
Dual full height riser with 2 PCI connectors		X		

COMMUNICATIONS - NETWORK ADAPTER (NIC)

NOTE: MT supports full height card, DT supports low profile card or full height card with optional riser. SFF supports low profile card.

	MT	DT	SFF	USFF
Intel® 82567LM Gigabit[1] Ethernet LAN 10/100/1000 (Remote Wake Up, PXE support and Intel Active Management Technology support)	Integrated on system board			
Broadcom NetXtreme 10/100/1000 PCIe Gigabit Networking Card	Optional via add-in card			

[1] This term does not connote an actual operating speed of 1 Gb/sec. For high speed transmission, connection to a Gigabit Ethernet server and network infrastructure is required.

COMMUNICATIONS – MODEM

NOTE: MT supports full height card, DT supports low profile card or full height card with optional riser.

	MT	DT	SFF	USFF
V.92 Data/Fax Controllerless Modem	Optional via add-in card			

COMMUNICATIONS – WIRELESS

	MT	DT	SFF	USFF
Dell Wireless 1505 PCIe WLAN card (802.11 Draft N)	Optional via add-in card			
Broadcom 1510 miniPCIe WLAN card (802.11 Draft N)				Optional

AUDIO AND SPEAKERS

	MT	DT	SFF	USFF
ADI 1984A High Definition Audio Codec	Integrated on system board			
Internal Dell Business Audio Speaker	Optional			
Dell AX210 2.0 Desktop Speakers	Optional			
Dell AX510/AX510PA Flat Panel Soundbar Speakers	Optional			
Dell AY410 2.1 Desktop Speakers	Optional			

KEYBOARD AND MOUSE

	MT	DT	SFF	USFF
Dell USB Entry Keyboard with optional palmrest	Standard			
Dell QuietKey Keyboard with optional palmrest	Optional			
Dell Multimedia Pro Keyboard	Optional			
Dell Smartcard Keyboard	Optional			
Dell USB Optical Mouse	Optional			
Dell Laser Mouse	Optional			
Dell Logo Mouse Pad	Optional			

SECURITY

	MT	DT	SFF	USFF
Trusted Platform Module (TPM) 1.2[1]	Integrated on system board			
Trusted Computing Module (TCM)	Integrated on system board (China only)			
Chassis Intrusion Switch	Optional			
Dell Smartcard Keyboard	Optional			
Chassis lock slot and loop support	Standard			

[1]TPM is not available in all countries. Depending on your country regulations, TCM or No-TPM system boards will be made available.

SERVICE AND SUPPORT

NOTE: For more details on Dell Service Plans please to go to: www.dell.com/service/service_plans

	MT	DT	SFF	USFF
3 Year Warranty[1] Next Business Day On-site[2] (3-3-3)	Standard			
ProSupport	Optional			

[1] For a copy of our guarantees or limited warranties, please write Dell USA L.P., Attn: Warranties, One Dell Way, Round Rock, TX 78682. For more information, visit www.dell.com/warranty.

[2] Service may be provided by third-party. Technician will be dispatched if necessary following phone-based troubleshooting. Subject to parts availability, geographical restrictions and terms of service contract. Service timing dependent upon time of day call placed to Dell. U.S. only.

SOFTWARE

	MT	DT	SFF	USFF
Dell Client Manager	Available via Dell.com			
Dell ControlPoint	Standard			
Norton 2009 Internet Security	30 Day Trial or Optional Subscription			
McAfee 10 SecurityCenter	30 Day Trial or Optional Subscription			

DETAILED ENGINEERING SPECIFICATIONS

SYSTEM DIMENSIONS (PHYSICAL)

NOTE: System Weight and Shipping Weight is based on a typical configuration and may vary based on PC configuration. A typical configuration includes: integrated graphics, one hard drive, one optical drive, and one diskette drive.

	MT	DT	SFF	USFF
Chassis Volume (liters)	33.0	16.0	10.7	3.7
Chassis Weight (pounds/kilograms)	25.8 / 11.7	18.2 / 8.26	15 / 6.80	7.0/ 3.2
Chassis Dimensions: (HxWxD)				
Height (inches/centimeters)	16.1 / 40.8	4.5 / 11.4	3.65 / 9.26	9.40/ 23.9
Width (inches/centimeters)	7.4 / 18.7	15.7 / 39.9	12.4 / 31.4	2.60/ 6.50
Depth (inches/centimeters)	17.0 / 43.3	13.9 / 35.3	13.4 / 34	9.30/ 23.6
Shipping Weight (pounds/kilograms - includes packaging materials)	43.5 / 19.73	28 / 12.7	21.3 / 9.66	13.5/ 6.12
Packaging Parameters (HxWxD)				
Height (inches/centimeters)	22.38 / 56.85	20.63 / 52.4	20.88 / 50.04	TBD
Width (inches/centimeters)	22.25 / 56.52	20.31 / 51.59	19.38 / 49.23	TBD
Depth (inches/centimeters)	14.25 / 36.2	11.75 / 29.85	10.63 / 27	TBD

SYSTEM BOARD CONNECTOR MAXIMUM ALLOWABLE DIMENSIONS

	MT	DT	SFF	USFF
PCI Slots	2	2	1	
Height (inches/centimeters)	4.376 / 11.115	2.731 / 6.89		
Length (inches/centimeters)	7.4 / 18.796*	6.6 / 16.764		
PCIe x16 Slots	1	1	1	
Height (inches/centimeters)	4.376 / 11.115	2.731 / 6.89		
Length (inches/centimeters)	7.4 / 18.796*	6.6 / 16.764		
PCIe x1 Slots	1			
Height (inches/centimeters)	4.376 / 11.115			
Length (inches/centimeters)	7.4 / 18.796*			
Risers: (replaces 1 PCI slot and 1 PCIe slot on DT system board)				
Combo Full Height Riser with 1 PCI and 1 PCIe connector (HxL)		1		
Height (inches/centimeters)		4.376 / 11.115		
Length (inches/centimeters)*,**		6.6 / 16.764		
Dual Full Height Riser with 2 PCI connectors (HxL)		1		
Height (inches/centimeters)		4.376 / 11.115		
Length (inches/centimeters)*,**		6.6 / 16.764		

* Card length can be longer than standard Half-Length Card but cannot be a Full-Length Card.

** 6.9/17.53 in/cm is longer than the standard Half-Length Card

SYSTEM LEVEL ENVIRONMENTAL AND OPERATING CONDITIONS

	MT	DT	SFF	USFF
Temperature				
Operating	10° to 35° C (50° to 95° F)			
Non-Operating (Storage)	-40° to 65° C (-40° to -149° F)			
Relative Humidity	20% to 80% (non-condensing)			
Maximum vibration				
Operating	0.25 G at 3 to 200 Hz at 0.5 octave/min			
Non-Operating	0.5 G at 3 to 200 Hz at 1 octave/min			
Maximum Shock				
Operating	Bottom half-sine pulse with a change in velocity of 50.8 cm/sec (20 inches/sec)			
Non-Operating	27-G faired square wave with a velocity change of 508 cm/sec (200 inches/sec)			
Maximum Altitude				
Operating	–15.2 to 3048 m (–50 to 10,000 ft)			
Non-Operating	–15.2 to 10,668 m (–50 to 35,000 ft)			

POWER

NOTE: These form factors utilize a more efficient Active Power Factor Correction (APFC) power supply. Dell recommends only Universal Power Supplies (UPS) based on Sine Wave output for APFC PSUs, not an approximation of a Sine Wave, Square Wave, or quasi-Square Wave. If you have questions, please contact the manufacture to confirm the output type.

