SECTION 3: CHAPTER 1

OPERATOR INTERFACE

3.1.1 OVERVIEW

Using the computer's keyboard and mouse activate screen menus which operates the RTP-600xp 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 ***Log On*** screen (see **Figure 3-1**).

3.1.2 RTP-600xp LOG ON SCREEN

The RTP-600xp provides three levels of system access via the ***Log On*** screen. This access is controlled by passwords protecting distinct system functions. Clicking

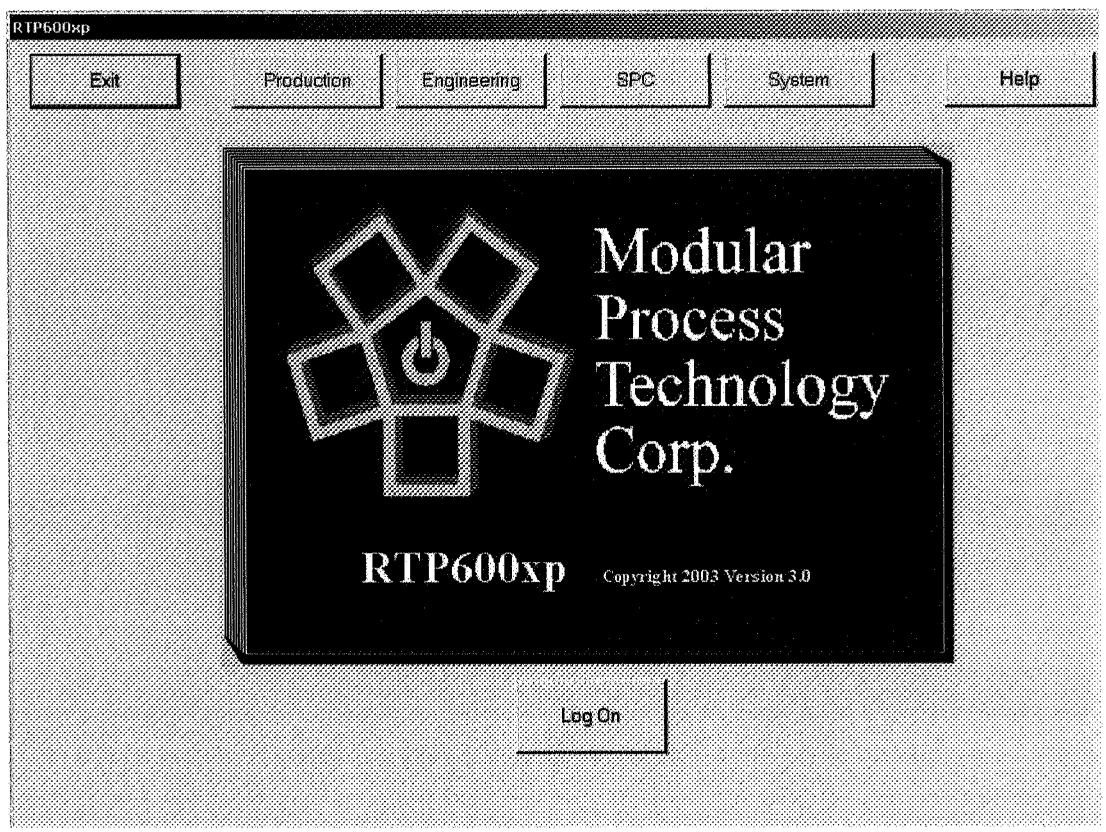

Figure 3-1. ***Log On Screen***

the ***Log On*** button will cause a ***User Name*** Pop-Up screen to appear (see ***Figure 3.2***). The ***User Name*** will be blank. Click the arrow at the end of the blank ***User Name*** window.

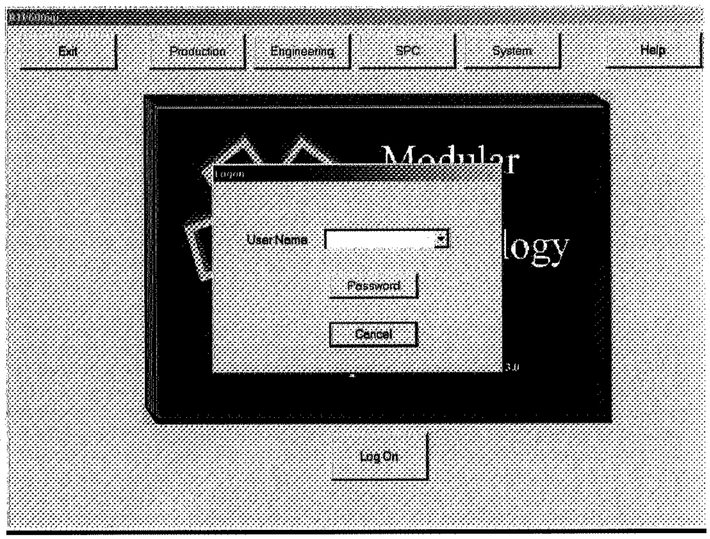

Figure 3-2. ***Log On Pop-Up Screen with User Name Blank***

A choice of any one of three modes, ENG, MPT, or PROD can be selected (see ***Figure 3-3***). Select the appropriate mode. Notice that the chosen mode now fills the previously blank **User Name** window. Click on the **Password** button. Enter the

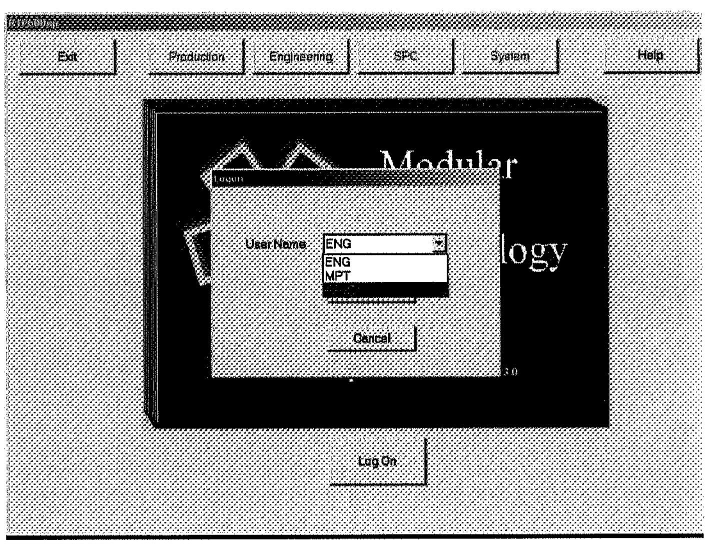

Figure 3-3. ***Log On Expanded Pop-Up Screen***

Password for the selected Mode via the ***Touch Screen Keyboard*** (see ***Figure 3-4***). If your system still has the basic Factory Installed passwords encoded into the software use E for ENG, M for MPT and P for PROD.

