



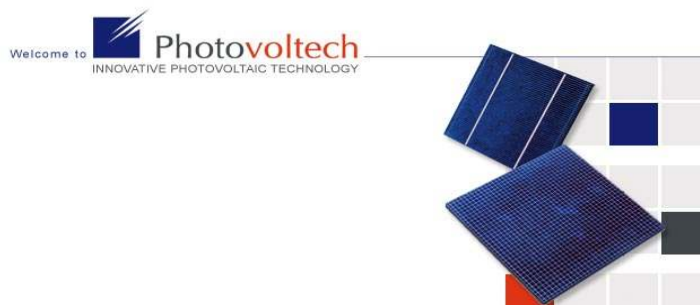
Owners Manual

Controlled Atmosphere Infrared Oven

July 17, 2004

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Owner's Manual



CONTROLLED ATMOSPHERE INFRARED OVEN

MODEL: LA-309

SERIAL NUMBER: 1303100402

FACTORY ORDER NUMBER: 40360

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Near-Infrared
Heating Technology

TABLE of CONTENTS

1. INTRODUCTION.....	8
1.1. Manual Contents Organization	8
1.2. Installation Requirements.....	8
1.2.1. Unpacking.....	8
1.2.2. Machine Placement.....	9
1.2.3. Machine Inspection.....	9
1.2.4. Providing Power	9
1.2.5. Providing Gas and Air	9
1.2.6. Process Exhaust Requirements	9
1.2.7. Installation of the Transport Belt.....	10
1.2.8. Removal of Shipping Restraint Screws	10
1.2.9. Radiant Technology Customer Service Startup (Optional).....	11
2. GENERAL SAFETY GUIDELINES	12
2.1. Electric Shock Hazard.....	12
2.2. Hazardous Materials.....	12
2.3. Normal Good Laboratory Practice	12
3. OPERATING INSTRUCTIONS	14
3.1. Power Controls and Indicators	14
3.1.1. Power Status Indicators	14
3.1.2. Controls.....	14
3.2. Basic Operation.....	15
3.2.1. Main Power.....	15
3.2.2. Uninterruptible Power Supply (UPS) “ON” Switch (Option).....	15
3.2.3. Power On/Startup.....	15
3.2.4. Fans.....	15
3.2.5. Furnace Log-on and Initial Operation	15
3.2.6. Security and User Information.....	15
3.2.7. Screen Menu (Located at bottom of screen).....	16
3.2.8. Atmosphere Supply Gas	17
3.2.9. Furnace Startup (Process Screen).....	18
3.2.10. Transport Speed.....	19
3.2.11. Power Off.....	19
3.2.12. Replace Covers	19
3.2.13. Shutdown Sequence.....	19
3.2.14. Auto Shutdown Sequence.....	19
3.2.15. Gas Shut Off.....	20
3.3. Software Operation	20
3.3.1. Recipe Setup Screen (Off Line Edit).....	20
3.4. Process Monitor Screen.....	21
3.4.1. Power Saving Feature (Option)	21
3.5. Recipe Setup.....	21
3.5.1. Setpoint Modification (Levels 2 and 3).....	21

TABLE of CONTENTS

3.5.2.	Power Distribution (Levels 2 and 3).....	21
3.5.3.	PID Zone Tuning (Levels 2 and 3).....	22
3.5.4.	Transport Speed (Levels 2 and 3).....	22
3.6.	Gas Flow Screen	23
3.6.1.	Gas Flow Settings.....	23
3.6.2.	Fan Speed Settings (Levels 1, 2, and 3).....	23
3.7.	Alarm Status (All Levels)	23
3.8.	Data Log/Alarms and Alerts	23
3.8.1.	Occurrence and Timed Logging Control (Levels 1, 2, and 3).....	23
4.	SERVICE INSTRUCTIONS	25
4.1.	Routine Maintenance	25
4.1.1.	Daily Maintenance.....	25
4.1.2.	Monthly Maintenance.....	25
4.1.3.	Other Scheduled Maintenance.....	26
4.2.	Troubleshooting	31
4.2.1.	Unable to log on, the OPTO22 control system does not have any power	31
4.2.2.	Temperature.....	31
4.2.3.	Conveyor System.....	32
4.3.	Hardware, Software Troubleshooting	33
4.3.1.	Controller Communication	33
4.3.2.	Process Problems.....	33
4.3.3.	Abnormal sensor behavior.....	34
4.3.4.	Remote control setup	34
4.3.5.	Calibration	34
4.4.	General Repair	36
4.4.1.	Lamp Change Procedure.....	36
4.4.2.	Transport Belt Replacement	38
4.5.	Element Test Procedure	40
4.5.1.	Required Equipment	40
4.5.2.	Test Procedure	40
5.	THEORY OF OPERATION - PROCESSING.....	43
5.1.	Energy Source	43
5.2.	Characteristics of Infrared Radiation	43
5.3.	Atmosphere Purity and Control	43
5.4.	Thick Film Processing.....	43
5.4.1.	Profile	44
5.5.	Solder Fusion, Die Attach, and Sealing Processing.....	44
5.5.1.	Profiling for Solder Fusion, Die Attach, and Sealing.....	44
6.	PRODUCT SPECIFICATION.....	
7.	OPTIONS.....	49

TABLE of CONTENTS

7.1. Temperature Profile - Profile Menu (Option)	49
7.2. Element Monitor (Option).....	49
7.3. Moisture and Oxygen Analyzer System (Option).....	52
7.3.1. Introduction.....	52
7.3.2. Description.....	52
7.3.3. Operation	53
7.4. Hydrogen Operation (Option)	55
7.4.1. Introduction.....	55
7.4.2. Description.....	55
7.4.3. Installation Requirements	57
7.4.4. Operating Instructions, OPTO22 Control System	57
7.4.5. Hydrogen Flowmeters	58
7.4.6. Functional Checkout (With Helium)	58
7.5. Modem/PcAnywhere (Option).....	61
7.5.1. Windows 95 Format	61
7.6. Product Viewing Area (Option).....	62
7.7. Exhaust Stack Heater (Option).....	62
7.8. Voltage Control (Option)	62
7.9. Product Sensor and On-Screen Tracking (Option)	63
APPENDIX A: DOCUMENTATION	67
Configurator	67
Channel Assignment Sheet	67
Drawings and Bills of Material.....	67
APPENDIX B: CONTROLLER INSTALLATION	70
APPENDIX C: ENGINEERING SPECIFICATIONS.....	72
00025 Procedure for Jumpering Analog, I/O and Expansion Cards for OPTO 22.....	72
00028 SCR Power Control PCB Calibration, OPTO 22 Control System.....	72
00034 Calibration Procedure for Motor Speed Controller Board and Conveyor Belt (OPTO 22) ..	72
00036 Setup for OPTO 22 Controller G4LC32 (WIN 95® Software).....	72
APPENDIX D: MATERIAL SAFETY DATA SHEETS	87
Kaowool.....	87
Mercury.....	87

TABLE of CONTENTS

FIGURES

Figure 3.1.2.1 Control Panel.....	14
Figure 3.2.6.1 Security Window, Log-on.....	16
Figure 3.2.8.1 Gas Flow Window.....	17
Figure 3.2.9.1 Process Control Window.....	18
Figure 3.3.1.1 Recipe Window.....	20
Figure 3.8.1.1 Event Logging.....	24
Figure 4.1.3.1 Scheduled Maintenance Window.....	26
Figure 4.1.3.2 User Selectable Maintenance Description.....	27
Figure 4.1.3.3 Maintenance Frequency Dialog Box.....	27
Figure 4.4.1.1 Lamp Schematic showing Kaowool Packing.....	36
Figure 4.4.2.1 Belt Orientation.....	38
Figure 4.4.2.2 Belt Installation.....	40
Figure 4.4.2.3 Inserting Belt Splice.....	40
Figure 5.5.1.1 Element Monitor PLC Control.....	49
Figure 5.5.1.2 Element Monitor System Diagram.....	51
Figure 5.5.1.3 Element Monitor Status Window.....	52
Figure 7.3.3.1 O ₂ Analyzer Sampling Window.....	54
Figure 7.4.2.1 H ₂ / Forming Gas Sequential Operation.....	55
Figure 7.5.1.1 Process Screen showing Lane Button(s), View Button and Recipe Button.....	63
Figure 7.5.1.2 Recipe Screen showing Product Length Box.....	65
Figure 7.5.1.3 Send Value Window.....	65
Figure 7.5.1.4 Product Tracking Window showing the Clear Product Counts Button.....	65
Figure 7.6. Product Viewing Window.....	56
Figure 7.7.Exhaust Stack Heater.....	56

INTRODUCTION and INSTALLATION REQUIREMENTS

1. INTRODUCTION

1.1. Manual Contents Organization

This manual is intended for users of the Radiant Technology infrared furnace system. The manual will help in understanding the machine's capabilities, uses, routine maintenance, and basic design features. The introductory section sets forth requirements for proper installation and initial startup.

Section 3 will be of specific interest to personnel who will set up and operate the furnace system. The service manual, beginning with Section 4, contains detailed information, including adjustments, alignments, maintenance, and troubleshooting. Section 5 contains a theory of operation. The Product Specification, which introduced and laid the groundwork for the machine, is included in Section **Error! Reference source not found.** Technical information applicable to your machine is covered in this section. Section 6 contains special operating instructions for options and custom features not found on standard production machines.

Each model and furnace contains many unique parts and assemblies that are not common to all. In addition to the unique parts, many custom features and options are routinely ordered and shipped with these furnaces. In order to control and record these variations, a top assembly bill of material, or "customer configurator", has been included in Section

Appendix A of this manual. This document, controlled by a serial number, is the index to all the documentation, which built a particular furnace.

1.2. Installation Requirements

1.2.1. Unpacking

Remove the banding from the shipping container and carefully disassemble. The shipping container should contain the shipping manifest listing the model of your furnace system and all options, accessories, and special configurations, which were ordered according to the original purchase order or specification. If any item listed is unaccounted for, immediately notify the carrier and the Radiant Technology Customer Service Department.

1.2.2. Machine Placement

Locate the machine on an unyielding floor in the final installation position. Lift the machine at the approximate locations shown on the installation drawing (see Documentation Section), and slide the shipment skid out from under the machine. Do not attempt to lift the machine at one point or at points other than recommended; failure to follow these instructions invites frame damage and will void the warranty.

NOTE: The lifting device must extend under the machine and support both sides of the frame structure.

Remove the base covers and adjust the leveling screws to level the frame within .06 inch overall. Each of the leveling screws should support an equal amount of weight.

1.2.3. Machine Inspection

Remove the upper and lower side covers from both sides of the machine. Inspect all lamp connections for soundness and for loose hardware that may have become dislodged during shipment. Inspect the lower electrical compartment for shipping damage, loose connections, or components. Finally, inspect the furnace interior, checking for broken lamps, foreign objects, or any components that may have come loose during shipment. Report any shipping damage immediately to the Radiant Technology Customer Service Department.

1.2.4. Providing Power

These machines are built and tested to the voltage specified on the nameplate located adjacent to the power entrance hole in the lower electrical compartment. Electrical power, matching the specifications on the nameplate, is to be connected to the contactor or circuit breaker located directly above the entrance hole. A ground terminal is provided for a safety ground. (5-wire system is optional.) All city and local codes should be followed when wiring this system for power.

1.2.5. Providing Gas and Air

Oil-free dry shop air, at a maximum recommended dew point of 59°F, is to be brought to the machine through a customer supplied line with a minimum inside diameter of 3/4 inch. In addition to the supply line, a pressure gauge and regulator is required if the supply pressure fluctuates or goes above 70 psi. Connections for gas require the same line size and a regulator to control the pressure to 70 psi maximum. The supply temperature of both gas and air should be above the dew point of the room air to prevent condensation from forming on the feed lines and dripping into the furnace.

WARNING: The flowmeters on these furnaces are rated at 70 psi maximum; operating beyond 70 psi exposes the operator to possible injury.

1.2.6. Process Exhaust Requirements

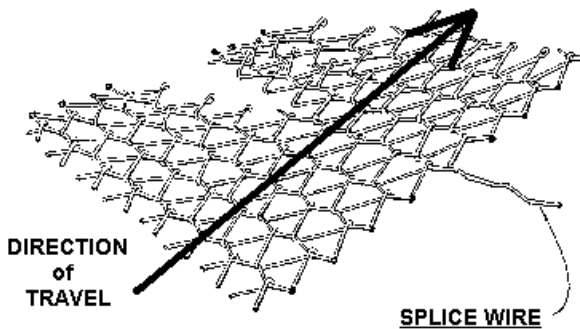
In most applications, process exhaust and heat should be vented to the outside atmosphere. It is the customer's responsibility to review the process, local laws, and

facility in deciding on an exhaust system. Insulated exhaust tubing and a collector hood with a 4 inch inside diameter, or larger, is routinely used. Do not make any direct connections to the chamber exhaust stacks. A minimum 8.0” clearance between the exhaust stacks and venting device is required

1.2.7. Installation of the Transport Belt

A portion of the transport belt which goes through the furnace chamber was intentionally left uninstalled to protect the furnace interior during shipment. When installing the belt, it will be helpful to have an assistant available to help guide the belt into the furnace entrance.

- 1.2.7.1. The portion of the belt which goes through the furnace is rolled up and secured at the entrance end of the furnace. Unroll the belt and attach it securely to the pull wire that was left in the furnace chamber.
- 1.2.7.2. Pull the belt through the chamber from the exit end of the furnace, while an assistant guides the belt into the entrance.
- 1.2.7.3. Once the belt has been pulled completely through the chamber, remove and discard the pull wire. Splice as shown in Figure below.



1.2.8. Removal of Shipping Restraint Screws

Large furnaces operating at high temperatures experience considerable growth from thermal expansion. All models are equipped with support slides which allow stress free expansion to take place. To secure the process chamber during shipment, restraining brackets (painted red) attach directly between the chamber and frame. The screws which secure these brackets to the frame must be removed before bringing the furnace up to operating temperature.

WARNING: Failure to remove slide restraint screws invites structural damage and will void the warranty.

1.2.9. Radiant Technology Customer Service Startup (Optional)

It is the customer's responsibility to accomplish the tasks described in 1.2.1 through 1.2.8, prior to scheduling a visit by a Radiant Technology Customer Service technician. When the Customer Service technician visits the user's plant, the technician will require the full-time help of at least one customer representative who will be responsible for the operation and maintenance of the furnace system. Tasks to be performed by the Customer Service technician include:

1.2.9.1. Prepare the machine for operation.

1.2.9.2. Apply power and bring up the machine to a fully operational state.

1.2.9.3. Run through the installation test procedure.

1.2.9.4. Report to the customer any deficiencies noted in the installation of the machine.

1.2.9.5. Instruct the appropriate personnel in the customer's plant how to set up and run the furnace system.

1.2.9.6. Teach the appropriate personnel in the customer's plant how to do the necessary preventive maintenance.

1.2.9.7. Turn over the machine and documentation to the customer.

1.2.9.8. Specification Limitation.

1.2.9.9. The specifications, as noted in this manual, are for standard production machines only. These specifications may not apply if the machine was ordered with custom features or non-standard options.

SAFETY

2. GENERAL SAFETY GUIDELINES

The following set of guidelines is intended to create awareness of potential health and safety hazards. Refer to the Infrared Furnace System Safety Features Addendum and Appendix D for more information.

2.1. Electric Shock Hazard

RTC 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.

2.2. 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 personnel wearing gloves, eye protection and a facemask to prevent inhalation of particulates.

2.3. Normal Good Laboratory Practice

Normal good laboratory practices apply to the operation of RTC 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.

EQUIPMENT OPERATION

3. OPERATING INSTRUCTIONS

3.1. Power Controls and Indicators

3.1.1. Power Status Indicators

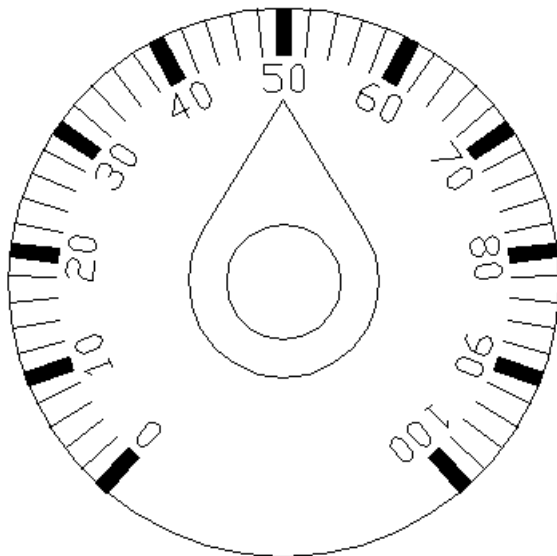
3.1.1.1. MAIN (Red Indicator)

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

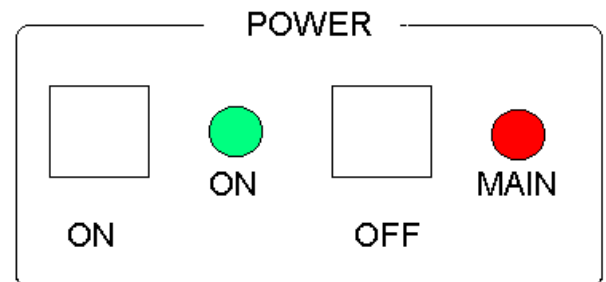
3.1.1.2. ON (Green Indicator)

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

3.1.2. Controls



FAN CONTROL



POWER CONTROLS and INDICATORS

Figure 3.1.2.1 Control Panel

3.1.2.1. POWER ON

Pressing this switch causes the furnace to go through its power up sequence, providing the MAIN lamp is lit and the EPOs (Emergency Power Off switches) and interlocks located in the doors are released. The ON indicator, described in 2.1.1.2, will illuminate.

3.1.2.2. POWER OFF

Before pressing POWER OFF, the furnace must be in cooldown mode. Pressing this switch causes the furnace to begin a timed power shutdown sequence. The heaters are shut down immediately, and after a cooldown (to 100°C) period, the fans, transport belt, and other functions are shut down.

3.2. Basic Operation

3.2.1. Main Power

The MAIN indicator must be lit before pressing the POWER ON button.

3.2.2. Uninterruptible Power Supply (UPS) “ON” Switch (Option)

The UPS power “ON” switch is located on the center front panel of the UPS.

3.2.3. Power On/Startup

Press the POWER ON button. The ON indicator illuminates. Press the monitor power button. The computer boots up and the logo screen is displayed.

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!

3.2.4. Fans

Check that the control enclosure fans, the cabinet cooling exhaust fans, and the turbulent 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 fan at greater than or equal to the power of the top fan. If this is not done the cooling system will not work properly.

3.2.5. Furnace Log-on and Initial Operation

Select “Security” icon to initiate access to “Security and User Information” screen.

3.2.6. Security and User Information

This window allows the operator to select access level, log-on or log-off, add or delete users, and modify password and access codes.

NOTE: Before turning off system, you **must** “Log-Off” through Security screen.

3.2.6.1. Access Level

Select Access Level by clicking on the User List, then log-on with the appropriate password.

The system is shipped with three (3) access levels, each with its own password.



Figure 3.2.6.1 Security Window, Log-on

Access Level 1 password: 1. This is the 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. This is the 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 is restricted to RTC personnel only.

3.2.7. Screen Menu (Located at bottom of screen)

Allows operator to select the desired screen by moving the cursor and clicking on the chosen screen.

3.2.8. Atmosphere Supply Gas

If the furnace has flowmeters, turn on the atmosphere supply gas and adjust the inlet regulator to 70 psi.