	MT APFC	MT EPA	DT APFC	DT EPA	SFF APFC	SFF EPA	USFF EPA
Power Supply Wattage	305W	255W High Efficiency	255W	255 W High Efficiency	235W	235W High Efficiency	180W High Efficiency
AC input Voltage Range	90 – 264Vac	90 – 264Vac	90 – 264Vac	90 – 264Vac	90 – 264Vac	90 – 264Vac	90 – 264Vac
AC input current (low ac range/high AC range)	5.6A / 2.8A	3.6A / 1.8A	5.0A / 2.5A	4.0A / 2.0A	4.5A / 2.25A	3.5A / 1.75A	2.6A / 1.3A
AC input Frequency	47HZ / 63HZ	47HZ / 63HZ	47HZ / 63HZ	47HZ / 63HZ	47HZ / 63HZ	47HZ / 63HZ	47 – 63 Hz
AC holdup time (80% load)	16MSEC	16MSEC	16MSEC	16MSEC	16MSEC	16MSEC	16 ms
Average Efficiency (Energy Star 5.0 Compliant)		87 – 90 – 87% @ 20 – 50 – 100% load		87 – 90 – 87% @ 20 – 50 – 100% load		87 – 90 – 87% @ 20 – 50 – 100% load	87 – 90 – 87% @ 20 – 50 – 100% load
Typical Efficiency (Active PFC)	65%		65%		65%		N/A
DC parameters							
+3.3v output	8.0A	8.0A	7.0 A	7.0 A	5A	5A	N/A
+5.0v output	16A	16A	15A	15A	16A	16A	N/A
+12.0v output	12vA/15A; 12VB/10A	12VA/13A; 12VB/7A	18A	18A	17A	17A	+12VA - 9.0 A & +12VB - 7.0 A Note: +12VB Rated at 0.4A when in Standby Mode.
+5.0v auxiliary output	4.0A	4.0A	4.0	4.0	4.0A	4.0A	N/A
-12.0v output	0.5A	0.5A	0.5A	0.5A	0.5A	0.5A	0.1 A
Max total power	305W	255W	255W	255W	235W	235W	180W
Max combined +3.3v / +5.0v power	80W	80W	91.5W	91.5W	88W	88W	N/A
Max combined 12.0v power (note: only if more than one 12v rail)	240W	240W	N/A	N/A	N/A	N/A	180W
BTUs/h (based on PSU max wattage)	1603 BTU	1000 BTU	1341 BTU	1000 BTU	1235 BTU	921 BTU	723 BTU
3.3v CMOS battery (type and estimated battery life)							
Power Supply Fan	80*25mm	80*25mm	92*25mm	92*25mm	80*15mm	80*15mm	N/A
Compliance:							
1watt requirement	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Blue Angel Compliant	Pending	Pending	Pending	Pending	Pending	Pending	Yes
Climate Savers / 80Plus Compliant	No	Yes	No	Yes	No	Yes	Yes
FEMP (CECP) Standby Power Compliant	No	Yes	No	Yes	No	Yes	Yes

AUDIO

INTEGRATED ADI 1984A HIGH DEFINITION AUDIO	MT	DT	SFF	USFF
High Definition Stereo support	X	X	X	X
Number of channels	2			
Number of Bits / Audio resolution	16, 20, and 24-bit resolution			
Sampling rate (recording/playback)	Independent 8, 11.025, 16, 22.05, 32, 44.1, 48, 88.2, 96, 176.4, and 192 kHz sample rates			
Signal to Noise Ratio	96+ dB audio outputs, 90+ dB audio inputs			
Analog Audio	X	X	X	X
Dolby Digital				
THX				
Digital out (S/PDIF)				
Audio Jack Impedance				
Microphone	150 kΩ			
Line-In	150 kΩ			
Line-Out	190 Ω			
Headphone	.5 Ω			
Internal Speaker Power Rating	2W			

COMMUNICATIONS - NETWORK ADAPTER (NIC)

NOTE: MT supports full height card, DT supports low profile card or full height card with optional riser. SFF supports low profile card.

INTEGRATED INTEL® 82567 GIGABIT1 ETHERNET LAN 10/100/1000	MT	DT	SFF	USFF
External Connector Type	RJ45			
Data Rates supported	10/100/1000 Mbps			
Controller Details				
Controller bus architecture (example PCIe 1.0a x1)	Intel Gigabit LAN Connect Interface (GLCI) and LAN Connect Interface (LCI)			
Integrated memory	N/A			
Data transfer mode (example Bus-Master DMA)	N/A			
Power consumption (full operation per data rate connection speed)	680mW (Max.)			
Power consumption (standby operation)	141mW (Max.)			
IEEE standards compliance (example 802.1P)	802.3			
Hardware Certifications (example FCC, B, GS mark…)	N/A			
Boot ROM Support	EEPROM (located in SPI)			
Network Transfer Mode (example Full Duplex, Half Duplex)				
Network Transfer Rate (example 10BASE-T (half-duplex) 10 Mbps 10BASE-T (full-duplex) 20 Mbps 100BASE-TX (half-duplex) 100 Mbps 100BASE-TX (full-duplex) 200 Mbps 1000BASE-T (full-duplex) 2000 Mbps	10 Mb (full/half-duplex) 100 Mb (full/half-duplex) 1000 Mb (full-duplex)			

COMMUNICATIONS - NETWORK ADAPTER (NIC) (CONT.)

INTEGRATED INTEL® 82567 GIGABIT1 ETHERNET LAN 10/100/1000 (CONT.)	MT	DT	SFF	USFF
Environmental				
Operating temperature	0° C to 70° C (32° F to 158° F)			
Operating humidity	20% to 80% (non-condensing)			
Operating System Driver Support	Windows® XP, Windows Vista® Ultimate, Windows Vista® Business 32 bit/64 bit, Windows Vista Home Basic			
Manageability (examples WOL, PXE)	WOL, PXE 2.1			
Management Capabilities Alerting	Intel® Standard Manageability, Intel Core 2 Duo/ Quad Processor with vPro Technology			

[1] This term does not connote an actual operating speed of 1 Gb/sec. For high speed transmission, connection to a Gigabit Ethernet server and network infrastructure is required.

COMMUNICATIONS – INTEGRATED LAN

NOTE: MT supports full height card, DT supports low profile card or full height card with optional riser. SFF supports low profile card.

Broadcom NetXtreme 10/100/1000 PCIe Gigabit[1] Networking Card	MT	DT	SFF	USFF
Connector Type	RJ45			
Data Rates supported	10/100/1000 Mbps Half/Full duplex			
Controller Details				
Controller bus architecture (example PCIe 1.0a x1)	PCIe c1.0a x1			
Integrated memory	64KBytes RX, 8KBytes TX			
Data transfer mode (example Bus-Master DMA)	Bus-Master DMA			
Power consumption (full operation per data rate connection speed)	2.84W (860mA @ +3.3V)			
Power consumption (standby operation)	Less than 300mW			
IEEE standards compliance (example 802.1P)	802.3, 802.2, 802.3x, 802.1p			
Hardware Certifications (example FCC, B, GS mark…)	FCC B, VCCI B, CE			
Boot ROM Support	No			
Network Transfer Mode (example Full Duplex, Half Duplex)	Full Duplex/Half Duplex			
Network Transfer Rate (example 10BASE-T (half-duplex) 10 Mbps 10BASE-T (full-duplex) 20 Mbps 100BASE-TX (half-duplex) 100 Mbps 100BASE-TX (full-duplex) 200 Mbps 1000BASE-T (full-duplex) 2000 Mbps	10BASE-T (full-duplex) 20 Mbps Max* 100BASE-TX (half-duplex) 100 Mbps Max* 100BASE-TX (full-duplex) 200 MbpsMax* 1000BASE-T (full-duplex) 2000 Mbps Max* * Depends on the system environment.			

[1] This term does not connote an actual operating speed of 1 Gb/sec. For high speed transmission, connection to a Gigabit Ethernet server and network infrastructure is required.

COMMUNICATIONS – INTEGRATED LAN (CONT.)

BROADCOM NETXTREME 10/100/1000 PCIE GIGABIT[1] NETWORKING CARD (CONT.)	MT	DT	SFF	USFF
Environmental				
Operating temperature	0° C to 55° C (32° F - 131° F)			
Operating humidity	5% ~ 85% (non-condensing)			
Operating System Driver Support	Windows® 7, Windows® XP, Windows Vista® Ultimate, Windows Vista® Business 32 bit/64 bit, Windows Vista Home Basic, Linux			
Manageability (examples WOL, PXE)	WOL, PXE2.1, ACPI			
Management Capabilities Alerting (example ASF 2.0)	None			

[1] This term does not connote an actual operating speed of 1 Gb/sec. For high speed transmission, connection to a Gigabit Ethernet server and network infrastructure is required.

COMMUNICATIONS – MODEM

V.92 DATA/FAX CONTROLLERLESS MODEM	MT	DT	SFF	USFF
Bus	PCI			
External Connector	RJ-11			
Data Transmission	PCM - Pulse Coded Modulation (V.92/V.90) TCM - Trellis Coded Modulation (V.90/V.34/V.32 bis/V.32)			
Data Speeds	56kbps receive, 48kbps transmit			
Data Standards	ITU V.92/V.90, V.34/V.32 bis/V.32			
Fax Speeds	14.4kbps			
Fax Mode Capabilities	2-wire, half-duplex, synchronous			
Error Correction and Data Compression	V.44, V.42, V.42bis, MNP 2-4, MNP 5			
Power Management	WOR (wake on ring) capable			
Upgradeability	Driver upgradeable			
Video	V.80 Synchronous Access Mode (SAM) can be supported by software applications (not driver)			
Operating Temperature	0~50 degree C			
Operating Humidity	45 degree C 90% max			
Operating System Support	Windows 7,Vista 32/64, Windows XP 32/64			
Operating System Driver Support	Windows 7,Vista 32/64, Windows XP 32/64			
Power Requirements	+3.0V~+3.6V, 116.6mW max			
Chipset	Conexant SmartHSFs/LF (CX11256 & CX20493)			
Dimensions of full height card inches/centimeters (L X H)	L: 5.25/13.325 H: 4.73/12.002			
Dimensions of low profile card inches/centimeters (L X H)		L: 5.26/13.366 H: 3.12/7.923		

COMMUNICATIONS – WIRELESS

NOTE: Native DisplayPort on system is not supported with optional wireless card on the DT and SFF chassis.

