Etched In Time, Inc.
Since 1983

Operation and Maintenance Manual

944 4-Target Sputtering System

Etched In Time, Inc
7700 S. River Pkwy.
Tempe, AZ. 85284

Phone: (480) 967-9333
Fax: (480) 626-1661

1 Introduction and Overview

This manual is intended to assist owners of the PI944 in maintaining and operating the associated equipment. It is not intended to replace or substitute existing owner developed standards and operating procedures.

1.1 Machine Overview

Machine Overview

The PI944 is a four target horizontal sputtering system. Sputtering systems are used to form layers of new materials onto existing products. The materials used, called *targets*, differ between owners and production lines; however, common targets are gold, Platinum, Ti-tungsten, Aluminum, etc. Likewise, the product receiving the target layers will also differ according to the owner's requirements with wafer substrates being the most common product.

The products are placed onto pallets for processing through the machine. The amount of product on each pallet depends on the size of the product, and is typically from 1 to 16 substrates. The sputtering process occurs within a high vacuum chamber. A load lock and elevator system allows the operators to remove finished pallets and load new pallets without disturbing the operational conditions of the high vacuum chamber.

During the sputtering process, the chamber is affected by a combination of gases and a DC power charge. Within the chamber, a horizontal carriage moves the pallet back and forth across the target area. The combination of the above three variables (gas, DC charge, and target) creates layers of the new material on the product surface. The speed of the carriage determines the thickness of each layer, while the number of scans determines the number of layers.

The chamber of the four target PI944 is mounted on the machine frame in a horizontal manner, and is capable of providing four different target materials during the sputtering process. In addition, the PI944 is equipped with an RF Etching system, which, though the application of RF signals, allows the surface of the product to be cleared of outside contaminants prior to execution of the sputtering process.

1.2 Machine Control

Primary control of the PI944 is achieved through a custom control program running in a TECHWARE-II Ultra System Controller. Various analog and digital I/O cards are installed in the back of the computer to provide control and monitoring of the various machine components.

TECHWARE-II Ultra System Controller

Control Console

Additional specialized controllers, such as the Televac Vacuum Gauge Controller, are used for specific functions throughout the sputtering process. When necessary, these specialized controllers communicate with the primary control program via analog and digital inputs and outputs on the back of the computer.

The primary control program functions can be divided into several subsystems, as listed below.

- Interlock System
- Hydraulics System
- Pressure Measurement System
- RF Etch System
- Target System
- DC Bias System
- Process Gas Flow Control System
- Heat/Temperature System
- Scan Motor System

Please refer to Chapter 3 – *System Descriptions* for a more detailed explanation of each subsystem and the role of the primary and specialized controllers.

2 Safety Precautions

The purpose of this section is to instruct personnel, especially those involved in system maintenance, to use proper safety precautions. Instructions provided herein are to be used in conjunction with safety procedures and practices currently in use, as well as those specified in the individual manufacturer's manuals provided with this machine.

Only qualified personnel are to engage in the inspection, cleaning, troubleshooting, part removal and replacement or other repairs of system equipment. The precautions specified in this section are to be observed by all personnel. It is recommended that personnel who regularly work around the equipment become familiar with this section and review it at continuing intervals. Performance of regular preventive maintenance, as discussed in Chapter 6 of this manual, will aid in the reduction of hazardous situations to both equipment and personnel.

The machine is equipped with various guards and interlocks to minimize the risk of electrical shock, exposure to gas, and pinch points of moving parts. Despite these precautions, all persons working on or around this machine should be familiar with the operations and activities of the machine, and should maintain a high level of alertness to avoid potential hazards.

Personnel who will be performing repairs or routine maintenance should familiarize themselves with the location of first aid stations. It is recommended that one person be designated to ensure adequacy of first aid kits located around equipment.

Personnel performing maintenance, especially major repair, must equip themselves with the proper tools in accordance with the class of work to be performed.

Portable electric tools used for repair of electrical equipment must be of the multi-conductor cord type having an identified grounding conductor and a grounding polarized plug-in receptacle.

Proper lighting can reduce hazards. Flashlights will suffice, but if bulbs attached to extension cords are used, they must be equipped with protective wire guards.

Tools should be maintained in a safe condition. Dielectric tests should be performed at three-month intervals for maintenance tools and/or equipment in storage.

Major repairs or maintenance which might require equipment to be down and equipment or lines being exposed for extended periods of time, should not be attempted without the use of proper warning and danger signs.

2.1 Machine Safety Features

In the event of an emergency situation, three emergency stop buttons are provided. These buttons are centered on front and rear of the machine. When pressed, these buttons will remove power from the entire machine, as well as remove all air and hydraulic pressure. A soft start valve and a vent valve are responsible for removing the air and hydraulic pressure in the event of any power loss.

The breaker box, as shown below, is equipped with a through-door disconnect, which will remove power from the breakers before allowing the enclosure door to be opened. This disconnect switch also includes lock out capabilities for the entire breaker box. A lock out provision is available for the air supply system as well.

3 System Descriptions

This chapter describes the operator interface, and each of the major subsystems that are controlled by the primary and specialized controllers. Each of the graphics screens will be described, in detail as part of section 3.1 – *Operator Interface and Computer Overview*. The following sections will focus on the control functions and components of each sub-system and their interface to the primary and specialized controllers.

3.1 Operator Interface and Computer Overview

This section reviews the computer hardware and software components including an I/O map and serial port connections. Please refer to the next chapter for a detailed description of each of the Graphical User Interface (GUI) screens.

3.1.1 Computer Hardware

As mentioned in the previous section, the primary controller is a TECHWARE-II Ultra System Controller, manufactured by Brooks Automation Software Corp. The hardware for this system consists of three major component types, the computer unit (or CPU), I/O interface modules, and peripheral devices.

The controller contains a VME-bus CPU board and CPU Companion board installed within a 19-inch rack-mountable frame. The VME-bus is a high speed, parallel communications bus which links the CPU board and the CPU Companion board with optional I/O modules. This configuration conforms to IEEE standards.

The optional I/O modules are mounted in the back of the 19-inch rack. These modules provide interfacing between the controller and the machine instrumentation. The following I/O modules are used in this system:

- One, thirty-two point digital input/output board (used as all input)
- One, thirty-two point digital input/output board (used as all output)
- One, sixteen point analog input board
- One, sixteen point analog output board
- One, sixteen point relay board

Peripherals are external devices that provide a variety of functions such as user interfacing, printing, and telecommunications. The following peripherals are provided with this system:

- Keyboard
- Mouse
- Monitor

For more information regarding the hardware of the TECHWARE-II Ultra System Controller please refer to the reference manual provided by Brooks Automation Software Corporation.

3.1.2 Computer Software

The operating system of the TECHWARE-II Ultra is Microware Systems Corporations, OS-9®. The primary functions of the OS-9® operating system are to:

- Provide an interface between the computer and the user.
- Manage the I/O operations of the system.
- Provide for the loading and execution of programs.
- Create and manage a system of directories and files.
- Manage timesharing and multitasking.
- Allocate memory for various purposes.

For more information regarding the OS-9® operating system please refer to the "*Microware Systems* Using Professional OS-9®" manual provided by Brooks Automation.

The operator is able to interface with the machine instrumentation and operations through the use of a custom application created using the CONTROL*Vision*™ OS-9® Graphical User Interface (GUI). The CONTROL*Vision*™ OS-9® GUI, created by Brooks Automation, consists of three main software components: an OS-9 real-time operating system, an equipment control interface, and the fourth generation Process Automation Language (PAL) software. PAL is used to create the programs, recipes, batches and other elements of the equipment control interface. OS-9® is the real-time environment in which PAL runs. A configuration file defines the interface between the software and the hardware I/O points. For more information regarding OS-9®, CONTROL*Vision*™, or PAL please refer to the various manuals provided by Brooks Automation.

3.1.3 I/O Mapping

An I/O map is used to determine the I/O address used for programming, as well as define where the wires should be terminated on the computer. Please refer to drawing number 944E-18 in the Schematics chapter of this manual for a list of the I/O map used in this application.

3.1.4 Serial Port Connections

Three RS232 serial communication ports are used to communicate with the Loadlock Cryo Pump (Port 3), Chamber Cryo Pump (Port 5), and the Scan Motor Encoder (Port 2). These connections allow for various parameters to be transferred between the computer and each device. Please refer to the appropriate user manuals for more information regarding the data that can be broadcast across these connections. Refer to section 3.12 for more information regarding the scan motor interface.

3.2 GUI Screen Descriptions

Several custom GUI (Graphical User Interface) screens have been created to allow the operator to control various machine functions and monitor the machine instrumentation. This section describes each screen layout and their available operations.

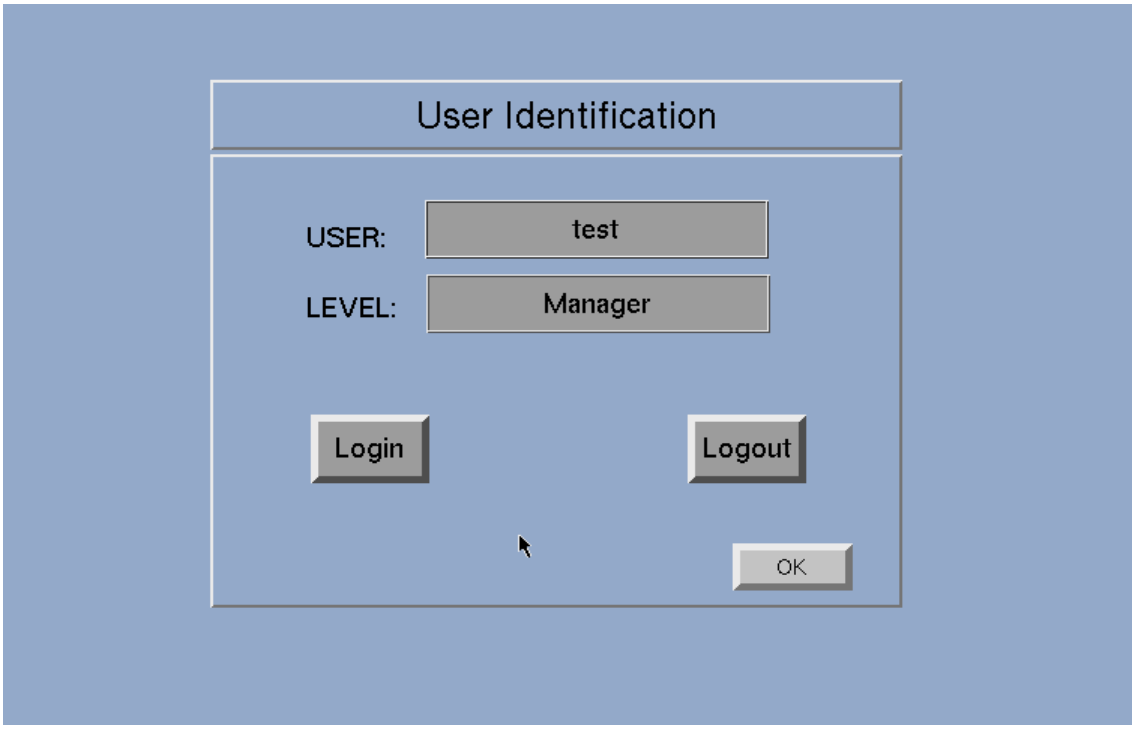
There are two main types of screens that are used throughout the GUI system. The most common screen type is “Replace”. As the name suggests, when a screen of this type is selected, it will replace the currently displayed screen with the new screen. Unless otherwise specified, this manual will assume that the screen type is “Replace”.

The second screen type is “Pop-up”. When a screen of this type is selected for display, a second, smaller screen will pop-up over the existing screen. Clicking on the OK button located at the bottom of the “Pop-up” screen will return the operator to the previous display.

3.2.1 User Identification Screen

The user login screen is the first screen that appears when the system is booted. To log into the GUI application, the operator must click on the *Login* button to enter their password. If properly entered, the user name will appear in the *USER* box and the appropriate security level will be displayed.

Clicking on the *OK* button will take the operator to the *Operations* screen, described later in this chapter. Once the operator has completed the work on the machine, he/she should return to this screen and press the *Logout* button. This will prevent other users from operating the machine unauthorized, or under an improper security level.



3.2.2 Screen Layout

The above picture is an example of the objects surrounding each screen display, excluding the login screen and pop-up windows (to be explained later). Located at the top

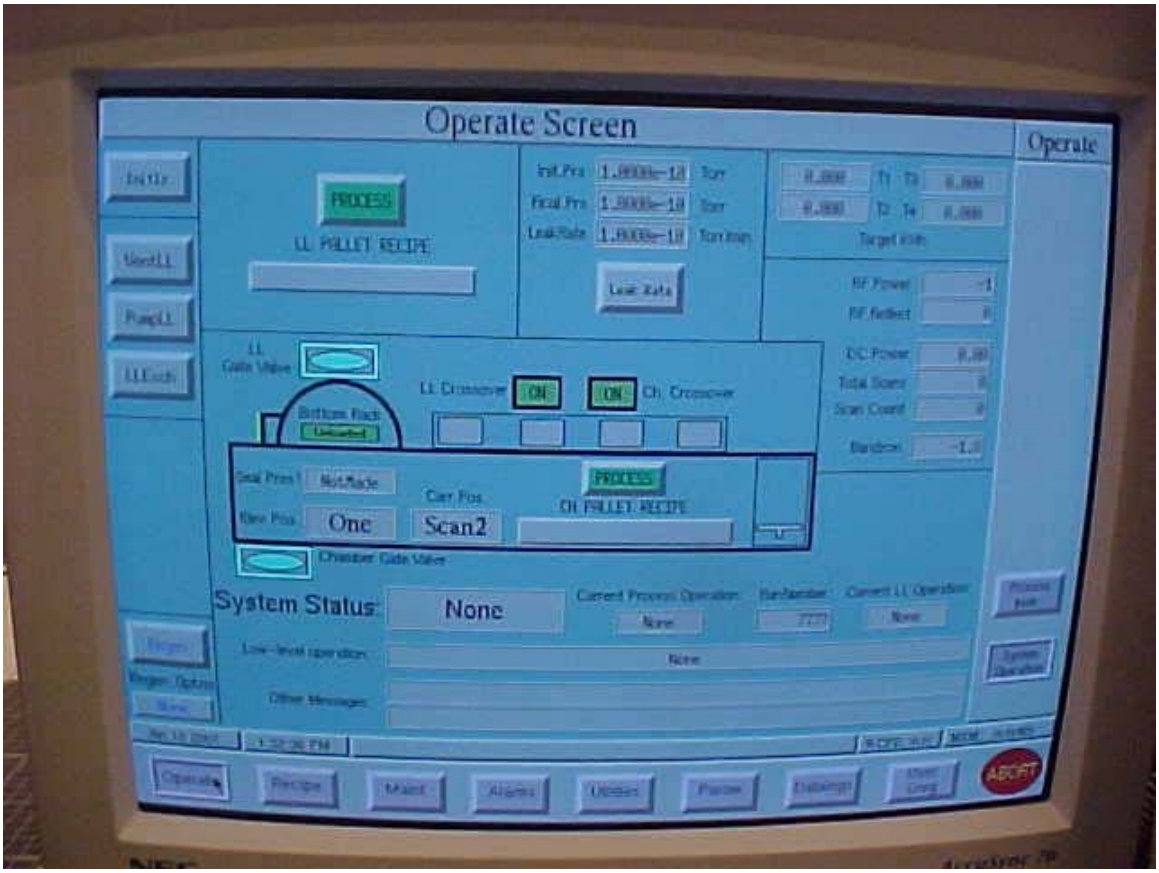
of the display is the title bar, where the name of the screen will be displayed. In the example above the title bar reads *Operate Screen*.

The next portion of the layout is the section located horizontally across the bottom of the screen. This section is used to allow the operator to manipulate between the screen categories, i.e. operation screens, maintenance screens, etc. Clicking on the appropriate button will replace the displayed screen with a screen in the newly selected category. In addition, a red *ABORT* button is located in the bottom right hand corner of the display. Clicking on this button will abort the process at the stage that it was in at the time the button is pressed.

Located directly above this section is a thin display of the time, date, and computer statistics. This display is for information purposes only.

Finally, the last section of buttons is located vertically on the right side of the screen. This section is used to manipulate between the sub screens within each category. In this example there are two screens within the *Operate* section of the GUI. They are *System Operation* and *Process Instr.* These buttons will change dependent on the category chosen at the bottom of the screen.

3.2.3 Operate Screen



The *Operate Screen* provides the majority of the functions required during normal operations. Along the left side of the screen are a series of buttons or indicators to indicate various machine operations as follows.

> The *Initlz* button performs an initialize function that places all equipment into a safe state (or standby mode). For example, the power supply is off and all gas valves are closed.
>
> *VentLL* and *PumpLL* are abbreviated for Vent Load Lock and Pump Load Lock, respectively. These buttons will open the load lock to atmosphere or pump down to vacuum. These features allow the operator to exchange product without disturbing the operational conditions of the high vacuum chamber.
>
> The *LLExch* or Load Lock Exchange button will run the procedure of unloading the completed pallet from the carriage and loading the new pallet onto the carriage for processing. Once the exchange is complete, the load lock area will be sealed off so that the operator may remove the old pallet and load a new pallet, prior to the next exchange.
>
> *LL Crossover* and *Ch. Crossover On/Off* Indicators determine the state of the load lock and chamber crossover pressure switches as configured on the Televac unit.
>
> The *Regen* button will start the Regen Cycle. This is used to remove frozen gasses from the cryo pump.

Just to the right of the *Initlz* button are a green *Process* button and a *LL Pallet Recipe* display. This section is used to indicate the recipe to be used for the new pallet loaded in the load lock area. Once the machine has completed the exchange process, this recipe will be used to determine process conditions and operations within the vacuum chamber. Clicking on the *Process* button will open a parameters screen to allow the operator to verify the parameters for the selected process. Once all of the parameters have been verified, click on the resume button to return to the Operate Screen. The new recipe should be displayed in the *LL Pallet Recipe* display area.

Continuing along the top of the screen, from left to right, the next section provides the operator with leak detection capabilities. A *Leak Rate* button will perform a leak rate test by pumping down the chamber, shutting the gate valve, and monitoring the chamber pressure over time. Once the test has completed, the results will be displayed above the button, including the initial pressure, the final pressure and the calculated leak rate.