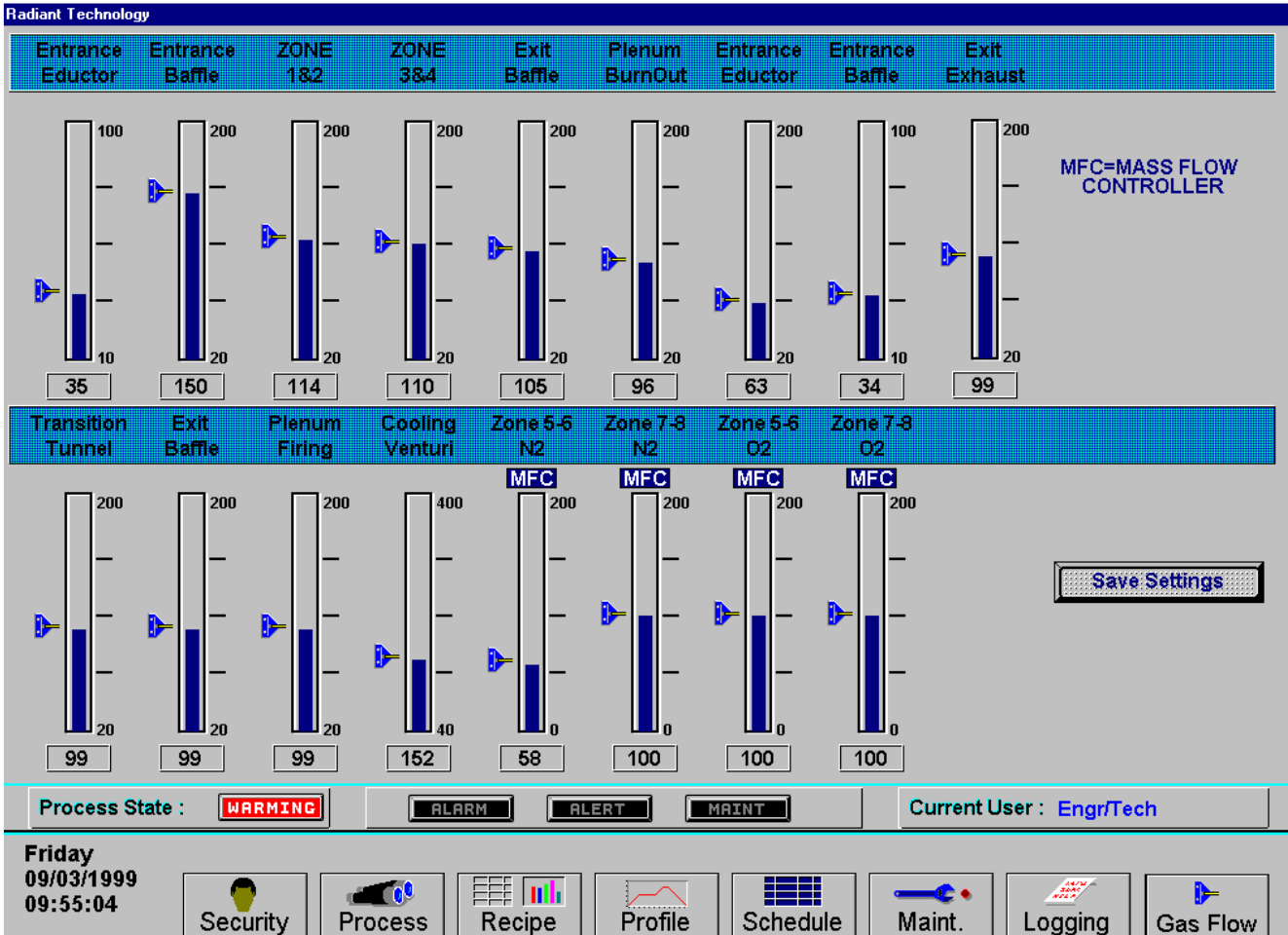


Figure 3.2.8.1 Gas Flow Window

3.2.8.1. Default Settings

Verify flowmeter settings are per recipe requirements. See Section 2.6.

NOTE: If operating on hydrogen, understand the appropriate features before attempting operation.

3.2.8.2. Optional Mass Flow Controller(S)

Flowmeters labeled as MFC provide control to mass flow controllers. Use the vertical Slide switch or numeric dialog box on the appropriated Mass Flow Controller to set the desired flow rate.

3.2.9. Furnace Startup (Process Screen)

Radiant Technology

S-1215XH Controlled Atmosphere Infrared Furnace

RTC

Lanes Active 1 2 3

Zones	1	2	3	4	5	6	7	8
Setpoint	100.0°C	100.0	100.0	100.0	100.0	100.0	100.0	100.0°C
Actual	22.8°C	23.8	24.3	23.4	24.5	23.2	24.9	24.3°C
Top Power	0.0%	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
Bottom Power	0.0%	0.0	0.0	0.0	0.0	0.0	0.0	0.0%

Edge Power L 0.0% R 0.0% R

Zone S O2 7 PPM
MA -53°C

Belt Speed 20.0 IPM
Actual 20.0 IPM

H2-1 -0.1% H2-2 -0.1% H2-3 -0.3%

N2 H2 Forming

Time Remaining Purge 0:00 0:00 Fill

Avg Pwr 0.0%
Water Out 30 °C
Water In 24 °C
Plenum RH 0.0%

Process State: OFF ALARM ALERT MAINT Current User: TECH/ENGR

Monday 24/03/97 13:06:44

Security Process Recipe Profile Schedule Maint. Logging Gas Flow

Click to silence alert / alarms

Figure 3.2.9.1 Process Control Window

3.2.9.1. Check for no active alarms or alerts.

If appropriate, move cursor to and click on “Acknowledge Events” to clear or silence an alarm/alert in order to proceed with furnace operation. If alarm/alert does not clear, see Troubleshooting Section 3.2.

3.2.9.2. Verify correct recipe is loaded.

If not, click on RECIPE icon for “Recipe” screen.

3.2.9.3. In Process field, select “Warm Up” to initiate the process selected.

In the “Warm Up” mode, the heating elements will come on. After 10 minutes, check the system for instability or cycling, and correct if necessary. See Service Information Section.

While the machine is heating, check for alarms and listen for the alarm buzzer. In particular, check for any exhaust fan failure alarms. Element failure alarms (if element monitor option is selected) usually occur in the "warmup" mode. 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 "ready" mode before processing any product.

3.2.9.4. The "Exit" field will terminate and take you out of furnace operation mode when a safe preset temperature is reached.

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

3.2.10. Transport Speed

Move the cursor to the Belt Speed field. Enter the desired transport speed. Vary the conveyor speed from minimum to maximum, checking for smooth operation at all speeds. To check for belt speed accuracy, set the speed at its midrange setting. Place a coin or metal ruler on the moving belt and time through two fixed points while the furnace is in the off or cooldown mode.

3.2.11. Power Off

Before pressing POWER OFF, the furnace must be in cooldown mode.

Press the POWER OFF button. Under normal conditions, the furnace will turn off when all zones cool below 100°C.

If POWER OFF is pressed while the furnace is in the warmup or ready mode, the furnace will remain in normal operation until the cooldown mode is selected.

3.2.12. Replace Covers

Install any covers that were removed during the functional checkout.

NOTE: All functions must operate properly before proceeding. Refer to the Service Information Section and correct any malfunctions before proceeding.

3.2.13. Shutdown Sequence

The furnace should be shut down when more than an hour will elapse between production runs. A shutdown conserves energy and prolongs the life of the furnace and elements. The furnace will enter the "cooldown" mode. Once the zones have cooled sufficiently and the furnace is in the "off" mode, the atmosphere supply can be shut off at the source.

3.2.14. Auto Shutdown Sequence.

The furnace must be in cooldown mode.

Press the POWER OFF button. The ON power indicator will turn off. Once the temperature falls below 100°C, all functions will automatically shut down.

3.2.15. Gas Shut Off

Turn the supply gas off. The functional checkout is now complete.

3.3. Software Operation

3.3.1. Recipe Setup Screen (Off Line Edit)

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.

Recipe Editor Recipe Name: **LOWTEMP** **Off Line Edit**

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	
SETPOINT	298.00	184.00	167.00	167.00	170.00	160.00	224.00	275.00	°C
GAIN	20.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	
INTEGRAL	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	
DERIVATIVE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
TOP POWER LIMIT	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	
BOTTOM POWER LIMIT	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	
HIGH ALARM DEV SETPOINT	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	
HIGH ALERT DEV SETPOINT	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	
LOW ALERT DEV SETPOINT	-10.00	-10.00	-10.00	-10.00	-10.00	-10.00	-10.00	-10.00	
LOW ALARM DEV SETPOINT	-20.00	-20.00	-20.00	-20.00	-20.00	-20.00	-20.00	-20.00	

Left Edge Heat Power: 0.0 % Belt Speed: 14.5 IPM
 Right Edge Heat Power: 0.0 %
 O2 Alarm Level: 75 PPM Boat Length: 10.0 In.
 Atmosphere Purge Time: 5 Min. Water Temps: 15 °C, 80 °C
 H2 Gas Fill Time: 5 Min. Lanes Active: 1 2 3

N2 H2 Forming Recipe in Furnace: **LOWTEMP**

Process State: **OFF** ALARM ALERT MAINT Current User: **TECH/ENGR**

Tuesday 06/05/97 15:34:02
 Security Process Recipe Profile Schedule Maint. Logging Gas Flow

Figure 3.3.1.1 Recipe Window

3.3.1.1. Load Recipe (Levels 1, 2, and 3)

3.3.1.2. Delete Recipe (Levels 2 and 3)

3.3.1.3. Edit Stored Recipe, Save Stored Recipe (Levels 2 and 3)

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

3.4. Process Monitor Screen

This 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.

3.4.1. Power Saving Feature (Option)

The actual power number reflects the actual power being used by the machine. This number is based on the % power applied to the zone and the lamp power of the zone. This number can be limited by the “Maximum power” value set up in the SCR 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.

NOTE: The edge heaters are not part of the calculation.

The total power will then always stay below the number set by the user.

WARNING: This may cause the machine to never reach the 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 degrees. In this case, the machine will just stay forever in the warm-up mode.

3.5. Recipe Setup

3.5.1. Setpoint Modification (Levels 2 and 3)

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 centigrade.

3.5.2. Power Distribution (Levels 2 and 3)

Default value is 50% 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%.

3.5.2.1. 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.

3.5.2.2. Edge Heaters (Levels 2 and 3)

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. The range is 0-100% and can be set in increments of 1%.

3.5.3. PID Zone Tuning (Levels 2 and 3)

3.5.3.1. Gain

Default value is 2

Gain influences the proportional response of the PID by amplifying the error between setpoint 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.

3.5.3.2. Integral and Derivative

Default value is 6.00 (Integral) and 0.00 (Derivative)

NOTE: The integral (or Reset) function corrects temperature offset.

Derivative is a rate function that clamps temperature overshoot/oscillation.

The maximum set point for the derivative function should be $\frac{1}{4}$ of the integral value.

On the recipe window, click on the desired “Edit Zone PID Setting” pushbutton. A Zone Tuning dialog box will appear with default values for proportional gain, integral, and derivative, if not already shown on the screen. Place the cursor on the value to be modified and click. Type the new setting and press enter from the keyboard.

3.5.4. Transport Speed (Levels 2 and 3)

On the Process window, place the cursor on the transport speed field, click, type in the new value and press enter from the keyboard.

NOTE: Transport speed is displayed in inches per minute.

3.6. Gas Flow Screen

3.6.1. Gas Flow Settings

This window represents flowmeter settings provided for selected recipe. See Paragraph 3.2.8.2 for optional mass flow controller operation.

3.6.2. Fan Speed Settings (Levels 1, 2, and 3)

The settings are in percent of maximum output power. Typical setting is between 60% and 70% for product cooling. Some models have a manual control at the operator control panel/interface.

3.7. Alarm Status (All 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 Troubleshooting section for further information.

3.8. Data Log/Alarms and Alerts

3.8.1. Occurrence and Timed Logging Control (Levels 1, 2, and 3)

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

Recent Events

Event Time	Event Data
06/05/97 16:17:21	ALARM- WATER INLET TEMP LOW
06/05/97 16:17:20	ALARM- Water Flow Switch
06/05/97 16:17:20	ALARM- N2 PRES SWITCH
06/05/97 16:17:17	Recipe Start:LOWTEMP
06/05/97 15:11:08	Logged On:TECH/ENGR

Color Legend: Alarm Alert Acknowledgement Message Other

Process State :

Current User : TECH/ENGR

Tuesday
06/05/97
16:19:21

Figure 3.8.1.1 Event Logging

SERVICE INFORMATION

4. SERVICE INSTRUCTIONS

4.1. Routine Maintenance

4.1.1. 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 up, each control and switch should be briefly checked to insure 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.

4.1.2. 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 often. Experience with the machine and process being performed should dictate the need.

4.1.2.1. Run a temperature profile, no less often than monthly, on machines that are used for sensitive processes, such as thick film firing.

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.

4.1.3. Other Scheduled Maintenance

4.1.3.1. See Preventive Maintenance Screen Figure 4.1.3.1 for Reference

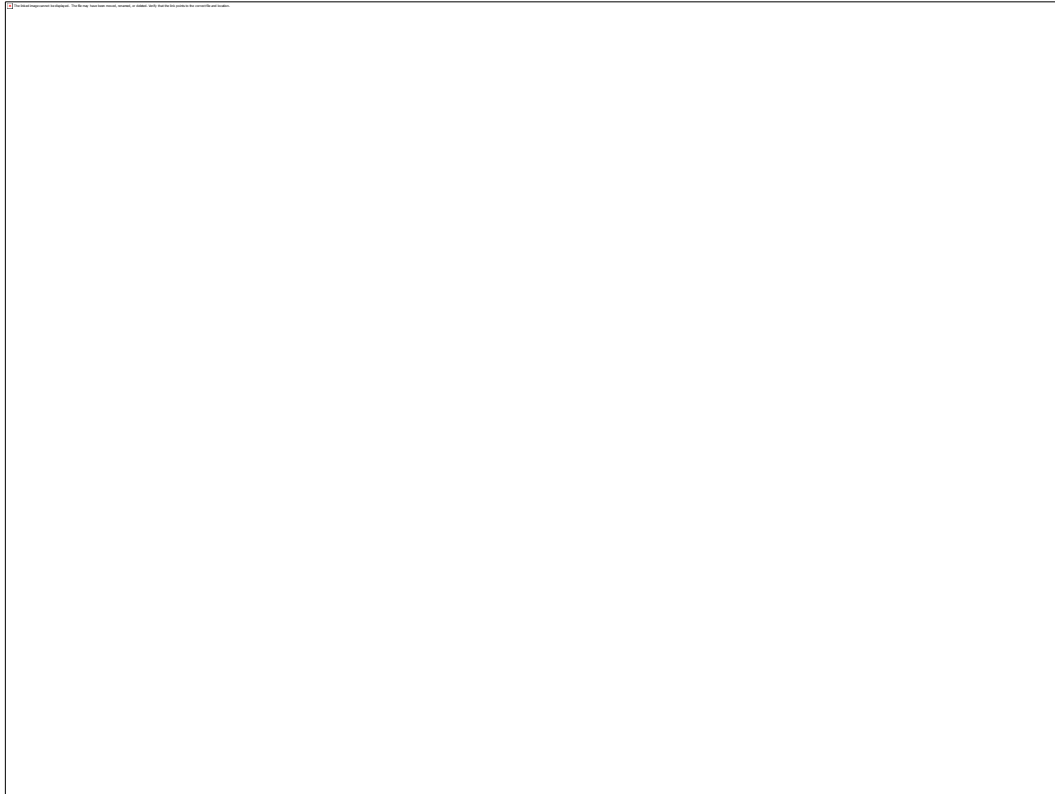


Figure 4.1.3.1 Scheduled Maintenance Window

The Remaining Time Status Bar on the Maintenance Window 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 Window will Flash.

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

4.1.3.2. User Defined Maintenance Items

The lower twelve rows of the Schedule Maintenance Window is reserved for User Specific Maintenance Requirements.

To Enter the Item Field, Click on the desired row in the column titled “Item”. The following dialog box will appear.

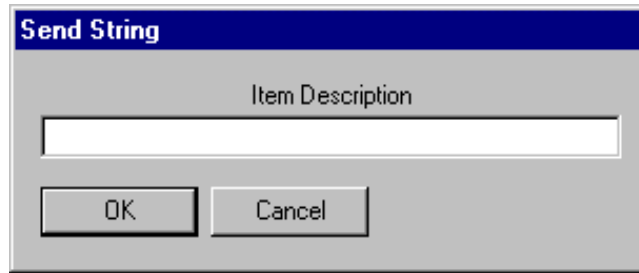


Figure 4.1.3.2 User Selectable Maintenance Description

Enter the description of the new maintenance item.

To Enter the new item's maintenance frequency, to the right of the recently added maintenance description field, Click on **#days box**. The dialog box in Figure 4.1.3.3 will appear.

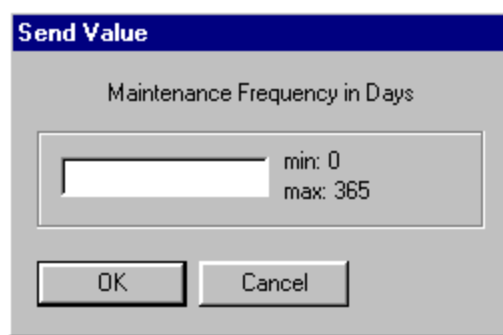


Figure 4.1.3.3 Maintenance Frequency Dialog Box

Enter the desired maintenance frequency in days.

4.1.3.3. 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.

4.1.3.4. Check (Optional) Mass Flow Controller “Zero” Output, after 6 months of operation.

Furnace Mode “OFF” mode and with all Mass Flow Controllers Set for zero flow (Gas Flow Window). After a thirty minute warm-up interval, check for each flowmeter output signal (refer to mass flowmeter schematic) for a 0.0 ± 0.05 vdc signal. If necessary, rotate the appropriate mass flow controller's “Zero Adjust” pot until the required output is achieved. The zero adjust pot is located on the side of the mass flow controller near the top.

Note: Refer to the mass flow controller schematic diagram for the output test point wiring detail.

4.1.3.5. Inspect all system cooling fans and flow switches, for freedom of movement and proper operation, every 6 months.

4.1.3.6. If the system has a belt brush, the unit should be inspected every 6 months to establish a maintenance cycle. Vacuum accumulated particulates as required.

4.1.3.7. After the first 6 months of operation, the drip trays, located under the process exhaust stacks, should be removed and cleaned.

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. To remove and clean the trays, proceed as follows.

4.1.3.7.1.Remove the top removable sections from the furnace.

4.1.3.7.2.Remove the tray and baffles.

NOTE: Some machines may require removing a cooling fan assembly.

4.1.3.7.3.Clean the trays with a suitable solvent.

4.1.3.7.4.Inspect the furnace insulation above the drip trays and gently scrape or knock loose any materials that have collected there.

4.1.3.7.5.Inspect the furnace walls and lamps for contamination. If a buildup is observed, increase the flow of gas to zone 1.

4.1.3.7.6.Re-assemble.

NOTE: On some machines the gas rakes must be removed before the tray and baffles can be installed.

4.1.3.7.7.Depending on the process, if very little buildup is found, cleaning may not be necessary more than once a year.

4.1.3.8. 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.

4.1.3.9. Lubricate the drive chain, after the first 30 days of operation, with RTC #100523 chain lube or a commercial quality non-dripping chain lube, and every 30 days thereafter.

4.1.3.10.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.

4.1.3.11. Inspect the lamp seals for loose or missing packing material.

On non-controlled atmosphere furnaces, once the side covers are removed, the lamp seals can be visually inspected. On controlled atmosphere models, the lamp seals are inside the plenum boxes, which would require breaking the plenum seal for inspection. On these furnaces the preferred inspection procedure is to run a temperature profile using a low-mass exposed junction thermocouple.

4.1.3.12. Drive Chain and Chain Tensioner

The chain drive system is contained in the motor enclosure at the exit end of the oven. The chains should be lubricated every 6 months with RTC P/N 100523 chain lubricant or an equivalent all-purpose chain lubricant.

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.

4.1.3.13. Sprocket Shaft Bearing Block

The sprocket shaft bearing block is equipped with a grease fitting for lubrication. The bearing block should be lubricated every 6 months 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.

4.1.3.14. Belt Shaft Bearings

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.

4.1.3.15. 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.

4.1.3.16. Belt Shaft Rollers, Inspection

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.

4.1.3.17. Clutch Inspection

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.

4.1.3.18. Heating Elements, Operation Life

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 in any way over time. Should failure occur, it will be sudden and catastrophic.