DELL WIRELESS 1505 PCIE WLAN CARD (802.11 DRAFT N WITH REMOTE WAKE UP SUPPORT)	MT	DT	SFF
External Connector Type	Custom WLAN Antenna Connector		
Controller Details			
Controller bus architecture	Electrically compatible with the PCI Express Base Specification v1.1 (x1 lane) and PCIe v1.0a.		
WLAN standards supported	802.11a, 802.11b, 802.11g, 802.11n		
802.11b Data Rates supported	11, 5.5, 2, 1 Mbps		
802.11a Data Rates supported	54, 48, 36, 24, 18, 12, 9, 6 Mbps		
802.11g Data Rates supported	54, 48, 36, 24, 18, 12, 9, 6 Mbps		
802.11n Data Rates supported	300, 270, 243, 240, 180, 150, 144, 135, 130, 120, 117, 115.5, 90, 86.667, 72.2, 65, 60, 57.8, 45, 43.3, 30, 28.9, 21.7, 15, 14.4, 7.2 Mbps		
Encryption	WEP 64-bit and 128-bit, TKIP, AES-CCMP 128-bit		
Operating temperature	0 to +70 °C		
Operating humidity	Max Operating Humidity 85 %		
Operating System Driver Support	Windows 7, Windows XP 32/64, Vista 32/64		

DELL WIRELESS 1510 PCIE MINI PCIE WLAN CARD (802.11 DRAFT N)	USFF
External Connector Type	Custom WLAN Antenna Connector
Controller Details	
Controller bus architecture	Electrically compatible with the PCI Express Base Specification v1.1 (x1 lane) and PCIe v1.0a.
WLAN standards supported	802.11a, 802.11b, 802.11g, 802.11n
802.11b Data Rates supported	11, 5.5, 2, 1 Mbps
802.11a Data Rates supported	54, 48, 36, 24, 18, 12, 9, 6 Mbps
802.11g Data Rates supported	54, 48, 36, 24, 18, 12, 9, 6 Mbps
802.11n Data Rates supported	300, 270, 243, 240, 180, 150, 144, 135, 130, 120, 117, 115.5, 90, 86.667, 72.2, 65, 60, 57.8, 45, 43.3, 30, 28.9, 21.7, 15, 14.4, 7.2 Mbps
Encryption	WEP 64-bit and 128-bit, TKIP, AES-CCMP 128-bit
Operating temperature	0 to +70 °C
Operating humidity	Max Operating Humidity 85 %
Operating System Driver Support	Windows 7, Windows XP 32/64, Vista 32/64

GRAPHICS/VIDEO CONTROLLER

NOTE: MT supports full height card, DT supports low profile card or full height card with optional riser. SFF supports low profile card.

INTEGRATED INTEL GMA 4500	MT	DT	SFF	USFF
Bus Type	Integrated			
GPU core clock	Gen5 core @ 667 350 MHz Integrated and with 350MHz 24 bit RAMDAC			
Frame Buffer Memory (onboard and shared) Size and Speed	XP: Up to 1GB shared system memory with 2GB system memory Vista: Up to 2GB shared system memory with 4GB system memory			
Maximum power consumption	4 W			
Overlay Planes	Yes			
Maximum Color Depth	32 bit			
Maximum Vertical Refresh Rate	85 Hz			
Multiple Display Support	Yes			
Operating Systems Graphics/ Video API Support	OpenGL 2.0/DirectX 10.0			
Supported Resolutions and Max Refresh Rates (Hz) (Note: Analog and/ or digital)	Up to 2560x11600 @ 60Hz (DP) Up to 1920x1200 @ 60Hz (DVI & VGA) Up to 1600x1200 @ 85Hz (VGA only)			
External Connectors	VGA, DisplayPort			
Environmental Operating Conditions (Non-Condensing):				
Operating Temperature Range	0° to 106° C (32° to 223° F)			
Relative Humidity Range	20% to 80% (non-condensing)			
Altitude Range	–15.2 to 3048 m (–50 to 10,000 ft)			
DisplayPort				
Bus Type	AUX 1, 2, 4 lanes			
Maximum supported resolution	Up to 2560x1600 @ 60Hz			
Maximum power consumption	N/A			
External connectors	DisplayPort			
DVI (Digital) Adder Card (MT,DT and SFF Only)				
Bus Type	sDVO			
Maximum supported resolution	Up to 1920x1566 @ 60 Hz			
Dimensions of full height card inches/centimeters (L x H)	5.75 x 2.75 / 14.61 x 6.99			
Dimensions of low profile card inches/centimeters (L x H)		5.75 x 2.75 / 14.61 x 6.99		
Maximum power consumption	N/A			
External connectors	DVI			

[1] Up to 1.7 GB of system memory may be allocated to support integrated graphics, depending on operating system, system memory size and other factors.
[2] DVI and VGA can be used concurrently for multi-monitor display in DOS. The DisplayPort controller does not support multi-monitor display in DOS
[3] Populating a discrete graphics card in the x16 slot disables onboard video.

GRAPHICS/VIDEO CONTROLLER (CONT.)

256MB AMD RADEON™ HD 3450 GRAPHICS DUAL DVI OR VGA AND TV OUT	MT	DT	SFF
Bus Type (example integrated or PCIe x16)	PCIEx16		
GPU core clock	600Mhz		
Frame Buffer Memory (onboard and shared) Size and Speed	500Mhz		
Maximum power consumption	22W		
Overlay Planes	Yes		
Maximum Color Depth	32-bit		
Maximum Vertical Refresh Rate	85Hz		
Multiple Display Support	Yes		
Operating Systems Graphics/ Video API Support	D3D and OpenGL		
Supported Resolutions and Max Refresh Rates (Hz) (Note: Analog and/or digital)	Max : 1920x1440/32bpp @ 75Hz Min : 640x480/8bpp @ 60Hz		
External connectors	DMS-59[1] and S-video		
Dimensions of full height card inches/centimeters (L x H)	6.6 x 4.7 / 16.764 x 12.0		
Dimensions of low profile card inches/centimeters (L x H)		6.6 x 3.35 / 16.764 x 8.5	
Environmental Operating Conditions (Non-Condensing):			
Operating Temperature Range	10°-50° C		
Relative Humidity Range	5-90% RH		
Altitude Range	0-20,000 ft.		

[1]DMS-59 to VGA or DMS-59 to DVI adaptors required.

256MB NVIDIA GEFORCE 9300 GE	MT	DT	SFF
Bus Type (example integrated or PCIe x16)	PCIEx16		
GPU core clock	540Mhz		
Frame Buffer Memory (onboard and shared) Size and Speed	500Mhz		
Maximum power consumption	25W		
Overlay Planes	Yes		
Maximum Color Depth	32-bit		
Maximum Vertical Refresh Rate	85Hz		
Multiple Display Support	Yes		
Operating Systems Graphics/ Video API Support	D3D and OpenGL		
Supported Resolutions and Max Refresh Rates (Hz) (Note: Analog and/or digital)	Max : 1920x1440/32bpp @ 75Hz Min : 640x480/8bpp @ 60Hz		
External connectors	DMS-59[1] and S-video		
Dimensions of full height card inches/centimeters (L x H)	6.6 x 4.7 / 16.764 x 12.0		
Dimensions of low profile card inches/centimeters (L x H)		6.6 x 3.35 / 16.764 x 8.5	
Environmental Operating Conditions (Non-Condensing):			
Operating Temperature Range	10°-50° C		
Relative Humidity Range	5-90% RH		
Altitude Range	0-20,000 ft.		

[1]DMS-59 to VGA or DMS-59 to DVI adaptors required.

GRAPHICS/VIDEO CONTROLLER (CONT.)

256MB AMD RADEON™ HD 3470 GRAPHICS W/ DUAL DP	MT	DT	SFF
Bus Type (example integrated or PCIe x16)	PCIEx16		
GPU core clock	750Mhz		
Frame Buffer Memory (onboard and shared) Size and Speed	500Mhz		
Maximum power consumption	18W		
Overlay Planes	Yes		
Maximum Color Depth	32-bit		
Maximum Vertical Refresh Rate	85Hz		
Multiple Display Support	Yes		
Operating Systems Graphics/ Video API Support	D3D and OpenGL		
Supported Resolutions and Max Refresh Rates (Hz) (Note: Analog and/or digital)	Max : 1920x1440/32bpp @ 75Hz Min : 640x480/8bpp @ 60Hz		
External connectors	2 Display Port		
Dimensions of full height card inches/centimeters (L x H)	6.6 x 4.7 / 16.764 x 12.0		
Dimensions of low profile card inches/centimeters (L x H)		6.6 x 4.7 / 16.764 x 12.0	
Environmental Operating Conditions (Non-Condensing):			
Operating Temperature Range	10°-50° C		
Relative Humidity Range	5-90% RH		
Altitude Range	0-20,000 ft.		