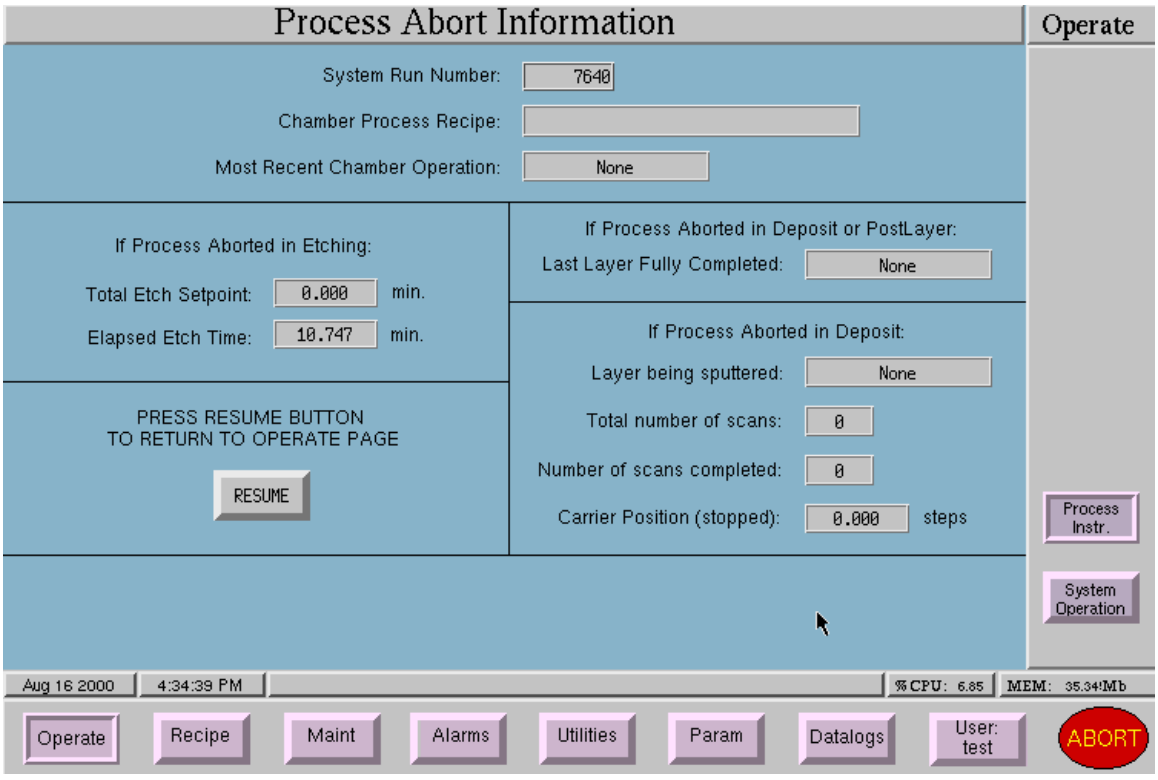
The top right corner of the screen displays the amount of each target that has been used. These values should be monitored and the target material replaced accordingly, to avoid process errors due to depleted targets.

Located directly below the *Target kWh* display is a series of process values, indicating *RF Power, RF Reflected Power, DC Power, Total Scans, Scan Count* and the *Baratron* pressure. The *Baratron* pressure indicates the process pressure within the chamber. In the center of the screen is an outline of the entire machine. This section displays information regarding the status of the machine and the current process that is being executed. In addition, there is another *Process* button, however, this one allows the operator to select the recipe for the pallet currently in the chamber. The following information is displayed:

- Load Lock Gate Valve: Open/Close
- Chamber Gate Valve: Open/Close
- Target Selection (T1-T4 On/Off)
- Elevator Position
- Carriage Position
- Chamber Pallet Recipe
- Etch Platform Position

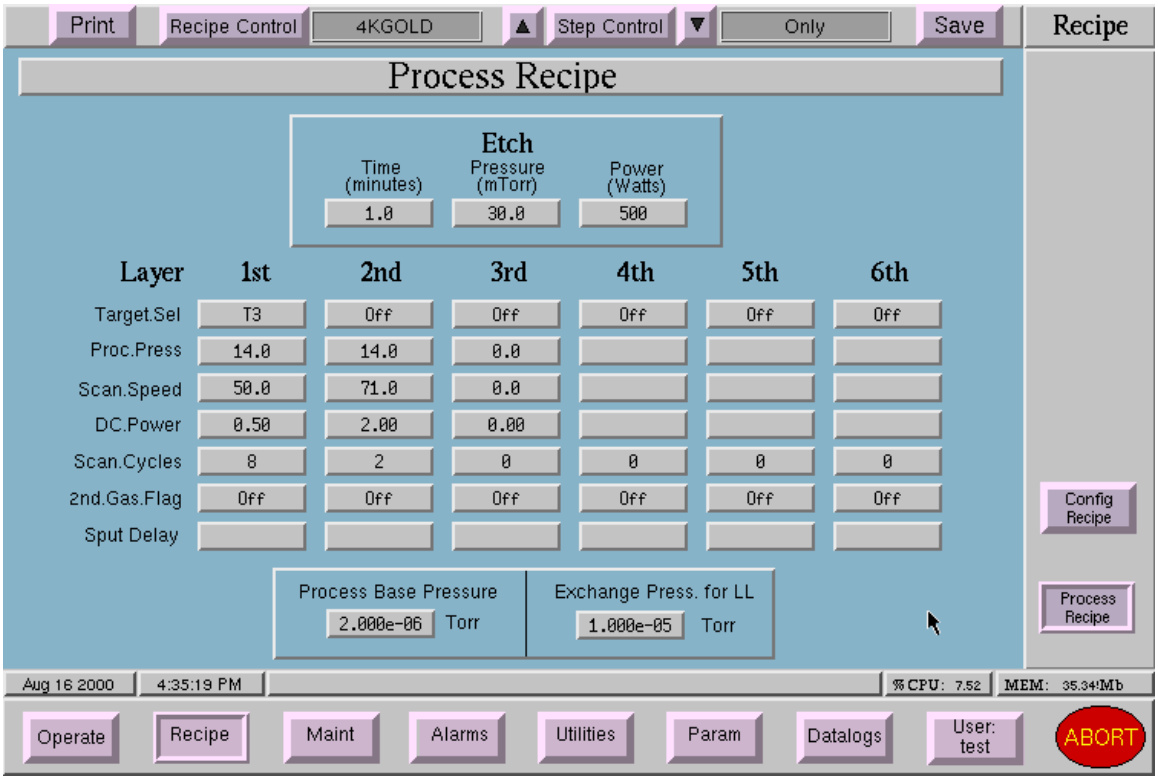
Finally, the bottom portion of the screen is dedicated to displaying the *System Status*. This section will indicate the status of the individual systems, such as the process chamber and the load lock area. In addition, any system operations that are being performed, such as pump down load lock, will be displayed. Finally, this section will display various alarms and messages to the operator.

3.2.4 Process Abort Information Screen



Clicking on the Operate Screen button accesses the Process Abort Information screen. The purpose of this screen is to inform the operator of the process status at the time of a process abort command. This information will be available regardless of the cause of the abort, i.e. pressing of the button, or the occurrence of a process alarm. Clicking on the *Resume* button will return the operator to the *Operate Screen*.

3.2.5 Process Recipe Screen

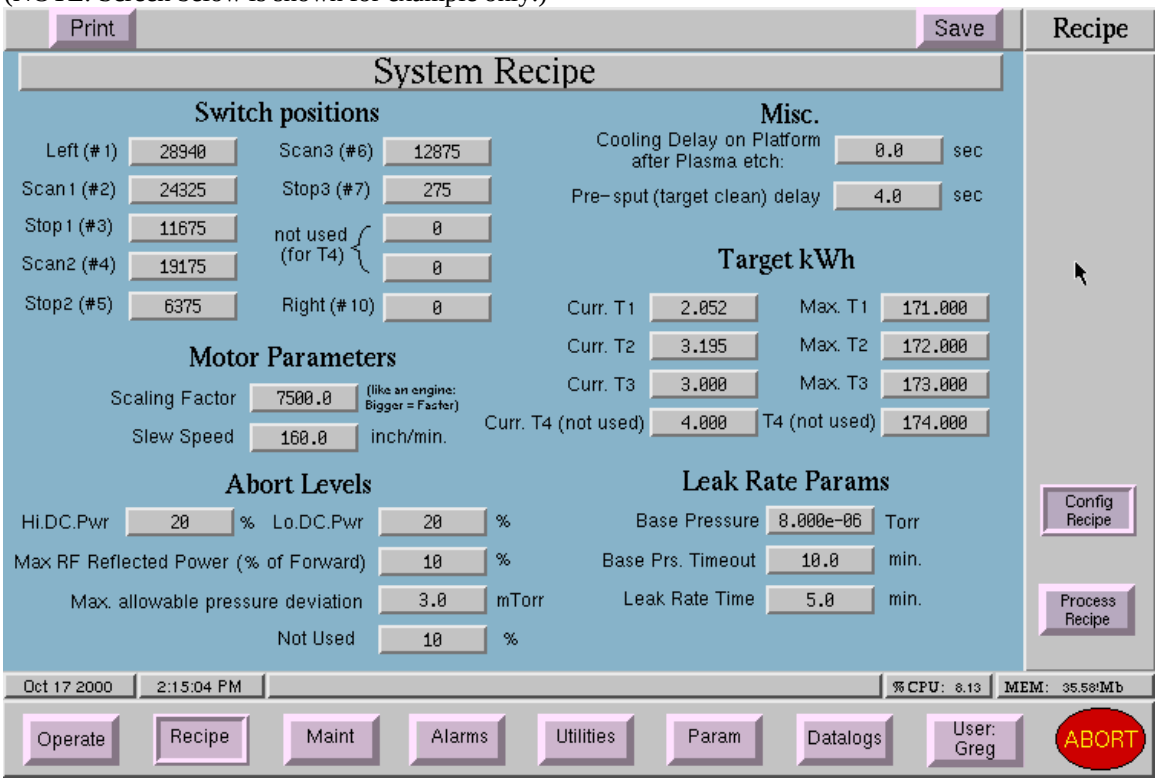


Under the *Recipe* screen category, the *Process Recipe* and *Config Recipe* screens allow the operators to modify existing recipes or create new recipes. A new section, located above the title bar, has appeared for these screens. This section allows the operator to print the screen and recipe parameters, select the recipe to edit, step through existing recipes, or save a modified recipe.

The *Process Recipe* screen provides access to all of the recipe process parameters, such as selection of targets, number of scans, and scan time. Clicking on the appropriate parameter field on the screen will allow the operator to change these parameters. Whenever a change is made, a yellow bar will appear around the recipe buttons on the bottom and right bars. Be sure to click on the save button to save any changes that are made to the recipes, at which point the aforementioned yellow bars will disappear, indicating a successful save operation.

3.2.6 System Recipe Screen

(NOTE: Screen below is shown for example only.)



The *System Recipe* screen is used to modify the operational parameters of each recipe. This includes scan switch positions and alarm set points.

The first section of values is the *Switch positions* set points. These values indicate the start and stop positions of the carriage for each scan.

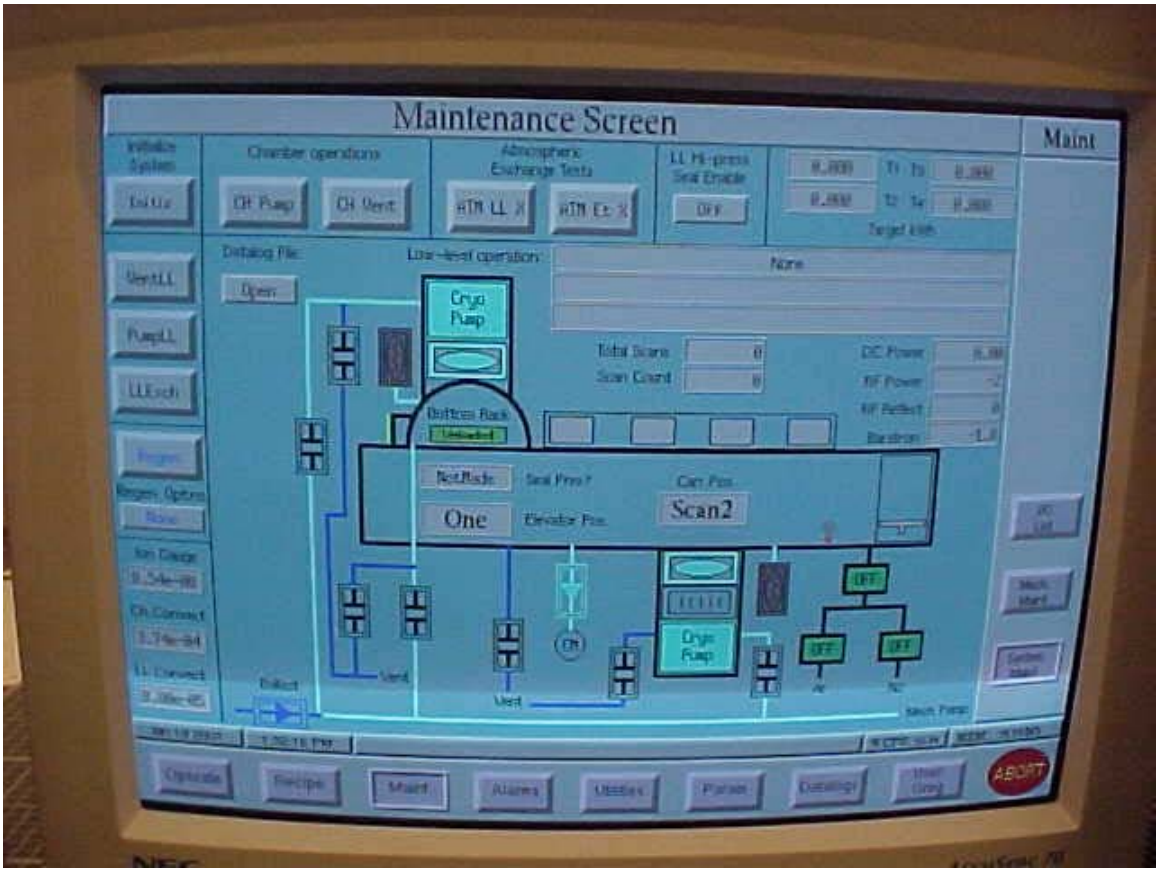
The next section lists the *Motor Parameters* as follows. The *Scaling Factor* allows for adjustment of scan speed. For example, if a distance/time check revels that the speed is 5% too low, this factor can be adjusted up by 5% and the motor will compensate. The *Slew Speed* is the maximum speed at which the pallet carrier slews from position to position. It can be adjusted up or down as desired, especially if the carrier is going too fast and generating particulates or dislodging wafers.

The bottom left section lists the *Abort Levels*. This section indicates the amount of deviation between the recipe set point (on the *Process Recipe* screen) and the actual value before the process is aborted and an operational alarm occurs.

In the top right portion of the screen are two miscellaneous set points that determine the *Cooling Delay* and the *Pre-sput* delay. The cooling delay is the amount of time that the pallet will sit at the RF Etching station before sputtering will begin. The pre-sput delay is the amount of time that the target will sputter prior to beginning the deposition scan.

Finally, the *Target kWh* section displays the current target kWh value and indicates the maximum allowable level before an alarm will prompt the operator to replace the target.

3.2.7 System Maintenance Screen



The maintenance screens allow personnel to perform special maintenance operations in addition to the normal operation procedures provided on the *Operate Screen*.

The first screen to discuss is the *System Maintenance* screen. This screen is very similar to the *Operate Screen*, however, the pumping manifold and related devices are also included.

Along the left side of the screen, there are the *Initlz, VentLL, PumpLL, LLExch* and *Regen* buttons, as described in the section describing the *Operate Screen*. Located below these buttons are indicators for *Pal. On Carr* (pallet on carrier) and *Pal.On.Etch* (pallet on etch).

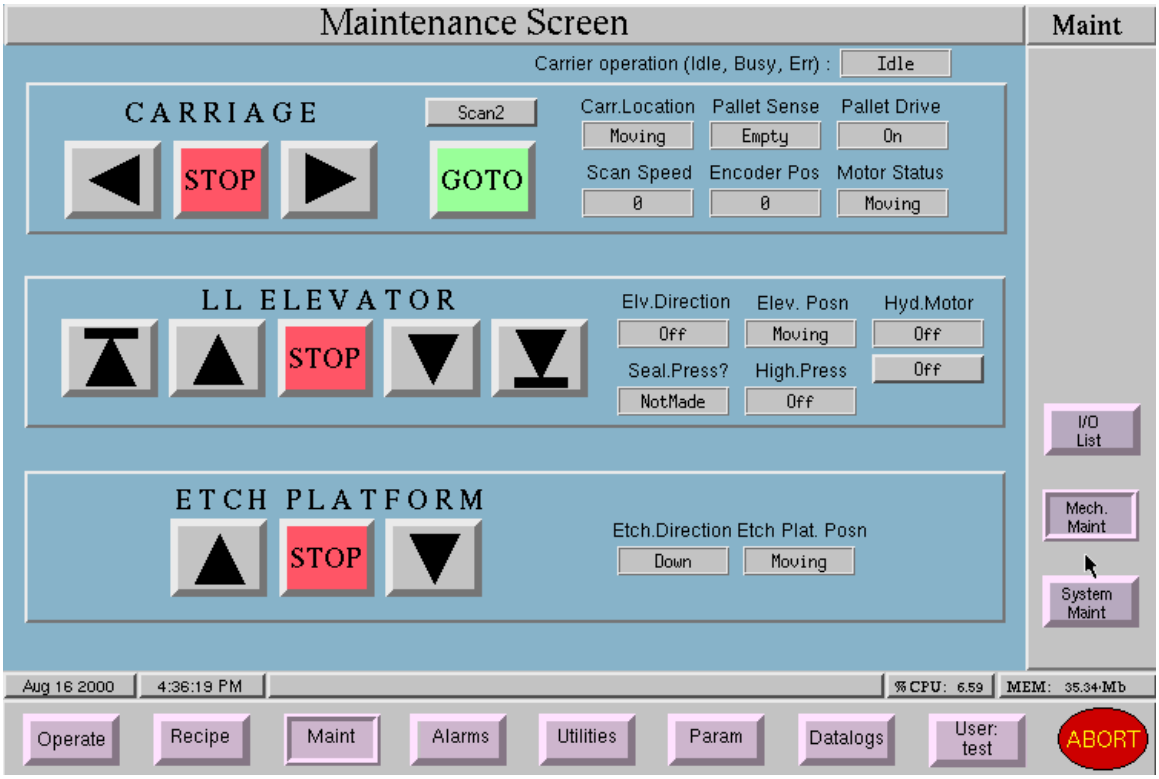
To the right of the *Initlz* button are *CH Pump* and *CH Vent* buttons. These buttons allow the operator to either pump down or vent the chamber, respectively.

The next two buttons perform *Atmospheric Exchange Tests*. This allows the operator to perform pallet exchange operations without pumping down the system. Another button is

provided to allow the operator to enable or disable the load lock high-pressure seal. The status of this option is indicated with the words *On* or *Off*, and the current status is also shown.

