

Modular Process Technology Corporation

RTP-600S Rapid Thermal Processor

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SECTION 1: CHAPTER 1

PRODUCT OVERVIEW AND PERFORMANCE

1.1.1 FEATURES AND APPLICATIONS

The RTPS600 uses radiation to heat a single wafer for a short time at precisely controlled temperatures.

These capabilities, combined with the heating chamber's cold-wall design and superior heating uniformity, provide significant advantages over conventional furnace processing.

Key features include:

- Closed-loop temperature control with pyrometer or thermocouple temperature sensing
- Precise time-temperature profiles tailored to suit specific process requirements
- Fast heating and cooling rates unobtainable in conventional technologies
- Consistent wafer-to-wafer process cycle repeatability
- Elimination of external contamination
- Small footprint and energy efficiency

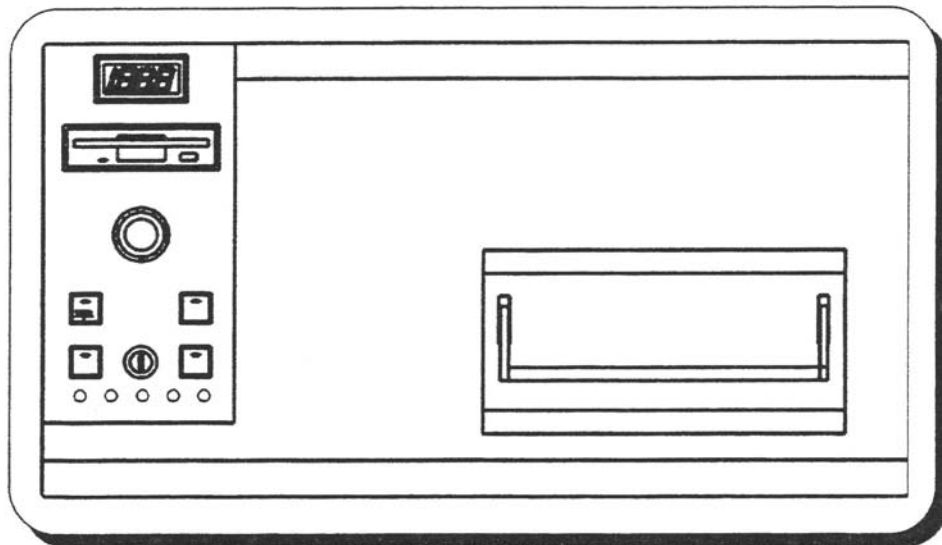


Figure 1-1. RTP-600S

The RTP-600S is a versatile tool, useful for many applications:

- Ion implant activation
- Polysilicon annealing
- Oxide reflow
- Silicide formation
- Contact alloying

- Oxidation and Nitridation
- Compound semiconductor processing

1.1.2 PERFORMANCE SPECIFICATIONS

- Steady-State Temperature Stability: $\pm 2^{\circ}\text{C}$, in the range of 250-1300 $^{\circ}\text{C}$
- Temperature Monitoring Mechanisms: Extended Range Pyrometer PLUS or a thermocouple.
- Heating Rate: 0-200 $^{\circ}\text{C}$ per second, user-controllable
- Cooling Rate: Temperature and Process dependent, max. 150 $^{\circ}\text{C}$ per second
- Maximum Non-Uniformity:
 - Radiant Flux: $\pm 0.25\%$
 - Sheet Resistivity: Uniformity $< 2\%$ (dose monitoring units)
 - (Post-anneal sheet resistivity measured on a 150 mm wafer annealed at 1000 $^{\circ}\text{C}$ for 10 seconds)
 - Implant: As, 1015, 75KeV, with implant uniformity $< 0.3\%$,
 - Silicon wafer, no screen oxide, P-type, $< 100 >$, 10-20 ohm-cm
- Steady State Time: 1-9999 sec. (1-600 sec. recommended)
- Wafer Sizes for the RTP-600S: 2", 3", 4", 5", 6", and smaller pieces

1.1.3 SYSTEM OPTIONS AND ACCESSORIES

Following is a partial list of options:

- Slip Free Ring Tray
- Slip Free Ring
- TC wafers
- Susceptor Assembly with Lid
- Inconel Susceptor TC's
- Printer Card
- Exhaust Collar

The RTP-600S system integrates the processing unit and an internal computer into one system unit. Each customer receives the following items:

- RTP-600S system unit
- Color Monitor (14")
- Keyboard
- Mouse (Windows version only)

The computer has at least the following capacities (depending on date of manufacture):

- IBM-compatible, '386 or higher
- 4 MB RAM memory
- VGA color monitor and adapter card
- Hard disk (120 MB or larger)

- 1.4 MB floppy disk drive (3.5")
- DOS software, version 3.2 or above, installed on the hard disk

1.1.4 WARRANTY

Modular Process Technology Corporation expressly warrants that it will either repair or replace on the terms described below any product or component which within twelve (12) months from the date of shipment proves to be defective in design, material, or workmanship in the course of its normal intended use.

Modular Process Technology Corporation products are normally intended to be used in a semiconductor-processing environment in accordance with the functional, environmental, and operational standards published by Modular Process Technology Corporation or generally accepted in the industry. Modular Process Technology Corporation shall have no warranty obligation with respect to any product, which has been modified or altered, or with respect to data contained in any product returned to Modular Process Technology Corporation by the customer.

SECTION 2: CHAPTER 1

SAFETY PRECAUTIONS

2.1.1 UTILITIES INSPECTION

Check the system utility connections and sources before switching on the RTP-600S (see **Figure 2-1** for the location of each utility connection at the rear of the unit).

Visually inspect the following utilities to make sure connections are secure:

- Electrical power
- Gas inlet and chamber exhaust
- Cooling water inlet and outlet
- Compressed air inlet

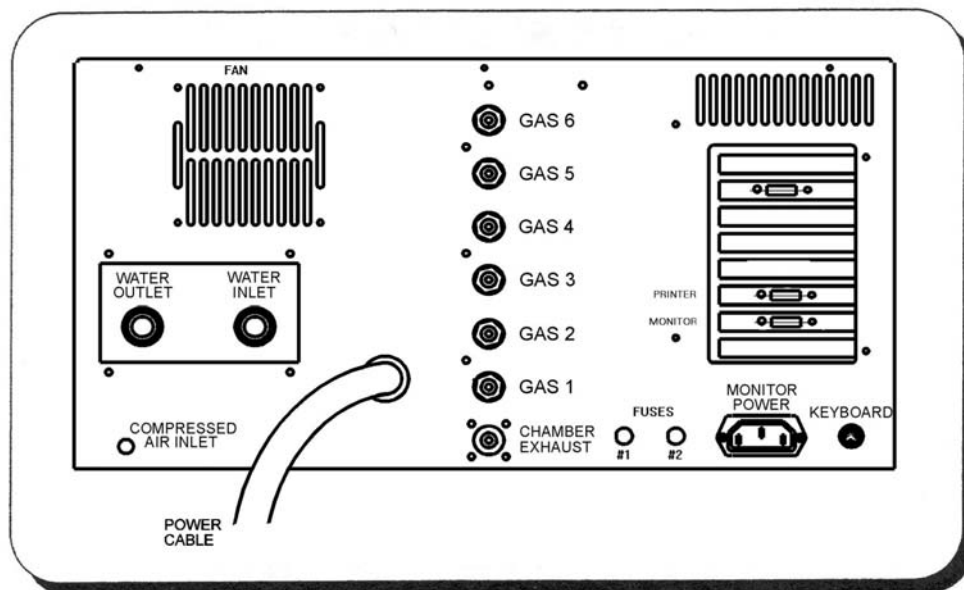


Figure 2-1. Utility Connections, Rear View of Heating Chamber

WARNING: Make sure the chamber exhaust is not restricted. This could cause the quartz tube to over pressurize and break.

Check for possible water leaks at the cooling water inlet and water outlet connections.

If any of the utilities are disconnected or any connections appear to be leaking, correct the problem before proceeding.

2.1.2 MAINTENANCE

During maintenance operations, observe the following precautions:

Do not use replacement parts that are not provided by Modular Process Technology Corporation.

WARNING: Modular Process Technology Corporation is not liable for any damage or injury that may occur when unauthorized parts are used.

Disconnect power to the system before performing any maintenance activity that requires the removal of access covers.

2.1.3 GAS HANDLING

Be aware of the following cautions when working with gases in the RTP-600S system:

Use only gases, which have been specified for use in the RTP-600S system.

CAUTION: Modular Process Technology Corporation is not liable for the use of gases not recommended by the factory.

Make sure the specified gases are connected to the proper inlets on the service panel.

WARNING: Failure to properly connect the gas lines may result in dangerous gas mixtures, which could cause harm to personnel and/or the system.

SECTION 2: CHAPTER 2

SYSTEM STARTUP

2.2.1 SOFTWARE INSTALLATION AND STARTUP

The executable RTP-600S control software is already installed on the hard disk. All the operator needs to do is power up the system and make sure the monitor is on. At this point, the RTP-600S Main Menu will appear on the screen.

A copy of the system software is provided on floppy disk, but as a precautionary measure, it is always advisable to make a backup copy of the RTP-600S software diskette. It may be needed in the event that the original diskette is misplaced or damaged.

Exiting the Program:

Exit to DOS by pressing **[Q]** (Quit) from the Main Menu.

To abort and reset the software program at any time, simultaneously press and hold down the **[CTRL, ALT & DEL]** keys on the keyboard. This will reboot the computer and reload DOS. This procedure cannot be used if there is no response from the keyboard. Alternately, the system can be powered down and then powered up.

2.2.2 POWER UP PROCEDURE

The power up procedure begins with power being switched on in the following sequence:

Power-on Sequence:

1. Turn on the wall circuit breaker for the RTP-600S
2. Turn on the front panel key switch

Then the RTP-600 is powered up using the following procedure:

Power Up Procedure:

1. Turn on the monitor if it is off. The "Power" LED on the monitor should be illuminated green.
2. Press the "EMO Reset" button - this turns the entire system on. Once the computer boots up, the system Main Menu should appear on the monitor screen. If it does not, check that the monitor is on.
3. Press the "Power On" button - this enables the heating unit.
4. The RTP-600S system now is ready for operation.

2.2.3 POWER DOWN PROCEDURE

The RTP-600S system may be left with power on continuously, unless maintenance to the system requires removing power from the system.

NOTE: Modular Process Technology Corp. recommends leaving the computer on when the system is not in use. The system should be turned off only for maintenance and service.

Power Down Procedure:

1. Press the "Power Off" button.
2. Quit the RTP-600S program by typing **[Q]** (Quit) from the Main Menu.

3. Press the EMO switch.
4. If any accessories are being used with the system, turn them off as needed.

SECTION 3: CHAPTER 1 OPERATOR INTERFACE

3.1.1 INTRODUCTION

The RTP-600S system consists of a heating chamber and a computer controller. The wafer to be processed is placed on a quartz tray, which slides into a quartz isolation tube in the chamber.

The controller uses a set of operating instructions known as recipes to control the RTP-600S. These recipes are created by the Process Engineer to control the parameters of the processing cycle. The Operator then uses the menu-driven software to select and run the process parameters (steady state temperatures, process times, ramp rates, etc.).

3.1.2 FRONT CONTROL PANEL

The front control panel displays system status and provides manual control over the system (see **Figure 3-1**).

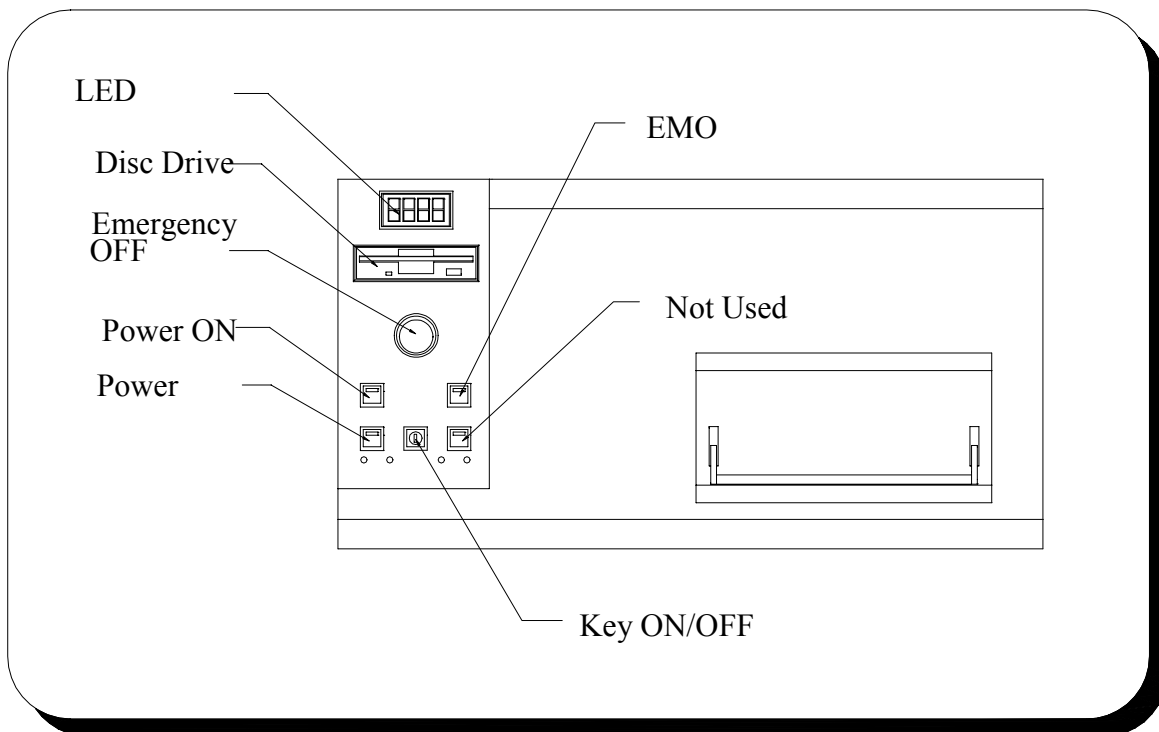


Figure 3-1. Front Control Panel

The controls and indicators used for system operation are located on the front panel of the RTP-600S as shown in Figure 3-1. These controls and indicators are:

- LED Readout - Displays measured process temperature in real time
- Floppy Disk Drive (1.44 MB, 3½") - Used for storing process data
- Emergency Off (EMO) - Shuts everything off when pressed
- EMO Reset - Resets the EMO circuit and restores power to the system
- Power On - Turns on the heating unit power

- Power Off - Turns off the heating unit power
- Door Unlock – Front Panel Door Unlock Switch (not used in Version 2.01 software)

3.1.3 RTP-600S MENU DISPLAYS

Using the computer's keyboard and the screen menus operates the RTP-600S system. The menu-driven display greatly reduces the learning process.

The menu screens are designed to allow straightforward operation. After a successful power-up, the controller automatically displays the **Main Menu** screen (see **Figure 3-2**). From this screen, pressing the desired function key can access any mode of operation.



Figure 3-2. Main Menu Screen

SECTION 3: CHAPTER 2
RECIPE PROGRAMMING MODE

3.2.1 PROGRAMMING TUTORIAL

The following is an operational tutorial. We will step down through the Menu Tree (see **Figure 3-3**) to introduce each screen and system function.

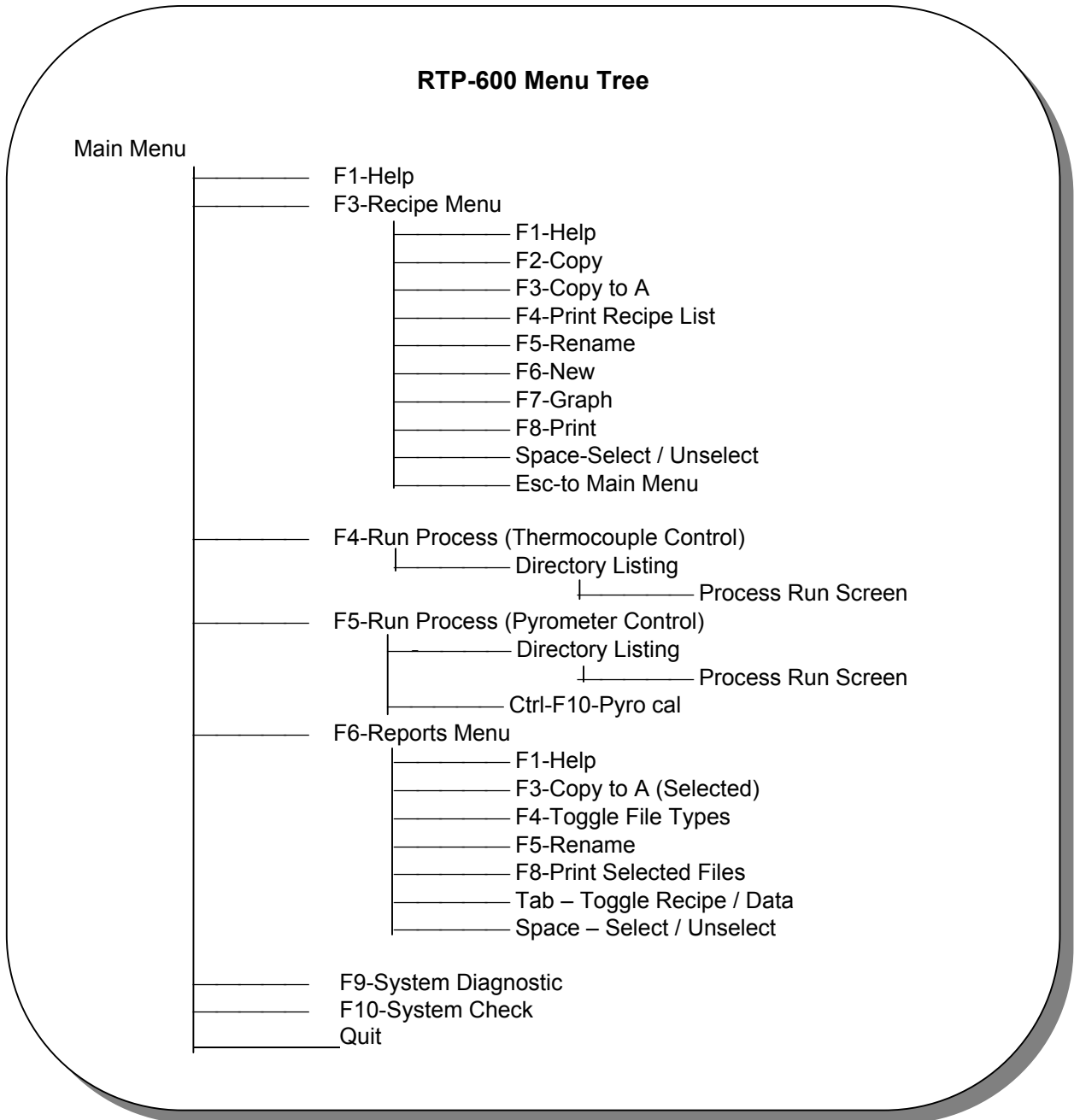


Figure 3-3. Menu Tree

3.2.2 Recipe Menu (Function Key F3)

1. Press [F3] from the Main Menu.
2. The *Recipe Data File Directory Screen* will appear (see Figure 3-4).

Recipe Data File Directory							
Copyright (C) Modular Process Technology Corp. Rev 2.01							
Recipe Name	Validate	Engineer	Title WAFER	Factors and wafer Type			
DEMO.RPD	YES, T			0.80,	1.00,	1.00,	WFR
PW1200XX.RPD	YES, P	MPT	Py,WFR,1200C,R150	1.60,	0.10,	3.00,	WFR
TW1100NP.RPD	YES, T	MPT	TC,WFR,1100C,R10	1.00,	0.60,	0.88,	WFR
TW1175NA.RPD	YES, T	MPT	TC,WFR,1175C,R10	1.00,	0.60,	0.90,	WFR
TW1175NP.RPD	YES, T	MPT	TC,WFR,1175C,R10	1.00,	0.60,	0.90,	WFR
TW12001X.RPD	YES, T	MPT	TC,WFR,1200C,R100	1.40,	0.60,	0.67,	WFR
TW120050.RPD	YES, T	MPT	TC,WFR,1200C,R50	1.00,	0.60,	0.85,	WFR
TW120075.RPD	YES, T	MPT	TC,WFR,1200C,R75	1.00,	0.60,	0.77,	WFR
TW1200XX.RPD	YES, T	MPT	TC,WFR,1200C,R150	1.60,	0.10,	3.00,	WFR

F1:Help, F2:Copy, F3:Copy to A:, F4:Prt Rcp List, F5:Rename, F6:New,
 F7:Graph, F8:Print, F9>Edit, Space>Select/Unselect, Esc:to Main Menu

Enter>Edit Recipe, Del>Delete Recipe, F10:Validate Recipe

Figure 3-4. Recipe Data File Directory Screen

NOTE: This menu allows the user to operate on recipes by either creating a new recipe, selecting a recipe from the directory for editing or printing, or validating a recipe.

3.2.3 Editing a New Recipe Data File

1. Press [F3] from the Main Menu.
2. The Recipe Data File Directory Screen will appear
3. Press [F6] to create a "New" Recipe File using the *Recipe Editor Screen*.