4.1.3.19. Chamber, Self Clean

The chamber should require no maintenance. If a problem with the chamber is suspected, an RTC field service engineer should be consulted. Because the process gas is forced through the insulation, the gas flow away from the insulation prevents contamination from building up on the chamber walls. If flux residue cleaning is necessary because of buildup elsewhere in the chamber, the zones can be set at 450°C and the oven can be put into a self-cleaning cycle for about an hour to burn out these organic residues.

4.2. Troubleshooting

To troubleshoot, follow all suggestions sequentially to determine cause of problem.

4.2.1. Unable to log on, the OPTO22 control system does not have any power

- A) Check fuse “FB” in safety enclosure box. (Ref: Power Control Schematic in Documentation Section)
- B) Check the Ethernet cable between the PC and the OPTO22 controller at the back of the PC and at the controller. See figure below. (Ref: Frame Wiring Schematic in Documentation Section)
- C) Check the setup of the installed Ethernet card. (Ref: Engineering Specification 00042 in Appendix B.)

4.2.2. Temperature

4.2.2.1. The furnace has been in "warmup" mode for more than 15 minutes.

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

- A) Check K1 main contactor (located in safety enclosure) to be sure it is operational. If not, check fuse “FD”. (Ref: Power Control Schematic in Documentation Section)
- B) Check K3 and K6 relays (located in safety enclosure) to be sure they are operational. If not, check interlock switches (located on pedestal doors) to be sure they are engaged. (Ref: Power Control Schematic in Documentation Section.)
- C) Check K4 relay (located on OPTO22 panel. (Ref: Channel Assignment Sheet) Check for illuminated LED, indicating an active output.

NOTE: K4 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

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

- A) The SCR needs calibration. See “Maint” screen for details. (Ref: Engineering Specification 00028 in Documentation Section)
- B) The SCR has failed and shorted. Replace SCR.

4.2.2.3. Zone temperature fluctuates.

- A) The SCR needs calibration
- B) Improper flowmeter setting(s)
- C) Adjacent zone temperature differentials are too large
- D) Improper PID setting(s)

NOTE: The following are factory typical settings:

Gain: 30

Integral: 90

Derivative: 8

4.2.3. Conveyor System

4.2.3.1. A Transport Speed Error occurred.

- A) Check fuse “FB” (located in safety enclosure box). (Ref: Power Control Schematic in Documentation Control Section)
- B) Check fuses “F1” and “F2” on Motor Speed Control PCB (located in the motor box). (Ref: Frame Wiring Schematic in Documentation Control Section)
- C) Inspect clutch for slippage. (Ref: Section 3.1.3.15)
- D) Visually inspect for belt jam or snag.
- E) Check the input signal on Motor Speed Control PCB (located in motor box); S1 is common, S2 is speed control. (Ref: Frame Wiring Schematic in Documentation Section)

At maximum speed the voltage is approximately 10 VDC.

4.2.3.2. Transport Motion Fault has occurred.

In addition to Section 3.2.3.1, the following items should be checked.

- A) Check for wear and tear on the small gear present on the transport motion sensor, and the gear located on the drive shaft at the exit end of the furnace.
- B) The optical coupler mounted on the sensor must be kept clean and positioned properly. The timing wheel must be adjusted so the edge of the wheel and the face of the wheel have the same spacing, with respect to the optical coupler.

Jerking or vibrating of transport system

See Maintenance Section 3.1.3.9 through 3.1.3.14.

4.3. Hardware, Software Troubleshooting

4.3.1. Controller Communication

The most often seen problem is no communication between the computer and the controller. This 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 Arcnet card, make sure the coaxial cable is plugged in, and the controller address is 1.
- out of memory, switching to low scan mode; there is insufficient memory to run the software. Contact RTC for additional memory.
- Incompatible gml file date/time; the source code has been changed, contact RTC.

If you have communication, but it looks like some data is frozen, it may be a loss of communication between the controller and the bricks. Check on the bricks to be sure the LEDs “RUN” and “REC” are on. The LED “TRX” should be on every time the brick talks to the controller.

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.

4.3.2. Process Problems

4.3.2.1. 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, section 3.3.5.2.

4.3.2.2. Temperature or large power fluctuation

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. Go to the PID tuning screen for that particular zone. Check the behavior of the PID Output signal. Once at ready state, it should be flat! If it's not, the PID is not tuned for the setpoint you are at right now. Go to the PID tuning section.

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 Documentation Section.

4.3.3. 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

- a temperature with a negative value,
- a gas analyzer readout that never changes value,
- a board counter that doesn't count.

For the digital sensors, first locate the relay 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 itself.

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

The analog inputs cannot be checked visually.

4.3.4. Remote control setup

To setup the remote control on the furnace for troubleshooting by RTC at the factory, start PcAnywhere, click on "Be a Host" and "Wait for Call". The computer should be connected to an ANALOG phone line.

WARNING: Do not use a digital phone, as found in most modern telephone installation. A digital phone line will damage the modem. The customer must provide RTC with the phone number for that particular phone line to obtain service.

4.3.5. Calibration

4.3.5.1. SCR

Follow the calibration procedure described in the Engineering Specification No. 00028.

4.3.5.2. Belt speed

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.

4.3.5.3. Thermocouples

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

4.3.5.4. PID tuning

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.

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

Go to the recipe screen and select the PID tuning for the zone you're interested in. 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 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.

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.

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 around 900°C. The machines are set up for one set of PID parameters at the factory. It is up to the process engineer at the customer's site to decide if he wants to fine tune the machine.

4.4. General Repair

4.4.1. Lamp Change Procedure

When a heating element requires changing, it is essential to observe the following procedure. This procedure will prevent premature element failures and air leaks.

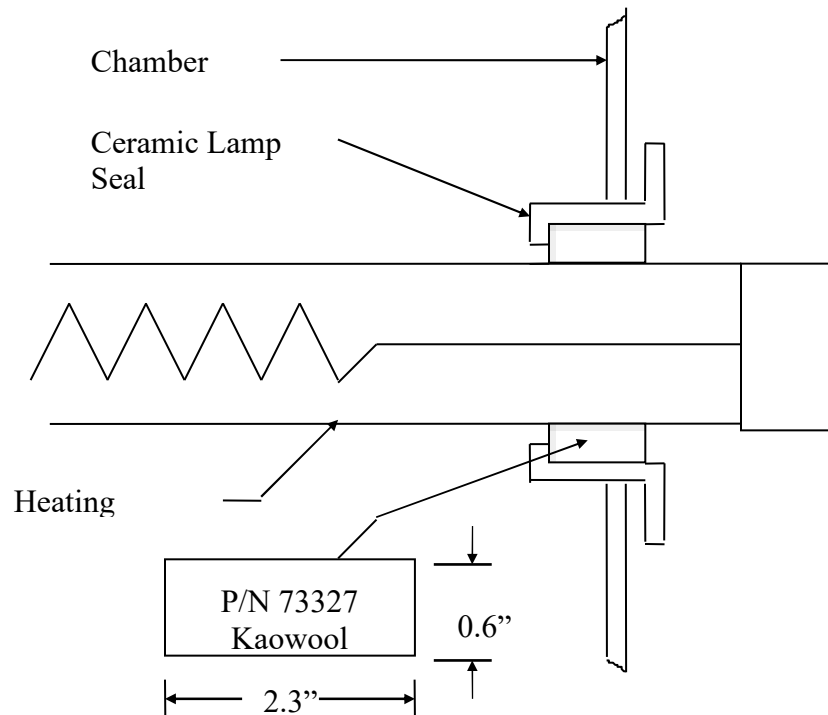


Figure 4.4.1.1 Lamp Schematic showing Kaowool Packing

4.4.1.1. Make sure all power is totally removed from the system, and all indicator lamps are OFF.

Remove all side covers, chamber doors and element end covers to completely expose all heating element terminations.

To prevent discharge shock, carefully short a lamp terminal in each zone to the frame to eliminate any capacitor charge.

4.4.1.2. Using two 3/8 inch wrenches, hold the nut below the element lead wire with one wrench while removing the top nut with the other wrench.

Do this at one end of the element only.

4.4.1.3. Use an ohmmeter and verify that the lamp filament is open.

If the element is bad, remove the nut and washers. Note that one cannot determine, in general, if an element is bad by visually inspecting the element with power applied or by an ohmmeter in-circuit check.

4.4.1.4. Remove the element and old packing material in both ceramic ends.

4.4.1.5. Before attempting to install a new element, it is absolutely imperative that two new pieces of insulating material (RTC P/N 73327) be available to use as packing material at both ends of the lamp.

NOTE: Failure to do so will cause a severe air leak and resulting profile deterioration.

4.4.1.6. Before installing the lamp, verify that the ceramic (RTC P/N 15499) is intact and the red silicone sealant is holding the ceramic.

G.E. RTV, type 106 is used here. This is also essential to prevent air leaks.

4.4.1.7. After items 3.3.1.5 and 3.3.1.6 have been satisfied, remove the element from the carton, being careful NOT TO TOUCH THE QUARTZ WITH BARE FINGERS.

Salts in the body oils will cause devitrification and failure. If the quartz is accidentally touched, clean it off with isopropyl alcohol or clean acetone before installation.

4.4.1.8. Illuminate the furnace side opposite the insertion side.

Before the lamp is pushed through, carefully straighten the lead to be pushed through. Sighting down the tube, push the element through the opposite side. When the lead emerges, use it to gently work the lamp through.

In tight situations, a dowel or stiff wire can be used. The lead wire is taped to the dowel (or stiff wire). When inserted through to the opposite side, the lamp can be gently led through by the dowel (or stiff wire).

4.4.1.9. Pack material between the lamp and ceramic on both ends of the lamp.

Be careful not to allow the packing material to cover the metal tab, or it will cause the tab to overheat (650°F max.). Also, do not allow the packing material to be pushed into the chamber, as packing material inside the chamber will cover the lamp and cause almost immediate lamp burnout.

4.4.1.10. Verify that the lamp is centered within .03 in., and do not proceed until it is. Premature lamp failure will result if this is not observed.

4.4.1.11. Carefully wrap the leads onto the terminals in the same rotational direction as the nut will be tightened.

Make certain that there is a flat washer first, an outside star lock washer second, and the nut last.

4.4.1.12. Leave enough slack to prevent the lead from becoming tight, making the lead 0.75 in., or about 2 cm longer than necessary.

4.4.1.13. The ceramic standoff mounting the connecting stud is intentionally loose. Do not tighten it or it will fracture.

Again, use two wrenches, one below and one above the lead, and tighten.

4.4.1.14. Cut off the excess element lead wire.

4.4.1.15. Recheck to be certain that the insulation is not covering either terminal. This is critical.

4.4.2. Transport Belt Replacement

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

4.4.2.1. Place the rolled up belt at the entrance end of the furnace and orient, as shown below.

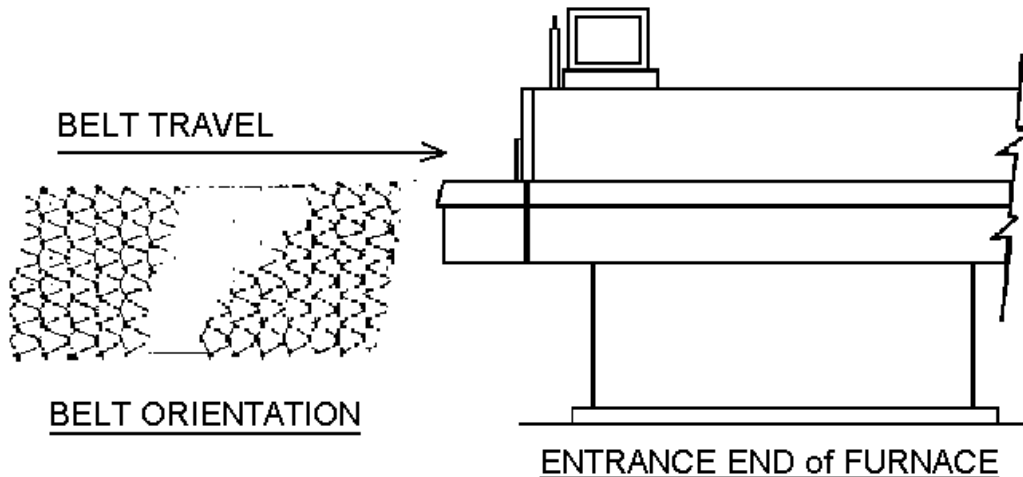


Figure 4.4.2.1 Belt Orientation

4.4.2.2. 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.

4.4.2.3. 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.

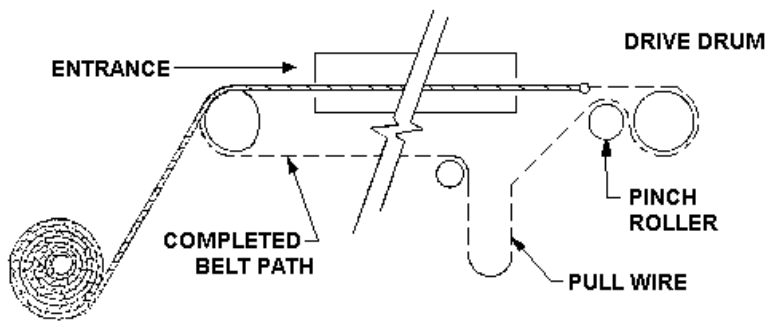


Figure 4.4.2.2 Belt Installation

4.4.2.4. Continue pulling the belt through the drive system using the wire, and then by hand, until the belt path is complete.

4.4.2.5. Splice the belt, as shown below.

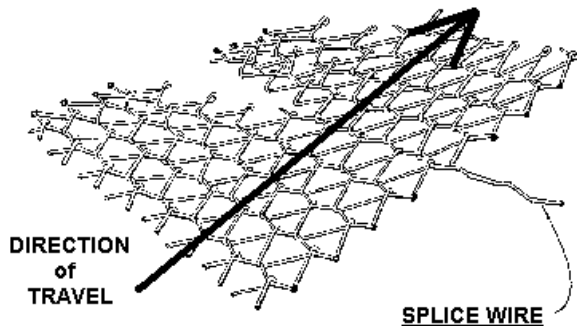


Figure 4.4.2.3 Inserting Belt Splice

4.5. Element Test Procedure

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

4.5.1. Required Equipment

1. Continuity Tester (Ohmmeter preferred)
2. 3/8" Box or Open End Wrench
3. Control & Element Wiring Schematic

4.5.2. Test Procedure

NOTE: It will be helpful to have an assistant available when performing these tests.

4.5.2.1. Procedure

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

Using the schematic as a reference, locate the bus bars linking the elements in each zone. The bus bars are made from aluminum, and are connected to the lamp terminal screws.

Starting at the front of the furnace, remove the bus bars for only zone 1 (top & bottom), taking note of which terminals the bus bars were connected to. Using the multimeter on ohms scale, and a technician on either side of the furnace, check each lamp by measuring the resistance across the terminations of the lamp. If the resistance is less than 10 ohms, the element is good. If resistance is greater, replace the element following the procedure in section 3.3 of the manual. Next, check the bottom half of the zone in the same manner. After verifying the top and bottom lamps, replace the bus bars on the proper terminals, and securely tighten all hardware.

Following the same procedure, check the other zones, one at a time, throughout the furnace.

Once the elements have been completely tested, replace the top and bottom 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.

THERMAL PROCESS

5. THEORY OF OPERATION - PROCESSING

5.1. Energy Source

The radiation source in the Radiant Technology near-infrared furnaces is a filament of tungsten or nickel chromium alloy, electrically heated to a temperature substantially above chamber or product temperature. These filaments, sheathed in quartz, are arrayed above and below the process area, supplying energy to the part by radiation. This energy transfer is dependent upon the difference between the fourth powers of the absolute temperatures of the source and the product. This may be expressed, in simplified form, by the equation

$$Q = K (T^4_{\text{source}} - T^4_{\text{product}}).$$

5.2. Characteristics of Infrared Radiation

The characteristic of thermal radiation of particular interest is that peak emitted wavelength decreases as the absolute temperature of the source increases. As a result of this decrease in wavelength, photon momentum is increased. If all other properties (absorptivity, index of refraction, etc.) remain constant over this wavelength/momentum change, the depth of useful energy absorption is increased.

Just as the "penetrating power" of x-rays is greater than that of visible light, so also is the "penetrating power" of near infrared greater (to a smaller degree) than that of far infrared.

It is precisely because of these characteristics, i.e., the greater temperature difference existing between the radiant heat source and the part, and the increase in "penetrating power" (photon momentum), that the near infrared furnaces are so remarkably effective in processing thick film structures, structures requiring solder reflow, solar cell diffusion, and a multitude of other micro-electronic applications.

5.3. Atmosphere Purity and Control

Control of atmosphere to less than 10 ppm of undesired impurity and the ability to intentionally mix gases (optional in some models) has opened an entirely new spectrum of product processes, limited only by the imagination of the user.

5.4. Thick Film Processing

As a result of the high equilibrium heat transfer, dwell time in a near infrared furnace is quite short compared to a conventional furnace. The physical structure of thick film materials is developed very quickly, and the overall thermal budget is relatively small.

Because of the very rapid internal build up of temperature during the volatile burnout stage, due to high ambient atmosphere temperature (850-900°), and the penetrating power of high

intensity short wave radiation, the organic volatiles within the inks essentially sublime completely from the structure without eruption. Structure depths up to 300 um thickness are possible without the unacceptable diffusions and migrations of materials encountered in conventional processing.

Similarly, in most cases, single print firing may be done wet, and the print/fire process will be shorter, even than the former print/dry process.

5.4.1. Profile

For most thick film processes in the RTC furnaces, the rate of temperature rise in the product can be made as fast as needed, the volatilization and sublimation of organic binders being completed long before polymerization or fusion temperatures are attained. To this end, zone 1 should be driven as hard as practical to maintain the highest intensity short wave radiation (near infrared), reaching process temperature at the beginning of subsequent holding zone(s). These are set at process fusion or polymerization temperatures. Dwell time in these zones should be just sufficient to drive the pyrolysis, fusion, or polymerization to completion. By limiting the time at temperature in this manner, unacceptable migrations or diffusions are avoided.

It has been found that substrate cracking is somewhat (if not entirely) dependent on cooling rates. The cooling module should be adjusted to provide cooling rates consistent with high yield and throughput.

5.5. Solder Fusion, Die Attach, and Sealing Processing

In general, these process operations involve components which are sensitive to time at temperature and exposure to atmosphere impurities. The ability to rapidly and linearly bring a unit to a temperature substantially below process temperature, and subsequently provide a "spike" of high intensity radiation to drive the process to completion, in an atmosphere under complete control, serves to limit the time/temperature/exposure product to a minimum, and increase yield and throughput substantially, compared to conventional processing.

5.5.1. Profiling for Solder Fusion, Die Attach, and Sealing

The profiles for these operations are derived by trial and error, because of the great number of variables involved affecting thermal response of the furnace and the system being processed.

Boats, fixtures, and other processing aids should have a thermal mass as small as practical, consistent with good manufacturing practice and requirements.

Conveyor speed should be adjusted as high as practical. Zone 1 (and 2) temperature should be set to a temperature which will bring the system being processed to an internal temperature substantially below the fusion temperature.

The spike zone (zone 2 or 3, depending on model) should be set such that the internal temperature achieved by the system will insure that fusion is complete, without exceeding limits imposed by the separate components of the system.

Generally, maintaining as large as possible temperature differential between the heating zone(s) and the spike zone, enables the furnace to generate the high intensity

spike. Dummy loading ahead of the systems being processed, to bring the furnace to a stable condition, is most desirable and is also determined by trial and error.

Atmosphere requirements are process dependent, and should be adjusted to provide proper flow direction for volatile removal (if any), and for atmosphere composition to control any adverse effects of atmosphere on the product at temperature.

5.5.2. PRODUCT SPECIFICATION

200 20-200 cfh air

OPTIONAL FEATURES

6. OPTIONS

This section contains operating instructions for optional equipment and features not found on standard production machines.

6.1. Temperature Profile - Profile Menu (Option)

To switch the viewing window between RTC Furnace Operations and the KIC Windows Application, press and hold down the ALT key, and then press TAB repeatedly. When the title “WINKIC Windows Application” appears, release ALT. The WINKIC Application appears in the foreground. Repeat the procedure to return RTC Furnace Operations to the active window.

6.2. Element Monitor (Option)

To select the Element Monitor Status Screen, move the cursor and click on the “Maint” pushbutton. On the Maintenance Window, click on the “Element Monitor” pushbutton to activate the Element Monitor status window. This is a display only screen which details the current status of the IR elements. Element strings are displayed for each monitored zone, dryer or edge heater.