The rest of the screen is comprised of display values of the current operation, as well as additional valves and equipment status information. Please refer to the sections referring to Valve Manifold #1, for more information regarding the various types of valves and their purpose.

3.2.8 Mechanical Maintenance Screen



The next screen in the Maintenance series is the *Mechanical Maintenance* screen. This screen provides the operator with a means of moving the devices within the system.

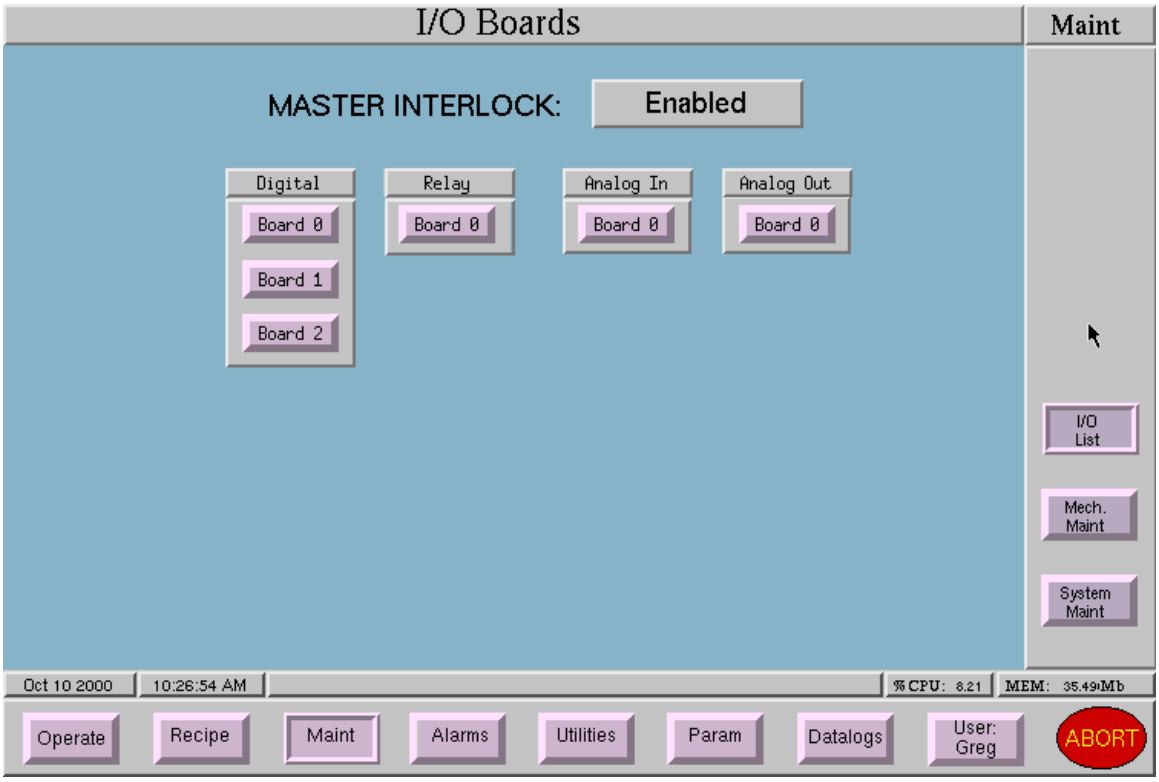
The top motion control section is for the carriage. With these buttons, the carriage can be jogged in either direction, or sent to a specific position with the GOTO button. Next to the *Carriage* buttons are display values indicating the current status of the carriage system.

The middle section of buttons controls the load lock elevator. The arrows with the lines drawn at the point (for example, ▼) will move the elevator forward or back one position, while the inside buttons have been disabled and replaced with the key switch which will jog the elevator in the indicated direction. As with the carriage system, the right side of

the screen displays the elevator status and allows the operator to turn the Hydraulic motor on and off only to verify if the system is working in a testing situation.

The bottom motion section controls the *Etch Platform* movements. Similar to the other motion controls, the arrows will move the platform up and down, and the status is displayed on the right side.

3.2.9 I/O Boards



The *I/O Boards* screen has a *MASTER INTERLOCK Enabled/Disabled* button that allows personnel to temporarily disable the software interlocks and get the system out of a mechanical bind or perform operations that the software would not normally allow. Once the Maintenance Subsystem is exited, this field automatically returns to *Enabled.*

This screen also has a button with the name of each of the I/O boards installed in the back of the TECHWARE-II Ultra System Controller. Clicking on each of these buttons will take you to a pop-up screen with a list of the I/O available on the selected VME I/O board.

Each of the pop-up windows contains up to four columns; *Ch#, User Label, Value,* and *Set point,* as described below:

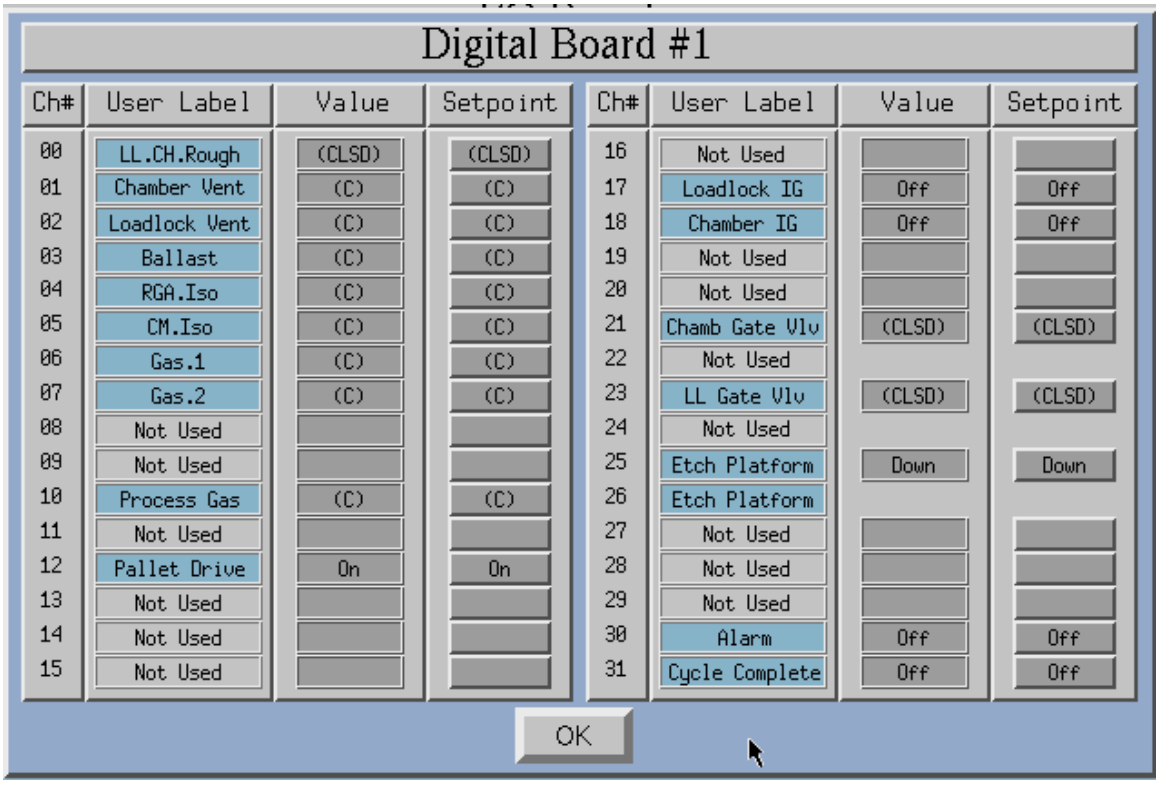
The *Ch#* column displays the channel number of each I/O point on the board.

The *User Label* column displays an abbreviated description of the I/O point.

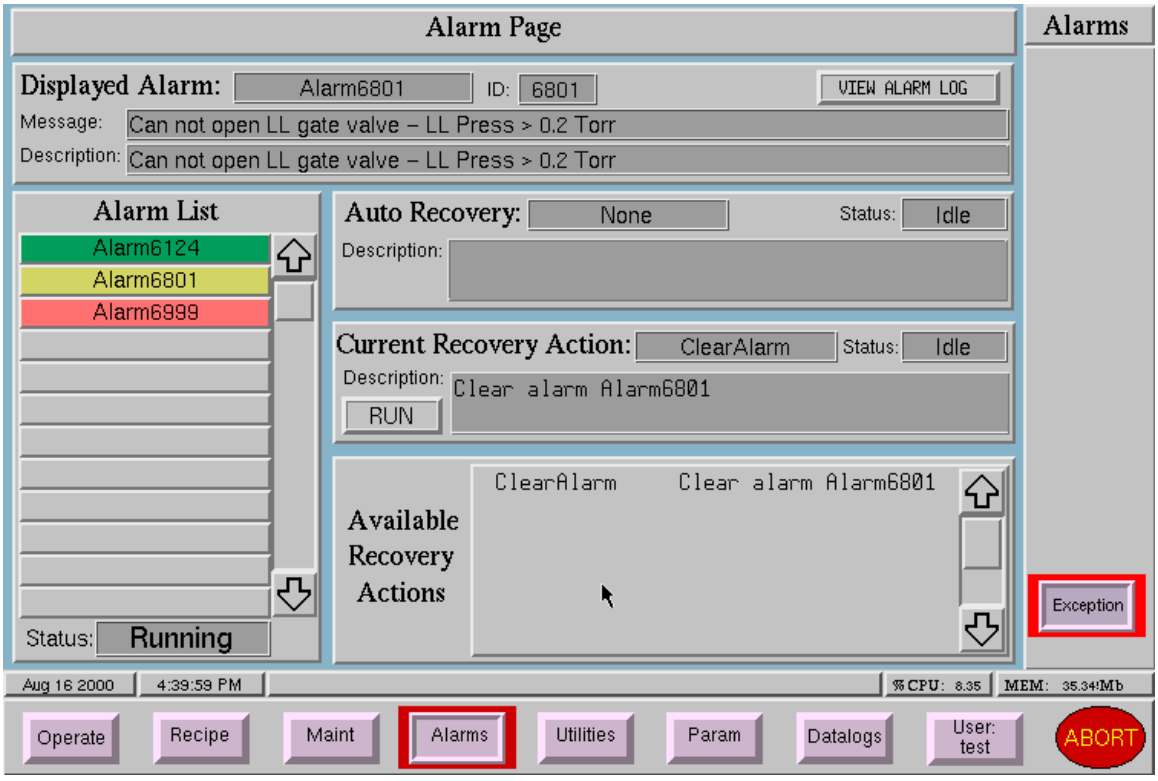
The *Value* column displays the current value of the I/O point.

The *Set point* column allows the operator to set or toggle appropriate output values.

An example of an I/O pop-up window is shown below for *Digital Board #1*.



3.2.10 Alarm Page Screen



Whenever an alarm occurs on the system, a red box highlights the *Alarms* button at the bottom of the screen. Pressing this button will open the *Alarm Page* Screen.

The *Alarm Page* screen is used to view the alarm conditions of the machine. This screen category only contains one screen, as shown above.

The top portion of the screen is dedicated to displaying the currently selected alarm information. Located below this section on the left side of the screen is the *Alarm List*, which lists all of the active alarms. Clicking on one of the alarms in this section will display the associated information in the *Displayed Alarm* section at the top of the screen. Within the *Displayed Alarm* section is a *View Alarm Log* button. Clicking on this button will bring up a history of alarms indicating when they occurred and when they were cleared.

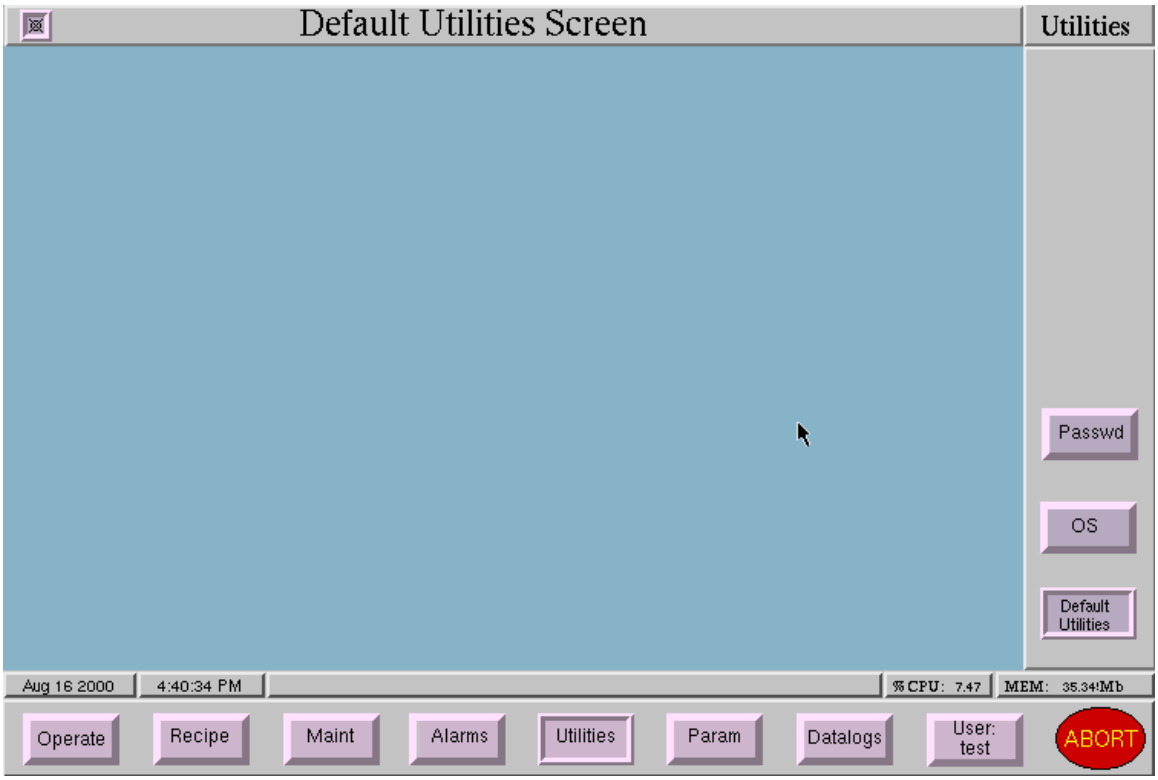
There are three colors that are used within the *Alarm List*, to represent the alarm status. A yellow color indicates that the alarm is currently displayed in the *Displayed Alarm* section of the screen. As only one alarm can be displayed, there will only be one yellow alarm indicator.

The remaining two colors that are used in the *Alarm List* are red and green. If an alarm is listed with a green color, this alarm has been previously viewed by an operator, or

acknowledged, by an operator. A red color indicates that this alarm has not been acknowledged by an operator and may require immediate attention.

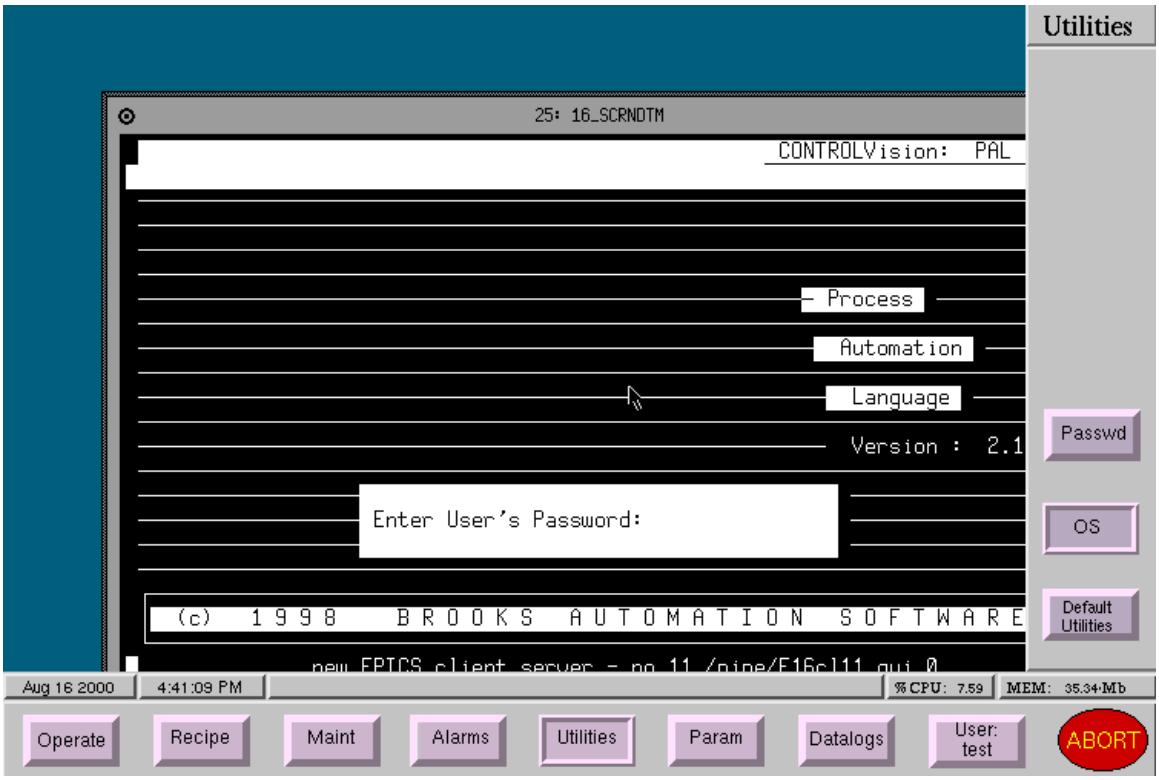
Located to the right of the *Alarm List* section are three recovery sections. Currently, the only recovery action available is the *Clear Alarm* action. This is the method required for removing an alarm from the *Alarm List*. To perform this action, click on the desired alarm, and then click on the *RUN* Button. This will clear the displayed alarm from the *Alarm List*.

3.2.11 Default Utilities Screen



The *Default Utilities Screen* is provided with each system to provide a consistent location for adding custom controls and operations. This screen is left blank unless special provisions have been made with the client, prior to delivery. If your contract specifies the use of this screen, please refer to the appendix of this manual for more information regarding these options.