RECIPE EDITOR										
File Name:		.RPD	Wafer Type:		WAFER		Factor1:		1.00	
Pyro Cali:		SYS_PYRO.WFR	Temp sensor:		THERMOCOUPLE		Factor2:		1.00	
Lamp Cali:		SYS_LAMP.WFR	Control Mode:		Close-loop		Factor3:		1.00	
Engineer :			Title:				Factor4:		1.00	
Step No.	Step Function	Time (sec)	Temp (°C)	Gas 1 N2 SLPM	Gas 2 O2 SLPM	Gas 3 He SLPM	Gas 4 XXXXX SCCM	Gas 5 XXXXX SCCM	Gas 6 XXXXX SCCM	
1	Stop	0	0	0	0	0	0	0	0	
2	Stop	0	0	0	0	0	0	0	0	
3	Stop	0	0	0	0	0	0	0	0	
4	Stop	0	0	0	0	0	0	0	0	
5	Stop	0	0	0	0	0	0	0	0	
6	Stop	0	0	0	0	0	0	0	0	
7	Stop	0	0	0	0	0	0	0	0	
8	Stop	0	0	0	0	0	0	0	0	
9	Stop	0	0	0	0	0	0	0	0	
10	Stop	0	0	0	0	0	0	0	0	

F1:Help, F2:Save, F3:Tg|FactGrps, F7:Graph, F10:Validate, Tab:Toggle, Esc:Exit

Put file name with .RPD.

Figure 3-5. "New" Recipe Editor Screen

The "New" Recipe Editor, Figure 3-5, is used to create and edit recipes to be run on the RTP-600S system. It is designed like a spreadsheet for easy data entry and readability. The editor is divided into two main sections. The top section (header) is where the user inputs comments and other information pertinent to the recipe. The lower section (data entry area) is for the process recipe data entry.

In the header, the Process Engineer enters the process **File Name**, **Temperature Sensor**, **Control Mode**, the **Engineer's** name or initials, and a **Title** for (or comment about) the process. The type of temperature sensor described here (pyrometer or thermocouple) is the one to be used as the temperature feedback device during the process. This file name can be any legal DOS filename (i.e., the recipe), excluding the path and extension. (The DOS path is always "DATA\" and the extension is "RPD".) This field cannot be left as NONAME, for it is used to later recall the recipe.

A recipe is divided into process steps; each step describes the state of the process for a specified amount of time (i.e., up to 100 steps can be specified).

Each column of the data entry area describes a parameter that is to be controlled or is used to describe how to control a parameter:

Step No. -- denotes the step number, and is non-editable.

Step Function -- denotes the type of process function this step describes. This step can either be a Ramp, Hold, Idle, or Stop. While in the Step Function column, to select a function simply press the first letter of that function's name (i.e., press [R] for Ramp).

Ramp -- increases the temperature at a constant rate until the desired temperature has been reached. The rate is calculated by dividing the difference between (the current step temperature and the previous step temperature) by the current step time. The

gas flow is set to the specified value as in a **Hold** step. The process controller cannot do two consecutive **Ramp** steps.

Hold -- increases or decreases the controlled parameter as fast as possible until the desired value has been reached, and then maintains that value until the step time has elapsed.

Idle -- sets the lamps at "off" while maintaining the gas flow at the specified flow rate for this step.

Stop -- ends the entire recipe. This is the last step in the recipe. Once the process controller sees a Stop, it stops all further processing.

Time (sec) -- the amount of time to elapse for this step. The time can be from 1 - 9999 seconds, in increments of 1 second. If you need a step that is longer than 9999 seconds, break the step into two steps. The software will restrict the maximum allowable time as the temperature increases.

<u>Temperature/Deg. C.</u>	<u>Maximum Time/Seconds</u>	<u>Temperature/Deg. C.</u>	<u>Maximum Time/Seconds</u>
1250	120	750	720
1200	150	650	1200
1150	200	600	1800
1100	300	550	3600
1050	327	500	2592
100	360	450	3200
950	400	400	4050
900	450	350	5280
850	514	300	7200
800	600	250	9999
700	900		(maximum programmable time)

Temperature (°C) -- this is the target temperature for this step.

Gas Line Settings

Gas 1 -- the value for the flow rate for the first gas of the system.

Gas 2 -- the value for the flow rate for the second process gas

Gas 3 -- the value for the flow rate for the third process gas

Gas 4 -- the value for the flow rate for the fourth process gas

Gas 5 -- the value for the flow rate for the fifth process gas

Gas 6 -- the value for the flow rate for the sixth process gas

When entering data values into the spreadsheet, the **Recipe Editor** checks for out-of-range entries. If a value is out-of-range, the editor will alert you and will give you the proper range.

For example: a simple cycle recipe may consist of: a starting idle step, ramp (up) step, hold step, ramp (down) step, idle step and stop step. (see Figure 3-6. **Simple Process Cycle**).

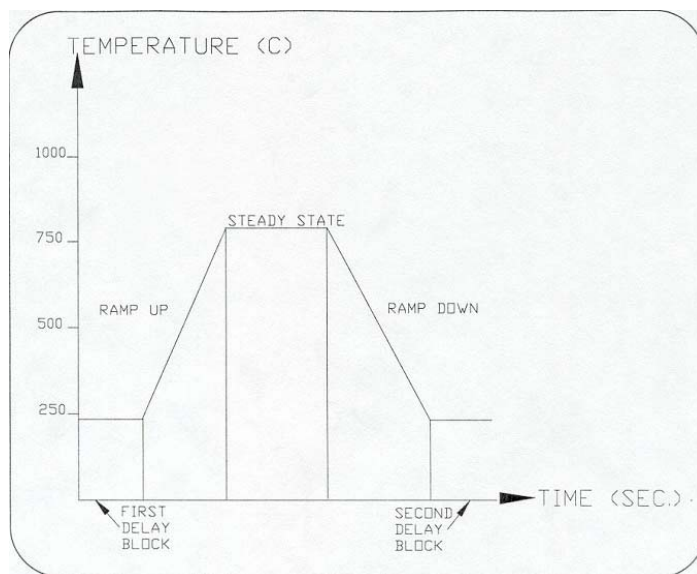


Figure 3-6. Simple Process Cycle

4. Recipe names are stored as filenames on the hard drive. The RTP-600S system includes a floppy disk drive to download recipes onto a formatted 3.5-inch floppy disk.
5. After editing has been completed, press **[F10]** to validate the recipe. Make any necessary changes if a validation message appears.
6. Press **[F2]** to save the recipe. Press **[F7]** to graph the computer model of the recipe.
7. Press [esc] to return to the Recipe Data File Directory Screen.

The procedure to run a predefined recipe is given in the Process Mode and in the System Diagnostic Mode chapters in this manual.

Recipe Editing Keys and Meanings:

[Home]	Go to beginning (Step No. cell) of line
[End]	Go to last column of step
[Up Arrow]	Move up one line
[Down Arrow]	Move down one line
[Left Arrow]	Move left one character (if editing a string)
[Right Arrow]	Move right one character (if editing a string)
[Page Up]	Move up one page
[Page Down]	Move down one page
[Ctrl + Left Arrow]	Move left one cell
[Ctrl + Right Arrow]	Move right one cell
[Ctrl + Home]	Move to top of page yet stay in same column
[Ctrl + End]	Move to bottom of page yet stay in same column
[Ctrl + Page Up]	Go to beginning of Recipe data
[Ctrl + Page Down]	Go to end of Recipe data
[F2]	Save Recipe
[Esc]	Leave Recipe Editor

3.2.4 Editing an Existing Recipe Data File

1. Press **[F3]** from the **Main Menu**.

2. The Recipe Data File Directory Screen will appear
3. Select Recipe that you wish to EDIT
4. Press **[F9]** or **[Enter]** to EDIT the selected recipe. The **Recipe Editor Screen** (see Figure 3-7) will appear with the recipe loaded.
5. Use the **[Up Arrow]** / **[Down Arrow]** keys to highlight the desired **Recipe File**.

RECIPE EDITOR										
File Name: IW1200XX.RPD			Wafer Type: WAFER			Factor1:1.60				
Pyro Cali: SYS_PYRO.WFR			Temp sensor: THERMOCOUPLE			Factor2:0.10				
Lamp Cali: SYS_LAMP.WFR			Control Mode: Close-loop			Factor3:3.00				
Engineer : MPT			Title: TC, WFR, 1200C, R150			Factor4:5.00				
Step No.	Step Function	Time (sec)	Temp (°C)	Gas 1 N2 SLPM	Gas 2 O2 SLPM	Gas 3 He SLPM	Gas 4 XXXXX SCCM	Gas 5 XXXXX SCCM	Gas 6 XXXXX SCCM	
1	Idle	20	0	20	0	0	0	0	0	
2	Idle	20	0	3	0	0	0	0	0	
3	Ramp	8	1200	3	0	0	0	0	0	
4	Hold	15	1200	3	0	0	0	0	0	
5	Idle	50	0	3	0	0	0	0	0	
6	Idle	150	0	20	0	0	0	0	0	
7	Idle	0	0	0	0	0	0	0	0	
8	Stop	0	0	0	0	0	0	0	0	
9	Stop	0	0	0	0	0	0	0	0	
10	Stop	0	0	0	0	0	0	0	0	
F1:Help, F2:Save, F3:TglFactGrps, F7:Graph, F10:Validate, Tab:Toggle, Esc:Exit										
Put file name with .RPD.										

Figure 3-7. Recipe Editor Screen

6. After editing has been completed, press **[F10]** to validate the recipe.
7. Press **[F2]** to save the recipe.
8. Press **[esc]** to return to the Recipe Data File Directory Screen

SECTION 3: CHAPTER 3
RUN PROCESS MODE – TC CONTROL RECIPES

3.3 Run Process – TC Control Recipes (Function Key F4)

1. Press **[F4]** from the Main Menu for recipes under T Control.
2. A directory listing of the TC Control recipes will appear (see **Figure 3-8**).

Recipe Data File Directory						
Copyright (C) Modular Process Technology Corp. Rev 2.01						
Recipe Name	Validate	Engineer	Title	Factors and Wafer Type		
DEMO.RPD	YES, T		WAFER	0.80,	1.00,	1.00, WFR
TW1100NP.RPD	YES, T	MPT	TC,WFR,1100C,R10	1.00,	0.60,	0.88, WFR
TW1175NA.RPD	YES, T	MPT	TC,WFR,1175C,R10	1.00,	0.60,	0.90, WFR
TW1175NP.RPD	YES, T	MPT	TC,WFR,1175C,R10	1.00,	0.60,	0.90, WFR
TW12001X.RPD	YES, T	MPT	TC,WFR,1200C,R100	1.40,	0.60,	0.67, WFR
TW120050.RPD	YES, T	MPT	TC,WFR,1200C,R50	1.00,	0.60,	0.85, WFR
TW120075.RPD	YES, T	MPT	TC,WFR,1200C,R75	1.00,	0.60,	0.77, WFR
TW1200XX.RPD	YES, T	MPT	TC,WFR,1200C,R150	1.60,	0.10,	3.00, WFR

F1:Help, F2:Copy, F3:Copy to A:, F4:Prt Rcp List, F5:Rename, F6:New,
 F7:Graph, F8:Print, F9>Edit, Space>Select/Unselect, Esc:to Main Menu

Enter:Auto process (Thermocouple Ctrl), F10:View Curve of Last Process Run.

Figure 3-8. Recipe Data File Directory – TC Control Recipes Screen

3. Use the **[Up Arrow]** / **[Down Arrow]** keys to highlight a validated **Recipe File**.
4. Press **[Enter]** to select the recipe file to be used for processing. The process controller to process the substrate inside the process chamber will use the selected recipe.
5. After initializing, the **Process Run** screen will appear (see **Figure 3-8**). The **Process Run** screen shows the process data in real-time. All process parameters are displayed on the screen, both the recipe values and the actual measured values.

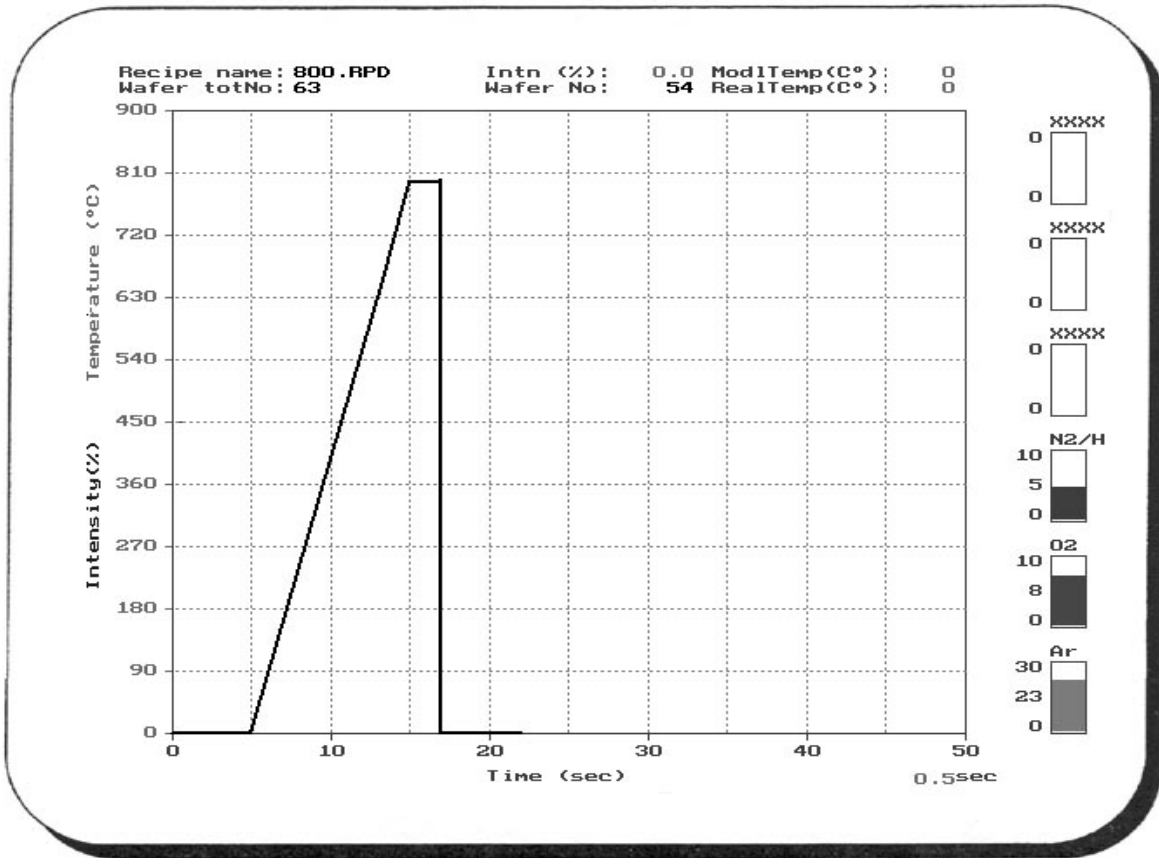


Figure 3-9. Process Run Screen

Header: Identification of the process and wafer being processed is displayed at the top of the screen.

Temperature: The blue line on the x-y graph depicts the process curve of the temperature vs. time as called for in the selected recipe. As the process progresses, the actual measured temperature is plotted in real time. The actual temperature is plotted in red, while the set point (model) temperature is plotted in green. The instantaneous values of both of these temperatures are also printed numerically at the upper right corner of the screen.

Gas Flows: The process gas flows are represented as bar graphs on the right side of the screen. The numerical value in the middle of each bar graph is the feedback from the MFC for that gas. The gas flows are also plotted on the x-y graph, as percentages of their full flow rates (i. e., for an MFC that is rated at 30 SLPM and is controlling its gas flow at 10 SLPM, the plot is 1/3 of the full scale of the graph, so if the graph full scale is 1,000 °C, the gas plot will be at 333 °C.) The plot colors for the gases are the same as their bar graph colors.

6. Pressing the **[Esc]** key during the run will abort the process and return to the **Recipe Data File Directory – TC Control Recipes Screen**.
7. After the process has completed, the words "Process Over" will appear, and the hardware will be shut off.

SECTION 3: CHAPTER 4
RUN PROCESS MODE – PYRO CONTROL RECIPES

3.4.1 Run Process – Pyro Control Recipes (Function Key F5)

1. Press **[F5]** from the Main Menu for recipes under Pyro Control.
2. A directory listing of the recipes will appear (see **Figure 3-10**).

Recipe Data File Directory Copyright (C) Modular Process Technology Corp. Rev 2.01				
Recipe Name	Validate	Engineer	Title	Factors and Wafer Type
PW1200XX.RPD	YES, P	MPT	Py,WFR,1200C,R150	1.60, 0.10, 3.00, WFR

F1:Help, F2:Copy, F3:Copy to A:, F4:Prt Rcp List, F5:Rename, F6:New, F7:Graph
F8:Print, F9>Edit, Ctrl-F10:Pyro-Cal, Space>Select/Unselect, Esc:to Main Menu

Enter:Auto process (Pyrometer Ctrl), F10:View Curve of Last Process Run.

Figure 3-10. Recipe Data File Directory – Pyrometer Control Recipes Screen

3. Use the **[Up Arrow]** / **[Down Arrow]** keys to highlight a validated **Recipe File**.
4. Press **[Enter]** to select the recipe file to be used for processing. The process controller to process the substrate inside the process chamber will use the selected recipe.
5. After initializing, the **Process Run** screen will appear (see **Figure 3-9**). The **Process Run** screen shows the process data in real-time. All process parameters are displayed on the screen, both the recipe values and the actual measured values.
6. Pressing the **[Esc]** key during the run will abort the process and return to the **Recipe Data File Directory – Pyrometer Control Recipes Screen**.
7. After the process has completed, the words "Process Over" will appear, and the hardware will be shut off.

3.4.2 PYROMETER CALIBRATION OVERVIEW

When pyrometer is used for closed-loop temperature control, calibration needs to be performed to establish correlation between pyrometer signals and thermocouple readings as the reference temperature. RTP-600S provides two level calibration, system level and recipe level.

3.4.2.1 SYSTEM LEVEL PYROMETER CALIBRATION

Two files reside in MAINTENANCE: CHAMBER CALIBRATION, SYS_PYRO.WFR and SYS_PYRO.SPT. These files contain system level pyrometer calibration data for wafer processing and susceptor processing, respectively. System level pyrometer calibration is performed before the system is released for delivery. This calibration should be performed by the user when pyrometer change and/or quartz tube change take place. Make sure a thermocouple is properly installed prior to performing the calibration.

Prior to performing system level pyrometer calibration with one of the two SYS_PYRO files, the user should save the current file. Select the file, click SET UP, and then enter a different file name and save. The newly named file can be re-instated as the SYS_PYRO file by click SAVE TO SYSTEM. Since SYS_PYRO files can be easily over written this way, the user is advised to save his calibration file to a different name as back up.

System level calibration captures correlation between pyrometer and thermocouple while lamp intensity is increasing. At HOLD step or RAMP step with different ramp rates, the relationship between pyrometer and thermocouple can be different from that obtained during the calibration. For applications where better correlation is needed, recipe level pyrometer calibration can be performed.

3.4.2.2 RECIPE LEVEL PYROMETER CALIBRATION

Recipe level pyrometer calibration can be performed for a given recipe with pyrometer control. The user must ensure that a proper TC is installed as reference temperature for pyrometer. The TC can be one that is in contact with the wafer when running wafer processing. When running susceptor processing, it can be on that is in contact with the wafer in the susceptor or with the susceptor itself.

With thermocouple properly installed, select **F5** from the Main Menu the **Recipe Data File Directory – Pyrometer Control Recipes Screen** will appear. Select the recipe, press **Ctrl-F10**. Ctrl-F10:Pyro-Cal will perform recipe level pyrometer calibration. When the process is completed, a file is created and saved that contains fine correlation between thermocouple and pyrometer for the particular recipe. The correction is applied when the recipe is run by pressing ENTER. Note that recipe level calibration is recipe specific. When steps in the recipe are altered by the user, the calibration must be performed again. For a recipe that no PYROCAL has ever been performed, the user can still run the recipe by clicking PROCESS START. However, no recipe level pyrometer correction is applied.

3.4.2 TEMPERATURE CONTROL FACTORS

RTP-600S employs a set of factors for closed-loop temperature control. The factors are recipe specific and reside in each recipe. The user can access and modify the factors in recipe editor.

3.4.3.1 OPTIMIZATION OF CONTROL FACTORS

It should be pointed out that RTP processing is very sensitive to process environment. In particular, correlation between the temperature of wafer inside the susceptor and the pyrometer reading from susceptor back surface can vary substantially if recipe is run under different starting conditions. You must keep hardware and environment constant and keep wafer-loading time between runs the same.

Factors 1 through 6 take values between 0.01 and 10, and Factor 7 between 1 and 20. The procedure below can be used to determine temperature control factors for a given recipe. It also explains the temperature control methodologies used in this revision.

SPECIAL NOTE: Factor 5 and 6 should be tuned before you work on other factors. Optimal values of Factor 5 and 6 are obtained when you have smooth connection for the linear intensity increase to the closed-loop ramp up.

You may either create a recipe by renaming an existing one and start with the factors for that particular recipe, or set defaults to 1 for all the factors. Run the recipe of your design.

Make sure you start your process runs at a consistent condition. For instance,

- a. Warm up the system with the recipe you selected to work on.
- b. Open the door to cool down the substrate. In the meantime, modify the factors as you wish.
- c. Wait until the substrate reaches a given temperature, e.g., between 30° and 40°C. Start the next run with the same recipe, or a similar recipe.

For susceptor processing, before the RAMP step starts, an “invisible”, susceptor warm up step takes place. The lamp intensity is set by Factor 7 in the recipe. The step will last up to 10 seconds, or until pyrometer starts to respond, whichever is earlier. WarmUpIntntn level should be based susceptor size and ramp up rate.

- a. For 6” OD susceptor and 10°C/sec ramp rate, the Factor 7 value should be about 3-5%.
- b. For 4” OD susceptor and 10°C/sec ramp rate, the Factor 7 value should be about 1%.

For wafer processing, this warm up step is not used.