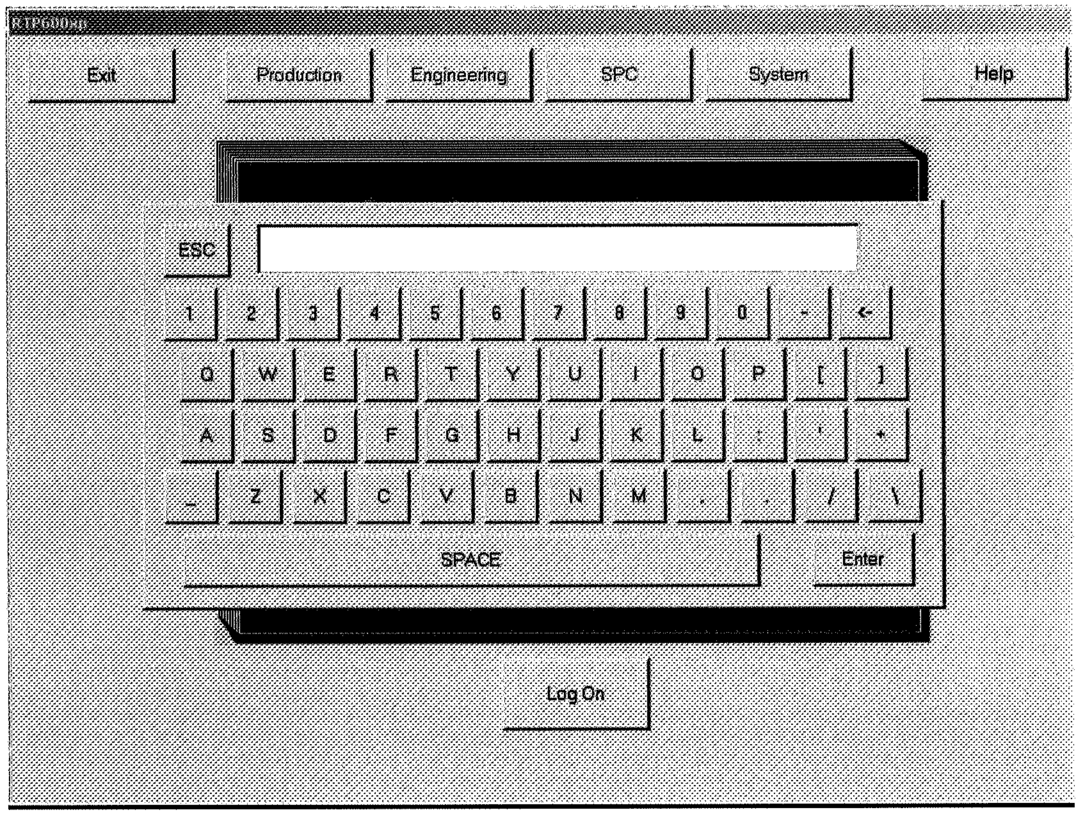

Figure 3-4. ***Touch Screen Keyboard***

The touch screen keyboard is a pop-up dialog that allows the user to enter data into the software (see Figure 3-4. ***Touch Screen Keyboard***). Having a pop-up keyboard allows for a cleaner and larger viewing area for the necessary data and graphics. The keyboard contains the normal alphanumeric keys found on most U.S. keyboards and the keys are also arranged in the same pattern as the U.S. keyboard. The keyboard is activated whenever the software requires alphanumeric data to be entered. This depends upon the data-entry field the user pressed. The pressed characters of the keyboard appear in the display of the keyboard. If the set of characters in the display are the intended data to be entered, the user can then press the Enter key. This will then pass the data to the data field. If the user makes a mistake, pressing the left arrow key (in the upper right corner) deletes the entered characters, one at a time starting from the right most character. If the user decides not to enter anything at this time, pressing the ESC key will discontinue the data input and not pass any data to the data field. The keyboard will disappear whenever either the Enter or Esc key is pressed.

3.1.3 RTP-600xp MAIN ACCESS LEVEL SCREENS

Once ***Log On*** is complete the Main Screen for the Access Level chosen will appear. Notice that the functions, which are NOT active for the Access Level chosen, will be lightened so that the printing appears gray and barely visible.

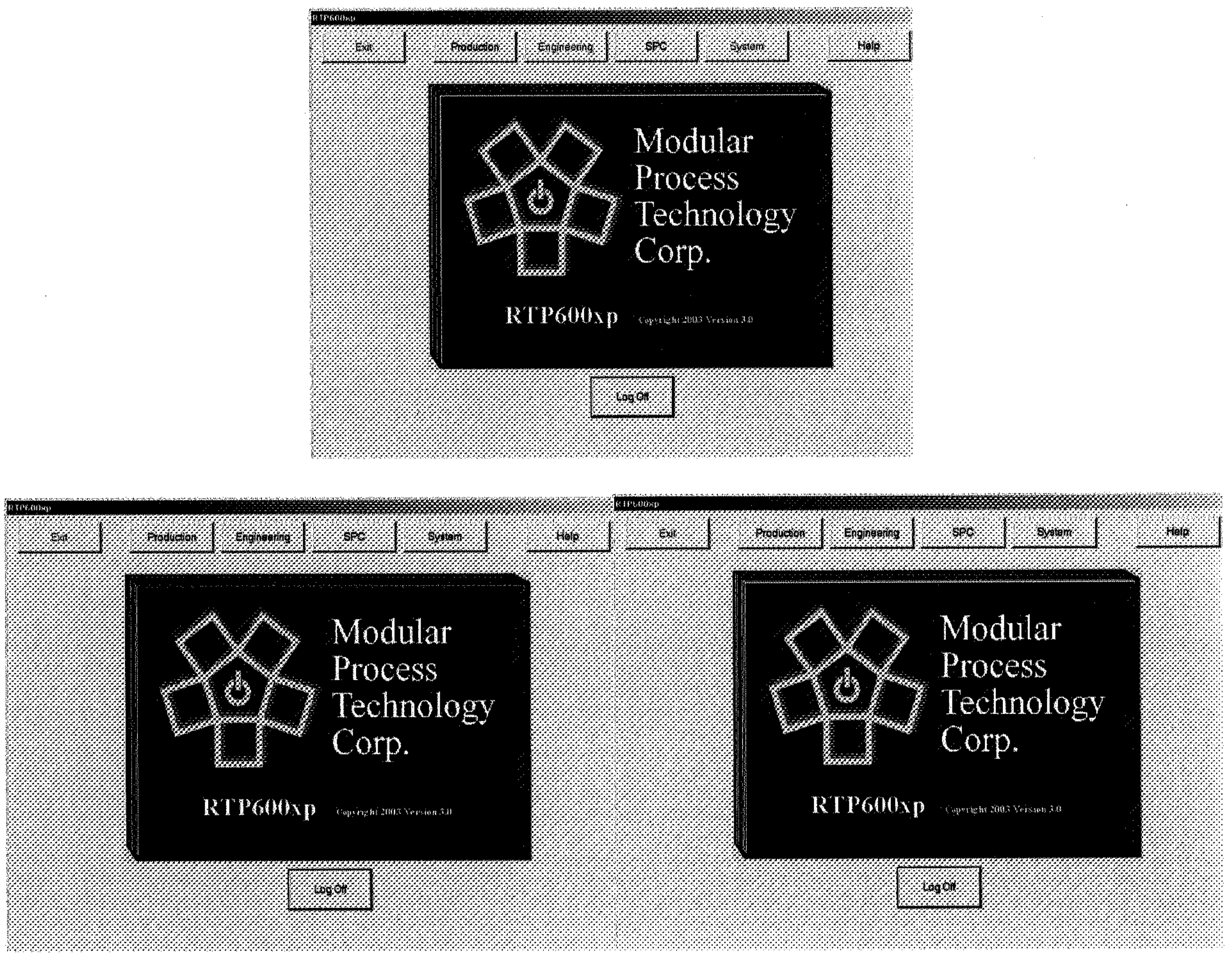

Figure 3-5. ***MAIN Screens for Access Level 1, 2, and 3***

3.1.4 RTP-600xp LOG OFF SCREENS

Logging Off the RTP-600xp from any of the three password protected levels of system access is accomplished in a similar manner via the ***Log OFF*** screens (see Figure 3-5 ***Log Off Screens***). Clicking the ***Log Off*** button at the bottom of the Main Screen for any of the Access Levels will cause a message box to appear. This message box allows the user to either click CANCEL to return to the current Access Level or to click OK to complete the ***Log Off*** process.