512MB NVIDIA QUADRO NVS 420	MT	DT	SFF
Bus Type (example integrated or PCIe x16)	PCIEx16		
GPU core clock	550Mhz		
Frame Buffer Memory (onboard and shared) Size and Speed	512MB, 700Mhz		
Maximum power consumption	40W		
Overlay Planes	Yes		
Maximum Color Depth	32-bit		
Maximum Vertical Refresh Rate	75Hz		
Multiple Display Support	Yes		
Operating Systems Graphics/ Video API Support			
Supported Resolutions and Max Refresh Rates (Hz) (Note: Analog and/or digital)	Max : 2560x1600 @ 60Hz (Digital) Max : 1920x1200 @ 60Hz (Analog)		
External connectors	VHDCI to Quad DisplayPort VHDCI to Quad single-link DVI-D		
Dimensions of full height card inches/centimeters (L x H)	6.6 x 2.731 / 16.764 x 6.936		
Dimensions of low profile card inches/centimeters (L x H)		6.6 x 2.731 / 16.764 x 6.936	
Environmental Operating Conditions (Non-Condensing):			
Operating Temperature Range	10°-50° C		
Relative Humidity Range	5-90% RH		
Altitude Range	0-20,000 ft.		

HARD DRIVES[1]

3.5” 160GB SATA 7200 RPM HDD	
Capacity (bytes)	160,041,885,696
Dimensions inches (W x D x H)	5.87 x 4 x 1
Interface type and Maximum speed	Up to 3Gb/s
Internal buffer size	8 MB
Average Seek Time	8.5 ms
Rotational Speed	7200 rpm
Logical Blocks	312,581,808
Power Source	
DC Power (Max)	Idle 7.0W, Active 10.0W
DC Current	5V (.8A) and 12V (1.8A)
Environmental Operating Conditions (Non-Condensing):	
Temperature Range	5^0C to 60^0C
Relative Humidity Range	20% to 80% non-condensing
Maximum Wet Bulb Temperature	29^0C
Altitude Range	-50 ft to 10000 ft
Environmental Non-Operating Conditions (Non-Condensing):	
Temperature Range	-40^0C to 65^0C
Relative Humidity Range	10% to 90% non-condensing
Maximum Wet Bulb Temperature	38^0C
Altitude Range	-50 ft to 35000 ft

3.5” 250GB SATA 7200 RPM HDD	
Capacity (bytes)	250,059,350,016
Dimensions inches (W x D x H)	5.87 x 4 x 1
Interface type and Maximum speed	Up to 3Gb/s
Internal buffer size	8 MB
Average Seek Time	8.5 ms
Rotational Speed	7200 rpm
Logical Blocks	488,397,168
Power Source	
DC Power (Max)	Idle 7.0W, Active 10.0W
DC Current	5V (.8A) and 12V (1.8A)

HARD DRIVES (CONT.)

2.5” 160GB FULL DISK ENCRYPTION SATA HDD	
Capacity (bytes)	160,041,885,696
Dimensions inches (W x D x H)	5.87 x 4 x 1 (includes sled)
Interface type and Maximum speed	Up to 3Gb/s
Internal buffer size	8 MB
Average Seek Time	8.5 ms
Rotational Speed	7200 rpm
Logical Blocks	312,581,808
Power Source	
DC Power (Max)	Idle 7W, Active 10W
DC Current	5V (.8A) and 12V (1.8A)
Environmental Operating Conditions (Non-Condensing):	
Temperature Range	50^{0}C to 60^{0}C
Relative Humidity Range	20% to 80% non-condensing
Maximum Wet Bulb Temperature	29^{0}C
Altitude Range	-50 ft to 10000 ft
Environmental Non-Operating Conditions (Non-Condensing):	
Temperature Range	-40^{0}C to 65^{0}C
Relative Humidity Range	10% to 90% non-condensing
Maximum Wet Bulb Temperature	38^{0}C
Altitude Range	-50 ft to 35000 ft

[1] For hard drives, GB means 1 billion bytes ; actual capacity varies with preloaded material and operating environment and will be less.

2.5” 64GB[3] SATA SOLID STATE DRIVE	
Capacity (bytes)	64,023,257,088
Dimensions inches (W x D x H)	3.94 x 2.75 x 0.374
Interface type and Maximum speed	Up to 3Gb/s
MTBF	1M hours
Average Seek Time	n/a
Performance: Sequential Read/ Write	220/200 (MB/s)
Performance: SYSmark ‘07 Overall Score	156
Logical Blocks	125,045,424
Power Source	
DC Power Consumption (Max)	Idle 0.205W, Active 0.435W
DC Current	5V (0.8A)

HARD DRIVES (CONT.)

3.5" 250GB SATA 7200 RPM HDD (CONT.)

Environmental Operating Conditions (Non-Condensing):	
Temperature Range	5^0C to 60^0C
Relative Humidity Range	20% to 80% non-condensing
Maximum Wet Bulb Temperature	29^0C
Altitude Range	-50 ft to 10000 ft
Environmental Non-Operating Conditions (Non-Condensing):	
Temperature Range	-40^0C to 65^0C
Relative Humidity Range	10% to 90% non-condensing
Maximum Wet Bulb Temperature	38^0C
Altitude Range	-50 ft to 35000 ft

3.5" 320GB SATA 7200 RPM HDD

Capacity (bytes)	320,072,933,376
Dimensions inches (W x D x H)	5.87 x 4 x 1
Interface type and Maximum speed	Up to 3Gb/s
Internal buffer size	16 MB
Average Seek Time	8.5 ms
Rotational Speed	7200 rpm
Logical Blocks	625,142,448
Power Source	
DC Power (Max)	Idle 7.0W, Active 10.0W
DC Current	5V (.8A) and 12V (1.8A)
Environmental Operating Conditions (Non-Condensing):	
Temperature Range	5^0C to 60^0C
Relative Humidity Range	20% to 80% non-condensing
Maximum Wet Bulb Temperature	29^0C
Altitude Range	-50 ft to 10000 ft
Environmental Non-Operating Conditions (Non-Condensing):	
Temperature Range	-40^0C to 65^0C
Relative Humidity Range	10% to 90% non-condensing
Maximum Wet Bulb Temperature	38^0C
Altitude Range	-50 ft to 35000 ft

HARD DRIVES (CONT.)

3.5” 500GB SATA 7200 RPM HDD	
Capacity (bytes)	500,107,862,016
Dimensions inches (W x D x H)	5.87 x 4 x 1
Interface type and Maximum speed	Up to 3Gb/s
Internal buffer size	16 MB
Average Seek Time	8.5 ms
Rotational Speed	7200 rpm
Logical Blocks	976,773,168
Power Source	
DC Power (Max)	Idle 7.0W, Active 10.0W
DC Current	5V (.8A) and 12V (1.8A)
Environmental Operating Conditions (Non-Condensing):	
Temperature Range	5^0C to 60^0C
Relative Humidity Range	20% to 80% non-condensing
Maximum Wet Bulb Temperature	29^0C
Altitude Range	-50 ft to 10000 ft
Environmental Non-Operating Conditions (Non-Condensing):	
Temperature Range	-40^0C to 65^0C
Relative Humidity Range	10% to 90% non-condensing
Maximum Wet Bulb Temperature	38^0C
Altitude Range	-50 ft to 35000 ft

3.5” 80GB SATA 10000 RPM HDD	
Capacity (bytes)	80,026,361,856
Dimensions inches (W x D x H)	5.87 x 4 x 1 (includes sled)
Interface type and Maximum speed	Up to 3Gb/s
Internal buffer size	16 MB
Average Seek Time	4.6 ms (average read)
Rotational Speed	10000 rpm
Logical Blocks	156,301,488
Power Source	
DC Power (Max)	Idle 7W, Active 10W
DC Current	5V (.8A) and 12V (1.8A)

HARD DRIVES (CONT.)

3.5" 80GB SATA 10000 RPM HDD (CONT.)

Environmental Operating Conditions (Non-Condensing):	
Temperature Range	5^0C to 60^0C
Relative Humidity Range	20% to 80% non-condensing
Maximum Wet Bulb Temperature	29^0C
Altitude Range	-50 ft to 10000 ft
Environmental Non-Operating Conditions (Non-Condensing):	
Temperature Range	-40^0C to 65^0C
Relative Humidity Range	10% to 90% non-condensing
Maximum Wet Bulb Temperature	38^0C
Altitude Range	-50 ft to 35000 ft

3.5" 160GB SATA 10000 RPM HDD

Capacity (bytes)	160,041,885,696
Dimensions inches (W x D x H)	5.87 x 4 x 1 (includes sled)
Interface type and Maximum speed	Up to 3Gb/s
Internal buffer size	16 MB
Average Seek Time	4.6 ms (average read)
Rotational Speed	10000 rpm
Logical Blocks	312,581,808
Power Source	
DC Power (Max)	Idle 7W, Active 10W
DC Current	5V (.8A) and 12V (1.8A)
Environmental Operating Conditions (Non-Condensing):	
Temperature Range	5^0C to 60^0C
Relative Humidity Range	20% to 80% non-condensing
Maximum Wet Bulb Temperature	29^0C
Altitude Range	-50 ft to 10000 ft
Environmental Non-Operating Conditions (Non-Condensing):	
Temperature Range	-40^0C to 65^0C
Relative Humidity Range	10% to 90% non-condensing
Maximum Wet Bulb Temperature	38^0C
Altitude Range	-50 ft to 35000 ft

HARD DRIVES (CONT.)