The RAMP step will then start. The lamp intensity will increase linearly from an initial value proportional to the ramp rate. The rate of linear increase is proportional to ramp rate and to Factor 6. The linear increase ends when

- a. TC temperature approaches model temperature, in case of TC control, or
- b. Pyrometer (or model) temperature reaches (Factor5 x 500°C), in case of pyrometer control

IMPORTANT: Factors 5 and 6 should be tuned before you work on other factors. Optimal values of Factor 5 and 6 are obtained when you have smooth connection from the linear intensity increase to the close-loop ramp up.

The closed-loop control will then take place for the rest of RAMP until the recipe approaches the HOLD step. Factor 4 is used to modulate system response during the RAMP control. Higher values of Factor 4 can cause oscillation and high noise level. Lower value of Factor 4 can cause excessive temperature undershoot during the ramp.

Toward the end of RAMP control and right before the beginning of HOLD, there is a transition step during which the lamp intensity decreases linearly. The duration of the transition step is proportional to Factor 2 and the intensity at the end of transition is proportional to that at the beginning of transition and to Factor 3. Adjust Factor 2 and 3 to optimize the transition.

The control response during HOLD is affected by Factor 1. Higher values can cause oscillation and high noise, while lower values result in slow response. Lower values with minimal over shoot or under shoot are preferred.

The control software has been made so that the interactions among the factors are minimal. However certain interactions should still be expected, and iterations in determining the factors may be necessary.

3.4.3.2 DEFINITION OF FACTORS

SPECIAL NOTE:Factor 5 and 6 should be tuned before you work on other factors. Optimal values of Factor 5 and 6 are obtained when you have smooth connection for the linear intensity increase to the closed-loop ramp up.

Factor 1:

Factor 1 affects steady state, or Hold step, temperature control. Higher values result in faster response. However, oscillation can occur with high values.

Factor 2:

Factor 2 strongly influences the transition from Ramp to Hold. It determines the duration of the transition. Higher values can cause under shoot at the beginning of Hold step, while lower values can result in over shoot.

Factor 3:

Factor 3 also strongly influences the transition from Ramp to Hold. It is a multiplier of lamp intensity going from RAMP to HOLD. Low values can cause under shoot at the beginning of Hold step, while high values can result in over shoot.

Factor 4:

Factor 4 affects response in Ramp steps. Low values can cause under shoot, while high values can result in instability, oscillation and high noise.

Factor 5:

Factor 5 is used in pyrometer control during initial ramp up. It determines the temperature at which the open-loop linear intensity increase ends and the closed-loop control starts. The optimal value will ensure that closed-loop control starts at or above a temperature where pyrometer begin to respond to temperature change.

Factor 6:

Factor 6 controls the rate of increase in lamp intensity during the initial stage of the temperature ramp up. Higher values result in faster rate. An optimal value will lead to a smooth start of closed-loop control in the ramp up.

Factor 7:

Factor 7 is the lamp intensity during pre-warm-up prior to ramp step for susceptor recipes ONLY.

.WarmUpIntn: Lamp intensity percentage during pre-warm step prior to ramp up. This Lamp intensity will run for 10sec. You will note that this intensity/time step is NOT represented in the recipe or on the real-time process event screen.

Factor 8:

Not Used. Set at 1.0

3.4.3.3 CONTROL FACTORS FOR SAMPLE RECIPES

The following factor settings work well for the given process:

- Susceptor Processing:
 - 6" OD Susceptor
 - TC Calibration with TC-on-wafer

- Wafer Processing:
 - TC-on wafer, touch contact

Note that several hardware items can affect processes and thus the factor setting, such as:

Substrate	Process		F1	F2	F3	F4	F5	F6	F7
Susceptor	400C, R=10C/S	1.0	0.8	0.40	0.8	0.3	1.5	3.0	
Susceptor	400C, R=20C/S	1.0	0.8	0.30	1.4	0.3	1.4	5.0	
Susceptor	600C, R=10C/S	1.0	1.0	0.60	0.8	0.3	1.5	3.0	
Susceptor	900C, R=10C/S	1.0	1.2	0.70	0.8	0.3	1.5	3.0	
Wafer	600C, R=30C/S		1.0	0.5	0.75	1.2	0.4	0.4	N/A
Wafer	700C, R=30C/S		1.0	1.0	0.65	1.2	0.4	0.4	N/A
Wafer	900C, R=30C/S		1.0	0.5	0.85	1.2	0.4	0.4	N/A

Factors shown above serve as reference samples. They may vary from system to system. However, same set of factors can be used for both TC control and pyrometer control for a given process.

For wafer processing, pyrometer response to wafer temperature depends on emissivity of wafer back surface. Emissivity varies with wafer type and wafer backside coating. The control factors are expected to change with wafer type. For un-doped silicon wafer without backside coating, optical emission is below the threshold of pyrometer response for temperature below 600C. In that case, pyrometer control can only be achieved for hold temperature above about 700C, and Factor 5 should be set at about 1.0.

SECTION 3: CHAPTER 5
RECORD MODE - HISTORICAL TIME/TEMPERATURE PROFILES

3.5 Reports Menu (Function Key F6)

1. Press [F6] Reports Menu from the *Main Menu*.
2. The *Process Data Files Screen* will appear (see Figure 3-11).

PROCESS DATA FILES				
Copyright (C) Modular Process Technology Corp. Rev 2.01				
Recipe Name	Data Name	Date and time	Data Name	Date and time
DEMO.RPD	PW1200XX.002	09-24-02 01:03p		
NEOPHOTO.RPD	TW12001X.004	09-24-02 01:00p		
SUSCEP~1	TW120050.004	09-24-02 00:59p		
TW1100NP.RPD	TW120075.002	09-24-02 00:59p		
WAFERH~1_	TW1200XX.016	09-24-02 01:01p		

F1:Help, F3:Copy to A (selected):, F4:Toggle File Types, F5:Rename,
F8:Print selected files, Tab:Toggle Recipe/Data, Space:Select/Unselect

Press Ctrl+Y:delete empty data dir.

Figure 3-11. Process Data Files Screen

The Process Data Files Screen provides Process Engineers and Service Personnel with the ability to easily retrieve historical Time/Temperature profiles.

3. Select a process data file to plot, and press [ENTER]. The data file is plotted as shown in **Figure 3-12**.

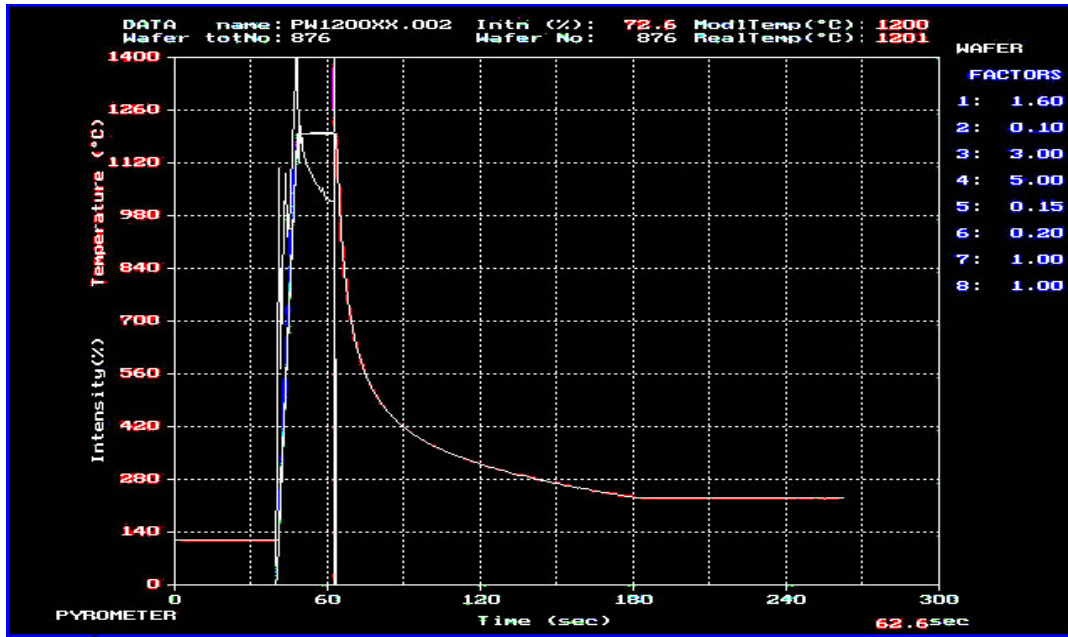


Figure 3-12. Historical Time/Temperature Profile

SECTION 3: CHAPTER 6 SYSTEM DIAGNOSTICS MODE

3.6.1 System Diagnostics (Function Key F9)

1. Press [F9] System Diagnostic from the *Main Menu*.
2. The *System Diagnostics Screen* will appear (see Figure 3-13).

The **System Diagnostics** screen (see **Figure 3-13**), is used to verify the proper operation of each device in the RTP-600S, independently of the other devices. Each gas flow and the lamp power can be manually set to any desired value within the limits of the device.

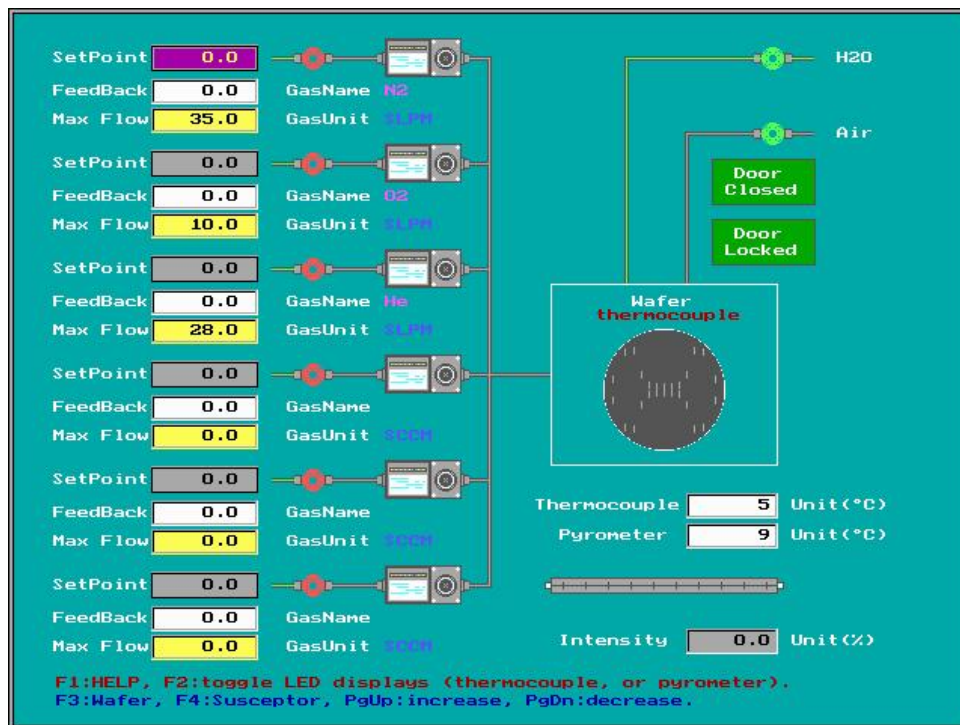


Figure 3-13. System Diagnostics Screen

It is possible to damage the system if the user does not follow proper safety precautions with the gases and temperature.

WARNING: Do not exceed a steady state temperature >1250^o C. A melting substrate will destroy the quartz tray and tube. The high temperature can also do other damage to the chamber itself.

WARNING: Do not exceed a combined Gas Flow of 30SLPM or 30,000 sccm. Quartz may break due to overpressure.

3.6.1 System Diagnostics Menu (Device Control)

This is done by pressing the appropriate [Up-], [Down-], [Left-], and [Right Arrow] keys until the desired field is highlighted. Once highlighted, pressing the [Enter] key enables the device to be controlled, and changes the device icon color to denote the device is active or not. (**Note:** For MFC's, the active color is green and inactive is red while for the lamps, yellow is inactive and red is active.)

Once a field is active, the operator can control the value by pressing the **[PgUp]** and **[PgDn]** keys to respectively increment and decrement the value. The operator can move the highlight away from the current device without the value changing. To turn off a device, move the highlight to the device and press **[ENTER]** until the inactive color is present.

To change temperature sensor type (Pyrometer or TC) to be displayed, toggle **[F2]**. To change wafer type (Susceptor or Wafer) press **[F4]** or **[F3]** respectively.

(**Note:** Choosing a wafer type is only meaningful for pyrometer readings in this menu due to activating different Pyrometer Calibration Files stored by the system.)

Upon exiting this **System Diagnostics** screen by pressing **[Esc]**, all devices are immediately turned off and disabled.

3.6.2 System Diagnostics Menu (Status Sensors)

- H2O and air sensors will be green when open and red when closed. Note: Lamps cannot be turned on unless these are active, which is controlled by power-on or button on control panel. Also, the H2O sensor senses water flow, so if flow is too low, sensor will be red.
- Thermocouple/pyrometer fields display current value of temperature. Note: Pyrometer values below 400°C will not be accurate and appropriate. Wafer type must be chosen before correct Pyrometer calibration File can be used by the system.

3.6.3 System Diagnostics Menu (Control Key Summary)

Summary of Control Keys:

[Up Arrow]	Moves the highlighter up to the next gas
[Down Arrow]	Moves the highlighter down to the next gas
[Left Arrow]	Moves the highlighter left to the gases
[Right Arrow]	Moves the highlighter right to the lamps
[Enter]	Enables and disables the highlighted device (toggles)
[Page Up]	Increments the set point for the highlighted device
[Page Down]	Decrements the set point for the highlighted device
[Ctrl + Page Up]	Increments the set point for the highlighted device by a factor of 10 faster than [Page Up]
[Ctrl + Page Down]	Decrements the set point for the highlighted device by a factor of 10 faster than [PgDn]
[Esc]	Exits the system diagnostics screen
[F2]	Toggling this key changes the temperature sensor type to be displayed on LED display/graphical depiction of wafer temperature on system diagnostic screen.
[F4]	Change wafer type to susceptor.
[F3]	Change wafer type to wafer.

SECTION 3: CHAPTER 7 SYSTEM SERVICE MODE

3.7.1 System Service Screen (Function Key F10)

The System Service Mode provides the Process Engineers and Service Personnel with the ability to operate the RTP-600S system in a single step mode.

1. Press **[F10]** from the Main Menu and immediately type the letters sys.
2. A directory listing of the System Service functions will appear (see **Figure 3-14**).



Figure 3-14. System Service Screen

WARNING: Menus **[F2]** and **[F3]** are meant for Modular Process Technology personnel use Only. Customer debugging of these devices should be done in System Diagnostic Screen **[F9]** from main menu.

3.7.2 MFC CONTROL (Function Key F2)

1. Press **[F2]** from the System Service Menu.
2. The *MFC Control Screen* will appear (see Figure 3-15).

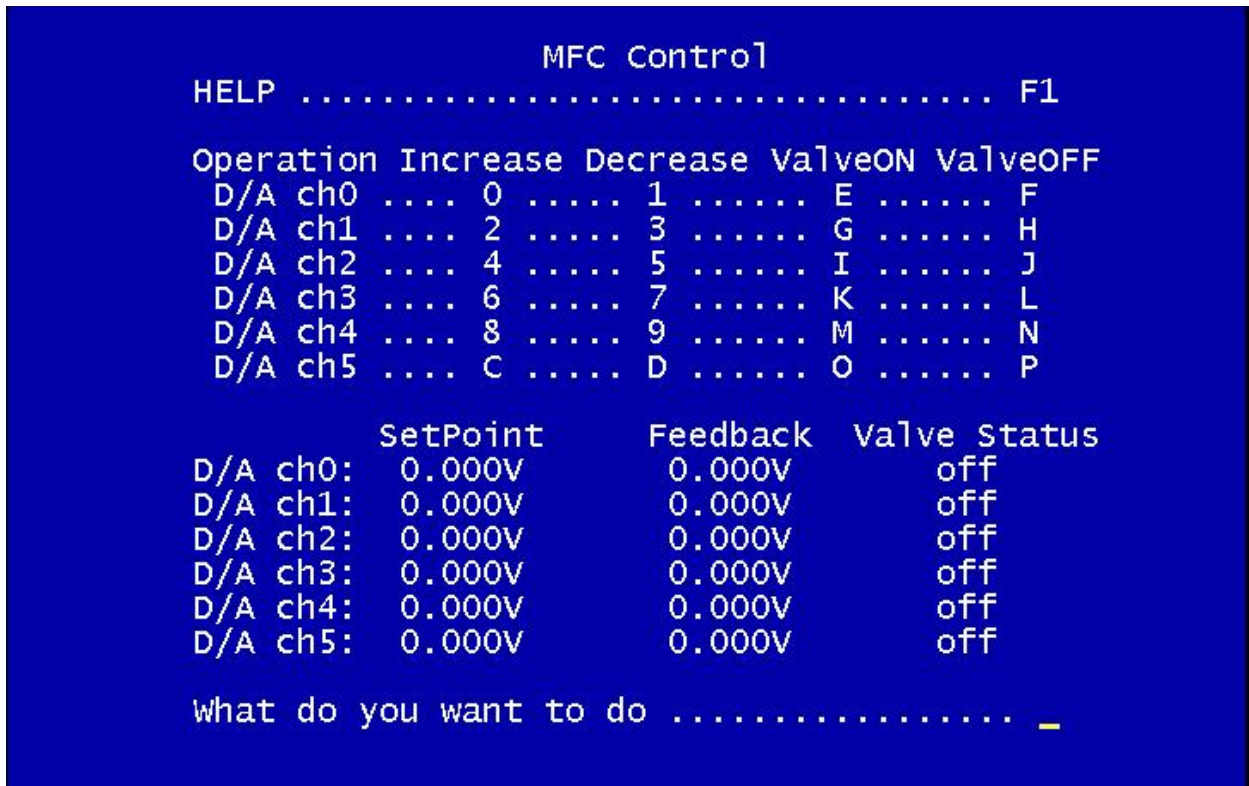


Figure 3-15. MFC Control Screen
DO NOT ATTEMPT THIS ON YOUR OWN

WARNING: The *MFC Control Screen* provides Factory or Certified Service Personnel with the ability to define specific parameters internal to the electronics of the system. This level of access is not recommended for normal system operational check. It is only supplied to help troubleshoot non-routine problems that may arise. If the operator does not take special precautions, the machine can be severely damaged, along with severe injury to people and equipment around machine.

3.7.3 BURR BROWN BOARD CONTROL (Function Key F3)

1. Press **[F3]** from the System Service Menu.
2. The *Burr Brown Board Control Screen* will appear (see Figure 3-16).

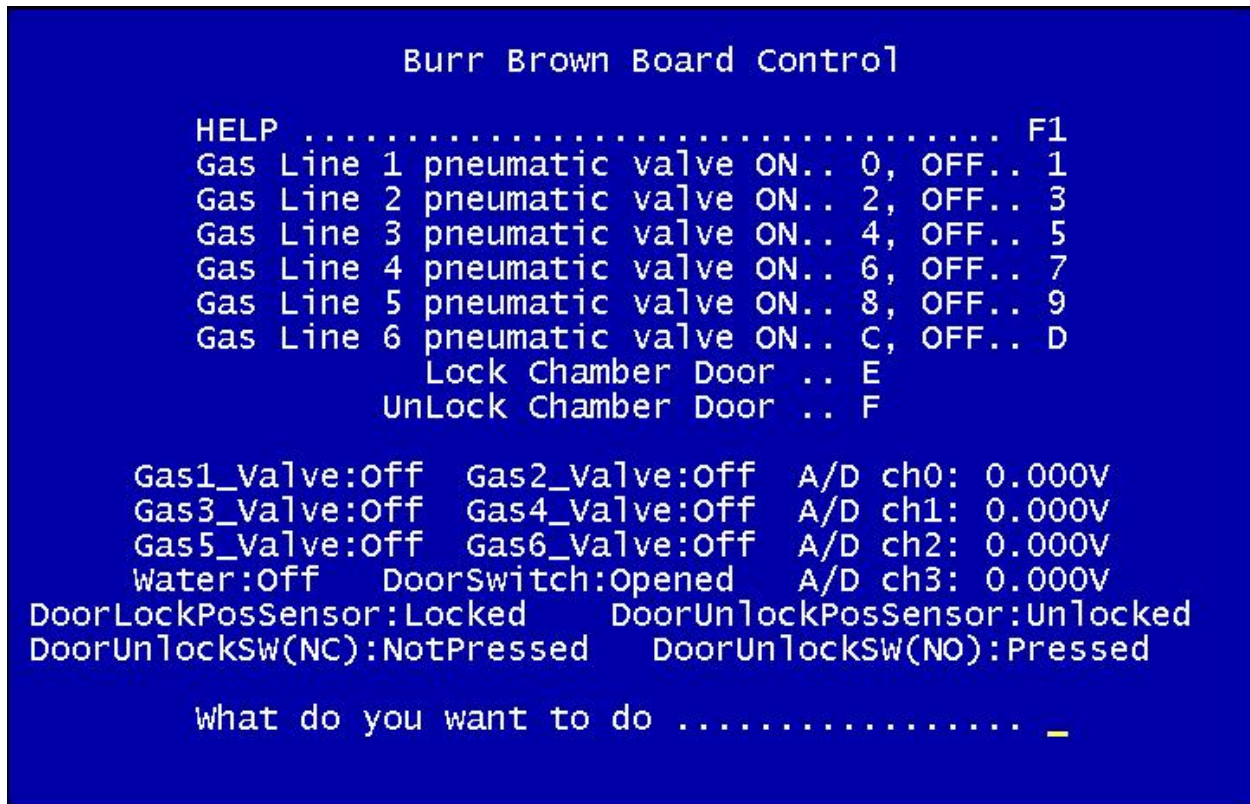


Figure 3-16. Burr Brown Board Control Screen
DO NOT ATTEMPT THIS ON YOUR OWN

WARNING: The *Burr Brown Board Control Screen* provides **Factory or Certified Service Personnel** with the ability to define specific parameters internal to the electronics of the system. This level of access is not recommended for normal system operational check. It is only supplied to help troubleshoot non-routine problems that may arise. If the operator does not take special precautions, the machine can be severely damaged, along with severe injury to people and equipment around machine.