3.2.12 OS Screen

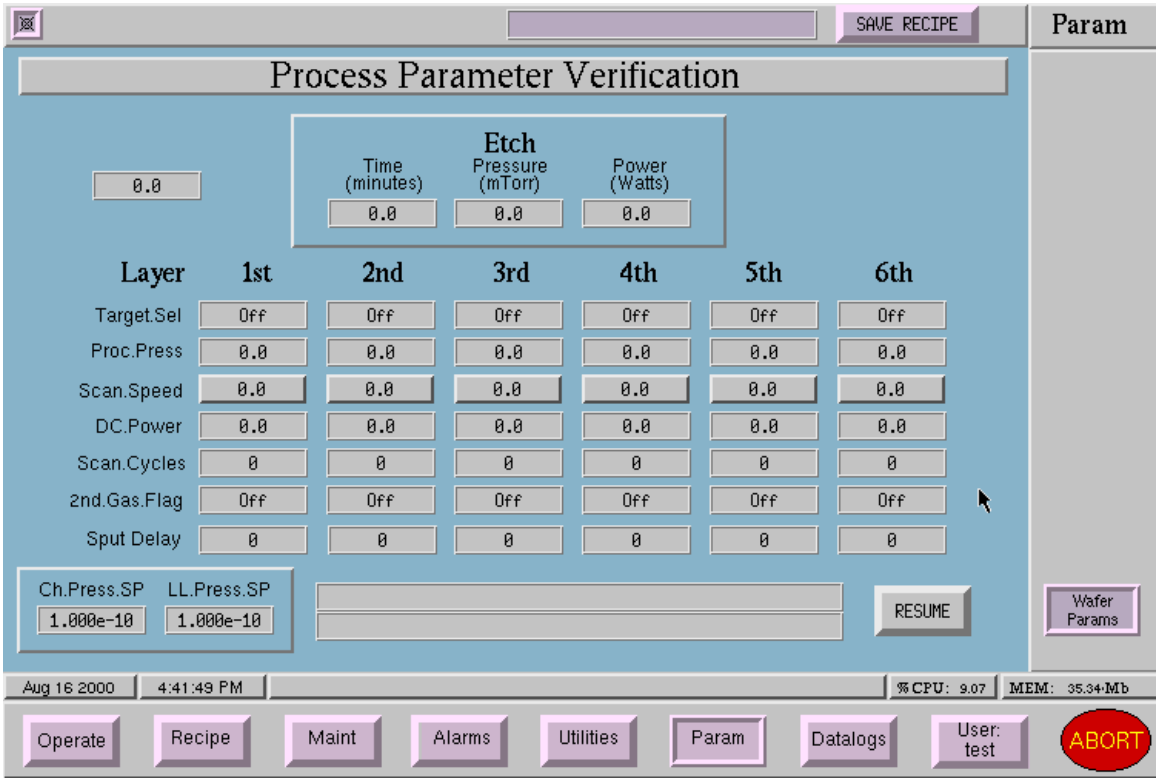


The *OS* screen, or Operating System screen can be accessed through the *Utilities* screen category. This screen provides the user with an interface to the OS-9® operating system. This screen is only to be used by Process Integration personnel or under the specific direction of Process Integration or Brooks Software personnel. For more information regarding this system please refer to the "*Microware Systems* Using Professional OS-9®" manual provided by Brooks Automation.

3.2.13 Password Editor Screen

The *Password Editor* screen is accessed through the *Utilities* screen category. This screen allows each operator to change their passwords by clicking on the existing password and typing in a new one. In addition, personnel with a Manager security level can add or delete users by clicking on the buttons provided.

3.2.14 Process Parameter Verification Screen



The *Process Parameter Verification* screen, available from the *Param* screen category, provides the operator with current recipe information. Whenever an operator presses a green *Process* button on the *Operate Screen*, the *Process Parameter Verification* screen is displayed automatically. The majority of the information displayed is read only, and cannot be altered from this location. The only exception is the *Scan Speed* parameter. This value can be changed by clicking on the buttons provided and entering a new value. The intention of this screen is to restrict all personnel's' ability to modify process recipes. To adjust parameters other than the scan speed, do so through the *Recipe* screen.

3.2.15 Datalog Screen Categories

Four screens make up the *Datalog* screen category; *Batch*, *Template, Report*, and *Print Log*. Each of these screens provides the operator with the interface required to configure a datalog. Please refer to the datalog process description and individual screen descriptions in the following pages.

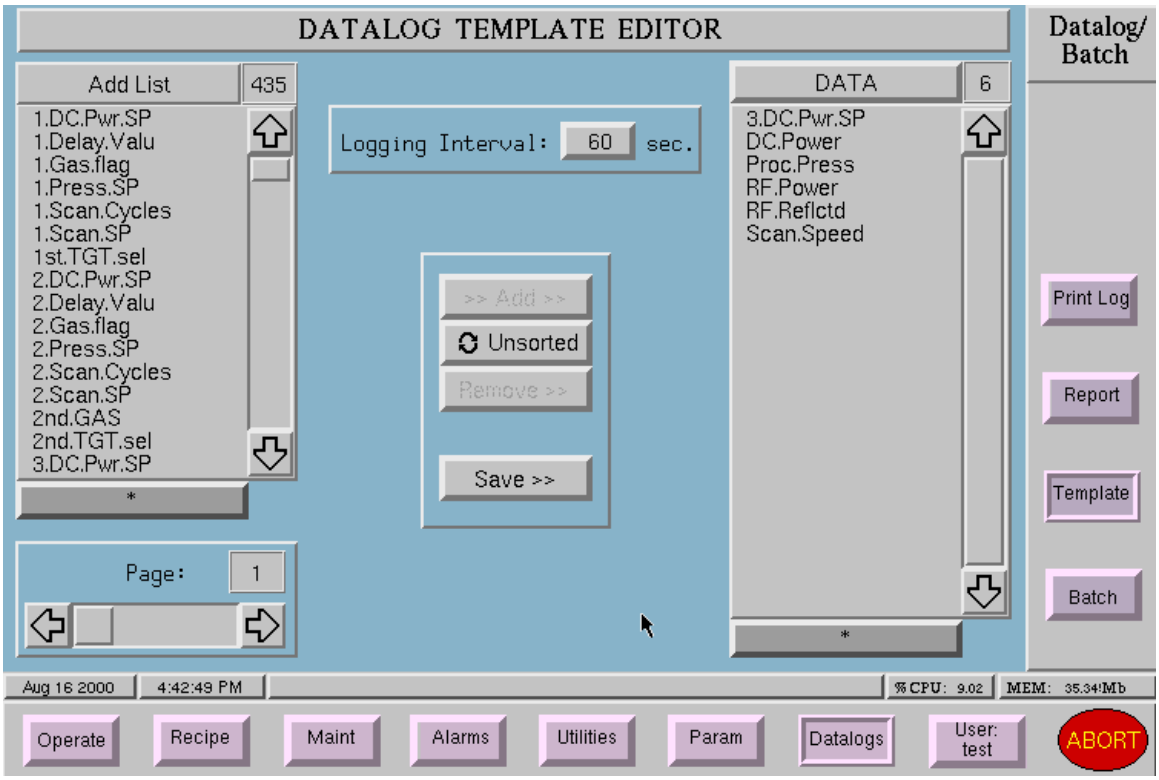
The first step for creating a datalog is to configure the template. Within the template, the logging interval is set, and each of the desired I/O points is selected. During process execution, all of these points will be datalogged, regardless of the reports defined.

Once a template is defined, individual reports can be created within the template. Several reports can be created within one template. The reports are used to divide the template I/O points into logical groups. The option of logging event messages can be selected as part of the report configuration.

Once the templates and reports have been created, they must be associated with the batch that actually configures the tool upon startup. This will open a new datalog file each time a process execution is performed.

After a batch is defined and data logging has begun, this information can be extracted through the *Print Log* option.

3.2.16 *Datalog Template Editor Screen*

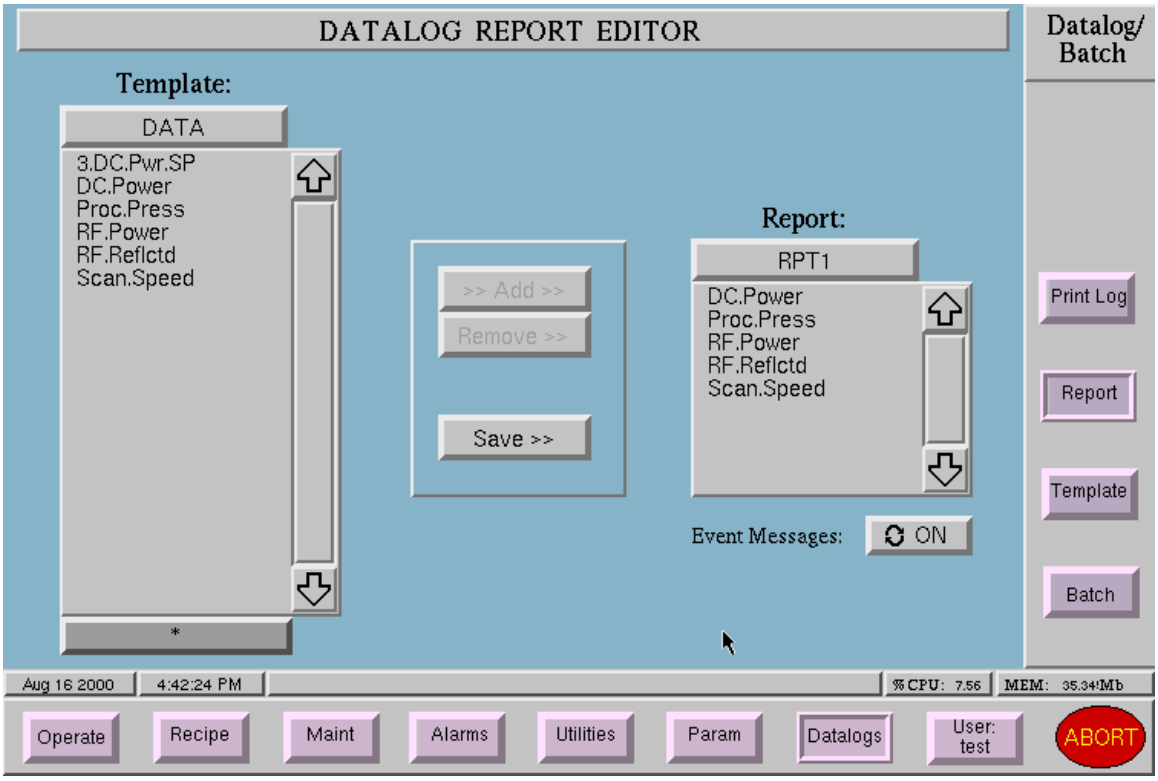


As briefly described above, this screen allows for template configuration for the datalog feature, and is accessed through the *Datalogs* screen category.

To add I/O points to the template, click on the desired I/O point within the *Add List* section and then click on the *Add* button. Likewise, to remove a point from the template list (on the right side of the screen) click on the point and then click on the *Remove* button. Toggling the *Unsorted/Sorted* button, located between the *Add* and *Remove* buttons, will either sort the template list alphabetically, or leave the points in the order they were selected.

In addition to determining the available I/O points within a template, the data-logging interval will be defined within this screen. To change the data-logging interval, click on the *Logging Interval* button and enter the new value (in seconds).

3.2.17 Datalog Report Editor Screen

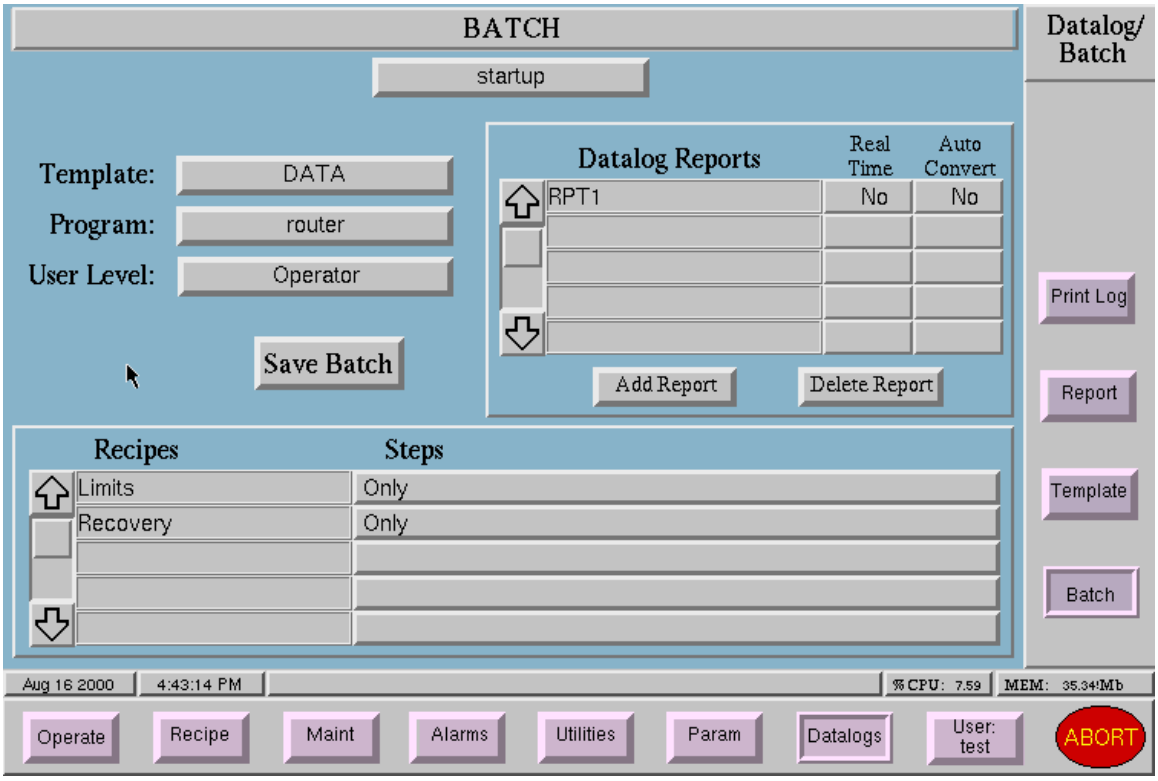


The *Datalog Report Editor* screen allows for report configuration of the datalogs, and is accessed through the *Datalogs* screen category.

A report combines each template I/O point into logical data sets, up to 9 at a time for comparison purposes. To add I/O points to the report, click on the desired I/O point within the Template selection on the left, and then click on the *Add* button. Likewise, to remove a point from the report list, click on the point and then click on the *Remove* button.

A *Save* button is provided for saving the report information that was created. In addition, an *Event Messages* button provides the ability to turn on/off the event message logging option. This option records one-time events logged during the process execution, such as “Base Pressure Reached”.

3.2.18 Batch Screen



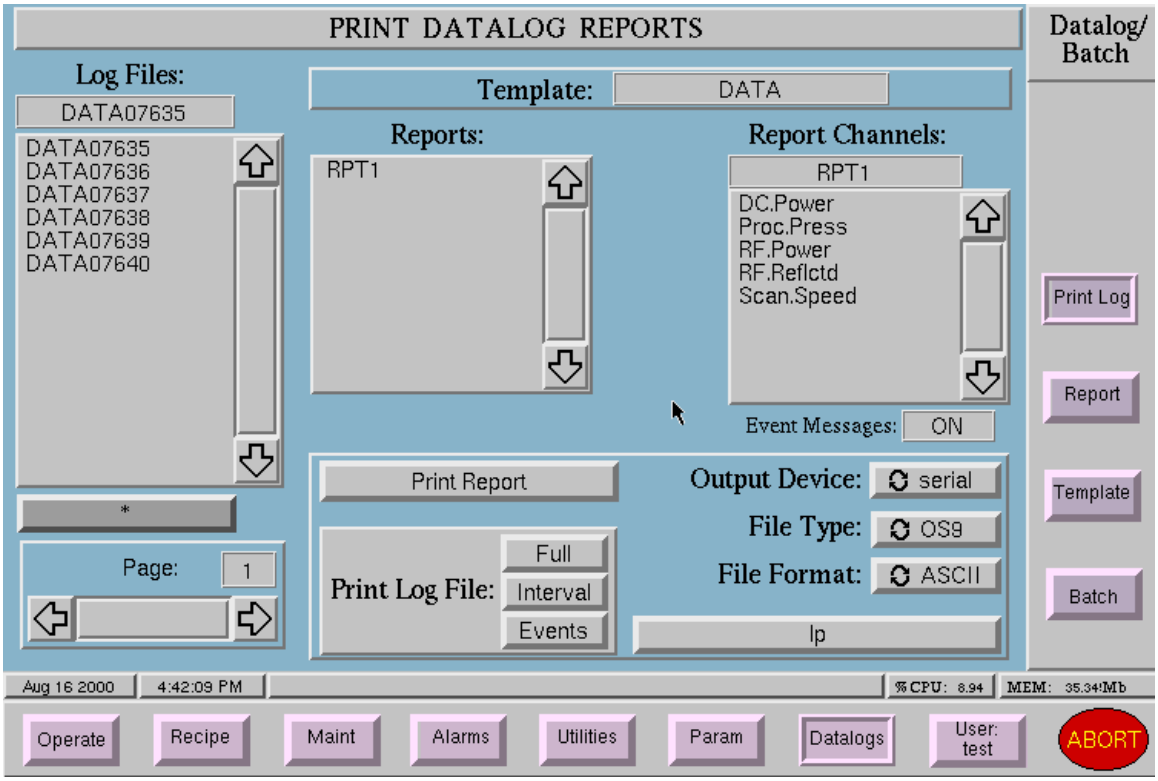
Once the template and reports are created, the data logging process must be started from the *Batch* screen, also accessed through the *Datalogs* screen category.

In the upper left portion of the screen, click on the *Template* button to indicate the template being used. The *Program* and *User Level* areas provide read only information and **must not** be changed.

The right side of the screen displays a list of reports that are to be logged. Click on the *Add Report* or *Delete Report* to edit the *Datalog Reports* list. In addition, specify if the *Real Time* or *Auto Convert* options are desired for each report.

The bottom portion of the screen lists the available recipes that the batch should run. Arrows are provided to scroll through this list.

3.2.19 Print Datalog Reports Screen



The *Print Datalog Reports* screen, accessed through the *Datalogs* screen category, allows the operator to specify the output destination of various report logs.

Along the top of the screen the operator should click on the button provided to select the desired template. Once a template has been defined, the *Log Files* and *Reports* lists will indicate the log files and reports available for the specified template. Click on the desired report from the *Reports* list to select it for printing. Once a report is specified, the report channels (or I/O points) within the report are listed in the *Report Channels* section. Below this list is an indication of whether or not the event messages were logged with this report.

Clicking on the *Print Report* button will print the selected report to the output device specified. Clicking on the *Output Device* button will toggle between the serial or file print options. If the output device is a file, the *File Type* may be toggled between OS9 or PC format (for IBM compatible computer files). In addition, the *File Format* should be specified as either ASCII text, or Lotus comma-delimited text files (for importing to spreadsheets). Again, clicking on the *File Format* button toggles the File Format option. Finally, for file printing, clicking on the long button at the bottom of the page (labeled *lp* above) will allow the operator to define the file location.

