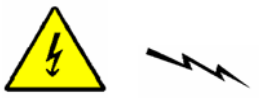
WARNING!

TROUBLESHOOTING THIS EQUIPMENT SHOULD BE CARRIED OUT ONLY BY HIGHLY EXPERIENCED PERSONNEL UTILIZING STANDARD APPROVED SAFETY PROCEDURES.

EXPOSED ELECTRICAL CIRCUITS AND HEATED SURFACES ARE PRESENT WITHIN THIS EQUIPMENT. GREAT CARE SHOULD BE EXERCISED AT ALL TIMES WHEN WORKING WITH IT.



DANGER!

HUMAN CONTACT WITH HEATED SURFACES CAN CAUSE SEVERE BURNS. CONTACT WITH ELECTRICAL CIRCUITS MAY CAUSE SEVERE BURNS, SHOCK, OR CAN BE FATAL.

WARNING!

IF, IN THE PROCESS OF TROUBLESHOOTING, IT BECOMES NECESSARY TO WORK WITH CIRCUITRY OR HEATED SURFACES, EXTREME CAUTION SHOULD BE OBSERVED. ALL TEST METER LEADS SHOULD BE IN GOOD REPAIR AND SHOULD HAVE SUFFICIENT INSULATION FOR A TEST VOLTAGE OF AT LEAST TWICE THAT TO BE MEASURED. DO NOT WORK IN CRAMPED SPACES OR AREAS THAT ARE CLUTTERED. DO NOT WORK IN A MANNER THAT WILL ALLOW TOOLS OR PARTS TO FALL ON ENERGIZED EQUIPMENT OR ON TO YOU.

OPERATION AND MAINTENANCE PROCEDURES

FOR

DEPOSITION SYSTEM MODEL

SOLUTION

CITY COLLEGE OF NEW YORK #5720

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Except as stated herein, seller makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except as stated herein, seller shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise. Statements made by any person, including representatives of seller, which are inconsistent or *in* conflict with the terms of this warranty shall not be binding upon seller unless reduced to writing and approved by an officer or seller.

WARRANTY REPLACEMENT AND ADJUSTMENT

All claims under warranty must be made promptly after occurrence of circumstances giving rise thereto, and must be received within the applicable warranty period by seller or its authorized representative. Such claims should include the product description, serial number when available, the date of shipment, and a full description of the circumstances giving rise to the claim. Before any products

Are returned for repair and/or adjustment, written authorization from seller or its authorized representative for the return and instructions as to how and where these products should be returned must be obtained. Any product returned to seller for examination shall be sent prepaid via the means of transportation indicated as acceptable by seller. Seller reserves the right to reject any warranty claim not promptly reported and any warranty claim on any item that has been altered or has been returned by *non*-acceptable means of transportation.

LIMITED WARRANTY STATEMENT CONTINUED

When any product is returned for examination and inspection, or for any other reason, customer will be responsible for all damage resulting from improper packing or handling, and for loss in transit, notwithstanding any defect or non-conformity in the product. In all cases seller has sole responsibility for determining the cause and nature of failure, and seller's determination with regard thereto shall be final.

If it is found that seller's product has been returned without cause and is still serviceable, customer will be notified and the product returned at its expense; *in* addition, a charge for testing and examination may be made on products so returned.

DAMAGES AND LIABILITY

Seller's liability for damages shall not exceed the amount seller actually receives for the product furnished or to be furnished, or service rendered, or to be rendered, as the case may be, which is the subject of claim or dispute, and *in no* event shall seller be liable for incidental, consequential or special damages. Liability to third parties for bodily injury, including death from seller is performance shall be determined in accordance law and the total liability limitation stated above shall not be construed as a limitation on seller for damages for any such bodily injury, including death.

SOLUTION

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1. INTRODUCTION

1.1 System Overview

The Solution Series Systems are an industry standard in high vacuum deposition system. Their simplicity in design, ease of operation and unmatched reliability make them an excellent choice for a wide range of production applications.

The Solution Series System handles various types of sources, such as electron beam, ion beam, etc.

They are equally productive in both sputtering and evaporation processing. These flexible systems are designed for sputtering operation with up to four DC cathodes.

1.2 Safety Issues

The Solution systems have been designed with safety features to protect operating personnel. In those instances when safety is a particular issue, a warning is prominently displayed in the manual with appropriate guidelines.

For Operating and Maintenance Personnel

1. Before servicing or operating this equipment, read all the component manuals supplied with the system and pay special attention to any safety precautions.

Important!

Read carefully any statement in this manual denoted by the Warning Box symbol shown below. The symbol denotes a safety warning.

WARNING!

2. Before servicing this equipment, disconnect the electrical power at the Main Power Switch. Use only a Main Power Switch that has a lockout feature. Lock the power OFF and keep the key with you while working on the equipment.

3. Certain electrical components (e.g., electrolytic condensers) hold a lethal voltage even after the main power is turned off. Be certain that such components have been discharged, by shorting the B+ terminals to ground before starting any repair.

4. Verify that equipment is connected to a power receptacle that has correct polarity and is grounded as prescribed by the National Electrical Code.

5. Do not touch high voltage leads.

6. This equipment contains electrical interlocks to help protect personnel from injury.

DANGER!
Do not defeat, override or bypass electrical interlock devices.

7. Do not work alone.

8. Wear safety glasses.

9. Operators shall not enter areas of the equipment intended for service access only. Only experienced service personnel may enter such areas after taking the various precautions described above, as well as studying the entire manual, including any and all updates, revision, etc.

10. Post High Voltage warning signs conspicuously in the operating area.

11. Remove rings, watches and bracelets before working around high voltage.

3. FRONT PANEL CONTROLS, INDICATORS AND KNOB SETTINGS

The Solution is a high vacuum Electron Beam Deposition System that is used to create high quality film. The front panel instruments and controllers are:

1. Simatic 8" Color Touchscreen
2. GP307 Vacuum Gauge Controller
3. CTI ON BOARD 8 Cryopump.with 8200 water cooled
4. HVSP Sycon Electron Beam Power Supply
5. Sycon STC-2000A Deposition Controller
6. Sycon EBS530 Sweep Control Power Supply
7. Kaufman and Robinson Model EH200F End-Hall Beam Source, Power Supply and Controller

3.1 Switch Settings for Automatic Operations

The following are the conditions and switch settings necessary for proper automatic operations.

The Granville-Phillips Ion Gauge Controller is factory-set and should not be changed unless absolutely necessary. Refer to the manual provided with it for further information.

A. Granville-Phillips Ion Gauge Controller

Open the hinged, lockable display door. Notice the Electrometer module to the far left. Set the emission range switch to the 10 milliampere range. Find the Convectron module in the middle. Set the arrow point for the potentiometer of the IG1 and IG2 to the OFF position. Find the panel labeled Process Control and set switches 1, 2, 3, 4, 5 and 6 to the SP position.

B. HVSP Sycon Electron Beam Power Supply should be on.

C. Sycon EBS530 Sweep Control Power Supply should be on.

D. Sycon STC-2000A Deposition Controller should be on.

E. CTI ON BOARD 8 Cryopump Controller should be on.

F. Kaufman and Robinson Model EH200F End-Hall Beam Source, Power Supply and Controller

4. HARDWARE AND SOFTWARE PACKAGE

4.1 Simatic 8” Color Touchscreen.

The MP277 8” Touchscreen offers new graphical, operational, communication and functional possibilities.

Features

- Backlit 7.5 “ TFT display with Resistive Analog Touch.
- High Performance
- Vector graphics for improved screen designs
- Resolution 640 x 480 pixels, 64K colors
- Combined SD/Multi Media Card Slot enables memory expansions for archives, recipes, backup/restore function, etc.
- Integrated 12Mbits/s MPI / Profibus Interface
- Integrated Profinet interface providing
- Profinet communication to PLCs
- Profinet IO capability
- Use of WinCC Flexible Sm@rtService, Sm@rtAccess and Audit runtime options
- Larger user memory (6MB), enabling larger configurations
- 5 Online languages, including Cyrillic and Asian
- 2 standard onboard USB interfaces for printer, keyboard, mouse, barcode reader, etc.
- Maintenance free alarm buffer (without battery and failsafe)

Figure 4-1 EZ Touch 8" Touchscreen

4.1.1 Siemens Simatic S7 312 Programmable Line Controller

The Simatic S7 312 Programmable Line Controller (PLC) with statement list type construction is used for automation of the system.

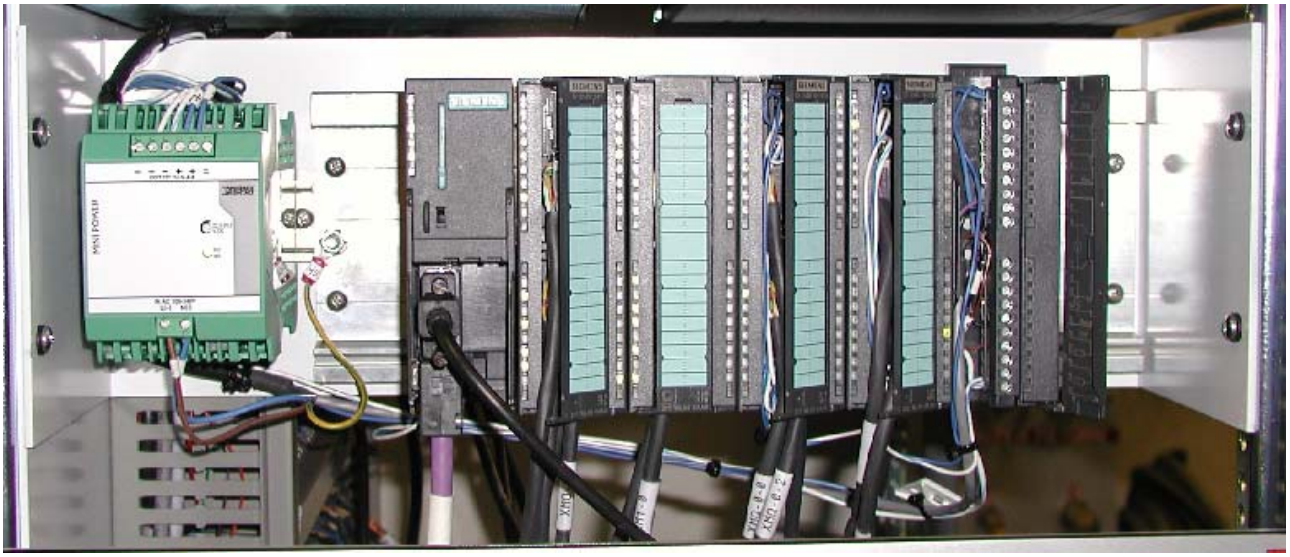


Figure 4-2 Simatic Step 7 312 PLC

Starting from the left of the central rack consists of:

Slot #1 - PS 307 (5A)
Slot #2 - SIEMENS Simatic S7 312 PLC
Slot #3 - 32-Pt. Digital Input Module
Slot #4 - 32-Pt. Digital Input Module
Slot #5 - 32-Pt. Digital Output Module
Slot #6 - 32-Pt. Digital Output Module
Slot #7 - 4 In / 2 Out Analog Combo Module
Slot #8- TC Analog Module

4.2 Software

4.2.1 SIMATIC Siemens Manager S7 Version 5.4

Siemens Simatic is a comprehensive control and Human Machine Interface (HMI) development tool powered by Siemens Automation.

Advanced PC-based control with enhanced HMI capabilities and an optional SQL interface.

System Requirements:

Hardware
Please note that you need increased main memory expansion for STEP 7 version 5.4. For STEP 7 V5.4 in Windows 2000/XP Professional your PC requires at least 512 MB RAM and a processor of at least 600 MHz. In Windows Server 2003 your PC requires at least 1 GB RAM and a processor of at least 2.4 GHz. It is generally recommended to have a main memory of at least 1 GB.

Software
STEP 7 version 5.4 is released for the following operating systems:

- MS Windows 2000 Professional as from SP4
- MS Windows XP Professional as from SP1 (or SP1a)
- MS Windows Server 2003 with or without SP1 as a workstation computer.

The STEP 7 software is released for Windows XP Professional, 32 bits. Installation in Windows XP Professional X64 (64-bit edition) is not possible.

Internet Explorer:
You need an Internet Explorer 6.0 (or higher).

4.2.2 WinCC Flexible 2005 Advanced Version 2005 SP1

WinCC flexible 2005 SP1 is the latest version of HMI software from Siemens, providing improved engineering performance, support for numerous new devices and various other enhancements.

WinCC Flexible 2005 SP1 is the continuing development of the innovative HMI software family from Siemens. It enabling the universal configuration of all Windows based SIMATIC HMI operator devices ranging from the smallest Micro Panel up PC based solutions. WinCC flexible 2005 SP1 has support for new devices in the SIMATIC HMI panel family, improved engineering features, performance, and traceability.

5. SYSTEM OPERATION

5.1 General Overview

The Solution is an Electron Beam Deposition system designed to make high quality thin films. The system automation is achieved using Siemens Simatic S7 programmable line control. The software uses object-oriented graphics and provides a wide range of animated capabilities to make the system operation user friendly.

The design philosophy encompasses a software package that can be learned quickly. The user can control the manual and the automatic operation by setting the parameters as desired.

5.2 Modes of Operation

There are two modes of operation:

- Automatic
- Manual

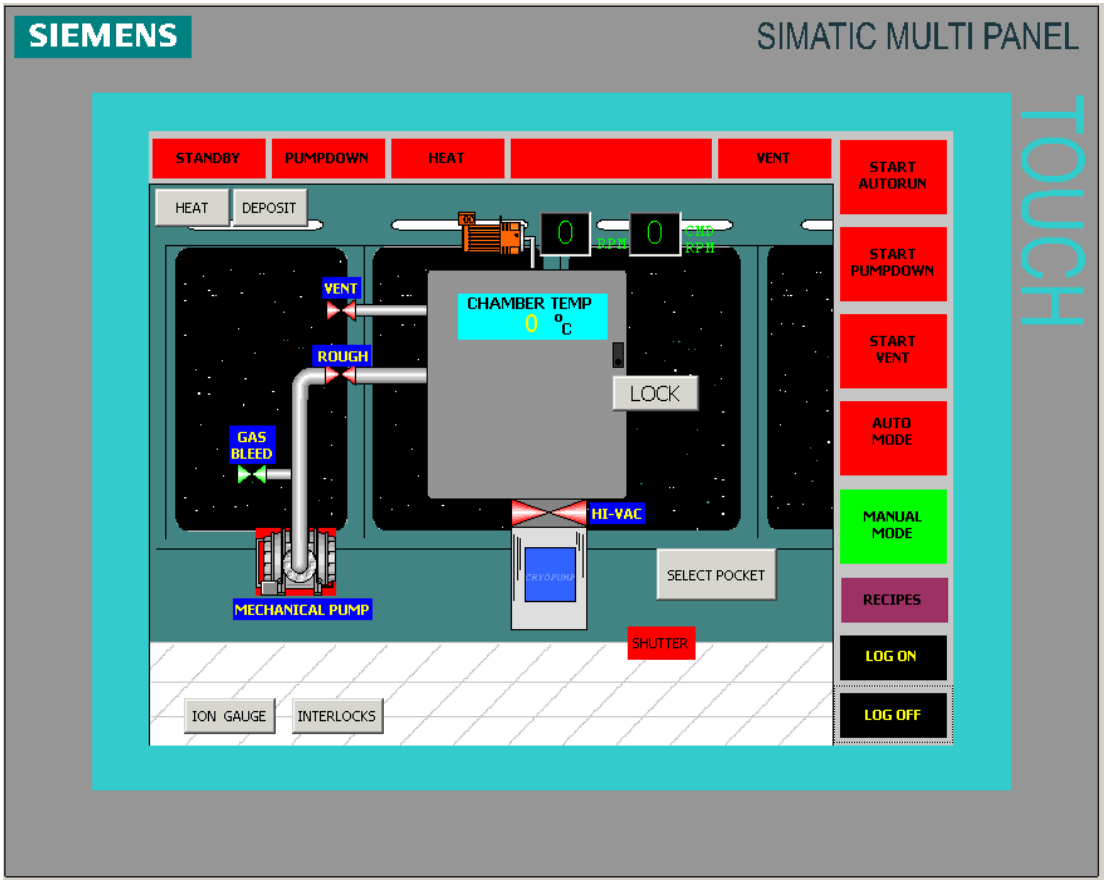


Figure 5-1 Manual Pumpdown

5.2.1 Automatic Mode

- Automatic process run
- Automatic pumpdown
- Automatic vent
- Standby

Standby is executed all the time, when none of the other operations listed above is being executed. As soon as one of these is selected, the standby program is disabled until the selected program is executed or aborted.

5.2.2 Manual Mode

Manual Electron Beam Power Supply / Manual Gun Rotation Control

Optional Manual Heat Control

Optional Manual Resistance Power Supply Control

Manual Pumpdown / Vent Valves / Chamber Door / Fixture Motor Control

The sequential nature of the program execution requires that all the recipe parameters and watchdogs in the recipe screen be set prior to the program execution run. All parameter settings are very critical to the proper system operation and must be set only by qualified personnel.

The details of each automatic operation and the manual controls are described in subsequent sections.

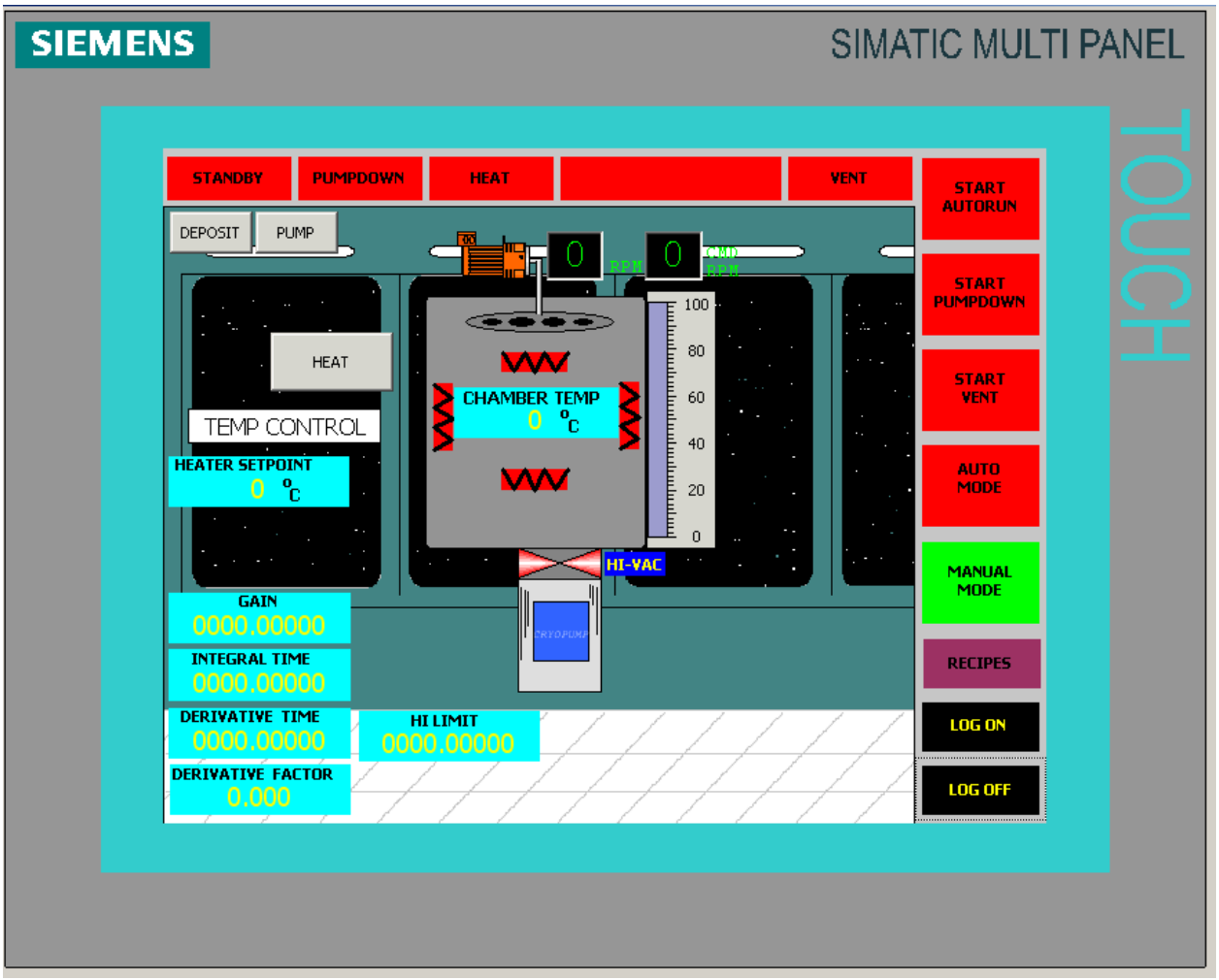


Figure 5-2 Optional Manual Heat Screen

You are able to perform any of the following:

A. Manual Operation
- Manual Pumpdown/Vent
- Optional Manual Heat
- Manual EB Deposition
- Optional Manual RPS Deposition

B. Automatic Operation
- Automatic Pumpdown
- Automatic Process
- Automatic Vent

C. Change recipe parameters

D. How to log on to the system

You must log on to the system to perform any of the following:

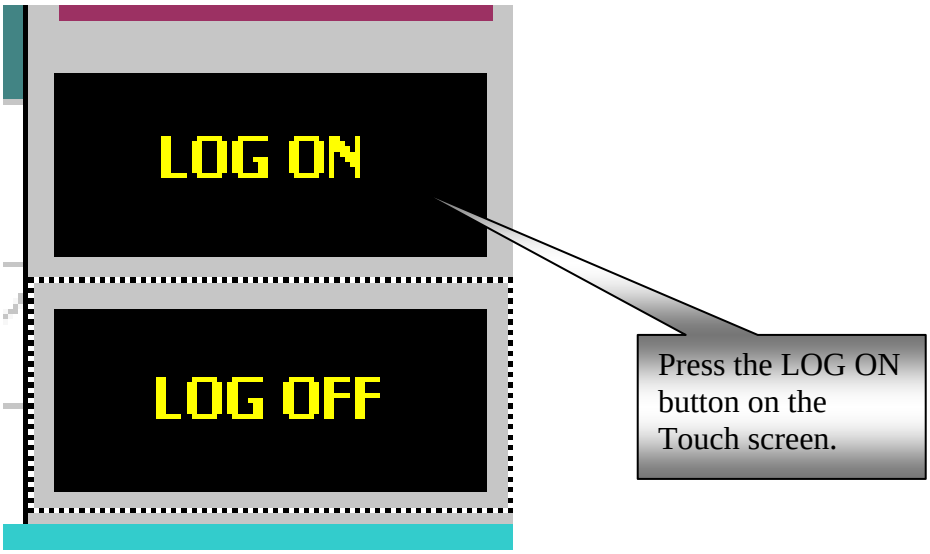
A. Manually operate.

B .Automatic operate.

C. Change the recipe parameters

To log on, perform the following:

1. Press the **LOG ON** button in the Side Menu.



2. The screen shown in Figure 5-3 will be displayed.

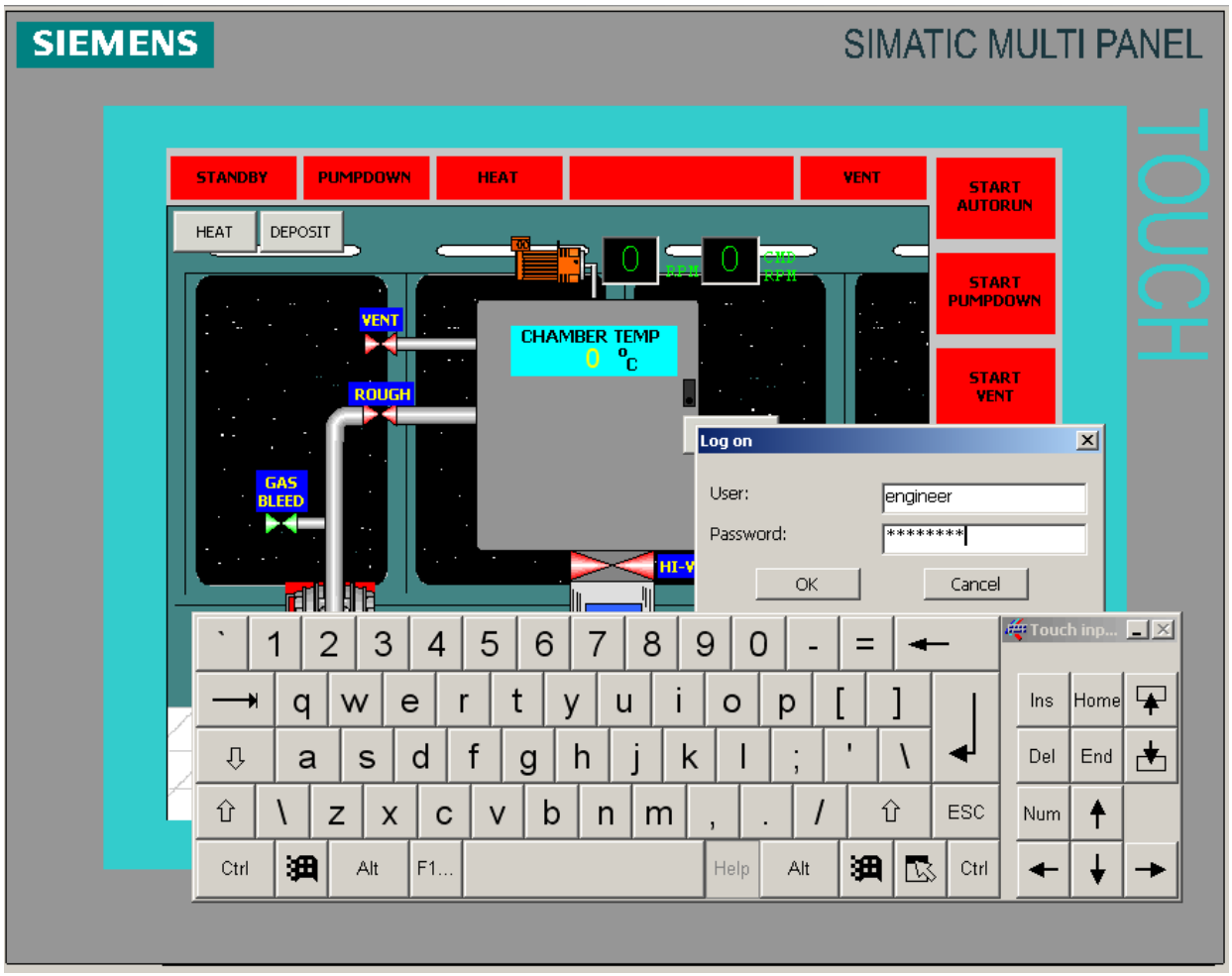


Figure 5-3 Log On Screen

3. **ENTER USER NAME engineer optional (e) or operator optional (o)**

A keyboard is displayed on the screen.

4. Use touch screen, to type the name.

5. **ENTER PASSWORD engineer for engineer optional (cha) or operator for operator optional (cha).**

6. Then press **OK** to enter the name and password.

The keyboard and log on disappears from the screen.

Access Levels For Various Groups

The access level is categorized into two levels:

Operators

Process Engineers

1. Operator Access Level

The user assigned to this group has access to only Automatic Process Run, Automatic Pumpdown, and Automatic Vent.

2. Process Engineer

The user assigned to this group has access to everything that the Operator levels have plus Manual and Recipe Parameter Screens.

6. THEORY OF AUTOMATIC PROCESS RUN

6.1 User Interface for Automatic Operation Of System

The monitor screen is designed to advise you of the current system status and allow you to perform actions.

These indicators highlight to let you know which particular stage is running at that moment or whether the system is in standby.