3.7.4 BANK CONTROL (Function Key F4)

1. Press **[F4]** from the System Service Menu.
2. The *Bank Control Screen* will appear (see Figure 3-17).

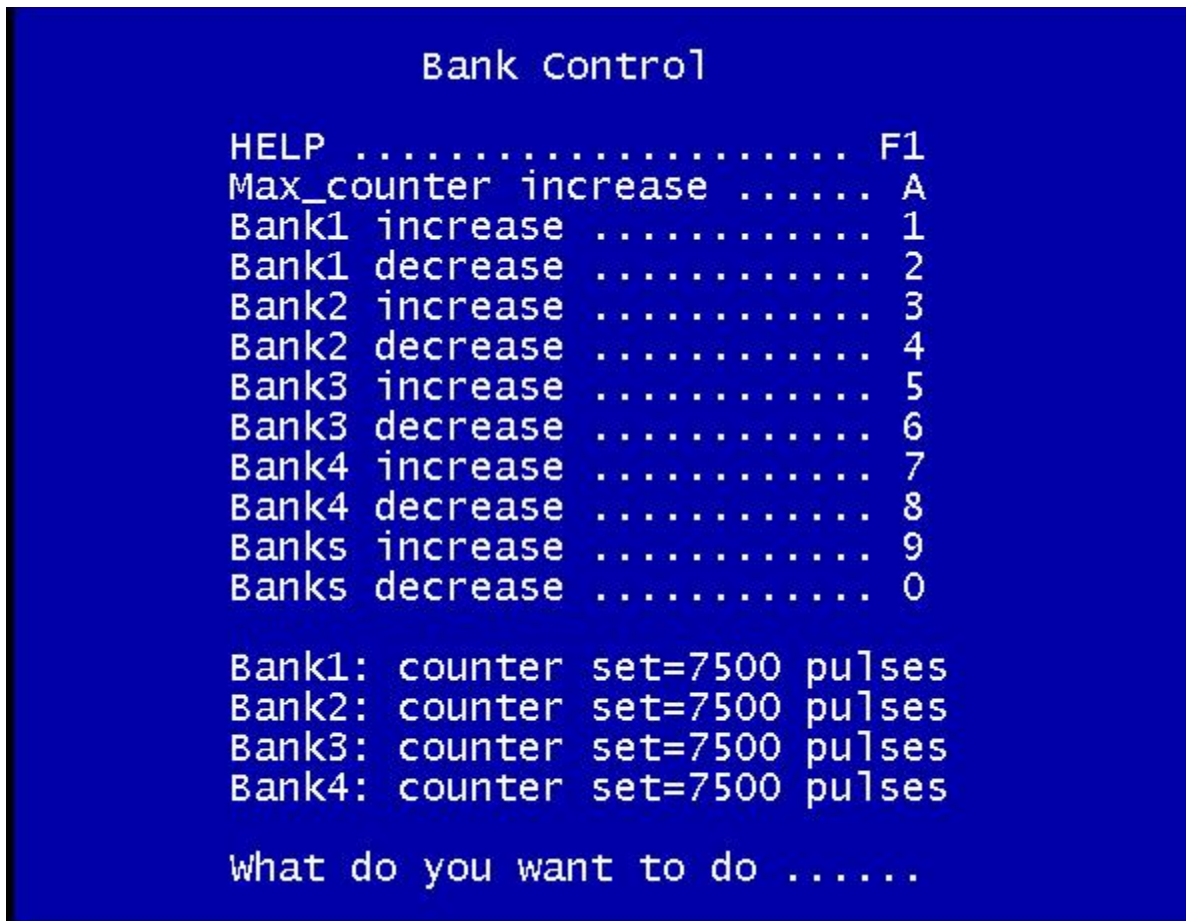


Figure 3-17. Bank Control Screen
DO NOT LOWER PULSES BEYOND 7000

WARNING: The *Bank Control Screen* provides Factory or Certified Service Personnel with the ability to visually monitor the **LOW LEVEL** turning on of the system's Lamps. This level of access is not recommended for normal system operational check. It is only supplied to help troubleshoot non-routine problems that may arise. If the operator does not take special precautions, the machine can be severely damaged, along with severe injury to people and equipment around machine.

The *Bank Control* (functionality check).

- a. Each bank is controlled by increasing or decreasing the number of pulses sent through its corresponding circuit. For example:
 - i. If you press the **2 key**, multiple times, the corresponding **bank1: counter set point** (located at the bottom of Figure 3-17), pulses will decrease and therefore allow lamps to turn on for that bank.
 - ii. A larger decrease in pulses corresponds to a higher intensity each lamp will output and therefore the temperature will rise inside chamber.

- iii. To turn lamps off, press the corresponding **Bank Increase Key** until set value reaches max value (7500) again or press **[ESC]** key to automatically stop all operations.
- b. Each individual bank, as well as the ALL bank function, operates in the same manner as stated above.

Note: Lamps will not turn on if **Power On** Button hasn't been engaged and **Top Cover Interlock Switch** hasn't been set as well as ensuring water flow is above 2.5 gal/ min.

WARNING: Decreasing the Bank Counter to less than 7,000 pulses can cause damage if left on for any length of time due to no lamp cooling gas flow. This test is an on/off check. If lamps appear to be on without reduction of pulses, then exit screen immediately and consult your service representative.

3.7.8 MANUAL CONTROL (Function Key F5)

1. Press **[F5]** from the System Service Menu.
2. The *Manual Control Screen* will appear (see Figure 3-18).

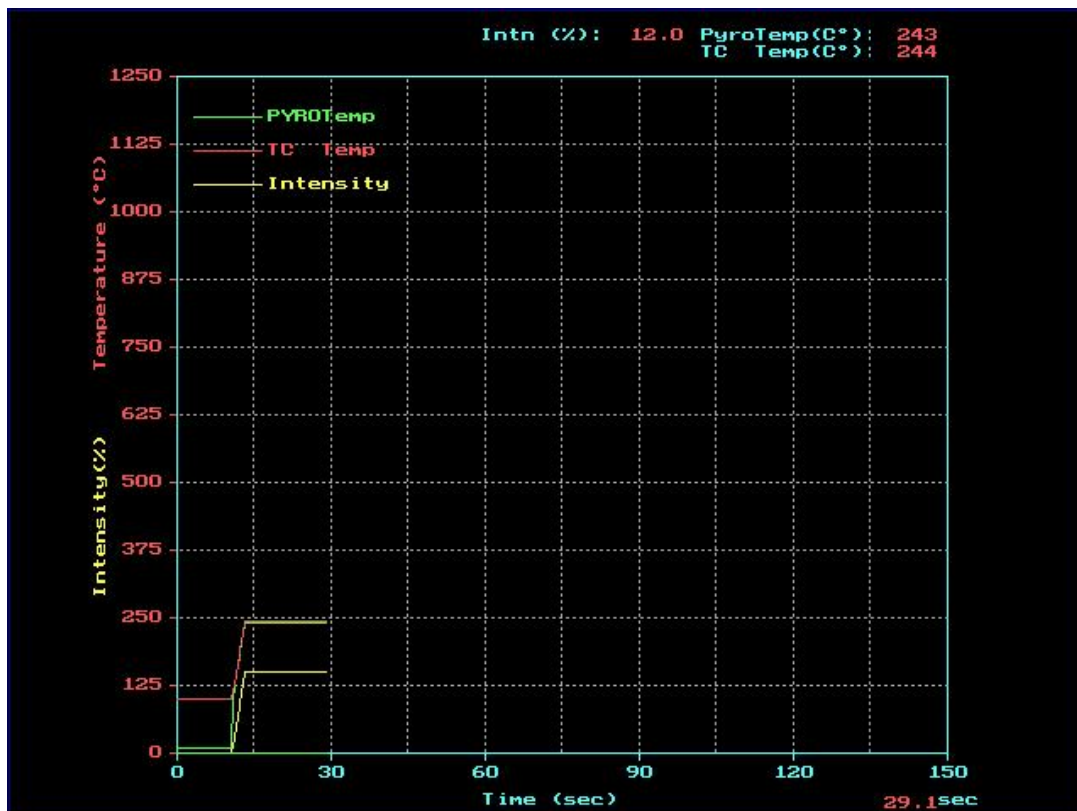


Figure 3-18. Manual Control Screen

Manual Control Screen, we can see a process run screen that indicates process temperature when the Lamp Intensity is manually increased or decreased.

Pyro Temp, TC Temp, and Intensity are plotted. Colors can be defined by your MPTC Service Engineer, but for this example – Green color means Pyro, Red color means TC and Yellow color means lamp intensity.

3.7.6 CHAMBER LAMP CALIBRATION (Function Key F8)... DONE AT THE FACTORY

1. The Chamber Calibration Data Screen provides **TRAINED FACTORY** Service Personnel with the ability to calibrate the RTP-600S Chamber automatically.
2. Press **[F8]** from the System Service Menu.
3. The *Lamp Calibration Data Screen* will appear (see Figure 3-23).

LAMP CALIBRATION DATA						
Copyright (C) Modular Process Technology Corp. Rev 2.01						
File Name	Calibrate	Engineer	Title	Factors and Wafer Type		
LAMP.WFR	NO, T		Old Data	1.00,	1.00,	1.00, WFR
LAMPCALI.WFR	YES, T		Old Data	1.00,	1.00,	1.00, WFR
SYS_LAMP.SPT	YES, T		Old Data	1.00,	1.00,	1.00, SPT
SYS_LAMP.WFR	YES, T		Old Data	1.00,	1.00,	1.00, WFR

F1:Help, F3:Copy to A:, F5:Rename, F6:Create New, F7:Translate to Text,
F10:View, Del:Delete, Space:Select/Unselect, Esc:to Main Menu

Enter:Edit Calibration Initial Parameter

Figure 3-23. Lamp Calibration Data Screen

Calibration of the chamber is necessary so the temperature control software understands the thermal dynamics of the process wafer as it is heated by the RTP chamber.

3.7.8.1 VIEWING HISTORICAL LAMP CALIBRATION FILES:

1. From the **Lamp Calibration Data Screen**, Select File Name whose data you wish to VIEW.
2. Press **[F10]**.
3. The *Historical Lamp Calibration File Curves* for that file will appear (see Figures 3-24.)

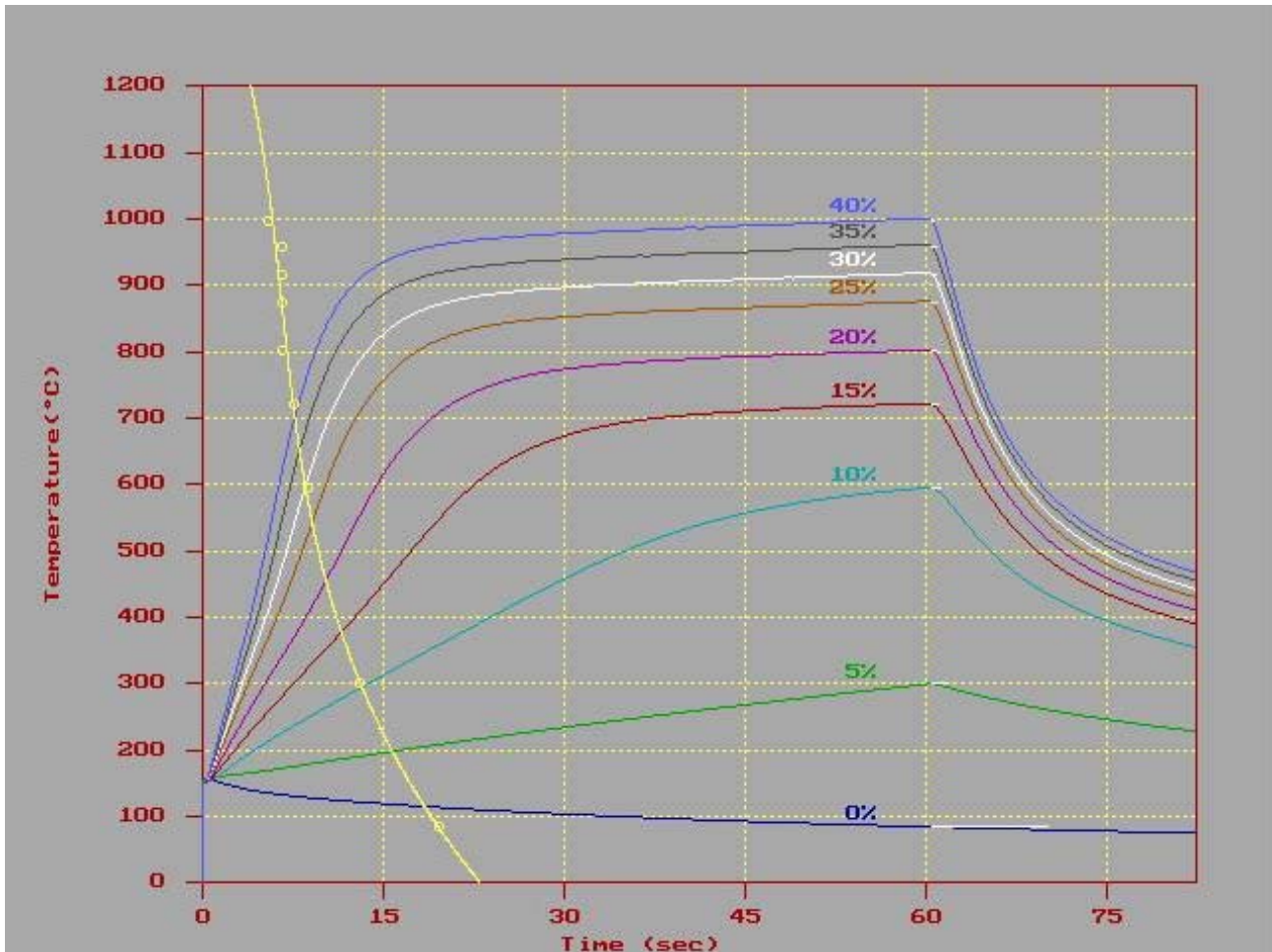


Figure 3-24. Historical Lamp Calibration Curve

4. Press [any key] and the *Historical Lamp Temperature vs. Intensity Curve* will appear (see Figure 3-25.)

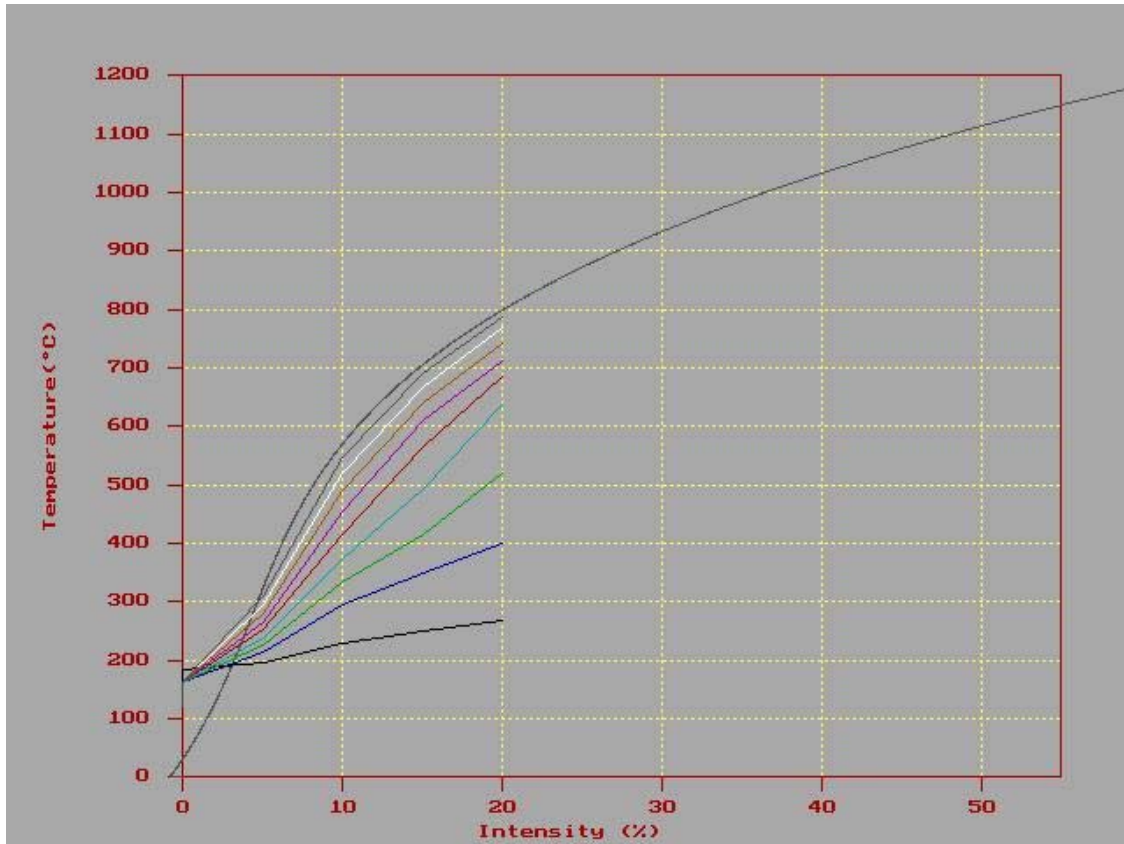


Figure 3-25. Historical Lamp Temperature vs. Intensity Curve

5. Press [any key] to return to the *Lamp Calibration Data Screen* (see Figure 3-23.)

3.7.8.2 CREATING A NEW LAMP CALIBRATION FILE:

1. From the Lamp Calibration Data Screen, Press [F6].
2. The Lamp Calibration Screen will appear (see Figure 3-24).



Figure 3-24. Lamp Calibration Screen

When Lamp Calibration is invoked with [F9] Calibrate, the Lamp Calibration process will not start until the **Initial Temperature (settable in the Lamp Calibration Screen)** is met. A suggested temperature is 210C. If it is below 210C, the lamp intensity will start to increase till the temperature reaches 210C. The calibration then starts. If the starting temperature is above 210C, the system will wait till it reaches 210C before the calibration starts.

Any existing Lamp calibration file can easily override the system calibration files, SYS_LAMP.SPT and SYS_LAMP.WFR, when Save-To-System is selected in the Edit screen. When conducting lamp calibration, you should use a different file name and select [F2] Save. Later, if you decide to make it SYS_LAMP.SPT or SYS_LAMP.WFR, simply select [F6] Save-To-System. This way you always have a back-up file.

When doing lamp calibration with a susceptor, use the following settings:

Maximum Temp = 1000C or less	Curve Begin	1
Initial Temp = 210C	Curve End	9
End Temp = 1000C or less	Curve Num	9
Gas – Nitrogen 3.0		

Intensity [1]	0	Intensity [2]	5	Intensity [3]	10
Intensity [4]	15	Intensity [5]	20	Intensity [6]	25
Intensity [7]	30	Intensity [8]	35	Intensity [9]	40
Intensity [10]	45	Intensity [11]	50	Intensity [12]	55
Intensity [13]	60	Intensity [14]	65	Intensity [15]	70
Intensity [16]	75	Intensity [17]	80	Intensity [18]	85

When doing lamp calibration with a susceptor, use the following settings:

Maximum Temp = 1250 or less	Curve Begin	1
Initial Temp = 210C	Curve End	9
End Temp = 1000C or less	Curve Num	9
Gas – Nitrogen 3.0		

Intensity [1]	0	Intensity [2]	5	Intensity [3]	10
Intensity [4]	15	Intensity [5]	20	Intensity [6]	25
Intensity [7]	30	Intensity [8]	35	Intensity [9]	40
Intensity [10]	45	Intensity [11]	50	Intensity [12]	55
Intensity [13]	60	Intensity [14]	65	Intensity [15]	70
Intensity [16]	75	Intensity [17]	80	Intensity [18]	85

3.7.8.3 LAMP CALIBRATION PROCEDURE:

During the lamp calibration procedure, either the Pyrometer or a TC can be used as the MASTER Indicator of Temperature. The RTP-600S temperature control hardware will use the temperature information so that the temperature control software understands the thermal dynamics of the process wafer as it is heated by the RTP chamber.

It is important that the chamber configuration be as close as possible to the actual configuration that is in use during customer processing. Use the same temperature control method, the same type of wafer, and the same type of internal chamber items (susceptor with lid for example) that will be used when processing your "real" wafers.

NOTE: Always run nitrogen purge gas during this procedure.

1. Make sure the quartz isolation tube and quartz tray are clean. Any opacity of the tube or tray will affect pyrometer readings.
2. Make sure that all hardware and facility conditions are stable.
3. Make sure that the configuration inside the chamber is as close to that to be used with "real" wafers as possible.
4. Make sure that the temperature control device is properly installed (if a TC is used) or properly calibrated (if the pyrometer is to be used).
5. From the *MAIN MENU*, Press [F10] and immediately type s y s (secret code to enter the System Service Screen).
6. From the Service Screen, Press [F8]. The Lamp Calibration Data Screen, will appear.
7. Select the file to over write or create a new file.
8. From Lamp Calibration Screen, verify settings
9. Press **[F9] Calibrate** to begin Lamp Calibration.
10. At the completion of the Lamp Calibration the **Lamp Calibration Screen** will appear. Press **[F2] Save** to save file to the directory. If you wish to also over write the system file, Press **[F6] Save to Sys**.
11. Press [esc] to return to the Lamp Calibration Data Screen.