The furnace Element Monitor Status Screen is grouped by each 8-module rack (brick) used. Each rack can accommodate up to eight I/O modules. Illustrated below is an 8-module rack with three digital I/O modules installed.

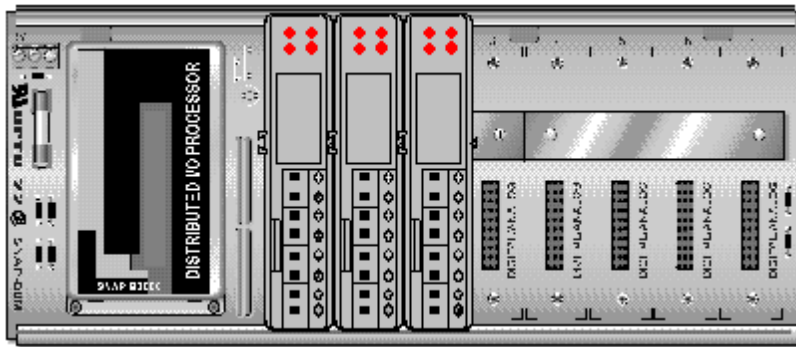


Figure 5.5.2.1 Element Monitor PLC Control

Digital I/O modules PLC (P/N 322-092202-02) are utilized to collect element status information from Element Monitor Board (P/N 370-101831-01). Each Element Monitor Board has four monitoring circuits. Each circuit utilized a transformer coil and rectifier network to pickup and convert the element status to a low voltage output signal. This output signal is received by a digital I/O module. Each digital I/O module can accommodate up to four signal inputs.

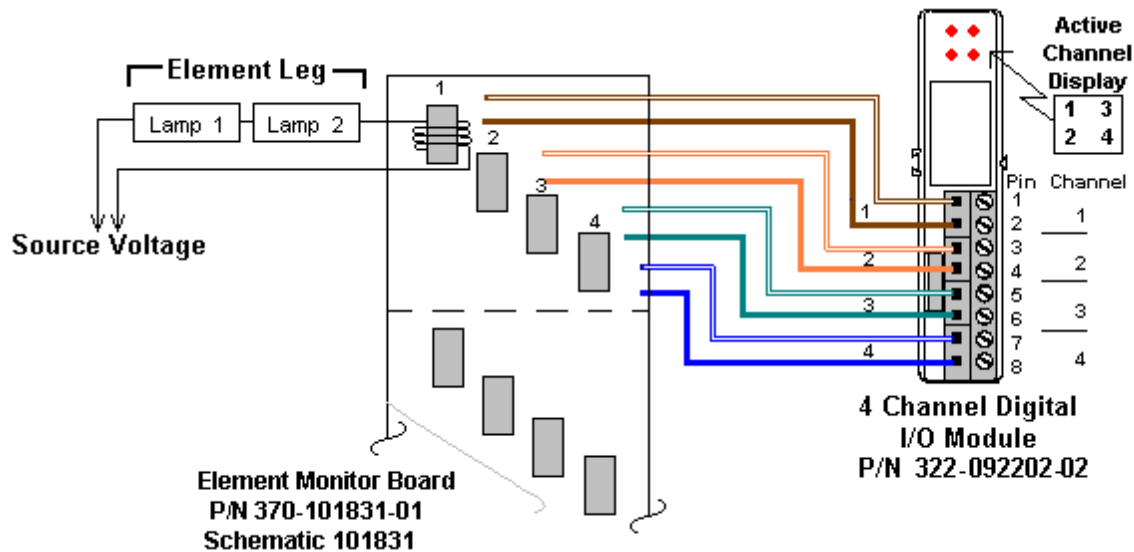


Figure 5.5.2.2 Element Monitor System Diagram

In conjunction with the four digital inputs, each module has four LED's that illuminate when its associated input is active. Input information is transmitted back the system controller for processing, alert notification, and display.

The Element Monitor Window provides active element status displays. For each element leg displayed, the following status information is provided:

- 1 8-Module rack identification
 - a) First Board (element sensors 1-32)
 - b) Second Board (element sensors 33-64)
 - c) Third Board (element sensors 65-96)
- 2 I/O module address & channel identifier
- 3 Sensor Location; Zone, Dryer, or Edge Heat number and (T)op, (B)ottom elements, (R)ight, or (L)eft edge heat.
- 4 Element Status (OK) or (Fail)

When an element failure is detected, an alert condition is enabled and a status message denoting the location of the failed element. Only the first failed element detected within the same zone/dryer/edge will be displayed on the process screen. However, the Element Monitor Window will display all failed element legs including multiple failures within the same zone.

Note: Applied power levels of less than 10% are below the threshold of the sensor circuit. Element legs operating in this range are reported as OK.

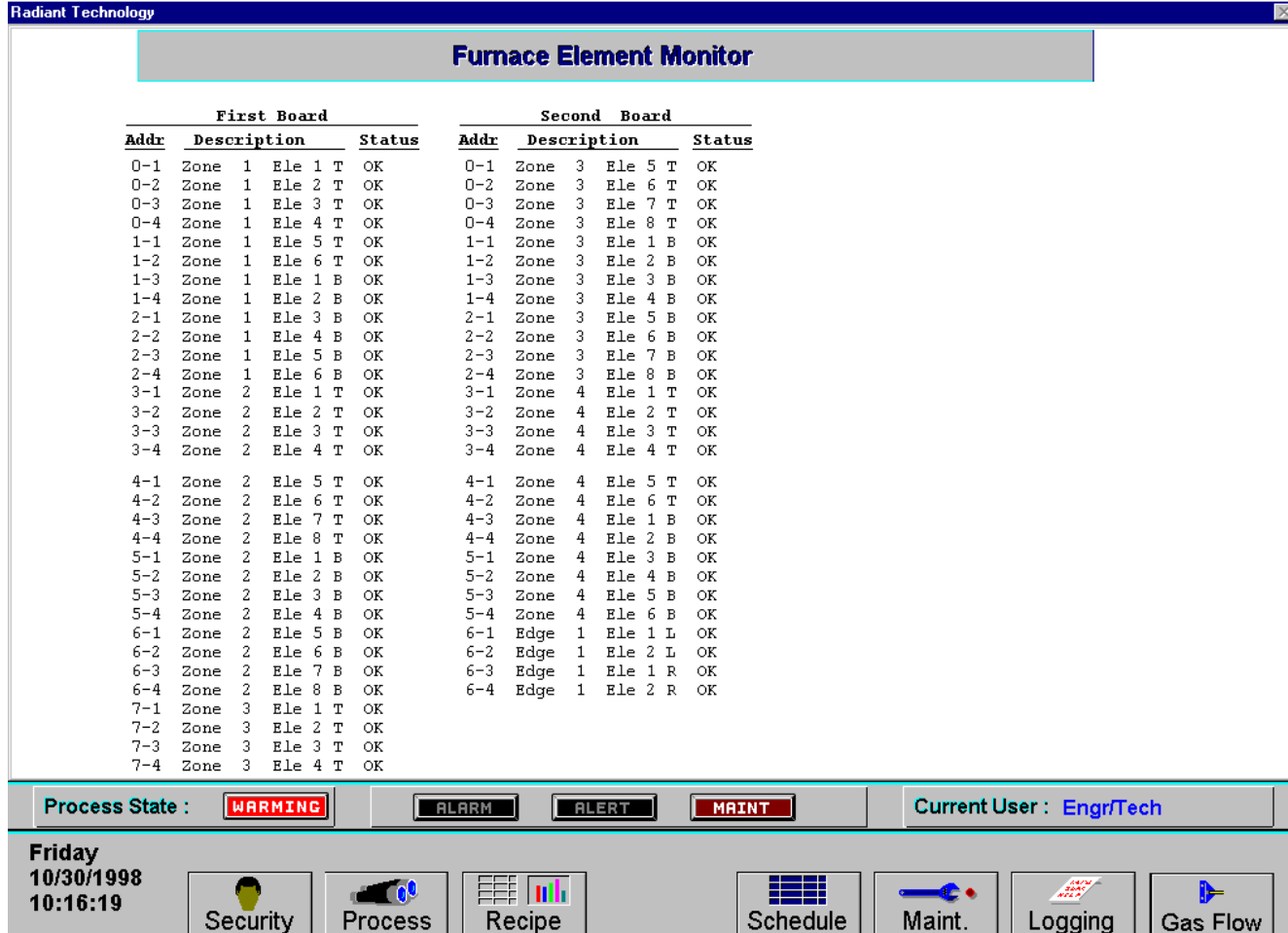


Figure 5.5.2.3 Element Monitor Status Window

6.3. Moisture and Oxygen Analyzer System (Option)

6.3.1. Introduction

This option provides a moisture and oxygen analyzer system. The Oxygen analyzer is a Delta F Type A unit which uses an electro-chemical cell to measure oxygen concentration. The cell used in this analyzer features a non-depleting electrode design which does not require periodic maintenance. The moisture analyzer is a Panametrics Series 4 model.

6.3.2. Description

The analyzer system typically uses four (4) sample lines. All but one of these lines sample process atmosphere at various parts of the furnace. The last line samples the source gas. The sample lines connect to a manifold. A series of computer controlled solenoid valves are used to switch from one sample line to another. From the

manifold, the sample is drawn through the moisture analyzer and then through the oxygen analyzer by a vacuum pump which is part of the oxygen analyzer. Note that the sample line which connects to the source gas uses a pressure regulator to regulate the source pressure to a level compatible with the oxygen analyzer.

6.3.3. Operation

6.3.3.1. General

Before the moisture and oxygen analyzer system is used, the manufacturer's manuals should be thoroughly read and understood. The oxygen and moisture analyzers are set up at the factory to operate automatically when the furnace is turned on. The oxygen or moisture analyzer output is displayed on the Process window within the computer control software.

6.3.3.2. Computer Control and Sample Port Selection

6.3.3.2.1. Sample Port Selection

The oxygen/moisture analyzer system has the capability to sample source gas and process gas from 3 different zones in the furnace. To change the location from which the sample is being drawn, first click on the desired "O₂ or MA Sampling Port" pushbutton. This pushbutton is located in both the Process and Recipe windows for your clicking pleasure. The appropriate O₂ or MA Port Selection display box will appear. Select "O₂ [MA] Sampling On" button to enable the sensor. Click on the desired sample location button, source or port location.

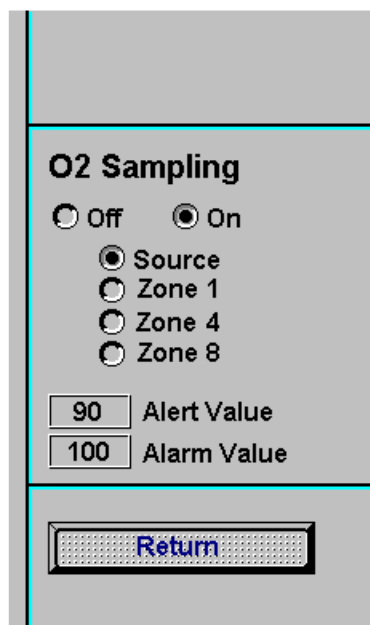


Figure 6.3.3.1 O₂ Analyzer Sampling Window

6.3.3.2.2. Optional Oxygen Level Alerts and Setting Oxygen Level Alert Limits (**H₂ Mode Only**)

The oxygen analyzer may give a high oxygen level alert during startup. The alert will continue until the process gas lines and the furnace chamber have operated in a nitrogen mode long enough to remove excessive oxygen.

NOTE: When the zone from which the sample is being drawn is changed (i.e. when the recipe is changed) the oxygen concentration may increase momentarily until the new sample line is cleared of any residual oxygen (air). This momentary rise in oxygen level may cause an oxygen level alert. After selecting the new sample location the oxygen level should peak and then begin to decrease rapidly within a matter of seconds. If the oxygen level exceeded the alert level and does not begin to rapidly decrease within 60 seconds, any hydrogen flow (optional) to the furnace should be stopped.

During hydrogen operation, if the oxygen PPM level exceeds the factory setpoint for hydrogen operation, the following will occur:

A dialog box will be displayed that notifies the operator that the “PPM setpoint levels have been exceeded”.

The furnace will automatically enter the cooldown/combustible gas purge cycle in twenty seconds. A time remaining count is displayed.

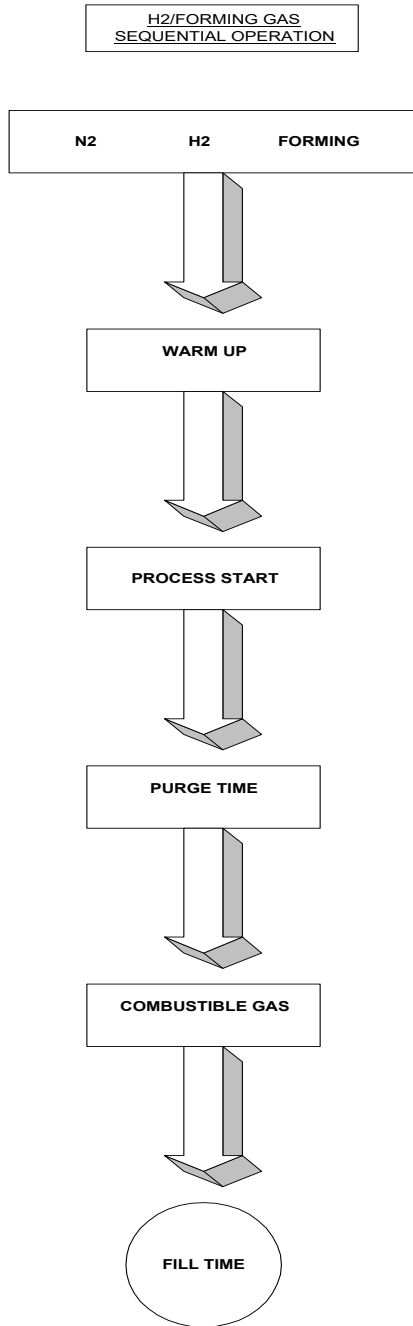
The operator has the option to click the “Purge” button to immediately start furnace cooldown/purge or the “Reset” button to restart the twenty second timer. The operator cannot delay the automatic cooldown/purge cycle for more than a total of sixty seconds.

To change the value of the oxygen level alarm or alert limits, click the appropriate alarm/alert value and type in the desired high value.

6.4. Hydrogen Operation (Option)

6.4.1. Introduction

The hydrogen operation option is designed to provide a means of introducing a reducing atmosphere into the furnace. **Because hydrogen is an extremely flammable gas and presents numerous handling and control problems, do not attempt to connect hydrogen to the machine until this section is read and understood.**



6.4.2. Description

The hydrogen operation system uses existing furnace plumbing and an additional gas flow control system to introduce hydrogen into the furnace chamber. The hydrogen is introduced into the furnace by allowing it to permeate through the porous ceramic fiber insulation, which preheats the gas before it enters the process area.

Entrance and exit baffles, located at each end of the furnace chambers, generate an inert gas curtain which effectively keeps ambient air from entering the furnace chamber and mixing with the hydrogen atmosphere. Venturi assisted exhaust stacks, located in the entrance baffle or in both entrance and exit baffles, draw off the excess hydrogen and direct it into a burner assembly. The excess hydrogen, which is drawn through the exhaust stack, is directed into the burner where it is mixed with ambient air and ignited with a hot wire Igniter.

Figure 6.4.2.1 H2 / Forming Gas Sequential Operation

6.4.2.1. Control System

The hydrogen control system is designed to prevent the possibility of introducing a combustible mixture of hydrogen into the furnace chamber. This is accomplished through logic which requires that nitrogen be run continuously in the exhaust venturis, entrance/exit baffles, furnace chamber, and in the transition tunnel/cooling muffle, if so equipped. The hydrogen control logic provides an automatic timed purge of from 5 to 30 minutes, with nitrogen, before hydrogen is allowed to enter the furnace. Nitrogen and hydrogen pressure switches, together with additional control logic, enhance the safety of the system by requiring that the following conditions be met.

6.4.2.1.1. Nitrogen Pressure

Nitrogen pressure must be present at all times during the purge cycle, as well as during straight hydrogen operation. In the event of nitrogen failure, hydrogen is automatically shut off, and the hydrogen cycle is aborted with alarm and display indication. Only after nitrogen pressure is restored can the cycle be restarted.

6.4.2.1.2. Hydrogen Pressure

Hydrogen pressure must be present during the purge cycle and during straight hydrogen operation. In the event of hydrogen failure, the cycle is aborted and nitrogen flow is initiated with an alarm and display indication. Only after hydrogen pressure is restored can the cycle be restarted.

6.4.2.1.3. Igniter

The hydrogen Igniter element(s) must start when the hydrogen burn-off operation is initiated, and run continuously during the delay cycle, as well as in the steady state. The furnace is manufactured with dual (2) igniters per stack. If both igniters in a single stack fail, the cycle is aborted with alarm and display indication. Manual restart is required to reinitiate the cycle. If only one igniter fails, the process is not aborted, but an alert occurs.

6.4.2.1.4. Seal or Plenum Pressure

Sensing a lack of seal pressure parts puts the machine into heat shut down with alarm and display indication.

6.4.2.2. Gas Flow Control

Gas flow control is accomplished manually with flowmeters. See section 2.12.4 for operating instructions.

6.4.3. Installation Requirements

Hydrogen is a flammable gas and, under certain conditions, it can be explosive. The user of this equipment must take adequate precautions to prevent the escape of hydrogen into the room air and to eliminate possible sources of ignition from the working environment. A common practice is to vent the upper part of the ceiling of the room containing the furnace, and to install a hydrogen leak detector system.

6.4.3.1. The room containing the furnace must be arranged to prevent direct air drafts from hitting the furnace. A direct air draft at the entrance or exit end of the furnace will unbalance the gas curtains and could cause hydrogen to escape into the room, or create an explosive mixture of air and hydrogen inside the furnace.

CAUTION: The flowmeters installed in the control panel are rated for 70 psi maximum; operating beyond 70 psi exposes the operator to possible injury.

6.4.4. Operating Instructions, OPTO22 Control System

6.4.4.1. Process Screen Controls and Indicators (Hydrogen Atmosphere)

Go to Process screen and click on “H₂.” Button. Click on “Warm-Up”. Wait until the process start light is flashing, and click on “Process Start”. This starts an automatic timed purge with nitrogen and lasts from 5 to 30 minutes. When the purge cycle is complete, click on “Combustible Gas On”. Nitrogen will be shut off and hydrogen will be turned on.

6.4.4.2. Hydrogen/Nitrogen (Forming Atmosphere)

Go to Process screen. Click on “Forming” button. Click on “Warm-Up”. Wait until the process start light is flashing, and click on “Process Start”. This starts an automatic timed purge with nitrogen and lasts from 5 to 30 minutes.

When the purge cycle is complete, click on “Combustible Gas On” and hydrogen will be turned on. This starts an automatic timed fill (manual set).

NOTE: Fill is defined as the amount of time required for the combustible gas to enter and fill the chamber cavity. Fill time is factory preset for 5 minutes, and can be user altered.

6.4.4.3. Terminate

Click on “Cooldown” (this returns the furnace to nitrogen operation), or go to Recipe screen and “Load Run” a new recipe.

6.4.4.4. Nitrogen or Manifold Pressure, Low

Low nitrogen pressure is indicated with a message and an audible alarm. The hydrogen operation cycle is aborted, and the machine goes into a heat shut down mode. The cycle cannot be restarted until nitrogen pressure is restored.

6.4.4.5. Hydrogen Pressure, Low

Low hydrogen pressure is indicated with a message and an audible alarm. The hydrogen operation cycle is aborted, and cannot be restarted until hydrogen pressure is restored.

6.4.4.6. Plenum Pressure, Low

Low seal pressure is indicated with a message and an audible alarm. The machine goes into a heat shut down mode and the hydrogen cycle is terminated.

CAUTION: Low plenum pressure can cause damage to the heating lamps. Do not continue to operate the machine with low plenum pressure indication. In the event of low plenum pressure indication, the machine should be shut down until the problem is found and corrected.