Automatic Run

Automatic Pumpdown

Automatic Vent

Standby

Automatic Pumpdown and Vent can be initiated by touching the function button on the Touch screen. The system must be in Standby, chamber door closed and latched, and last you must be in Auto Mode before any of the automatic runs can be initiated.

As previously noted, anytime the system is turned on and no other process is running the system is in standby.

The Screen is a representation of the system displayed on the screen. The valves and buttons displayed on the screen are color-coded. Green indicates on or open status and red indicates off or closed status.

The Pop-up indicators are notes that the system displays on the screen to advise you about the progress of the process.

The Jog button rotates the planetary fixture for loading and unloading. The Jog function key is a momentary push button. Rotation continues as long as the button is pressed and stops when the button is released.

The Abort button aborts (or halts) any process in progress and places the system in standby. The abort button is displayed anytime an automatic process is in progress.

The Emergency OFF button stops ALL system activity. There are two Emergency Off (EMO) buttons. One is located on the front panel, and one on the rear. The EMO is a red button with about one and one half inches in diameter.

6.2 Standby Mode

When the system is brought up from a cold start, it automatically resets all the outputs. The mechanical pump is turned on. The program verifies the power is on to the Granville Phillips 307 gauge. The program verifies the temperature of the cryo pump is below set point. The ion gauge should be on at this time. If it is not, manually turn it on.

The following is a partial list of the interlocks that are continually checked by a subroutine when the system is running. Mechanical pump is on, power to the Granville Phillips 307 is on, power to the cryo pump compressor is on, and the cryo pump is below temperature set point.

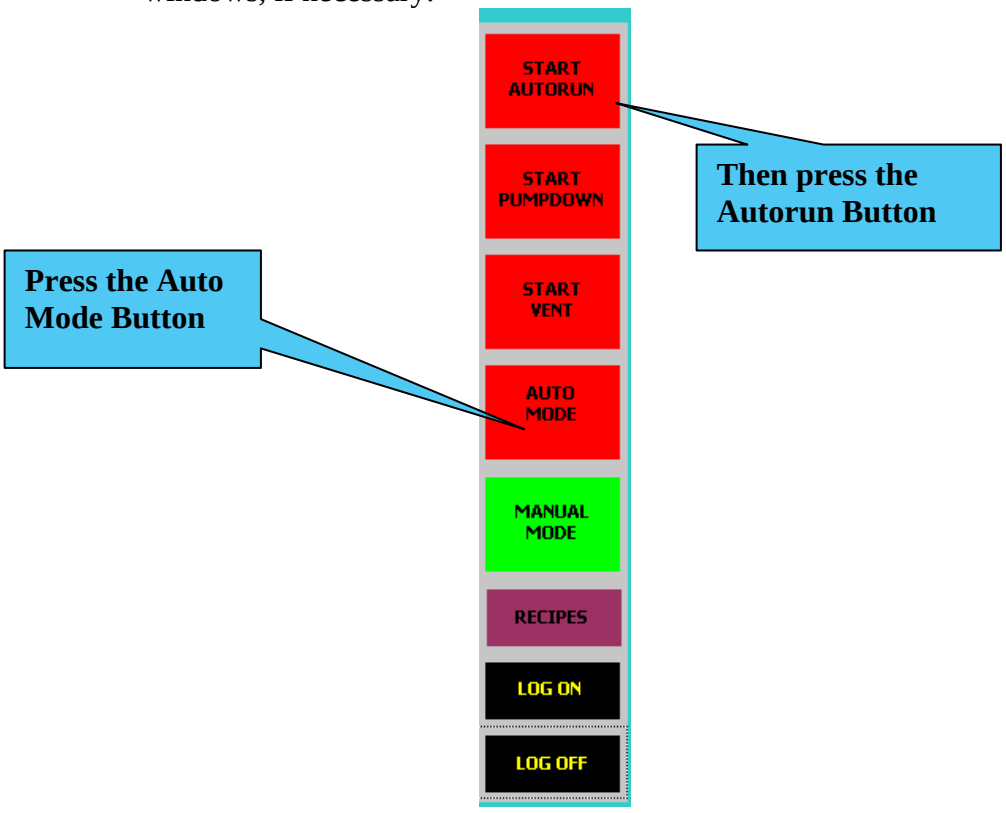
6.3 Initiating the Automatic Process Run

To initiate the automatic process run, press the Auto Mode button when the system is in standby then press the Autorun function key on the touch screen.

CAUTION

NEVER attempt to change any switch settings after pressing the <Autorun> key. Doing so could cause the PLC to abort the process run.

The program resets the standby, vent complete and process complete pop-up windows, if necessary.



The screen switches to the Automatic Pumpdown screen. To abort, touch the abort button. The system will go into standby automatically.

If the cryo pump stack pressure is not below the setpoint, a pop-up indicator appears to indicate this condition. The program will continue as before until the stack pressure setpoint is achieved. When the cryo pump stack pressure is below the set point, the program proceeds to the next step, scanning the interlocks.

6.4 Interlock Checks

When **Autorun** is pressed to start the automatic process run, the Programmable Line Controller (PLC) checks ALL of the interlocks. When **Autopump** or **Autovent** is pressed, the program checks only the interlocks relevant to that particular run. A subroutine continually rechecks the interlocks during the process run. In the event an interlock is violated during the automatic run, a pop-up window appears indicating that the program has been aborted and the system automatically goes into **standby** mode.

Refer to System Interlock Flowchart for interfacing all interlock options.

DANGER!
Do not defeat, override or bypass electrical interlock devices.

6.5 Pumpdown

The program checks whether the roughing crossover setpoint is reached. If the setpoint has been reached already, there is no need for roughing down. The rough valve remains closed (red), and the program proceeds to the next step, opening the Hivac valve.

If the crossover setpoint is not made, the program pauses for twenty seconds, opens the rough valve (turns green). A watchdog timer counts down the roughing time. If the timer expires before the roughing crossover setpoint is made, then you will see a pop-up window that states the program has been aborted because the roughing watchdog has expired before crossover setpoint was made, and the system aborts. When the crossover setpoint is achieved before the watchdog timer expires, the program closes the rough valve, opens the rough gas bleed, pauses for 5 seconds, and

then opens the hivac valve. You see the rough valve turn red, rough gas bleed and the hivac valve turn green.

When the crossover setpoint is made, ion gauge 2 filament is pulsed on. If IG2 does not come on, the program pauses for fifteen seconds, then tries again. The program will make up to two attempts to turn on IG2. If it still is not on, then you will see a pop-up indicator that states the ion tube filament #2 is off and the system automatically goes into standby.
When the IG2 gauge comes on, a watchdog timer begins the countdown. If the IG2 setpoint 1 is not achieved before the timer expires, then you will see a pop-up indicator that states the IG2 setpoint is not made the system automatically goes into standby. When the IG2 setpoint 1 is achieved, the program proceeds to the next step.

6.6 Deposition

The Sycon STC2000A or IC5 takes full control of the Deposition Process and the Deposition Screen is now displayed on the touchscreen.

When all the parameters in event one are complete in the deposition controller, then event two starts and so on until the last event in the deposition controller is complete.

When all events have been completed in the process; the program proceeds to the next step, venting.

6.7 Vent

The screen changes to the Pumpdown Screen and Autovent is now highlighted. A pop-up window appears to inquire whether you want to vent or not. The program waits indefinitely, until you press the **YES** button. When you press the YES button, the program turns on Ion Gauge 1.

6.8 Ion Gauge #1 Is Turned On

If the IG1 does not come on, the program pauses for twenty seconds, then tries again. The program will make a maximum of two attempts to turn on the IG1. If the IG1 still isn't on after two tries, then a pop-up window appears that states the ion tube filament is off and the system goes into standby. Touch the **OK** button. The process run aborts, the system automatically goes into standby and a pop-up window states the system is in standby. You can press the **OK** button to remove the pop-up window from the screen.

When the IG1 comes on, the program closes the hivac valve, pauses a few seconds then opens the vent valve. A watchdog timer begins timing the venting process. If the chamber pressure has not reached 760 torr when the timer expires, a pop-up window appears indicating this condition. When the chamber pressure reaches 760

torr (atmospheric pressure), the preset extended purge timer begins the purge countdown. When the extended purge timer expires, the vent closes.

A pop-up window shows the process is complete. You can press the **OK** Latch/Unlatch chamber, Fixture Jog and Rotate Pocket buttons appear on the screen. They allow you to open and close the chamber, jog the fixture for loading and unloading and refill the source.

6.9 THE STANDBY ABORTED SCREEN

When the system aborted, because of an interlock problem the Standby Aborted screen appears allowing the user to enter Manual mode and change recipe parameters if required, i.e. if the Mech.pump was not operating properly, you would be able to enter Manual mode, turn on the pump, and restart standby. This procedure would allow you to repair pumps, address errors and continue. Error messages appear in graphic form on each standby aborted screen. The cause for each error is described in the message. Some corrective action(s) may require technical support from CHA

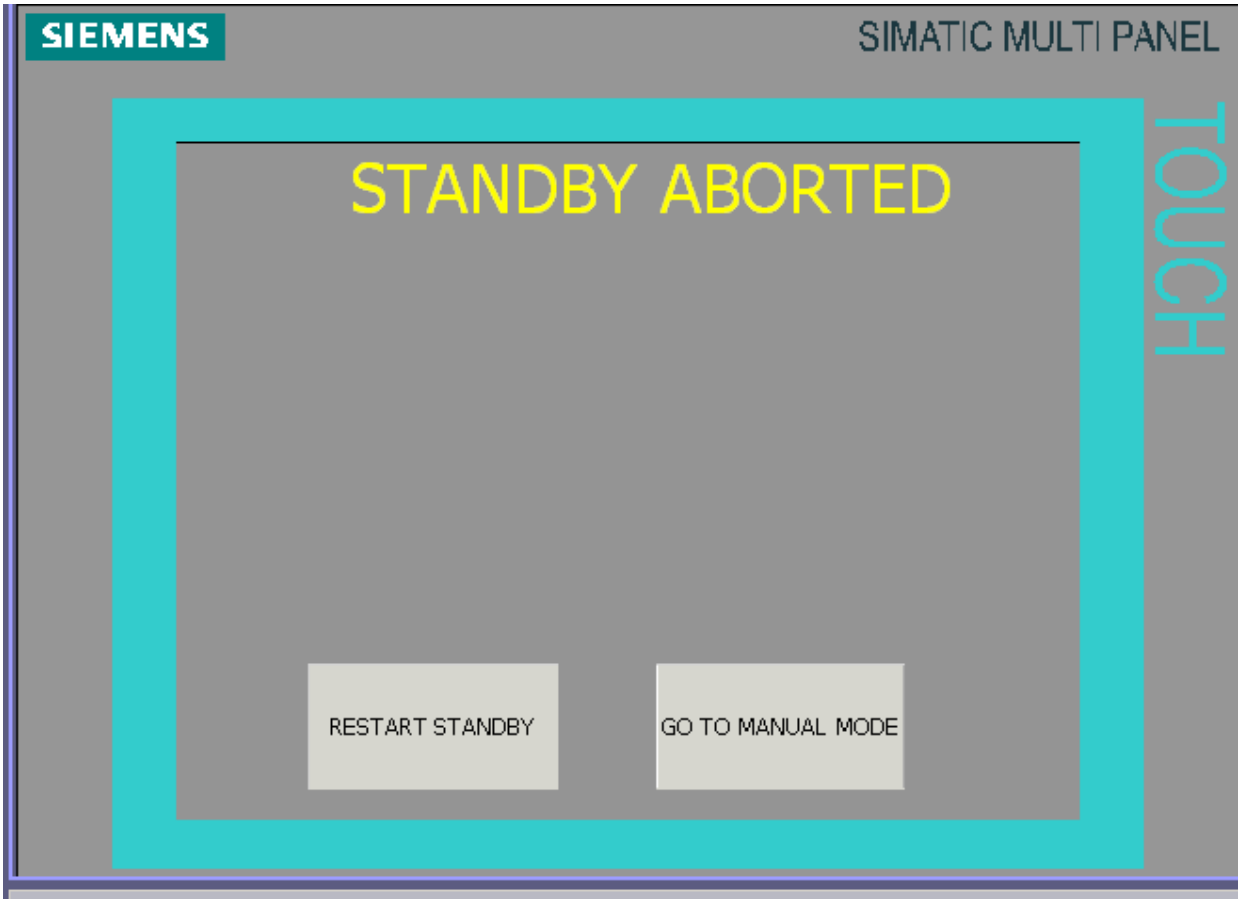


Figure 6-2 OPTIONAL STANDBY ABORTED SCREEN

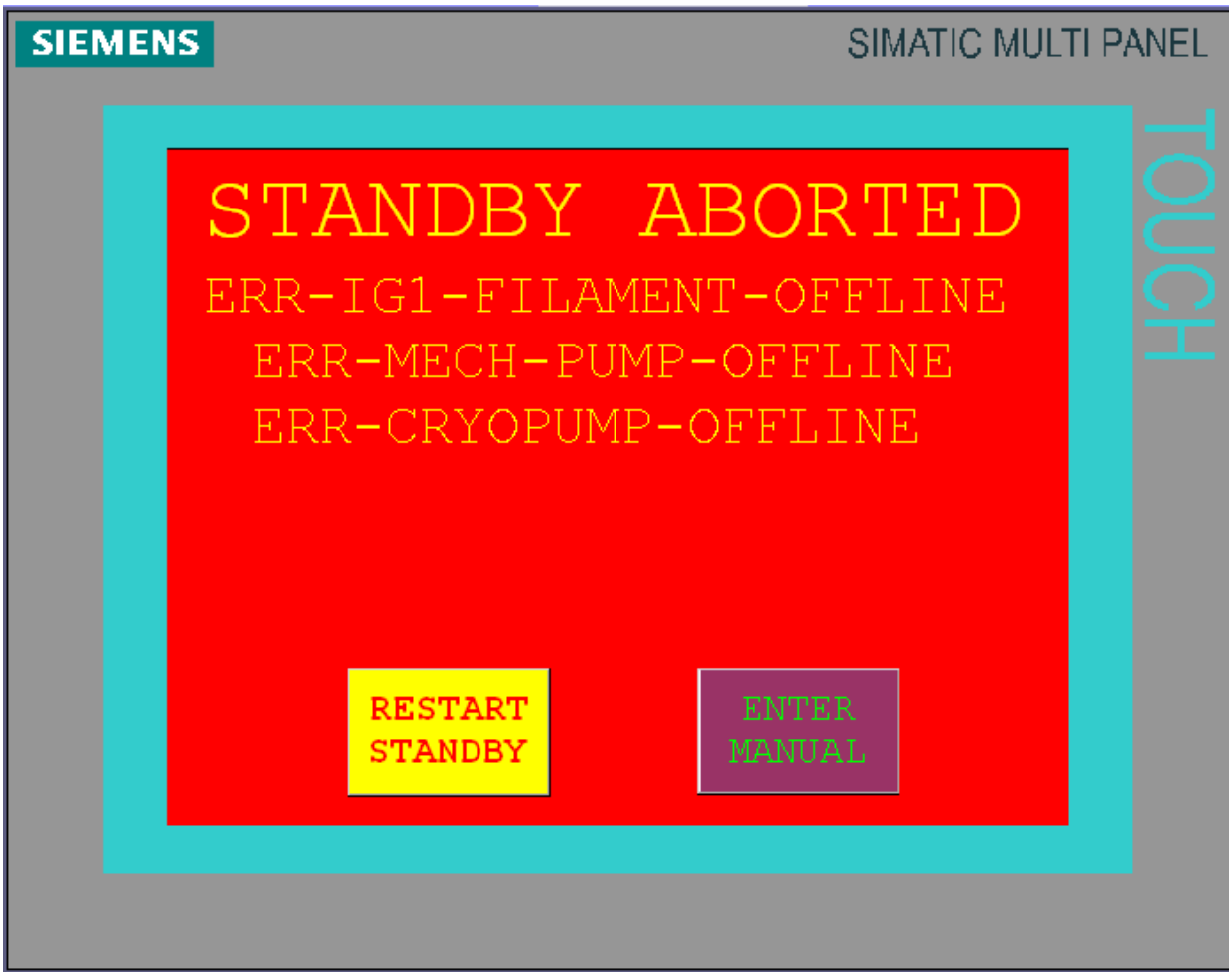
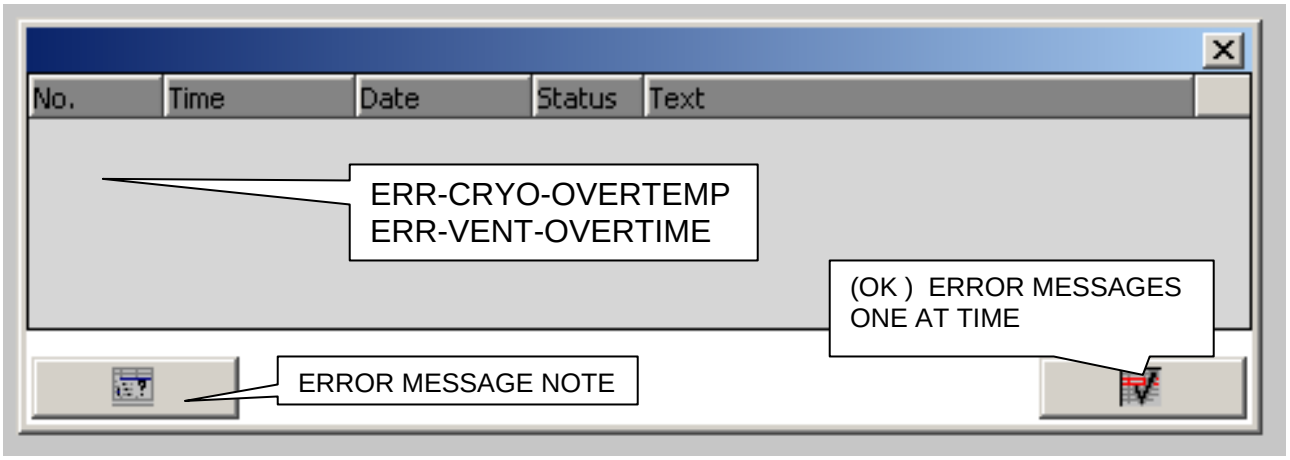


Figure 6-2A STANDBY ABORTED SCREEN



OPTIONAL ERROR MESSAGE SCREEN

7. DESCRIPTION OF AUTOMATIC PROCESSES

7.1. How To Initiate An Automatic Process Run

NOTE:

The system will abort the automatic process run if the switches are not in the proper position.

NEVER attempt to change any switch settings after pressing the Auto run. Doing so could cause the PLC to abort the process run.

Refer to flowchart for interfacing of all automatic options.

1. Ensure the PLC is in the automatic mode and is in Standby.

2. Ensure all the relevant switches are in the proper position. Refer to Section 3 for information on switch and knob settings.

3. To initiate the automatic process run, press the **Auto run** button on the Touch Screen.

4. The system scans the system interlocks in the background. If any of the interlocks should fail, the system aborts. (See System Interlocks)

5. The system initially checks Convectron B setpoint #1 (5), if not satisfied the rough watchdog timer is started.

6. Seconds later the rough valve is opened and rough gas bleed valve is closed.

7. If the roughing watchdog times out before Convectron B setpoint #1 (5) is satisfied, system aborts.

8. If Convectron B setpoint #! (5) is satisfied within the time limit, the rough valve is closed & seconds after the rough gas bleed valve is opened.

9. If Convectron B setpoint #2 (6) turns OFF during the scan, that means there is Overpressure in the chamber, therefore system aborts.

10. If Ion Gauge 1 remains ON during the scan, the Hi-Vac valve is opened.

11. Ion Gauge 2 delay from recipe, and then filament is pulsed ON. (Limit of 2 pulses)

12. If Ion Gauge 2 filament is ON and stable, the system awaits for input Ion Gauge 2 setpoint 1.

13. Observe the screen indicator change to “Waiting for Ion Gauge 2 setpoint 1.”

14. If Ion Gauge 2 setpoint 1 watchdog times out before reaching the pressure setpoint, system aborts.

15. If Ion Gauge 2 setpoint 1 is satisfied within the watchdog time limit, the screen will change back to “Auto Pump/Vent.”

16. Observe the screen change to the Heat Mode.

17. The optional Heat was selected in the General Recipe Parameters or pocket recipes parameters, and then the heat comes on at this time. The screen changes. In the chamber, the heater arrays turn green (simulating the heat is on). When the temperature setpoint is made, the heat soak timer counts down. When the soak timer has expired, the heat switches off or if continuous heat was selected the heat will remain on the rest of the auto run.

18. Observe the screen change to the Deposition Mode.

19. The High Voltage Filament is turned ON & two seconds after the High Voltage is turned ON.

20. Ion Gauge 2 setpoint 2 watchdog is started.

21. The system scans for the Ion Gauge 2 setpoint 2 input signal.

22. Observe the screen indicator change to “Waiting for Ion Gauge 2 setpoint 2.”

23. If the input is not satisfied within Ion Gauge 2 setpoint 2 watchdog time limit, screen will change to “Ion Gauge 2 setpoint #2 not made!” – system aborts.

24. If the input is satisfied within the watchdog time limit, screen changes back to “Deposition”

25. The Sycon STC2000A or IC6 will now send the start pulse.

26. The crucible watchdog timer is started. (At the same time the PLC is scanning the Sycon STC2000A’s or IC6 BCD crucible feedback signals)

An internal comparison is done with the input signals. If no Pocket is recognized before the crucible watchdog times out, screen changes to "Crucible not in position." – system aborts.

Once the Pocket input signal is matched with the STC2000A's or IC6 Feedback signals, the Electron Beam Power Supply is turned ON & ready for Deposition.

27. Observe the screen change to "Deposition"

28. The Sycon STC2000A or IC6 takes over Deposition Process.

NOTE:

Refer to Deposition flowchart for interfacing of all automatic options.

Is Process Complete ON? (Feedback Signal from STC2000A or IC6)

YES - System disables Fixture Motor.
- System is ready to Vent. (**Refer to Vent**)

NO – **Is Layer Complete ON?** (Feedback Signal from STC2000A or IC6)

YES - Hi-Voltage / optional Ion Gun turns off /optional Heat turns off / optional Resistance Power Supply turns off.
- Hi-Voltage turns off.
- Hi-Voltage Filament turns off.
- Five second delay.

NO – **Is Deposition Watchdog timed out?**

YES – Screen change "Deposition WD Overtime" – system aborts.

NO – **Is Process Complete ON?**

YES – System disables Fixture Motor.
- System is ready to Vent.

NO – Multiple Layer Run Process.

Go back to Start Process.

Figure 7-1 Process Complete

7.2 How To Handle Aborts In An Automatic Process Run

When the system aborts, during event processing because of an interlock problem like (ion gauge offline, filament off, and STC2000A or IC5 offline) an interlock error message screen will appear allowing the user to restart the event or abort the process. Error messages appear in graphic form. The cause for each error is described in the message. Some corrective action(s) may require technical support from CHA

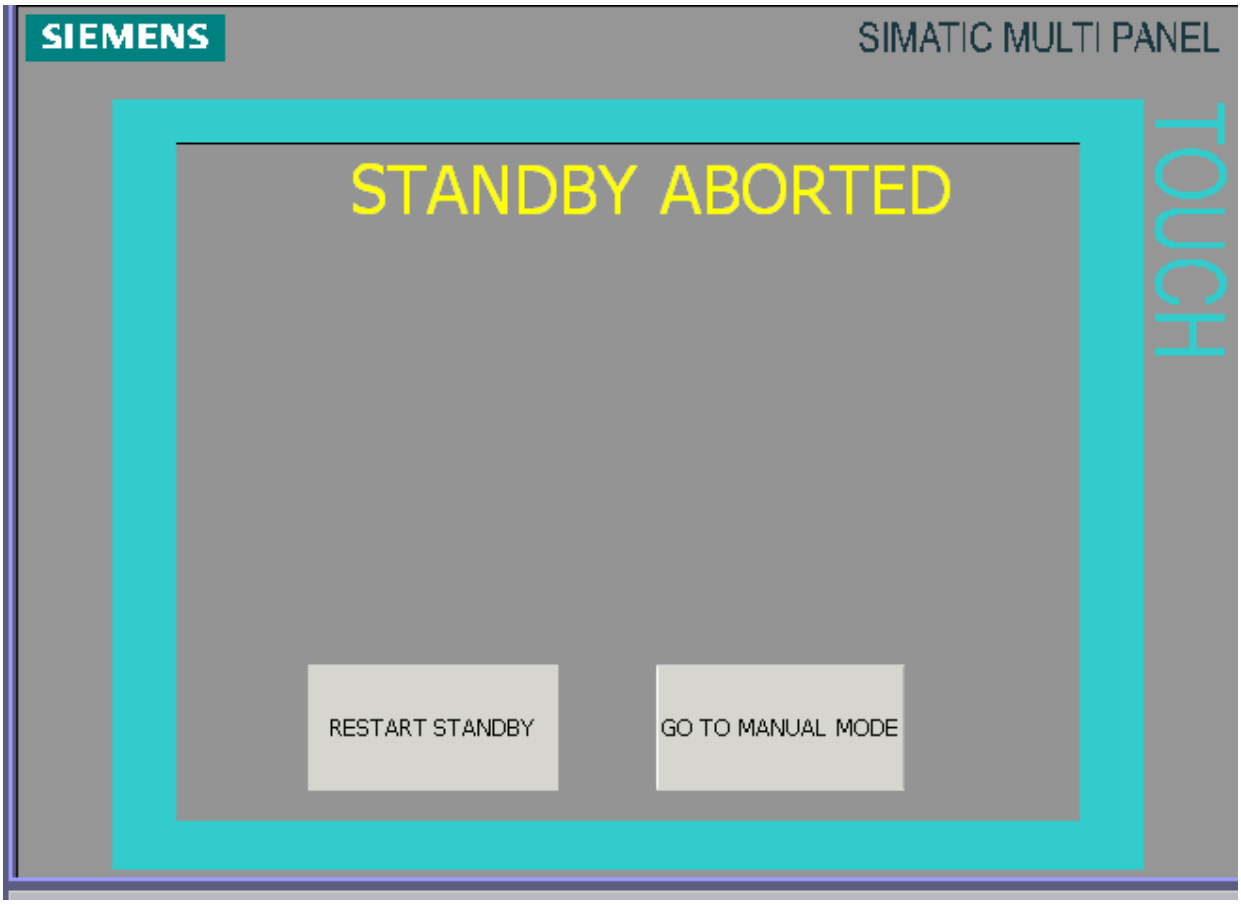
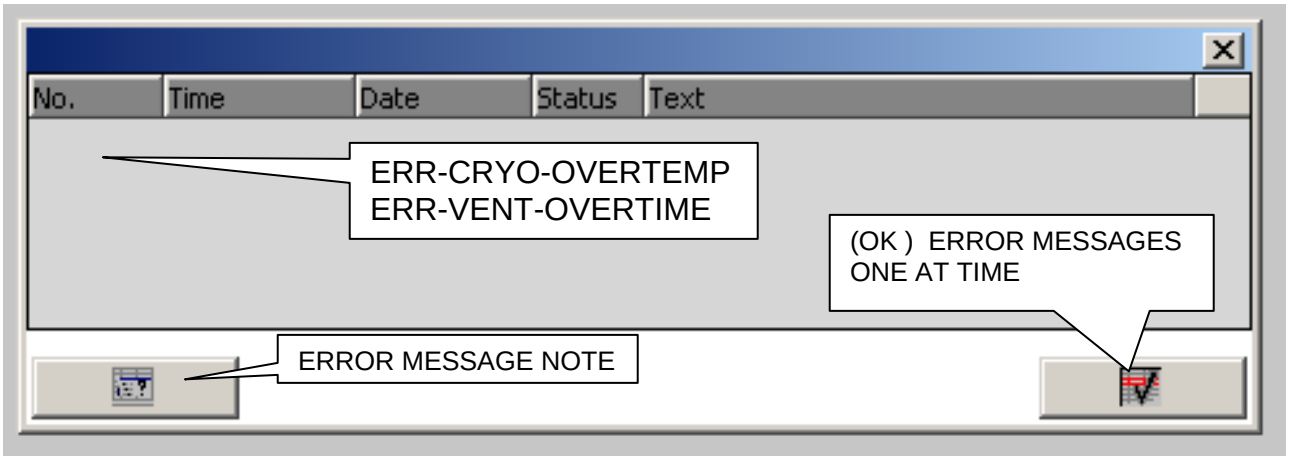


Figure 7-2 Optional System Aborted



OPTIONAL ERROR MESSAGE SCREEN

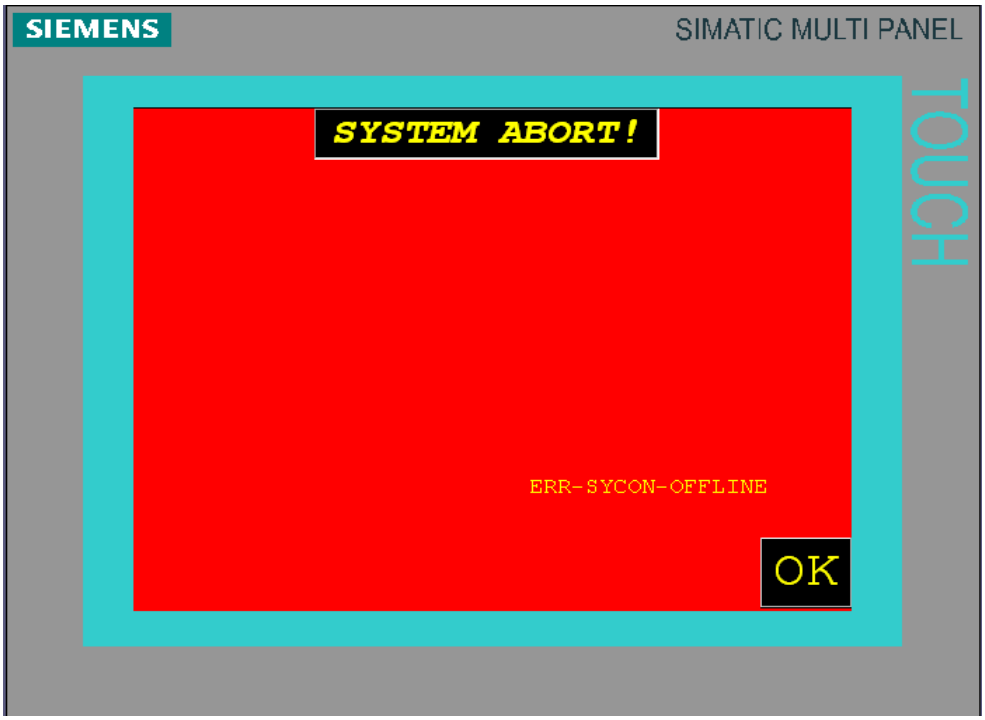


Figure 7-2A System Aborted

NOTE:

Refer to Pumpdown flowchart for interfacing of all automatic pumpdown options.