SECTION 4: CHAPTER 1

HEATING CHAMBER

4.1.1 HEATING CHAMBER

The heating chamber contains upper and lower banks of high intensity, tungsten-halogen lamps (see **Figure 4-1**). There are 10 lamps on the top and 11 lamps on the bottom. The lamps emit radiant energy to heat the wafer. At low temperatures the wafer absorbs visible light, and at high temperatures it absorbs infrared radiation.

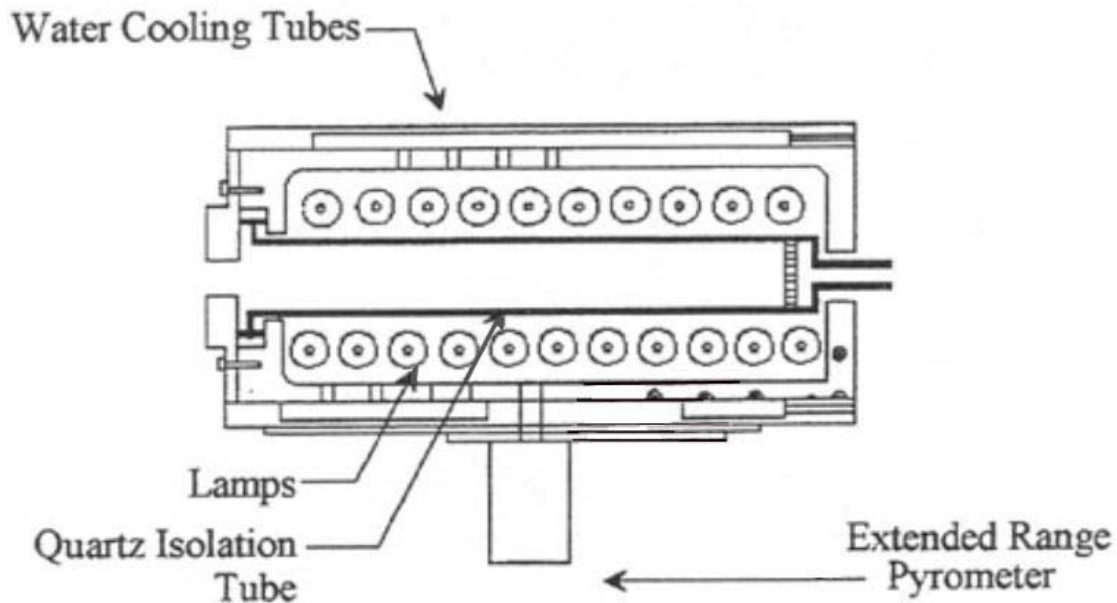


Figure 4-1. Heating Chamber and Components

Proprietary reflective plating on the oven walls intensifies the effect of the lamps. This plating reduces the lamp intensity needed for processing at high temperatures, thereby increasing the life of the lamp. The plating also enhances heating uniformity and ramp-up speed.

4.1.2 CLOSED-LOOP TEMPERATURE CONTROL

The RTP-600S temperature control system is a responsive closed-loop temperature monitoring system. The temperature of the wafer is monitored using a pyrometer or a thermocouple (TC).

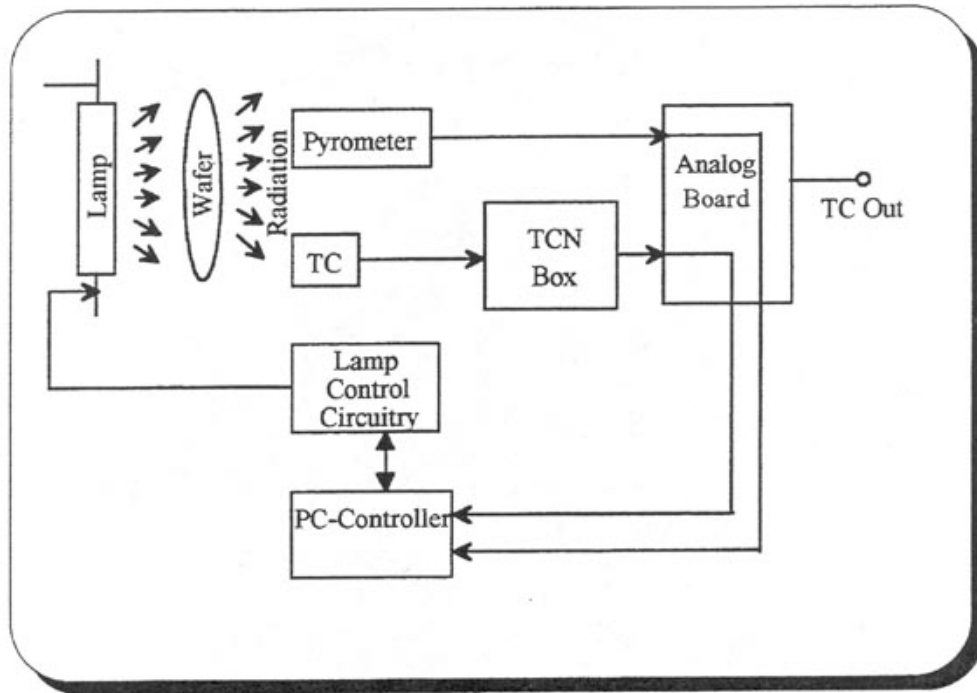


Figure 4-2. Temperature Signal Block Diagram

The TC signal is fed to the TCN Box, where it is linearized and scaled, and then to the Analog Board; the Pyrometer signal goes directly to the Analog board. The Analog Board performs A-D conversion, and the digitized signals are sent to the Controller, where time-temperature values are stored. The Controller sends command signals to the Lamp Control Circuitry, which controls the lamp intensities.

The system contains the following printed circuit boards: Controller Board, Analog Board, and Lamp Control Circuitry consisting of a Timer Board, OCB Board, and Zero-Crossing Board. All of these boards are in the system cabinet, behind the front panel. The Analog Board performs the A-D conversions and transfers signals from the temperature sensors to the Controller. The Timer Board receives lamp intensity data from the Controller for the purpose of controlling the firing of the SCR feeding power to each lamp. The OCB Board is the interface between the lamps and the Timer Board. The Zero-Crossing Board detects the AC-voltage as each alternation crosses through zero volts, when it signals the Timer Board to start counting. When the Timer Board finishes counting it tells the OCB Board to fire the lamp's SCR.

SECTION 4: CHAPTER 2

TEMPERATURE MEASUREMENT INSTRUMENTS

4.2.1 USES OF THE PYROMETER & THERMOCOUPLE

The RTP-600S system has two types of temperature monitoring devices: a pyrometer and a thermocouple.

The thermocouple is used below 800^o C for silicon wafer processing and below 950^o C for susceptor processing.

4.2.1.1 The Pyrometer

The pyrometer design is proprietary and is noted for its fast response time and low service requirements.

The pyrometer (which is discussed in detail in the following section) is attached to the bottom plate of the oven. The pyrometer remains permanently in place, even when not in use. Radiation from the wafer reaches the pyrometer by passing through the bottom of the transparent quartz isolation tube and through a small opening in the oven floor. The pyrometer converts light energy to a voltage.

The Extended Range Pyrometer (ERP_{PLUS}) is a dual infrared detector, which provides accurate and consistent temperature measurement during rapid thermal processing of semiconductor wafers. The ERP_{PLUS} measures wafer temperature by detecting infrared radiation emitted from the wafer at specified wavelengths. The resulting signal is then adjusted for non-wafer radiation sources.

During extended heating cycles, the temperature of the RTP quartz isolation tube gradually increases and distorts pyrometer temperature measurement. To insure consistently accurate temperature measurements throughout all phases of the heating cycle, the quartz tube is cooled with compressed air, which maintains its temperature within a specified range.

However, wafer temperature measurement is a complex issue, requiring consideration beyond merely cooling the pyrometer and quartz isolation tube. To accurately measure wafer temperature inside an RTP heating chamber, undesired radiation emitted from non-wafer sources must be compensated for or filtered out. Sources of undesired radiation include the tungsten-halogen heating lamps and infrared energy emitted from the isolation tube. **Figure 4-3** shows the distribution of each primary source of radiation within the heating chamber.

The ERP_{PLUS} incorporates a bandpass filter, operating in a proprietary range, to eliminate the measurement of wavelengths shorter than a specified cutoff wavelength. This minimizes the effects of radiation from the tungsten halogen lamps. The selective use of wavelengths also optimizes the detection of radiation from the wafer at lower temperatures.

Standard pyrometers measure wafer temperature by "looking" at the wafer through the quartz isolation tube. During part of the wafer processing cycle, this tube appears opaque to the ERP_{PLUS}. To eliminate this problem, a proprietary "window" has been installed into the bottom of the tube. Mounted below a small hole in the bottom plate of the RTP heating chamber, the ERP_{PLUS}'s Wafer-Sensing Pyrometer measures the wafer temperature through this opening (see **Figure 4-1**). To further ensure accuracy, pyrometer circuitry calibration is performed using thermocouples attached to sample wafers in the heating chamber.

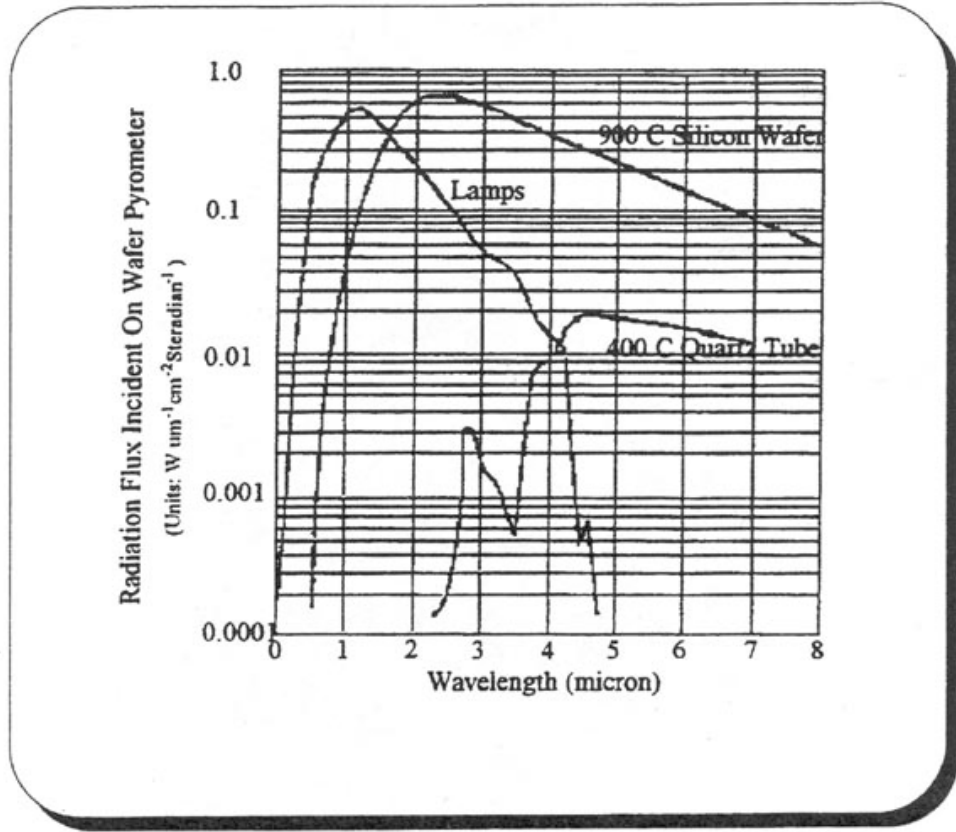


Figure 4-3. Radiation Distributions

PYROMETER PLACEMENT:

The internally cooled extended range pyrometer (ERP+) is attached to the bottom plate of the oven. The pyrometer remains permanently in place, even when not in use. Radiation from the wafer reaches the pyrometer by passing through the bottom of the transparent quartz isolation tube and through a small opening in the oven floor. The pyrometer converts light energy readings to a voltage.

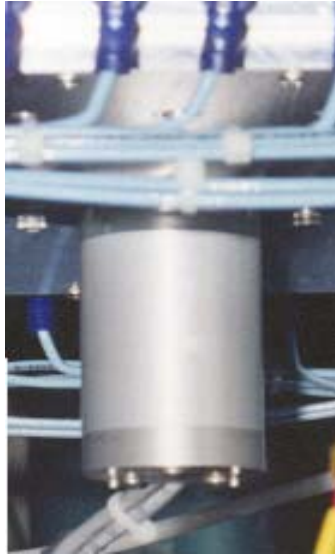


Figure 4-4. INSTALLED PYROMETER Photograph

4.2.1.2 The Thermocouple

The TC assembly is used for several functions in the RTP-600S.

- Calibrating the system pyrometer.
- Susceptor processing for temperatures under 950 °C.
- Wafer processing for temperatures under 800°C.
- Calibrating individual pyrometer recipe files

The K-type thermocouple is situated inside the quartz isolation tube. Thermocouple life is shortened by continuous operation at temperatures higher than 950°C or with the use of process gases other than Nitrogen or Argon.

The thermocouple is to be removed and the calibrated pyrometer used for continuous processing of silicon wafers for temperatures above 800°C or for susceptor processing above 950 °C.

The thermocouple assembly can be of the following types:

- **Cantilever TC Assembly:** This type is a 10-mil type K chromel-alumel bead thermocouple in direct contact with the backside of the wafer. The thermocouple is held against the wafer by two spring wires, which also serve as the thermocouple leads. The Cantilever thermocouple is distinguished by its use of the small thermocouple bead.
- **TC Wafer Assembly:** This is a type K chromel-alumel thermocouple that is cemented to a wafer. The cement used is a sodium-free ceramic cement (see **Figure 4-5**). The TC Wafer assembly is typically used for the calibration of the pyrometer or as a carrier for small pieces of R&D samples needing to be annealed.
- **Inconel TC Assembly:** This is a type K chromel-alumel thermocouple that is sheathed in Inconel. This assembly is used with the susceptor process.

For thermocouple assemblies, the two thermocouple wires run through a ceramic/or "other insulating material" tube to a type K connector on the inside of the oven door. The wires are run through gas-tight seals in the door to a terminal block on the front of the door, inside the faceplate.

Thermocouple voltages are fed to a temperature compensation circuit. The thermocouple compensation circuit contains an analog linearizing circuit, with an output calibrated to 1 mV per degree centigrade. The signal is digitized (see **Section 4.1.2**) and sent to the Controller for the temperature control system.

The TC Wafer assembly (see **Figure 4-5**) has a thermocouple embedded in and cemented to the wafer.

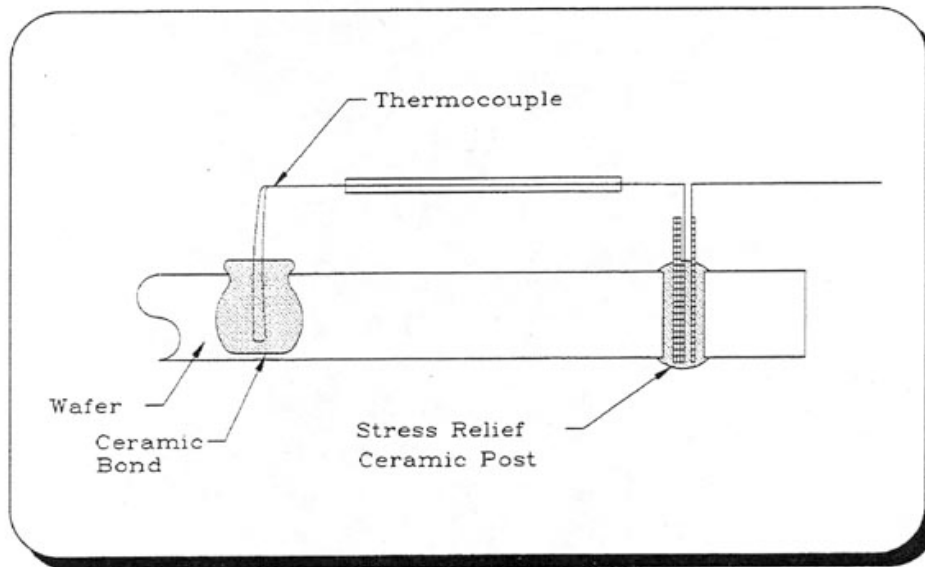


Figure 4-5. TC Wafer Assembly

4.2.2 SELECTION OF TEMPERATURE MONITOR

To select the type of temperature sensor to be used (pyrometer or thermocouple), use the RTP-600S software

4.2.3 THERMOCOUPLE INSTALLATION AND PERFORMANCE CHECK

The TC assembly may be used in place of the pyrometer for the measurement of oven temperature.

4.2.3.1 Installing the Thermocouple

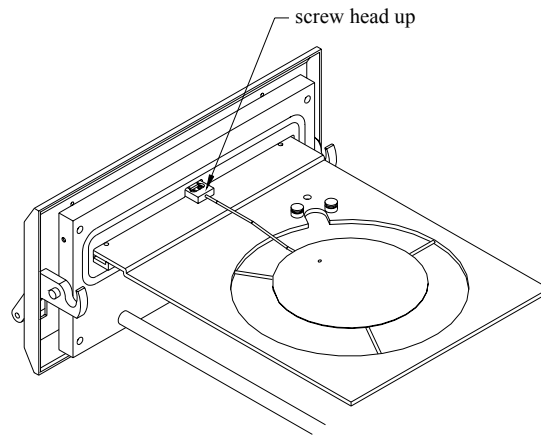
Wear the gloves whenever you are handling oven quartz ware or TCs. When the thermocouple is installed, its operation should be checked before it is used for processing wafers.

4.2.3.2 Checking Thermocouple Operation

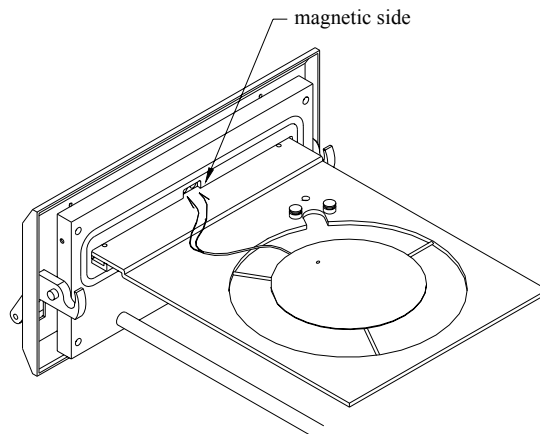
1. Power-up the system if it is off.
2. From the **Main Menu** to go to the **System Diagnostics** screen.
3. Insure that the TC Assembly is installed correctly.
4. Enable the lamps, and increase the lamp intensity to 15%.
5. Observe the temperature feedback of the thermocouple display
6. Upon successful monitoring of temperature feedback the system is ready for TC controlled processing.

4.2.4 Drawings showing Installed TC Assemblies

Drawing showing Modular Process Technology's single point K-type instrumented TC wafer installed in an RTP-600S.



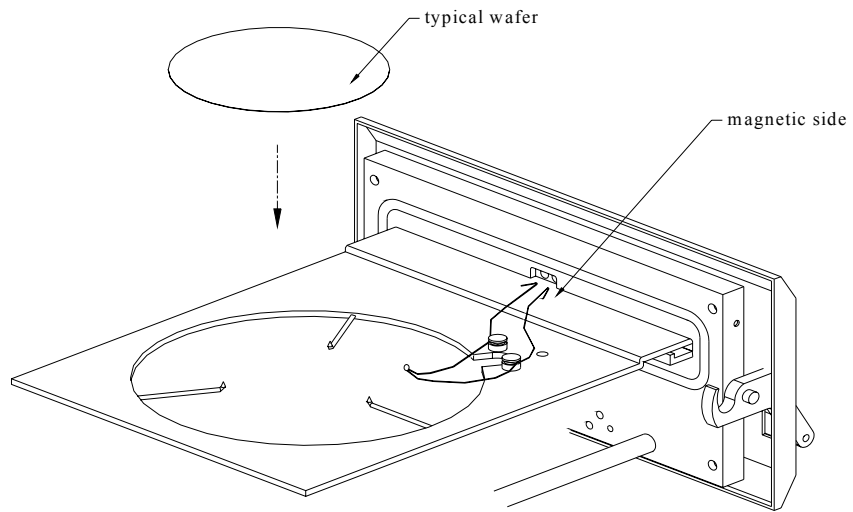
OR



NOTE: When using the TC Wafer Assembly, it is best to use a process specific customer wafer with the exact process front side and backside conditions. For the customer TC wafer, place the backside of the TC wafer toward the pyrometer.

When a customer wafer TC Assembly is not available, a TC Assembly made using a prime wafer of the same process material as is used by the customer is an excellent alternative. For the Prime Wafer TC wafer, place the polished surface of the TC wafer toward the pyrometer to eliminate the issue of non-repeatable TC Calibration Wafer backside conditions.

Drawing showing Modular Process Technology's single point K-type Inconel TC Instrumented susceptor installed in a RTP-600S.



SECTION 4: CHAPTER 3
QUARTZWARE SERVICE

4.3.1 INTRODUCTION

The quartz wafer tray and isolation tube may need to be removed for cleaning if they become contaminated. A severely contaminated tube will decrease the amount of energy reaching the wafer. Any opacity will reduce radiated energy reaching the pyrometer and affect temperature measurement.

This section describes the procedure for removing and installing the wafer tray and isolation tube for routine cleaning or replacement.