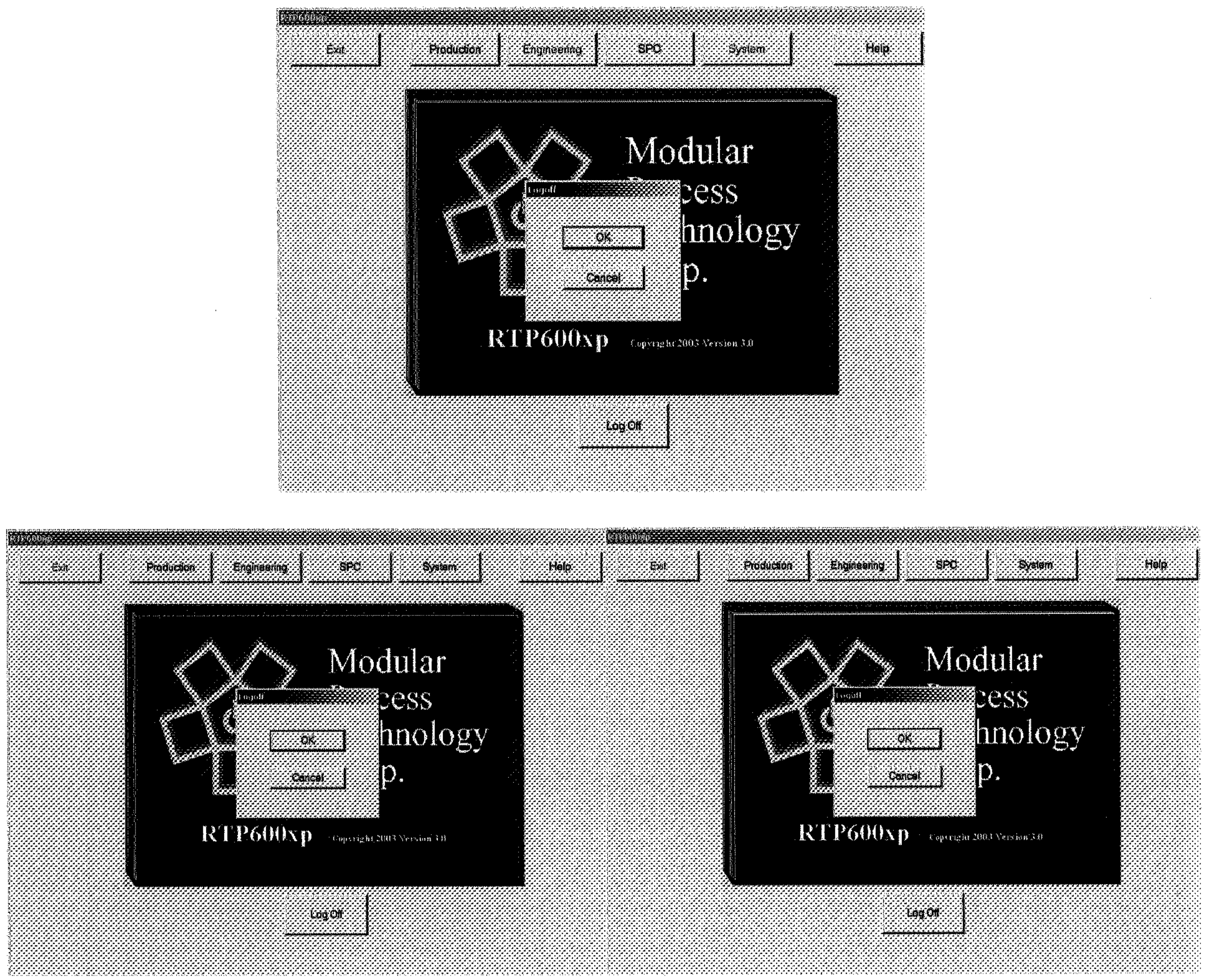

Figure 3-6. ***Log OFF Screens for Access Level 1, 2, and 3***

SECTION 3: CHAPTER 2

PRODUCTION MODE

The Production Mode is provided for the user who wishes to either RUN a previously created recipe or view the Time/Temperature Profile of the Last Run processed.

3.2.1 PRODUCTION MODE ACCESS FROM MAIN SCREEN

Click **[Production]** from the Main Menu (see **Figure 3-7**).

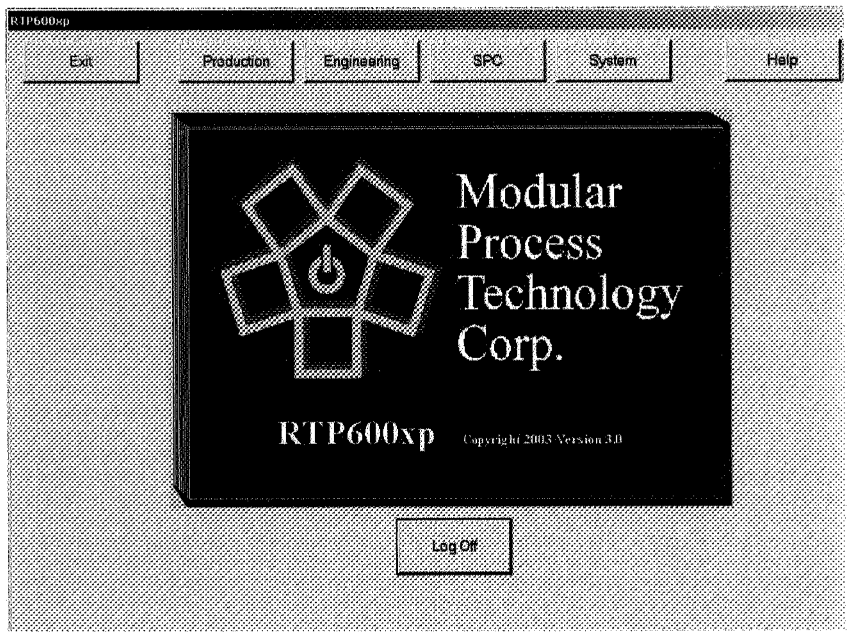

Figure 3-7. ***Main Menu Screen***

3.2.2 PRODUCTION PROCESSING – TC AND PYRO CONTROL RECIPES

By Clicking **[Production]** from the Main Menu (see **Figure 3-7**), the **Production Screen** will appear (see **Figure 3-8**). This screen is a directory listing of both TC and Pyro control recipes stored in the system.

To Run a TC or Pyro controlled recipe:

1. Click on your desired **Recipe File** to highlight the recipe for further access.
2. Click **[Start Process]** to begin recipe. The process controller will use the selected recipe to process the substrate inside the process chamber.

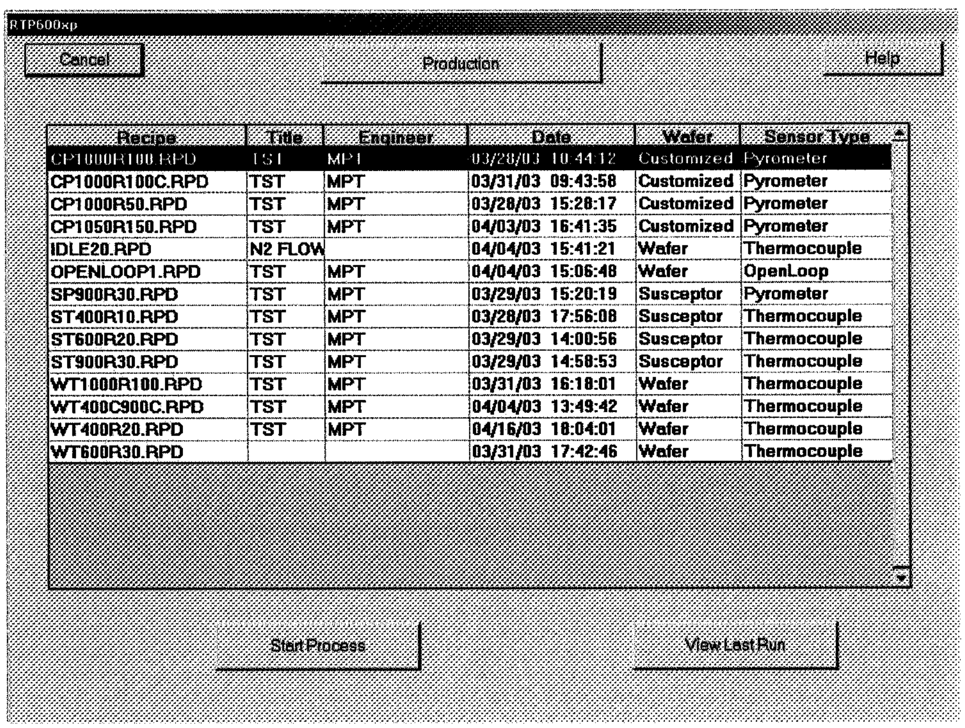

Figure 3-8. ***Production Screen***

3. After initializing, the ***Process Execution*** screen will appear (see **Figure 3-9**). The ***Process Execution*** 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.