2.5" 64GB[3] SATA SOLID STATE DRIVE (CONT.)	
Environmental Operating Conditions (Non-Condensing):	
Temperature Range	0°C to 70°C
Relative Humidity Range	10 to 90%
Maximum Wet Bulb Temperature	29°C
Altitude Range	-200 to 5,000 m
Op Shock (@0.5ms)	1,500G
Environmental Non-Operating Conditions (Non-Condensing):	
Temperature Range	-55°C to 95°C
Relative Humidity Range	5 to 95%
Maximum Wet Bulb Temperature	38°C
Altitude Range	-200 to 10,600 m

2.5" 160GB SATA 7200 RPM HDD	
Capacity (bytes)	160,144,285,696
Dimensions inches (W x D x H)	Approximately (3.93 x 2.75 x 0.374 inches)
Interface type and Maximum speed	Up to 3Gb/s
Internal buffer size	16 MB
Average Seek Time	12 ms (Read)
Rotational Speed	7200 rpm
Logical Blocks	312,581,808
Power Source	
DC Power (Max)	Idle 1.0W, Active 3.25W
DC Current	5V (.8A)
Environmental Operating Conditions (Non-Condensing):	
Temperature Range	5^0C to 60^0C
Relative Humidity Range	10% to 90% non-condensing
Maximum Wet Bulb Temperature	29^0C
Altitude Range	-50 ft to 10000 ft
Environmental Non-Operating Conditions (Non-Condensing):	
Temperature Range	-40^0C to 65^0C
Relative Humidity Range	10% to 90% non-condensing
Maximum Wet Bulb Temperature	38^0C
Altitude Range	-50 ft to 35000 ft

[1] For hard drives, GB means 1 billion bytes ; actual capacity varies with preloaded material and operating environment and will be less.

HARD DRIVES (CONT.)

2.5" 250GB SATA 7200 RPM HDD	
Capacity (bytes)	
Dimensions inches (W x D x H)	Approximately (3.93 x 2.75 x 0.374 inches)
Interface type and Maximum speed	Up to 3Gb/s
Internal buffer size	16 MB
Average Seek Time	12 ms (Read)
Rotational Speed	7200 rpm
Logical Blocks	488,397,168
Power Source	
DC Power (Max)	Idle 1.0W, Active 3.25W
DC Current	5V (.8A)
Environmental Operating Conditions (Non-Condensing):	
Temperature Range	5^0C to 60^0C
Relative Humidity Range	10% to 90% non-condensing
Maximum Wet Bulb Temperature	29^0C
Altitude Range	-50 ft to 10000 ft
Environmental Non-Operating Conditions (Non-Condensing):	
Temperature Range	-40^0C to 65^0C
Relative Humidity Range	10% to 90% non-condensing
Maximum Wet Bulb Temperature	38^0C
Altitude Range	-50 ft to 35000 ft

[1] For hard drives, GB means 1 billion bytes ; actual capacity varies with preloaded material and operating environment and will be less.

OPTICAL DRIVES

DVD +/- RW[1]	MT	DT	SFF	USFF
External Dimensions inches/centimeters (Without Bezel – W x H x D)	148.2mm(6in)/42mm (2in)/ 190.5 (max)	148.2mm(6in)/42mm (2in)/ 190.5 (max)	128.0 mm (5.04)/ 12.7mm (0.5 in)/ 126.1mm (4.97in)	128.0 mm (5.04)/ 12.7mm (0.5 in)/ 126.1mm (4.97in)
Weight (max) pounds/ kilograms	800g	800g	170g	170g
Interface type and speed	SATA 1.5Gbit/s	SATA 1.5Gbit/s	SATA 1.5Gbit/s	SATA 1.5Gbit/s
Disc Capacity	Standard	Standard	Standard	Standard
Internal buffer size	supplier dependent	supplier dependent	supplier dependent	supplier dependent
Access Times (typical)	supplier dependent	supplier dependent	supplier dependent	supplier dependent
Maximum Data Transfer Rates				
Writes	16x DVD/48x CD	16x DVD/48x CD	8x DVD/ 24x CD	8x DVD / 24x CD
Reads	16x DVD/48x CD	16x DVD/48x CD	8x DVD/ 24x CD	8x DVD/ 24x CD
Power Source				
DC Power Requirements	12V, 5V	12V, 5V	5V	5V
DC Current	1200mA (12V)/ 900mA (5V)	1200mA (12V)/ 900mA (5V)	1000mA	1000mA
Environmental Operating Conditions (Non-Condensing):				
Operating Temperature Range	5C to 50C	5C to 50C	5C to 50C	5C to 50C
Relative Humidity Range	20% to 80% RH	20% to 80% RH	20% to 80% RH	20% to 80% RH
Maximum Wet Bulb Temperature	29C	29C	29C	29C
Altitude Range	-200 to 3048	-200 to 3048	-200 to 3048	-200 to 3048
Environmental Non-Operating Conditions (Non-Condensing):				
Operating Temperature Range	-40C to 65C	-40C to 65C	-40C to 65C	-40C to 65C
Relative Humidity Range	5% to 95% RH	5% to 95% RH	5% to 95% RH	5% to 95% RH
Maximum Wet Bulb Temperature	38C	38C	38C	38C
Altitude Range	-200 to 10600m	-200 to 10600m	-200 to 10600m	-200 to 10600m

[1] Discs burned with this drive may not be compatible with some existing drives and players; using DVD+R media provides maximum compatibility.

DVD-ROM	MT	DT	SFF	USFF
External Dimensions inches/centimeters (Without Bezel – W x H x D)	148.2mm(6in)/42mm (2in)/ 190.5 (max)	148.2mm(6in)/42mm (2in)/ 190.5 (max)	128.0 mm (5.04)/ 12.7mm (0.5 in)/ 126.1mm (4.97in)	128.0 mm (5.04)/ 12.7mm (0.5 in)/ 126.1mm (4.97in)
Weight (max) pounds/ kilograms	750g	750g	165g	165g
Interface type and speed	SATA 1.5Gbit/s	SATA 1.5Gbit/s	SATA 1.5Gbit/s	SATA 1.5Gbit/s
Disc Capacity	Standard	Standard	Standard	Standard
Internal buffer size	supplier dependent	supplier dependent	supplier dependent	supplier dependent
Access Times (typical)	supplier dependent	supplier dependent	supplier dependent	supplier dependent
Maximum Data Transfer Rates				
Writes	N/A	N/A	N/A	N/A
Reads	16x DVD/48x CD	16x DVD/48x CD	8x DVD/ 24x CD	8x DVD/ 24x CD

OPTICAL DRIVES (CONT.)

DVD-ROM (CONT.)	MT	DT	SFF	USFF
Power Source				
DC Power Requirements	12V, 5V	12V, 5V	5V	5V
DC Current	1200mA (12V)/ 900mA (5V)	1200mA (12V)/ 900mA (5V)	800mA	800mA
Environmental Operating Conditions (Non-Condensing):				
Operating Temperature Range	5C to 50C	5C to 50C	5C to 50C	5C to 50C
Relative Humidity Range	20% to 80% RH	20% to 80% RH	20% to 80% RH	20% to 80% RH
Maximum Wet Bulb Temperature	29C	29C	29C	29C
Altitude Range	-200 to 3048m	-200 to 3048m	-200 to 3048m	-200 to 3048m
Environmental Non-Operating Conditions (Non-Condensing):				
Operating Temperature Range	-40C to 65C	-40C to 65C	-40C to 65C	-40C to 65C
Relative Humidity Range	5% to 95% RH	5% to 95% RH	5% to 95% RH	5% to 95% RH
Maximum Wet Bulb Temperature	38C	38C	38C	38C
Altitude Range	-200 to 10600m	-200 to 10600m	-200 to 10600m	-200 to 10600m