Thermal processing occurs inside a quartz isolation tube located between the upper and lower lamp banks (see **Figure 4-1**). The wafer being processed rests on a quartz wafer tray inside this isolation tube (see **Figure 4-6**).

The wafer tray is held in position by a holding device on the inside of the oven door. The tray can be easily removed for cleaning, size change, or thermocouple replacement. One tray is supplied with the RTP-600S System. Trays for other sizes of wafers, as well as Slip Free Ring Trays, TC's and susceptors, are available as options.

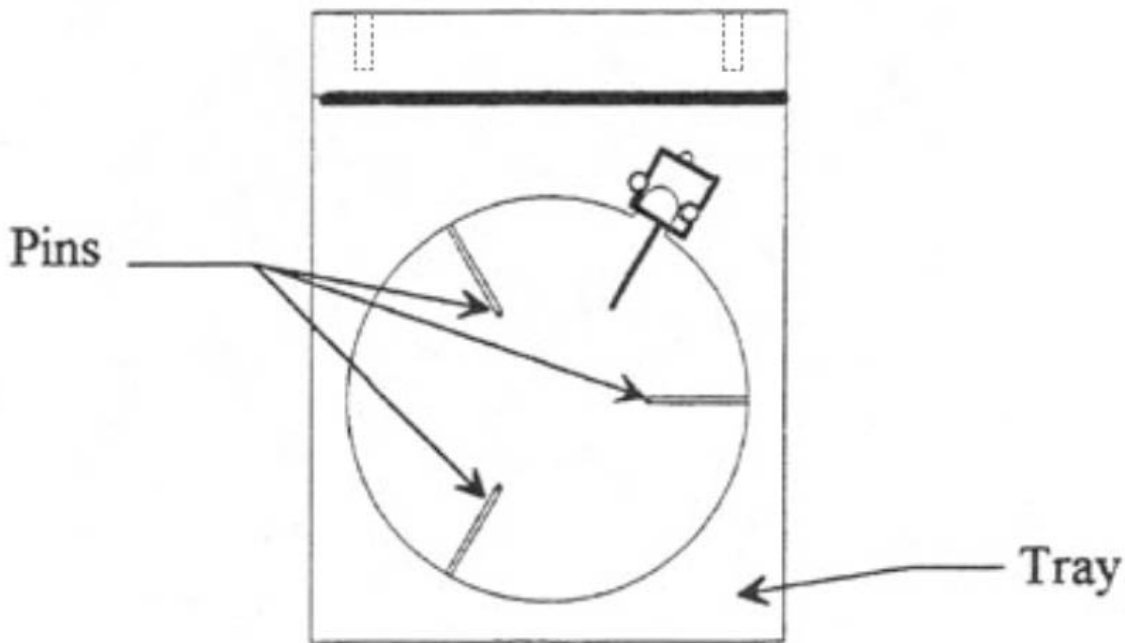


Figure 4-6. Wafer Tray

4.3.2 QUARTZWARE REMOVAL

Tools and Supplies:

- Allen wrench set (US type)
- Phillips screwdriver
- Latex gloves
- 0.050 Allen Head wrench

WARNING: Make sure the wall circuit breaker for the RTP-600S is off and be sure the system is cool before handling.

CAUTION: Always use latex gloves when handling quartz ware.

NOTE: See Sections 6.6.1 & 6.6.2 for additional information.

4.3.2.1 Isolation Tray Removal

1. Shut off power from the system. If a thermocouple is not being used, go to Step 3.
2. Open the oven door and pull it out half way. Put on latex gloves. Disconnect the thermocouple at the terminals on the inside of the oven door. Remove and store Thermocouple.
3. Pull the oven door fully out. Put on latex gloves. Use 0.050 Allen Head wrench to push door flange o-ring forward/out of the way (without damaging the o-ring) and then loosen the two tray set-screws.
4. Lift out the wafer tray, taking care not to strike the tray against the oven door or any other hard object (Note: Store the tray on a clean surface, preferably of quartz ware).

4.3.2.2 Isolation Tube Removal

1. Remove the top cover of the system cabinet by first removing the cabinet screws and then lifting on the rear of the cover and lifting the complete cover upward.
2. Remove the eight flange screws on the door flange plate (see **Figure 4-7**). Be careful not to drop the O-ring inserted in the groove on the surface of the plate. Allow the flange to rest on the door rails.
3. Remove the knurled gas connector fitting (see **Figure 4-8**).
4. Remove the gas connector. (Note: A nipple on the rear of the quartz isolation tube fits into an O-ring in the gas connector.)
5. Gently press the nipple forward to loosen the quartz isolation tube.
6. Remove the O-ring.
7. Reach into the oven and carefully extract the tube. Do not bump it against the chassis or heat lamps.

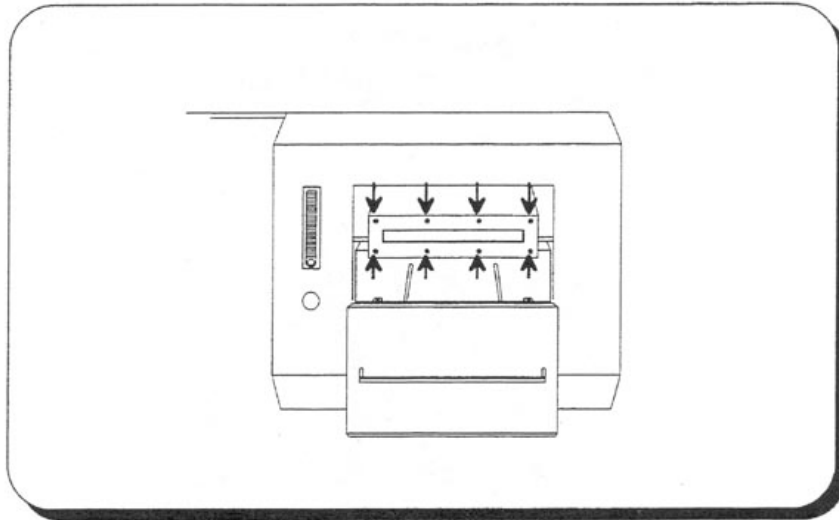


Figure 4-7. Front Flange Screw Locations

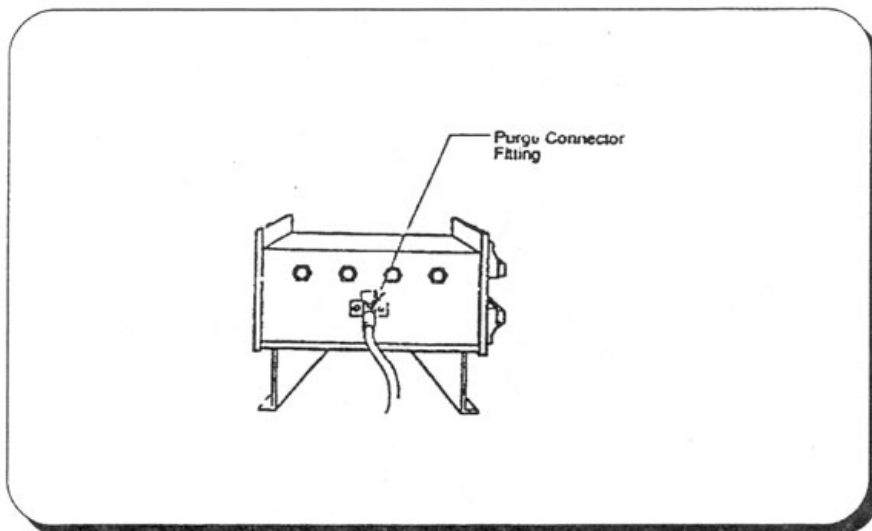


Figure 4-8. Rear Access To Quartz Isolation Tube

4.3.3 QUARTZWARE INSTALLATION

Tools and Supplies:

- Allen wrench set (US type)
- Phillips screwdriver
- Latex gloves
- 0.050 Allen Head wrench

WARNING: Make sure the wall circuit breaker for the RTP-600S is off and be sure the system is cool before handling.

CAUTION: Always use latex gloves when handling quartz ware.

NOTE: See Sections 6.6.1 & 6.6.2 for additional information.

4.3.3.1 Isolation Tube Installation

1. Step 1. Examine the O-ring on the heating chamber flange surface. If it is damaged or burned, replace it.
2. Step 2. Install the isolation tube by inserting it straight back into the heating chamber. The isolation tube contains a small window. The tube should be inserted with the window on the bottom.

CAUTION: Use caution when inserting the isolation tube in the chamber to make sure that you do not strike the lamps. The tube nipple must be inserted through the hole in the rear of the oven.

3. Step 3. When the tube is fully inserted, wiggle it slightly to ensure that it is fully positioned on the inner O-ring. The front lip of the tube should then be flush with the outer surface of the oven flange.
4. Step 4. Inspect the O-ring on the outer flange plate. Check it for damage or wear. Replace it if necessary.
5. Step 5. Press the outer flange plate against the tube lip, and re-install the eight screws that hold the assembly together. Be sure to tighten the screws uniformly, by tightening each screw a little at a time, in a star pattern.
6. Step 6. Slip the small O-ring onto the rear nipple, and reconnect the outer half of the inlet fitting, finger tight. Always use a new O-ring.
7. Step 7. Re-install the top cover of the RTP-600S system.

4.3.3.2 Wafer Tray Installation

Tools and Supplies:

- Allen wrench set (US type)
- Phillips screwdriver
- Latex gloves
- 0.050 Allen Head wrench

WARNING: Make sure the wall circuit breaker for the RTP-600S is off and be sure the system is cool before handling.

CAUTION: Always use latex gloves when handling quartz ware.

8. **NOTE:** See Sections 6.6.1 & 6.6.2 for additional information. The tray rests on the lip on the inner side of the oven door, and is supported by its own weight. The wafer tray must be leveled with respect to the oven (see **Section 4.3.4**).
9. Step 1. Pull the oven door fully out. Use 0.050 Allen Head wrench to push door flange o-ring forward/out of the way (without damaging the o-ring) and then loosen the two tray set-screws.
10. Put tray onto door support, taking care not to strike the tray against the oven door or any other hard object.
11. Use 0.050 Allen Head wrench to tighten the two tray set-screws.
12. Push door flange o-ring back into place and then proceed to Section 4.3.4 to level the tray.

4.3.4 WAFER TRAY LEVELING

When a new wafer tray is installed it must be leveled. This helps maintain consistent heating uniformity. The procedure is as follows:

Tools and Supplies:

- Allen wrench set (US type)
- Bubble level
- Ruler
- Latex glove
- 0.050 Allen Head wrench

NOTE: See **Section 6.6.2** for additional information.

1. Close the oven door until the edge of the tray is flush with the oven flange. (See Figure 4-9, part (a)). Using a ruler, measure the distance from the bottom of the oven flange to the top edge of the wafer tray. Measure the tray on both sides to verify that it is level from side-to-side.

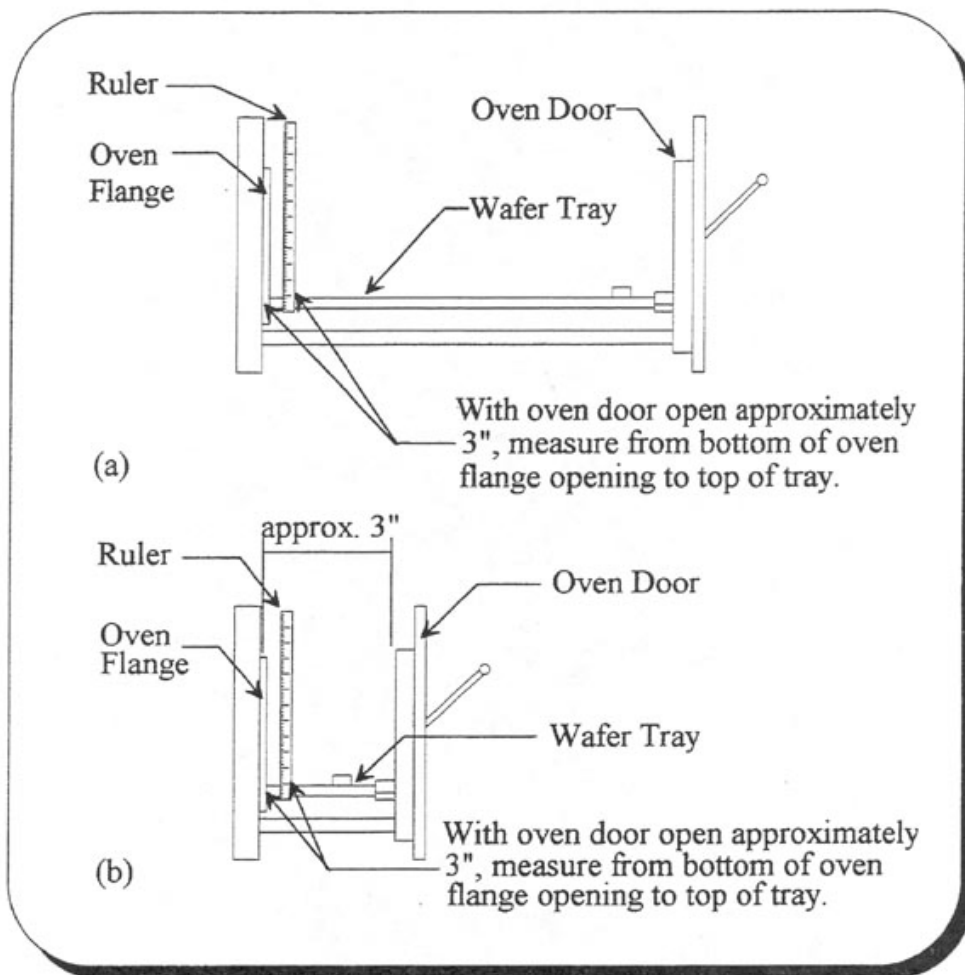


Figure 4-9. Leveling the Wafer Tray

2. If the tray is level from side-to-side, go on to the next step. If the tray is not level from side-to-side, then adjust the tray using the leveling screws. The level of the tray should be adjusted so that the end of the tray is centered with the opening in the oven flange (see **Figure 6-8** for the locations of the tray leveling screws). Once the tray has been leveled from side-to-side, note the distance from the bottom of the oven flange to the top edge of the wafer tray.
3. Close the oven door until it is open about 3 inches. Using a ruler, measure the distance from the bottom of the oven flange to the top edge of the wafer tray. This distance should be the same as the distance noted in Steps 1 and 2 above. If it is the same, then the wafer tray is level. If it is not the same, then the tray needs to be leveled from front-to-back using the leveling screws.
4. Repeat Steps 1 through 3 to verify that the wafer tray is level. The distance should be the same between the bottom of the oven flange and the top of the wafer tray on both sides of the tray with the door almost open and near the front of the tray with the door open only 3 inches.

NOTE: There may be some movement of the tray from left to right. This is normal and should not be a reason for concern.

5. Place a wafer on the tray. Slowly close the door of the heating chamber. Listen for any scraping sounds, which indicate that the quartz is not properly aligned. If you notice any scraping sounds or resistance to door movement, realign the tray and repeat this step.

CAUTION: To avoid damaging the quartz tray, never force the heating chamber door.

4.3.5 QUARTZWARE CLEANING

NOTE: The quartz ware isolation tube and the quartz wafer tray must be always handled with latex gloves to avoid contamination.

To ensure uniform wafer heating, the quartz isolation tube and the wafer tray must be kept clean. Thin films deposited on the quartz ware may not be visible. If there is a loss of heating uniformity, clean the isolation tube and wafer tray, even if no deposits are visible. The quartz ware should also be cleaned prior to performing a temperature calibration.

WARNING: Always use caution when handling chemicals to prevent injury or burns. Follow standard Semiconductor Acid safety procedures.

CAUTION: Be very careful not to break the pins when cleaning and handling quartz wafer trays.

1. Obtain the following cleaning materials:
 - Concentrated Nitric Acid
 - Semiconductor Grade Soap
 - Semiconductor Grade Sponge / Cleaning Pad or Cleaning Brush
 - 10% Hydrofluoric Acid
 - Deionized Water
 - Clean Dry Nitrogen
2. If stains / deposited material are visible on the quartz ware, scrub with "hot" (warm to the touch) deionized soapy water until all visible residue is removed.
3. Rinse with deionized water for 10 minutes.
4. If stains are still visible on the quartz ware, soak in concentrated nitric acid; otherwise, proceed to Step 6.

5. Rinse with deionized water for 10 minutes.
6. Soak in 10% hydrofluoric acid, for no longer than 1 minute, or excessive etching will occur.
7. Rinse with deionized water for 10 minutes.
8. Blow quartz ware dry with clean, dry nitrogen.

4.3.6 QUARTZWARE STORAGE

When storing the quartz ware, it is extremely important to do so with the minimum possibility of contamination. Even thin films of contaminants not visible to the naked eye can effect heating uniformity and/or contaminate wafers being processed.

SECTION 4: CHAPTER 4

COOLING SUBSYSTEMS

The heating chamber incorporates two cooling subsystems:

- A water cooling subsystem for the oven walls and door
- An air (or nitrogen) cooling subsystem to reduce residual heating of the quartz tube

The oven's water system remains on continuously for as long as the "Power On" switch is on. The air/nitrogen system provides a continual flow through the system cabinet; this removes residual heat from the chamber.

4.4.1 OVEN COOLING SUBSYSTEM

The water-cooling subsystem protects the heating chamber from overheating, and ensures rapid cool down at the termination of each steady-state temperature period. The subsystem circulates water through cooling tubes in the oven walls and door. It includes several components:

- An on/off solenoid valve that enables water flow whenever the "Power On" switch is on. The RTP-600S system switches the water flow off and on, respectively, when the "Power On" and "Power Off" switches are pressed.
- A flow sensor is connected directly to the lamp power supply to disable the lamps if water flow falls below 2.5 GPM.

4.4.2 QUARTZ TUBE COOLING SUBSYSTEM

When the system is in continuous use (e.g., long-period processing), excess infrared radiation from the hot wafer raises the quartz tube temperature. The tube cooling subsystem prevents the tube from reaching excessive temperatures.

Compressed clean, dry air (or nitrogen) is blown through holes in the top and bottom of the oven. This air circulates around the outside of the quartz tube and disperses through the lamp sockets. The compressed air (or nitrogen) must be *water-free*, *oil-free*, and *particulate-free*. It must be delivered to the RTP-600S at a flow rate of 10 to 15 SCFM.

SECTION 4: CHAPTER 5

GAS HANDLING SUBSYSTEM

4.5.1 OVERVIEW

The RTP-600S incorporates a multi-gas process subsystem, which provides a versatile, contamination-free wafer environment. The process gases may include inert argon or nitrogen, and/or gases that take an active part in wafer processing, such as oxygen, ammonia, nitrous oxide, and forming gas. In this manual, the term "process gas" refers to either or both types, whichever is in use.

Process gases enter the system at the rear utility panel of the RTP-600S cabinet, and go through the MFC's inside the cabinet. The process gases are carried within the RTP-600S by stainless steel tubing.

Gas enters the oven through a sealed extension on the rear of the quartz isolation tube. During thermal processing, the door seals against a stationary metal flange, which in turn is sealed against the front opening of the isolation tube. This creates a hermetically sealed processing environment. The gas leaves the isolation tube through a single hole in the flange. It is then delivered via tubing to the rear utility panel for exhausting.

WARNING: It is important to exhaust process gases of all types to a safe exhaust system, outside the processing area.

4.5.2 GAS COMPATIBILITY FEATURES

Gas Groups in RTP-600S Rev. 2.01:

- a. Active Agents: H₂, N₂/H₂, Ar/H₂, NH₃
- b. Oxidizers: O₂, O₃, N₂O
- c. None of the above: N₂, Ar, He

Group a) and b) are incompatible. Group c) is compatible with either Group a) or b).

Recipe Validation Rules on Gas Compatibility:

1. Only Group c) gases are allowed in the first step and the last step of a recipe.
2. Group a) gas and Group b) gas cannot be present in the same step.
3. Minimum purge before a step with gases in Group a) or Group b) is 600 (second*SLPM).
4. Minimum purge after a step with gases in Group a) or Group b) is 600 (second*SLPM).
5. Minimum purge after the last step with gases in Group a) or Group b) and before the end of the recipe is 1800 (seconds*SLPM)

Gas Purge Features in Diagnostics Screen:

When a pneumatic valve is attempted to open:

1. If a single gas line is chosen, you may set desired flow rates and should see flow feedback; and/or
2. If multiple gas lines are chosen, the software will check compatibility and prevent both Group (a) and Group (b) gases flowing at the same time.
3. A pre-purge and a post-purge are implemented for all Group (a) and Group (b) gases.

Gas Restriction in Pyrometer and Chamber Calibrations:

Gases selectable for pyrometer or chamber calibrations is limited to Group c) only.

4.5.3 EXHAUST PLUMBING

Process gases are carried out through the chamber exhaust on the back of the RTP-600S cabinet. Depending on the process gases being used and the type of wafers being processed, the exhaust may be toxic and hazardous. In this case, the chamber exhaust must be connected to a facility scrubber.

SECTION 5: CHAPTER 1 MAINTENANCE AND DIAGNOSTICS

5.1.1 PREVENTIVE MAINTENANCE

Preventive maintenance checks should be performed on a weekly and quarterly basis to ensure consistent operation of RTP-600S.

WARNING: Switch off the power to the heating chamber at the wall breaker whenever you remove the cover. Even when the panel switch is in the "OFF" position, there is power to the triac plate, on top of the oven.