7.3 How To Initiate An Automatic Pumpdown

The Auto pump function allows you to complete a pumpdown run according to preset parameters. (See Section 9 for information on setting parameters.) The following describes how to initiate the automatic pumpdown run and what is shown on the screen during the pumpdown run.

NOTE:

The system must be in Standby mode before the automatic pumpdown can be initiated.

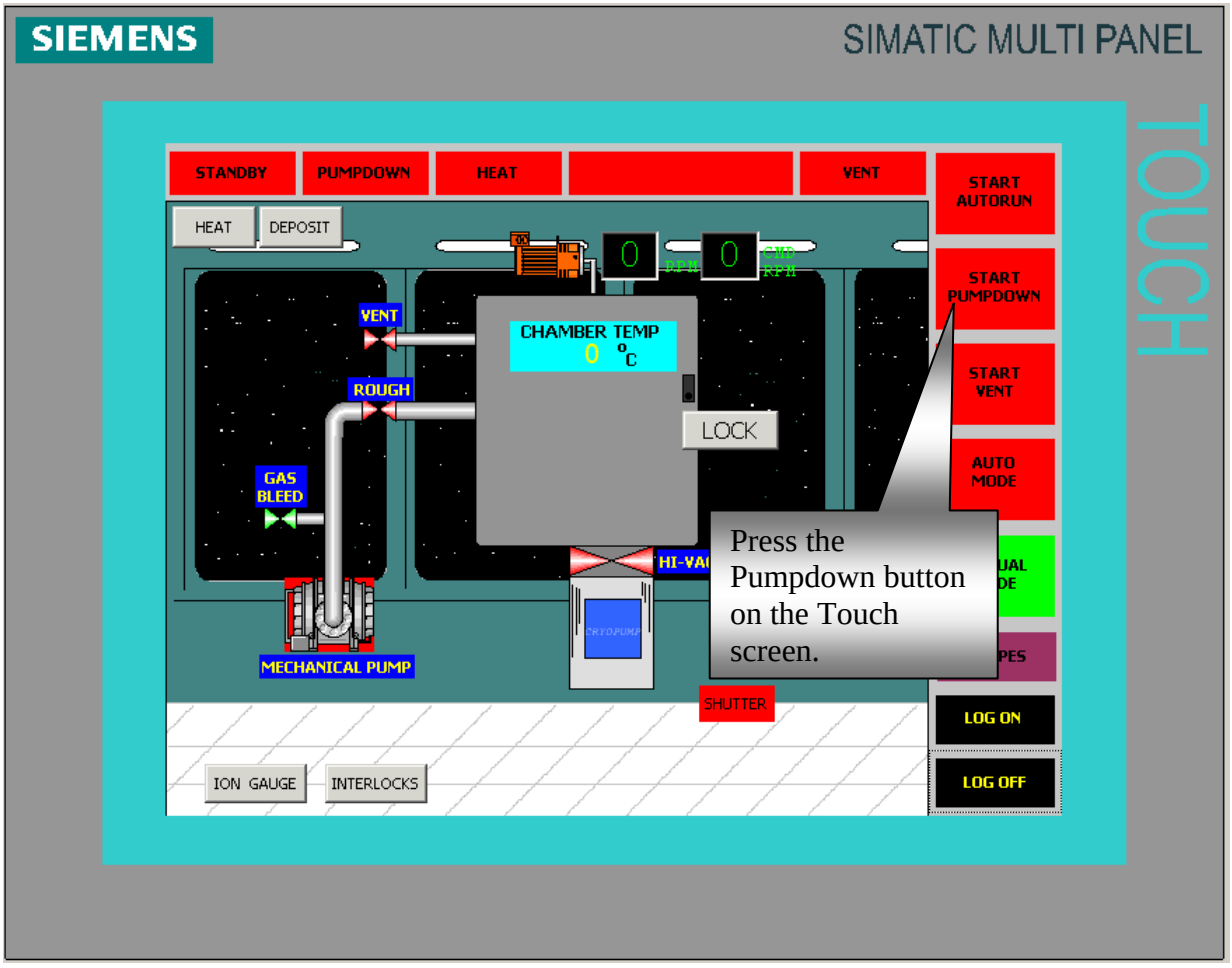
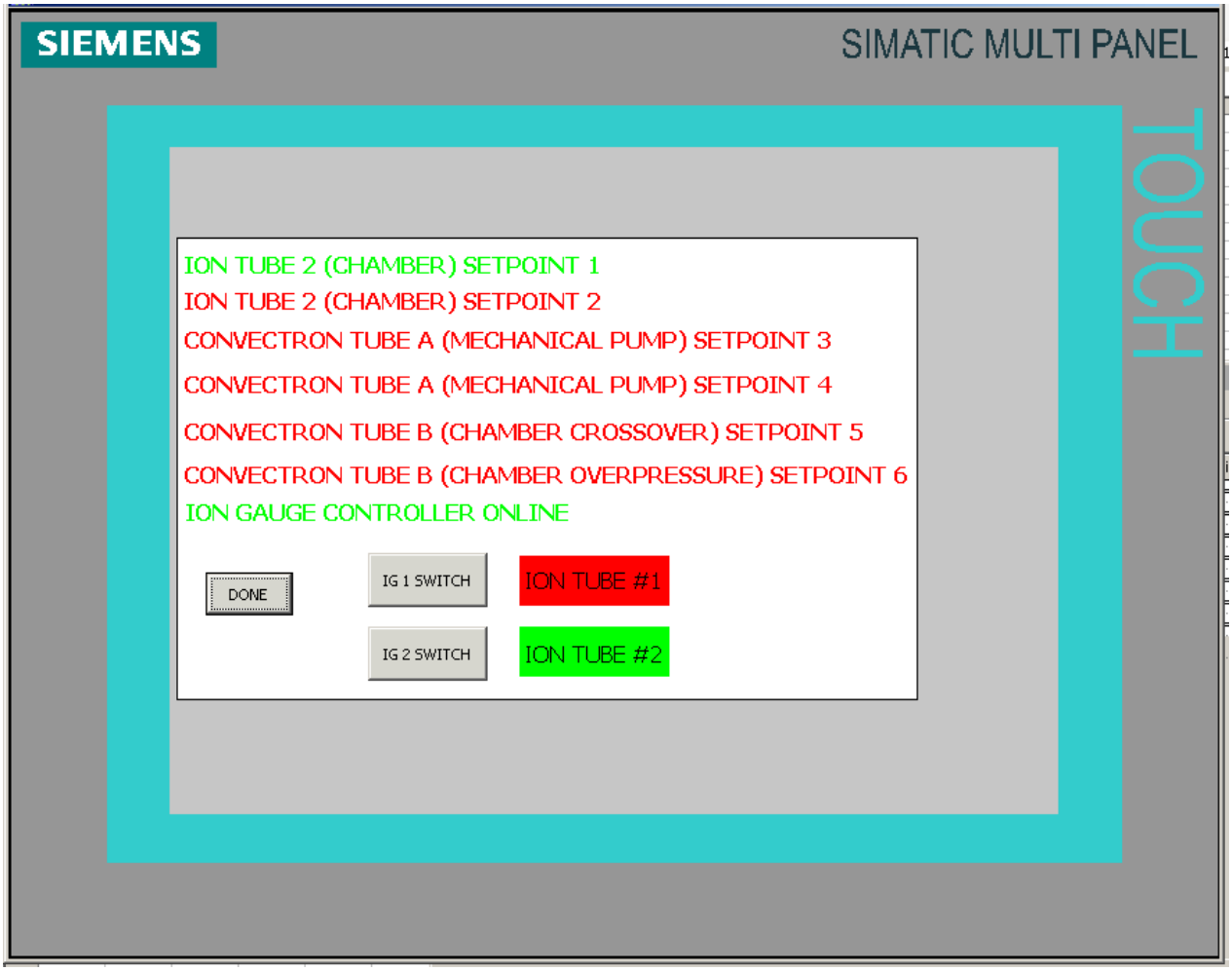


Figure 7-3 Pumpdown Screen

1. Ensure the PLC is in automatic mode and is in Standby.

2. To initiate the automatic pumpdown: press the Pumpdown button on the Touch screen.



NOTE:

The rest of the steps describe what is shown on the screen. There are no more steps for the operator to perform until the vent is ready to be initiated.

3. The Solution initially checks Ion Gauge Convectron B setpoint #1 (5) to be satisfied, If not, the rough valve is opened & pumping begins.

4. Seconds after the Rough-gas bleed valve is closed.

5. If the roughing watchdog timer times out before Convectron B setpoint #1 (5) is made, system aborts.

6. If Convectron B setpoint #1 (5) is satisfied within the time limit, the rough valve is closed & seconds after the rough-gas bleed valve is opened.

7. If Convectron B setpoint #2 (6) turns off, there is Overpressure in the chamber, system aborts.

   If Convectron B setpoint #2 (6) stays on, the Hi-vac valve is opened.

8. There is an operator time delay before Ion Gauge 2 filament is pulsed on.
   - Limit of 2 pulses if Ion Gauge 2 filament is not stable.

9. If Ion Gauge 2 filament is ON & stable, the system awaits input-Ion Gauge 2 setpoint #1.

10. If Ion Gauge 2 setpoint #1 watchdog times out before reaching the setpoint, system aborts.

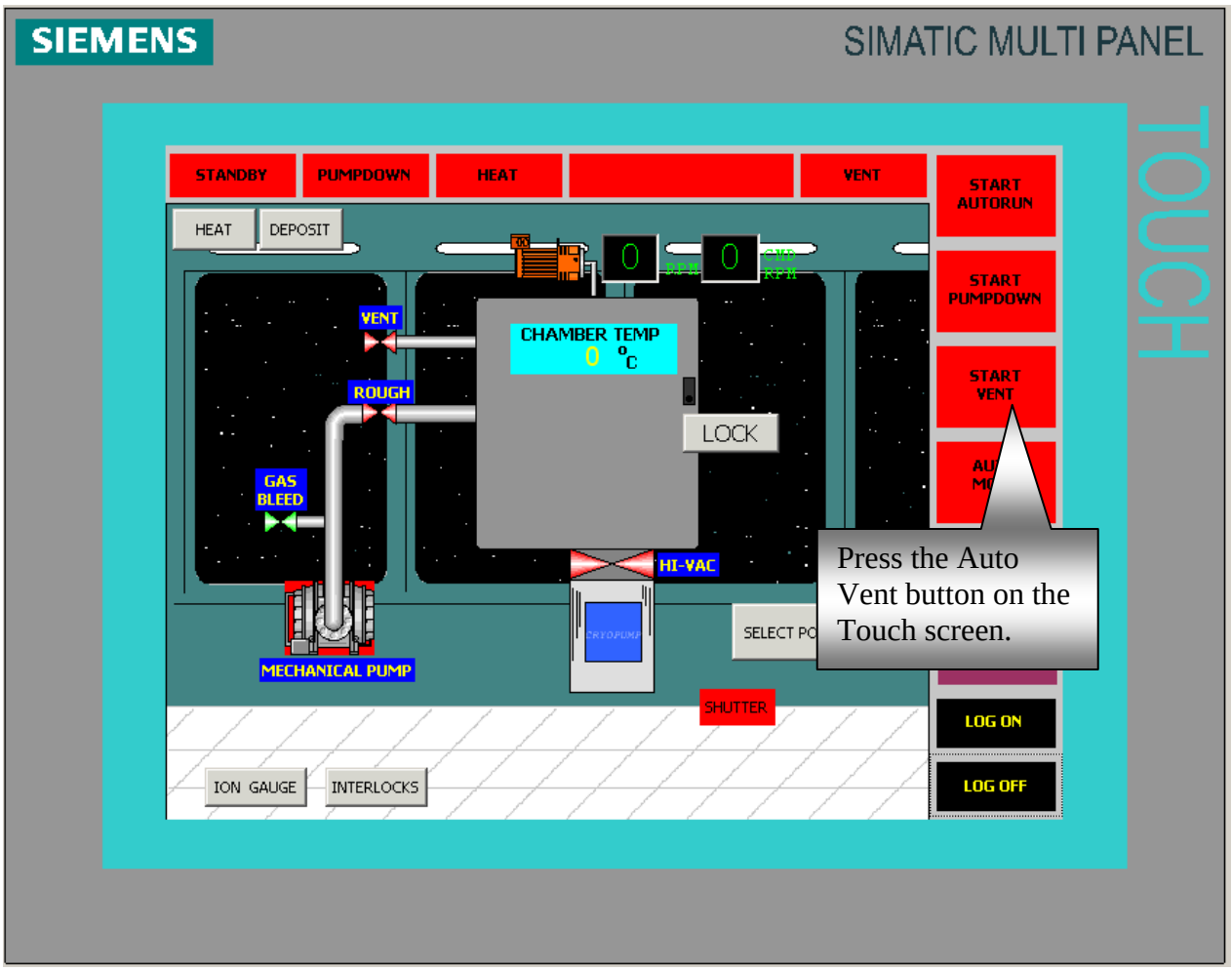
11. If Ion Gauge 2 setpoint #1 is satisfied within the watchdog time limit, Pumpdown is complete.

Figure 7-4 Pumpdown Complete

7.4 How To Initiate An Automatic Vent

The Auto vent function allows completion of an automatic vent run

1. To initiate automatic vent, press the Auto vent button on the Touch screen. You can see Vent in the status line and the vent valve is green, indicating that venting is in process.



2. Ensure the relevant switches are in the proper position. (See Section 3 for switch settings.)

3. The vent time is preset in the recipe page.

4. Notice the Granville-Phillips pressure gauge reading increases until it reaches 760 torr or more. As soon as atmospheric pressure is reached, an extended

purge time is counted down. When the timer expires, notice a pop-up window that indicates the vent cycle is completed. You may open the chamber at this time. The vent valve is now closed.

5.

Figure 7-6 Vent Cycle Completed

6. The operator has the choice to:

-go to standby
-open the chamber door
-jog the fixture motor
-switch crucible pockets to replenish process materials.

6. To remove the window from the screen, acknowledge the OK button. Standby is automatically invoked and a pop-up indicator is displayed indicating the system is in Standby. The Vent cycle is now complete.

7.5 How To Invoke Automatic Standby

Press **Standby** the Touch screen to invoke automatic Standby. As soon as Standby is selected, Standby is active and is now in effect.

When Standby takes effect, all the following take place:

A. Hi-vac valve closes (if open)

B. The IGl turns on (if not already on)

C. Standby screen is displayed in the auto mode.

8. OVERVIEW OF MANUAL PROCESS RUN

The Manual Operation Mode allows an automatic process run that was aborted to be completed or an entire process to be run manually.

As in the automatic operation, the system will not allow any function to be performed that violates the interlocks. Notice throughout Section 8 that the valves and buttons on the screens are color-coded. Green indicates ON (open status) and red indicates OFF (closed status).

8.1 User interface for Manual Operation

The user interface for manual operation is similar to, but not exactly the same as, the user interface for the automatic operation described in Section 6.

Figure 8-1 is a typical Manual Screen, showing various buttons for individual valve and pump down.

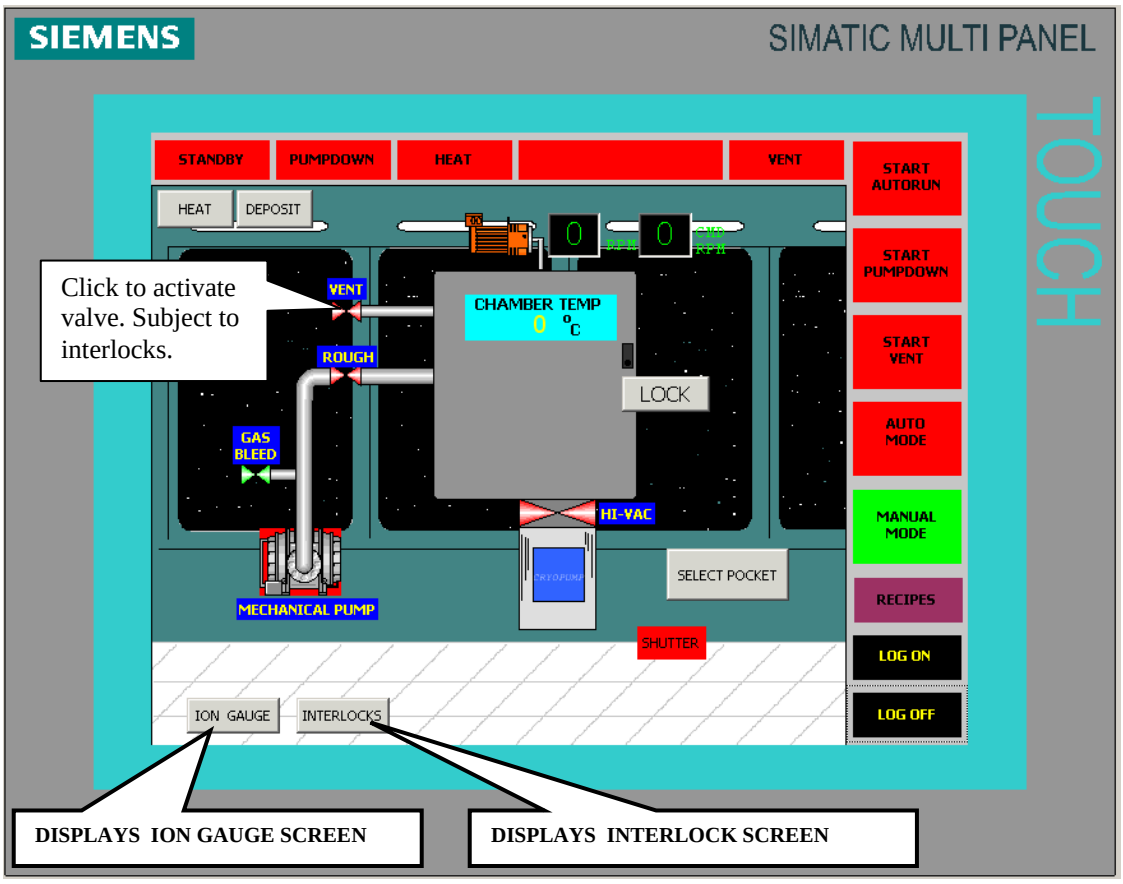


Figure 8-1 Manual Pumpdown Screen

The screen, as shown in Figure 8-1, is a pictorial representation of the system displayed on the touchscreen. The green color-coded valves and buttons indicate ON (open status) and the red-coded valves and buttons indicate OFF (closed status).

There are screens for manual operation: Manual Pumpdown, Optional Manual Ion Gun, Optional Manual heat, Manual deposition and Optional Manual RPS (swing source) deposition. To view one screen to another manually, use the screen buttons in the left top corner.

8.2 Prerequisites For Manual Operation

The system must be in Standby before entering the manual mode. In Standby the mechanical pump, cryo pump are on and all valves are closed. When the system is in Standby there will be a "System In Standby" indicator.

NOTE:

When Manual Operation is invoked, you can perform any action at any time, as long as the interlocks are not violated.

8.2.1 Loading the Deposition Material and the Substrates

1. Chamber must be at atmospheric pressure. Unlatch and open chamber door.
2. Open and Close the shutter by using the touchscreen shutter button.
3. Load the substrate holders then close and latch chamber door.

8.3 Manual Pumpdown Operation

To manually Pumpdown the chamber, perform the following steps:

1. Close and latch chamber door.
2. Ensure the mechanical pump and the cryo pump is on.
3. Ensure the cryo pump stack pressure is in the range of 10^{-7} to 10^{-8} range.
   If the chamber is not at crossover pressure open the rough valve. As soon as the Convectron B#1 (SP5) gauge reaches the desired crossover setpoint, close the rough valve
   .
   (The typical crossover pressure setpoint is one hundred twenty-five microns.)
4. Wait five seconds before opening the hi-vac valve.

5. Wait 10 seconds and then turn on the IG2 filament manually by pressing the switch on the Granville Phillips Vacuum Gauge Controller