The *Print Log File* section allows the operator to select a log file, by clicking on it within the *Log File* list, and print *Full, Interval* or *Events* to the *Output Device* specified.

Clicking on the *Interval* button will print the data logged at the predefined time interval (set within the template configuration). Clicking on the *Events* button will only print the log file's event messages, and clicking on the *Full* button will print both of these options.

3.3 Interlock System

The 944 is equipped with four electrical interlocks, wired in series, to a single digital input channel in the TECHWARE-II Ultra System Controller (computer). The computer program (CONTROL*Vision*™) monitors the status of this input, and will limit machine operations if the interlock circuit is not made. If any of these four switches are not made, the computer will not receive the Interlock OK input signal, and will not allow the RF igniter Control Relay, the RF Supply Control Relay or the DC power supply to energize.

In addition to the computer input, four yellow LEDs are mounted on the Maintenance Panel, shown below. An interlock switch on each of the four target box covers controls these LEDs. As these interlock switches are mounted in series, only one LED will light at one time. The order of these interlocks is as follows:

- Interlock and LED 1 – Cathode Water Flow (FS 1)
- Interlock and LED 2 – RF Match Water Flow (FS 2)
- Interlock and LED 3 – Vacuum Switch
- Interlock and LED 4 – External Signal

Maintenance Panel

3.4 Hydraulics System

A hydraulic elevator is installed inside the load lock area to manage the pallet exchange process. The elevator moves a two position rack up and down to allow the carriage to deposit the completed pallet on the lower position and pick up the new pallet from the upper position. The Hydraulic System is responsible for monitoring and controlling the I/O points required for proper operation of the hydraulic elevator. The hardware used within this system is comprised of a Hydraulic Valve Block, a Hydraulic Motor Relay, and a Hydraulic Power Unit.

The Hydraulic Valve Block contains four valves and a Seal Pressure Sensor. Three of the valves are energized by relay outputs in the computer to control the elevator direction (one for forward and one for back) and the load lock high pressure. The fourth valve is a safety pressure release, which vents the hydraulic pressure whenever the system power is removed.

A fourth relay output is used to energize the Hydraulic Motor Relay (K1A) and allow the motor to start. Three-phase power is provided to the Hydraulic Motor Relay, via CB6 in the AC Distribution Box. Once the Motor Relay is energized, the three-phase power is allowed to pass to the Hydraulic Power Unit and the elevator begins to move in the specified direction.

Finally, an Elevator Manual Position Control Switch is located on the maintenance panel of the machine. This switch is wired in parallel with the Up, Down, and Motor On/Off computer outputs, and will energize the associated equipment, regardless of the computer program operation.

For more information please refer to drawing number 944-08 located in Chapter 9, Schematics, of this manual.

3.5 Pressure Measurement System

The pressure measurement system is responsible for monitoring and controlling the ion gauge pressure, load lock pressure, and the chamber pressure. The equipment used in this system is comprised of a 360 Ion/TC Gauge Controller, a 316 TC Gauge Controller, and a Remote Supply.

The main controller for this system is the 360 Ion/TC Gauge Controller. The computer has two (2) digital outputs to provide IG1 (Ion Gauge) and IG2 On/Off inputs to the Ion/TC Gauge Controller. In addition, this controller provides the computer with two (2) digital inputs indicating the load lock crossover and chamber crossover status. Also provided to the computer are three analog inputs: ion gauge pressure, load lock pressure and chamber pressure. In this system, the computer is used as an operator interface, with all-important process decisions being made by the 360 Ion/TC Gauge Controller. Load

lock convectron and chamber convectron units are connected to Channel 3 and 5 of this controller, respectively.

Also interfacing with the Ion/TC Gauge Controller is a 316 TC Gauge Controller. This controller communicates with the 360 Ion/TC Gauge Controller via Process Control ports on each controller. One additional convectron unit is connected to the 316 TC Gauge Controller, the Rough Pump Convectron gauge.

Finally, two ion gauges, one chamber ion gauge and one load lock ion gauge, are powered by a Remote Supply and connected to the IG1 and IG2 collector ports on the 360 Ion/TC Gauge Controller, respectively.

For more information regarding the equipment specified in this section, please refer to the appropriate manufacturers user manuals.

3.6 Cryo Pump System

The cryo pump system is significant in the role of pumping down the chamber, and maintaining the internal vacuum operating conditions. This system consists of a CT8F Cryo Pump, a CT10 Cryo Pump, and a Helium Compressor. The Cryo Pumps communicate with the computer via an RS232, serial communications link (ports 3 and 5). The compressor receives its input power via CB3 on the AC Distribution Box. For more information regarding this equipment, please refer to the associated manufacturer user manuals.

3.7 RF Etch System

The RF Etch System is used to clear the product of surface contaminants, prior to execution of the sputtering process. An RFG/AZX Minipanel Controller controls this process. Other devices required include an RF Power Supply, an RF Tuner, a Filament Transformer and an Igniter Filament.

Through the use of an interposing relay (K6A), a computer relay output provides the RFG/AZX Minipanel Controller with an on/off signal. This signal will only be active if the interlocks, described in section 3.3, are made. Other I/O points used in this system include an analog output to the controller, indicating the desired RF set point, and three computer input signals from the controller. The input signals are one digital input, notifying that the RF level is at the desired set point, and two analog inputs specifying the RF power level and the reflected power.

The other two components in this system are the Filament Transformer and the Igniter Filament. Again, an interposing relay and a computer relay output are used to send a signal to the Filament Transformer and energize the Igniter Filament. As with the RFG/AZX Minipanel Controller on/off signal, the Igniter Filament can only be energized if the interlocks, described in section 3.3, are made.

3.8 Target System

This system controls the application of the target materials during the sputtering process. The main components of this system are the four target applicators and a DC power supply.

A computer relay output is provided to control the DC power supply on/off status. As described in section 3.3, the interlock system must be made before this output will energize. In addition, there are four target lid interlocks wired in series between the computer output and the DC power supply input. If any of the four target lids are open, the DC power supply will not receive the "power on" signal from the computer. Similar to the interlocks described in section 3.3, three LEDs are connected to these interlock switches. These LEDs will illuminate, one at a time, if there is a problem with the associated interlock switch. They will only illuminate if the target box cover is removed AND the computer has attempted to turn the DC Power Supply on. The LEDs are located on the maintenance panel and are labeled "Target Box Covers", "1", "2", "3", and "4".

A computer analog output provides the DC power supply with the desired DC power level set point, while a computer analog input reads the actual DC power level from the DC power supply. The DC power supply provides the computer with two (2) digital input signals, indicating that the DC power level is at the set point, and that a DC arc is present.

The DC power supply, via coax RG-8U cabling, provides DC power to the target contactors, at the given set point. In addition, the target contactors are activated by three computer relay outputs, one for each target.

3.9 DC Bias System

The DC Bias System is not used in this application, and therefore will not be discussed in this manual.

3.10 Process Gas Flow Control System

The process gas flow control system is responsible for monitoring the chamber process pressure and the flow of the chamber gases during the sputtering process. The main controllers for this system are the MKS 250-B and the MKS 247C. Similar to the other controllers, the computer provides the MKS 250-B with a pressure level set point via the analog output board, while the MKS 250-B provides an actual pressure level signal to the analog input board of the computer.

A capacitance manometer is controlled by the MKS 250-B with the associated pilot valve being activated by a computer digital output. This valve is physically located on SMC Valve Manifold #1. Please refer to section 3.12 for more information regarding valve manifold #1. This portion of the system controls the vacuum pressure of the chamber during process operations.

In addition to the capacitor manometer, there is a flow controller for controlling the process gas. The flow controller is connected to the MKS 247C, which, in turn, is connected to the MKS 250-B. Similar to the manometer, digital computer outputs are used to activate the associated pilot valve located on SMC Valve Manifold #1.

3.11 Heat/Temperature System

The Heat/Temperature System is not used in this application, and therefore will not be discussed in this manual.

3.12 Scan Motor Interface System

The scan motor interface system controls the movements of the carriage throughout the machine, including the scanning functions during process operations. The drive motor for the pallet carrier is comprised of three primary parts: The SilverMax stepper motor/controller, the interface program for the computer (the "driver"), and the application software that runs the system as a whole. For more information regarding this equipment please refer to the following subsections.

CB13 of the AC Distribution Box provides AC input power to the 24VDC power supply (PS2), which in turn provides the scan motor with 24VDC. In addition to monitoring the encoder values, the speed controller provides the scan motor with on/off signals and speed control values, as defined in the process recipe (section 3.2.5). An RS232, serial communications port (Port 2), located on the back of the computer, is connected to the speed controller to provide an operator interface with the speed controller readings and set points.

For more information regarding the equipment in this system, please refer to the associated manufacturer user manuals and to drawing 944E-07.

3.12.1 SilverMax Stepper motor/controller

The SilverMax controller is an all-in-one stepper motor and controller package, to which a reduction gearbox is added before the unit is attached to the system.

The controller itself has an internal configuration parameter file that is loaded by Process Integration prior to tool shipment. Once properly configured, the controller itself interfaces over an RS232 serial link to a driver program running on the Techware.

The exception to this interface is a digital signal that connects directly to the Techware controller's I/O. Its function is to serve as an indicator signal that changes state when the motor is moving.

3.12.2 Driver:

The RS232 driver program is a standalone process which runs in parallel with the other processes active at any given time on the Techware controller.

The driver accepts commands and query requests from the application code and translates them into the appropriate RS232 codes and sends them to the SilverMax over the RS232 link. Furthermore, the driver decodes any responses, passing the information along to the application code in the relevant variables, or "channels".

The channels with which the driver interacts with the application are defined in the configuration file "/dd/WIN.PAL/CONFIGS/smax_e.cfg". Since most of the RS232 codes sent to the SilverMax are numerically based, an attempt was made to relate the command number to the channel fields in the configuration file. In this way, the command can be cross-referenced within the SilverMax RS232 User's Manual.

3.12.3 Application:

Since the bulk of the motor parameters will not vary during the run (such as maximum torque limits, clutch emulation parameters, etc.), these parameters are included in the SilverMax internal configuration file to simplify the interface between the Techware and the SilverMax.

Several of the commands can be used for diagnostics purposes; their particulars may be found in the SilverMax reference manual. The most commonly used ones are:

- ESCurrPos: This channel contains the current position of the motor, in steps
- ESTargetPos/Vel/Acc: The target Position, Velocity, and Acceleration values used for moves; these numbers are stored in registers within the SilverMax.
- ESVelBMove: Sends the motor on a velocity-based move per the three parameters listed above, stored in the SilverMax's internal registers.
- ES.Stop: Immediate motor stop
- ESMtrAtHome: Homes the motor at its current location (sets position to "0")

The motor control during a normal process is performed automatically by the application code. It uploads the desired scans speeds from the process recipes and the endpoint locations (in steps) from the Limits recipe.

For manual operation, the motor can be controlled from the Mechanical Maintenance screen. The large Left/Right VCR buttons jog the motor in the appropriate direction;

each successive depression of the buttons will adjust the speed by a factor of 10in./min., while the STOP button will halt the motor.

By choosing a location and pressing the green “GOTO” button, the carrier will travel at normal slew speed (defined in the Limits recipe) to the desired location. The other seven status fields show the location of the motor and several related parameters.

3.13Valve Manifold #1

Valve manifold #1 is an SMC VV5Q1113N3FU0-DG1S manifold, with SMC VQ1100-5 and VQ1200-5 valves. A 25-pin cable is connected to the manifold with each individual wire connected to a relay or digital output channel in the computer. Each valve is designated to perform a specific function, and is connected to an individual output channel. The following operations are performed through this valve manifold:

- Load Lock/Chamber Rough
- Chamber Vent
- Load Lock Vent
- Ballast
- RGA Isolation
- Cap Manometer Isolation
- Gas 1
- Gas 2
- Process Gas
- Throttle
- Chamber Gate Valve Open/Close
- Load Lock Gate Valve Open/Close
- Etch Platform Up
- Etch Platform Down

3.14 Valve Manifold #2

Valve Manifold #2 is used only on the CC603 and is not installed on the PI944.

3.15 Position Switches/Sensors

Several limit switches and sensors are mounted throughout the machine to determine the position, or status, of several machine devices. All of these switches/sensors are connected to digital input channels in the computer. Most of the position information will be indicated throughout the various GUI screens. In addition, the status of these signals will be monitored during process operations to ensure that all equipment remains in the proper operating positions. A list of each of the switch descriptions is as follows:

- Etch Platform Up
- Etch Platform Down
- Dome Door Position
- Load Lock Position One
- Load Lock Position Two
- Load Lock Position Three
- Load Lock Position Four
- Load Lock Position Five
- Chamber Gate Valve Open
- Chamber Gate Valve Closed
- Chamber Gate Valve Third Position
- Pallet Sense

3.16 Outlets

Five, 110VAC outlets are installed throughout the machine to provide input power to various controllers as well as some spare outlets provided for maintenance purposes. Listed below are the outlet purposes, along with the AC Distribution Box circuit breaker that feeds it.

- Chamber Maintenance Light, Box 5b – CB12
- Console Maintenance Light, Box 3a - CB12
- RF Match Outlet, Box 3a – CB4
- Maintenance Outlet, Front, Box 6a and b – CB9
- Maintenance Outlet, Back, Box 5a – CB10
- MKS and Televac Outlet Box, 4a, b, c, and d – CB11
- Water Flow Switch Outlet Box 2a and 2b – CB 14
- Computer and Monitor, Box 1a and b – CB7

4 Installation Instructions

This chapter contains the essential information regarding the initial installation of the PI944 machine. Please read and follow these instructions carefully. If the setup and installation is not properly performed, system operations may be affected.

4.1 Unpacking

Place the packing crate in a location having a smooth floor allowing access to all sides. Before any unpacking is begun, visually inspect the packing crate for external damage. If any evidence is found, it is highly recommended that the shipper representative be present before any further unpacking is accomplished in order to verify possible damage to the machine. The shipping crate is not intended to be reused, however, care must be exercised when removing the panels so as not to inflict any damage to the machine. Remove the screws and nails from the top panels, carefully slide the panel off the crate body, and set aside. Remove the screws and nails from one long side panel and remove it from the crate body. Continue removing fasteners, working around the crate one panel at a time. To prevent injury, ensure no screws or nails are left protruding into any area where someone may be working.

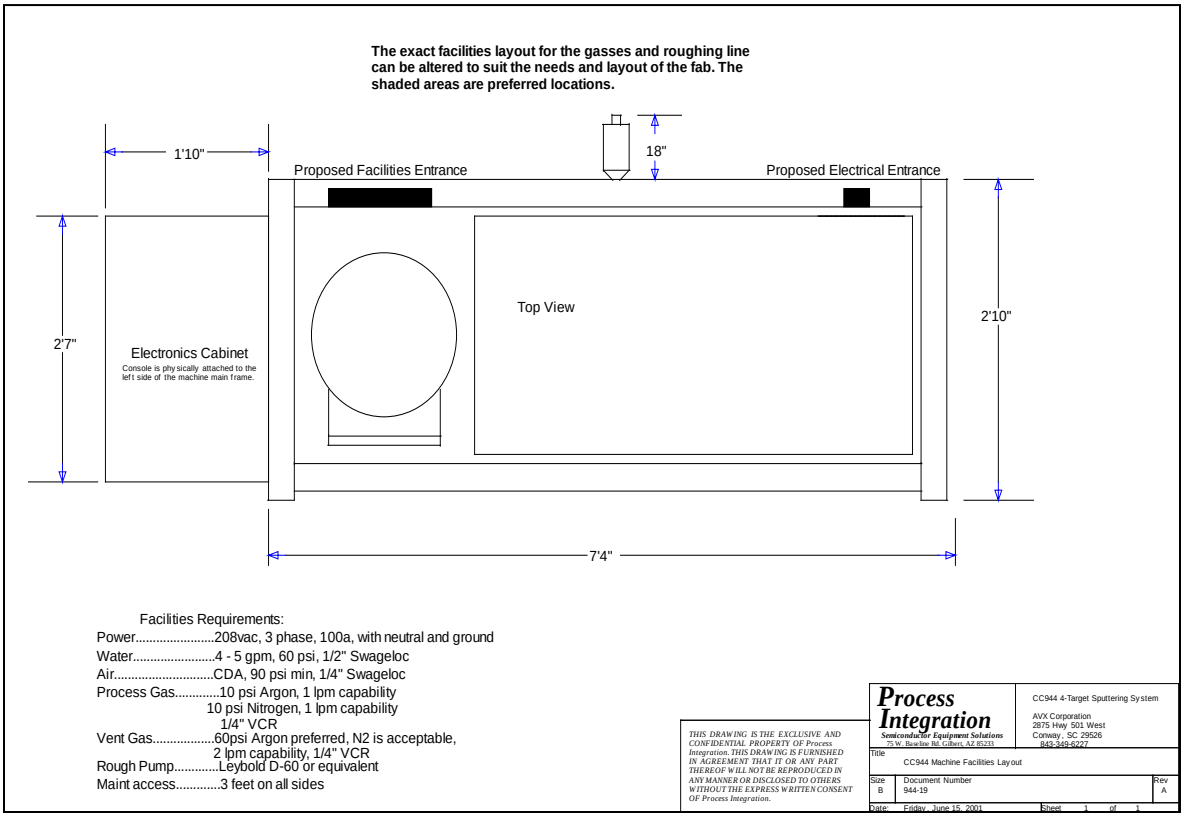
Finally, remove any straps and brackets holding the machine to the crate base. The machine can now be removed from the crate body using a forklift. Use caution when lifting the machine because of the off-side center of gravity. The machine is slightly heavier at the console end and should be picked up toward the left side of center. Ensure the forks are spread as far as possible and extend past the rear frame of the machine. DO NOT ALLOW THE MACHINE TO LEAN AGAINST THE FRAME OF THE FORKLIFT because of possible damage to the sheet metal covers. Raise the machine just off the crate base and check for stability. It is highly recommended that the machine NOT be moved on the forklift. Raise the machine just high enough to slide the crate base from out under it. Lower the forks gently until the machine is on the casters. When moving the PI944 on its own wheels, always remember it weighs about 4500 lbs. Use care when the machine is being relocated to not hit bumps, uneven surfaces, or cracks because excessive vibration may damage the sensitive electronics inside.

4.2 Inspection for Damage

After removing all packaging from around the machine, carefully inspect the machine for alignment or binding of moving parts, broken or missing parts, mounting, and any other conditions that may affect operation. Although the machines are carefully packaged, they also require proper handling by the freight or shipping company. Should you discover any damages to parts or equipment, immediately report these problems to Process Integration to ensure that proper actions are taken.