6.4.4.7. Igniter Failure

Igniter failure is indicated with a message and an audible alarm. If both igniters in a single stack fail, the hydrogen operation cycle is aborted and cannot be restarted until the igniters are repaired. If only one igniter fails in a single stack, the process is not aborted, but an alert occurs.

6.4.5. Hydrogen Flowmeters

Each of the hydrogen flowmeters is identified with a label as to specific function, and is adjustable from zero flow to full scale by means of an integral control valve. See section 2.12.6.7.i for flow correction factors.

6.4.5.1. Control Knob

Turning this knob clockwise decreases the flow; counterclockwise increases the flow.

6.4.6. Functional Checkout (With Helium)

RTC recommends that a functional checkout of the hydrogen system be made using helium gas for safety. It is further recommended that a trace oxygen analyzer and helium detector be made available for the checkout.

RTC has taken precautions to design the furnace so that it can be safely and reliably operated on hydrogen. However, if the gas flows are not properly set, air can be drawn into the machine, or the furnace atmosphere can be discharged out the entrance or exit, causing a fire hazard. If it is not possible to perform a functional checkout with helium, RTC recommends, as a minimum, a trace oxygen analyzer and combustible gas monitor be used to guide final process settings.

6.4.6.1. Furnace System Functional Check

First perform the recommended furnace system functional checkout. Correct any malfunctions, as necessary, before proceeding.

6.4.6.2. Helium Supply Gas

Temporarily connect a supply of helium gas to the hydrogen input line and adjust the input regulator to 50 psi. Make sure that the hydrogen flowmeters are completely shut off at this time.

6.4.6.3. Turn On Furnace

Turn on the furnace and bring it up to a fully operational state using the suggested gas flow settings from your operation manual.

6.4.6.4. Initiate the Hydrogen Operation Cycle

Adjust the hydrogen flowmeters to the same flow rates that the equivalent nitrogen flowmeters were set at.

6.4.6.5. Check Oxygen Concentration

Check the oxygen concentration inside each zone of the furnace, using a trace oxygen analyzer. The oxygen concentration can vary considerably, depending on flow settings; but as long as 100 ppm, or less, is maintained in the furnace, combustion will not occur. If the concentration of oxygen is above the 100 ppm limit, increase the flow of helium in small increments and retest the oxygen level. Allow several minutes between gas flow corrections and oxygen testing for the analyzer to stabilize.

6.4.6.6. Check For Escaping Gas

Check each end of the furnace with a helium detector to see if any furnace gas is escaping. If furnace gas escapes, increase the flow to the appropriate eductor in small increments and retest.

The eductor operates with a venturi assisted exhaust stack that produces an approximate multiplication ratio of 10:1. In general, the gas flows into the furnace chamber and baffles should be balanced by the gas flows out of the eductor stacks.

For example, if the total flow of gas into the furnace chamber and end baffles is 1000 SCFH, the flow of gas to each eductor should be as follows for a two exhaust system:

Total Exhaust = 500 SCFH through each eductor

Drive Gas = 50 SCFH to each eductor venturi

6.4.6.7. Nitrogen/Hydrogen Mixing

Selecting the nitrogen/hydrogen atmosphere, with the furnace in the hydrogen mode will unbalance the ratio of input to exhaust gas. This happens because nitrogen is introduced in addition to the volume of hydrogen that is already flowing into the furnace. Before pressing nitrogen/hydrogen mixing, perform the following:

Calculate the volume of helium flowing into the furnace when the machine is running in a balanced condition.

Decide what ratio of helium to nitrogen is to be run and the volume of each gas required.

Select the nitrogen atmosphere mode to return the furnace to nitrogen operation.

Adjust the nitrogen volume to the values calculated in 2.12.6.6. Shut off the hydrogen flowmeters.

Select the hydrogen atmosphere mode, and select the nitrogen/hydrogen mix mode before the purge cycle is complete.

Then adjust the hydrogen flowmeters. The machine should now be operating in a balanced condition, with the proper volume of nitrogen/hydrogen.

Check the oxygen level in the furnace and ends of the furnace for helium, and correct as necessary.

This completes the functional checkout.

Gas Correction Factors

<u>GAS</u>	<u>SP.G</u>
Argon (A)	1.38
Carbon Monoxide (CO)	.966
Carbon Dioxide (CO ₂)	1.51
Helium (He)	1.38
Hydrogen (H ₂)	.070
Hydrogen Chloride (H ₂ Cl)	1.59
Hydrogen Sulphide (H ₂ S)	1.39
Methane (Me)	.553
Natural Gas	.55-.66
Nitrogen (N ₂)	.966
Nitrous Oxide (N ₂ O)	1.52
Oxygen (O ₂)	1.103
Propane (C ₂ H ₂)	1.56-1.99
Sodium Dioxide (SO ₂)	2.2-2.26

Butane-N	2.4
Butane-ISO	1.99

6.5. Modem/PcAnywhere (Option)

In order to allow for remote examination of in-process furnace operations, a modem with communication software is provided. The remote operator, in conjunction with on-site personnel, can simultaneously view the Process screen and have access to input and control features.

6.5.1. Windows 95 Format

- A) Click on “Start” (bottom left-hand corner of screen).
- B) Select “Programs” and highlight.
- C) Select “PcAnywhere 32” and highlight.
- D) Select “PcAnywhere” and double click with touchpad/trackball.
- E) Select “Be A Host PC” and click/highlight.
- F) Double click on “MODEM”.

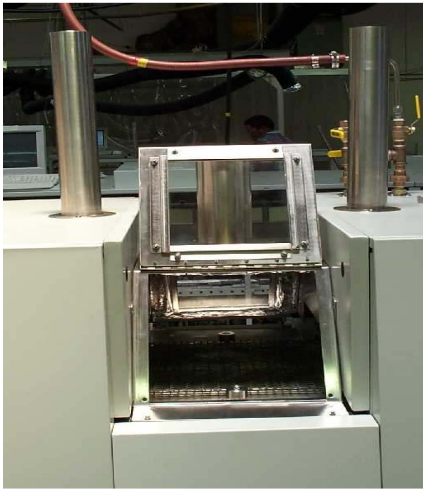


Figure 7.6. Product Viewing Area

6.6. Product Viewing Area (Option)

This option is only available on furnaces with separate drying and furnace areas. The viewing area is set between these two sections and it has an opening panel that allows access to the product inside.



Figure 7.7. Exhaust Stack Heater

6.7. Exhaust Stack Heater (Option)

The exhaust stack heater is used to heat up gases escaping from the exhaust. This is to prevent condensation of the gasses and the possibility of them dripping backing into the chamber and/or clogging the exhaust stack. The heater has a power control that is set at the computer. The customer can specify the number and location of heaters.

6.8. Voltage Control (Option)

Voltage Control means manual control of the power applied to the lamp by the operator, by manually entering the percentage of power in each of the zone power fields.

When Voltage Control is installed, a check box is visible on the main process screen. Clicking on it will enable Voltage Control.

Once this box is checked, the power settings for the zones stay at the last values calculated by the PID control. The operator can then enter a manual setting for the zone power. Since this power would then be dependent on the line voltage fluctuation, a sensor monitors the line

voltage and adjusts the power according to this voltage. Fluctuations are adjusted for $\pm 15\%$ around the nominal voltage. Beyond those values, no adjustments are made.

Since the user takes control of the system, the machine automatically goes into process ready. It is up to the user to adjust the setpoint of each zone so that the alerts and alarms for temperature deviation reflect the user's need.

For the most efficient use of the system, it is recommended that the user allow the machine to automatically reach a ready state at around the desired temperature, and then switch to Direct Control.

Clicking again on the Direct Control check box will return the system to automatic mode.

WARNING: Manual voltage control at the maximum temperature setting for the furnace may result in over temperature and damage to the equipment.

6.9. Product Sensor and On-Screen Tracking (Option)

The purpose of the product sensor and on-screen tracking feature is to count the number of product- units travelling through the furnace. A set of sensors at the entrance and exit detect the leading edge of a product-unit leaving the loading station or arriving at the unloading station. The tracking feature sets off an alarm if the exit sensor does not detect the arrival of an expected product-unit at the unloading station.

To initiate the count, activate one or more tracking lanes by clicking the lane button(s) on the upper left corner of the process screen. See Figure 0.1.

Figure 0.1 Process Screen showing Lane Button(s), View Button and Recipe Button

RTC S610 Controlled Atmosphere Infrared Furnace

Lanes Active
Lane Button(s)

Zones	1	2	3	4	5	6
Setpoint	500.0°C	500.0°C	500.0°C	500.0°C	500.0°C	500.0°C
Actual	22.1°C	21.7°C	21.7°C	22.1°C	22.6°C	22.4°C
Top Power	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %
Bottom Power	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %

View Product Tracking Window

Left Power 0.0 %
Right Power 0.0 %

Belt Speed 0.0 cm/min 0
Avg Power 0.0 %
Cabinet Temp. 23°C

Process State: OFF ALARM ALERT MAINT Current User: RTC

Tuesday 23/05/2000 11:18:45

Security Process Recipe Schedule Maint. Logging Gas Flow

To define a unique product-unit length click the recipe button on the process screen. Once in the recipe screen, shown in Figure 0.2, double click the product length box. A pop-up window labeled “Send Value” will appear (). Define the product-unit length in the product length window, and click OK.

Figure 0.2 Recipe Screen showing Product Length Box

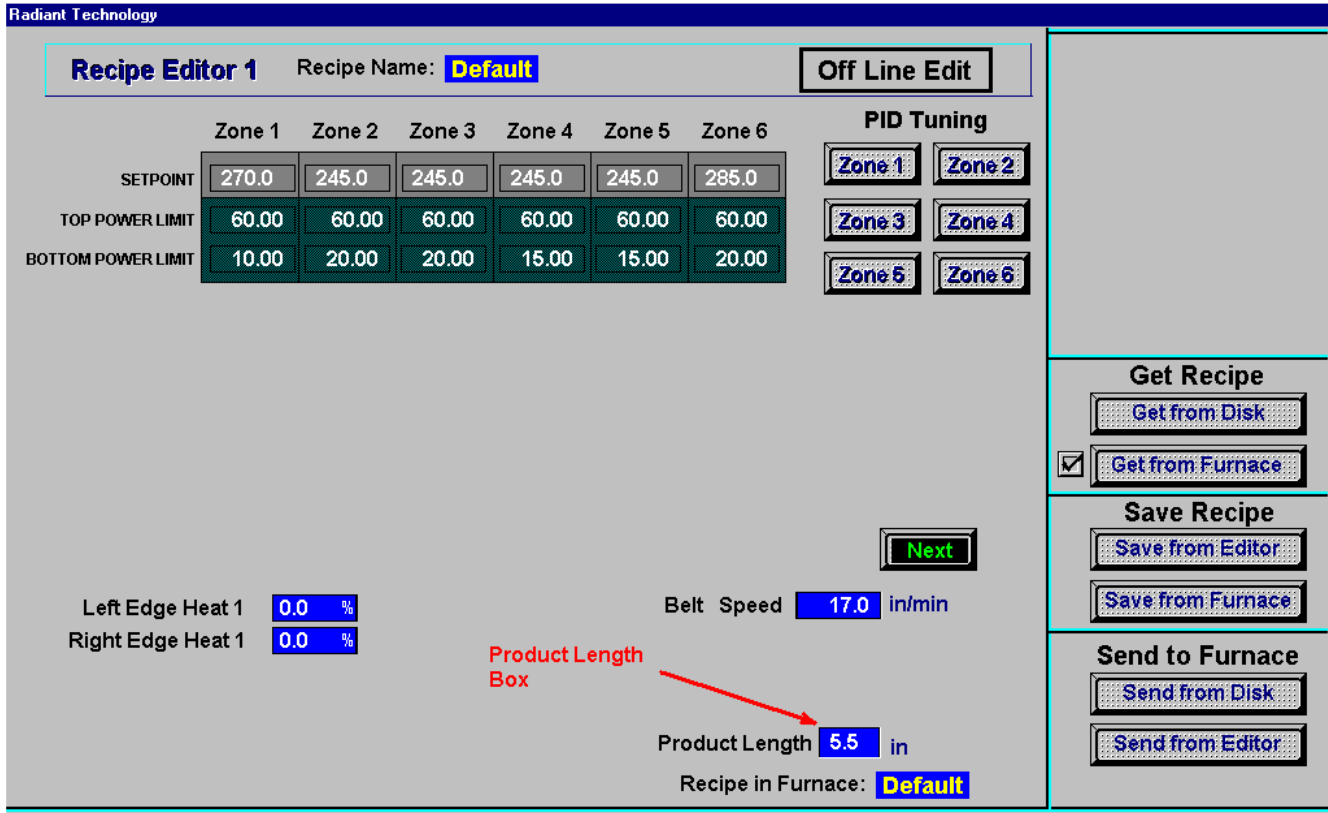
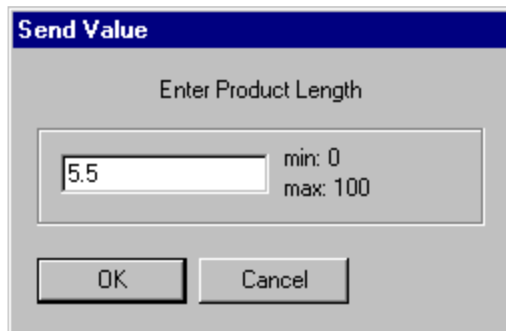


Figure 0.3 Send Value Window



To view the product tracking window, return to the recipe screen shown in Figure 0.1 and click the view button. Figure 0.4 shows the product tracking window labeled “Product”. Rectangular representations of the defined product-unit length will scroll this screen at the set belt speed. The number of units which have entered the furnace will appear in the “ENTR” column. The number of units processed through the furnace will appear in the “EXIT” column. The number of units still in process will appear in the “INSIDE” column. Click on the “Clear Product Counts” button to reset the count to zero.

Figure 0.4 Product Tracking Window showing the Clear Product Counts Button

Product

Ent Baffle	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Trans Tunnel	Cold Process	Exit Baffle	Cooling
------------	--------	--------	--------	--------	--------	--------	--------------	--------------	-------------	---------

View Product Tracking

Clear Product Counts Button

ENTR	INSIDE	EXIT
Lane 1 INACTIVE		
15	5	10
Lane 3 INACTIVE		

Clear Product Counts

DOCUMENTATION PACKAGE

DOCUMENTATION

- Channel Assignment Sheet
- Bill of Materials and Schematics Listing for Electrical/Electronics
- Bill of Materials for Mechanical
- Electrical Schematics
 - Power Control Schematic
 - Element Wiring Schematic
 - Signal Control Schematic
 - Frame Wiring Schematic
 - Options Schematics
- Drawings
 - Installation Drawing
 - Transport Drawing

Controller Installation

Follow Engineering Specifications 25, 28, 34, and 42 to set up the jumpers and switches for the bricks and the controller.

Connect the various cables between the bricks, the controller and the computer.

Turn the computer on. When the WIN 95 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.

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 radiant group in Windows. This will download the kernel (the Operation System for the controller) and the RTC 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 troubleshooting section.

Check the log in dialog box for the 3 proposed users: operator, tech and rtc.

Engineering Specifications

- 00025 Procedure for Jumpering Analog, I/O and Expansion Cards for OPTO 22
- 00028 SCR Power Control PCB Calibration, OPTO 22 Control System
- 00034 Calibration Procedure for Motor Speed Controller Board and Conveyor Belt (OPTO 22)
- 00042 Ethernet Installation and Troubleshooting



radiant technology corporation

ENGINEERING SPECIFICATION

ES NO: 00025

REVISIONS	A E.O. 4906					
7. APPROVAL	Don Adams					

PROCEDURE FOR JUMPERING ANALOG, I/O AND EXPANSION CARDS FOR OPTO 22

1.0 Scope

This document is intended to describe the procedure for jumpering an addressing all cards in the OPTO 22 control system.

2.0 The brain boards have 3 groups of jumpers which must be set for proper operation; addressing, baud, and loop back jumpers. (See figure 1 for jumper location on brain board.)

2.1 ADDRESSING: Every I/O or Analog card (brick) needs a unique address.

Card or Brick number	JP 1							
	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	X
2	0	0	0	0	0	0	X	0
3	0	0	0	0	0	0	X	X
4	0	0	0	0	0	X	0	0
5	0	0	0	0	0	X	0	X
6	0	0	0	0	0	X	X	0
7	0	0	0	0	0	X	X	X
8	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	X
10	0	0	0	0	X	0	X	0

X = JUMPER INSTALLED 0 = NO JUMPER INSTALLED

2.2 BAUD JUMPERS: All cards (bricks) must have the same baud rate setting, 115.2 K

	JP 2							
	7	6	5	4	3	2	1	0
	0	0	X	X	X	X	X	0

=115.2 K

2.3 LOOP BACK JUMPERS: Install loop back jumpers on last card (brick) only.

JP 3					
	7	6	5	4	3
	X	X	X	X	X

3.0 ANALOG CARD (BRICK) EXPANSION: Analog card (brick) which has an associated Expansion card (brick) must have the expansion cable attached to the brain card.

NOTE: No jumpers required. See figure 2 for expansion cable installation.

8. ORIGINATOR: ALEX REY	9. DATE: 7/29/96	PAGE
ISSUED: Lee Lablin	DATE:	1 OF 2

REVISIONS	A					
10. APPROVAL						

Local SERVO Control Brick Brain

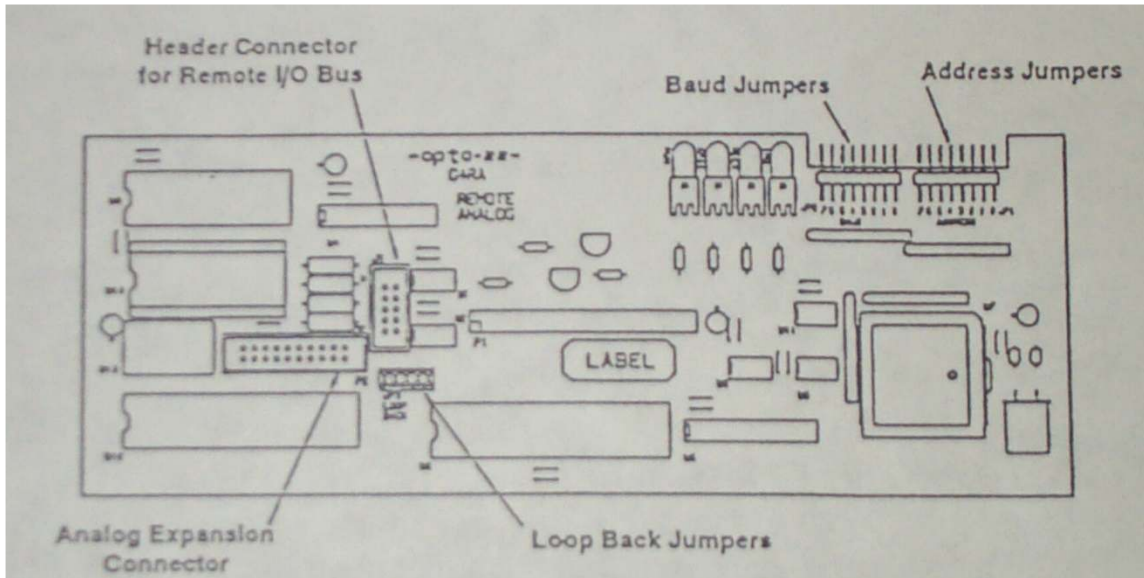


FIGURE 5

10.1. Expansion Board

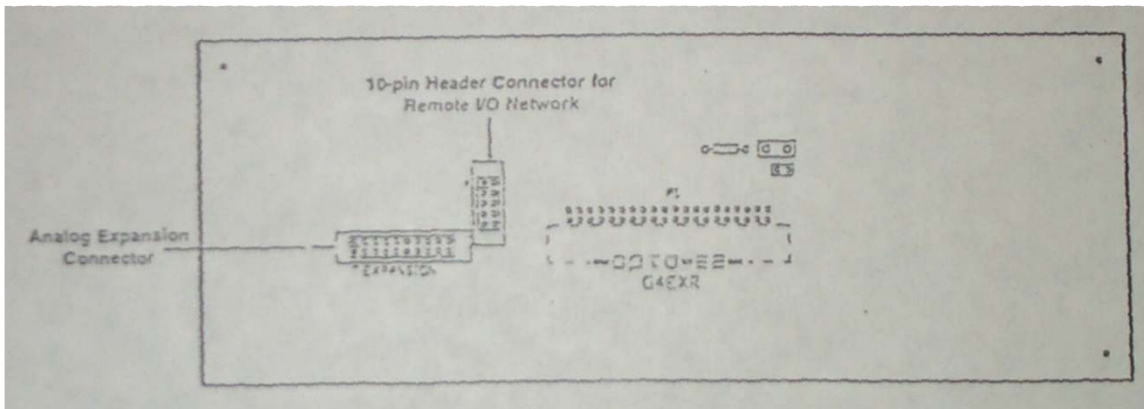


FIGURE 6

11. ORIGINATOR: ALEX REY	12. DATE: 7/29/96	PAGE
ISSUED:	DATE:	2 OF 2



radiant technology corporation

REVISIONS	12.1. A	12.2. J				
13.APPROVAL	09/16/96	05/26/99				

SCR POWER CONTROL PCB CALIBRATION, OPTO22 CONTROL SYSTEM

1. SCOPE

This procedure covers the zero crossing and span adjustment for 50Hz or 60Hz SCR power control PCB.