6. Wait for IG2 filament setpoint 1 = 5.0 x 10-6

7. System is pumped down & ready for process runs.

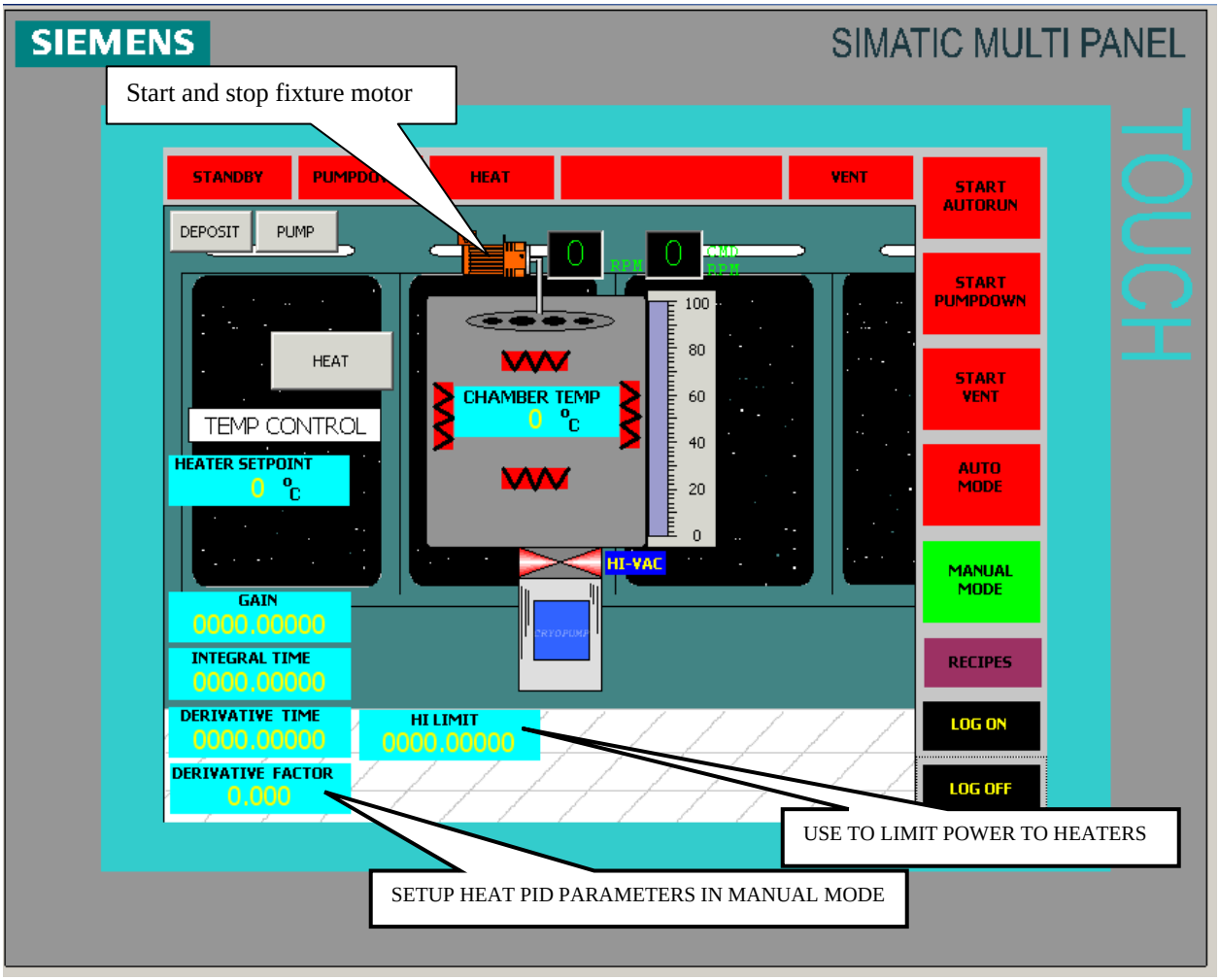


Figure 8-2 Optional Manual Heat Screen

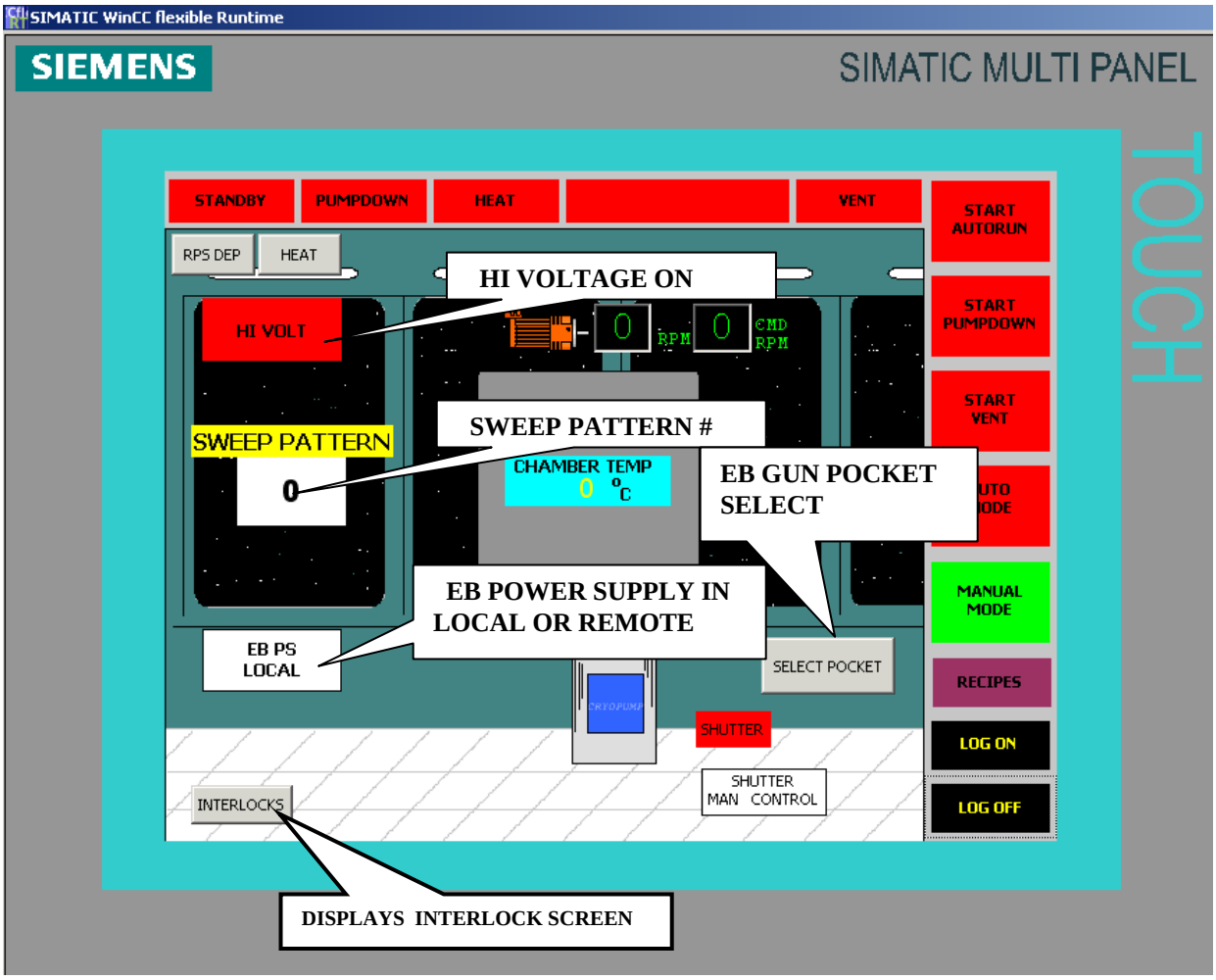


Figure 8-3 Manual Deposition Screen

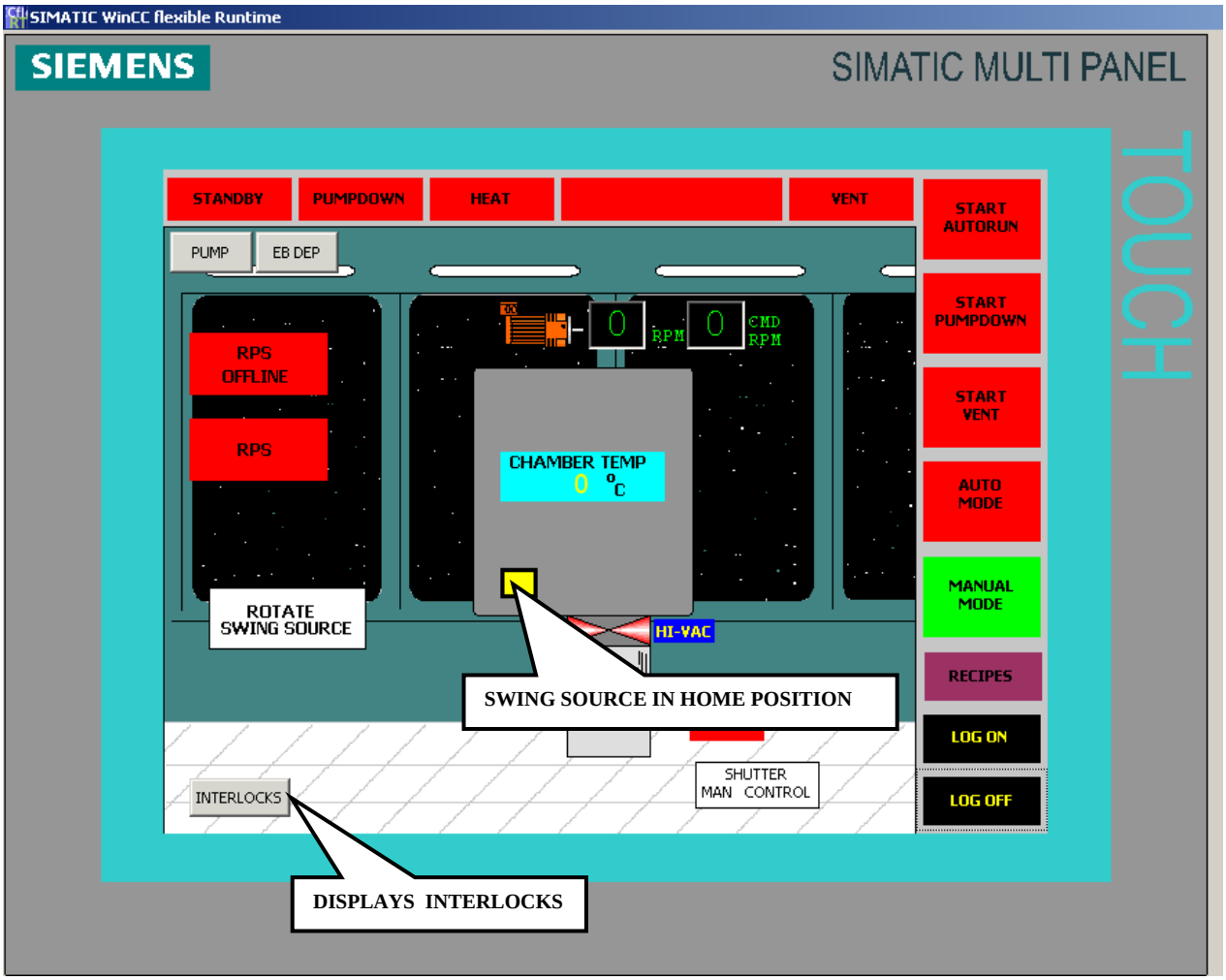
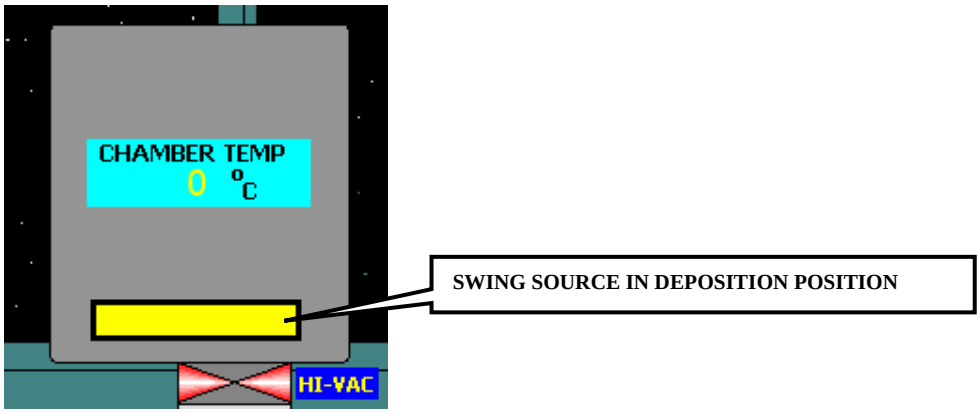


Figure 8-3A Optional Manual RPS Deposition Screen



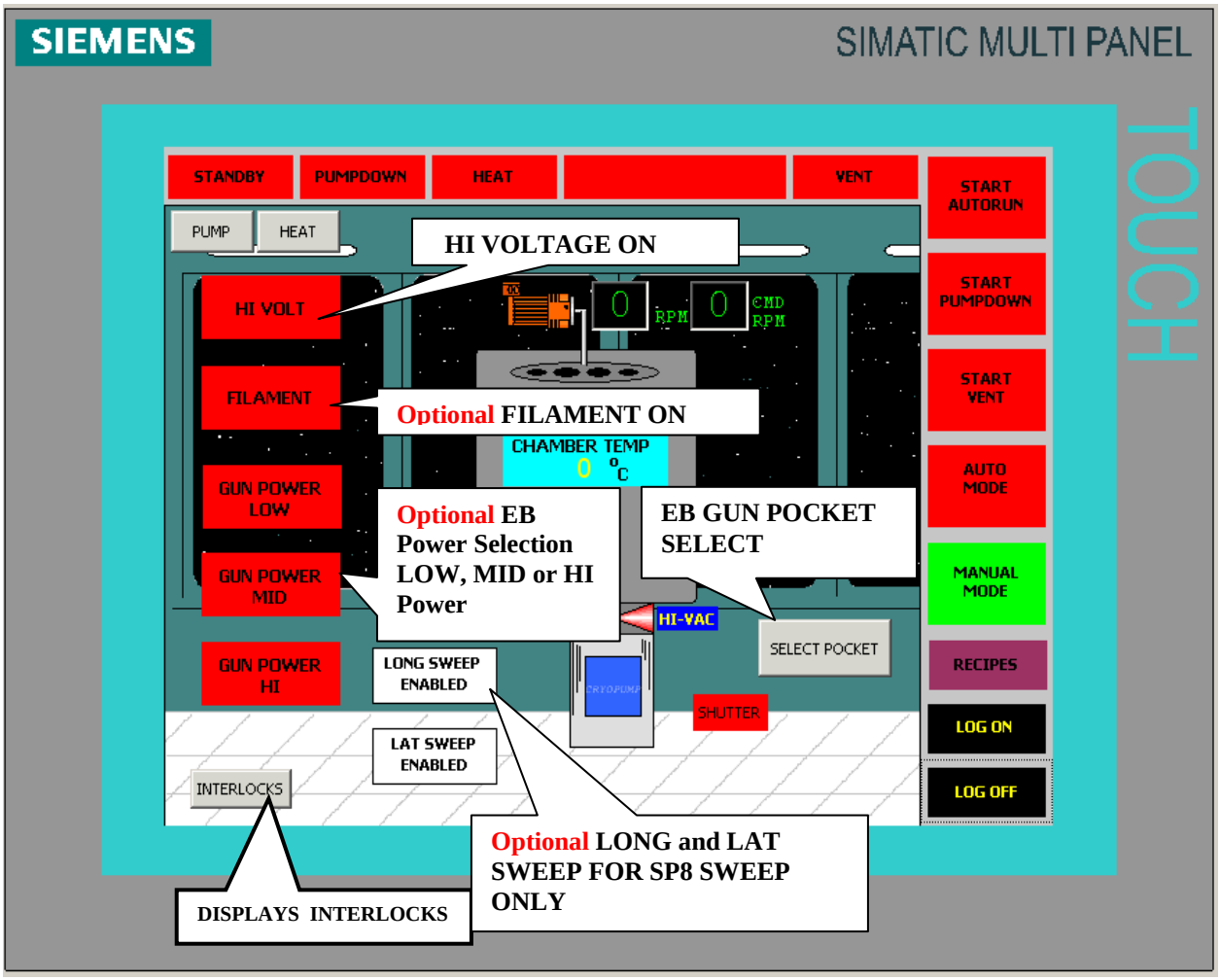


Figure 8-3B Optional Manual Deposition Screen

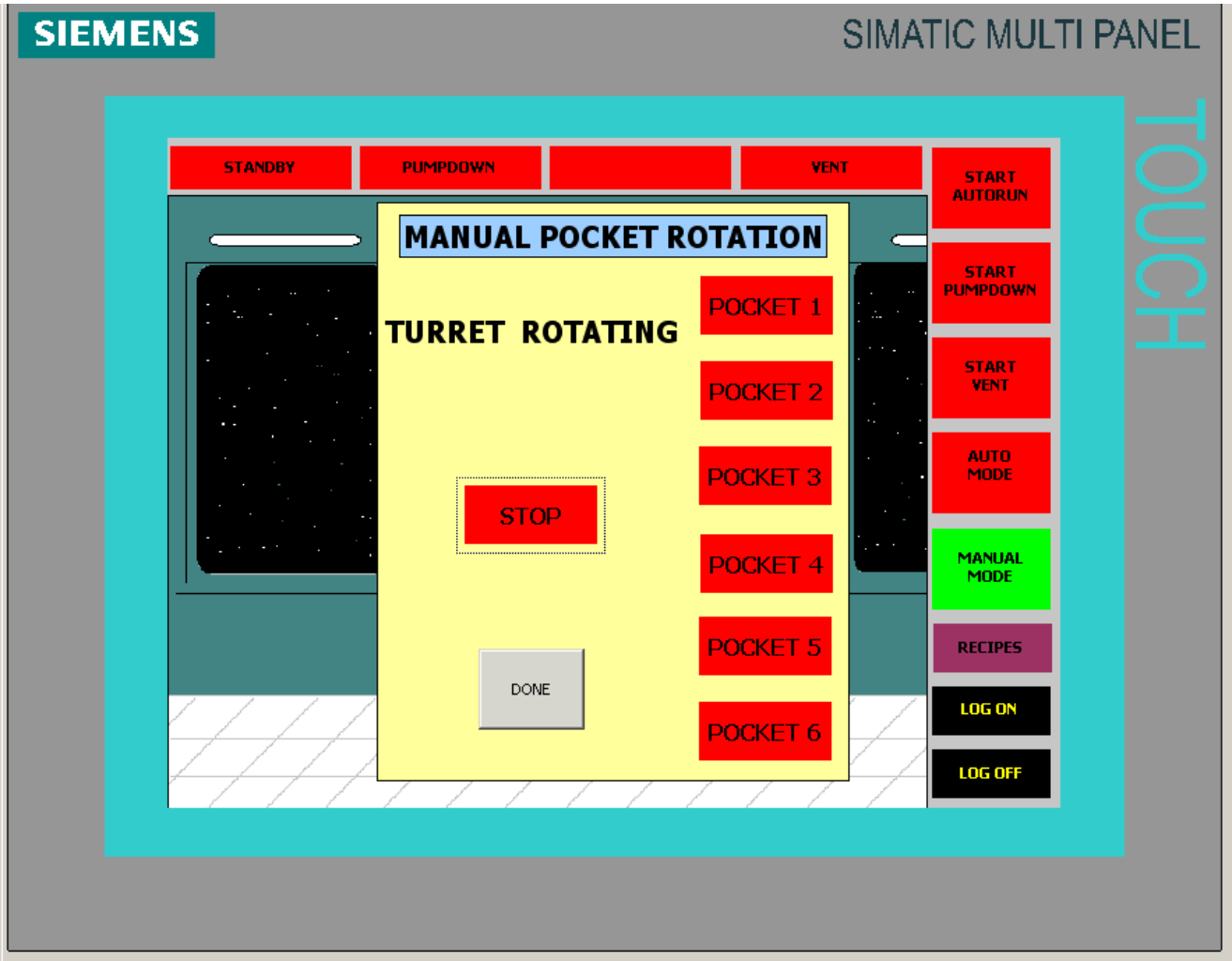


Figure 8-4 Manual Pocket Rotation Screen

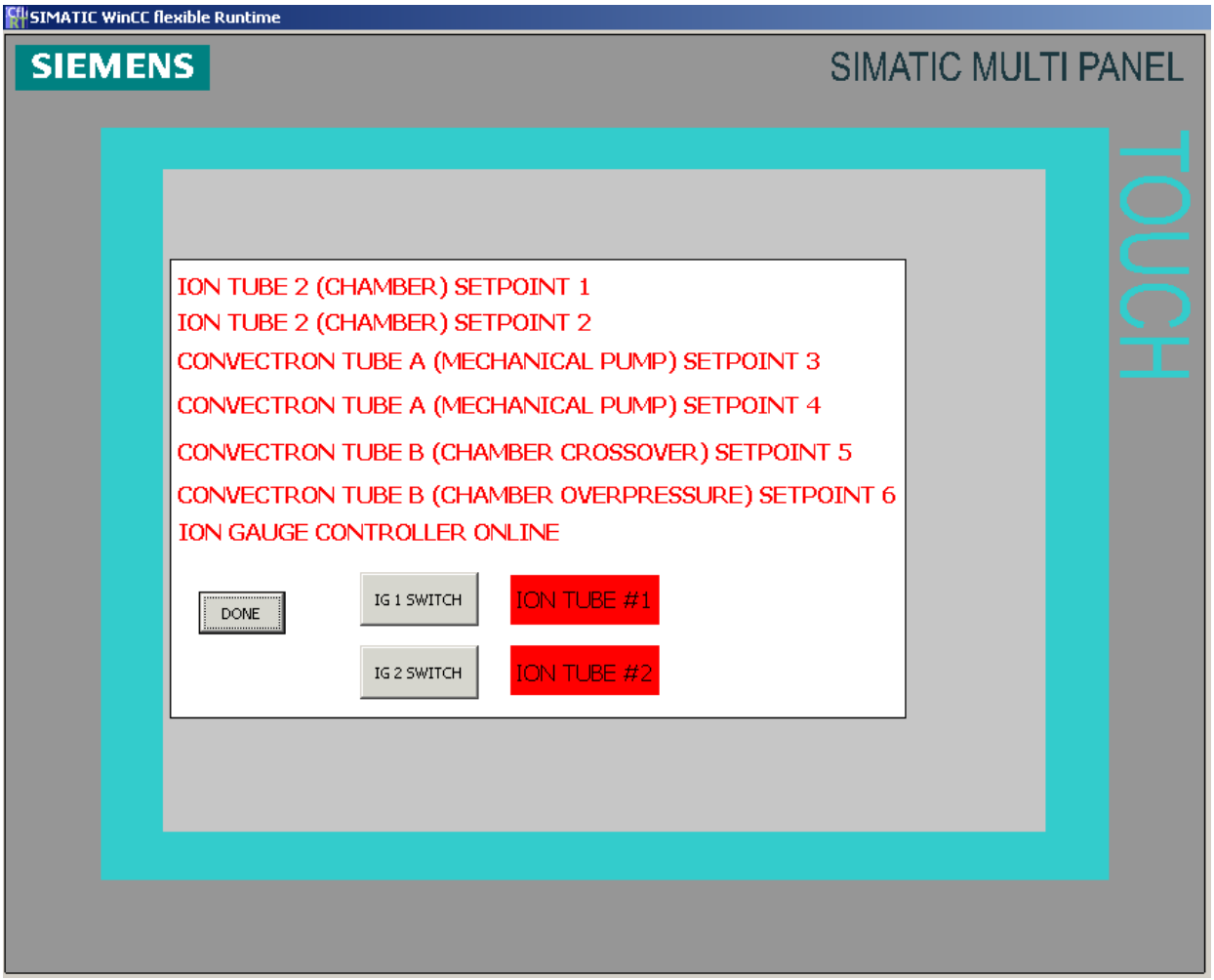


Figure 8-5 Ion Gauge Screen

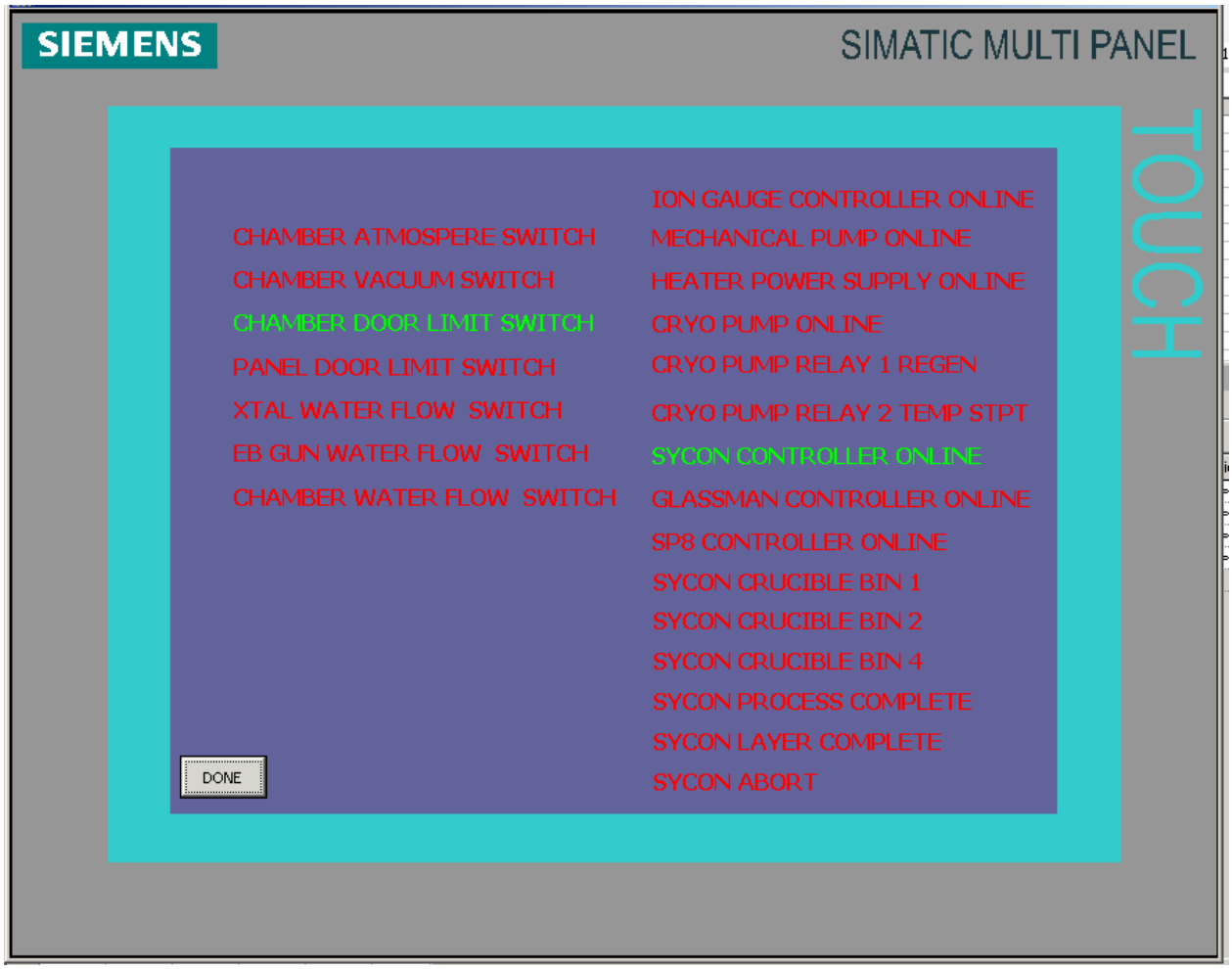


Figure 8-6 Interlock Screen

8.4 Manual Vent Operation

The Screen for the Manual Vent Operation is the Manual Pumpdown Screen, Figure 8-1.

1. Close the Hi-vac valve (if open).

2. Wait a few seconds, and then **turn** on the Ion Gauge 1 filament**.**

3. Open the vent valve**.** You can see the vent valve turn green.

4. Wait until the chamber pressure reaches 760 torr (atmospheric pressure)

5. Close the vent valve**.** Venting is now complete.

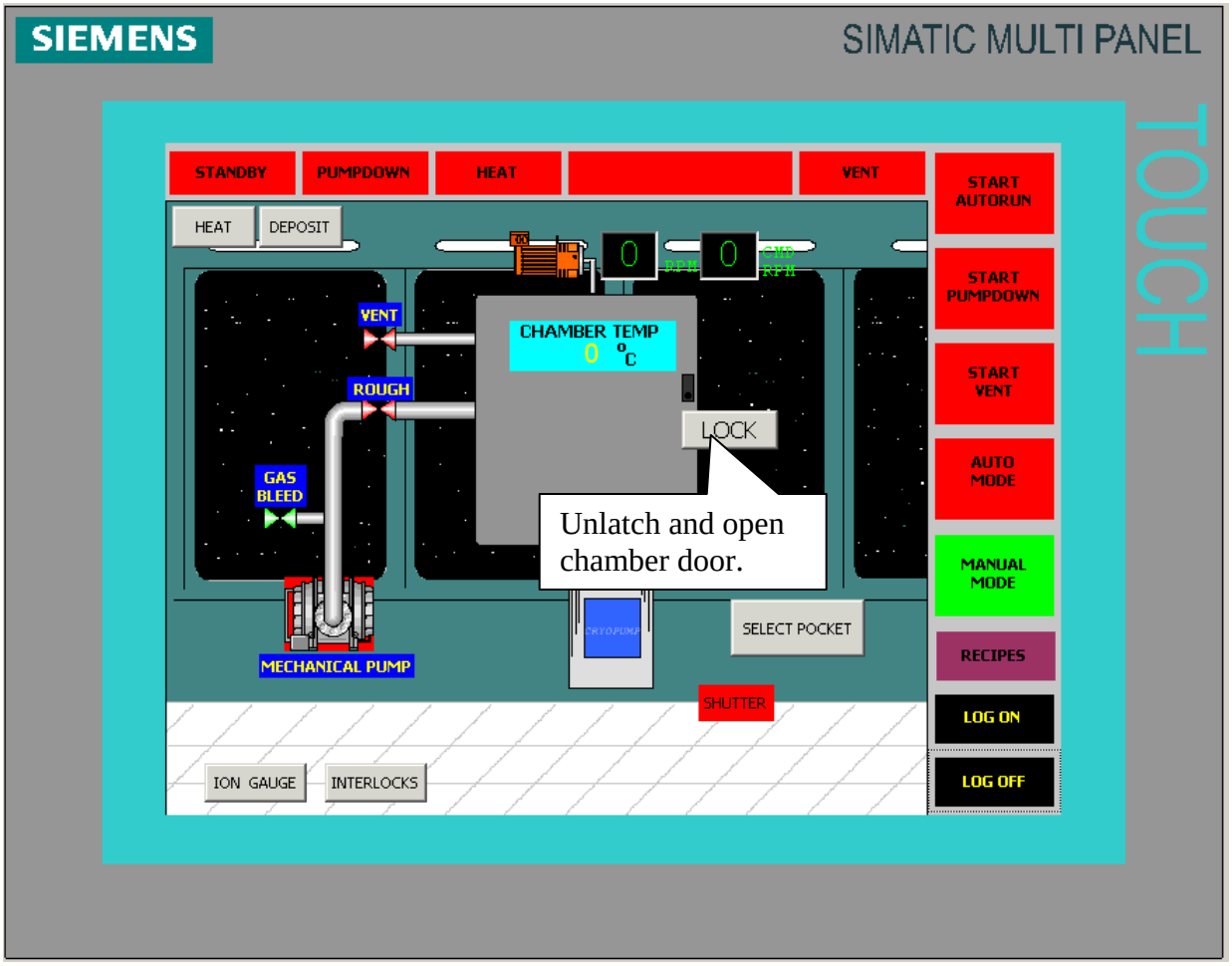


Figure 8-7 Manual Pumpdown and Vent Screen

9. HOW TO SET THE RECIPE PARAMETERS

9.1 Prerequisites

Before you can enter the General Recipe Parameter Menu, the system must be in Standby.