COMBO DVD/ CDRW	MT	DT	SFF	USFF
External Dimensions inches/centimeters (Without Bezel – W x H x D)	148.2mm(6in)/42mm (2in)/ 190.5 (max)	148.2mm(6in)/42mm (2in)/ 190.5 (max)	128.0 mm (5.04)/ 12.7mm (0.5 in)/ 126.1mm (4.97in)	128.0 mm (5.04)/ 12.7mm (0.5 in)/ 126.1mm (4.97in)
Weight (max) pounds/ kilograms	750g	750g	165g	165g
Interface type and speed	SATA 1.5Gbit/s	SATA 1.5Gbit/s	SATA 1.5Gbit/s	SATA 1.5Gbit/s
Disc Capacity	Standard	Standard	Standard	Standard
Internal buffer size	supplier dependent	supplier dependent	supplier dependent	supplier dependent
Access Times (typical)	supplier dependent	supplier dependent	c	supplier dependent
Maximum Data Transfer Rates				
Writes	48x CD	48x CD	24x CD	24x CD
Reads	16x DVD/48x CD	16x DVD/48x CD	8x DVD/ 24x CD	8x DVD/ 24x CD
Power Source				
DC Power Requirements	12V, 5V	12V, 5V	5V	5V
DC Current	1200mA (12V)/ 900mA (5V)	1200mA (12V)/ 900mA (5V)	900mA	900mA
Environmental Operating Conditions (Non-Condensing):				
Operating Temperature Range	5C to 50C	5C to 50C	5C to 50C	5C to 50C
Relative Humidity Range	20% to 80% RH	20% to 80% RH	20% to 80% RH	20% to 80% RH
Maximum Wet Bulb Temperature	29C	29C	29C	29C
Altitude Range	-200 to 3048m	-200 to 3048m	-200 to 3048m	-200 to 3048m
Environmental Non-Operating Conditions (Non-Condensing):				
Operating Temperature Range	-40C to 65C	-40C to 65C	-40C to 65C	-40C to 65C
Relative Humidity Range	5% to 95% RH	5% to 95% RH	5% to 95% RH	5% to 95% RH
Maximum Wet Bulb Temperature	38C	38C	38C	38C
Altitude Range	-200 to 10600m	-200 to 10600m	-200 to 10600m	-200 to 10600m

BIOS DEFAULTS

Drives	Diskette drive:	USB
	SATA Operation;	RAID On
	SMART Reporting:	Disable
	SATA-0:	Enable
	SATA-1:	Enable
	External SATA:	Enable
System Configuration	Integrated NIC:	Enable
	USB Controller:	Enable
	Parallel Port:	PS/2
	Parallel Port Address:	378h
	Serial Port #1:	Auto
	Serial Port #2:	Auto
	Front USB:	Enable
	Rear Quad USB:	Enable
	Rear Dual USB:	Enable
	PCI Slots:	Enable
	Audio:	Enable
Video	Primary Video:	Auto
Performance	Multiple CPU Core:	Enable
	Intel® SpeedStep™:	Disable, unless the customer purchased a SpeedStep™ capable processor.
	C States Control:	Disable
	Limit CPUID Value:	Disable
	HDD Acoustic Mode:	Bypass
Virtualization Support	Virtualization:	Disable
	VT for Direct I/O:	Disable
Security	Administrator Password:	Not set
	System Password:	Not set
	Password Changes:	Enable
	TPM Security:	Disable
	CPU XD Support:	Enable
	Computrace®:	Deactivate
	SATA-0 Password:	Not set

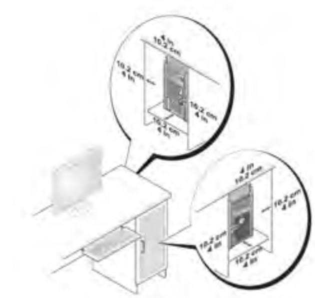
BIOS DEFAULTS (CONT.)

Power Management	AC Recovery:	Power Off
	Auto On Time:	Disable
	Low Power Mode:	Disable
	Remote Wake Up:	Disable
	Suspend Mode:	S3
	Fan Control Override:	Disable
Maintenance	Service Tag:	Set by the factory
	Asset Tag:	Optional User Entry
	SERR Message:	Enable
Post Behavior	Fast Boot:	Enable
	Numlock LED:	Enable
	POST HotKeys:	Enable
	Keyboard Errors:	Enable
	MEBx HotKey	Enable

CHASSIS ENCLOSURE & VENTILATION REQUIREMENTS

ENCLOSURE VENTILATION

If your enclosure has doors, they need to be of a type that allows at least 30% airflow through the enclosure (front and back).



ENCLOSURE MINIMUM CLEARANCE

Leave a 10.2 cm (4 in.) minimum clearance on all vented sides of the computer to permit the airflow required for proper ventilation.

RECOMMENDED ENCLOSURE

Do not install your computer in an enclosure that does not allow airflow. This restricts the airflow and impacts your computer's performance, possibly causing it to overheat.

OPEN DESK MINIMUM CLEARANCE

If your computer is installed in a corner, on a desk, or under a desk, leave at least 5.1 cm (2 in.) clearance from the back of the computer to the wall to permit the airflow required for proper ventilation.

REGULATORY COMPLIANCE AND ENVIRONMENTAL

Product related conformity assessment and regulatory authorizations including Product Safety, Electromagnetic Compatibility (EMC), Ergonomics, and Communication Devices relevant to this product may be viewed at www.dell.com/regulatory_compliance. The Regulatory Datasheet for this product is located at http://www.dell.com/regulatory_compliance.

Details of Dell's environmental stewardship program to conserve product energy consumption, reduce or eliminate materials for disposal, prolong product life span and provide effective and convenient equipment recovery solutions may be viewed at www.dell.com/environment. Product related conformity assessment, regulatory authorizations, and information encompassing Environmental, Energy Consumption, Noise Emissions, Product Materials Information, Packaging, Batteries, and Recycling relevant to this product may be viewed by clicking the Design for Environment link on the webpage.

ACOUSTIC NOISE EMISSION INFORMATION (TBD)

OPTIPLEX 780 MT

Component	**Typical Configuration**	**High-end Configuration**
CPU	E8500	Q9650
Memory	1GB DDR3 1066 MHz (x1)	2GB DDR3 1066 MHz (x2)
HDD (#, capacity)	160 GB 7200 RPM SATA2	250 GB 7200 RPM SATA2 (x2)
RMSD	DVDRW/DVD dual config	DVDRW/DVD dual config
Graphics Adapter	Radeon HD3450	Radeon HD3470

The Declared Noise Emission in accordance with ISO 9296 for the Dell Optiplex 780 MT is as follows:
(all values L_{WAd} expressed in bels; 1 bel=10 decibels, re 10^{-12} Watts)

Operating Mode	**Typical Configuration Declared Sound Power (L_{WAd})**	**High-end Configuration Declared Sound Power (L_{WAd})**
Idle		
HDD Operating		
90% CPU		
ODD Operating		

The Declared A-weighted Sound Pressure Level in decibels (re $2x10^{-5}$ Pa), at Operator, Bystander, and Desk Side Positions are measured in accordance with ISO 7779 7.6.1, 7.6.2, and C.15.2 and declared in accordance with ISO 9296 for this product is as follows[1]:

Operating Mode	**Typical Configuration Declared Sound Pressure (LpA)**				**High-end Configuration Declared Sound Pressure (LpA)**			
	Table-Top		**Floor-Standing**		**Table-Top**		**Floor- Standing**	
	Operator Position (LpA)	**Bystander Position (LpA)**	**Operator Position (LpA)**	**Bystander Position (LpA)**	**Operator Position (LpA)**	**Bystander Position (LpA)**	**Operator Position (LpA)**	**By-stander Position (LpA)**
Idle								
HDD Operating								
90% CPU								
ODD Operating								

[1] All tests are conducted according to ISO 7779 and declared according to ISO 9296 except 90% CPU. For this mode, the system CPU was stressed at 90% utilization with no other peripheral device actively seeking. This test mode is not specified in ISO 7779, but was measured using the same microphone distances and measurement techniques defined for the other reported operating modes.
[2] Declared Sound Power rounded to nearest tenth of a bel per ISO 9296 section 4.4.2

ACOUSTIC NOISE EMISSION INFORMATION (TBD)

OPTIPLEX 780 DT

Component	Typical Configuration	High-end Configuration
CPU	E8500	Q9650
Memory	1GB DDR3 1066 MHz (x1)	2GB DDR3 1066 MHz (x2)
HDD (#, capacity)	160 GB 7200 RPM SATA2	250 GB 7200 RPM SATA2 (x2)
RMSD	DVDRW/DVD dual config	DVDRW/DVD dual config
Graphics Adapter	Radeon HD3450	Radeon HD3470

The Declared Noise Emission in accordance with ISO 9296 for the Dell Optiplex 780 DT is as follows:
(all values L_{WAd} expressed in bels; 1 bel=10 decibels, re 10^{-12} Watts)

Operating Mode	Typical Configuration Declared Sound Power (L_{WAd})	High-end Configuration Declared Sound Power (L_{WAd})
Idle		
HDD Operating		
90% CPU		
ODD Operating		

The Declared A-weighted Sound Pressure Level in decibels (re $2x10^{-5}$ Pa), at Operator, Bystander, and Desk Side Positions are measured in accordance with ISO 7779 7.6.1, 7.6.2, and C.15.2 and declared in accordance with ISO 9296 for this product is as follows[1]:

Operating Mode	Typical Configuration Declared Sound Pressure (LpA)				High-end Configuration Declared Sound Pressure (LpA)			
	Table-Top		Floor-Standing		Table-Top		Floor- Standing	
	Operator Position (LpA)	Bystander Position (LpA)	Operator Position (LpA)	Bystander Position (LpA)	Operator Position (LpA)	Bystander Position (LpA)	Operator Position (LpA)	By-stander Position (LpA)
Idle								
HDD Operating								
90% CPU								
ODD Operating								