NOTE: This procedure should be performed every six months to ensure proper furnace operations.

3.1 Zero Crossing Adjustment

The zero potentiometer has both positive and negative voltages available. By turning the zero control clockwise the unit's output voltage will increase proportionately to the adjustment. Turning it counterclockwise will decrease it.

3.2 Span Adjustment

The span potentiometer is used to adjust the maximum output. It will adjust a command signal input. Clockwise adjustment increases the output while counterclockwise decreases the output.

2. TEST EQUIPMENT REQUIRED

2.1 You MUST use a true RMS Voltmeter.

2.2 Trimpot adjustment tool.

3. PROCEDURE

3.1 For windows 3.1 you must be in "Warm-Up" state.

For Windows 95 you must be in "Cool-Down" state.

3.2 Click on icon "MAINT"

3.3 Click on "CALIBRATE SCR"

3.4 Click on "START". Make sure the lamp power is on. (Indicator light must be green; if it is not you are not in a "Warm-Up" state.)

3.5 Go to the SCR power control PCB and adjust the zero potentiometer until the LED indicator is flashing. Turn to the lowest setting possible with the LED still flashing.

3.6 Click on "Stop"

3.7 Click on "Done"

14. ORIGINATOR: Alex Rey	15. DATE: September 16, 1996	PAGE
ISSUED:	DATE:	1 of 2

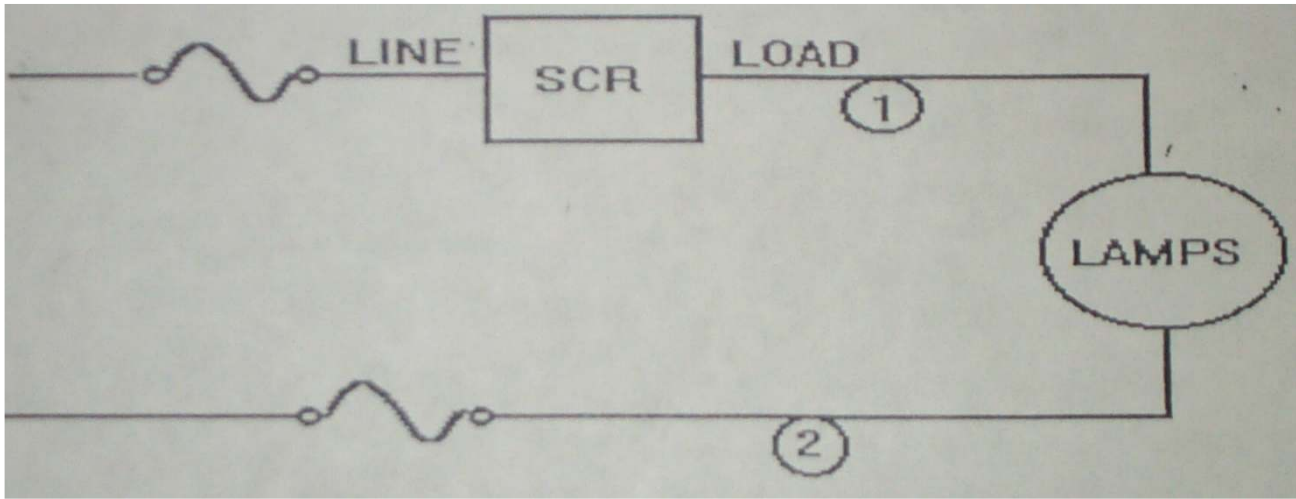
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16. APPROVAL							

3.8 Span: Set all zones and edge heats to 0% power.

3.9 Set the true RMS voltmeter to AC voltage and connect the leads across the load; the positive lead to load on SCR power control PCB (1) and the negative lead to either side of the return fuse (2). See Element Wiring Schematic for details.

EXAMPLE:



3.10 Set the applied power in the appropriate zone for 50% power and go to “Warm-Up” state. Adjust the span potentiometer to 50% of the line voltage using the following formula:

$$50\% = \frac{\text{INPUT VOLTAGE}}{\sqrt{2}}$$

NOTE: Due to some interaction between controls, it may be necessary to repeat adjustments 3.0 through 3.10

17. ORIGINATOR:	18. DATE:	PAGE
ISSUED:	DATE:	2 of 2

REVISIONS	18.1. B	18.2.				
19. APPROVAL	Alex Rey					

**CALIBRATION PROCEDURE FOR MOTOR SPEED
CONTROLLER BOARD AND CONVEYOR BELT (OPTO 22)**

1.0 SCOPE

This document is intended to describe the configuration of the motor control board and calibration procedure for the OPTO 22 controller system.

2.0 The motor speed controller board has a horsepower select switch on the main control board (see figure 1 for switch location on board). The proper DIP switch settings for various Bodine motor types can be set using the following procedure.

Determine the first four digits of the motor’s type from the motor nameplate. Find the same four digits in the following chart and set the switches accordingly.

MOTOR TYPE	DIP SWITCH LEVERS IN THE “ON” POSITION	MOTOR CONTROL BOARD	MOTOR FUSE (F2)
34B3	(1,2,3,) / (1,2,3,6,8)	ABL-3910C / 3911C	1-1/2 AMPS
34B4	(2,4) / (2,4,6,8)	ABL-3910C / 3911C	2 AMPS

2.1 The control output or “Motor Fuse” must be selected based on the size of the motor. Its rating can be determined by referring to the chart.

2.2 Direction switch: CLOSE = CW, OPEND = CCW (See figure 1 for switch location.)

2.3 The motor control board is designed to operate on a nominal 120 VAC, 50 or 60 Hz. If a 50 Hz source is

used, jumper J5 on the main control board must be cut. (See figure 1 for jumper location.)

3.0 PROCEDURE FOR BELT CALIBRATION

- a. Set the transport speed to half the maximum transport speed.
- b. Calculate the desired time for a part to travel through the furnace.
 $L = \text{total length of chamber} \mid S = \text{belt speed} \mid \text{Desired time} = L/S$
- c. Run a part through the furnace and time it from the entrance to the exit of the chamber. This is the actual time.
- d. Go to MAINT. SCREEN.
- e. Click SETUP ICON.
- f. Go to belt speed field and enter the actual time.
- g. Exit from SETUP window.

20. ORIGINATOR: Alex Rey	21. DATE: 03/08/00	PAGE
ISSUED:	DATE:	1 of 3

REVISIONS	21.1.	B	21.2.			
22. APPROVAL	Alex Rey					

Model 3911C

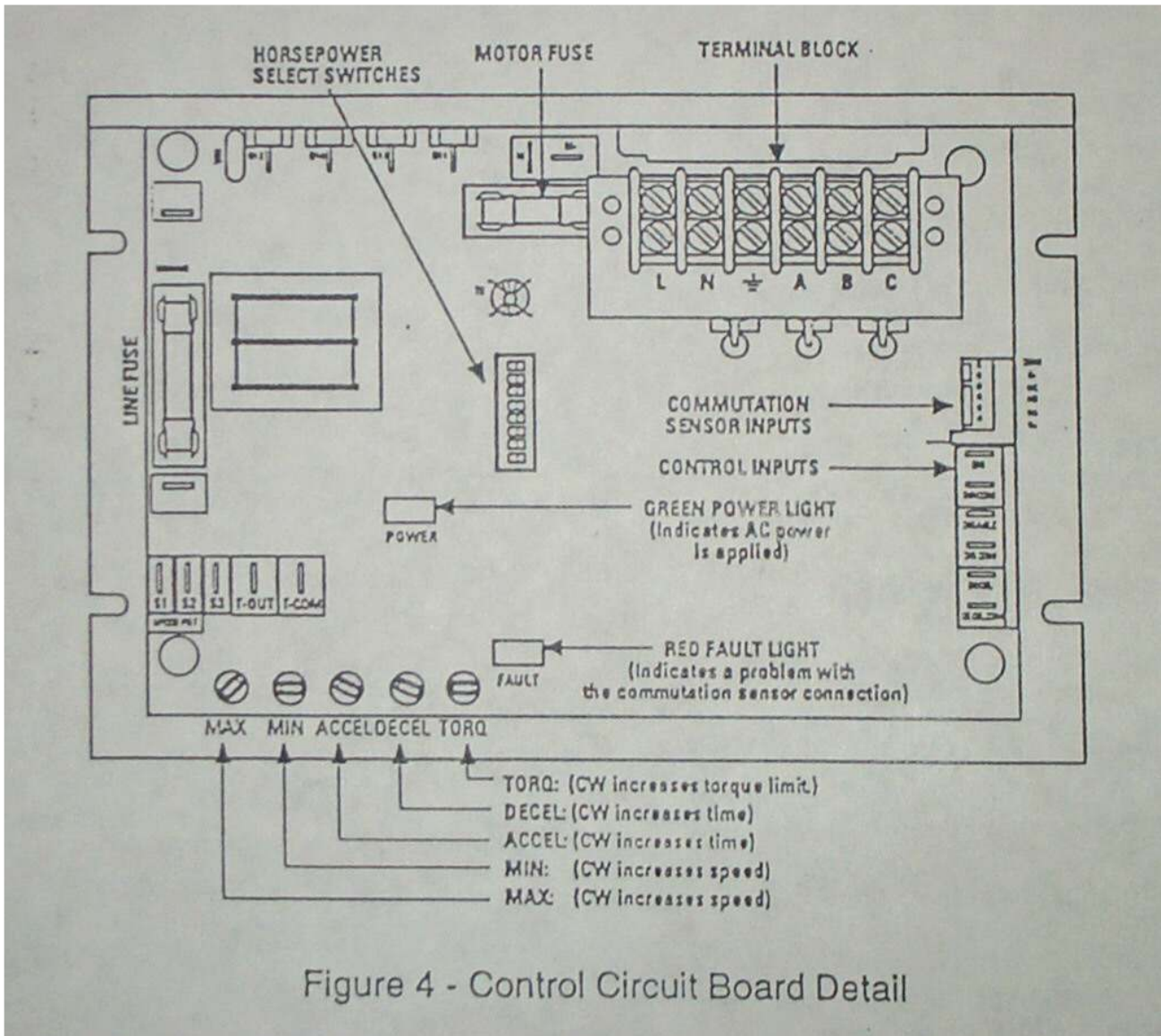


FIGURE 4 – CONTROL CIRCUIT BOARD DETAIL

23. ORIGINATOR:	24. DATE:	PAGE
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25. APPROVAL	Alex Rey					

CONTROL CIRCUIT BOARD DETAIL

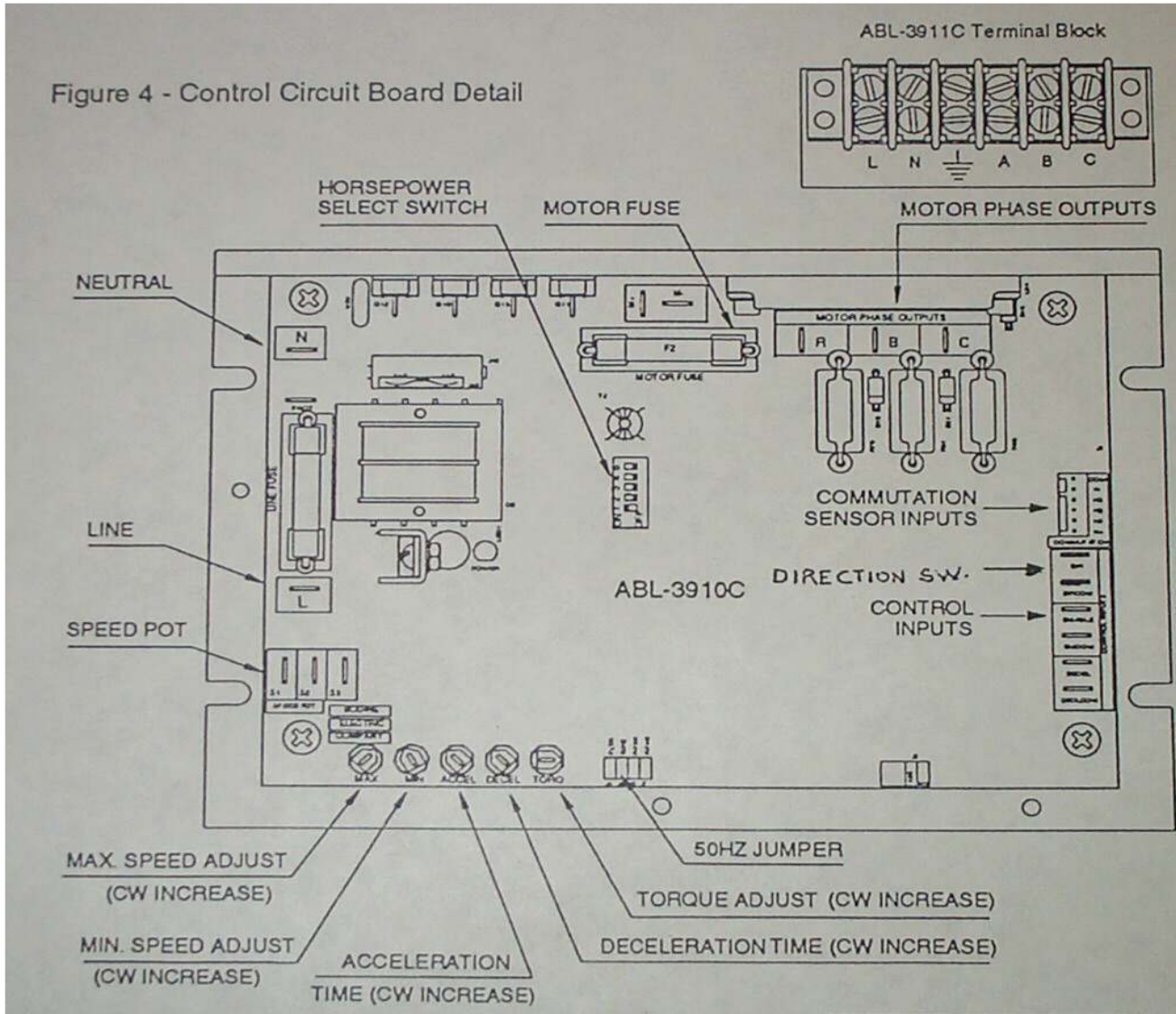


FIGURE 4 CONTROL CIRCUIT BOARD DETAIL

ISSUED:	DATE:	3 of 3

TOC

1. SETUP OF WINDOWS© PC ETHERNET INTERFACE 81

2. RESET AND ASSIGN AN IP ADDRESS TO THE LCM4 CONTROLLER’S ETHERNET CARD.
82

3. TROUBLESHOOTING WINDOWS© SETUP OF ETHERNET CONNECTION 84

4. VERIFY THAT THE EXTERNAL OPTO22 SNAP-LCM4 CONTROLLER’S JUMPERS ARE
CONFIGURED CORRECTLY 86

26.Setup of Windows© PC Ethernet Interface

26.1. Insert the Windows 98© CD into the drive.

26.2. Open Windows Control Panel <start/settings/control panel>

Double click on the “Network” Icon.

26.2.1. Select “Add” from the “Configuration” Dialog box.

26.2.2. Select “Client” from the “Select Network Component Type” Dialog box, then “ADD” from the “Select Network Client? Dialog box.

In the Data window, select “Microsoft/Client for Microsoft Networks”, then select the “OK” pushbutton.

26.2.3. Again, Select “Add” from the “Configuration” Dialog box.

26.2.4. Select “Protocol” from the “Select Network Component Type” Dialog box, then “ADD” from the “Select Network Client? Dialog box.

In the Data window, select “Microsoft/NetBEUI”, then select the “OK” pushbutton.

26.2.5. From the “Components installed Window” on the “Network” dialog box, Select the “TCP/IP->...Ether....> component.

26.2.6. Then on the TCP/IP “Properties” for “FastEtherLink ... Dialog Box, Select the “Specify an IP Address” Bullet

Enter the following IP Address: 10.192.105.100 and Subnet Mask as 255.255.255.0, then click “Ok”.

26.2.7. On the Re-boot system Dialog Box, Select NO.

26.2.8. On the “Network” Dialog box, select the “Identification” TAB.

26.2.8.1.Change the Computer Name: <FO #>

26.2.8.2.Change the Workgroup: Furnace

26.2.8.3.Change the Computer Description: <Furnace Model #>

Then Select “Ok”

26.2.8.4.On the Re-boot system Dialog Box, Select NO.

26.2.9. On the “Network” Dialog box, select the “File & Print Sharing” pushbutton.

26.2.9.1.Click the “I want to be able to give others access to my files” checkbox.

26.2.9.2.Enter the User Name as “<FO#>” then select “OK”

26.2.10.On the “System Settings Change”, Dialog box, select “Yes” to Reboot.

26.2.11. On Windows® desktop, Double Click the “My Computer” Icon, then Right Click The “C:” disk drive icon.

26.2.11.1. On the pull down menu, Select Sharing

26.2.11.2. On The “C: Properties/Sharing” Dialog box, Select the “Shared As” Bullet, then Select “Ok”.

Note: Leave all other item to their default setting (Name C, Read Only).

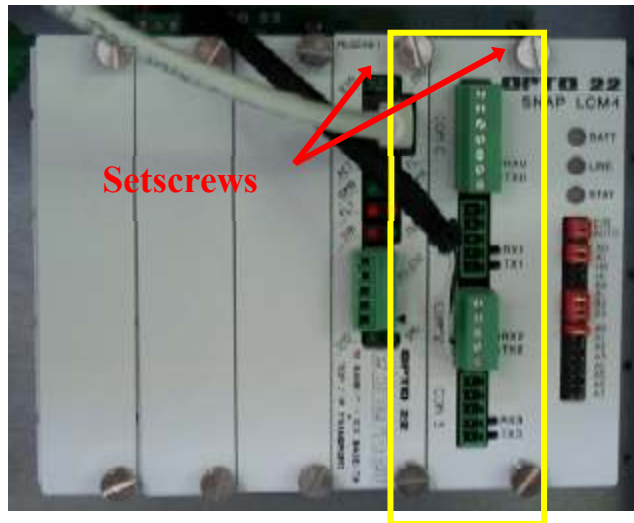
27. Reset and Assign an IP Address to the LCM4 Controller’s Ethernet Card.