1. Clear the Standby notice by pressing OK.

2. Touch the Recipe button.

3. You can see the recipe button displayed on the screen.

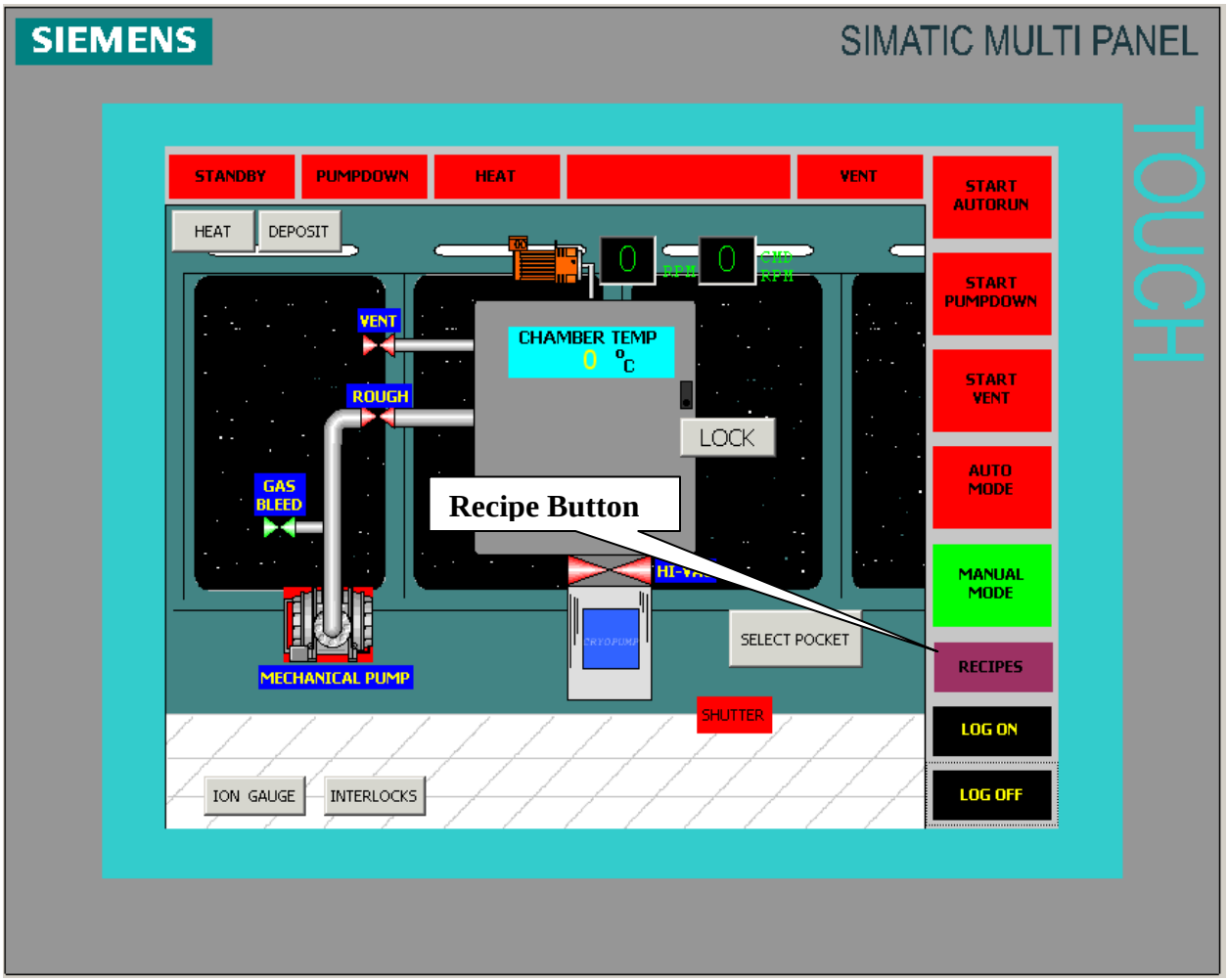


Figure 9-1 Standby Mode

NOTE: Refer to Flowchart when filling out POCKET RECIPES process parameters.

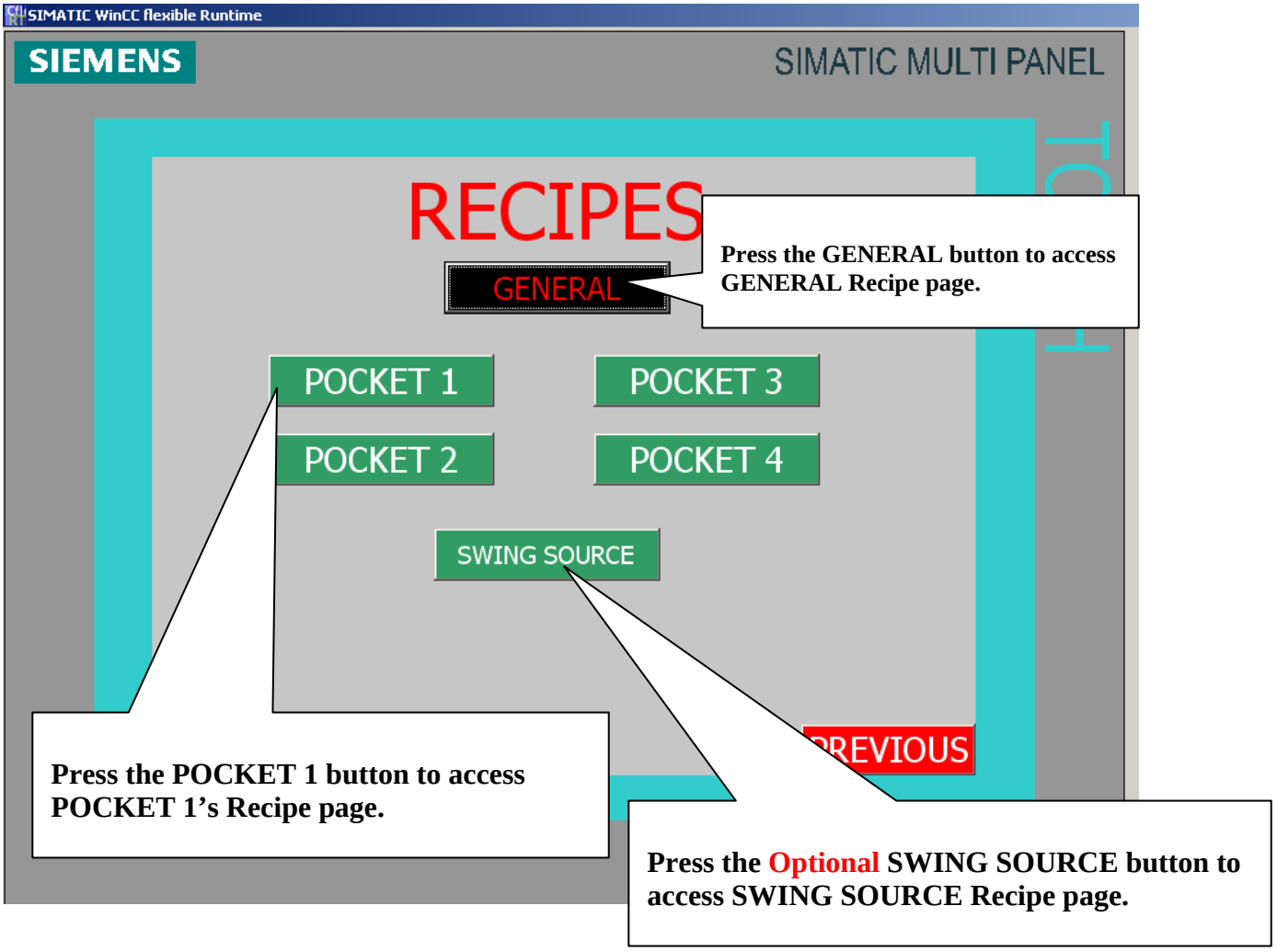


FIGURE 9-2 Recipe Tree

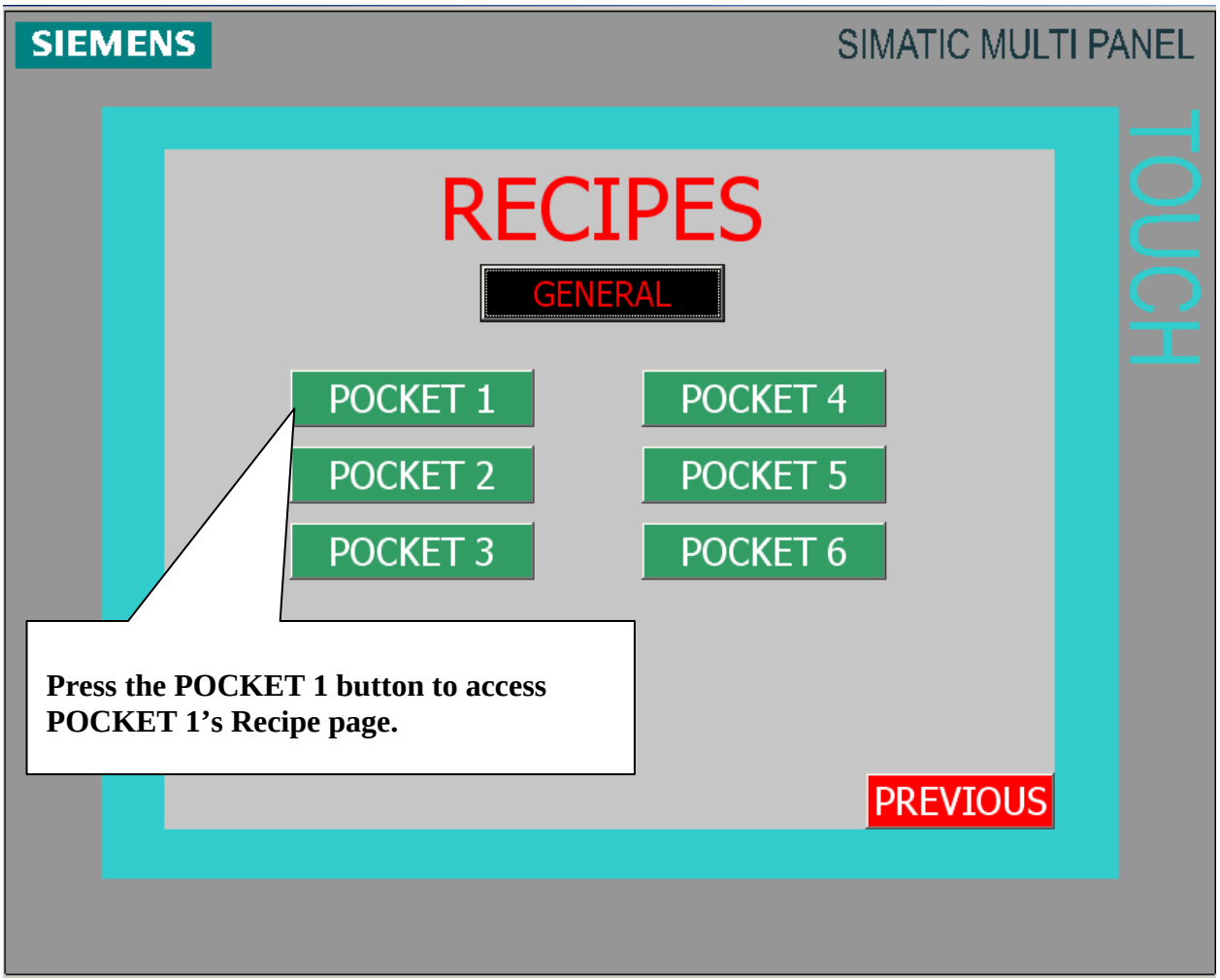


FIGURE 9-2A Optional Recipe Tree

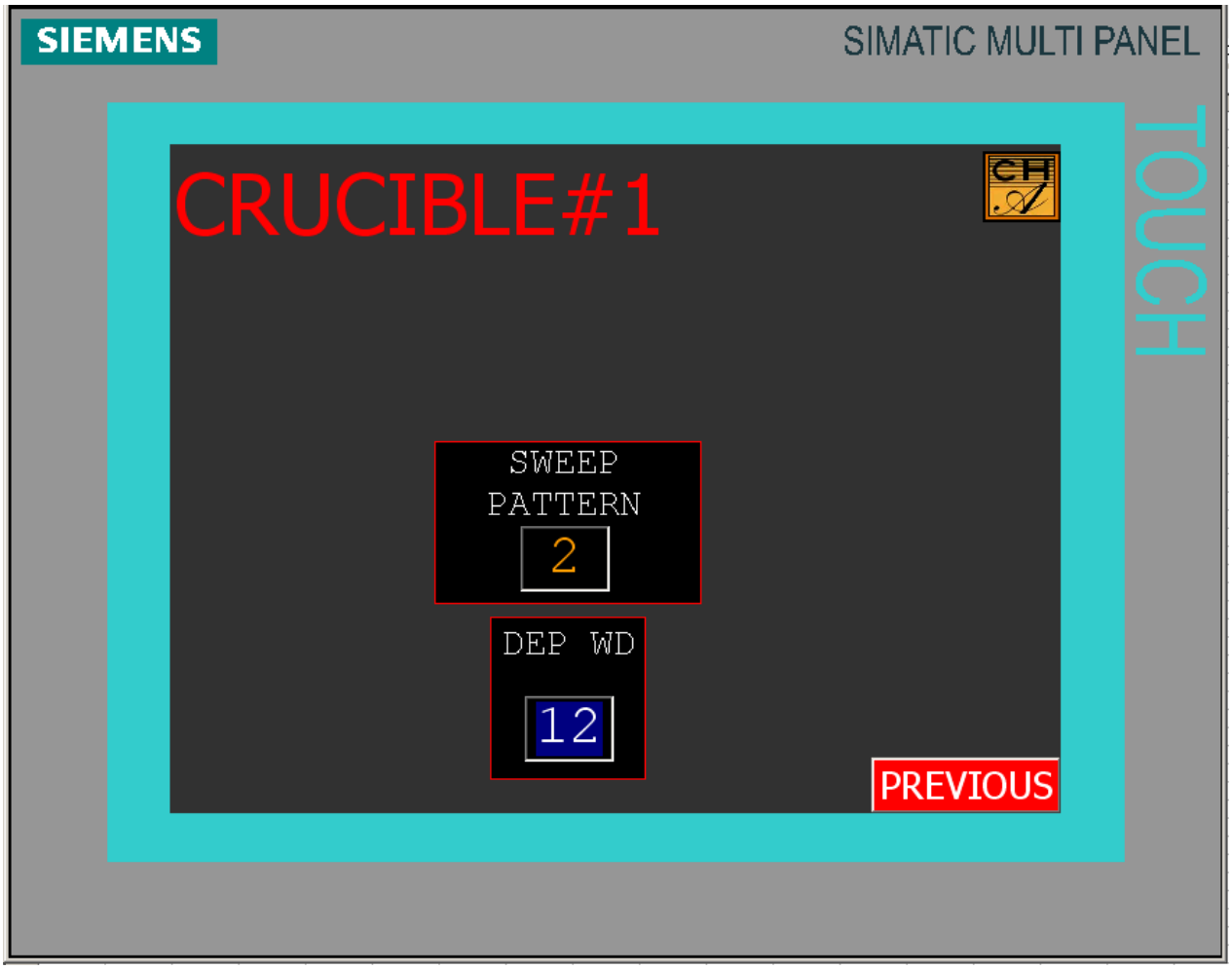


FIGURE 9-3 Optional Crucible #1 EB Gun

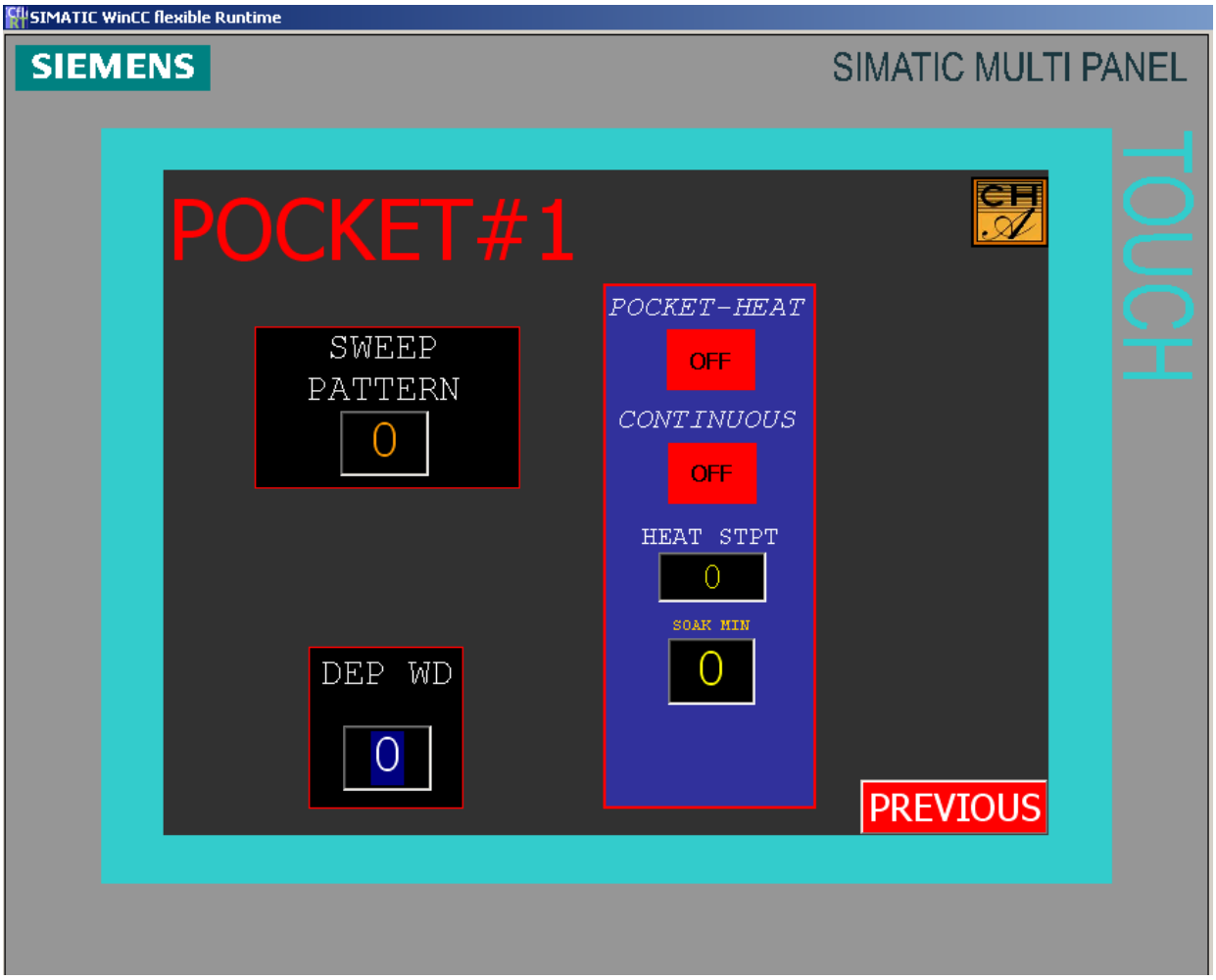


FIGURE 9-3A Optional Pocket #1 EB Gun and Heat

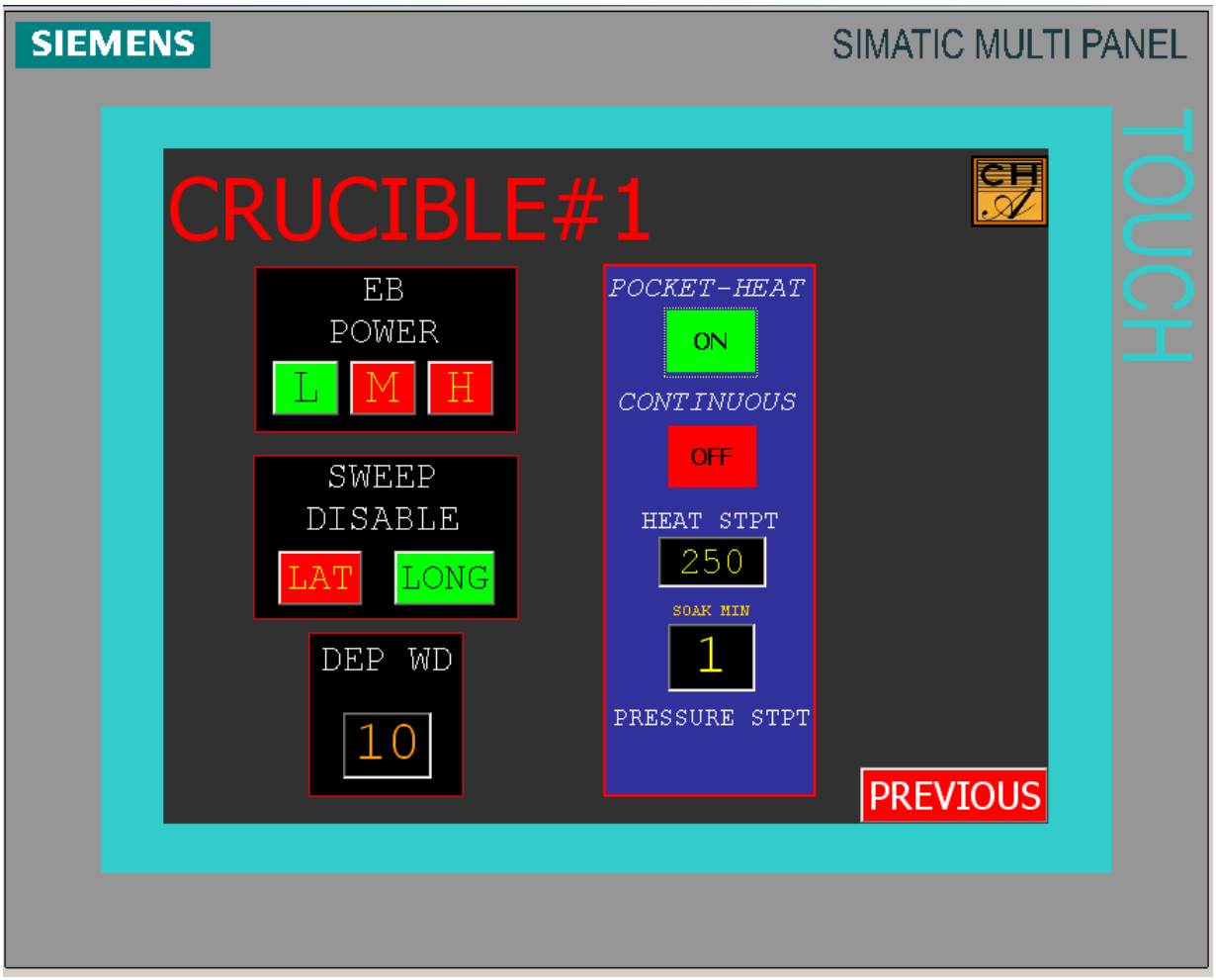
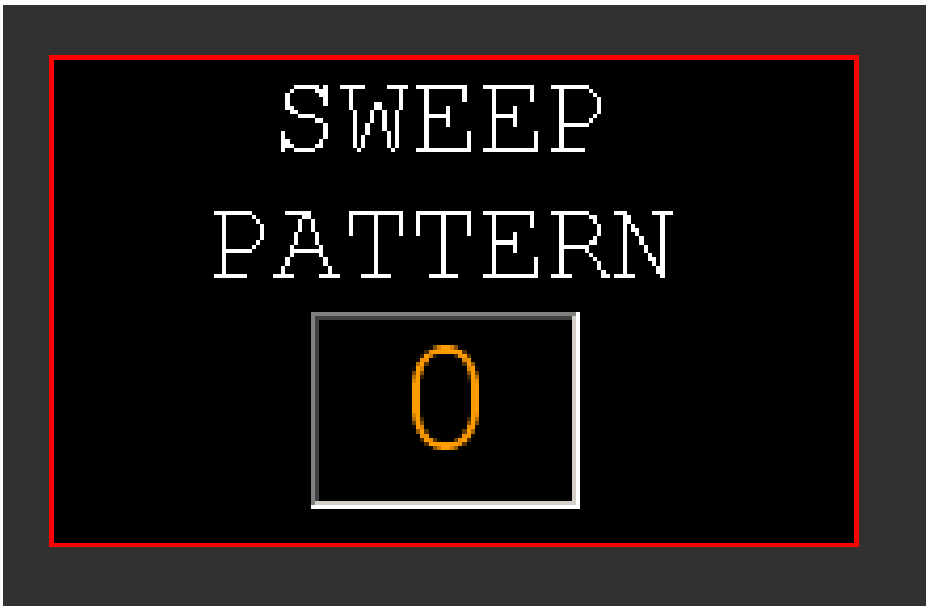
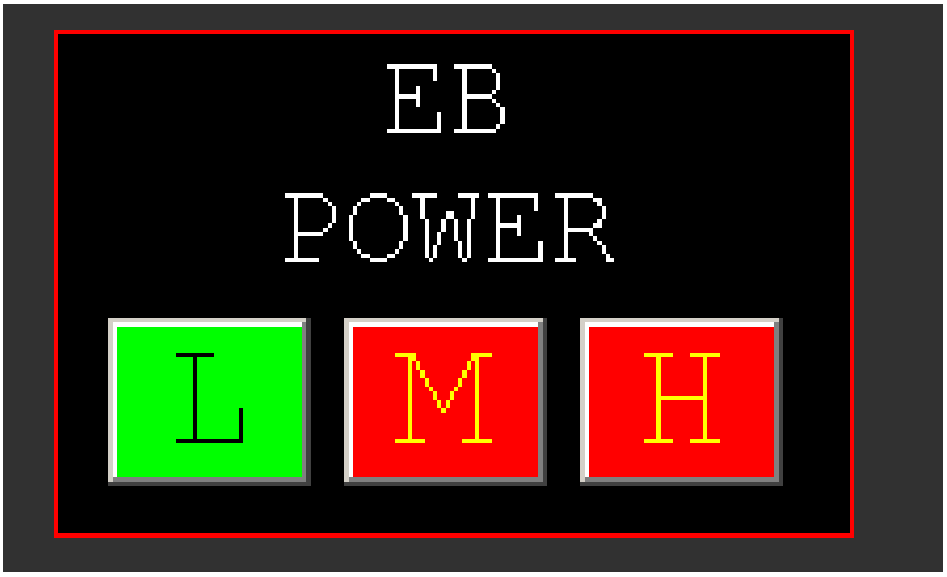


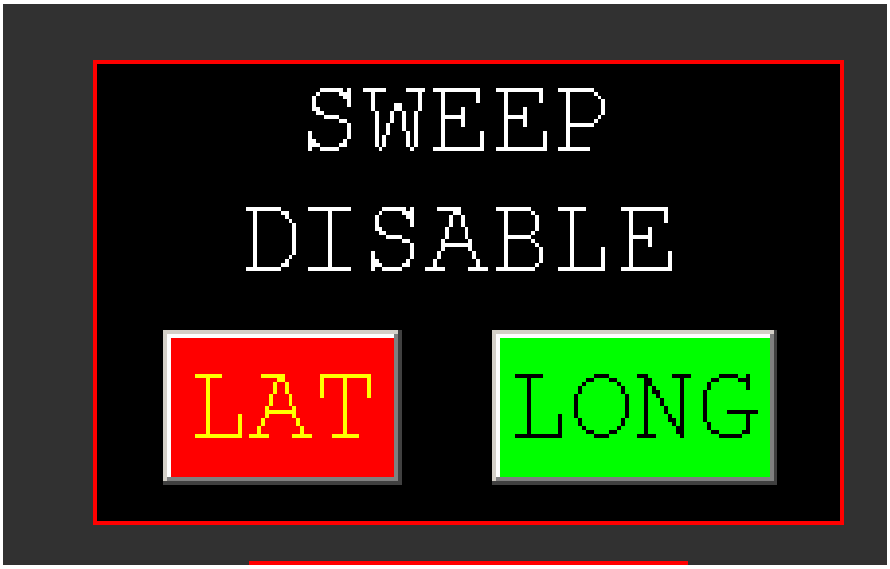
FIGURE 9-3B Optional Crucible #1 EB Gun, SP8 and Heat



Optional **E.B. Gun Sweep Pattern Selection** allows you to select a sweep pattern per pocket of the sweep power supply. This is for multi-pocket guns, during an auto process run.