5.1.1.1 Weekly Maintenance

- **Water flow** -- Connect an external flow meter in series to the water inlet line. Check the flow, and replace the filter if water flow drops below 2.7 GPM. Check the chiller water level to ensure that the level hasn't fallen below the low water level marker.
- **Cleanliness** -- Check the quartz isolation tube and wafer tray for contamination. Also inspect the heating chamber for signs of water and particles. If the quartz ware is dirty, clean it according to the instructions in **4.3.5**.
- **Leakage** -- If cross contamination is not an issue, run a Titanium Silicidation Anneal to ensure that the quartz isolation tube is hermetically sealed.
- **Thermocouple** (if the thermocouple is connected) -- When the system is cold, check the temperature from the system diagnostics screen. It should display ambient temperature. Increase the lamp intensity and check for temperature rise. Note that to do this the cover must be on the unit or the interlocks must be overridden.
- **Lamps** -- Check uniformity: run a test wafer and measure the resistivity uniformity. Compare the values with those obtained on the wafer measured when the unit was first installed. If the uniformity measurements are unacceptable, check the continuity of the lamps using an ohmmeter (refer to **Section 5.1.3.1**).

5.1.1.2 Quarterly Maintenance

- **Oven** -- Inspect for frayed or damaged wiring to lamps. Check the front flange O-ring for burning or other damage
- **Interlocks** -- Check the water interlock by turning off water supply to the system and trying to run a process cycle via the RTP-600S software. Check the door interlock by opening door and trying to run a process cycle via the RTP-600S software. The interlocks should prevent the process being run.
- **Quartz** -- Inspect the quartz isolation tube and wafer tray for signs of cracking, chipping, or other unusual wear. If the quartz ware is dirty, clean it according to the instructions in **4.3.5**.
- **Leakage** -- If cross contamination is not an issue, run a Titanium Silicidation Anneal to ensure that the quartz isolation tube is hermetically sealed.
- **Lamps** -- Visually inspect lamp sockets for cracks or discoloration.
- **Water** -- Inspect for water leaks and bad hoses. Check the water flow against the last quarterly flow reading. If the flow is significantly lower, change the filter. If this does not correct the flow, check the water lines for clogging by checking differential pressure across the oven.

5.1.2 DIAGNOSTIC CHECK

The system diagnostic check consists of two procedures. The first procedure tests the heating chamber control, and the second procedure ensures that the heating chamber is communicating with the controller.

5.1.2.1 Heating Chamber Control

This test verifies that the lamps are turning on properly:

1. Make sure the system is on and the monitor is on.
2. From the *Main Menu*, press **[F9]** to show the **System Diagnostics** screen.
3. Enable the lamps by turning on the "Power On" switch.

CAUTION: Do not place a wafer in the chamber at this time. A wafer could accidentally be melted and damage the system.

4. Slowly increase the intensity of the lamps, and watch for a rise in temperature in the pyrometer temperature feedback.
5. Return lamp intensity to zero, and turn off the "Power Off" switch.

5.1.2.2 Heating Chamber Communication

This test verifies that the heating chamber is communicating properly with the controller:

- 1.
- 2.
- 3.
- 4.
- 5.

5.1.3 MAINTENANCE PROCEDURES

System maintenance procedures are provided in the following sections.

- **5.1.3.1 Lamp Troubleshooting and Replacement**
- **5.1.3.2 O-Ring Check**
- **5.1.3.3 Water Filter Check**
- **5.1.3.4 600S MFC FACTOR Check FOR BROOKS 5850 & 5964 MFCs calibrated for Nitrogen**

5.1.3.1 Lamp Troubleshooting and Replacement

A sudden change in process results (uniformity) may indicate a lamp failure. (Air-cooling flow and dirty quartz ware may also affect uniformity.) Check lamp continuity to verify that all lamps are properly connected.

1. Turn off the system power by turning off its "Power Off" switch and also shutting off the wall circuit breaker.
2. Remove the cabinet cover. The cover is held in place with 13 screws.
3. Remove the lamp wiring harness from each lamp socket on the right side of the chamber (as you face the front panel). This insures that each lamp is in an open circuit.

NOTE: Be careful not to damage the lamp sockets when unplugging the wires. The lamp sockets are fragile.

4. Using an ohmmeter, check the continuity of each lamp. Ground one lead to the harness connecting the lamp sockets that are on the left side of the chamber. Use the other lead to measure each individual lamp on the right side. If a lamp indicates an open circuit, that lamp is burned out. This lamp should be replaced. Call Modular Process Technology Corporation for replacement lamps.

To replace a lamp, follow the procedures below:

NOTE: If you have not already done so, be sure to turn off all power to the heating chamber and remove the cover. Also, wear latex gloves while handling the lamps. When installing a new lamp, be sure first to clean it with ethanol.

1. Remove the lamp wiring harness on the right side of the oven (as you face the front panel) from the lamp to be replaced.
2. Loosen the lamp socket screw on the right side of the oven (as you face the front panel). Gently remove the old lamp.
3. Notice the bump on the new lamp: on the top bank of lamps this bump must point up; on the bottom bank of lamps this bump must point down. Gently slide the new lamp into the socket hole; making sure the lamp is seated in the proper socket for the lamp being replaced.
4. Retighten the socket screw so it fits snugly. Do not over tighten.
5. Replace the lamp wiring harness, and the cover.

5.1.3.2 O-Ring Check

1. Open the oven door. Remove the eight screws, which hold the flange to the heating chamber (see **Section 4.3.2**). Let the flange rest on the door rails.
2. Check the O-ring on the flange. If it is burned or damaged, replace it.
3. Reinstall the flange and the screws. Retighten the screws a little at a time, in a star pattern.
4. Inspect the O-ring on the gas inlet. If it is damaged, replace it.
5. Inspect the O-ring on the inside of the door. If it is damaged, replace it.

5.1.3.3 Water Filter Check

1. Turn off the power and water supply to the system.
2. Remove the water inlet hose on the rear utility panel.

3. Inspect the filter at the mouth of the water inlet for blockage. Replace the filter if necessary.
4. Replace the water inlet hose, and turn on the power and water supply.

5.1.3.4 600S FACTOR Check FOR BROOKS 5850 & 5964 MFCs calibrated for Nitrogen

Gas Type	Gas Symbol	600S Factor For Brooks 5850 & 5964 MFC's Calibrated For Nitrogen
Nitrogen	N ₂	1.0
Oxygen	O ₂	1.0
Argon	Ar ₂	1.4
Forming Gas in Nitrogen	10% H ₂ / 90% N ₂	1.0
Ammonia	NH ₃	0.8
Nitrous Oxide	N ₂ O	0.8

NOTE: It is always better to use a MFC calibrated for the Process Gas that is being used.

SECTION 5: CHAPTER 2

TROUBLESHOOTING

5.2.1 TROUBLESHOOTING GUIDE

If your RTP-600S unit is malfunctioning, consult the troubleshooting guide below. If you need additional assistance, please contact Modular Process Technology Corporation.

Problem

Recommended Action

Computer:

No display

Check all power switches.
Make sure the power cable is plugged in, and connected to the monitor.

No response to menu selections or commands

Make sure the computer circuit boards are configured correctly, and securely plugged into the computer.
Make sure the computer has a properly installed VGA-graphics card and monitor.
Make sure the keyboard is properly plugged in.

Heating Chamber:

No power

Make sure there is power at the circuit breaker, and the system is switched on. Check the 2 fuses on the back panel of the system cabinet. Take off the system cover, and check the 3 large fuses on top of the heating chamber.

No display on digital readout

Check power to the computer and make sure it is on, since it supplies power for the LED readout.
Check the cable connections between the computer and the LED display and make sure the heating chamber is turned on.

Air leak

Make sure the O-ring in the door flange securely fits in its groove.
Check all other O-rings.
Make sure the gas inlet and outlet fittings are tight.
Make sure the door is closed and locked.
Visually inspect the quartz isolation tube for cracks or roughness.
Check that the screws holding the oven front flange to the quartz isolation tube are secure.

Lamps will not turn on

The oven cooling water may be turned off, or the flow may be too low.
Water flow must be greater than 1.6 GPM to satisfy the interlock.
Check all cable connections inside the oven cabinet, and between the computer and the oven.
Verify the computer cards are configured properly, and are securely plugged into their slots.

Thermocouple

Circuits:

Front panel readout does not respond to temperature variations

Check thermocouple connections on the inside of the oven door.

Erratic, negative, or low readings

Check thermocouple connections; make sure leads are not shorted to ground or reversed.

Negative temperature reading on front panel readout

Check thermocouple leads; Make sure leads are not reversed at door connection.

Pyrometer Circuits:

Front panel readout does not respond to temperature variations

Check the power to the heating chamber.
Make sure all connections to the circuit cards are secure.
Install a thermocouple, and verify whether temperature rises under thermocouple control.

SECTION 6: CHAPTER 1

PREFACE

6.1.1 INTENDED AUDIENCE

This Installation Manual is designed to assist Fab Maintenance Engineers and Technicians to install the RTP-600S Rapid Thermal Processing System. Building Planners may also use this document to plan facilities in which the RTP-600S system will be used.

6.1.2 MANUAL USE

Suggested manual use is as follows:

- Facilities personnel -- read **Chapter 2**.
- Service Engineers and Technicians -- read entire manual.

6.1.3 CONTENT DESCRIPTION

Chapter 1: Preface.

This chapter is a description of the Installation Manual.

Chapter 2. Installation Process Overview.

Provides an overview of the installation process for the RTP-600S system. It describes what must be done to prepare for and initiate the installation process, and what tools are required to perform the installation.

Chapter 3. System Inspection.

Describes the procedure for inspecting the system, and reporting damage, or missing parts.

Chapter 4. Installation Site Requirements.

Describes the principal installation site requirements, including the dimensions of the system and electrical connections, as well as gas, quartz isolation tube cooling, and water specifications and connections.

Chapter 5. Connecting the Utilities.

Offers step-by-step instructions for connecting the utilities to the RTP-600S system.

Chapter 6. Quartz ware Installation.

Describes the quartz ware installation process for the quartz isolation tube and wafer tray.

Chapter 7. System Power Up and Testing.

Describes the procedures required to power up the system, and the tests, which must be performed to ensure safe RTP operation. These tests include the manual mode test, diagnostic check, and temperature control test.

Chapter 8. Troubleshooting Guide.

A troubleshooting guide is provided, which suggests practical recommendations for common errors, which may occur during installation procedures. Three types of errors are described: leaks, controller errors, and heating chamber errors.

SECTION 6: CHAPTER 2

INSTALLATION PROCESS OVERVIEW

6.2.1 INSTALLATION PROCEDURES

This manual describes how to install the RTP-600S system and perform an operations check. These activities are outlined in the following sequence of steps:

1. Prepare the site utility connections.
2. Unpack the heating chamber and monitor.
3. Inspect the system for damage or missing parts.
4. Channel the utilities.
5. Install the quartz ware.
6. Check the quartz isolation tube for air-leaks.
7. Power up the system.
8. Confirm proper operation.
9. Check for resistivity accuracy.

6.2.2 REQUIRED TOOLS

You will need the following tools to install the RTP-600S system:

- Allen wrench set (US style)
- Screwdriver set (regular and Philips)
- Open-end wrenches (US style)
- Teflon tape
- Latex gloves
- Test wafers

SECTION 6: CHAPTER 3

SYSTEM INSPECTION

6.3.1 SYSTEM INSPECTION

Visually inspect each unit for dents, scratches or other visible signs of shipping damage. If you notice any shipping damages, notify the carrier immediately.

Compare the contents of the accessories box with the Modular Process Technology Corporation packing list to make sure all items have been received. Handle the quartz ware with care and always while wearing latex gloves. If any parts are missing or broken, notify Modular Process Technology Corporation immediately.

SECTION 6: CHAPTER 4 INSTALLATION SITE REQUIREMENTS

6.4.1 SYSTEM DIMENSIONS

The dimensions of the oven and monitor are listed below.

Oven: 24" (61 cm) W x 14" (35 cm) H x 23" (58 cm) D

Monitor: 14" (36 cm) W x 15.5" (40 cm) H x 15.5" (40 cm) D

6.4.2 ELECTRICAL CONNECTIONS

Power requirements differ between the United States, England, Japan, and Europe. Specifications for each is shown in the following list:

- United States / Korea... 4 wires
208 V (240 V on request)
Three Phase + Gnd
60 Hz
90 Amps/phase
[3ϕ Watts/phase = $V \times I \times \sqrt{3}$]
- England... 5 wires
415 V
Three Phase + Neutral + Gnd
50 Hz
60 Amps/Phase
[3ϕ Watts/phase = $V \times I \times \sqrt{3}$]
- Europe... 5 wires
380 V
Three Phase + Neutral + Gnd
50 Hz
60 Amps/phase
[3ϕ Watts/phase = $V \times I \times \sqrt{3}$]
- Japan... 4 wires
200 V
Three Phase + Gnd
50 Hz Eastern Japan including Tokyo
60 Hz Western Japan including Nagoya,
Kyoto, and Osaka
90 Amps/phase
[3ϕ Watts/phase = $V \times I \times \sqrt{3}$]

6.4.3 GAS AND COOLING REQUIREMENTS

Gas, quartz isolation tube cooling, and water requirements are described below:

Gas(es): Any non-corrosive gas(es) may be used.

- Each gas should be regulated to <35 PSI, and be pre-filtered to <1 micron.
- Inlet connections are VCR-4, Male.
- Outlet connection is VCR-8, Male.

Quartz Tube cooling must use oil- and water-free compressed air or nitrogen.

Tube Air/nitrogen should be filtered to <3 microns.

Cooling: Tube cooling is to be regulated at 125 psi of pressure, with a minimum of 10 CFM flow.

- Inlet connection is 3/8" Swagelok fitting. MUST USE MINIMUM 3/8" TUBING.

Water: 10,000 watts at 20°C (34,100 BTU/hr) for full temperature range operation in production environment

- Water should be filtered to <100 microns, with a 2 GPM minimum flow.
- Water Resistivity is to be maintained at 1- 3 meg ohm.
- Maximum inlet pressure is 75 PSI; the differential pressure is 40 PSI.
- Maximum inlet temperature should be <35°C.
- Inlet and outlet connections are 3/4" Male garden hose fittings or 1/2" NPT Female

6.4.4 CABINET EXHAUST REQUIREMENTS

- 4" diameter duct... the attachment collar to system can be ordered from factory.
- See local Safety Codes... this exhaust handles Lamp Cooling and accidental escape of Process Gases.
- DO NOT USE plastic.

6.4.5 PROCESS EXHAUST REQUIREMENTS

- Maximum Backpressure or Draw < 2" water
- NOTE: [1" H2O = 0.036psi] [1PSI = 27.6" H2O] [1PSI = 51.7 Torr].
- Install Pressure Gauge Capacitive Manometer or 1000 Torr Baritron
- Electronic Manometer at outlet of Process Exhaust using T connection.
- See local Safety Codes... this exhaust handles Process Gases flowing into the chamber.
- Outlet connection is VCR-8 Male.
- DO NOT USE plastic.

SECTION 6: CHAPTER 5 CONNECTING THE UTILITIES

All utilities are connected at the rear utility panel of the RTP-600S (see **Figure 4.1**).

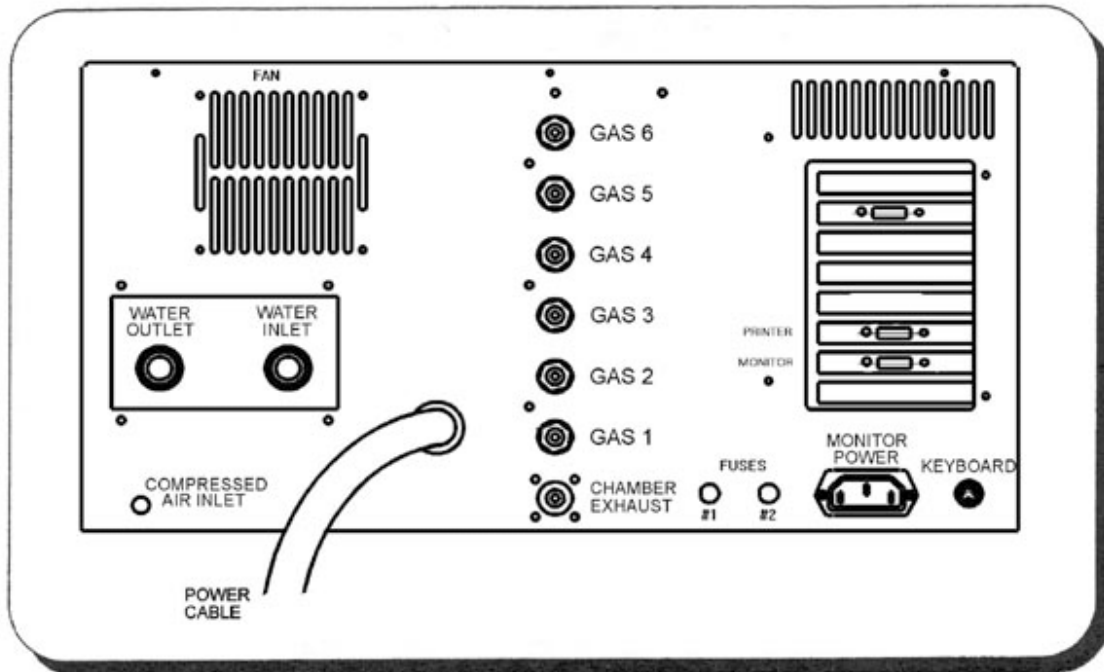


Figure 6-1. Rear Utility Panel

The following steps describe the sequence for connecting each utility. Refer to **Figure 6.1** for the location of each connector.

1. Connect the following electrical components:
 - Main power cable, to wall circuit breaker
 - Monitor power cable, to monitor and rear utility panel of RTP-600S
 - Monitor signal cable
 - Keyboard
 - Printer (if used)
2. Connect the gas connections:
 - Inlet (Gas #): VCR-4, MALE
 - Outlet (Exhaust): VCR-8, MALE
3. Connect the tube cooling Compressed Air Inlet: 3/8" Swagelok
4. Connect the water connections:
 - Water Inlet: Garden hose fitting
 - Water Outlet: Garden hose fitting

5. Review all connectors to insure that you have attached the utilities to their proper connectors. Double-check the gas; tube cooling, and water pressures against the specifications listed in **Section 6.4.3**.
6. Connect the Cabinet Exhaust. Review all connectors to insure that you have
7. attached the utilities to their proper connectors. Double-check against
8. the specifications listed in **Section 6.4.4**.
9. Connect the Process Exhaust. Review all connectors to insure that you have
10. attached the utilities to their proper connectors. Double-check against
11. the specifications listed in **Section 6.4.5**.

SECTION 6: CHAPTER 6
QUARTZ WARE INSTALLATION
(ISOLATION TUBE AND WAFER TRAY)

Two major pieces of quartz ware exist for the RTP-600S system: the quartz isolation tube and quartz wafer tray. Procedures for installing this quartz ware are described below:

6.6.1 Installing the Quartz Tube

1. Open the oven door and look inside the heating chamber to visually inspect the quartz isolation tube. If there is an isolation tube present and it is in good condition, do not install a new quartz tube; install a quartz wafer tray only.
2. If no tube is present in the heating chamber, turn off the main power at the circuit breaker.
3. Remove the top cover of the system cabinet. See **Figure 6-2** for the location of the screws.

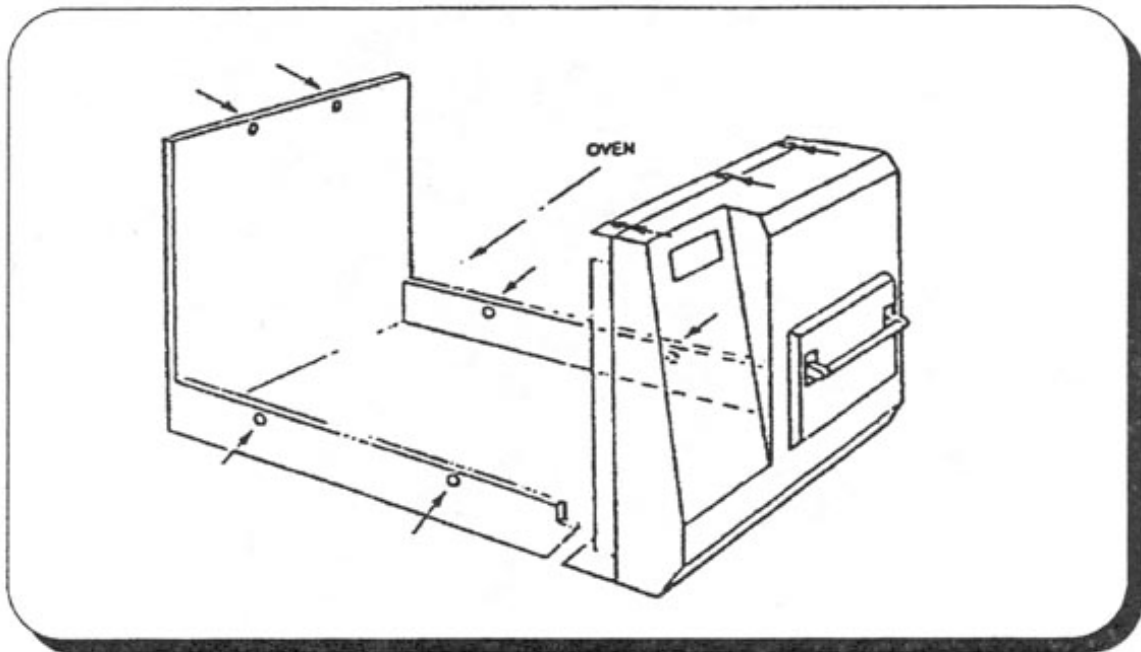


Figure 6-2. System Cabinet Screw Locations

4. Carefully remove the eight screws, which hold the front oven flange in place. Put the screws in a safe place (see **Figure 6-3**).