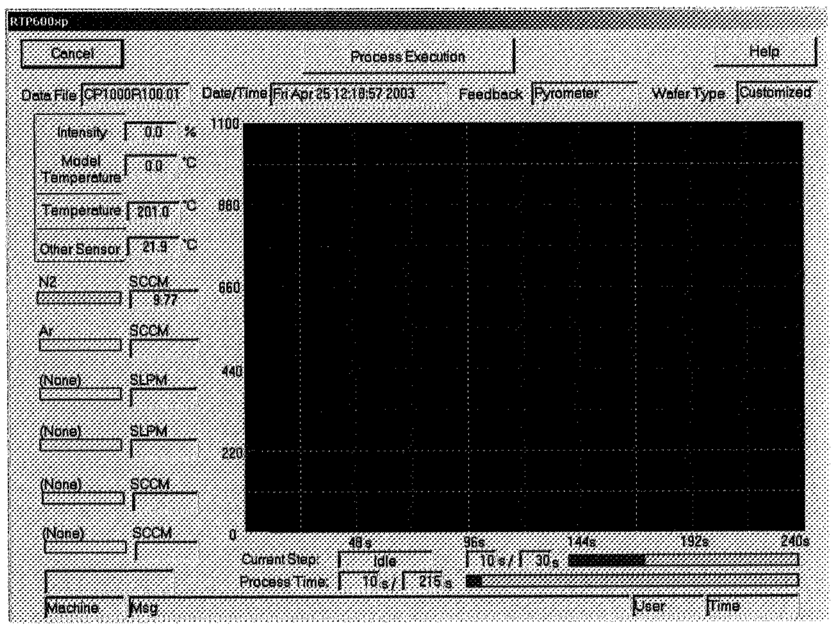

Figure 3-9. ***Process Execution Screen***

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 left hand side of the screen.

Gas Flows: The process gas flows are represented as bar graphs on the left hand side of the screen. The numerical value in the middle of each MFC Data Window 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.

4. Clicking **[Cancel]** during the run will abort the process and return to the ***Production Screen***.

5. After the process has completed, the words ***"Process Over"*** will appear across the screen.

6. Click **[Cancel]** to return to the Production Screen.

3.2.3 VIEW LAST RUN SCREEN

By Clicking **[View Last Run]** from the **Production Screen** (see **Figure 3-8**), the **Process Data Display and Analysis screen for the last run processed by the system** will appear (see **Figure 3-10**).

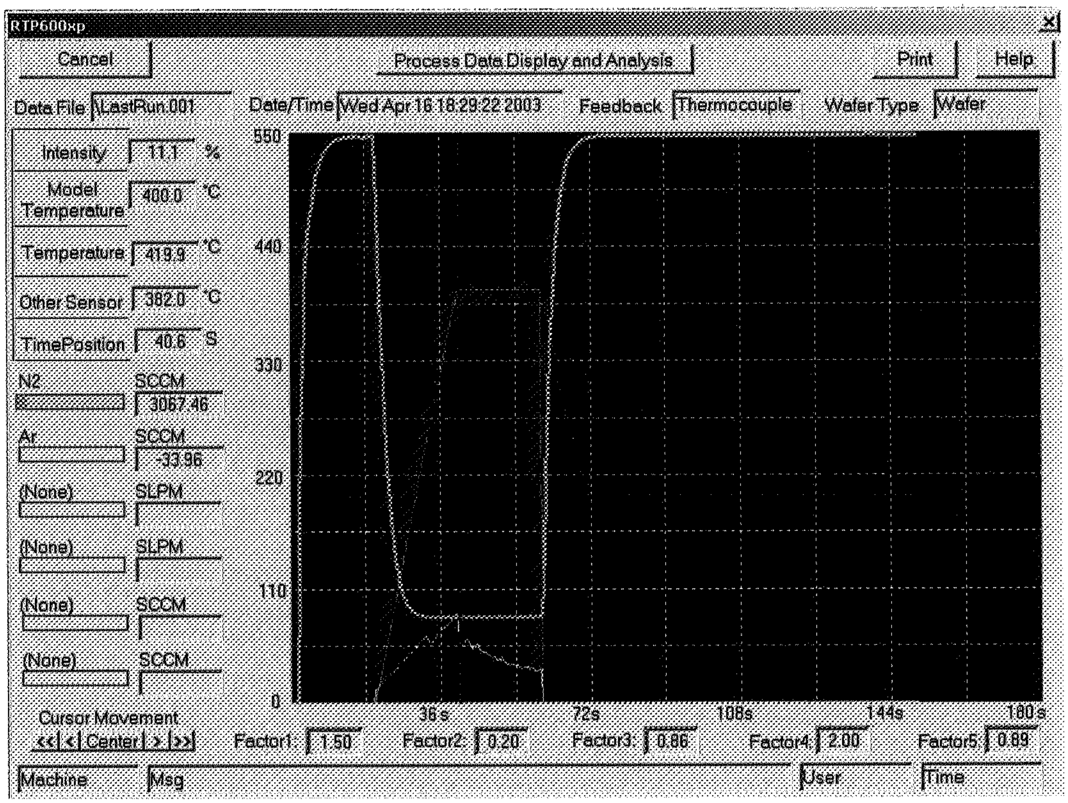

Figure 3-10. ***View Last Run Screen***

SECTION 3: CHAPTER 3

ENGINEERING MODE

The Engineering mode is provided for the user who wishes to either CREATE a new recipe or EDIT a pre-existing recipe.

3.3.1 ENGINEERING MODE ACCESS FROM MAIN SCREEN

1. Click **[Engineering]** from the Main Menu (see **Figure 3-11**).

2. The ***Engineering Screen*** will appear (see **Figure 3-12**).

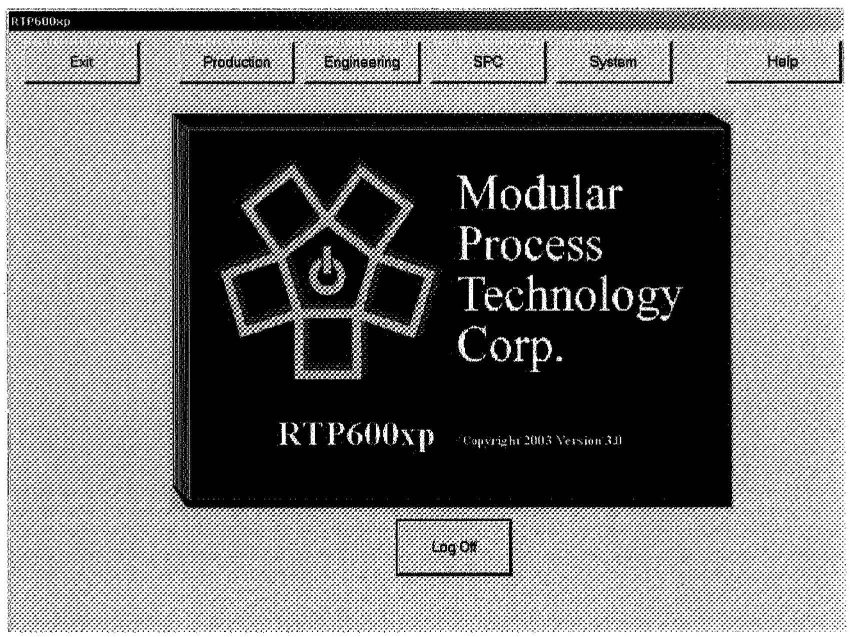

Figure 3-11. ***Main Menu Screen***

3.3.2 ENGINEERING SCREEN

This screen allows the user to operate on recipes by either CREATING a new recipe or selecting a recipe from the directory for EDITING, PRINTING, COPYING, DELETING, or VIEWING LAST RUN.

This screen also allows the user to select pre-validated recipes for START PROCESS or Recipe Level PYROMETER CALIBRATION.