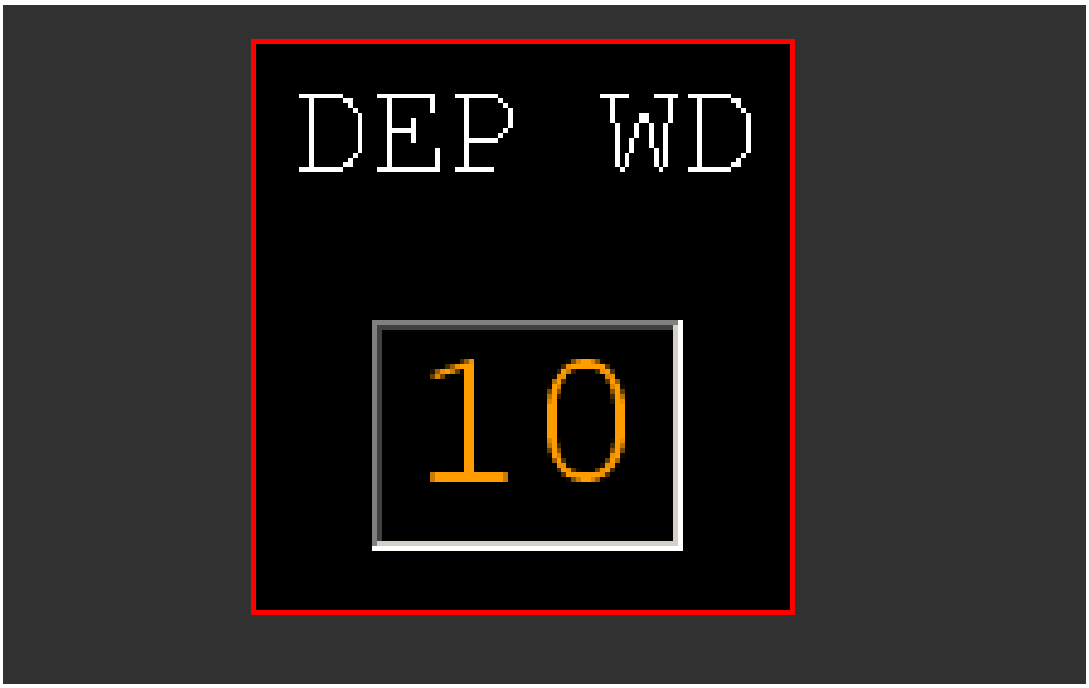


Optional **E.B. Gun Power Selection** allows you to select low, medium or high power per pocket of the SP8 power supply. This is for multi-pocket guns, during an auto process run.

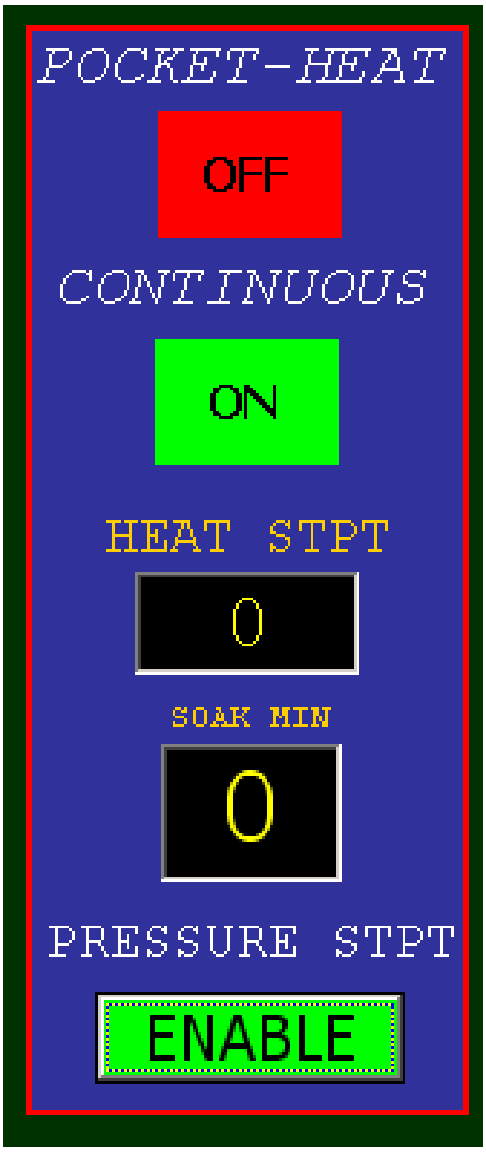


Optional LONG SWEEP ENABLED or DISABLED is a user-selectable toggle switch, which can be selected to turn the long sweep on or off by (enabled or disabled) the sweep power per pocket in the SP8 power supply, during an auto process run.

Optional LAT SWEEP ENABLED or DISABLED is a user-selectable toggle switch, which can be selected to turn the lat sweep on or off by (enabled or disabled) the sweep power per pocket in the SP8 power supply, during an auto process run.



Deposition Watchdog Timer, if the timer is exceeded per pocket, the program is aborted and a pop-up window appears indicating the situation (ERR-DEPOSITION-OVERTIME), during an auto process run.



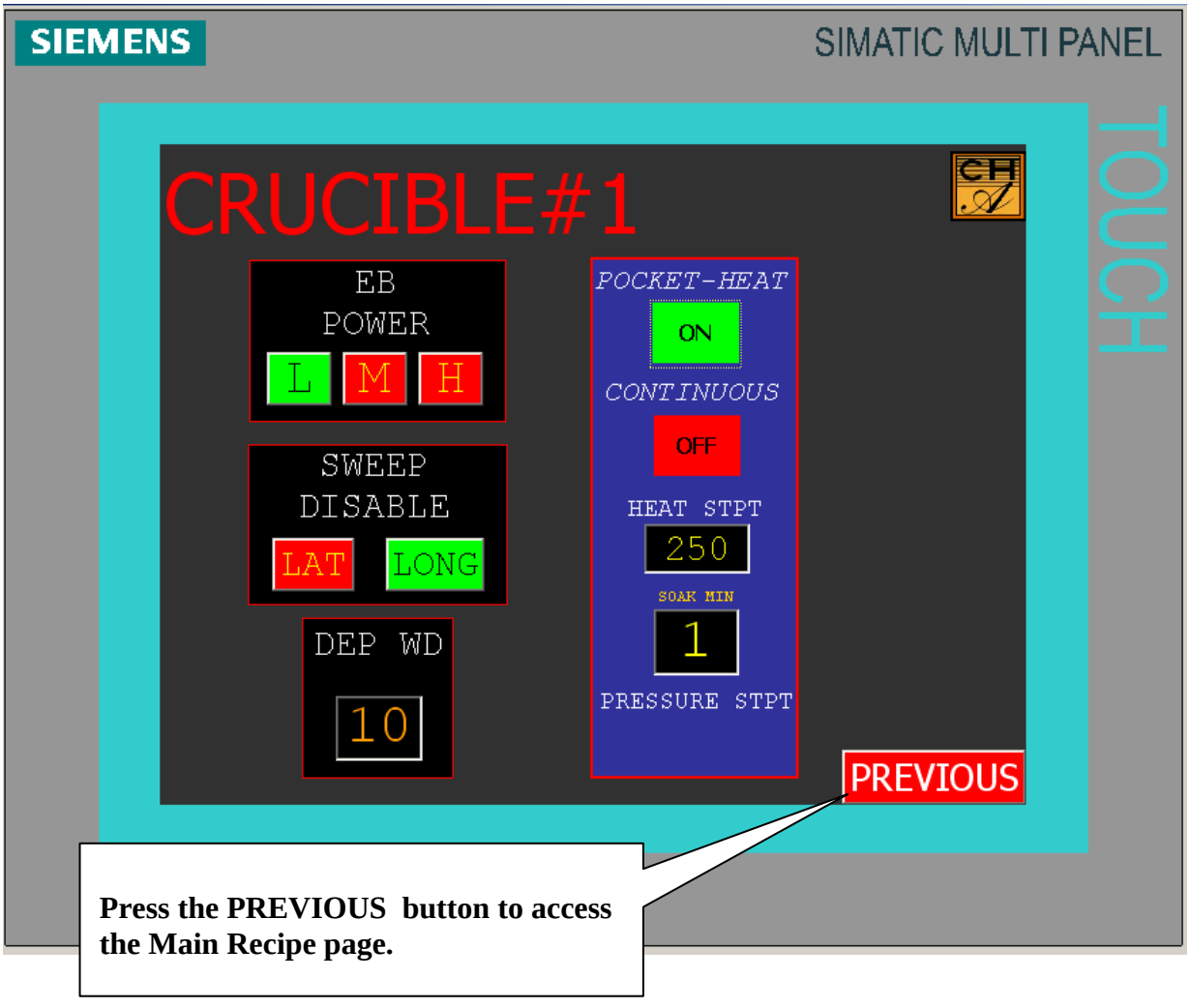
Optional Heat ON or OFF is a user-selectable toggle switch, which can make the heat available during an auto process per pocket.

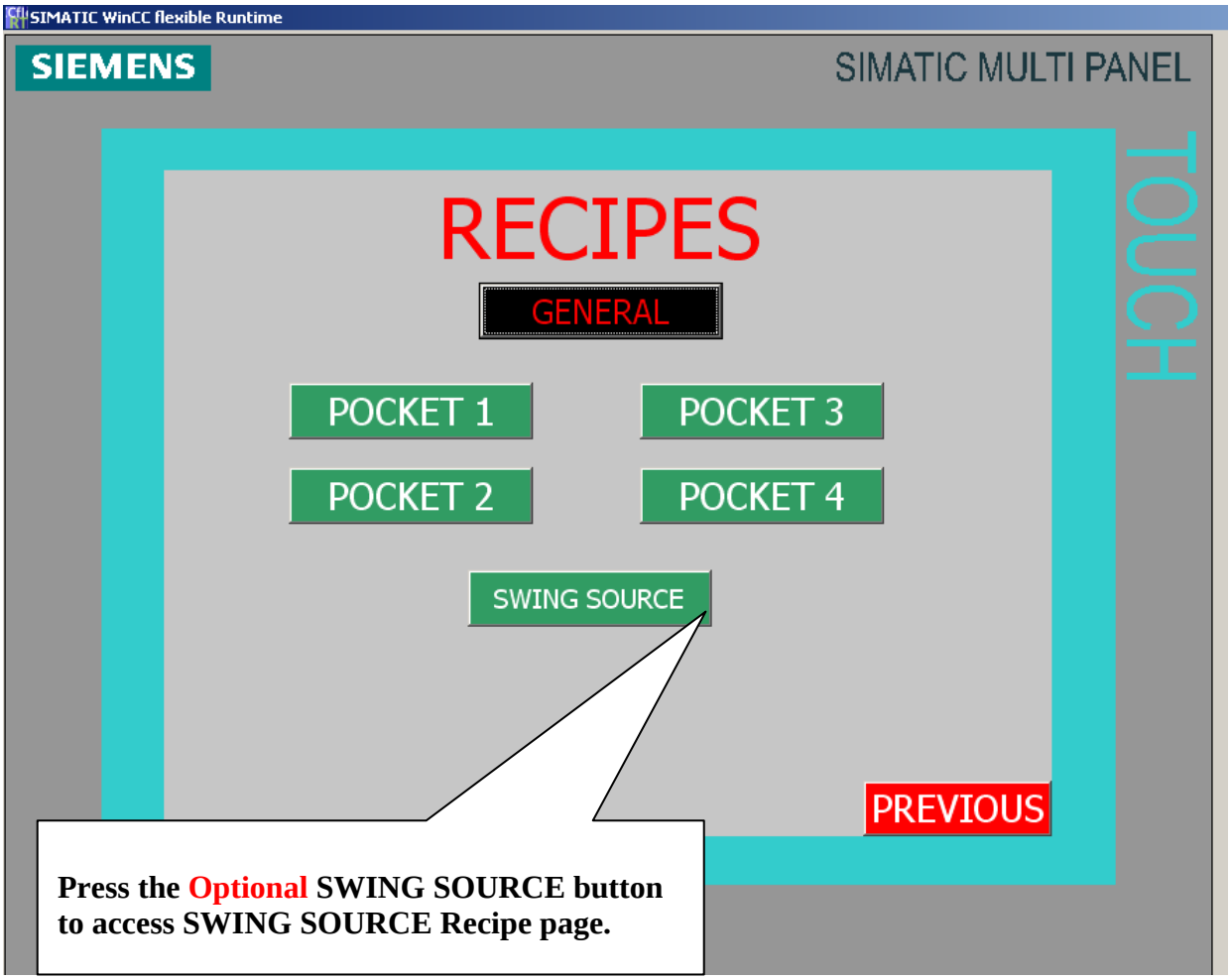
Optional Continuous Heat ON or OFF is a user-selectable toggle switch, which can make the heat available during an auto process per pocket.

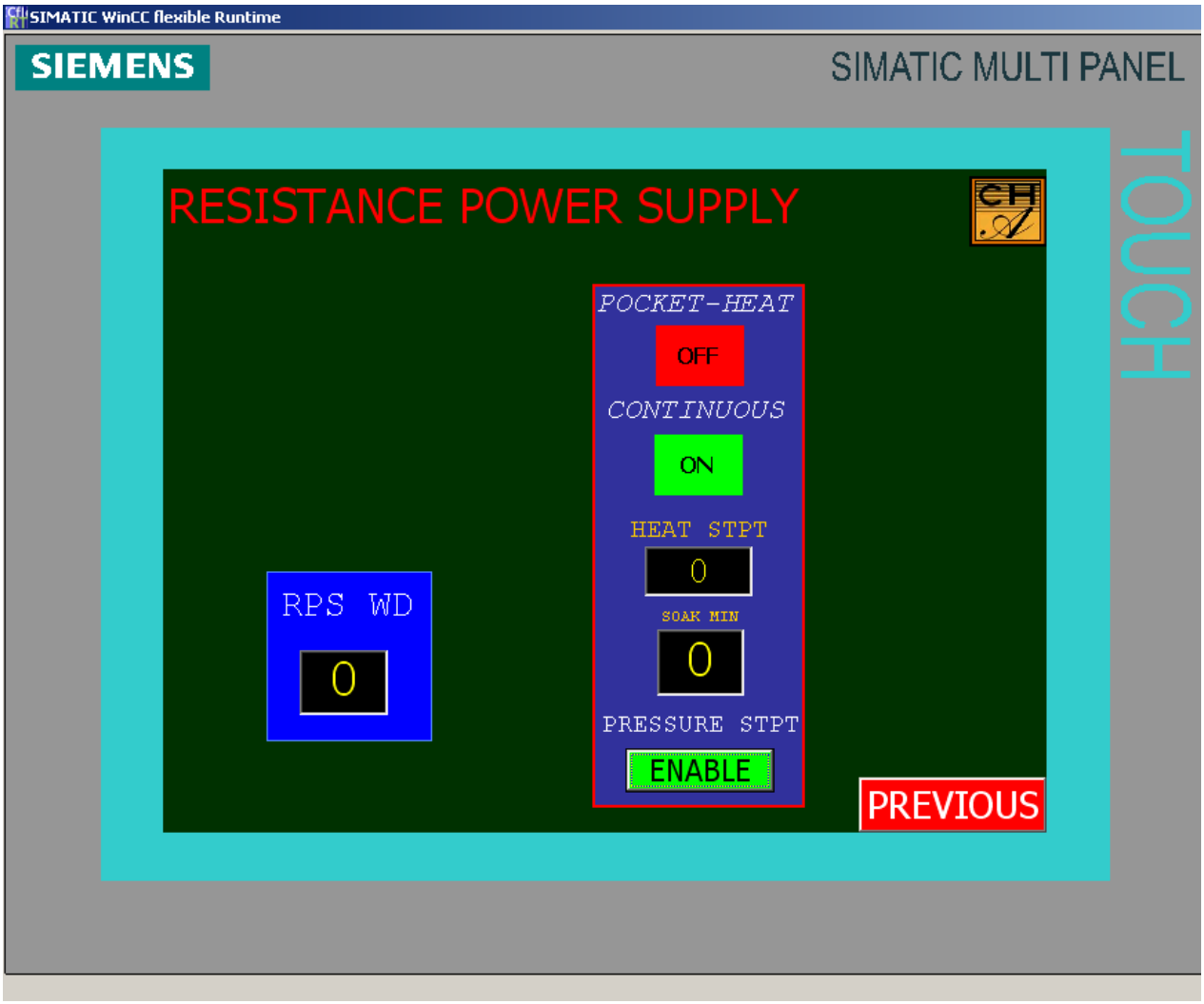
Optional Pressure STPT is a user-selectable toggle switch, which can enable the pressure setpoint of IG2 available during an auto process per pocket. Refer to Flowchart when enable pressure setpoint sheet 9 PER-POCKET HEAT RECIPES process parameters.

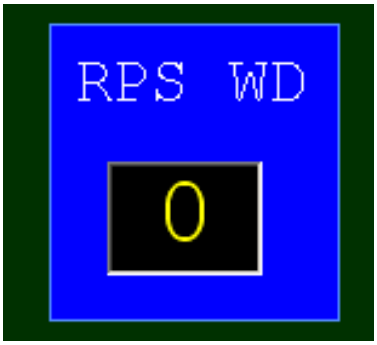
Optional HEAT TEMPERATURE SETPOINT NUMBER allows the user to select heat setpoints per pocket in the PLC temperature controller (1°C to 350°C).

Optional HEAT SOAK TIME allows the user to select the amount of time the heat is on at setpoint temperature before the process run can progress to the next event, during an auto process run per pocket.

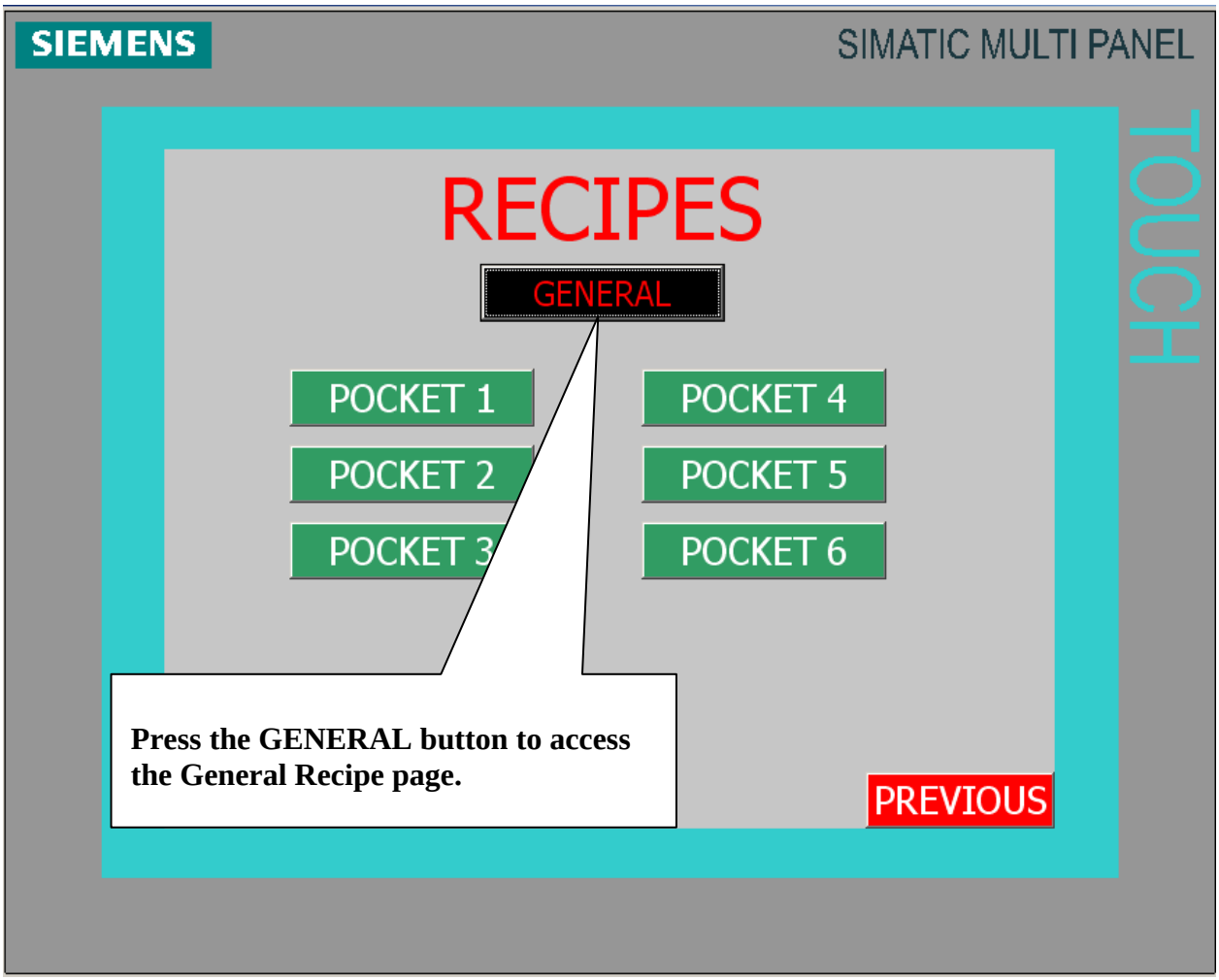



SIMATIC WinCC flexible Runtime
SIEMENS
SIMATIC MULTI PANEL
TOUCH
RECIPES
GENERAL
POCKET 1
POCKET 3
POCKET 2
POCKET 4
SWING SOURCE
PREVIOUS
Press the Optional SWING SOURCE button to access SWING SOURCE Recipe page.





RPS Deposition Watchdog Timer, if the timer is exceeded, the program is aborted and a pop-up window appears indicating the situation (ERR-DEPOSITION-OVERTIME), during an auto process run.


SIEMENS
SIMATIC MULTI PANEL
TOUCH
RECIPES
GENERAL
POCKET 1
POCKET 2
POCKET 3
POCKET 4
POCKET 5
POCKET 6
Press the GENERAL button to access the General Recipe page.
PREVIOUS

NOTE: Refer to Flowchart when filling out GENERAL RECIPE process parameters.

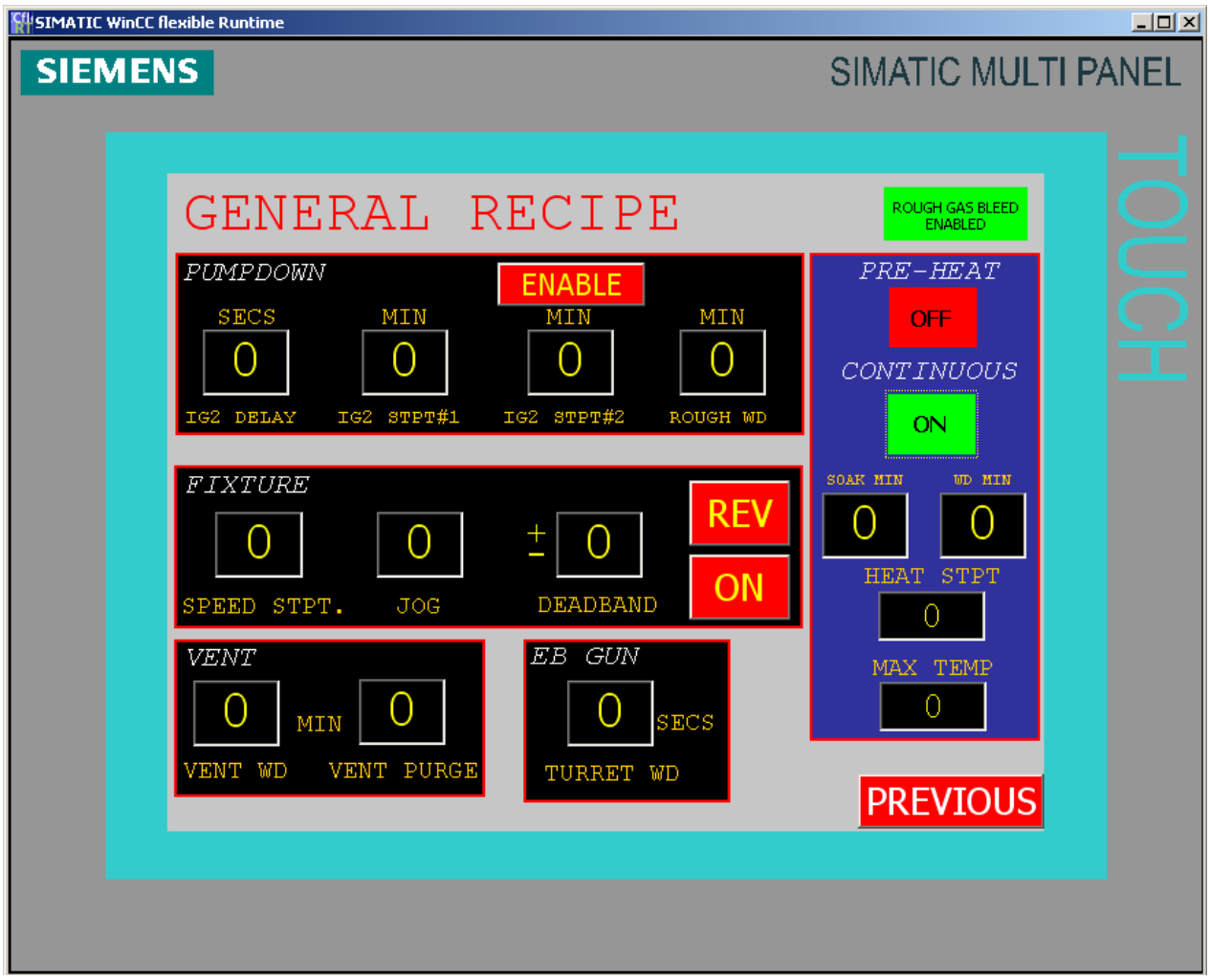
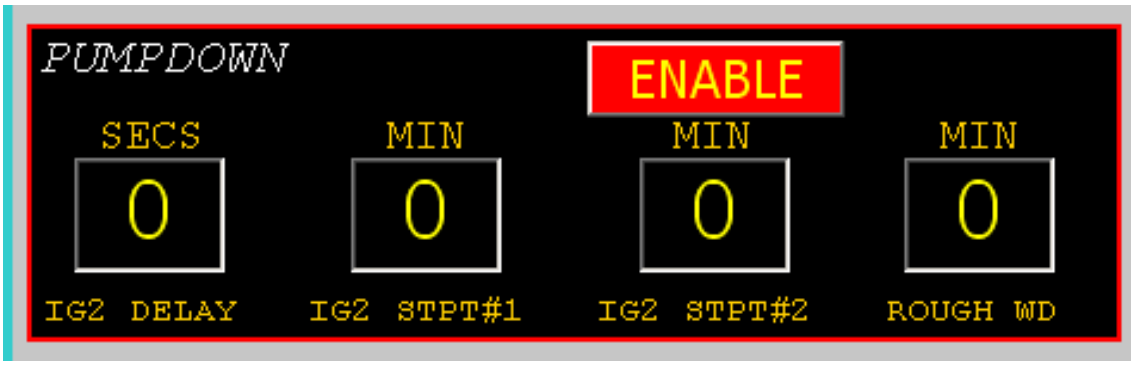


FIGURE 9-4 General Recipe page.



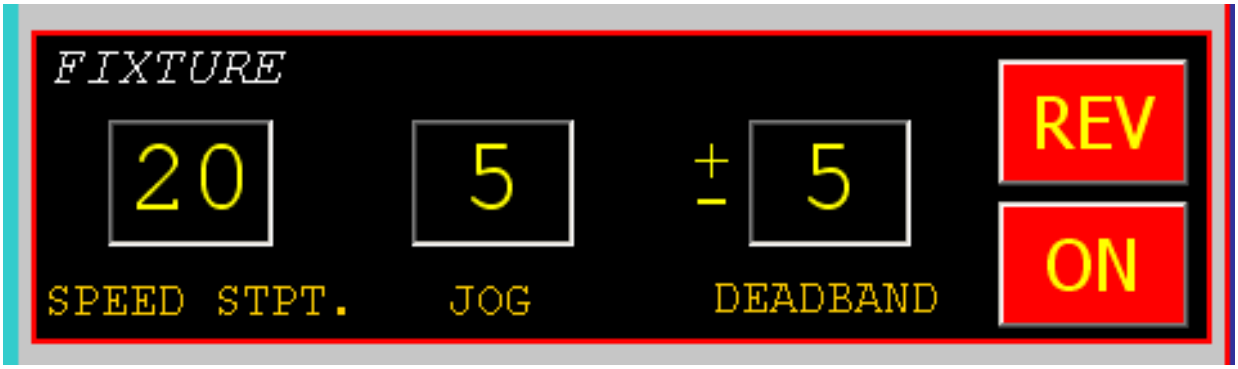
IG2 Delay WD is used for delaying the time from IG2 turning on after the HiVac is opened. This allows the pressure to settle so that IG2 does not blow off from the HI pressure. (99 Sec MAX).