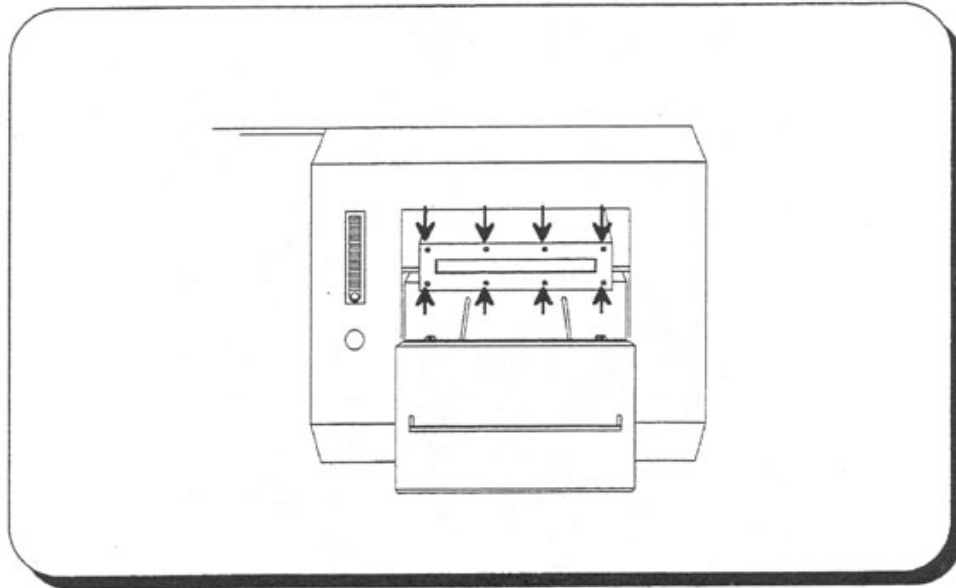


Figure 6-3. Front Flange Screw Locations

5. Remove the two screws holding the gas inlet fitting to the isolation tube, and carefully pull out the gas inlet fitting (see **Figure 6.4**).

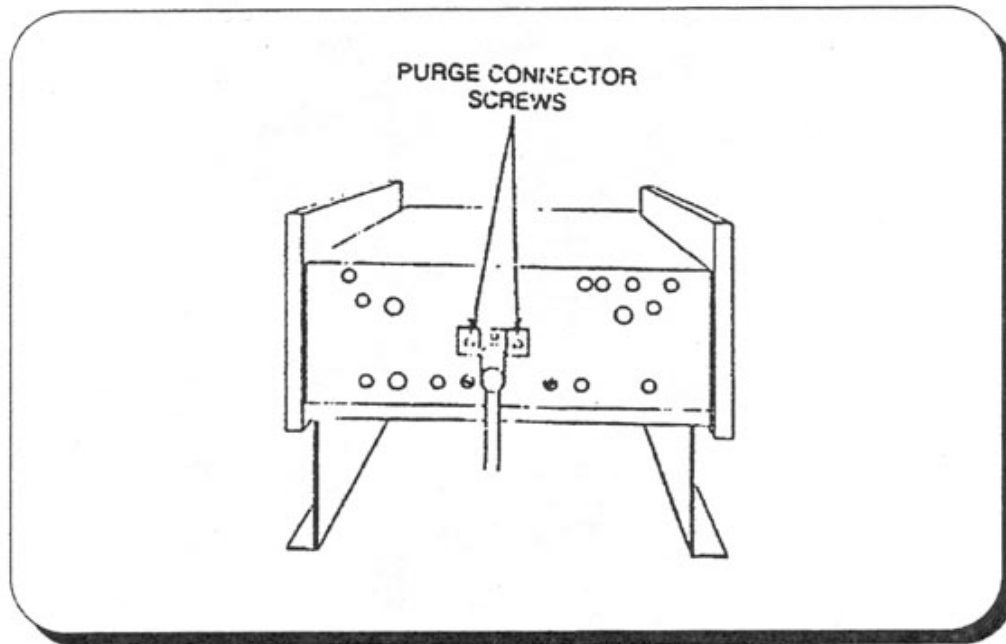


Figure 6-4. Gas Inlet Fitting Locations

6. Install the inner flange O-ring. (See **Figures 6.5** and **6.6**.)

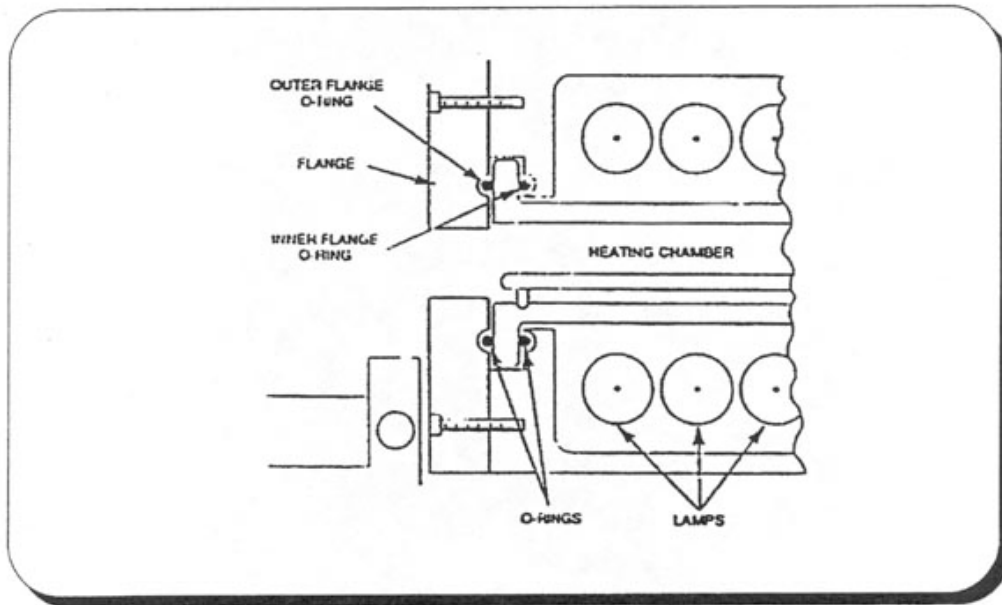


Figure 6-5. Flange O-rings

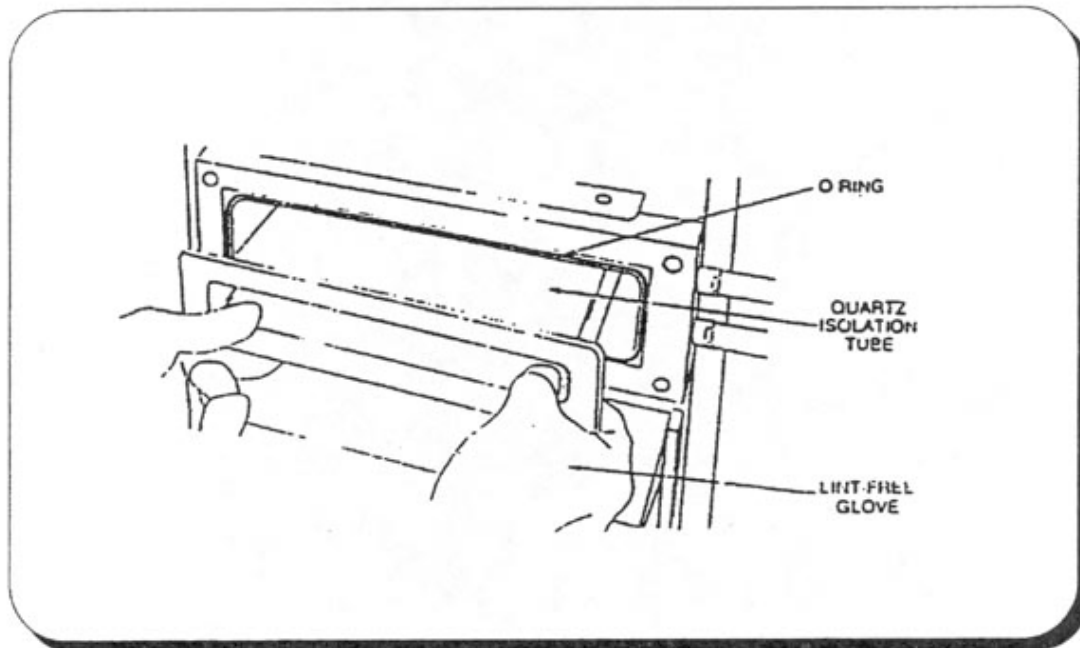


Figure 6-6. Installing the Quartz Isolation Tube

7. Install the quartz isolation tube by inserting it into the heating chamber with the window at the bottom (see **Figures 6-5 & 6.6**).

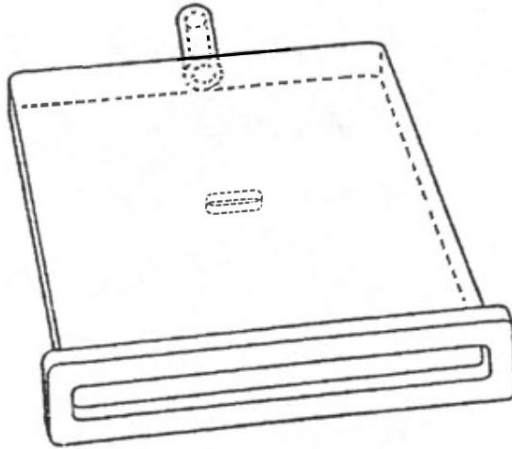


Figure 6-6. Quartz Isolation Tube

8. Install the outer O-ring to the flange, as shown in **Figure 6.5**.
9. Place the front flange against the isolation tube flange, and install the eight screws you removed earlier in this procedure.
10. Install the gas inlet O-ring.
11. Install the gas inlet connector.

6.6.2 Installing the Quartz Wafer Tray

1. Remove the top portion of the door O-ring (see **Figure 6-8**).

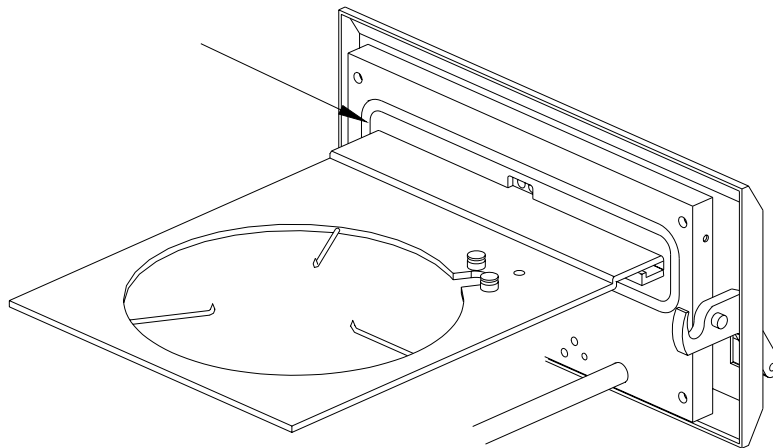


Figure 6-8. Top Portion of Door O-ring

2. Loosen the two tray leveling screws. (See **Figure 6.9**.)

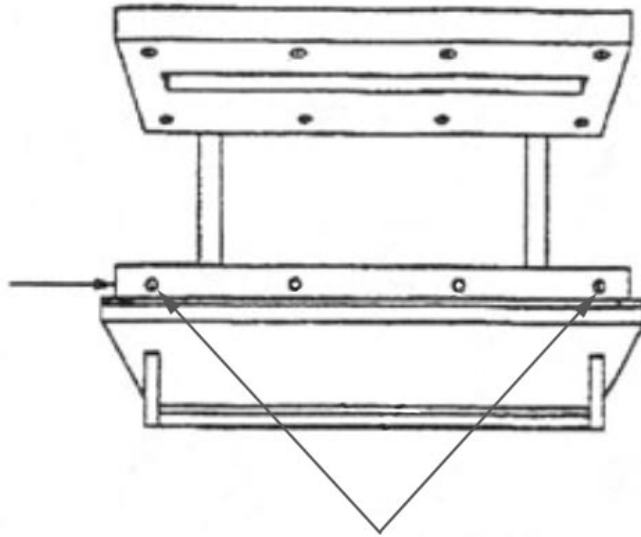


Figure 6-9. Leveling Screw Locations

3. Install the O-ring
4. Install the quartz tray, with the wafer support pins up.
5. Using the leveling screws, adjust the tray so that the end of the tray is centered with the opening of the tube. (Refer to **Section 4.3.4.**)
6. Slowly close the door of the heating chamber. Listen for any scraping sounds, which may mean that the quartz is not properly aligned. If you notice any scraping sounds or resistance to door movement, realign the tray and repeat this step.

SECTION 6: CHAPTER 7

SYSTEM POWER UP AND TESTING

This section describes the procedures for powering up the system, and the test procedures (manual mode test), which must be performed directly after power up to ensure safe system operation.

6.7.1 Utilities Inspection

Check the system utility connections and sources before switching on the RTP-600S (see **Figure 6-10**) for the location of each utility connection at the rear of the unit. Visually inspect the following utilities to make sure connections are secure and utilities are on:

- Electrical power
- Gas inlet and chamber exhaust
- Cooling water inlet and outlet
- Compressed air inlet

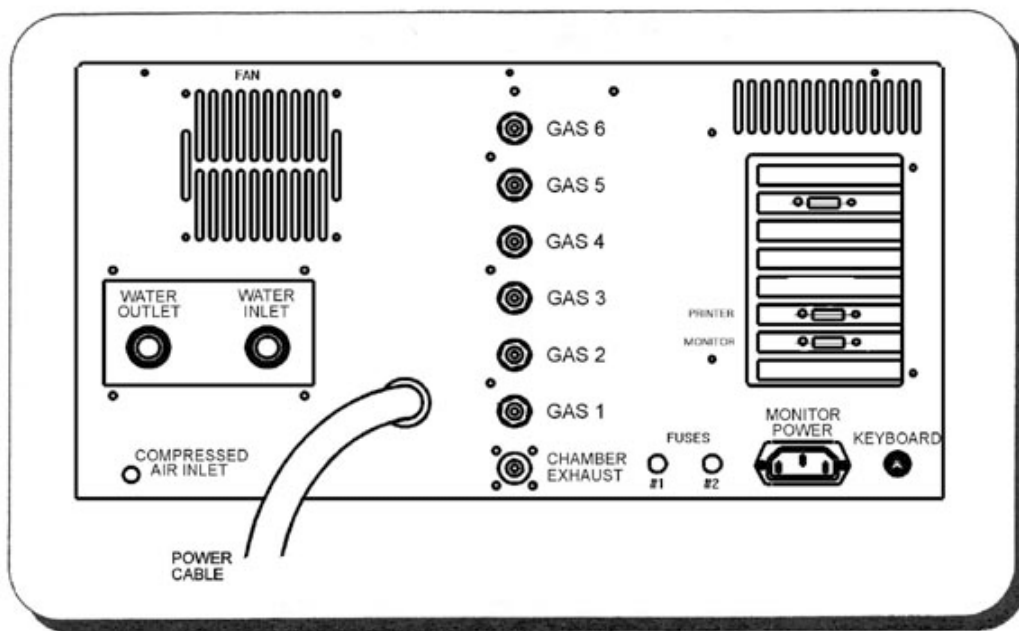


Figure 6-10. Utility Connections (rear view of system cabinet)

WARNING: Make sure the chamber exhaust is not restricted. This will cause the quartz tube to over pressurize and break.

Check for possible water leaks at the cooling water inlet and water outlet connections. If any of the utilities are disconnected, or any connections appear to be leaking, correct the problem.

6.7.1.1 Maintenance

During all maintenance operations, observe the following precautions:

1. Do not use replacement parts that are not provided by Modular Process Technology Corporation.

WARNING: Modular Process Technology Corporation is not liable for any damage or injury that may occur when unauthorized parts are used.

2. Disconnect power to the system before performing any maintenance activity that requires the removal of access covers.
3. Whenever the quartz isolation tube is changed, perform a gas leak test on the oven. Replace the O-ring on the isolation tube nipple each time the tube is removed.

6.7.1.2 Gas Handling

Be aware of the following cautions when working with gases in the RTP-600S system:

1. ONLY use gases, which have been specified for use with the RTP-600S system.

WARNING: Modular Process Technology Corporation is not liable for the use of gases not recommended.

2. Make sure the specified gases are connected to the proper inlets on the service panel.

WARNING: Failure to properly connect the gas lines may result in dangerous gas mixtures, which could cause harm to personnel or the system

6.7.1.3 Gas Flow Calibration

The gas flow controllers are calibrated for use with nitrogen. Gas calibration factors are used by the software to compensate for the densities of different gases. These gas calibration factors are implemented at the factory at shipping. If gases are changed later, new software calibration factors must also be implemented. Contact Modular Process Technology Corporation for assistance.

6.7.2 System Power Up

At this point in the installation procedures you are now ready to power up the RTP-600s system. The following steps describe the power up sequence (see **Figure 6-11**):

1. Switch on the facilities circuit breaker(s).
2. Turn the key switch so the key is horizontal.
3. Turn on the RTP-600S using the EMO Reset switch.
4. Turn on the Power On switch.

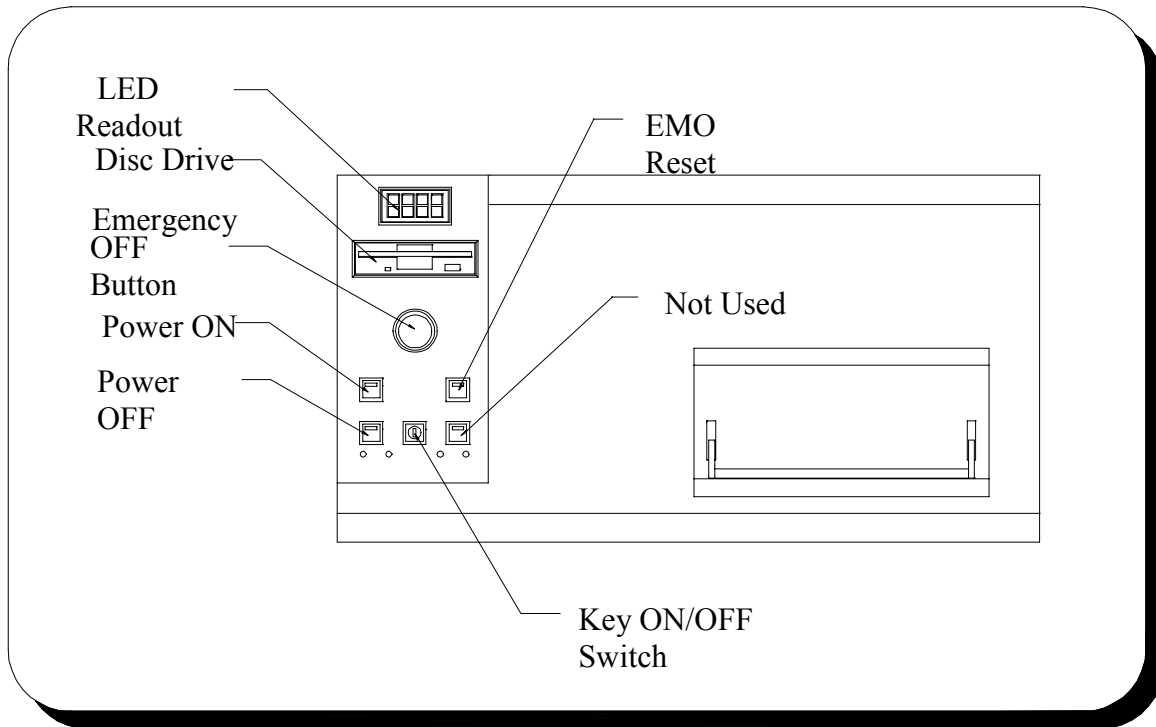


Figure 6-11. Front Panel Controls

6.7.3 Manual Mode Test

This test verifies that your RTP-600S system lamps are turning on properly:

1. From the **Main Menu** screen, press **[F9]** to go to the **System Diagnostics** screen.
2. Press the **[Right Arrow]** key to highlight the Lamp Intensity Control.
3. Press the **[Enter]** key to enable the lamps.
4. Increment the lamp intensity by pressing **[Page Up]** or **[CTRL+Page Up]**. Watch for a rise in temperature on the pyrometer temperature readout (LED display). After you have observed a rise in temperature, press **[Enter]** again to turn off and disable the lamps. If you do not see a rise in temperature, call Modular Process Technology Corporation for assistance.

SECTION 6: CHAPTER 8 TROUBLESHOOTING GUIDE

This guide is intended to help you fix some of the common errors, which may occur during installation. If you need further help, contact Modular Process Technology Corporation.

6.8.1 Gas Leak Check Failure

If the system is not leak tight, perform the following:

1. Check all the O-rings for proper placement and seating.
2. Tighten the gas inlet and outlet connectors.
3. Ensure that the door is closed and locked.
4. Check the quartz isolation tube flange for polished smoothness and cleanliness.
5. Check to ensure that all screws are tight on the flange.

6.8.2 Controller Errors

If the controller has no display, use the following troubleshooting steps:

1. Ensure that the power is turned on at the source, at the RTP-600S, and at the monitor.
2. Make sure the RTP-600S is connected to the proper power.

6.8.3 Heating Chamber Errors

Troubleshooting steps for heating chamber errors are described below.

Green Power Light Not On:

1. Check to make sure the power is on at the wall circuit breaker.
2. Check that the key switch is in the horizontal position.
3. Check the "Power On" switch to make sure it is on.
4. Check the fuses (2) on the cabinet rear panel.

No Display On Digital Readout:

1. Check the power to the system (see above).

Pyrometer Does Not Show A Temperature Rise:

1. Check the power to the heating chamber.