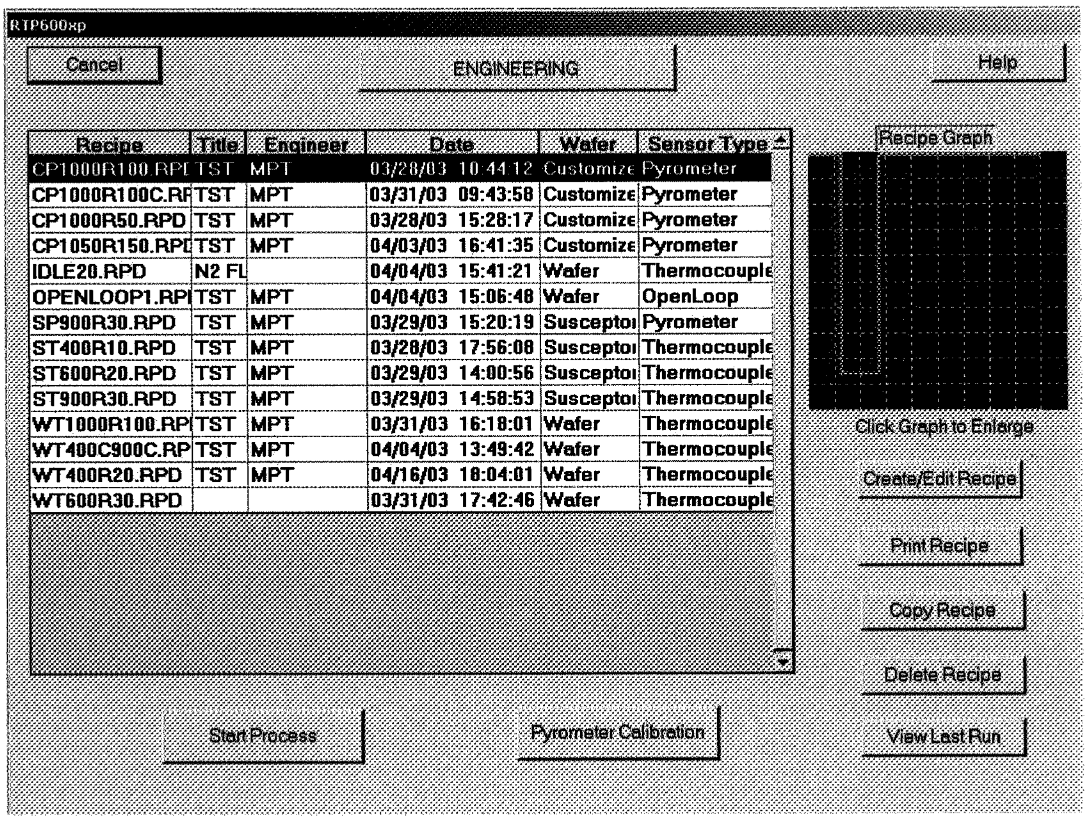

Figure 3-12. ***Engineering Screen***

3.3.3 THE "NEW" RECIPE DATA FILE

1. Click **[Create/Edit Recipe]** from the ***Engineering Screen***.
2. The ***Recipe Editor Screen*** for your highlighted Recipe will appear.
3. Click **[New]** to obtain a blank ***Recipe Editor Screen*** (see **Figure 3-13**).

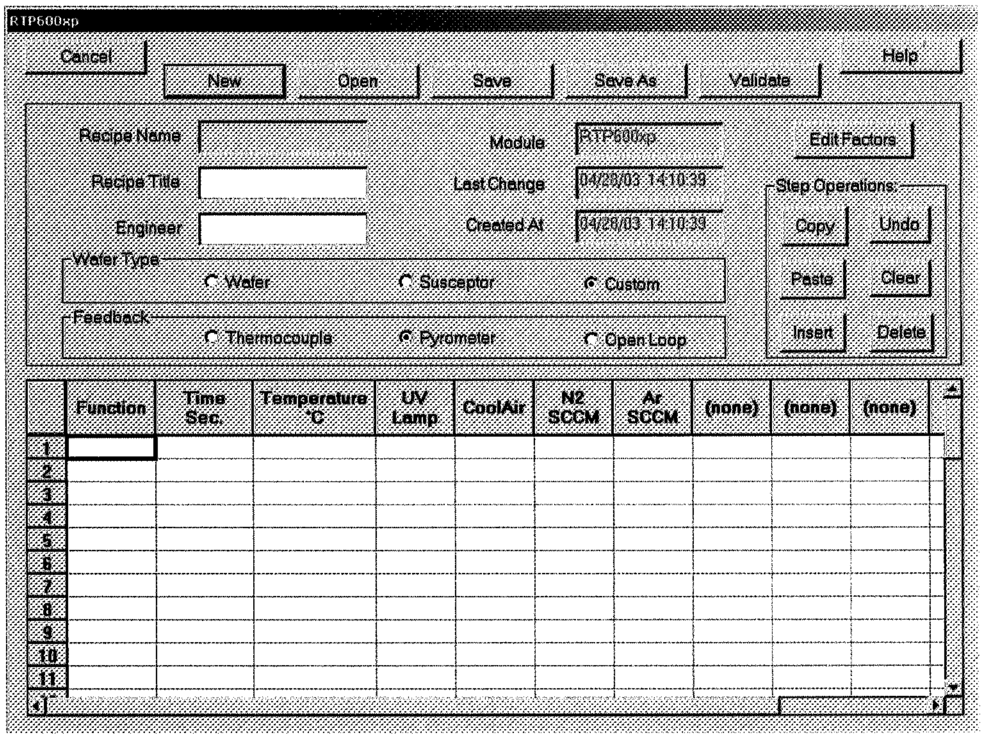

Figure 3-13. ***"New" Recipe Editor Screen***

The **"New"** ***Recipe Editor***, **Figure 3-13**, is used to create and edit recipes to be run on the RTP-600xp 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 **Wafer Type**, **Feedback**, 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 or Open Loop) is the one to be used as the temperature feedback device during the process. This file name can be any legal Windows filename (i.e., the recipe), excluding the path and extension. This field cannot be left as NONAME, for it is used to later recall the recipe.

3.3.3.1 <u>RECIPE CREATION</u>

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 3-14. ***Simple Process Cycle***).

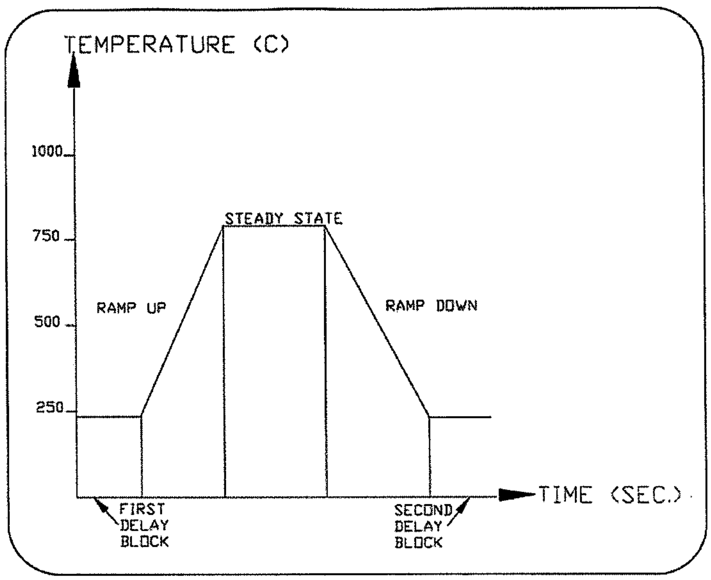

Figure 3-14. ***Simple Process Cycle***

Recipe names are stored as filenames on the hard drive. The RTP-600xp system includes a floppy disk drive to download recipes onto a formatted 3.5-inch floppy disk.

The Recipe Editor of the RPT-600xp allows for a straight forward implementation by having a recipe divided into process steps; each step describes the state of the process for a specified amount of time (i.e., up to 50 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 **Function** column, to select a function simply click on the desired **[cell]**. A pop-up window will appear with the choices of Ramp, Hold, Idle, Stop, and Cancel. Click the desired function. Once clicked the function will automatically write itself into the pre-selected cell.

Ramp -- increases the temperature at a constant rate until the desired temperature has been reached. For best process results the gas flow during Ramp is set to the same specified value as in the **Hold** step. The process controller cannot do two consecutive **Ramp** steps, so in multiple ramp recipes the critical ramp must chosen for optimization.

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. The software will restrict the maximum allowable time as the temperature increases (see table below):

Temperature/Deg. C.	Maximum Time/Seconds
1250	120
1200	150
1150	200
1100	300
1050	327
1000	360
950	400
900	450
850	514
800	600
750	720
700	900
650	1200
600	1800
550	3600
500	2592
450	3200
400	4050
350	5289
300	7200
250	9999 (maximum programmable time)

Temperature (^{o} C) -- this is the target temperature for this step.

Gas Line Settings

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

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

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

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

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

6. **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.

After editing has been completed, click **[Validate]** to validate the recipe. Make any necessary changes if a validation message appears. Re-validate the recipe.

Click **[Save]** to save the recipe.

Click **[Cancel]** to return to the ***Engineering Screen.***

From the ENGINEERING Screen the computer model of the recipe can be reviewed. Click to graph to enlarge the computer model of the recipe.

The procedure to run a predefined recipe is given in the ***Production Mode*** chapter in this manual.

The procedure to Minimize Temperature Overshoot/Undershoot by Optimizing Recipe Factors for a predefined recipe is given in the next section.