27.1. Remove the M4Senet-100 Opto Ethernet card from the controller chassis.

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

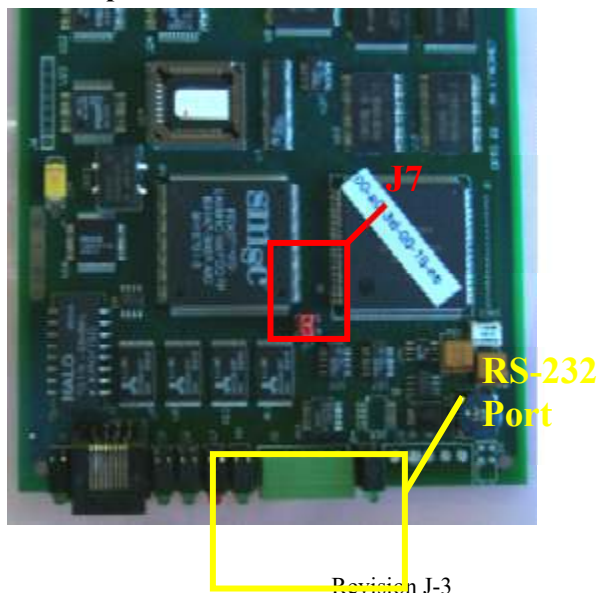
27.1.1. Remove Ethernet and RS-232 connectors

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



27.1.3. Remove Card from chassis.

27.2. Move the J7 Jumper to the Module Reset Position as shown in the following diagram



27.3. Reinstall the M4SENET-100 card into the Opto22 controller box.

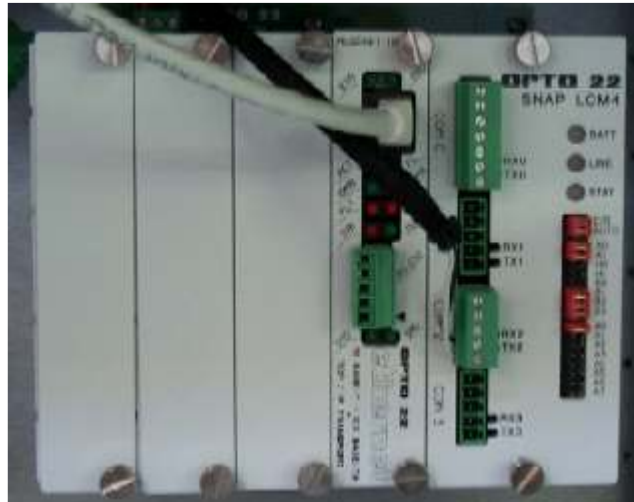
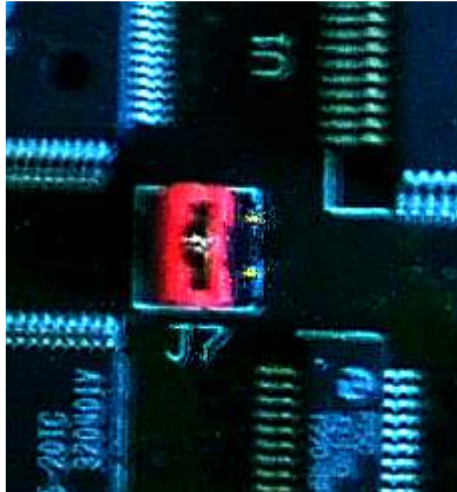
27.4. Apply power to the system.

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

27.4.1. Wait for the STD LED on the M4SENET Card to stop blinking, and then turn remove power from the system.

Note: This procedure resets the Opto22 Ethernet Card to its factory default settings.

27.5. After removing power from the system, again remove the M4SENET card and restore the J7 Jumper to its normal position as shown below



- 27.6. Reinstall the M4SENET-100 card into the Opto22 controller box making sure the covers and set screws are in place.
- 27.7. From the Windows© Toolbar, Select <Start/Programs/Opto22/OptoEnet-IO/OptoBootP Utility>
- 27.8. On the “Opto BootP” Dialog box, Click the “Listen” Pushbutton.
- 27.9. 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.
- 27.10. Double Click on the 0.0.0.0 field to assign an IP Address
- 27.11. 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.
- 27.12. Click on the “Send” pushbutton to assign the entered address.
- 27.13. The Data Window should now be updated to display a “Yes” under the “Sent” Column.
- 27.14. Click on “Exit” to leave the Opto BootP application.

28. Troubleshooting Windows© Setup of Ethernet Connection

- 28.1. Click on the “Start” button
- 28.2. Select the “Settings” menu
- 28.3. Select the “Control Panel” folder
- 28.4. Find, Select and Open the “Network” icon
- 28.5. Click on the “Configuration” tab
- 28.6. Check to see that the following appear under the listing for “The following network components are installed:”

(Note: as the actual Ethernet card installed in each furnace may vary, the actual text may reflect the specific model of Ethernet card actually installed. Below, the protocol is simply referenced as “... Ethernet ...”)

NetBEUI -> ... Ethernet ...

TCP/IP -> ... Ethernet ...

- 28.7.** Select and highlight the “TCP/IP -> ... Ethernet ...” protocol in the menu.
- 28.8.** Click the “Properties” button.
- 28.9.** Click on the “IP Address” tab
- 28.10.** Check to make sure the “Specify an IP address:” selector switch is marked.
- 28.11.** If not, select and set the following
 - IP Address: 10.192.105.100
 - Subnet Mask: 255.255.255.0
- 28.12.** Click the “OK” button

29. Verify that the external Opto22 SNAP-LCM4 controller's jumpers are configured correctly

Jumper the following

- | | |
|------|----|
| E/R | B1 |
| AUTO | B2 |
| XO | B3 |
| X1 | A0 |

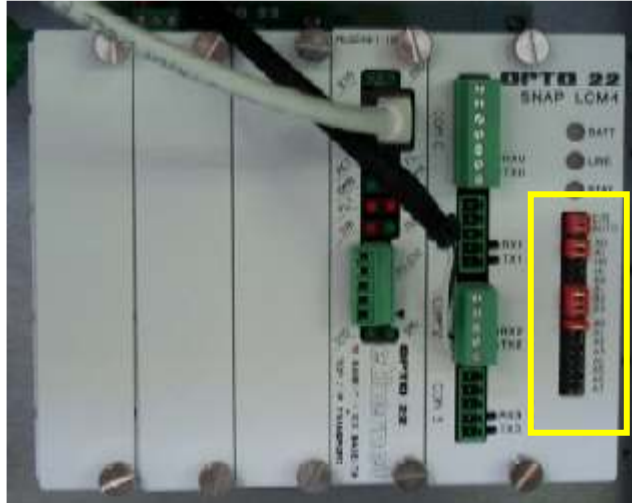


Figure 29-1 LCM4 External Jumpers

Material Safety Data Sheets

Kaowool

Mercury

MATERIAL SAFETY DATA SHEET

1. CHEMICAL PRODUCT

Trade Name:

Chemical Name: VITREOUS ALUMINOSILICATE FIBERS

Synonym(s): Ceramic fiber; refractory fiber; MMVF; refractory ceramic fiber; RCF
synthetic vitreous fiber (SVF), man-made vitreous fiber (MMVF)

Grade(a):

Manufacturer/Supplier:

CHEMTREC Assistance: 1-800-424-9300

Effective Date: 03/16/98 Supersedes- 09/18/97

2. COMPOSITION / INFORMATION ON INGREDIENTS

<u>COMPONENTS</u>	<u>CAS NUMBER</u>	<u>% BY WEIGHT</u>
Aluminosilicate fiber (vitreous)	142844-00-6	1100

(See Section 8 "Exposure Controls / Personal Protection" for exposure guidelines)

3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW

WARNING! POSSIBLE CANCER HAZARD BY INHALATION. MAY CAUSE SKIN, EYE, AND RESPIRATORY TRACT IRRITATION. MAY BE HARMFUL IF INHALED. HAZARD DEPENDS ON DURATION AND LEVEL OF EXPOSURE. WHITE ODORLESS FIBROUS BLANKET.

HAZARD RATINGS

HAZARDOUS MATERIALS INFORMATION SYSTEM (HMIS) RATINGS:

Health: 1* Flammability: 0 Reactivity: 0 Personal Protection Index: X

POTENTIAL HEALTH EFFECTS

TARGET ORGANS: Skin, eyes, and lungs.

INHALATION: If inhaled in sufficient quantity, may cause respiratory tract irritation. Symptoms may include scratchiness of the nose or throat, cough or chest discomfort,

EYE CONTACT: Slightly to moderately irritating. Fibers may be abrasive; prolonged contact may cause damage to the outer surface of the eye.

SKIN CONTACT: Slightly to moderately irritating. Exposure may result in irritation, inflammation, rash or itching.

INGESTION: If ingested in sufficient quantity, may cause gastrointestinal disturbances. Symptoms may include nausea, vomiting, or abdominal pain.

CHRONIC EFFECTS: Studies to date, involving occupationally exposed workers, have not identified any increased incidence of respiratory disease. Long-term, high-dose exposure to specially-sized, rodent respirable fiber has resulted in the development of fibrosis, lung cancer and mesothelioma in rats & hamsters. See Sections 11 & 16 of this MSOS for more information.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE:

Pre-existing medical conditions, including dermatitis, asthma or chronic lung disease may be aggravated by exposure; individuals who are atopic (with a history of allergies) may experience greater amounts of skin and respiratory irritation.

HAZARD CLASSIFICATION: Although studies, involving occupationally exposed workers, have not identified any increased incidence of respiratory disease, results from animal testing have been used as the basis for hazard classification:

The Seventh Annual Report on Carcinogens (1994), prepared by the National Toxicology Program (NTP), classified respirable RCF and glass wool as substances reasonably anticipated to be carcinogens.

The International Agency for Research on Cancer (IARC) has classified ceramic fiber, fibrous glass wool and mineral wool (rock wool & slag wool) as possible human carcinogens (Group 2b) based on sufficient evidence of carcinogenicity in animals, but insufficient data in humans.

The State of California, pursuant to Proposition 65, The Safe Drinking Water and Toxic Enforcement Act of 1988, has listed "ceramic fibers (airborne fibers of respirable size)" as a material known to the State of California to cause cancer.

The Commission of The European Communities (DG XI) has classified RCF as substances which should be regarded as if they are carcinogenic to man.

IARC has also classified respirable Crystalline silica, a possible byproduct of RCF devitrification following sustained, high-temperature (> 1 800°F) use, as a substance known to be carcinogenic to humans (Group 1).

4. FIRST AID MEASURES

FIRST AID PROCEDURES

INHALATION:

If respiratory tract irritation occurs, relocate individual to a dust free environment. Get medical attention if irritation persists. See Section 8 for additional measures to reduce or eliminate exposure.

EYE CONTACT:

If eyes become irritated, flush immediately with large amounts of lukewarm water for at least 15 minutes. Eyelids should be held away from the eyeball to ensure thorough rinsing. Do not rub eyes. Get medical attention if irritation persists.

SKIN CONTACT:

If skin becomes irritated, remove contaminated clothing. Do not rub or scratch exposed skin. Wash area of contact thoroughly with soap and water. Using a skin cream or lotion after washing may be helpful.

INGESTION: If gastrointestinal irritation occurs, relocate individual to a dust free environment. Seek medical attention if symptoms persist.

NOTES TO PHYSICIANS: Skin and respiratory effects are the result of mechanical irritation; fiber exposure does not result in allergic manifestations.

5. FIRE FIGHTING MEASURES

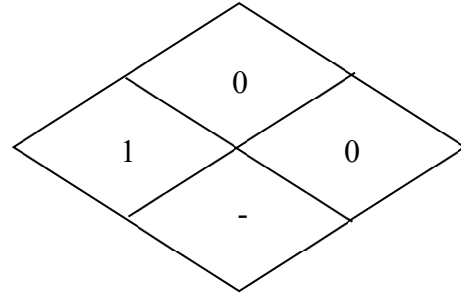
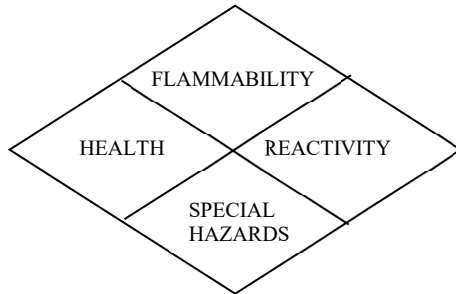
4 -- EXTREME

3 -- HIGH

2 -- MODERATE

1 -- SLIGHT

0 -- INSIGNIFICANT



NFPA Unusual Hazards: None

Flammable Properties:
Flash point: None
Method: N. App

Flammable Limits:
Lower Flammable Limit: N. App.
Upper Flammable Limit: N. App.

Autoignition Temperature: None

Hazardous Decomposition Products: None

Extinguishing Media: Use extinguishing media suitable for type of surrounding fire.

Unusual Fire and Explosion Hazard: None

6. ACCIDENTAL RELEASE MEASURES

SPILL PROCEDURES

Use vacuum suction with HEPA filters to clean up spilled material. Use wet sweeping or a dust suppressant where sweeping is necessary.

7. HANDLING AND STORAGE

HANDLING AND STORAGE

Handle ceramic fiber with caution. Minimize airborne dusts by avoiding the unnecessary disturbance of materials.

Prolonged exposure to high temperatures generally increases the relative friability of Aluminosilicate fibers. Removal and clean up of after service product may result in exposure to a mixture of crystalline phase silica and vitreous Aluminosilicate fiber (See Section 16 for more details).

Depending on product use, other contaminants may also be present. During removal, the exposed material should be frequently misted with water to minimize airborne dust. A surfactant may be added to the water to improve the wetting process. Use only enough water to wet the insulation. Do not allow water to accumulate on floors.

Clean Up

Dust suppressing cleaning methods such as wet sweeping or vacuuming should be used to clean the work area. If vacuuming is used, the vacuum must be equipped with a HEPA filter. Compressed air or dry sweeping should not be used for cleaning. Dust suppressing compounds may be used to clean up light dust.

EMPTY CONTAINERS: Product packaging may contain residue. Do not reuse.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

EXPOSURE GUIDELINES

<u>Components</u>	<u>OSHA (PEL)</u>	<u>ACGIH (TLV)</u>	<u>SUPPLIER</u>
Aluminosilicate fiber (vitreous) 8-hr		None Established	None Established 0.6 fiberize TWA (RCFC)*

* Pending the results of long-term health effects studies, airborne exposures should be controlled at or below the Refractory Ceramic Fiber Coalition (RCFC) Recommended Exposure Guidelines listed above.

ENGINEERING CONTROLS

Dust suppressing control technologies - such as local exhaust ventilation, point of generation dust collection, down draft work stations, emission controlling tool designs, and materials handling equipment are effective means of minimizing airborne fiber emissions.

PERSONAL PROTECTION EQUIPMENT

Respiratory Protection:
Aluminosilicate Fiber

When engineering and/or administrative controls are insufficient, the use of appropriate respiratory protection, pursuant to the requirements of OSHA 1910.134 AND 29 CFR 1926.103, is recommended. The following information is provided as an example of appropriate respiratory protection for Aluminosilicate fibers. The evaluation of workplace hazards and the identification of appropriate respiratory protection are best performed, on a case by case basis, by a qualified Industrial Hygienist.

OSHA HAS NOT ESTABLISHED A SPECIFIC PERMISSABLE EXPOSURE LIMIT (PEL) FOR RCF.

SUPPLIERS' RESPIRATORY PROTECTION RECOMMENDATIONS (WHEN HANDLING RCF PRODUCTS)	
Respirable Airborne Fiber Concentration	Respirator Recommendation
Less than 0.5 f/cc	No specific recommendation. User preference based upon conditions present.
0.5 f/cc to 5.0 f/cc	Half-face, air-purifying respirator equipped with a high-efficiency particulate air (HEPA) filter cartridge.
5.0 f/cc to 25 f/cc	Full-face, air-purifying respirator equipped with a high-efficiency particulate air (HEPA) filter cartridge.
More than 25 f/cc	Full-face piece, positive pressure supplied air respirator.

OTHER INFORMATION:

- (1) Concentrations based upon an eight-hour time weighted average (TWA) as determined by air samples collected and analyzed pursuant to NIOSH method 7400 (B) for airborne fibers.
- (2) During fumace tear-out activities/after service RCF removals, the manufacturer recommends, at a minimum, the use of full-face piece air purifying respirator equipped with a high-efficiency particulate air (HEPA) filter cartridge to control fiber and potential crystalline silica exposure.
- (3) In the absence of other objective data or when concentrations are unknown, the manufacturer recommends the use of half-face, air purifying respirator equipped with a high-efficiency particulate air (HEPA) filter cartridge.
- (4) Situations involving a potential exposure to airborne contaminants should be evaluated by a qualified industrial hygienist for the selection of appropriate respiratory protection and air monitoring.
- (5) The American Conference of Governmental Industrial Hygienists (ACGIH) has not adopted a threshold limit value (TLV) recommendation for RCF.

SKIN PROTECTION: Wear gloves, head coverings and full body clothing as necessary to prevent skin irritation. Washable or disposable clothing may be used. If possible, do not take unwashed clothing home. Work clothes should be washed separately from other clothing and the washing machine rinsed thoroughly following use. Inform the launderer of the proper procedures. Store work clothes and street clothes separately to prevent contamination.

EYE PROTECTION: Wear safety glasses or chemical goggles to prevent eye contact. Do not wear contact lenses unless chemical goggles are also worn. Do not touch eyes with contaminated body parts or materials. Have eye washing facilities readily available where eye contact can occur.

See Section 16 regarding handling considerations for after service Aluminosilicate fiber.

9. PHYSICAL AND CHEMICAL PROPERTIES

Odor and Appearance: White, odorless fibrous blanket.
Chemical Family: Vitreous Aluminosilicate fibers

Boiling Point:	N. App.	% Solubility in Water	N. App.
Melting Point:	1760°C (3200°F)	Specific Gravity:	2.73
Vapor Pressure:	N. App.	pH:	N. App.
Vapor Density (Air=1):	N. App.	% Volatile:	N. App.
Molecular Weight:	N. App.	Molecular Formula:	Al ₂ O ₃ .1.6 SiO ₂

10. STABILITY AND REACTIVITY

CHEMICAL STABILITY: Stable under conditions of normal use.

INCOMPATIBILITY: Soluble in hydrofluoric acid, phosphoric acid, and concentrated alkali.

CONDITIONS TO AVOID: None.

HAZARDOUS DECOMPOSITION PRODUCTS: None.

HAZARDOUS POLYMERIZATION: Not Applicable.

11. TOXICOLOGICAL INFORMATION

The existing toxicology and epidemiology data bases for RCF's are based on ongoing studies. The following is a summary of the results to date:

EPIDEMIOLOGY

An epidemiologic investigation, being conducted by the University of Cincinnati, of RCF production workers in the U.S. is ongoing. The evidence obtained from employees in U.S. RCF manufacturing facilities, is as follows:

- 1) There is no evidence of any fibrotic lung disease (interstitial fibrosis) on x-ray.
- 2) There is no evidence of an elevated incidence of lung disease among RCF manufacturing employees who were exposed to RCF.
- 3) In the exposed population, a statistical "trend", comparing initial test results (circa 1987) to predicted norms as based on breathing tests, was observed between the duration of exposure to RCF and a decrease in some measures of pulmonary function. The observations are considered to be statistically significant, but clinically insignificant. In other words, if these observations were made on an individual employee, the results would be interpreted as being within the normal (predicted) respiratory range. A more recent longitudinal study of employees with 5 or more pulmonary function tests found that there was no further effect on lung function associated with RCF production experience.
- 4) Initial data (circa 1987) indicated that the decrease in pulmonary function appears to be greater in employees who smoke. RCF exposure and smoking behavior seem to demonstrate an interactive effect; in other words, RCF-exposed smokers seemed to show a greater decrease in respiratory function than would be produced by combining the average decrease observed from RCF-exposure only and smoking behavior only. More recent data and analysis have found that the smoking/production interactive effect is no longer observable. Nonetheless, to promote good health practices, employees are still actively encouraged not to smoke.
- 5) Pleural plaques, which are discrete areas of pleural thickening usually on the parietal pleura or diaphragm, have been observed in a small number of RCF employees. There appears to be a dose-response relationship between the occurrence of pleural plaques on chest radiographs and the following variables: a) years since RCF production hire date; b) duration of RCF production employment; and c) cumulative RCF exposure. The best evidence to date indicates that pleural plaques are a marker of exposure only. There is virtually no evidence to suggest that pleural plaques are a precursor mechanism of respiratory conditions such as interstitial fibrosis, lung cancer, or mesothelioma. Under most circumstances, pleural plaques are not associated with pulmonary impairment. The pathogenesis of pleural plaques remains incompletely understood; however, the mechanism appears to be an inflammatory response caused by inhaled fibers transported via lymphatics to the sub-pleural area.

TOXICOLOGY

Man-made vitreous fiber (MMVF) based products, including RCF, contain fibers of different sizes, some of which are small enough to be respirable by humans. Scientists have been conducting research since the 1950's to determine the potential risks for adverse health effects which may result from fiber inhalation.

