FERMILAB
Technical Division
Superconducting Radio Frequency Development Department

INSTALLATION AND OPERATING INSTRUCTIONS FOR THE 1.3-GHZ CAVITY VACUUM FURNACE AT IB-4

Prepared by: Date: 18 MAR 2013 Mayling Wong, Responsible Engineer	**Organization** TD/SRFDD	**Extension** x2532
Reviewed by: Date: 18 MAR 2013 Allan Rowe, Cavity Processing Group Head	**Organization** TD/SRFDD	**Extension** x4474
Approved by: Date: 21 Mar 2013 Vyacheslav Yakovlev, SRFD Department Head	**Organization** TD/SRFDD	**Extension** x3888

Revision History

Revision	Date	Section No.	Revision Description
None	13-June-11	All	Initial Release – TRR 2205
A	18-Mar-2013	Initial Startup	• Replaced gas names (Ar, N2, etc) with line names (backfill line, etc) • Updated "Purge BACKFILL and GAS BLEED lines" procedure
		Operating Procedure	• Updated Elog website • Replaced gas names (Ar, N2, etc) with line names (backfill line, etc) • Modified "Set up Existing Recipe for Baking" • Added "Pump down chamber to high vacuum pressure" • Modified "RGA and Data logging startup" • Modified "Screen shots during the Bake Cycle" • Added "During cooldown period"
		Scheduled Maintenance	• In Monthly Maintenance section, added Step 11 • In Other Periodic Maintenance section, moved Step 3 to Step 8 • In Other Periodic Maintenance section, added Steps 9-10

Review History

The review period for this document is three years.

Revision	Date	Comments
None	June, 2014 (expected review date)	

Table of Contents

Scope iv
Personal Protective Equipment (PPE) v
Initial Start-Up vi
Operating Procedure to Bake 1.3-GHz SRF Cavities (Fermilab drawing 5520.000-MD-457528) viii
Shut down sequence xv
Scheduled Maintenance xvi
Monthly Maintenance xvi
Annual Maintenance xviii
Other Periodic Maintenance xix
Material Restrictions xxi
Appendix A xxii

Scope

The 1.3-GHz Cavity Vacuum Furnace, located in the Industrial Building 4 (IB4) at Fermilab, will be operated in accordance with the procedure in this document. The procedure is specific to the hydrogen degassification of 1.3-GHz SRF cavities.

Included in this document is T-M Vacuum Furnace's operating manual titled, *Installation and Operating Instructions - Super Series Vacuum Furnace - Model SS12/72-10MCX.* See Appendix A. A hard copy, which was provided by the vendor, remains with the furnace. The operating manual lists all safety warnings and details instructions for using all features of the furnace.

Personal Protective Equipment (PPE)

Upon entering the softwall clean room, while standing on the sticky mat, all personnel must don the following PPE:

- Powder-free nitrile gloves
- Hair net
- Shoe covers

If loading or unloading a cavity, all personnel must don the following:

- ❒ Steel-toed shoes

Initial Start-Up

Provide power to furnace

- ❑ Confirm that all utility lines are hooked up and open to flow
    - ❑ Confirm that the CRYO PURGE line has a pressurized nitrogen gas source and the regulator is open to flow
    - ❑ Confirm that the BACKFILL line has an pressurized inert gas source (nitrogen or argon) and the regulator is open to flow
    - ❑ Confirm that the GAS BLEED LINE has a pressurized nitrogen gas source and the regulator is open to flow
    - ❑ Confirm that the valve to the SYSTEM AIR line is open to flow
    - ❑ Confirm that all WATER flow gauges show flow (greater than 1-GPM)
    - ❑ Confirm that water temperature is 68°-70°F
    - ❑ Confirm that all utility valves at the furnace ports are open to flow
- ❑ A qualified person must close the 480-V power disconnect (DS-SRF VACUUM FURNACE), located wall that is west of the furnace
- ❑ Move the breaker switch on the furnace's electrical control box to the “ON” position
- ❑ Remove side panel to the right and above the electrical control box to access the UPS
- ❑ Turn on the UPS by pressing the power button twice. On the LED panel on the front of the UPS, verify that the Input and Output readings are 120-V. The furnace’s vacuum gauges and overtemperature control displays will switch on.
- ❑ Place panel back on
- ❑ Turn on the computer and monitor
- ❑ Enter login name and password
- ❑ On the computer Desktop, double click on the “09-1274 Fermilab SS” icon to start the furnace control program
- ❑ At the initial window, click on “Run Program”
- ❑ At the T-M Vacuum logo window of the furnace program, click on “Main”
- ❑ Push the “Emergency Stop” button, then pull it out
- ❑ Push the “System Power” button on the panel to the right of the computer monitor
- ❑ As part of the start-up default, the alarm bell will sound and a message on the computer will show an alarm message regarding system power being off. Push the “Alarm Reset” button on the panel to the right of the computer monitor to acknowledge the alarm.