3.3.3.2 FACTOR OPTIMIZATION

1. Click **[Edit Factors]** from the ***Recipe Editor Screen.***

2. The ***Recipe Edit Factors Screen*** will appear (see Figure 3-15).

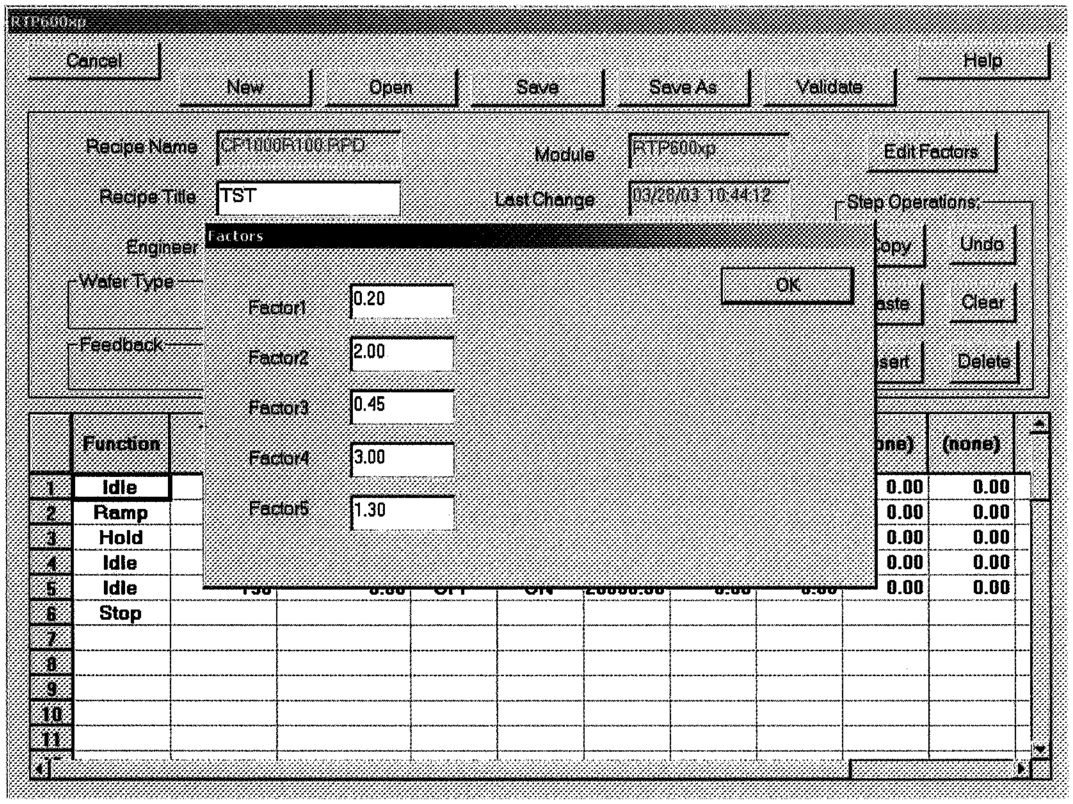

Figure 3-15. ***Recipe Edit "Factors" Screen***

RTP-600xp 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.

3.3.3.2.1 RECIPE CONTROL FACTOR OPTIMIZATION STRATEGY

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 5 take values between 0.01 and 10. 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 should be tuned before you work on other factors. An optimal value of Factor 5 is obtained when you have smooth connection for the linear intensity increase to the closed-loop ramp up.

1. 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.
2. **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 your pre-selected temperature or your pre-selected post pull out time elapses. When that specific temperature or time is reached, start the next run with the same recipe, or a similar recipe. (The pre-selected temperature or time is often chosen on the basis of how cool the processed material needs to be before it can be re-introduced into the oxygen-rich ambient of the cleanroom without harmful effects.)
3. For susceptor processing, before the RAMP step starts, an "invisible", susceptor warm up step takes place. The lamp intensity is set at the Factory in the ***System Setup Screen*** (*Pre-Warm Intensity* and *Pre-Warm Duration*).
   a. For 6" OD susceptor and 10°C/sec ramp rate, the ***System Setup Screen*** (*Pre-Warm Intensity* and *Pre-Warm Duration*) values should be about 3-5% for 5-10sec.
   b. For 4" OD susceptor and 10°C/sec ramp rate, the ***System Setup Screen*** (*Pre-Warm Intensity* and *Pre-Warm Duration*) values should be about 1% for 5-10sec.

   For wafer processing, this warm up step is typically not used.
4. 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 5. The linear increase ends when the temperature is within the pre-defined *Ramp Change Starting Temp* and *Ramp Change Ending Temp* window, which has been Factory Set on the ***System Setup Screen***.

IMPORTANT: Factor 5 should be tuned before you work on other factors. An optimal value of Factor 5 is obtained when you have smooth connection from the linear intensity increase to the closed-loop ramp up.

5. 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.

6. 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.

7. 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. Pyrometer control recipes require very low values of Factor 1 to keep any signal noise from amplifying into the recipe control algorithm.

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.

3.3.3.2.2 DEFINITION OF FACTORS

SPECIAL NOTE: Factor 5 should be tuned before you work on other factors. An optimal value of Factor 5 is 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.

Factor 5:

Factor 5 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.

3.3.3.2.3 CONTROL FACTORS FOR SAMPLE RECIPES

The following factor settings work well for the given process:

- TC Control:
  - 6" OD Susceptor with Inconel TC
  - TC Calibration with TC-on-wafer
  - Cantilever TC, touch contact

Substrate	Process	F1	F2	F3	F4	F5
Susceptor	400C, R=10C/S	1.0	0.8	0.40	0.8	0.3
Susceptor	400C, R=20C/S	1.0	0.8	0.30	1.4	0.3
Susceptor	600C, R=10C/S	1.0	1.0	0.60	0.8	0.3
Susceptor	900C, R=10C/S	1.0	1.2	0.70	0.8	0.3
Wafer	400C, R=30C/S	1.0	0.5	0.75	1.2	0.4
Wafer	600C, R=30C/S	1.0	0.5	0.75	1.2	0.4
Wafer	700C, R=30C/S	1.0	1.0	0.65	1.2	0.4
Wafer	900C, R=30C/S	1.0	0.5	0.85	1.2	0.4
Wafer	1100C, R=30C/S	1.0	0.5	0.85	1.2	0.4

- Pyrometer Control:
  - 6" OD Susceptor
  - Silicon Wafer Processing

Substrate	Process	F1	F2	F3	F4	F5
Susceptor	400C, R=10C/S*	-	-	-	-	-
Susceptor	400C, R=20C/S*	-	-	-	-	-
Susceptor	600C, R=10C/S*	-	-	-	-	-
Susceptor	900C, R=10C/S	1.0	1.2	0.70	0.8	0.5
Wafer	400C, R=30C/S*	-	-	-	-	-
Wafer	600C, R=30C/S*	-	-	-	-	-
Wafer	700C, R=30C/S	1.0	1.0	0.65	1.2	0.5
Wafer	900C, R=30C/S	1.0	0.5	0.85	1.2	0.5
Wafer	1100C, R=30C/S	1.0	0.5	0.85	1.2	0.5

Note that several hardware items can affect processes and thus the factor settings. 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.

* Pyrometer control is for processes above 700°C

3.3.3.3 PYROMETER CALIBRATION OVERVIEW

When a 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-600xp provides two level calibration, system level and recipe level.

3.3.3.3.1 SYSTEM LEVEL PYROMETER CALIBRATION

There are two critical files, which govern system level pyrometer control: *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 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.

3.3.3.3.2 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 the reference temperature for the pyrometer. There are several basic styles of TC. The most common are: (1) the **TC Wafer** which has the TC embedded directly into a wafer; (2) the **Cantilever TC** which is in contact with the wafer when running wafer processing; and (3) the **Inconel TC** which is used with susceptor processing (NOTE: The Inconel TC can be placed so that it is in contact with the wafer in the susceptor or with the susceptor itself).

With thermocouple properly installed, select **[Engineering]** from the Main Menu the ***Engineering Screen*** will appear (See **Figure 3-12**).

Select the recipe, press **[Pyrometer Calibration]**. **Pyrometer Calibration** 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 **[Start Process]**. 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.

3.3.4 EDITING AN "EXISTING" RECIPE DATA FILE

1. Click **[Engineering]** from the **Main Menu.**
2. The ***Engineering Screen*** will appear.
3. Click on your desired **Recipe File** to highlight the recipe for further access.
4. Click **[Create/Edit Recipe]** from the Engineering Screen.
5. The ***Recipe Editor Screen*** for your highlighted Recipe will appear.