[1] All tests are conducted according to ISO 7779 and declared according to ISO 9296 except 90% CPU. For this mode, the system CPU was stressed at 90% utilization with no other peripheral device actively seeking. This test mode is not specified in ISO 7779, but was measured using the same microphone distances and measurement techniques defined for the other reported operating modes.
[2] Declared Sound Power rounded to nearest tenth of a bel per ISO 9296 section 4.4.2

ACOUSTIC NOISE EMISSION INFORMATION (TBD)

OPTIPLEX 780 SFF

Component	**Typical Configuration**	**High-end Configuration**
CPU	E8500	Q9650
Memory	1GB DDR3 1066 MHz (x1)	2GB DDR3 1066 MHz (x2)
HDD (#, capacity)	160 GB 7200 RPM SATA2	250 GB 7200 RPM SATA2 (x2)
RMSD	DVDRW/DVD dual config	DVDRW/DVD dual config
Graphics Adapter	Radeon HD3450	Radeon HD3470

The Declared Noise Emission in accordance with ISO 9296 for the Dell Optiplex 780 SFF is as follows:
(all values L_{WAd} expressed in bels; 1 bel=10 decibels, re 10^{-12} Watts)

Operating Mode	**Typical Configuration Declared Sound Power (L_{WAd})**	**High-end Configuration Declared Sound Power (L_{WAd})**
Idle		
HDD Operating		
90% CPU		
ODD Operating		

The Declared A-weighted Sound Pressure Level in decibels (re $2x10^{-5}$ Pa), at Operator, Bystander, and Desk Side Positions are measured in accordance with ISO 7779 7.6.1, 7.6.2, and C.15.2 and declared in accordance with ISO 9296 for this product is as follows[1]:

Operating Mode	**Typical Configuration Declared Sound Pressure (LpA)**				**High-end Configuration Declared Sound Pressure (LpA)**			
	Table-Top		**Floor-Standing**		**Table-Top**		**Floor- Standing**	
	Operator Position (LpA)	**Bystander Position (LpA)**	**Operator Position (LpA)**	**Bystander Position (LpA)**	**Operator Position (LpA)**	**Bystander Position (LpA)**	**Operator Position (LpA)**	**Bystander Position (LpA)**
Idle								
HDD Operating								
90% CPU								
ODD Operating								

[1] All tests are conducted according to ISO 7779 and declared according to ISO 9296 except 90% CPU. For this mode, the system CPU was stressed at 90% utilization with no other peripheral device actively seeking. This test mode is not specified in ISO 7779, but was measured using the same microphone distances and measurement techniques defined for the other reported operating modes.
[2] Declared Sound Power rounded to nearest tenth of a bel per ISO 9296 section 4.4.2

ACOUSTIC NOISE EMISSION INFORMATION

OPTIPLEX 780 USFF

Component	**Typical Configuration**
CPU	E8500
Memory	2GB DDR3 1066 MHz (x1)
HDD (#, capacity)	160 GB 7200 RPM SATA2
RMSD	DVDRW
Graphics Adapter	Integrated

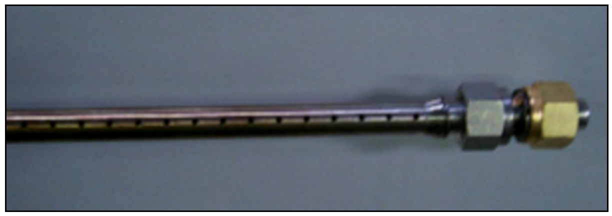
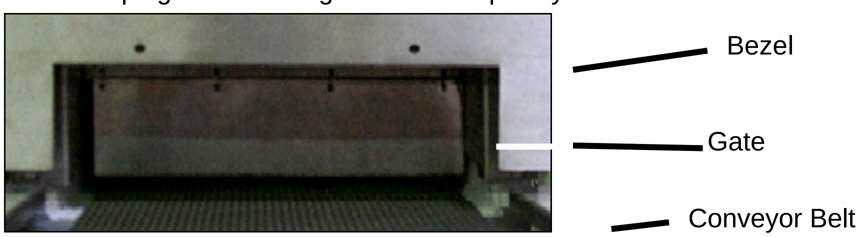
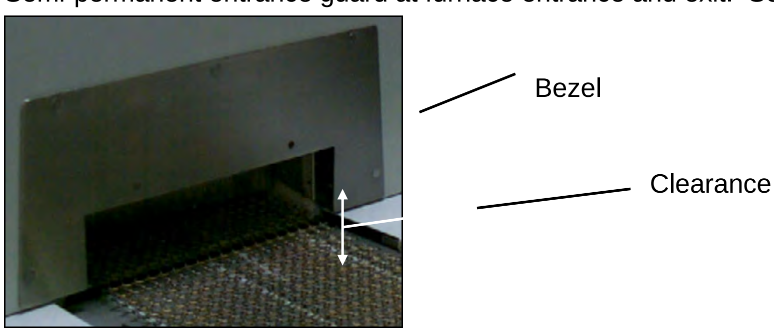
The Declared Noise Emission in accordance with ISO 9296 for the Dell Optiplex 780 USFF is as follows:
(all values L_{WAd} expressed in bels; 1 bel=10 decibels, re 10^{-12} Watts)

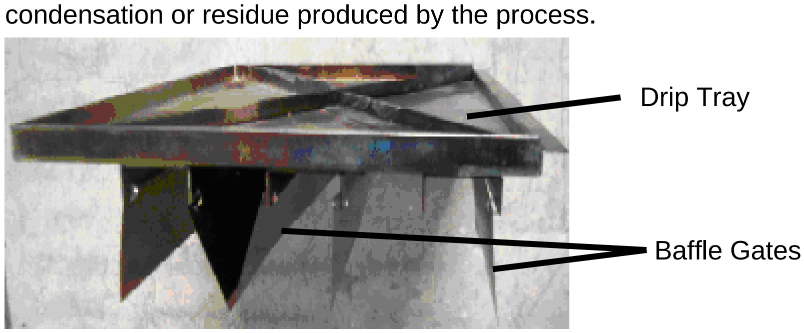
Operating Mode	**Typical Configuration Declared Sound Power (L_{WAd})**
Idle	3.9
HDD Operating	3.9
90% CPU	4.4
ODD Operating	4.8

The Declared A-weighted Sound Pressure Level in decibels (re $2x10^{-5}$ Pa), at Operator, Bystander, and Desk Side Positions are measured in accordance with ISO 7779 7.6.1, 7.6.2, and C.15.2 and declared in accordance with ISO 9296 for this product is as follows[1]:

[1] All tests are conducted according to ISO 7779 and declared according to ISO 9296 except 90% CPU. For this mode, the system CPU was stressed at 90% utilization with no other peripheral device actively seeking. This test mode is not specified in ISO 7779, but was measured using the same microphone distances and measurement techniques defined for the other reported operating modes.
[2] Declared Sound Power rounded to nearest tenth of a bel per ISO 9296 section 4.4.2

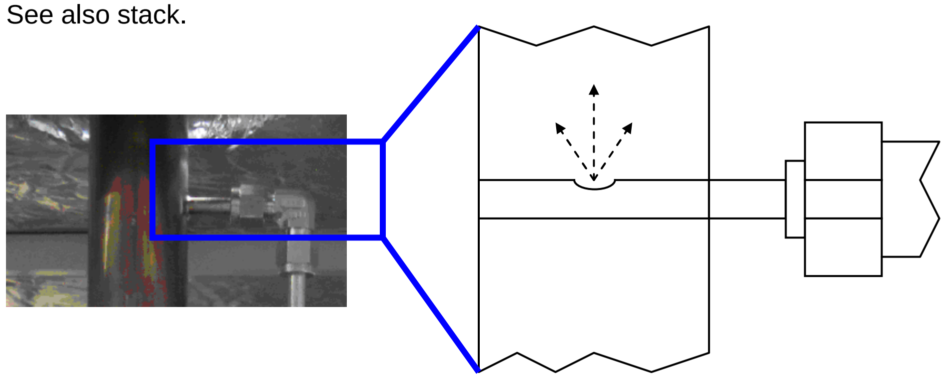
10.2 Glossary

Across-the-Belt	In reference to an area perpendicular to the direction of travel through the furnace; the width of the conveyor belt.
Actual Temperature	The instantaneous temperature in the furnace as reported by the thermocouple.
Air-Rake	Long tube set across-the-belt with proportionally spaced small holes. 
Air-Regulator Tubes	Air rakes charged with air or N2 installed in the entrance and exit baffles, used in establishing a controlled atmosphere.
Blade	Hinged flaps at entrance and exit of furnace that help prevent furnace atmosphere from escaping. See also figure under Drip Trays. 
Bezel	Semi-permanent entrance guard at furnace entrance and exit. See also Gate. 
CDA	Clean dry air – filtered, dry compressed air used as process gas.
Chamber	See heating chamber.