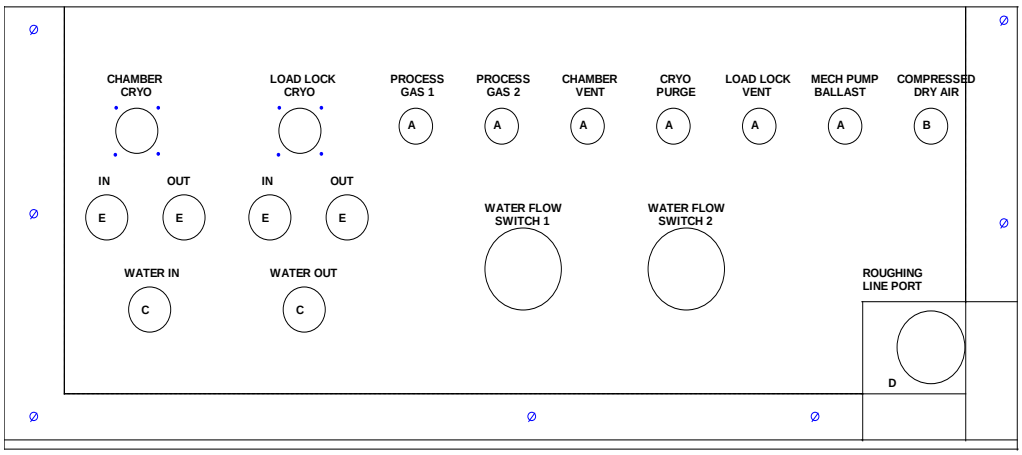
4.3 Installation Requirements

NOTE: DO NOT OPEN ANY OF THE VACUUM CHAMBER DOORS UNTIL THE MACHINE HAS BEEN PLACED IN POSITION AND ALL LEVELING FEET ARE IN CONTACT WITH THE FLOOR. Please refer to the machine layout drawings, shown below, for installation dimensions and facility requirements. Verify that the machine is mounted on a flat surface and is level in both directions (use the machine leveling feet for adjustment).



4.4 Facilities Connections

The facilities panel drawing, shown below, indicates the location and fitting size for each of the facility connections. This should contain all of the information required for facility connections, however, for more information regarding the chamber connections and facility distribution refer to drawing number 944-22, located in section 9, *Schematics*.



A.....1/4" VCR Fittings, 2" on center
B.....1/4" FNPT Fitting, 2" on center from A
C.....1/2" Swageloc Fittings
D.....1-1/2 pipe, KF-40 flange
E.....AeroQuip Bulkhead Fittings

Internal frame members shown by _____

THIS DRAWING IS THE EXCLUSIVE AND CONFIDENTIAL PROPERTY OF Process Integration. THIS DRAWING IS FURNISHED IN AGREEMENT THAT IT OR ANY PART THEREOF WILL NOT BE REPRODUCED IN ANY MANNER OR DISCLOSED TO OTHERS WITHOUT THE EXPRESS WRITTEN CONSENT OF Process Integration.

Process Integration
Semiconductor Equipment Solutions
75 W. Baseline Rd. Gilbert, AZ 85233

CC944 4-Target Sputtering System
AVX Corporation
2875 Hwy 501 West
Conway , SC 29526
843-349-6227

Title: Facilities Panel Layout
Size: B | Document Number: 944-22 | Rev: A
Date: Friday , June 15, 2001 | Sheet 1 of 1

4.5 Initial Adjustment and Settings

Once all of the facilities have been connected and associated inlet valves opened, the machine is ready to be powered up. Verify that all breakers are on and that all of the controllers are receiving power.

Although the machine was tested thoroughly prior to shipment, it is recommended that a complete I/O check be performed whenever the machine is moved. The highest quality of equipment and workmanship was used during production of this machine; however, mechanical parts and wiring may be affected if proper care was not taken during shipping or relocation. Please refer to section 3.2.9, I/O List Screen, for information regarding the monitoring and toggling of all I/O points.

Once the I/O check has been completed, pump down the chamber in preparation for normal operating procedures described in chapter 5 of this manual. The chamber pump down procedure can be initiated by clicking on the *Ch Pump* button located on the *System Maintenance* Screen as described in section 3.2.7 of this manual. Please note that the chamber operates under a high vacuum and that it may require up to one or more hours to reach the proper operating conditions, depending on the condition of the chamber prior to pump down.

In addition to the above described adjustments and settings, some manufacturing facilities may have specific site procedures and standards for initializing and testing the machine prior to normal production. Some examples may include a target burn in procedure or pallet conditioning procedures. Please refer to your site standards and supervisors to verify that all local initialization procedures have been followed prior to normal operations of the machine.

5 Normal Operating Procedures

Once all of the installation instructions of Chapter 4 have been followed, the machine should be ready to begin cycling product. Under normal operating conditions, the *Operate Screen*, described in section 3.2.3, should provide the operator with all of the necessary control and monitoring information. Please refer to this chapter for more information regarding the buttons and indicators available.

Normal operating procedures require minimal operator interaction as outlined below:

1. Vent the load lock system.
2. Open the dome door and remove the pallet from the lower portion of the elevator (if the pallet is present).
3. Load the new pallet onto the top plate of the elevator.
4. Enter the desired recipe for the pallet loaded in the load lock area.
5. Close the dome and pump down the load lock area.
6. Wait for the cycle complete indicator to verify that the sputtering and exchange processes have completed.
7. Repeat steps 1 – 6 as product demand dictates.

6 Preventive Maintenance

The information contained in this chapter is provided as a quick reference guide for the user of the PI944. This information is not intended to replace or substitute the information provided in the individual manufacturer manuals. To ensure proper safety precautions, please refer to the indicated manufacturer manual prior to handling any of these devices.

6.1 Machine Maintenance

A periodic visual inspection of the PI944 is recommended. This inspection should ensure that all components are securely mounted, without damage. Equipment and areas that require regular inspection include:

- N_2 pressure to the machine and mechanical pump.
- Water flow to the machine and mechanical pump.
- Water flow to the cryo compressor.
- Cryo helium pressure.
- Purge gas pressure.
- Process gas pressure.
- Air pressure.
- Hydraulic fluid level
- Hydraulic system pressures
- Smooth movement of the load lock elevator.
- Movement of the pallet carrier.
- Exchange process (position adjustments of elevator and carrier).
- Vacuum integrity of the chamber, load lock and process gas line.

This section includes a recommended maintenance schedule, as well as additional preventive maintenance tips for each of the individual components.

6.1.1 Recommended Maintenance Schedule

This section provides a recommended maintenance schedule for the PI944 machine.

6.1.1.1 At every target change

The following checks should be made whenever there is a target change.

- Replace internal shielding.
- Clean chamber, as applicable.
- Verify all internal mechanical alignments.

6.1.1.2 Daily

The following checks should be made at the conclusion of each day.

- Check Pallet Sensing / Replace Pallets
- Record chamber base pressure.

6.1.1.3 Weekly

The following checks should be made at the conclusion of each week.

- Check rough pump oil level.
- Check ballast $N_{2.}$
- Check H_2O Flow.
- Clean load lock.
- Record cryo temperature
- Record cryo pressure
- Record cryo compressor pressure.
- Check N_2 pressure.
- Check air pressure.
- Check Argon pressure.
- Check water-cooling flow.
- Regen cryo pumps, as applicable

6.1.1.4 Monthly

The following checks should be made at the conclusion of each month.

- Check hydraulic fluid level.
- Record seal pressure.
- Perform main chamber leak rate to E-Torr in 6 minutes.
- Check cooling water resistivity.
- Check chiller re-pump pressure, if used.
- Check chiller re-pump temperature, if used.
- Check chiller re-pump water level, if used.

6.1.1.5 Quarterly

The following checks should be made at the conclusion of each quarter.

- Replace rough pump oil and filter, as applicable.
- Vent main chamber and clean, as applicable.
- Perform atmosphere exchanges.
- Check Argon line leak integrity.

6.1.1.6 Bi-annually

The following checks should be made at the conclusion of each six months.

- Check pressure control and calibrate as applicable.
- Check pressure monitoring and calibrate as applicable.
- Check throttle valve assembly and calibrate as applicable.

6.1.2 Limit Switches

All limit switches should be visually inspected for:

- Proper mounting.
- Damaged or misalignment of switch actuators.
- Secure wire connections.
- Damaged wire insulation.
- Dents, cracks or damage to housing.

Please refer to Chapter 9, Schematics, to locate all limit switches. If damage is observed and cannot be easily corrected (such as damaged wire insulation), the component should be replaced to prevent injury or complete failure during production.

6.1.3 Proximity Sensors

All sensors should be visually inspected for:

- Proper orientation on mounting bracket and secure mounting bolts.
- Dents or damage to housing.
- Damaged wire insulation.
- Flag condition and security.

Please refer to Chapter 9, *Schematics*, to locate all sensors. If damage is observed and cannot be easily corrected (such as damaged wire insulation), the component should be replaced to prevent injury or complete failure during production

6.1.4 Maintenance Panel

The maintenance panel should be visually inspected as follows:

- Ensure that all pushbuttons, selector switches, and indicator lamps are securely mounted, without damage.
- Examine modules, components and devices for correct mounting
- Inspect cable and wiring connections for tightness
- Inspect cable/wire harness clamps and restraints for tightness

- Examine all devices for evidence of excessive heat or burning
- Inspect all frayed wire or cable insulation.
- Examine for broken, or damaged wires, connectors, terminals and components.

Please refer to drawing 944-19 in Chapter 9, Schematics, for more information regarding the equipment within the Maintenance Panel. Preventive maintenance for the CTI Controller will be discussed in a separate section of this chapter.

6.1.5 Facilities Panel and Pneumatics

Visually inspect the facilities panel and pneumatic lines as follows:

- Examine and listen for leaks.
- Examine modules, components and devices for correct mounting.
- Inspect for damaged conduit, fittings or clamps.
- Tighten fittings and clamps.
- Check flow switches to ensure proper operation.

6.1.6 Hydraulic System

The electrical portion of the Hydraulic System should be visually inspected as follows:

- Examine modules, components and devices for correct mounting
- Inspect cable and wiring connections for tightness
- Inspect cable/wire harness clamps and restraints for tightness
- Examine all devices for evidence of excessive heat or burning
- Inspect all frayed wire or cable insulation
- Examine for broken, or damaged wires, connectors, terminals and components.

The fluid portion of the Hydraulic System should be visually inspected as follows:

- Examine assemblies for leaks.
- Examine modules, components and devices for correct mounting.
- Inspect for damaged tubing, fittings or clamps.
- Tighten fittings and clamps.
- Check pump window for proper fluid level.

6.2 TECHWARE-II Ultra System Controller

The TECHWARE-II Ultra System Controller is a self-contained unit with factory installed CPU boards, CPU Companion boards, and optional I/O interface modules. This component is manufactured by Brooks Automation (Canada) Corporation, and all service performed on this equipment should be in accordance to the written procedures within the Brooks Automation, *TECHWARE-II Ultra Manual and Specifications* book provided with this machine.

The preventive maintenance recommendations for this controller are as follows:

- Examine controller unit for proper mounting and damage
- Inspect cable and wiring connections for tightness
- Inspect cable and wiring connections for excessive strain
- Regularly check system and I/O board fuses as outlined in the Maintenance portion of the *TECHWARE-II Ultra Manual and Specifications* book.

6.3 Series 316 Vacuum Gauge Controller

The Series 316 Vacuum Gauge Controller is manufactured by Granville-Phillips. Along with two (2) Convectron Gauge (CG) Modules, this unit is capable of providing pressure measurement from 1.0×10^{-3} Torr to 999 Torr. All service performed on this equipment should be in accordance to the written procedures within the Granville-Phillips, *Series 316 Vacuum Gauge Controller Instruction Manual* provided with this machine.

The preventive maintenance recommendations for this controller are as follows:

- Examine controller unit for proper mounting and damage
- Inspect cable and wiring connections for tightness
- Inspect cable and wiring connections for excessive strain
- As necessary, perform the convectron calibration procedures, as described in the Granville-Phillips, *Series 316 Vacuum Gauge Controller Instruction Manual.*

6.4 Series 360 STABIL-ION® Vacuum Measurement System

As with the Series 316, the Series 360 STABIL-ION® Vacuum Measurement System is manufactured by Granville-Phillips. Throughout the *Series 360 STABIL-ION® Vacuum Measurement System Installation, Operation, and Maintenance Instructions,* it is repeatedly stated that "Qualified Service Personnel" must perform service on this system. This manual recognizes that not all problems require service, and recommends calling the Granville-Phillips Customer Service Department at 1-303-443-7660 for troubleshooting help.

The preventive maintenance recommendations for this controller are as follows. Contact the service department, or other Qualified Service Personnel should you discover any problems during this inspection.

- Inspect the cables and plugs for damage
- Inspect for evidence of liquid spills on or around the product
- Inspect the enclosure for damage and proper mounting
- Verify that the product performance is as expected (a distinct change in performance indicates a need for service).

6.5 MKS Pressure Control System

6.5.1 MKS Baratron® Type 627B Absolute Pressure Transducer

The MKS Baratron® Type 627B Absolute Pressure Transducer, manufactured by MKS Instruments, is designed to provide pressure measurements in the range from 1k Torr to as low as 0.02 Torr Full Scale. All service performed on this equipment should be in accordance to the written procedures within the *MKS Baratron® Type 627B Absolute Pressure Transducer Instruction Manual*, provided with this machine.

The preventive maintenance recommendations for this component are as follows:

- Inspect the cables and plugs for damage
- Inspect the enclosure for damage and proper mounting
- As necessary, perform the zero adjustment procedure as outlined in the *MKS Baratron® Type 627B Absolute Pressure Transducer Instruction Manual.*

6.5.2 MKS Type 250E Pressure/Flow Controller

The MKS Type 250E Pressure/Flow Controller, manufactured by MKS Instruments, is capable of pressure, flow, or flow ration control, depending on the type of the feedback device used, either a pressure transducer or a mass flow meter, respectively. All service performed on this equipment should be in accordance to the written procedures within the *MKS Type 250E Pressure/Flow Controller Instruction Manual* provided with this machine.

The preventive maintenance recommendations for this controller are as follows:

- Inspect the cables and plugs for damage
- Inspect the enclosure for damage and proper mounting
- Periodically wipe down the unit with a damp cloth
- As necessary, replace the line fuses, as outlined in the *MKS Type 250E Pressure/Flow Controller Instruction Manual*
- As necessary, perform the controller alignment procedure, as outlined in the *MKS Type 250E Pressure/Flow Controller Instruction Manual*

6.5.3 MKS Type 1179A and 2179A Mass-Flo® Controller and Type 179A Mass-Flo Meter

The MKS Type 1179A and 2179A Mass-Flo® Controllers measure and control the mass flow rates of gases, with the Type 179A Mass-Flo Meter measuring the flow rate of gases. All service performed on this equipment should be in accordance to the written procedures within the *MKS Type 1179A and 2179A Mass-Flo® Controller and Type 179A Mass-Flo Meter Instruction Manual* provided with this machine.

The preventive maintenance recommendations for this controller are as follows:

- Inspect the cables and plugs for damage
- Inspect the enclosure for damage and proper mounting
- As necessary, perform the zero adjustment procedure as outlined in the *MKS Type 1179A and 2179A Mass-Flo® Controller and Type 179A Mass-Flo Meter Instruction Manual.*

6.5.4 MKS Type 247D Four-Channel Readout

The MKS Type 247D Four-Channel Readout is designed as a power supply/readout and set point source for four analog mass flow controllers. The unit can also power and monitor the flow rate through analog mass flow meters. All service performed on this equipment should be in accordance to the written procedures within the *MKS Type 247D Four-Channel Readout Instruction Manual* provided with this machine.

The preventive maintenance recommendations for this component are as follows:

- Inspect the cables and plugs for damage
- Inspect the enclosure for damage and proper mounting
- Periodically wipe down the unit with a damp cloth
- As necessary, replace the line fuses, as outlined in the *MKS Type 247D Four-Channel Readout Instruction Manual.*

6.6 Proteus 100 Series Flow Switch

The Proteus 100 Series Flow Switch monitors liquid flow rates and trips a relay indicating whether the flow rate is above or below an adjustable trip point. All service performed on this equipment should be in accordance to the written procedures within the *Proteus 100 Series Flow Switch Manual* provided with this machine.

The preventive maintenance recommendations for this component are as follows:

- Inspect the cables and plugs for damage
- Inspect the enclosure for damage and proper mounting
- Inspect the chamber for cleanliness. Annually, as a minimum guideline, clean the chamber as outlined in the *Proteus 100 Series Flow Switch Manual.*
- Annually, as a minimum guideline, recalibrate the trip point as outlined in the *Proteus 100 Series Flow Switch Manual.*

6.7 Vacuum Pump

The vacuum pump for this machine has been supplied by the customer and will not be covered in this manual.

6.8 SilverMax™ "E" Series Motion Control System

The SilverMax™ "E" Series Motion Control System, manufactured by QuickSilver Controls, Incorporated, is used to control and monitor the movement of the carriage. All service performed on this equipment should be in accordance to the written procedures within the *SilverMax™ "E" Series Motion Control System User Manual* provided with this machine.

The preventive maintenance recommendations for this component are as follows:

- Examine controller unit for proper mounting and damage.
- Inspect cable and wiring connections for tightness.
- Inspect cable and wiring connections for excessive strain.

Please contact QuickSilver Controls, Incorporated, at www.qcontrol.com, for more information regarding preventive maintenance of this component.

6.9 On-Board® High-Vacuum Pump System

The On-Board® High-Vacuum Pump System, manufactured by CTI-CRYOGENICS, includes two On-Board® Cryopump Modules, a CTI 8200 Compressor and a CTI 9600 Compressor. All service performed on this equipment should be in accordance to the written procedures within the *On-Board® High-Vacuum Pump System Installation, Operation and Servicing Instructions* provided with this machine.

The preventive maintenance recommendations for the On-Board® Cryopump Modules are as follows:

- Examine controller unit for proper mounting and damage
- Inspect cable and wiring connections for tightness
- Inspect cable and wiring connections for excessive strain
- Listen for *ratcheting* noise, as outlined in the *On-Board® High-Vacuum Pump System Installation, Operation and Servicing Instructions,* and correct as described.

The preventive maintenance recommendations for the 8200 and 9600 Compressors are as follows:

- Examine controller unit for proper mounting and damage
- Inspect cable and wiring connections for tightness
- Inspect cable and wiring connections for excessive strain
- Every 12 months, replace the compressor adsorber as outlined in the *On-Board® High-Vacuum Pump System Installation, Operation and Servicing Instructions*
- As necessary, perform the compressor decontamination procedures, as outlined in the *On-Board® High-Vacuum Pump System Installation, Operation and Servicing Instructions.*

6.10 Advanced Energy® AZX Series Tuner

The AZX tuner, manufactured by Advanced Energy Industries, Incorporated, is an RF matching network designed to convey the complex impedance of a plasma at 13.56 MHz to a 50-Ω resistive load. All service performed on this equipment should be in accordance to the written procedures within the *Advanced Energy® AZX Series Tuner User Manual* provided with this machine.