IG2 STPT#1 is the time limit used to pump the system down to process pumping setpoint. If the setpoint is not satisfied within IG2 STPT#1 WD, system ABORTS. "IG2 stpt#1 Not Made. (ERR-IG2-STPT1-N-MADE) (99 Min MAX. Mandatory Input)

IG2 STPT#2 is the time limit used to pump the system down to process run setpoint. If the setpoint is not satisfied within IG2 STPT#2 WD, system will ABORT. "IG2 Stpt#2 Not Made." (ERR-IG2-STPT2-N-MADE) (99 Min MAX. Mandatory Input).

Optional **ENABLE IG2 STPT#2** is a user-selectable toggle switch, which if enable the IG2 setpoint is available per pocket during an auto. Refer to Flowchart when enable pressure setpoint sheet 9 PER-POCKET HEAT RECIPES process parameters. If the setpoint is not satisfied within IG2 STPT#2 WD, system will ABORT. "IG2 Stpt#2 Not Made." (ERR-IG2-STPT2-N-MADE)

Rough WD is the time limit used to ROUGH the chamber down to Conv. B Cross-over Stpt. If timed out, "Roughing Overtime" alarm will appear. (ERR-ROUGHING-OT) (99 Min MAX. Mandatory Input)



Fixture Speed Setpoint is used to set the RPM of the planetary control for the Automatic run. Calibration is preset to the recommended speed (20RPM).

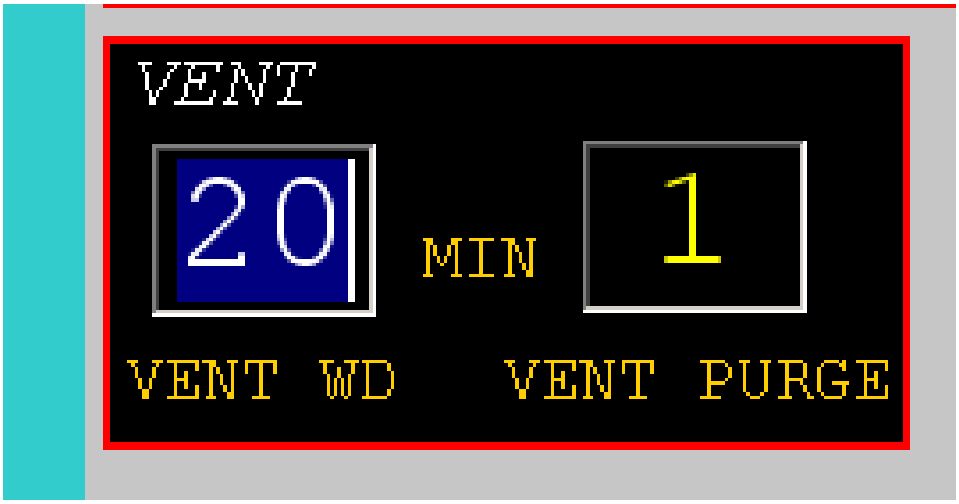
The Fixture Jog Speed sets the amount of substrate fixture jog rotation speed (rpm) when the system is in standby, the jog speed is for loading and unloading the substrate during an auto process run. (5 RPM)

Fixture Deadband is used to set a bandwidth for the Fixture Rotation. I. E. If the Fixture is set at 20 with a deadband of 5, the speed cannot exceed 25 and cannot decline under 15 rpm. In an auto run the system will ABORT, alarm will appear (ERR-FIXTURE-ROTATION)

SOLUTION

The **REV** toggle button is only used if you need the Substrate Holder to rotate backwards during an Automatic Process Run.

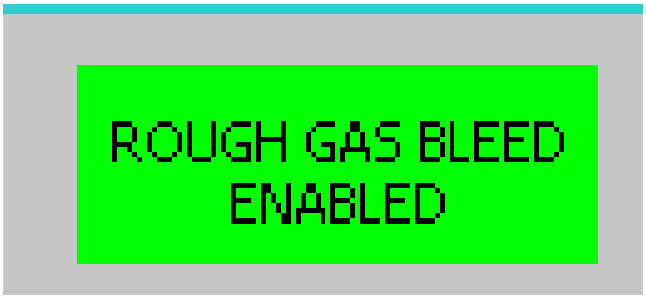
Fixture ON button should be selected for an Automatic Process Run. If not, the Fixture Rotation will NOT operate properly during an Automatic Run and will ABORT.



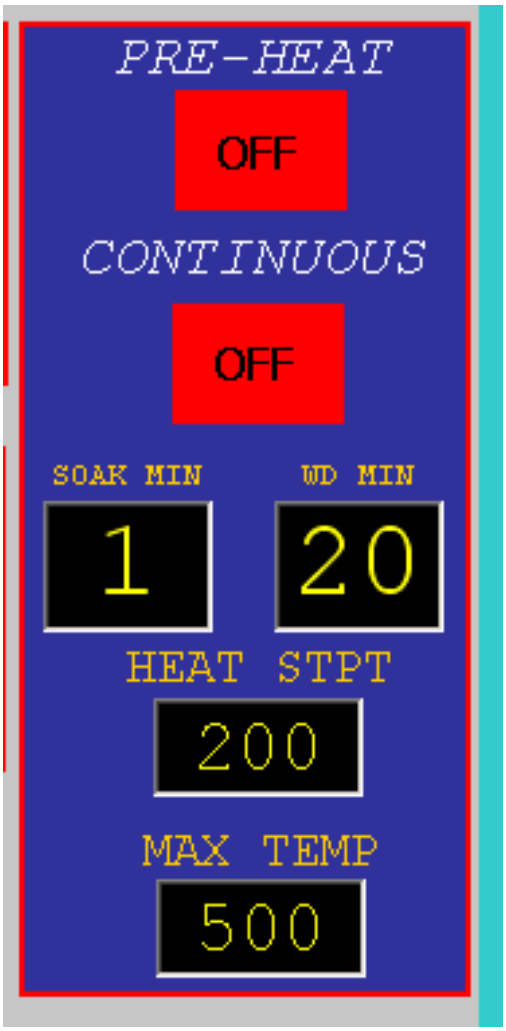
Vent WD is the timer used to vent the system. If not vented within the watchdog time, system will abort. Alarm will appear "VENT OVERTIME." (ERR-VENT-OVERTIME) (99 Min Max).

Vent Purge Time is the amount of time that the system must purge after the chamber reaches 760 torr (atmospheric pressure).

Turret Watchdog Timer sets the maximum amount of time allowed for the turret to select the required crucible, which is usually set to 30 seconds. If this time is exceeded, the program is aborted and a pop-up window appears indicating the situation. (99 Sec Max. Mandatory Input)
(ERR-CRUC-POSITION-EB)



Optional **Rough Gas Bleed Enabled or Disabled** is a user-selectable toggle switch, which can be selected to have the rough gas bleed enabled or disabled during all auto process run.



Optional **Pre Heat ON or OFF** is a user-selectable toggle switch, which can make the heat available during an auto process.

Optional **Continuous Heat ON or OFF** is a user-selectable toggle switch, which can make the heat continuously available during an auto process.

Optional **HEAT SOAK TIME** allows the user to select the amount of time the pre heat is on at setpoint temperature before the process run can progress to the next event, during an auto process run.

Optional **HEAT TEMPERATURE SETPOINT NUMBER** allows the user to select heat setpoints in the PLC temperature controller (1°C to 350°C).

Optional **Heat Maximum Temperature Setpoints** sets maximum temperature allowed for the system, which is 350 degree C.

10. INTERLOCKS

10.1 Hardwired Interlocks

Hardwired interlocks are always active, regardless of the mode.

1 Chamber Door
2. Chamber Water flow switch
3. Crystal Water flow switch
4. EB Gun Water flow switch
5. Optional RPS Water flow switch
6. Panel Door switch
7. IG2 Filament
8. Hi-Vac Valve

10.2 Software Interlocks

The following is a listing of the interlock conditions that must be met before the item will function:

1. Rough Valve.
   Mechanical pump online
   Chamber door switch
   Front door closed and latched
   Hi Vac Valve closed
   Vent valve closed

2. Vent Valve.
   Rough valve closed
   Hi Vac Valve closed

3. Hi Vac Valve.
   Chamber vacuum switch
   Rough valve closed
   Vent valve closed
   Chamber convectron cross-over pressure ok

4. Optional Rough Gas Bleed
   Rough valve closed
   Conv. A setpoint 2

11. TROUBLESHOOTING

11.1 How to Reset the PLC

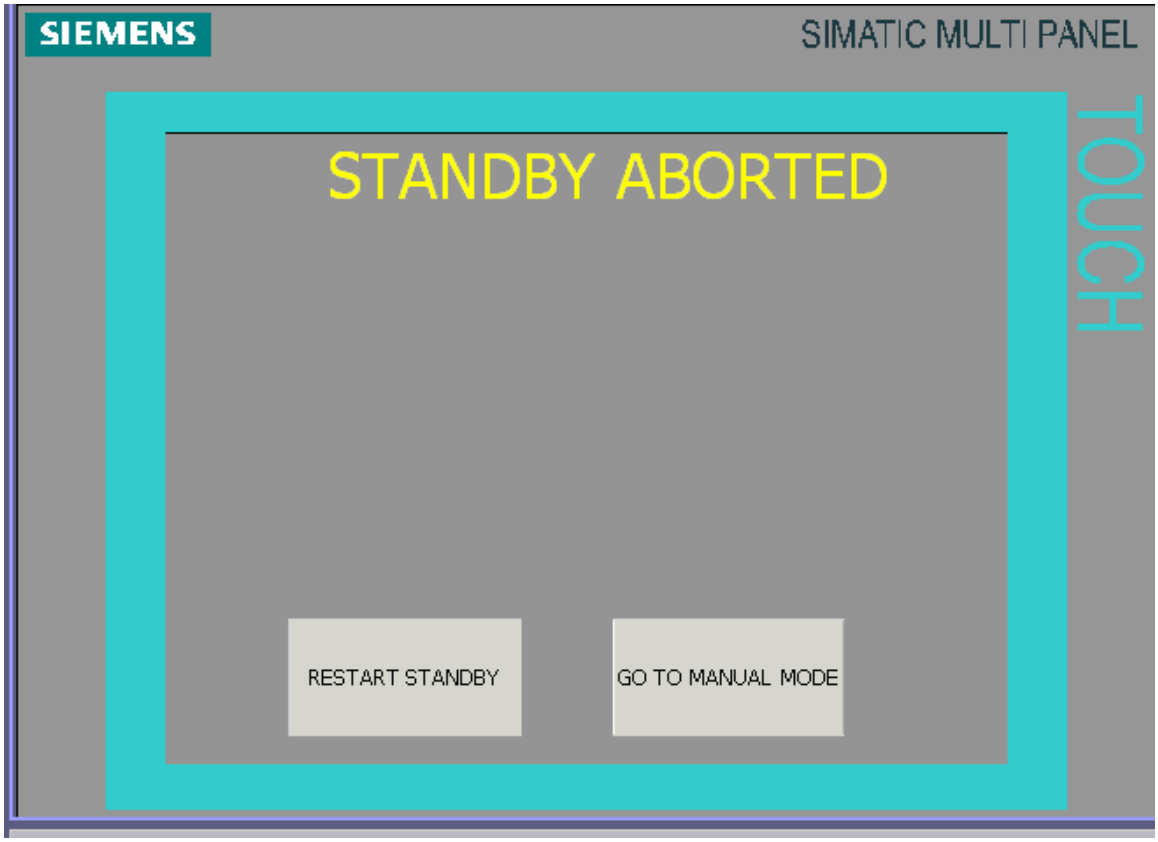
If the touchscreen "hangs up," i.e., does not respond and no longer invokes any action, reset the PLC.

Hold down Reset, LED blinks, Hold until LED stops blinking. Release reset then quickly press and hold reset again until LEDS stop blinking. PLC is reset.

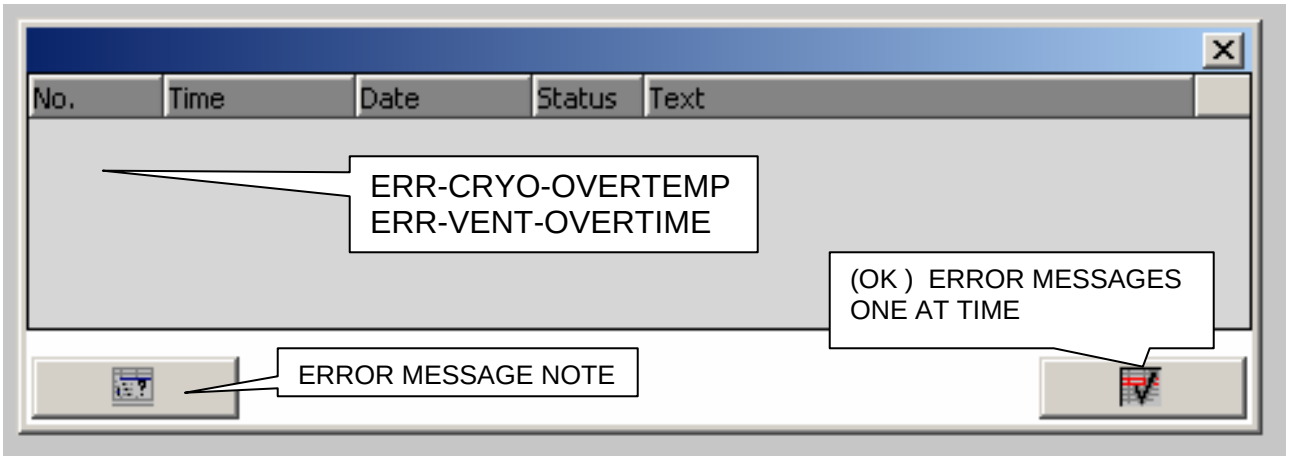
11.2 Error Messages

Error messages appear in graphic form. The cause for each error is described below along with the corrective action the user must take. Some corrective action(s) may require technical support from CHA.

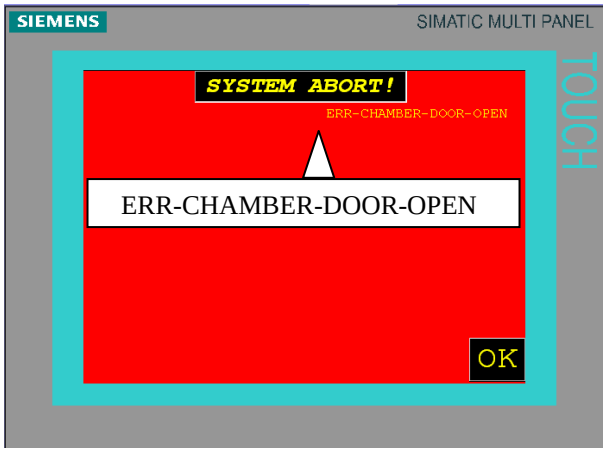
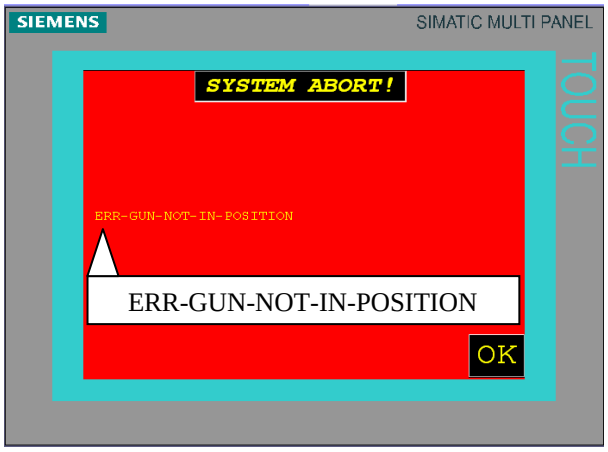
ERR-CRYO-OVERTEMP
ERR-CRYOPUMP-REGEN
ERR-GP307-OFFLINE
ERR-IG1-FILAMENT-OFF
ERR-DOOR-NOT-LATCHED
F-12-ABORT-ACTIVE
ERR-MECH-PMP-OFF
ERR-CRYOPUMP-OFFLINE
ERR-PANEL-DOOR-OPEN
ERR-CHAMBER-DOOR-OPEN
ERR-CRUC-POSITION-EB
ERR-VENT-OVERTIME
ERR-FIXTURE-ROTATION
ERR-COOLING-CHAMBER
ERR-COOLING-XTAL
ERR-COOLING-EB-GUN
ERR-HI-VAC-OVPS
ERR-ROUGHING-OT
ERR-RATE-OF-RISE
ERR-IG2-FILAMENT-OFF
ERR-IG1-STPT-N-MADE
ERR-IG2-STPT1-N-MADE
ERR-IG2-STPT2-N-MADE
ERR-SP8-OFFLINE
ERR-GM-OFFLINE
ERR-EB-FILAMENT-OFF
ERR-EB-HI-VOLT-OFF
ERR-SYCON-OFFLINE
ERR-SYCON-STOP
ERR-HEAT-OVERTIME
ERR-HEAT-MAX-TEMP



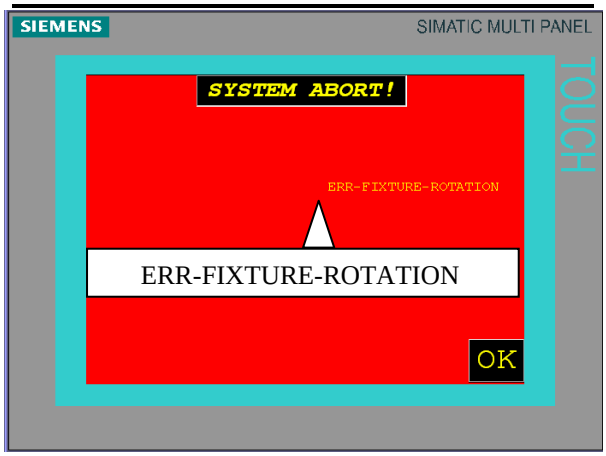
OPTIONAL STANDBY ABORTED SCREEN



OPTIONAL ERROR MESSAGE SCREEN

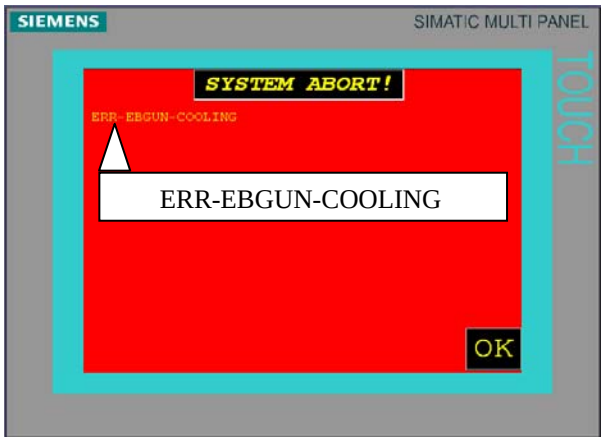
ERROR MESSAGE	CAUSE	SOLUTION
	1. The chamber door may be open. 2. The micro switch for the door, which is located on side of the chamber, may not be made up (closed).	1. Close and latch the chamber door. 2. Adjust the microswitch.
	1. The crucible could be stuck half way. 2. Bad connections between the 8-pin male/female feedthrough connections.	1. Check the rotation of the gun from pocket to pocket manually from the Manual Deposition Screen. If it is NOT ok, call CHA for assistance. 2. If the #1 test fails, check the feedthrough contacts for each pocket position.

SOLUTION



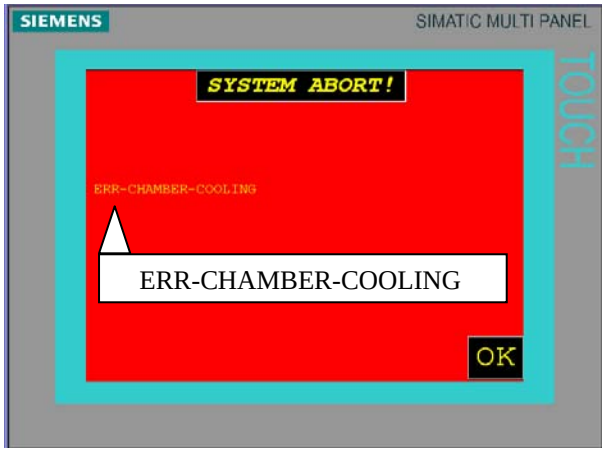
1. Fixture rotation motor is not rotating.
2. Fixture rotation motor is not @ desired speed

1. Ensure the fixture rotation speed pot in the back panel is not in the CCW or zero position.
2. Check for a blown fuse on the Fixture Controller.
3. Set the pot to the desired speed.



1. EB Gun water-cooling may be off.
2. Flow rate may be too low.

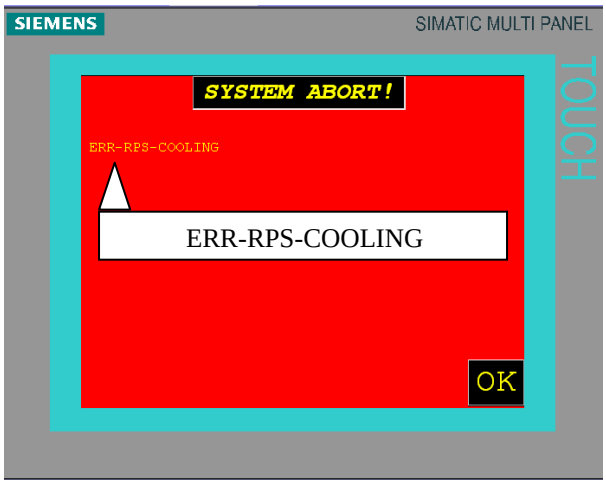
1. Ensure the EB gun water flow is on and check for the proper flow rate.



1. Chamber water-cooling may be off.
2. Flow rate may be too low.

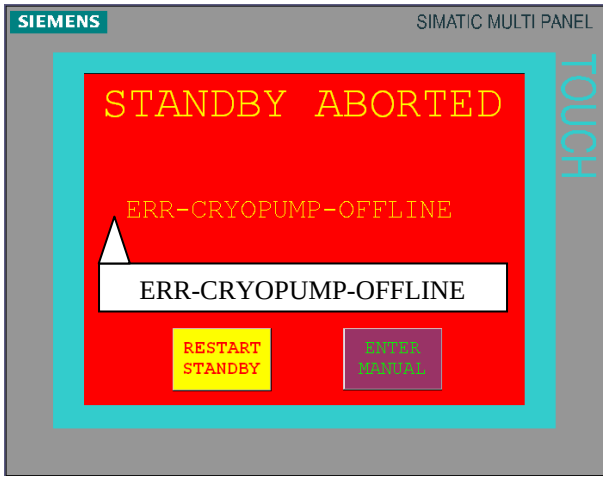
1. Ensure the water-cooling is on and check for proper flow rate.

SOLUTION



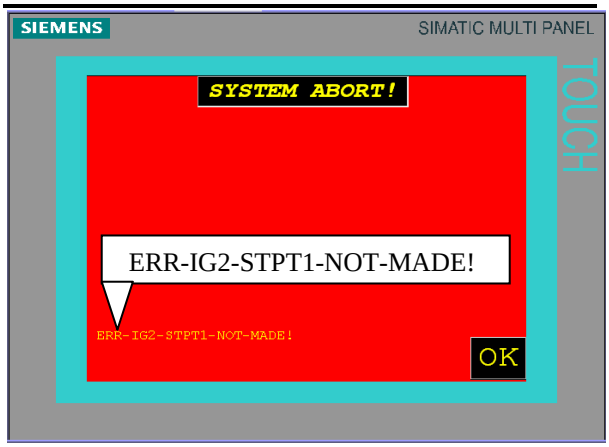
1. RPS water-cooling may be off.
2. Flow rate may be too low.

1. Ensure the water-cooling is on and check for proper flow rate.



Cryopump is off

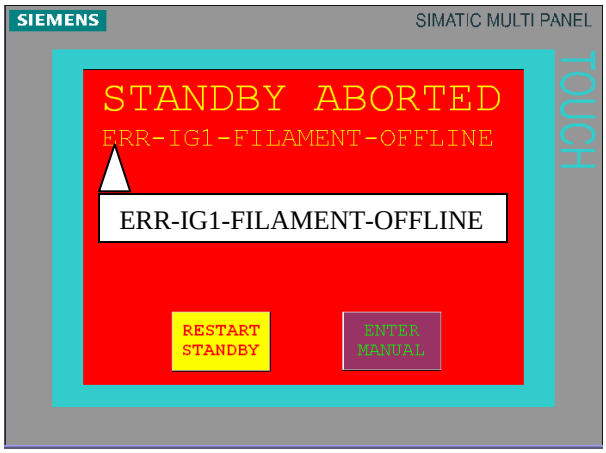
1. Check Cryopump compressor breaker.
2. Check all plugs that are on the Cryopump compressor.



During the automatic run, the IG2 Setpoint 1 is not made after the system went into Hi-Vac.

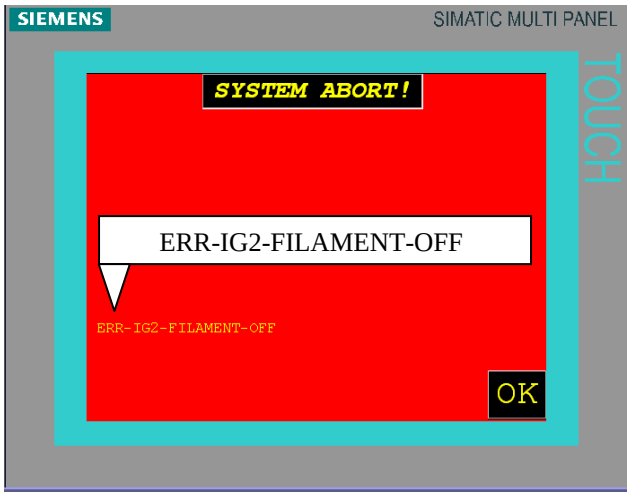
1. Ensure the recipe setpoint for IG2 is properly set.
2. Check for the presence of vacuum leaks into the system.
3. Keep the system clean.
4. Ensure the timer setpoint in the recipe is set properly.

SOLUTION



IG1 filament is off.

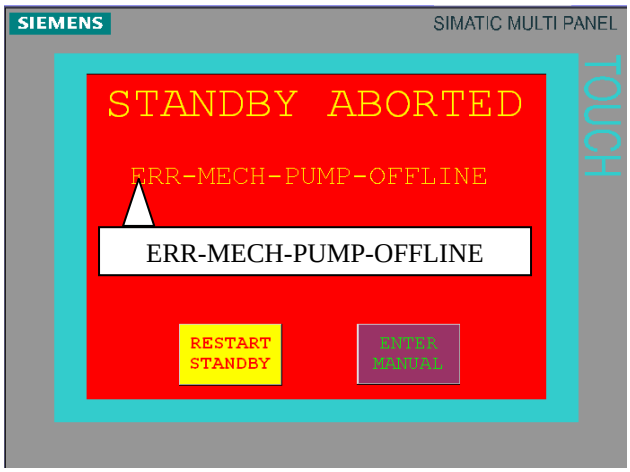
1. Normally the IG1 is on when the system is in standby. Try to turn the IG1 on manually. If the IG1 does not remain on, there may be an over-pressure condition in the stack area.
2. The tube filament may be broken.