Clearance	The distance at furnace entrance between the conveyor belt and the bezel. See diagram under bezel.
Contaminants	Anything present in the process section that could negatively impact product quality including but not limited to O_2, moisture or particulate matter.
Convection	The process of heating a product via indirect transmission of heat from adjacent high-temperature air.
Controller	Control system that stabilizes temperature, monitors belt speed, alarm conditions and other functions.
Controlled Atmosphere	The atmosphere generated from the process gas, and gas flow patterns within the process section.
Cooling Section	The portion of the furnace that includes the transition tunnel, if any, exit baffle and any additional modules provided for the purpose of cooling the product.
Derivative	The calculated temperature rate of change; used in the PID equation.
Dilution Purge	The continuous process of adding clean gas while exhausting contaminated gas.
Dominant Wavelength	The wavelength of highest occurrence emitted by a radiating element at a specific temperature as described by Wein's Displacement Law.
Drip Trays	Trays positioned beneath stacks with attached baffle gates; used to catch condensation or residue produced by the process. 
Edge Heater	Heaters along edge of chamber used to maintain uniform temperature across-the-belt in a designated part of the heating chamber.

Eductor

Metered gas exit used to draw exhaust gas out of the chamber and through the stack. See also stack.



Effluents

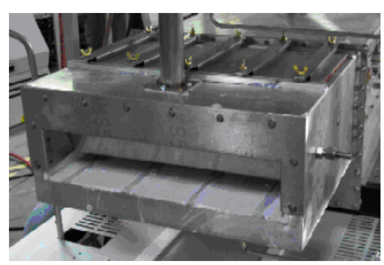
Contaminants expelled from a product during a thermal process. See also volatiles.

EMO

An Emergency off switch.

Entrance Baffle

The section at the entrance of the furnace incorporating an air-regulator tube, hanging gates and an exhaust stack; used to establish a controlled atmosphere inside the process section.



Exhaust Gas

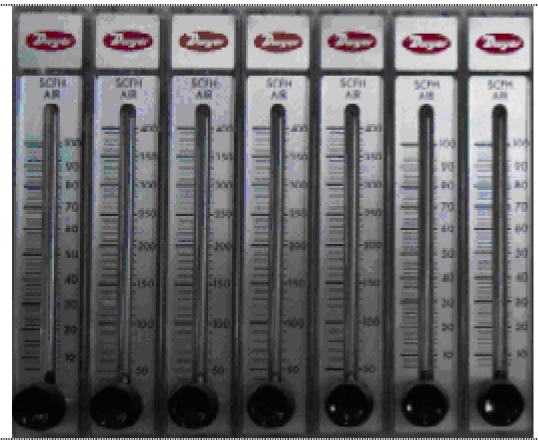
Spent process gas.

Error

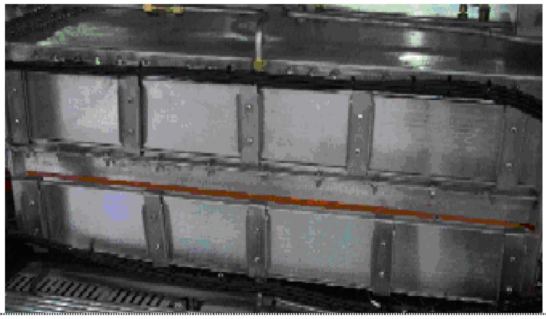
Difference between actual temperature and setpoint.

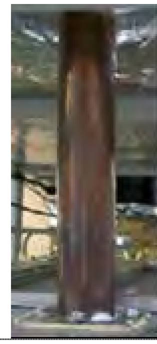
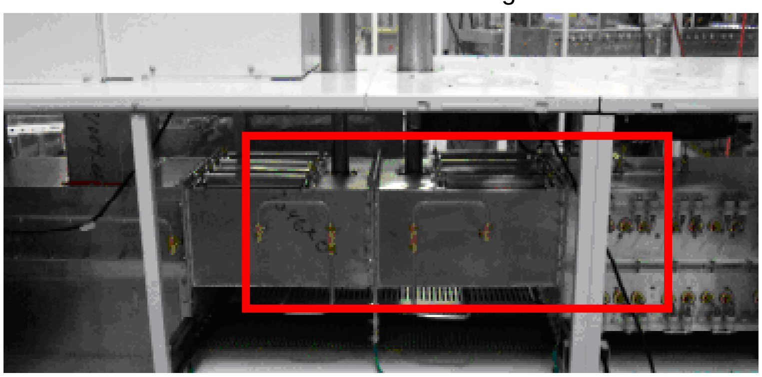
Flash

The point at which organic vapors have reached the temperature and concentration necessary for spontaneous combustion.

Flow Meter	A manually adjustable gauge used to control the flow of gas or liquid to the process section. 
FG or Forming Gas	A type of process gas that consists of any mixture of H_2 and N_2 gasses.
Furnace Length	The length of the entire furnace. The sum of the process section and any loading and unloading stations.
Gain	Term in PID equation to calculate how far temperature is from setpoint.
Gate	Plate that divides furnace into sections that can allow better control of the processing environment. See Blade and Drip Trays for picture.
H_2	Hydrogen gas.
Heat Lamp	Double ended metal sleeve clear quartz infrared (IR) heat lamp element or emitter.
Heated Length	See “Heating Chamber”, next.
Heating Chamber	Furnace area where heating takes place. Also referred to as the chamber, or heated length.
Heating Section	The portion of the furnace including the entrance baffle and the heating chamber.
Hydrogen Detector	Detect hydrogen escaping from furnace.
Integral	Mathematical operation that is one term in the PID equation.
Interlocks	Switches on some cabinet doors that stop furnace operation and removes power when doors are opened.

IR	Electromagnetic wave. Wavelengths between 0.78 and 1000 µm in the electromagnetic spectrum.
Lamp Strings	A single lamp circuit which may include one lamp, or two or more lamps in series. LA-309/LA-310 Standard Power furnaces are wired with two lamps per string in zones 1 and 3. Zone 2 is wired with 3 lamps per string at all voltages above 240 Vac*. LA-309/LA-310 High Power furnaces are wired with two lamps per string in all zones at all voltages above 240 Vac*. *208-240 Vac LA-309/LA-310 furnaces are wired with one lamp per string in all zones.
LPM	Liters per minute. Units of flow equivalent to 2.119 CFH.
Micron	One millionth of a meter, $1.0 * 10^{-6}$ m, 1.0 µm
MMI	Man machine interface software development tool for creating user interface to PLC controller.
Module	A section of the furnace designed for a specific function; may be 15, 30, 45 or 60 inches in length.
N_2	Nitrogen gas.
O_2	Oxygen gas.
Oxygen Analyzer	Detects oxygen content at predetermined locations. Usually installed to read process gas source, and up to three locations in the heating chamber.
Phase Angle Firing	Technique that activates AC power to be applied for only certain times during AC cycle.
PC	Personal computer. The PC provides the main operator interface for operating the furnace. The PC interfaces with the PLC.
PID	Proportional+Integral+Derivative: Three-term closed loop control equation that adjusts power sent to heat lamps. See also Gain, Integral and Derivative.
PLC	Programmable Logic Controller. An industrial computer which provides input and output control of the furnace.
Plenum	Cutout area of chamber insulation where process gas is injected.

Plenum Box	Pressurized region, enclosing ends of heat lamps, part of the hermetic seal option. 
PPM	Parts per million. Useful ratio for measuring small amounts of one gas in an area dominated by another.
Process Gas	The gas used in creating a controlled atmosphere. Some examples are CDA, N_2, H_2, forming gas or other N_2/H_2 mixtures.
Process Environment	The description of the area inside the furnace at any time including the temperature, flow patterns, and the presence or absence of product, process gas, process effluents, or contaminants.
Process Section	The physical area inside the furnace from the entrance bezel to the exit bezel. The sum of the heating section and cooling section.
Profile	See Temperature Profile.
Proportional Band	The temperature range used in the PID equation in applying a portion of the available power to the heat lamps based on the deviation of the actual temperature from the setpoint.
Recipe	Instructions, including temperatures and belt speed that the furnace follows.
Resonant Frequency	The frequency at which the atomic structure of a material is easily excited into physical vibration resulting in excellent heat transfer characteristics.
SCFH	Standard Cubic Foot per Hour. Measurement for gas flow volume. Equivalent to 0.472 standard liters per minute.
SCR	Silicon Controlled Rectifier. The electronic device used to regulate power to the heat lamps through signals sent by the PLC controller.
Setpoint	The target temperature for a zone.

Sparger Tubes	Highly porous, sintered metal tube charged with process gas; typically used in controlled atmosphere cooling modules.
Stack	Exhaust stack containing eductor. See also eductor. 
STP	Standard temperature and pressure: 21.1 C (70 F) 1 Atm, 1.013 Bar (14.7 psig)
Temperature Profile	Temperature recorded over a period of time.
Thermal Process	The idealized process description for a particular product as it passes through the process section, including the product temperature profile and process environment.
Thermal Process Profile	Empirical record of the thermal process
Thermocouple	An electronic device that measures temperature.
Throat	The throat of the furnace describes the maximum height of any product allowable through the process section.
Transition Tunnel	Chamber section between heat and cooling section. 
Volatiles	Hydrocarbon based product effluents.

With-the-belt	In reference to the area of the conveyor belt that extends through the process section.
Zone	Area within the chamber where temperature can be independently controlled.