In 1987 the International Agency for Research on Cancer (IARC) classified man-made vitreous fibers including glass wool, rock wool, slag wool, and RCF as possible human carcinogens (2B). More recently, the U.S. Department of Health and Human Services classified the respirable fibers of glass wool and RCF as "substances which may reasonably be anticipated to be carcinogens" (National Toxicology Program, 7th Annual Report on Carcinogens, 1994).

To date, a number of toxicological studies have been conducted which utilize non-physiological exposure methods such as intra-pleural, intraperitoneal and intra-tracheal implantation or injection. Some of these studies concluded that RCF is a potential carcinogen. Some experts, however, suggest that these tests have limited relevance because they bypass many of the biological mechanisms which prevent fiber deposition or facilitate fiber clearance.

Other toxicological studies utilizing a physiological exposure method, inhalation, have produced findings of respiratory disease in rodents. The most recent RCF-inhalation studies were conducted at the Research and Consulting Company, Geneva, Switzerland. Rats and hamsters were exposed, using a nose-only inhalation system, to the "maximum tolerated dose" of 30 mg/m³ (about 200 fibers/cc) of specially-prepared RCF for 6 hours/day, 5 days/week, for up to 24 months. In another research effort, other rats were exposed, in a multi-dose study with a similar protocol, to doses of 3 mg/m³, 9 mg/m³, and 16 mg/m³, which corresponds to about 25, 76, and 115 fibers/cc.

No acute respiratory effects were seen in the rats in the 3 mg/m³ exposure group. Some cases of mild parenchymal fibrosis and one mesothelioma were observed in the 9 mg/m³ group. Some cases of pleural and parenchymal fibrosis were seen in the 16 mg/m³ and in the 30 mg/m³ exposure group. In addition to a statistically significant increase in lung tumors, two mesotheliomas were also observed in the 30 mg/m³ group. Hamsters, exposed to only the highest dose, did not develop lung tumors. However, a moderate amount of interstitial fibrosis was seen, as well as a 42% incidence rate of mesothelial tumors.

These studies have found RCF to be a rodent carcinogen, under the conditions of lifetime exposure at high doses. These studies suggest that there may be a dose/response threshold, below which irreversible respiratory impacts do not occur.

12. ECOLOGICAL INFORMATION

Ecotoxicological Information: No data available.

Distribution: No data available.

Chemical Fate Information: No data available.

13. DISPOSAL CONSIDERATIONS

DISPOSAL: Aluminosilicate fiber is not classified as a hazardous waste according to Federal regulations (40 CFR 261). Check local, regional, state or provincial regulations for applicable requirements for disposal. Any processing, use, alteration or chemical additions to the product, as purchased, may alter the disposal requirements. Under Federal regulations, it is the waste generator's responsibility to properly characterize a waste material, to determine if it is a "hazardous" waste.

EMPTY CONTAINERS: Product packaging may contain product residue. Do not reuse.

14. TRANSPORT INFORMATION

U.S. DEPARTMENT OF TRANSPORTATION (DOT)

BILL OF LADING DESCRIPTION(49 CFR 172.202): NON-REGULATED

UNITED NATIONS (UN) NUMBER: NOT APPLICABLE

NORTH AMERICA (NA) NUMBER: NOT APPLICABLE

15. REGULATORY INFORMATION

Key statutory and regulatory classifications or listings for the product, as manufactured, which may impact product storage, use, handling or disposal:

U.S. FEDERAL REGULATIONS

Comprehensive Environmental Response
Compensation and Liability Act of 1990 (CERCLA):

Constituents regulated as hazardous substances under the Comprehensive Environmental Response
Compensation and Liability Act (CERCLA 40 CFR 302):

<u>Constituent</u>	<u>RQ in Pounds</u>
NONE	

Most RCF products, including this product, are composed of RCF with an average diameter greater than 1 micron, and therefore are not considered CERCLA hazardous substances. See 60 FR 30934 (June 12, 1995).

Clean Air Act (CAA):

Substances regulated as hazardous air pollutants under Section 112 of the Clean Air Act
Amendments of
1990:

Chemical Name

NONE

Most RCF products, including this product, are composed of RCF with an average diameter greater than 1 micron, and therefore are not considered hazardous air pollutants. See 60 FR 30934 (June 12, 1995).

Toxic Substances Control Act (TSCA):

All substances in this product are listed, as required, on the TSCA inventory. Refractory ceramic fiber has been assigned a CAS number; however, it is a simple mixture and therefore not required to be listed on the TSCA inventory. The components of RCF are listed on the inventory.

This product contains refractory ceramic fiber and is subject to an EPA TSCA Section 5(e) Consent Order and may be subject to TSCA Section 12(b) Export Notification requirements. Monitoring of airborne workplace fiber concentrations is being conducted under the consent order.

Superfund Amendments and Reauthorization Act (SARA) Title III Information:

SARA Hazard Category:

Listed below are the hazard categories for the Superfund Amendments and Reauthorization Act (SARA)

Section 311/312 (40 CFR 370):

Immediate Hazard: - Fire Hazard: - Reactivity Hazard: -
Delayed Hazard: X Pressure Hazard: -

SARA 311/312 Information:

Toxic chemical(s) subject to the annual reporting requirements of the Superfund Amendments and Reauthorization Act (SARA) Section 313 (40 CFR 372):

<u>Chemical Name</u>	<u>CAS Number</u>	<u>Concentration</u>
NONE		

EPA has proposed to place man-made mineral fibers, including PCF, on the list of substances subject to the annual TRI reporting requirements, but a final listing decision has been deferred indefinitely. See 69 FR 61439 (November 30, 1994).

SARA 302/311/312 Information:

Extremely hazardous substances subject to the notification and inventory reporting requirements of the Superfund Amendments and Reauthorization Act (SARA) Section 302 (40 CFR 355) and Section 311/312 (40 CFR 370) respectively:

<u>Chemical Name</u>	<u>CAS Number</u>	<u>Concentration</u>
NONE		

STATE REGULATIONS

California:

Substance(s) listed by the State of California on Proposition 65, the Safe Drinking Water and Toxic Enforcement Act of 1986:

<u>Chemical Name</u>	<u>CAS Number</u>
Ceramic fibers (airborne particles of respirable size)	142844-00-6

New Jersey:

Chemical(s) which are listed as a special health hazard substance as defined in New Jersey Worker and Community Right to Know Act, New Jersey Administrative Code, Title 8, Department of Health, Chapter 59, Subchapter 10.

<u>Chemical Name.</u>	<u>CAS Number</u>
NONE	

Pennsylvania:

Chemical(s) which are listed as a special health hazard substance as defined in Pennsylvania Right-to-Know Law, Section 3800:

<u>Chemical Name</u>	<u>CAS Number</u>
NONE	

INTERNATIONAL REGULATIONS

Canadian Workplace Hazardous Materials Information System (WHMIS):

The following Canadian Workplace Hazardous Materials Information System (WHMIS) categories apply to this product:

Compressed Gas: - Flammable/Combustible: - Oxidizer: - Acutely Toxic: -
Other Toxic Effects: X Biohazardous: - Corrosive: - Dangerously Reactive: -

Canadian Environmental Protection Act (CEPA):

All substances in this product are listed, as required, on the Domestic Substances List (DSL).

Chemical(s) which are listed on the Non-Domestic Substances List:

<u>Chemical Name.</u>	<u>CAS Number</u>
NONE	

16. OTHER INFORMATION

After Service RCF: Removal

As manufactured, RCF products are vitreous Aluminosilicates which do not contain respirable crystalline silica. However, following sustained, high temperature (> 1800°F) use, it is possible for portions of the exposed RCF to devitrify into mullite or crystalline phase silica (cristobalite or quartz). Chronic exposure to respirable crystalline silica may lead to lung disease. IARC has concluded that: “Crystalline silica inhaled in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (Group 1). [IARC Monograph 68, June 1997, p. 210-211]. The Occupational Safety and Health Administration (OSHA) has adopted a permissible exposure limit (PEL) for respirable cristobalite at 0.05 mg/m³. When needed, the use of proper exposure controls and respiratory protection is recommended to reduce potential health risks and to ensure compliance with OSHA requirements. The evaluation of workplace hazards and the identification of appropriate respiratory protection is best performed, on a case by case basis, by a qualified Industrial Hygienist.

Definitions:

ACGIH:	American Conference of Governmental Industrial Hygienists
CAS:	Chemical Abstracts Service
EPA:	Environmental Protection Agency
f/cc:	Fibers per cubic centimeter
HEPA:	High Efficiency Particulate Air
HMIS:	Hazardous Materials Information System
mg/m ³ :	Milligrams per cubic meter of air
NFPA:	National Fire Protection Association
NIOSH:	National Institute for Occupational Safety and Health
OSHA:	Occupational Safety and Health Administration
29 CFR 1910.134 & 1926.103:	OSHA Respiratory Protection Standard
29 CFR 1910.1200 & 1926.69:	OSHA Hazard Communication Standard
PEL:	Permissible Exposure Limit
FCRA:	Resource Conservation and Recovery Act
SARA:	Superfund Amendments and Reauthorization Act
Title III:	Emergency Planning and Community Right to Know Act
Section 302:	Extremely Hazardous Substances
Section 304:	Emergency Release
Section 311:	MSDS/List of Chemicals and Hazardous Inventory
Section 312:	Emergency and Hazardous Inventory
Section 313:	Toxic Chemicals and Release Reporting
SVF:	Synthetic Vitreous Fiber
TLV:	Threshold Limit Value (ACGIH)
TSCA:	Toxic Substances Control Act

DISCLAIMER

The information presented herein is based on data considered to be accurate as of the data of preparation of this Material Safety Data Sheet. However, no warranty or representations express or implied, is made as to the accuracy or completeness of the foregoing data and safety information. In addition, no responsibility can be assumed by vendor for any damage or injury resulting from abnormal use, from any failure to adhere to recommended practices, or from any hazards inherent in the nature of the product.

CITY CHEMICAL -- MERCURY - MERCURY,ACS

MATERIAL SAFETY DATA SHEET

NSN: 6810002817453

Manufacturer's CAGE: 8G980

Part No. Indicator: A

Part Number/Trade Name: MERCURY

General Information

Item Name: MERCURY,ACS
Company's Name: CITY CHEMICAL CO
Company's Street: 100 HOBOKEN AVE
Company's City: JERSEY CITY
Company's State: NJ
Company's Country: US
Company's Zip Code: 07310
Company's Emerg Ph #: 201-653-6900/800-424-9300 (CHEMTREC)
Company's Info Ph #: 201-653-6900
Distributor/Vendor # 1: CITY CHEMICAL CORPORATION (201-653-6900)
Distributor/Vendor # 1 Cage: 83628
Record No. For Safety Entry: 007
Tot Safety Entries This Stk#: 007
Status: SE
Date MSDS Prepared: 24APR95
Safety Data Review Date: 02AUG95
Supply Item Manager: CX
MSDS Preparer's Name: UNKNOWN
MSDS Serial Number: BXGYF
Specification Number: O-C-265C
Spec Type, Grade, Class: NONE
Hazard Characteristic Code: C2
Unit Of Issue: BT
Unit Of Issue Container Qty: 500 G
Type Of Container: GLASS BOTTLE
Net Unit Weight: 1.1 LB
NRC/State License Number: NOT RELEVANT

Ingredients/Identity Information

Proprietary: NO
Ingredient: MERCURY (SARA 313) (CERCLA)
Ingredient Sequence Number: 01
Percent: UNKNOWN
NIOSH (RTECS) Number: OV4550000
CAS Number: 7439-97-6
OSHA PEL: C, 0.1 MG/M3; Z-2
ACGIH TLV: S,0.025 MG/M3; A4;95
Other Recommended Limit: NONE RECOMMENDED

Physical/Chemical Characteristics

Appearance And Odor: SILVERY-METALLIC HEAVY, MOBILE LIQUID - ODORLESS.

Boiling Point: 674F,357C
Melting Point: -38F,-39C
Vapor Pressure (MM Hg/70 F): <0.01 @68F
Vapor Density (Air=1): 7
Specific Gravity: 13.534
Evaporation Rate And Ref: NOT RELEVANT
Solubility In Water: INSOLUBLE
Viscosity: UNKNOWN
Corrosion Rate (IPY): UNKNOWN

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Fire and Explosion Hazard Data
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Flash Point: NON-FLAMMABLE
Extinguishing Media: USE SUITABLE MEDIA FOR SURROUNDING FIRES. COOL FIRE EXPOSED CONTAINERS WITH WATER SPRAY. MOVE CONTAINERS OUT IF POSSIBLE
Special Fire Fighting Proc: WEAR FULL PROTECTIVE CLOTHING AND NIOSH-APPROVED SELF-CONTAINED BREATHING APPARATUS OPERATED IN THE POSITIVE PRESSURE MODE IF METAL IS EXPOSED TO FIRE.
Unusual Fire And Expl Hazrds: EMITS TOXIC FUMES OF MERCURY.

=====
Reactivity Data
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Stability: YES
Cond To Avoid (Stability): EXCESSIVE HEAT
Materials To Avoid: STRONG ACIDS, ALKALI METALS, ALUMINUM, STRONG OXIDIZING AGENTS, HALOGENS, ACETYLENE, AMMONIA, METHYL AZIDE, CHLORATES
Hazardous Decomp Products: MERCURY VAPORS
Hazardous Poly Occur: NO
Conditions To Avoid (Poly): NOT RELEVANT

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Health Hazard Data
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LD50-LC50 Mixture: TLV FOR MERCURY IS 0.05 MG/M3 (S).
Route Of Entry - Inhalation: YES
Route Of Entry - Skin: YES
Route Of Entry - Ingestion: YES
Health Haz Acute And Chronic: TARGET ORGANS:SKIN, LIVER, KIDNEYS. ACUTE-HIGHLY TOXIC. READILY ABSORBED THROUGH SKIN. MAY BE FATAL IF INHALED, SWALLOWED OR ABSORBED THROUGH SKIN. VAPORS/MISTS ARE IRRITATING TO EYES, MUCOUS MEMBRANES. MAY CAUSE ALLERGIC SKIN REACTION. MAY CAUSE NERVOUS SYSTEM DISTURBANCES. CHRONIC- KIDNEY & LIVER DAMAGE, CNS EFFECTS
Carcinogenicity - NTP: NO
Carcinogenicity - IARC: NO
Carcinogenicity - OSHA: NO
Explanation Carcinogenicity: NONE
Signs/Symptoms Of Overexp: COUGHING, CHEST PAIN, HEADACHE, NAUSEA, VOMITING, DIARRHEA, PULMONARY EDEMA, IRRITATION, CORROSION OF MOUTH, THROAT AND STOMACH, GASTROINTESTINAL PAIN, WEAKNESS
Med Cond Aggravated By Exp: KIDNEY DISORDERS
Emergency/First Aid Proc: GET MEDICAL HELP IF SYMPTOMS PERSIST.
INHALED:REMOVE TO FRESH AIR. PROVIDE CPR/OXYGEN IF NEEDED. EYES:FLUSH WITH WATER FOR 15 MINUTES, HOLDING EYELIDS OPEN. SEE PHYSICIAN. SKIN:WASH WITH SOAP & WATER. ORAL:IF CONSCIOUS, RINSE MOUTH WITH WATER. SEEK IMMEDIATE MEDICAL ATTENTION.

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Precautions for Safe Handling and Use
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Steps If Matl Released/Spill: PROVIDE ADEQUATE VENTILATION. WEAR PROTECTIVE EQUIPMENTS. CLEAN UP SPILLS PROMPTLY. PREVENT SKIN CONTACT.

CONDUCT MERCURY AIR MONITORING TO DETERMINE AIRBORNE CONCENTRATIONS. AVOID BREATHING VAPORS.

Neutralizing Agent: NOT RELEVANT

Waste Disposal Method: MERCURY SHOULD BE SALVAGED FOR PURIFICATION.

DISPOSE OF IN ACCORDANCE WITH ALL LOCAL, STATE AND FEDERAL REGULATIONS. RQ IS 1 POUND. CALCIUM POLYSULFIDE WITH EXCESS SULFUR MAY BE SPRINKLED INTO CRACKS/INACCESSIBLE SITES. HAZARDOUS WASTE # U151.

Precautions-Handling/Storing: STORE IN SECURE AREA AWAY FROM INCOMPATIBLE MATERIALS. PROTECT FROM PHYSICAL DAMAGE. KEEP OUT OF REACH OF CHILDREN.

Other Precautions: DANGER; MAY BE FATAL IF SWALLOWED, INHALED OR ABSORBED THROUGH SKIN. CAUSES IRRITATION. KEEP AWAY FROM HEAT. DO NOT BREATHE VAPORS. AVOID CONTACT WITH EYES OR SKIN. WASH THOROUGHLY AFTER HANDLING.

=====
Control Measures
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Respiratory Protection: IF VENTILATION DOES NOT MAINTAIN INHALATION EXPOSURES BELOW PEL (TLV), USE NIOSH APPROVED FULL FACE POSITIVE PRESSURE SELF-CONTAINED BREATHING APPARATUS. USE WITH ADEQUATE VENTILATION.

Ventilation: PROVIDE SUFFICIENT GENERAL/LOCAL EXHAUST VENTILATION TO CONTROL INHALATION EXPOSURES BELOW OSHA'S PEL.

Protective Gloves: RUBBER IF NEEDED

Eye Protection: CHEMICAL SAFETY GOGGLES

Other Protective Equipment: EYE WASH STATION, QUICK DRENCH SHOWER AND IMPERVIOUS CLOTHING

Work Hygienic Practices: OBSERVE GOOD PERSONAL HYGIENE PRACTICES AND RECOMMENDED PROCEDURES. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING.

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Transportation Data
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Trans Data Review Date: 95214
DOT PSN Code: IWD
DOT Symbol: A,W
DOT Proper Shipping Name: MERCURY
DOT Class: 8
DOT ID Number: UN2809
DOT Pack Group: III
DOT Label: CORROSIVE
IMO PSN Code: JKJ
IMO Proper Shipping Name: MERCURY
IMO Regulations Page Number: 8191
IMO UN Number: 2809
IMO UN Class: 8
IMO Subsidiary Risk Label: -
IATA PSN Code: PYF
IATA UN ID Number: 2809
IATA Proper Shipping Name: MERCURY
IATA UN Class: 8
IATA Label: CORROSIVE
AFI PSN Code: PYF
AFI Prop. Shipping Name: MERCURY
AFI Class: 8
AFI ID Number: UN2809
AFI Pack Group: I
AFI Basic Pac Ref: 12-13

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Disposal Data
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Label Data
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Label Required: YES
Technical Review Date: 02AUG95
Label Date: 24APR95
MFR Label Number: UNKNOWN
Label Status: G
Common Name: MERCURY
Signal Word: DANGER!
Acute Health Hazard-Severe: X
Contact Hazard-Slight: X
Fire Hazard-None: X
Reactivity Hazard-None: X
Special Hazard Precautions: TARGET ORGANS:SKIN, LIVER, KIDNEYS. ACUTE-
HIGHLY TOXIC. READILY ABSORBED THROUGH SKIN. MAY BE FATAL IF INHALED,
SWALLOWED/ABSORBED THROUGH SKIN. VAPORS/MISTS ARE IRRITATING TO EYES,
MUCOUS MEMBRANES. MAY CAUSE ALLERGIC SKIN REACTION, CNS DISTURBANCES.
CHRONIC- KIDNEY & LIVER DAMAGE. STORE AWAY FROM INCOMPATIBLES. CLEAN UP
SPILLS PROMPTLY. AVOID BREATHING VAPORS. FIRST AID- GET MEDICAL HELP IF
SYMPTOMS PERSIST. INHALED:REMOVE TO FRESH AIR. PROVIDE CPR/OXYGEN IF
NEEDED. EYES:FLUSH WITH WATER FOR 15 MINUTES. HOLD EYELIDS OPEN. SEE
PHYSICIAN. SKIN:WASH WITH SOAP & WATER. ORAL:IF CONSCIOUS, RINSE MOUTH WITH
WATER. SEEK IMMEDIATE MEDICAL ATTENTION
Protect Eye: Y
Protect Skin: Y
Label Name: CITY CHEMICAL CO
Label Street: 100 HOBOKEN AVE
Label City: JERSEY CITY
Label State: NJ
Label Zip Code: 07310
Label Country: US
Label Emergency Number: 201-653-6900/800-424-9300 (CHEMTREC)
Year Procured: 1995