IG 2 filament is off.

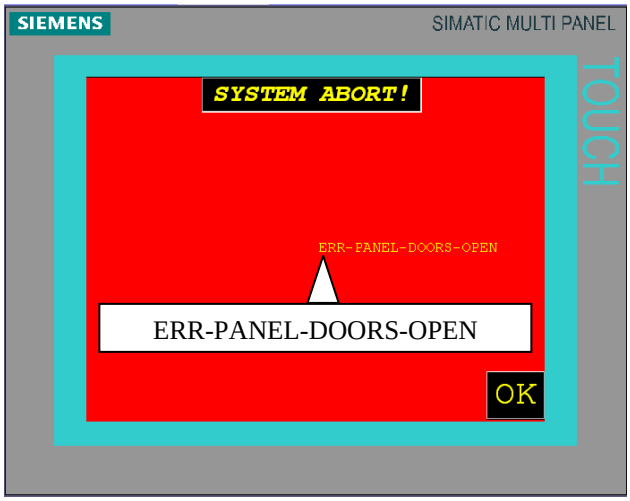
1. The tube filament may be broken.
2. The vacuum chamber pressure may be too high.

SOLUTION



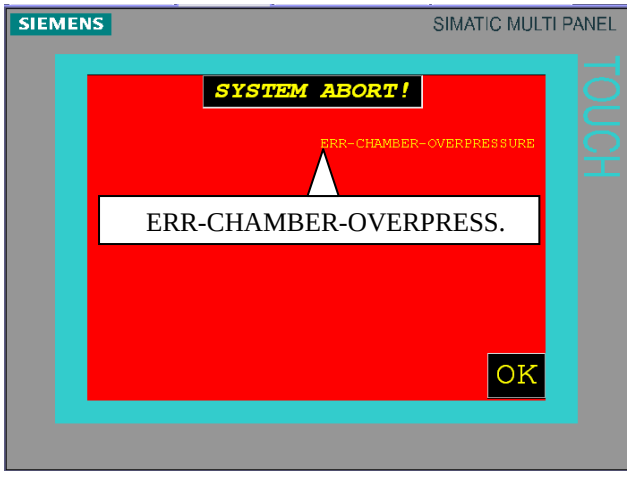
The mechanical pump is off.

1. Ensure the mechanical pump is plugged in and the 3-phase contactor is on. The contactor is located in the control box on the pump chassis.
2. Reset the overload relay if necessary.
3. Check condition and adjustment of the mini-convectron on the mechanical pump line.



The panel door is open

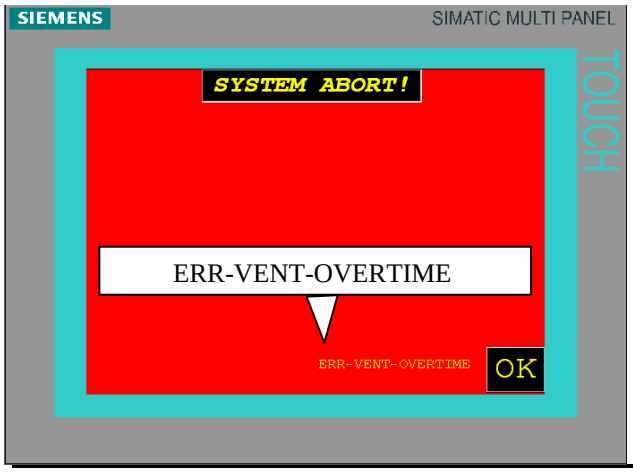
1. Close all panel doors.



The rate of rise of the chamber pressure is above the limit preset in the recipe.

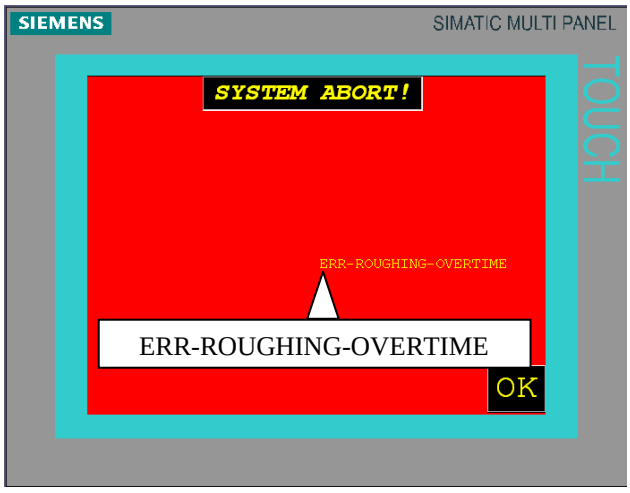
1. Ensure the preset limit is large enough.
2. If the problem persists, check for vacuum leaks.

SOLUTION



It took longer to vent the system than was preset in the recipe.

1. Ensure the vent overtime timer is set properly.
2. Since system performance may degrade over a period of time, use higher settings on the timer.
3. Ensure vent gas supply is acceptable.



Pumpdown did not reach crossover setpoint before roughing watchdog expired.

1. Make sure rough valve is plugged in.
2. Ensure there is no leak in the chamber.

Appendix B: Glossary

absolute melting point The melting point of a substance measured in degrees Kelvin (absolute temperature).

absolute pressure See pressure, *absolute.*

absolute temperature The temperature scale which starts at "true" or absolute zero. It is often called the Kelvin scale.

absorption The binding of a gas in the interior of a solid or liquid.

adsorption The condensing of a gas on the surface of a solid.

amorphous Usually refers to a particle or grain size smaller than 30 A that does not show a crystal structure when using x-ray diffraction techniques. *atom* The smallest identifiable part of an element. An atom has a nucleus with particles called protons and neutrons. Under normal conditions, it is surrounded by a number of electrons equal to the number of protons. Neutrons are neutral, protons are positively charged, and electrons are negatively charged.

atomic mass unit A way of classifying atoms according to their weight, or mass. Atoms of the different elements have different weights, or masses.

Avogadro's Law The gas law that states that one mole of any gas has 6.023×10^{23} particles and under standard conditions occupies 22.4 liters.

backing pump See forepump.

backstreaming The small amount of pump fluid vapor that moves in the wrong direction, i.e., toward the work chamber.

bakeout The degassing of a vacuum system by heating during the pumping process.

bar Unit of pressure measurement. There are 1.010 bar in one standard atmosphere. One bar equals 1 x 106 dynes per square centimeter.

base pressure That pressure which is typically reached with your system when it is clean, empty, and dry.

beam density Describes what is scientifically the power density of electron beam striking a target to be melted or evaporated.

belljar A container open at the bottom and closed at the top which is used as a vacuum chamber or test vessel. Also called a work chamber.

bellows-sealed valve A valve type in which the stem seal is accomplished by means of a flexible bellows, one end of which is attached to the sealing disk, the other end to either the bonnet or the body.

binary alloy A composition of two or more metals. An alloy may a compound, a solid solution, a heterogeneous mixture, or any combination of these.

bleed A colloquial term in vacuum technology referring to the admission of a small quantity of gas into a vacuum system.

blower pump A type of vacuum pump which functions from l0 torr to 0.0001 torr. Also called a booster or Roots pump.

body That part of a valve which contains the external openings for entrance and exit of the controlled fluid.

bomb test A form of leak test in which enclosures are immersed in a fluid. The fluid is then pressurized to drive it through possible leak passages and thus into the internal cavities. The enclosures are then placed in a leak detector to detect the escaping fluid.

bonnet In general, that part of the valve through which the stem enters the valve, and which is rigidly attached to the valve body.

bourdon gauge A roughing gauge that responds to the physical forces that a gas exerts on a surface.

Boyle's Law The gas law that states PIV, = **P2V2,** or original pressure times original volume equals new pressure times new volume. This equation predicts new pressure or new volume whenever the other is changed by any amount (providing that the temperature is unchanged).

calibrated leak An external reference standard that permits calibration of a helium leak detector.

capacitance manometer A vacuum gauge which senses pressure by the change in capacitance between a diaphragm and an electrode.

Charles'Law The gas law that describes what happens to the volume of gas as the temperature is changed. As a gas is cooled, its volume gets smaller. As a gas is heated, its volume increases (at constant pressure).

Chemical pumping The removal of gas from a vacuum system by acting it with another to form a compound of very low vapor pressure. See gettering.

chemisorption The binding of a gas on or in a solid by chemical action. See gettering.

chip A term used in the microelectronics industry to describe a self-contained circuit on a wafer. A wafer may contain many chips on its surface.

closed-loop refrigeration system A refrigeration system in which the coolant is recycled continuously.

cold cap A component mounted on top of the jet assembly in a diffusion pump. This cap helps to keep pump fluid vapor out of the work chamber.

cold cathode discharge A visible glow caused by the recombination of electrons and ions. The color is characteristic of the gas species present.

cold cathode gauge See ionization gauge.

cold trap See cryotrap

compound Two or more elements combined chemically in specific proportions. ***condensation*** The process of a gas turning back into a liquid.

conductance A term used to indicate the speed with which atoms and molecules can flow through a particular region such as an orifice or pipe.

conductance limited The inability to make use of the rated speed of a pump due to the use of an opening or pipe smaller than the inlet diameter of the pump.

conduction The transfer of energy (heat, light, etc.) by direct contact. In the case of gaseous conduction, the transfer of energy by molecules directly contacting surfaces and other molecules.

convection The transfer of heat from one place to another by the circulation of currents of heated gas or other fluid.

Cosine law The intensity of light from a point source impinging on a flat surface is proportional to the cosine of the angle subtended by the source at the plane surface. The thickness of material deposited by physical vapor deposition from a point source on a plane is also related to the cosine of the angle subtended by the source at the plane surface.

critical forepressure See maximum *tolerable foreline pressure.*

crossover The pressure at which a vacuum chamber is changed from being pumped by a roughing pump to being pumped by a high vacuum pump.

cryocondensation The pumping of gases that are condensed at cold temperatures. For example, water vapor on a liquid nitrogen trap at -196^{0}C.

cryogenic pump By reducing the temperature of a surface to very low values, all vapors can be condensed and removed from a vacuum. If all gases, including helium, are to be pumped, temperatures below 12 [UNITS????] must be reached.

cryosorption The pumping of gases that are not readily condensed (or pumped) at cold temperatures, by the process of sticking onto a cold surface.

cryotrap A device usually placed before the inlet of a high vacuum pump to "trap" or freeze out gases such as pump oil vapor and water vapor. Cryotraps commonly use liquid nitrogen as the coolant. Also called cold trap or liquid nitrogen trap.

dark space Loosely applied to the faraday dark space which occurs between a cathode and plasma in a glow discharge.

degassing The removal of gas from a material, usually by application of heat under high vacuum. See bakeout.

desorption See outgassing.

diffusion *(1)* The flow of one substance through another by random molecular motion.
(2) The process by which molecules intermingle as a result of their thermal motion.

diffusion pump A vapor pump having boiler pressures of a few torr and capable of pumping gas continuously at intake pressures not exceeding about 2 mtorr and discharge pressures (forepressures) not exceeding about 500 mtorr. The term diffusion should be applied only to pumps in which the pumping action of each vapor jet occurs as follows: The gas molecules diffuse through the low-density scattered vapor into the denser, forward-moving core of a freely expanding vapor jet. Most of the gas molecules are then driven at an acute angle toward the wall and on into the fore vacuum.

dynamic seat A seal that moves. (See *static seal)*

electron A negatively charged particle. (See atom.)

electronic structure A portion of an atom where electrons are located in their respective orbits or shells.

element A substance entirely consisting of atoms having the same atomic number.

epitaxy The growth of one substance upon another in which the crystal structure of the substrate is copied by the growing substance and substituted for its natural structure.

evaporation The process that happens when a liquid or solid becomes a gas.

feedthrough A device used to allow some sort of utility service to go from the outside world to the inside of a vacuum system while maintaining the integrity of the vacuum; for example, an electrical feedthrough.

foreline The section of a pump through which the gases leave.

foreline valve A vacuum valve placed in the foreline to permit isolation of the pump from its forepump.

forepump The pump which is used to exhaust another pump which is incapable of discharging gases at atmospheric pressure. Also called the backing pump.

fractionation A process that helps to purify the condensed fluid in a diffusion pump. This process distills out contaminants produced by decomposition of pump fluid.

gas A state of matter where the individual particles are free to move in any direction and tend to expand uniformly to fill the confines of a container.

gas ballast A method used with any oil-sealed rotary pump which allows a quantity of air to be admitted during the compression cycle to prevent condensation of water vapor. The amount of air admitted is regulated by the gas ballast valve. The use of a gas ballast raises the ultimate pressure of the pump.

gas density The number of molecules per unit of volume.

gas load The amount of gas being removed from a vacuum chamber by the vacuum pumps. Typically measured in torr-liters per second, cubic feet per minute, or cubic meters per hour.

gauge pressure See pressure, gauge.

Gay-Lussac's Law The gas law that states that if the temperature of a volume of gas at O°C is changed by 1°C, the volume will change (plus or minus, as appropriate) by 1/273 of its original value.

general gas law The gas law that covers pressure, volume, and temperature in one single equation, or $P_1V_1T_2 = P_2V_2T_1$

gettering A method of pumping gases through chemical reaction of a material with gas molecules. The material usually used is an active element such as titanium. See chemisorption.

helium mass spectrometer leak detector (HMSLD) See mass *spectrometer leak detector.*

high vacuum Pressure which ranges from about 10^{-4} torr (0.0001 torr) to approximately 10^{-8} torr (0.00000001 torr).

high vacuum pump A vacuum pump which will function in the high vacuum range. Common examples are the diffusion pump and the mechanical cryopump.

high vacuum valve A large diameter valve usually placed between the vacuum chamber and the vacuum pumps. It is used to isolate the vacuum chamber from the pumps when it is necessary to work on something in the chamber. Also called hi-vac valve, gate valve, or trap valve.

implosion In vacuum work, the inward collapse of the walls of a vacuum system, caused by external pressure.

inside-out leak detection technique A method of leak detection whereby the tracer gas is placed under pressure inside the container to be leak checked. A detector probe attached to a leak detector is used to locate leaks.

ion A charged particle consisting of an atom or molecule which has an excess of positive or negative charge. Typically produced by knocking an electrons) out of an atom or molecule to produce a net positive charge. ***ion pump*** An electrical device for pumping gas. The ion pump includes a means for ionizing the gas with a system of electrodes at suitable potentials, and also a magnetic field. The ions formed move toward a cathode or a surface on which they are reflected, buried, or cause sputtering of cathode material.

ionization The process of creating ions. See ion.

ionization gauge A vacuum gauge that has a means of ionizing the gas molecules, electrodes to enable the collection of the ions formed, and a means of indicating the amount of the collected ion current. Various types of ionization gauges are identified according to the method of producing the ionization. The common types are:

1. *hot cathode ionization gauge* The ions are produced by collisions of gas molecules with electrons emitted from a hot filament (or cathode) and accelerated by an electric field. Also called hot-filament ionization gauge, or simply ion gauge.
2. *cold cathode* ionization gauge The ions are produced by a cold cathode discharge, usually in the presence of a magnetic field which lengthens the path of the electrons.

jet assembly A nozzle assembly that directs oil vapors in a diffusion pump.

latent heat of evaporation The energy required to convert material from the liquid (or solid interface of subliming materials) to the vapor phase under isothermal conditions.

leak Leaks may be of three different types: (1) a real leak, which is a crack or hole allowing gases to pass through; (2) a virtual leak, which is caused by outgassing of some volatile material inside a vacuum system or trapped volume; and (3) a permeation leak, which consists of atomic-scale holes throughout the material of construction: for example, 0-rings are quite permeable.

leak detector A device for detecting, locating, and/or measuring leakage.

leak rate Mass flow through an orifice per unit time. Vacuum system leakage rates are typically measured in atm cc per second or torr-liters per second.

liner An insert placed in a water cooled copper crucible which is used to contain the material to be evaporated to reduce conductive heat transfer.

liquid nitrogen trap See cryotrap

mass A fundamental characteristic of matter which is most closely related to the unit of weight.

mass spectrometer (MS) An instrument that is capable of separating ionized molecules of different mass/charge ratio and measuring the respective ion currents. The mass spectrometer may be used as a vacuum gauge that measures the partial pressure of a specified gas, as a leak detector sensitive to a particular tracer gas, or as an analytical instrument to determine the percentage composition of a gas mixture.

mass spectrometer leak detector A mass spectrometer adjusted to respond only to the tracer gas. Helium is commonly used as the tracer gas, and thus the instrument is normally referred to as a helium leak detector.

maximum tolerable foreline pressure A measure of the ability of the diffusion pump to pump gases against a certain discharge pressure. Also called critical forepressure.

mean free path The average distance between molecular collisions. Of importance for vacuum systems where one is interested in getting some particular type of particle from a source to a surface. For example, ion implanters, coaters, or television tubes.

microelectronics Electronics reduced to a very small scale by using integrated circuits.

micrometer A device using a screw thread as its basis to measure lengths accurately.

micron Pressure unit equivalent to 1 mtorr.

millibar Unit of pressure measurement, equal to l/1000 bar.

millimeter of mercury See torr.

millitorr Unitofpressuremeasurement,equaltol/1000torr.

mole The number of particles in equal volumes of gases under the same conditions of temperature and pressure. One mole of any gas has 6.023×10^{23} particles.

molecular density The number of molecules in a unit of volume such as a cubic centimeter. There are approximately 3×10^{19} molecules per cc at one standard atmosphere.

molecular flow The type of flow which occurs when gas molecules are spread far apart. There are few collisions so that the molecules tend to act independently of any other molecules which may be present. The molecular directions are completely random.

molecular sieve A very porous material used to contain the pumped gases in sorption pumps. May also be used in a foreline trap to constrain oil molecules.

molecular sieve trap A device used to collect oil vapors backstreaming from oil-sealed mechanical pumps.

molecular weight A way of classifying molecules according to their weight, or mass. Molecular weight or mass is the sum of the individual atomic weights that make up the molecule.

molecule One atom, or two or more atoms joined together and having definite chemical and physical characteristics.

neutron A particle located in the nucleus of an atom which has no electrical charge but does have mass. (See atom.)

nucleus The dense center portion of an atom containing protons and neutrons. (See atom.)

open-loop refrigeration system A refrigeration system in which the coolant vents to atmosphere.

outgassing The process in which a gas particle leaves a surface and moves into the volume of a vacuum chamber. This, of course, adds to the gas load and may or may not be desirable. In extreme cases, it prevents "pumping down" a vacuum system to the specified pressure. The system is then said to be "hung up," or outgassing. Also called desorption or virtual leak.

outside-in leak detection technique A leak detection technique where the leak detector senses a tracer gas which passes from the outside of the container to the inside of the container. May be used to determine the size and/or the location of a leak.

partial pressure See pressure, partial.

Pascal Unit of pressure measurement. There are 101,325 pascals in one standard atmosphere. A pascal equals one newton per square meter.

permeation leak Molecular-scale holes through a material of construction. See leak.

physical vapor deposition Transfer of material via the vapor phase by simple physical changes such as boiling.

Pirani gauge A vacuum gauge used to measure pressure in the rough vacuum range.

planetary A device used in metallizing microelectronic devices to produce an even thickness and to assist covering all portions of the steps.

plasma An ionized gas containing approximately equal numbers of positive and negative charged carriers.

powers of ten A convenient way of describing very large and very small numbers. A number is written as some value from 1 and up to 1 0 (but not including 1 0). Then, it is multiplied by either a positive or negative power of ten. Also called exponential notation or scientific notation.

pressure Force per unit area. The force is created when atoms, molecules or "particles" strike the walls of their container. Common pressure units for vacuum work are torr, pounds per square inch relative (psig), inches of mercury, millimeters of mercury, bar, millibar, and pascal.

pressure measurement A measurement of the pressure (the number and intensity of particle impacts) on a given unit of area. There are several different scales for pressure measurement: for example, torr, millitorr, bar, millibar, and pascal. These scales may be used as absolute or relative scales.

pressure, absolute Pressure above zero pressure (corresponding to totally empty space) as distinguished from "gauge" pressure. In vacuum technology, pressure is always measured from zero pressure, not atmospheric pressure, and therefore the term absolute pressure is not required.

pressure, gauge The difference between absolute pressure and atmospheric pressure. The most common unit is probably psig.

pressure, partial A measurement of the pressure of one particular gas in a mixture of gases. For example, the partial pressure of oxygen in air is about 160 torr.

pressure, relative See pressure, gauge.

pressure, total The sum of all of the partial pressures of every gaseous species. The force exerted by all the gas molecules in any mixture of gases. We commonly assume that a pressure gauge reads total pressure.

pressure, vapor The pressure exerted by molecules after they have escaped from a liquid or solid and formed a vapor (gas). One tries, in general, to put substances of low vapor pressure into a vacuum system so as to decrease the gas load on the vacuum pumps.

probe A tube having a fine opening at one end, used for directing or collecting a stream of tracer gas.

probe test A leak test in which the tracer gas is applied by means of a probe so that the area covered by the tracer gas allows tracer gas to enter and locate the leak.

prorilometer A profile measuring device which drags a fine stylus over a surface and records the deflections of the stylus.

proton A positively charged particle. (See atom.)

psia Pounds per square inch absolute, a unit of pressure measurement. There are 14.69 psia in one standard atmosphere.

psig Pounds per square inch gauge. a unit of pressure measurement. Gauge pressure is the difference between absolute pressure and atmospheric pressure. One standard atmosphere equals 0 psig.

pump-down curve A graphic plot of pressure versus time as a vacuum system is being pumped. Usually plotted on loglog graph paper. Can be used to distinguish real leaks from virtual leaks.

pumping speed A measure of the ability of a vacuum pump to remove gases. It is typically measured in liters per second. cubic feet per minute, or cubic meters per hour.

radiation Heat transfer by energy from infrared light. Radiated heat is the only way to transfer heat inside of a vacuum system at high vacuum.

rate of rise The rate of pressure increase versus time when a vacuum system is suddenly isolated from the pump by a valve. The volume and temperature of the system are held constant during the rate-of-rise measurement.

rate-of-rise test A method of determining whether a leak is present in a system, or of obtaining an estimate of the magnitude of a leak, by observing the rate of rise of pressure in the evacuated system when the system is isolated from the pump. This method also can determine if leakage is real or virtual.

real leak A crack or hole that allows gases to pass through in both directions. See leak.

refractive index Ratio of the sine of the angle of incidence to the sine of the angle of refraction of light as it enters a body. It is also the ratio of the velocity of light in the body compared with the velocity light in vacuum.

regeneration Some vacuum pumps and traps fill up from usage (containment pumps) and must be emptied periodically. The process of emptying the pump is called regeneration.

residual gas analyzer A gauge that measures partial pressure.

resistance heating Heating a material by passing an electric current through the material.

Roots blower See blower pump.

rough pump A vacuum pump which will function in the rough vacuum range.

A roughing pump is often used to "rough" a vacuum chamber. Typical examples of rough pumps are the mechanical pump and the sorption pump.

rough vacuum Pressure which ranges from just below atmospheric pressure to about 10-3 torr (0.001 torr).

roughing The initial evacuation of a vacuum system.

scanning electron microscope It is an electron microscope which projects an image produced from a surface by the secondary electrons derived from a primary electron beam displayed in a raster pattern. The image shows three dimensional topography with high resolution an high magnification.

sightports Holes covered with glass through which the inside of a vacuum system may be observed.

Silicon wafer A thin slice of single crystal silicon of it particular crystallographic orientation doped to produce it specific bulk receptivity on which integrated circuits may be formed.

sniffer probe See probe. (More correctly called a detector probe.)

spectrophotometer A device which continually measures light intensity at specific frequencies over a broad band of frequencies.

sputtering The release of one or more molecules from a cathode surface when that surface is struck by a high-energy ion.

standard atmosphere At 45° **N** latitude, at sea level, and O°C, the average pressure exerted on the earth's surface, This average pressure is 14.69 pounds per square inch (absolute), or 14.69 psia.

standard cubic centimeter The quantity of gas in a volume of 1 cc at standard temperature and pressure (O'C, 760 torr).

static seal A seal that does not move. (See dynamic seat.)

sublimation The process in which a substance can go directly from the solid state to the vapor state, without passing through a liquid state.

sublime Vaporization which occurs directly from a solid without first transforming to the liquid.

sublimes Changes directly from a solid to a vapor state.

TC gauge *See thermocouple gauge.*

temperature A qualitative measurement of energy. The hofter something is, the more energy it contains, thus its temperature is higher.

thermal expansion rate Materials change in size as their temperature changes. This size-to-temperature relationship of the material is called its thermal expansion rate.

thermocouple gauge A vacuum gauge used to measure pressure in the rough vacuum range.

throughput Pumping speed times the pressure. It is a term used to measure the quantity of gas per unit of time flowing through a vacuum system or through a component of that system, such as a pump. Typical units are torr-liters per second. It is a unit of power:

5.70 torr-liters/sec = 1 waft

torr Unit of pressure measurement, equal to the force per unit area exerted by a column of mercury one millimeter high. There are 760 torr in one standard atmosphere.

trace element An element which occurs as an impurity in small amounts; usually less than 1 %.

tracer gas A gas which, passing through a leak, can be detected by a specific leak detector and thus reveal the presence of a leak.

transfer pressure *See crossover pressure.*

transition range A range of pressure that cannot be correctly defined as either a viscous flow condition or molecular flow condition.

translational energy Energy associated with the motion of a molecule.

trap A device which will hold selected molecules and not let them pass. Two common types are the molecular sieve trap and the liquid nitrogen trap.

tubulation A pipe or hose used in a vacuum system.

ultimate pressure The lowest pressure a vacuum pump or vacuum system can reach when clean and empty. is dependent upon the particular gas species being pumped.

Ultra high vacuum Pressure which ranges from about $l0^{-8}$ torr(O.00000001 torr) to less than 10^{-14} torr.

Ultra high vacuum pump A vacuum pump which will function in the ultra high vacuum range. Typical examples are the ion pump and the TSP (titanium sublimation pump).

useful operating range The pressure range of a vacuum pump between the higher pressure limit where it will begin pumping and the base (or ultimate) pressure, which is the pump's lower operating limit.

vacuum Any pressure lower than atmospheric pressure.

vacuum pump A type of pump which is capable of removing the gases in an enclosed volume such as a vacuum chamber. Vacuum pumps are typically divided into three broad categories: (1) roughing pumps, (2) high vacuum pumps, and (3) ultrahigh vacuum pumps.

vapor The gas produced as a result of evaporation.

vapor pressure See pressure, vapor.

vent valve A valve used for lifting atmospheric air or other gas into a vacuum system. Also called a BTA or back-to-air valve.

virtual leak An apparent leak that is caused by release of gas from a trapped volume or outgassing of some volatile material or trapped gas inside a vacuum system. See leak.

viscous flow The type of flow which occurs when gas molecules are packed closely together and collide with each other quite frequently.

work chamber A contained volume from which some of the air and other gases have been removed. The work chamber separates the vacuum from the outside world. The portion of a vacuum system where the process is performed. See belljar.

When properly installed, the equipment described herein will perform in accordance with the instructions and information contained in this manual and its referenced documents when operated and maintained in compliance with such instruction. The equipment must be checked periodically. Defective equipment should not be used. Parts that are broken, missing, plainly worn, distorted or contaminated should be replaced immediately.

CHA Industries recommends that a telephoned or written request for service advice be made in regards to repair or replacement of components.

The equipment, or any of its parts, should not be altered without the prior written approval of CHA Industries. The user and/or purchaser of this equipment shall have the sole responsibility for any malfunction which results from improper use, faulty maintenance, damage, improper repair or alteration by any other party other than CHA Industries.

Printed in U. S. A.

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PREFACE

This manual provides information to trained operation and maintenance personnel for the operation and maintenance of the SOLUTION Deposition System.

Only qualified personnel should attempt any examination, repair or maintenance. Use this manual primarily as a reference manual.

A thorough understanding of the safety instructions before performing any service.