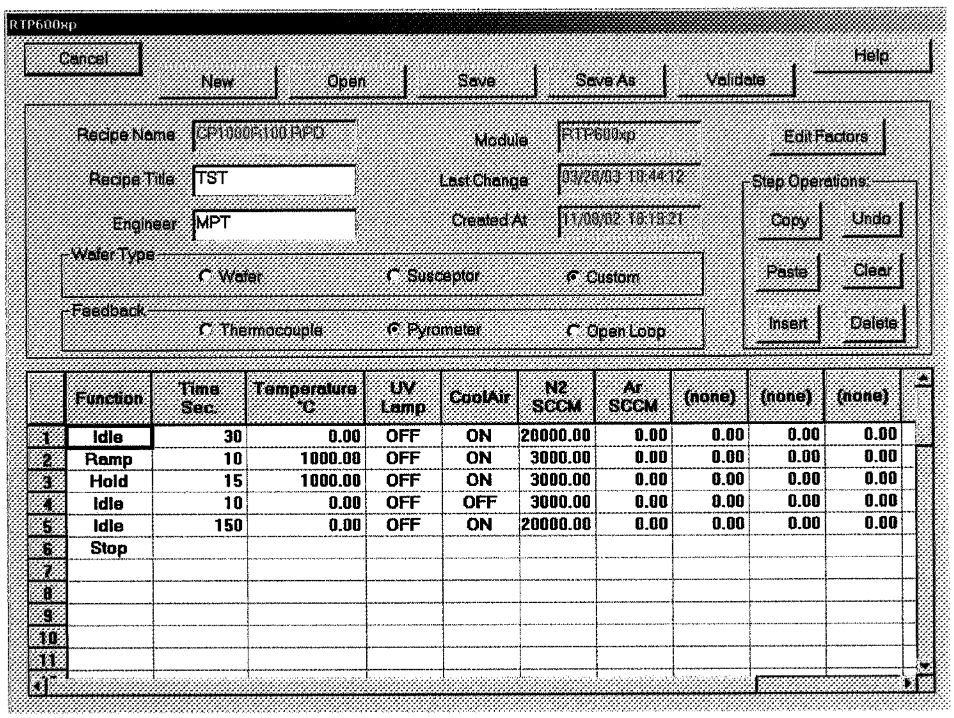

Figure 3-16. ***Recipe Editor Screen***

6. After editing has been completed, click **[Validate]** to validate the recipe.
7. Click **[Save]** to save the recipe.
8. Click **[Cancel]** to return to the ***Engineering Screen***.

SECTION 3: CHAPTER 4

SPC MODE

The SPC mode provides Process Engineers and Service Personnel with the ability to retrieve a historical record of Time/ Temperature profiles as well as a historical record of System Alarm/ Log In Events.

3.4.1 SPC MODE ACCESS FROM MAIN SCREEN

1. Click **[SPC]** from the Main Menu Screen
2. The **SPC Mode Directory Pop-Up Screen** will appear (see **Figure 3-17**).

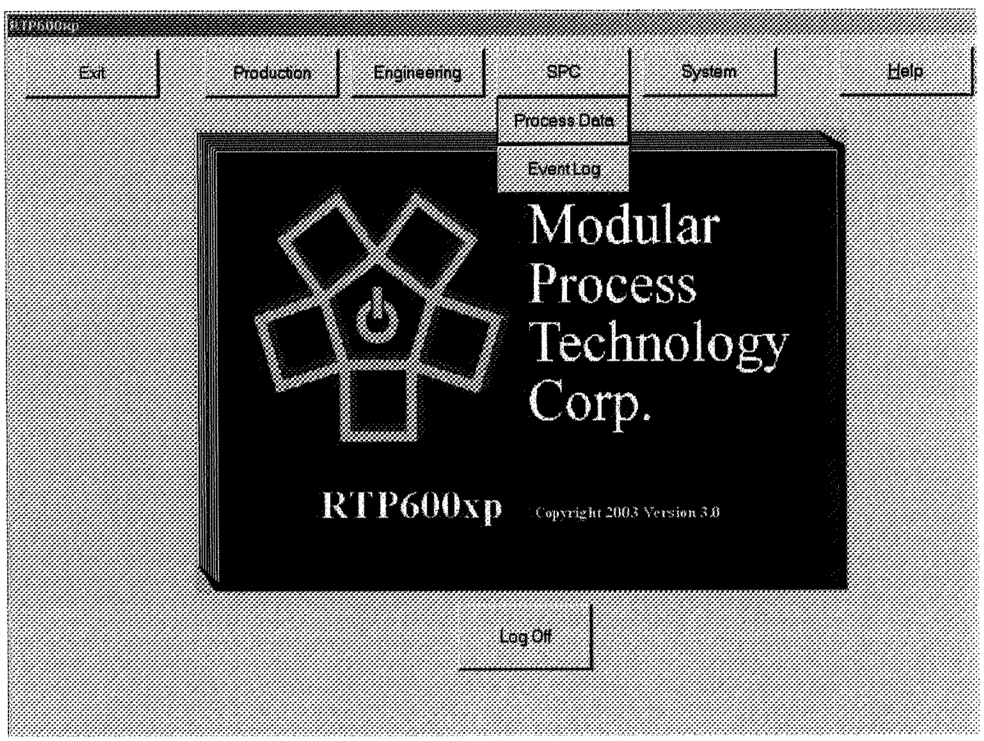

Figure 3-17. ***SPC Mode Directory Pop-Up Screen***

From the SPC Mode Directory Pop-Up screen, the two types of historical data that can be retrieved are displayed. A selection of either Process Data or System Event Log can be made.

3.4.2 SPC MODE PROCESS DATA SCREEN

1. From the ***SPC Mode Directory Pop-Up Screen*** click **[Process Data]**
2. The ***Historical Process Data File Directory Screen*** will appear (see **Figure 3-18**).

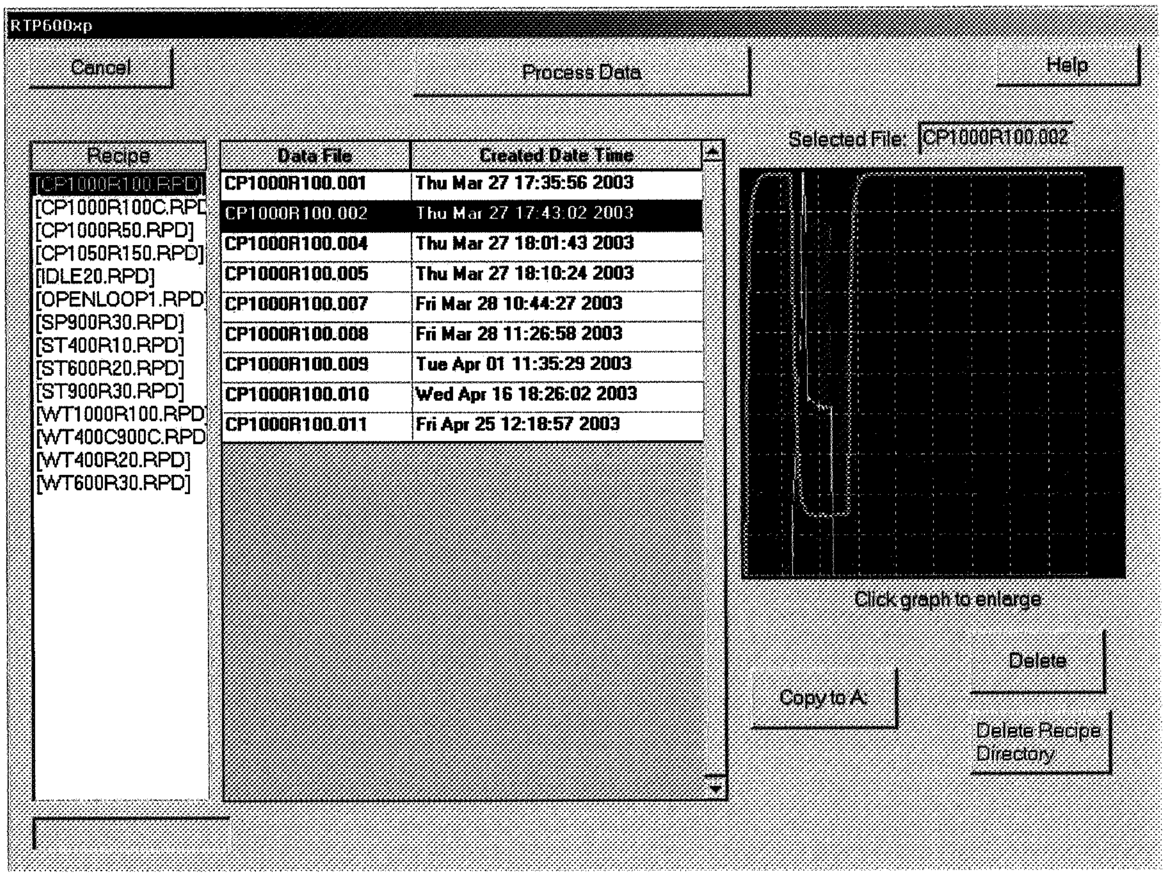

Figure 3-18. ***SPC Mode Process Data Screen***

The SPC Mode Process Data Screen provides Process Engineers and Service Personnel with the ability to easily retrieve historical Time/ Temperature profiles. On the Process Data Menu Screen, all the recipes that are stored in the system are listed under "Recipe". Under "Data File"/ "Created Date Time" is a listing in sequence of the individual run data files from the "selected" recipe. On this screen it is also possible to copy the file to Floppy Drive A.