The preventive maintenance recommendations for this component are as follows:

- Examine controller unit for proper mounting and damage
- Inspect cable and wiring connections for tightness
- Inspect cable and wiring connections for excessive strain

6.11 RFG 1250 Generator

The RFG 1250 Generator, manufactured by Advanced Energy Industries, Incorporated, is a 13.56 MHz RF generator capable of providing up to 1200 W into a 50- Ω non-reactive load. All service performed on this equipment should be in accordance to the written procedures within the *RFG 1250 Generator User Manual* provided with this machine.

The preventive maintenance recommendations for this component are as follows:

- Examine controller unit for proper mounting and damage
- Inspect cable and wiring connections for tightness
- Inspect cable and wiring connections for excessive strain

6.12 Advanced Energy® RFG/AZX Minipanel

The Advanced Energy® RFGAZX Minipanel, manufactured by Advanced Energy Industries, Incorporated, is a compact, rack-mountable panel for controlling and monitoring an RFG generator and as AXC impedance-matching network (“tuner”). All service performed on this equipment should be in accordance to the written procedures within the *Advanced Energy® RFG/AZX Minipanel User Manual* provided with this machine.

The preventive maintenance recommendations for this component are as follows:

- Examine controller unit for proper mounting and damage
- Inspect cable and wiring connections for tightness
- Inspect cable and wiring connections for excessive strain

6.13 MDX-10 kW (400-800 vdc) UHF Output

The MDX-10 kW (400-800 vdc) UHF Output, manufactured by Advanced Energy Industries, Incorporated, is a dc power supply designed to provide power to the DC target system. All service performed on this equipment should be in accordance to the written procedures within the *MDX-10 kW (400-800 vdc) UHF Output User Manual* provided with this machine.

The preventive maintenance recommendations for this component are as follows:

- Examine controller unit for proper mounting and damage.
- Inspect cable and wiring connections for tightness.
- Inspect cable and wiring connections for excessive strain.
- Ensure cooling fans are clean and operational.

7 Troubleshooting Procedures

The information contained in this chapter is provided as a quick reference guide for the user of the PI944. This information is not intended to replace or substitute the information provided in the individual manufacturer manuals. To ensure proper safety precautions, please refer to the indicated manufacturer manual prior to handling any of these devices.

7.1 General Machine Troubleshooting

This section explains some of the general engineering techniques used during development of this machine. Understanding of these techniques will aid maintenance personnel in reading and following the schematic drawings and tracking problems throughout the machine.

7.1.1 I/O Types

The controls of this machine are accomplished through the use of several I/O types. This includes digital inputs, digital outputs, relay outputs, analog inputs, and analog outputs, as described in the following sections. All digital I/O points use active low logic, as described below.

7.1.1.1 Active Low Logic

Active low logic, otherwise know as negative logic, is used for all digital I/O points throughout the system. With active low, or negative logic, a low voltage represents a true condition and a high voltage represents a false condition.

For example, Channel 0 on Digital Board 1 (Outputs) represents the Chamber Rough output. If one lead of a dc voltmeter is placed on this output point, and the other is placed to ground the following could be determined:

- A low voltage, or voltage close to zero, would indicate that this output is energized and should turn on the Chamber Rough.
- A high voltage, or voltage close to 24 vdc, would indicate that this output is not energized and should not turn on the Chamber Rough.

Likewise, Channel 0 on Digital Board 0 (Inputs) represents the DC at Set Point input. If one lead of a dc voltmeter is placed on this input point, and the other is placed to ground the following could be determined:

- A low voltage, or voltage close to zero, would indicate that this input is energized and the DC power supply is at set point.
- A high voltage, or voltage close to 5 vdc, would indicate that this input is not energized and the DC power supply is not at set point.

7.1.1.2 Digital Inputs

All digital inputs use 5 vdc negative logic. These signals can only be in one of two states, on or off. For an on condition, the computer is looking for ground. If the computer does not find a connection to ground the input is determined to be off.

7.1.1.3 Digital Outputs

All digital outputs use 24 vdc negative logic. These signals can only be in one of two states, on or off. For an on condition, the computer will make a ground connection to the output point. For an off condition, the computer will remove the ground connection.

7.1.1.4 Relay Outputs

Similar to digital I/O, relay outputs can only be in one of two states, on or off. When a relay output is energized (or on), a normally open contact will close to complete a circuit, much like a switch. Likewise, when the relay output is off, the contact will return to its normally open condition and break the circuit.

7.1.1.5 Analog Inputs

The Analog inputs circuits read either 0 – 5 vdc or 0 – 10 vdc signals. The exact voltage reading at the input board is proportional to the state of the connected device. Not all of the analog signals in this machine use linear scales, therefore, reference to a software lookup table may be required.

7.1.1.6 Analog Outputs

The Analog output circuits provide either 0 – 5 vdc or 0 – 10 vdc signals. The exact voltage signal at the output board is proportional to the desired state of the connected device. Not all of the analog signals in this machine use linear scales, therefore, reference to a software lookup table may be required.

7.1.2 Mil-Spec Wire Numbers

All wires are labeled in the Mil-Spec wiring format. This format is as follows:

XX##X##

XX A two-letter designation that identifies which system the wire is part of.
A two-number designation that identifies the wire number within the system.
X A one-letter designation that begins with A and increments one letter after entering and exiting a terminal block.
A two-number designation that identifies the gauge of the wire.

7.2 TECHWARE-II Ultra System Controller

The TECHWARE-II Ultra System Controller provides a Diagnostics program for quality control and debugging. For quality control, this program performs a series of tests on the hardware, displaying and logging pass/fail information. As a debugging tool, the diagnostics program can be run in manual mode, letting the user select which test to run, and displaying the board status. All service or diagnostics performed on this equipment should be in accordance to the written procedures within the Brooks Automation, *TECHWARE-II Ultra Manual and Specifications* book provided with this machine.

7.3 MKS Baratron® Type 627B Absolute Pressure Transducer

The MKS Baratron® Type 627B Absolute Pressure Transducer, manufactured by MKS Instruments, is designed to provide pressure measurements in the range from 1k Torr to as low as 0.02 Torr Full Scale. All service performed on this equipment should be in accordance to the written procedures within the *MKS Baratron® Type 627B Absolute Pressure Transducer Instruction Manual*, provided with this machine.

The manufacturers troubleshooting guide for the MKS Baratron® Type 627B Absolute Pressure Transducer is as follows:

Symptom	**Possible Cause**	**Solution**
Overrange positive or negative signal.	A shorted transducer or a damaged interconnect cable (transducer to electronics module).	Measure supply voltages at the connector. Inspect cable and transducer. Replace if necessary.
Measurement slowly goes positive over time.	Overpressure and/or a buildup of contamination in the measurement cavity.	Return to MKS for servicing or transducer replacement.

Unstable zero output.	The ambient temperature may be too high. *OR* The ambient temperature is varying over a wide range.	Ensure the ambient temperature is within product requirements; refer to *Appendix A: Product Specifications,* page 39 of the *MKS Baratron® Type 627B Absolute Pressure Transducer Instruction Manual.*

7.4 MKS Type 250E Pressure/Flow Controller

The MKS Type 250E Pressure/Flow Controller, manufactured by MKS Instruments, is capable of pressure, flow, or flow ration control, depending on the type of the feedback device used, either a pressure transducer or a mass flow meter, respectively. All service performed on this equipment should be in accordance to the written procedures within the *MKS Type 250E Pressure/Flow Controller Instruction Manual* provided with this machine.

The manufacturers troubleshooting guide for the MKS Type 250E Pressure/Flow Controller is as follows:

1. Check for obvious problems such as power off, open fuse, defective line cord, input power failure, or loose connections.
2. Check all control settings.

FRONT PANEL

Power	ON (Power light should be on)
Set Point	Switch on INT. Control at proper level.
Input Select	As required (normally 10 V)
Phase	As required (normally 1 to 5 sec.)
Gain	As required (normally 100%)
Mode	AUTO or EXT

INSIDE

Nor/Rev	Normal

REAR PANEL

115/230	As required by AC power supply

3. Determine the probable cause from the Troubleshooting Chart below.

Symptom	**Checks and Probable Causes**
Error Meter shows oscillation or noise. (Optional DVB reading is noisy.)	a. Check to see if input gas pressure is steady. b. Check that pressure transducer has a steady output (vibration isolation may be required). c. Check that diffusion pump is not choking. Refer to *System Design*, page 14 of the *MKS Type 250E Pressure/Flow Controller Instruction Manual.* d. Readjust PHASE and/or GAIN controls. Refer to *How To Tune-Up the Controller*, page 30 of the *MKS Type 250E Pressure/Flow Controller Instruction Manual.*

Symptom	Checks and Probable Causes
Error Meter shows steady error greater than +/- 0.25%. (Optional DVB reading does not agree with set point.)	a. Increase GAIN setting. Refer to *How To Tune-Up the Controller*, page 30 of the *MKS Type 250E Pressure/Flow Controller Instruction Manual.* b. If reading is higher than set point, try lowering BIAS. c. If reading is lower than set point, check that incoming gas supply is adequate. d. Check valve operation in Manual mode. e. If mode control is in EXT, remote controller may be overriding. Remove Interface connector to verify. f. Check that Normal/Reverse switch (inside) is set correctly (usually NORMAL). g. Check that set point input is correct.
Error Meter shows error less than 0.25% but pressure is not correct.	a. Check that Power is ON. b. Check that pressure transducer signal is proportional to pressure. c. Trouble in Amplifier or Set Point Amplifier.

7.5 MKS Type 1179A Mass-Flo® Controller / Type 179A Mass-Flo Meter

The MKS Type 1179A and 2179A Mass-Flo® Controllers measure and control the mass flow rates of gases, with the Type 179A Mass-Flo Meter measuring the flow rate of gases. All service performed on this equipment should be in accordance to the written procedures within the *MKS Type 1179A and 2179A Mass-Flo® Controller and Type 179A Mass-Flo Meter Instruction Manual* provided with this machine.

The manufacturers troubleshooting guide for MKS Type 1179A and 2179A Mass-Flo® Controllers is as follows:

Symptoms	Possible Cause	Remedy
No output or overrange at zero (after warm-up).	Improper cable. Valve override function applied. Electronics malfunctioning.	Check cable for type. Disconnect valve override. Return for service.
Unit indicates a negative flow.	Unit installed in gas stream backwards.	Reinstall unit in proper flow direction.

Symptoms	Possible Cause	Remedy
Controller does not track set point.	Improper zero adjustment.	Zero meter output, according to *How To Zero the Flow Controller*, page 40 of the *MKS Type 1179A and 2179A Mass-Flo® Controller and Type 179A Mass-Flo Meter Instruction Manual.*
Controller does not function.	Electronics malfunctioning. Valve sticking.	Return for service. Readjust the valve, following the instruction in *How To Adjust the Valve Preload*, page 50 of the *MKS Type 1179A and 2179A Mass-Flo® Controller and Type 179A Mass-Flo Meter Instruction Manual.*
Oscillation	Controller gain set too high. Incorrect upstream pressure regulator. Upstream pressure too high.	Reduce (turn counter-clockwise). Check manufacturers' specifications. Reduce upstream pressure.
Excessive closed conductance.	Inadequate valve preload.	Readjust the valve, according to *How To Adjust the Valve Preload*, page 50 of the *MKS Type 1179A and 2179A Mass-Flo® Controller and Type 179A Mass-Flo Meter Instruction Manual.*

Symptoms	Possible Cause	Remedy
Unit does not achieve full flow.	Upstream pressure too low.	Increase upstream pressure.
	Excessive valve preload.	Readjust the valve, according to *How To Adjust the Valve Preload*, page 50 of the *MKS Type 1179A and 2179A Mass-Flo® Controller and Type 179A Mass-Flo Meter Instruction Manual.*

7.6 MKS Type 247D Four-Channel Readout

The MKS Type 247D Four-Channel Readout is designed as a power supply/readout and set point source for four analog mass flow controllers. The unit can also power and monitor the flow rate through analog mass flow meters. All service performed on this equipment should be in accordance to the written procedures within the *MKS Type 247D Four-Channel Readout Instruction Manual* provided with this machine.

This manufacturer does not provide a quick reference, troubleshooting guide. Please refer to the *MKS Type 247D Four-Channel Readout Instruction Manual* for detailed troubleshooting procedures.

7.7 Series 316 Vacuum Gauge Controller

The Series 316 Vacuum Gauge Controller is manufactured by Granville-Phillips. Along with two (2) Convectron Gauge (CG) Modules, this unit is capable of providing pressure measurement from 1.0×10^{-3} Torr to 999 Torr. All service performed on this equipment should be in accordance to the written procedures within the Granville-Phillips, *Series 316 Vacuum Gauge Controller Instruction Manual* provided with this machine.

The manufacturers troubleshooting guide for the power supply board is as follows. (Refer to picture on page 1.10 of the *Series 316 Vacuum Gauge Controller Instruction Manual.)*:

Symptom	**Possible Cause**
Unit won't power-up, no response to power switch.	Power fuse (17) blown.
Power fuse (17) blows repeatedly.	Wrong line voltage selection, see Fig. 1.1. Wrong fuse rating.
LED (12) out (labeled +15 on control board.)	+15 volt supply faulty (power to capacitance manometer).
LED (13) out (labeled +12 on control board.)	+12 volt supply faulty (power to analog circuitry and RS232).
LED (14) out (labeled +5 on control board.)	+5 volt supply faulty (power to logic and display).
LED (16) out (labeled –15 on control board.)	-15 volt supply faulty (power to capacitance manometer).

The manufacturers troubleshooting guide for the Convectron Gauge Module is as follows. (Refer to picture on page 2.20 of the *Series 316 Vacuum Gauge Controller Instruction Manual.)*:

Symptom	**Possible Cause**
Overcurrent indicator lit (LED 31).	Cable short, pins 1-3 on CGB (CGA).
Overcurrent indicator lit (LED 32).	Cable short, pins 1-3 on CGC.
Indicators (33) or (34) lit.	Bridge amplifier circuit failure.
Indicator (35) lit.	CGC unplugged, broken sensor wire.
Indicator (36) lit.	CGB (CGA) unplugged, broken sensor wire.
Microprocessor reset LED (37) lit or flashing.	Microprocessor failure.
Indicator (38) lit or flashing.	A/D integration failure.
Display reads 9.99 +9.	Broken sensor wire
Display reads -	Tube or cable at controller unplugged.
Pressure reading very inaccurate.	Controller out of calibration, unknown gas type, sensor tube mounted in wrong orientation, sensor damaged (e.g., by reactive gas), tube very dirty, extremes of temperature or mechanical vibration.

7.8 Series 360 STABIL-ION® Vacuum Measurement System

As with the Series 316, the Series 360 STABIL-ION® Vacuum Measurement System is manufactured by Granville-Phillips. Throughout the *Series 360 STABIL-ION® Vacuum Measurement System Installation, Operation, and Maintenance Instructions*, it is repeatedly stated that "Qualified Service Personnel" must perform service on this system.

This manual recognizes that not all problems require service, and recommends calling the Granville-Phillips Customer Service Department at 1-303-443-7660 for troubleshooting help.

The manufacturers general troubleshooting guide for the Series 360 is as follows. For more information please refer to the *Series 360 STABIL-ION® Vacuum Measurement System Installation, Operation, and Maintenance Instructions* manual provided with this machine.

Symptom	**Possible Cause**
Unit will not power-up, no response to power switch.	Power fuse blown. Wrong line voltage selection, see Section 2.2 on page 2-14 of the *Series 360 STABIL-ION® Vacuum Measurement System Installation, Operation, and Maintenance Instructions.* Power interconnect cable is improperly connected. See Figure 3-17 on page 3-19 of the *Series 360 STABIL-ION® Vacuum Measurement System Installation, Operation, and Maintenance Instructions.*
Power fuse blows repeatedly.	Wrong fuse rating. Wrong line voltage selection, see Section 2.2 on page 2-14 of the *Series 360 STABIL-ION® Vacuum Measurement System Installation, Operation, and Maintenance Instructions.*
Fault relay tripped.	Unplugged *CONVECTRON* Gauge or sensor broken in *CONVECTRON* Gauge. *CONVECTRON* Gauge badly out of calibration. Microprocessor reset occurring on a module (probable circuit failure). Checksum failure on process control board. (See Section 6.10 on page 6-9 of the *Series 360 STABIL-ION® Vacuum Measurement System Installation, Operation, and Maintenance Instructions.)* Cycle power and check all set points.

Symptom	**Possible Cause**
IG will not turn on, or turns on briefly then shuts off.	IG at too high pressure. Auto turn off circuit in *CONVECTRON* Gauge module is shutting off IG. Emission current setting wrong for pressure in gauge. Improper IG connector hookup. Badly contaminated IG. Damaged or contaminated cathode coating, will not sustain emission. Try alternate cathode. Short in IG cable. Short between IG electrodes. Open cathode in IG. Try alternate cathode.
IG display shows a steady number when IG is off.	Scale factor switch is not in its center position.
CONVECTRON Gauge display reads a fixed (non changing) pressure.	IG AUTO switch is left in the SET position.
Pressure reading is higher than expected.	IG contaminated. Low (L) pressure range is not selected appropriately (pressure is below 10^{-7} Torr). Interference from other ion source. Poor conductance in gauge's vacuum connection to chamber. Gas source in plumbing to gauge, such as leak or contamination. Chamber pressure high because of leak, contamination, or pump failure. Poor location selected for gauge. Faulty gauge or power cable. Faulty electrometer.
Degas will not turn on.	System pressure above 5×10^{-5} Torr. IG not turned on.
IG shuts off when degas is initiated.	Degas fuse blown. Badly contaminated IG.
IG pressure reads extremely low.	Collector unplugged. Bad collector cable. Faulty electrometer.
IG pressure readout very erratic.	IG badly contaminated. Improper IG or Controller grounding. Bad collector cable. Excessive noise source. Interference from other charged particle source in chamber. Faulty electrometer.

Symptom	Possible Cause
Green +18 LED out on control board.	Improper connection of Power supply cable. +18 volt supply to relays faulty.
Green +15 LED out.	+15 volt supply faulty (power to analog circuitry and RS-232).
Green –15 LED out.	-15 volt supply faulty (power to analog circuitry and RS-232).
Green +5 display LED out.	+5 volt supply to display LED's faulty.
Green +5 logic LED out.	+5 volt logic supply faulty.