3. Select a process data file to plot. The historical Time/Temperature plot is automatically shown in the Selected File box on the Process Data Screen. By clicking on the graph the Process Data Display and Analysis Screen is displayed (see Figure 3-19).

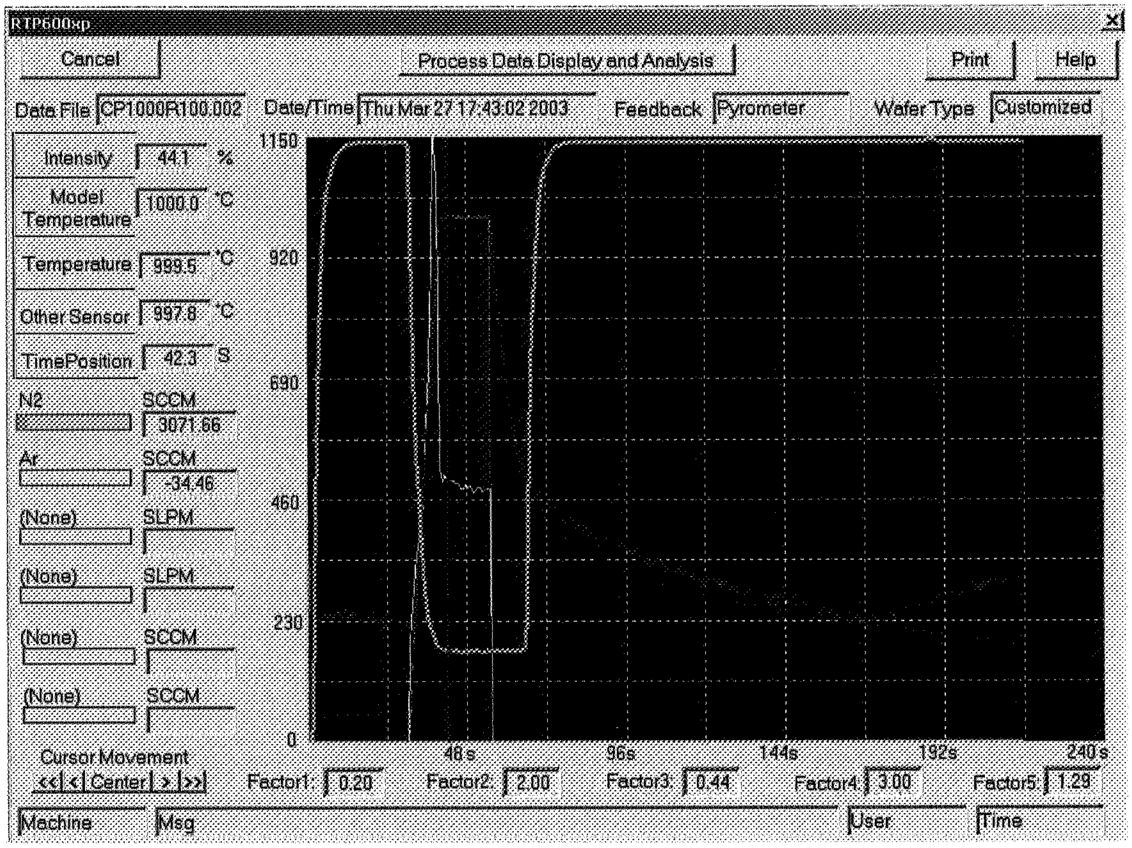

Figure 3-19. ***Historical Time/Temperature Profile***

3.4.3 SPC MODE EVENT LOG SCREEN

1. From the ***SPC Mode Directory Listing Pop-Up Screen*** click **[Event Log]**
2. A Log listing recorded System Events/Alarms will appear (see **Figure 3-20**).

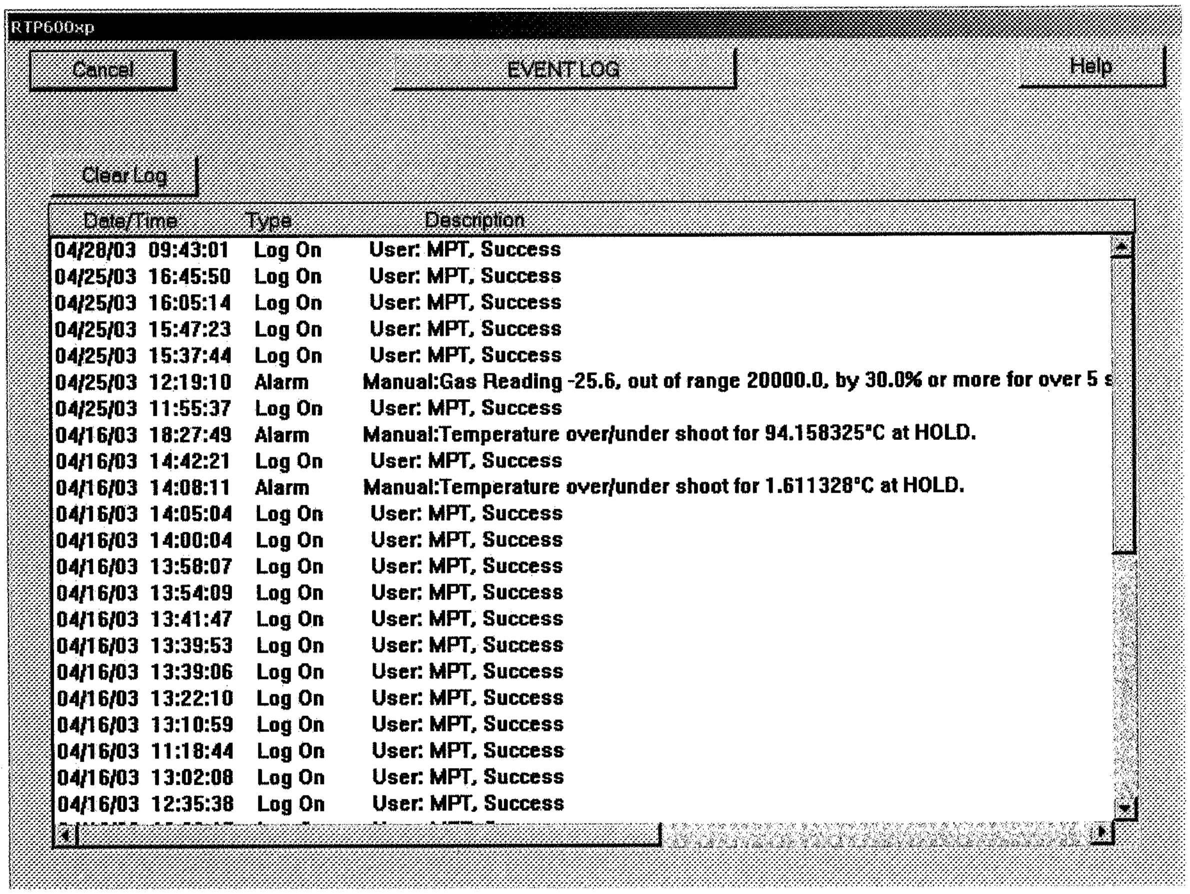

Figure 3-20. ***Historical System Event/Alarm Log***