7.9 Proteus 100 Series Flow Switch

The Proteus 100 Series Flow Switch monitors liquid flow rates and trips a relay indicating whether the flow rate is above or below an adjustable trip point. All service performed on this equipment should be in accordance to the written procedures within the *Proteus 100 Series Flow Switch Manual* provided with this machine.

This manufacturer does not provide a quick reference, troubleshooting guide. If problems arise, check all plumbing and electrical connections as outlined in the *Proteus 100 Series Flow Switch Manual.*

7.10Vacuum Pump

The vacuum pump for this machine has been supplied by the customer and will not be covered in this manual.

7.11 SilverMax™ "E" Series Motion Control System

The SilverMax™ "E" Series Motion Control System, manufactured by QuickSilver Controls, Incorporated, is used to control and monitor the movement of the carriage. All service performed on this equipment should be in accordance to the written procedures within the *SilverMax™ "E" Series Motion Control System User Manual* provided with this machine.

This manufacturer does not provide a quick reference, troubleshooting guide. If problems arise, check all electrical connections prior to contacting the manufacturer. **Warning: Do not disassemble the unit at the gearbox. Special calibration is required for proper operation.**

7.12 On-Board® High-Vacuum Pump System

The On-Board® High-Vacuum Pump System, manufactured by CTI-CRYOGENICS, includes two On-Board® Cryopump Modules and the 9600 Compressor. All service performed on this equipment should be in accordance to the written procedures within the *On-Board® High-Vacuum Pump System Installation, Operation and Servicing Instructions* provided with this machine.

The manufacturers Error Message guide for the On-Board® High-Vacuum Pump System is as follows. Each module must be polled for this information as outlined in the *On-Board® High-Vacuum Pump System Installation, Operation and Servicing Instructions* manual.

Error Message	**Response**	**Error Condition**
No Pump Power (S3)	Logically AND the response with 01H Logically AND the response with 02H	A result means that 1 phase of power is missing. A result means that both phases of power are missing.
Heater Failure (v)	Logically AND the response with 04H Logically AND the response with 01H Logically AND the response with 02H	If TRUE, a heater problem exists and the pump warm-up temperature is reduced to 285K. If TRUE, rough valve contention exists. If TRUE, no purge gas was detected and the warm-up temperature is reduced to 285K.
CRYO TC Gauge interlock (B1)	A response of G or H as the first letter after the $ in the response string	Indicates the CRYO TC gauge cannot be turned ON because the temperature of the second stage is above 20K.

The manufacturers troubleshooting guide for the On-Board® High-Vacuum Pump System is as follows:

Problem	**Possible Cause**	**Corrective Action**
High base pressure of vacuum system, and a cryo pump temperature *below* 20K.	Air-to-vacuum leak in vacuum system or in the cryo pump.	Check cryo pump relief valve for proper seating. Check cryo pump for leaks. Check vacuum chamber and Hi-Vac valve for leaks.
	High partial pressures of non-condensable gas (helium, hydrogen, or neon) within the cryo pump because the 15K array has reached full capacity.	Regenerate the cryo pump as described in the appropriate **On-Board Module Programming and Operation Instructions.**
	One of the arrays is loose, thereby preventing good thermal contact with its cold station on the cold head.	Warm the cryo pump to ambient temperature, and retighten the arrays to 15-20 inch/pounds.
High base pressure of vacuum system, and a cryo pump temperature *above* 20K.	Decrease in cryo pump cold head performance.	If the helium return pressure gauge reads below the normal operating return pressure 100-120 psig (690-827 kPa), add gas as described in the **9600 Compressor Manual.**
	High partial pressures of non-condensable gas (helium, hydrogen, or neon) within the cryo pump because the 15K array has reached full capacity.	Re3generate the cryo pump as described in the appropriate **On-Board Module Programming and Operation Instructions.**
	Excessive thermal load on frontal array.	Reduce the thermal radiation load by 1) shielding the cryo pump or 2) lowering the temperature of the radiating surface.
Cryopump fails to cool down to the required operating temperature or takes too long	Low helium supply pressure.	Add gas as described in the **9600 Compressor Manual.**

Problem	Possible Cause	Corrective Action
to reach that temperature (20K).	Compressor problems.	Refer to the **9600 Compressor Manual.**
	Leak in vacuum system or cryo pump.	Check the cryo pump relief valve for proper seating. Check cryo pump for leaks. Check vacuum system for leaks.
	Incomplete regeneration may not have fully cleaned the adsorbing array. Partial pressures of non-condensable gas (hydrogen, neon or helium) may remain.	Regenerate the cryo pump as descried in the appropriate **On-Board Module Programming and Operation Instructions.**
No display.	No power to On-Board cryo pump.	Check electrical connections; be sure the power switch at the compressor controller is turned on. Check fuses. If power is turned on, try turning it off and onto reboot the electronics. Change electronics module.
Display does not update, and/or keys do not function.	Electronics has locked up.	Try to reboot the system by turning the On-Board power switch located at the compressor controller off and on. Replace the On-Board electronic module.
Rough valve clicks but does not open and close.	Too little or no air pressure to drive valve.	Increase air pressure to 60 psig minimum, 80 psig maximum.

The manufacturers troubleshooting guide for the 8200 and 9600 Compressors is as follows. **Warning: Disconnect the compressor before performing any troubleshooting procedures. The compressor pump is hot after operating. Wait for the pump to cool down before working on the inside of the compressor.**

Problem	**Possible Cause**	**Corrective Action**
1) System power ON/OFF switch (CB1) and compressor switch (S1) remains in the ON position when switched on but the compressor will not run. Refer to Figure C-1 of the *8200 Compressor Installation, Operation and Service Instructions* for identification of all electrical components.	1) The thermal protective switch (TS1) is closed, activating the relay-trip coil in the ON/OFF switch (SW1).	1) Test switch (TS1) on air-cooled compressor; test (TS1) and (TS2) on water-cooled compressor. If continuity is found in any switch, contact the Product Service Department.
	2) Incorrect phasing at input power.	2) Correct phase sequence at input power cable.
	3) Excessive current drain has activated the series trip in the compressor ON/OFF switch.	3) Measure and record the current and contact the Product Service Department.
2) System power ON/OFF switch (CB1) remains in the ON position, but the compressor will not run.	1) No power coming from the power source.	1) Check service fuses, circuit breakers, and wiring associated with power source, and repair as needed.
	2) Incorrect or disconnected wiring within the compressor	2) Check the compressor against its electrical schematic, Figure C-1 of the *9600 Compressor Installation, Operation and Service Instructions.*
3) Compressor stops after several minutes of operation and remains off.	1) High temperature of the compressor is caused by insufficient cooling water, resulting in the opening of thermal protective switch (water-cooled compressor only).	1) Confirm that cooling water to the compressor is flowing. Confirm that proper cooling water flow rate and pressure exist by referring to Figure 3-3 of the *9600 Compressor Installation, Operation and Service*

Problem	Possible Cause	Corrective Action
		Instructions.
	2) After turn-off, very cold cooling water was left running through the compressor. The resulting low oil temperature has caused a restriction of oil flow through the metering orifice during startup.	2) Turn on the compressor and allow it to run until it has stopped several times, allowing the oil temperature to rise and the compressor to operate continuously for one hour minimum.
	3) Very cold cooling water is circulating through the compressor. The resulting low oil temperature causes a restriction of oil flow through the metering orifice during startup.	3) Recheck for proper cooling water temperature per, **Cooling Water Requirements (Water-Cooled Compressors Only).**
	4) Ambient temperature is unusually high resulting in the opening of the thermal protective switch (air-cooled compressor only).	4) Provide a free flow of air to the compressor. Confirm a 12-inch (30 cm) clearance at the front and back of the compressor. Confirm unobstructed and clean heat exchanger surfaces.
	5) Insufficient helium supply pressure is indicated by the supply pressure gauge.	5) Add helium per **Unscheduled Maintenance.**
	6) High temperature of the compressed helium in the discharge line from the compressor pump has tripped the thermal protective switch.	6) Confirm that oil is visible I the compressor sight glass (air-compressors only).
	7) Mechanical seizure.	7) Contact the Product Service Department.

Problem	Possible Cause	Corrective Action
4) Compressor pump stops after several minutes of operating and then switches ON and OFF at short intervals.	1) Intermittent power source voltage.	1) Confirm power source voltage between 198-250V, 60 Hz or 180-220V, 50 Hz and restore if necessary.
5) Compressor operates but cold head motor does not run.	1) Loose or defective cable.	1) Check cold head cable.

7.13 Advanced Energy® AZX Series Tuner

The AZX tuner, manufactured by Advanced Energy Industries, Incorporated, is an RF matching network designed to convey the complex impedance of a plasma at 13.56 MHz to a 50-Ω resistive load. All service performed on this equipment should be in accordance to the written procedures within the *Advanced Energy® AZX Series Tuner User Manual* provided with this machine.

The manufacturers troubleshooting guide for the AZX Series Tuner is as follows.
Danger: All servicing function involving input and output connections can expose you to lethal voltages. Make sure you follow proper safety precautions before you attempt to troubleshoot the unit.

Symptom	Action/Possible Cause
TCM front panel displays “Error”.	High voltage inside the tuning network. Turn TCM power off. Wait 10 sec. and turn it back on.
Tuning network won’t tune and LIMIT LED is lit.	The load may be outside the range of the tuner. Try tuning in manual mode. Change the load pressure or gas flow.
Reflected power is greater than 1% of forward power but the tuner has stopped moving.	The tuner has reached a limit indicating that the load impedance is outside the range of the tuner. Check the capacitor positions to verify. The tuner has reached a tuning null according to the internal phase and magnitude detector but has not satisfied the generator. See the section on adjusting minimum reflected power on page 4-9 of the *Advanced Energy® AZX Series Tuner User Manual.*
The TCM front panel does not light up.	The unit is not connected to an ac power source or a fuse is blown. Check the ac power connections and fuses.

Symptom	Action/Possible Cause
The TCM lights but the tuner does not operate in manual or automatic modes.	24 V power fuses are open. Check the 1.5-A fuses inside the TCM.
The tuning network seems to oscillate when in automatic mode after the plasma is lit.	Unstable load or plasma mode. Change the gas pressure or flow, if possible, to verify.
The tuning network won't track when the load is changed.	The load moved outside the tune range. The unit is not in automatic mode.

7.14 RFG 1250 Generator

The RFG 1250 Generator, manufactured by Advanced Energy Industries, Incorporated, is a 13.56 MHz RF generator capable of providing up to 1250 W into a 50- Ω non-reactive load. All service performed on this equipment should be in accordance to the written procedures within the *RFG 1250 Generator User Manual* provided with this machine.

The manufacturers troubleshooting guide for the RFG RF Generator is as follows:

No Power

AC ON LED	RF ON LED	Intlk Open LED	Over Temp LED	Power Limit LED	Probable Cause	Action
On	Off	On	Off	Off	The interlock string is open. The RF output cable is not connected or loose. *Pins 10* and *23* on the User port are not connected.	Install and/or tighten the RF output connector. Connect *pins 10* and *23* on the User port. After the condition is resolved, toggle the RF On command off and then back on again.
Off	Off	Off	Off	Off	The circuit breaker is off. The generator had no cooling water from a long period of time resulting in AUX supply shutdown.	Turn the circuit breaker on. Check the cooling water for proper operation. Let the generator cool down. The AUX supply will automatically turn back on when cool.
On	On	Off	On	Off	An over temperature condition has been detected in the generator. Cooling water is probably out of specifications.	Check cooling water and ensure it is within specifications. After over temperature condition is resolved, toggle RF On command off and then on again.

The Power Level Doesn't Meet Set Point

AC ON LED	RF ON LED	Intlk Open LED	Over Temp LED	Power Limit LED	Probable Cause	Action
On	On	Off	Off	On	The generator is unable to supply the requested power level due to limiting conditions in the generator. Power limits can be caused by load mismatches.	Adjust the load or reduce the power level.

7.15 Advanced Energy® RFG/AZX Minipanel

The Advanced Energy® RFGAZX Minipanel, manufactured by Advanced Energy Industries, Incorporated, is a compact, rack-mountable panel for controlling and monitoring an RFG generator and as AXC impedance-matching network ("tuner"). All service performed on this equipment should be in accordance to the written procedures within the *Advanced Energy® RFG/AZX Minipanel User Manual* provided with this machine.

This manufacturer does not provide a quick reference troubleshooting guide. If problems arise, check all electrical connections prior to contacting the manufacturer.

7.16 MDX 10 kW (400-800 Vdc) UHF Output

The MDX-10 kW (400-800 Vdc) UHF Output, manufactured by Advanced Energy Industries, Incorporated, is a dc power supply designed to provide power to the RF generator and tuning system.. All service performed on this equipment should be in accordance to the written procedures within the *MDX-10 kW (400-800 Vdc) UHF Output User Manual* provided with this machine.

The manufacturers troubleshooting guide for the MDX-10 kW (400-800 Vdc) UHF Output is as follows:

LED	On	Off	Status
FRONT PANEL LED's and DISPLAYS	X		Normal

LED	On	Off	Status
FRONT PANEL LED's and DISPLAYS		X	The unit is not receiving ac input power. Power the unit off. Using all applicable safety precautions, inspect your ac input power source to ensure that it is properly connected and that the specified voltage is being applied to the MDX-10kW unit. (See the "Troubleshooting" chapter *in the MDX-10 kW User Manual* for ac input power specifications.)
OUTPUT	X		Normal
OUTPUT		X	The Pinnacle unit is not producing output. (See the "Troubleshooting" chapter *in the MDX-10 kW User Manual* for ac input power specifications.)
SETPOINT	X		Normal
SETPOINT		X	The unit is not operating within set point. (See the "Troubleshooting" chapter *in the MDX-10 kW User Manual* for procedures.)
INTERLOCK	X		Normal
INTERLOCK		X	An interlock fault condition exists. (See the "Troubleshooting" chapter *in the MDX-10 kW User Manual* for procedures.)
Blank			Blank
Blank			Blank
OVERTEMP	X		An over-temperature fault condition exists. Note the error code on the display and see "Error Code Troubleshooting Table" below, or on page 7-5 of the *Pinnacle™ 10 kW (400-800 Vdc) UHF Output User Manual.*
OVERTEMP		X	Normal
ARC	X		After the output shuts off, this LED lights momentarily to indicate that the hard arc count limit was reached during the previous run.
ARC		X	During an on cycle, this LED normally remains unlit. After the output shuts off, if this LED remains unlit, the hard arc limit was not reached during the previous run.

The manufacturers Error Code Troubleshooting Table for the MDX-10 kW DC Power Supply is as follows:

Error Code and Message	Problem Indicated	Suggested Action
FAIL	Displayed whenever any of the following “E” codes is displayed.	Clears when “E” code is cleared.
E01	MDX has failed the internal software test.	Run the test again. Contact AE if failure occurs again.
E02	One (or more) control panel switches is stuck.	Repair or replace control panel.

Error Code and Message	Problem Indicated	Suggested Action
E10	Communication error between MDX control panel and internal MDX microprocessor.	Will clear itself IF communication is restored.
E12	Out of set point shutdown.	Output shut off because the MDX was not able to produce output equal to the programmed set point level in the amount of time specified by the operator. Press OUTPUT OFF to clear message.
E13	Soft-start failed	Internal MDX bus voltage has failed to reach soft-start levels. Press OUTPUT OFF to clear message.
E14	Internal MDX buss voltage too high	Press OUTPUT OFF to clear message.
E17	Internal MDX buss voltage too low	Press OUTPUT OFF to clear message.

Error Code and Message	Problem Indicated	Suggested Action
EOFF	Indicates that the EMERGENCY STOP button has been pushed in	Pull EMERGENCY STOP button out and press OUTPUT OFF to clear message.
OFF	MDX Mode is OFF	Appears on both digital meters whenever MODE KEY is set to the OFF position.

8 Glossary

CPU – *Central Processing Unit*

Degas – A means of removing contaminants from the vacuum system.

Diagnostics – Various debugging programs.

Footprint – The physical dimensions of a system.

G-WINDOWS – The GESPAC software tool for creating and modifying windows and graphical objects to be used in a GUI running in the OS-9® environment.

Grounding – A method used to eliminate any R.F. noises.

GUI – *Graphical User Interface* – This is an on-screen graphical representation of a software package, allowing the user to implement software commands and processes by manipulating graphical objects displayed in "Windows" on the monitor screen.

Hydraulic – Operated by the movement and force of liquid.

I/O – *Input/Output*

I/O Channel – Used to represent a dingle digital or analog I/O connection.

Module – A self-contained hardware or software component that interacts with a larger system. Hardware modules are often made to plug into a main system.

Operating System – The master control program that manages the operation of the computer and provides commonly used functions such as I/O for other programs.

OS-9® – OS-9®, registered trademark of Microware Systems Corporation, is a sophisticated operating system for microcomputers.

PAL – *Process Automation Language* – A specialized programming language for control systems.

Peripheral – An external device that provides a variety of functions such as: local file storage, user interfacing, printing, and networking.

R.F. Noise – Radio frequency interference.

RS-232 – A serial communications protocol.

Regeneration (REGEN) – A function that allows the cryo pump to warm-up to room temperature so that both gases and water vapor collected on the arrays are purged from the pump.

Serial port – A socket on a computer used to connect a modem, mouse, scanner or other serial interface device to the computer.

Target – The materials to be placed on the product during the sputtering process.

VMEbus – *VersaModule Eurocard bus* – A 32-bit bus that is widely used in industrial, commercial and military applications with over 300 manufacturers of VMEbus products worldwide.

9 Spares Lists

O-ring size	Qty	Location
120	4	CHAMBER GAS BLANKS
152	1	ETCH BELLOWS
171	1	8" GATE TO CRYO
206	2	WATER JACKET
222	1	V4 FLANGE DRIVE SEAL
226	1	ETCH SHAFT/LOWER BELLOWS SEAL
228	1	LOADLOCK BELLOWS TO BEARING HOUSING
230	2	LOADLOCK BELLOWS
232	1	ETCH PLATE INSULATOR GLASS
236	1	LOADLOCK BEARING HOUSING ETCH BELLOWS
240	1	ETCH BEARING HOUSING
245	1	ETCH PLATE
247	1	LOADLOCK DOOR GLASS
266	1	8" GATE TO DOME
275	1	LOADLOCK GATE
278	1	MAIN CHAMBER CRYO
280	2	PTFE WINDOWS
281	1	GATE CHAMBER
323	4	L/L KNUCKLES
327	4	LOADLOCK SHAFT KNUCKLES
386	1	LOADLOCK SEAL PLATE
467	1	LOADLOCK DOME CHAMBER SEAL
1277MM X 0.210 C/S	1	LOADLOCK DOOR
207" X .0210"	1	MAIN CHAMBER