Automatic Start-Up of the furnace – From a system shutdown, this process starts up the roughing and cryopumps. The cryopumps are pumped to high vacuum pressure and cryogenic temperature.

- ❑ Verify that all valves leading to the chamber are closed as indicated in the operator interface on the computer
- ❑ Verify that the furnace is in “Automatic” mode
- ❑ Click on “Start Up” to begin the pump down process. Follow Section 3.2.1 in the furnace operating manual (Appendix A) for further explanation of the process.
- ❑ When the cryopumps’ temperatures drop below 17°K the Start Up light will go out, and the display will read “Ready - Automatic.”

Purging the BACKFILL and GAS BLEED lines – This needs to be done whenever new sources of gas at the BACKFILL and GAS BLEED lines are connected.

- ❒ Use the Auto Purge feature of the furnace by following Section 3.3.1 of the furnace operating manual (Appendix A).

Operating Procedure to Bake 1.3-GHz SRF Cavities (Fermilab drawing 5520.000-MD-457528)

Note: As good practice, when operator is not at the furnace, at the computer, logoff as "Expert" so that the computer is on "Default"

Set Up Furnace Operation

- ❑ Check that there are no errors shown in chiller's remote control unit (located inside the IB4 cleanroom's anteroom, to the right of the door that leads into the cleanroom)
  - o If there are errors, contact Les Peters
- ❑ Confirm that all utility lines are hooked up and open to flow
  - o CRYO PURGE line
    - ▪ Nitrogen gas source
    - ▪ 25 psig max
    - ▪ Regulator is open to flow
  - o BACKFILL line
    - ▪ <u>If BACKFILL line is connected to a dry air cylinder, switch to an inert gas source (nitrogen or argon).</u>
    - ▪ Inert gas source (nitrogen or argon)
    - ▪ 25 psig max
    - ▪ Regulator is open to flow
  - o GAS BLEED line
    - ▪ Nitrogen gas source
    - ▪ 25 psig max
    - ▪ Regulator is open to flow
  - o SYSTEM AIR line
    - ▪ 70-80 psig
    - ▪ Valve is open to flow
  - o WATER flow gauges show flow (greater than 1-GPM)
  - o Confirm that water temperature is 68°-70°F
  - o Confirm that all utility valves at the furnace ports are open to flow
- ❑ Record date, operator, cavity number, cycle description, soak temperature, and ramp rate on run sheet
- ❑ Enter process run information (cavity identifier, process parameters, etc.) in Elog under the "ICPA/Vacuum_Oven" category, located here:

  http://dbweb3.fnal.gov:8080/ECL/ilc/E/index

Set up Existing Recipe for Baking – follow these steps to load an existing recipe if the recipe that is shown is not the one that will be used

- ❑ On the computer, login as "Expert"
- ❑ In the Main window, click on the title of the program to view/edit the existing recipe
- ❑ At the bottom Toolbar, click on the tab "Edit" to maximize the window showing the recipe
- ❑ If not already, bring up the existing recipe
  - o Under the File menu, click on "Open"
  - o Select name of existing recipe

- Under the File menu, click on "Save to PLC"
- ❑ Close window

Unload the cavity/cavities/hearth from the chamber

- ❑ Prepare cart for use inside oven
  - Wipe surfaces of forks with alcohol wipes
  - Use CR tape to collect pain chips on panel
- ❑ Bring the chamber up to atmospheric pressure
  - Verify that the BACKFILL line is connected to an inert gas source (nitrogen or argon)
  - Set control to "Manual"
  - Click on "Vent Valve" to vent the chamber with inert gas. Venting will end when chamber pressure is greater than 670-mm Hg.
  - Verify that the chamber pressure is 760-mm Hg. If needed, click on "backfill valve" by clicking on it on the computer screen to bring chamber pressure up to 760-mm Hg

    * Note – The chamber will not pressurize greater than 2-psig due to relief valve
  - Verify that all valves are closed
  - Chamber is ready to open.
- ❑ Unlock the door by simultaneously pressing the "Door Lock" button on the panel to the right of the computer monitor and pressing the button on the door.
- ❑ Open the door.
- ❑ Unplug thermocouples (if attached)
- ❑ Line up loading cart in front of the chamber
- ❑ Raise the forks up to rest on the lower mechanical stop (on the cart) so that they are just under level to the furnace hearth
- ❑ Push the loading cart toward the chamber to bring the forks under the hearth
- ❑ Raise the forks up to the upper mechanical stop to lift the hearth off of the rails
- ❑ Pull the loading cart, with the hearth, out of the chamber
- ❑ Close and lock the chamber door
  - Close the chamber door shut
  - Lock the door by simultaneously pressing the "Door Lock" button on the panel to the right of the computer monitor and pressing the button on the door.
- ❑ Lower the forks to desired working height
- ❑ Remove the work piece(s) from the hearth

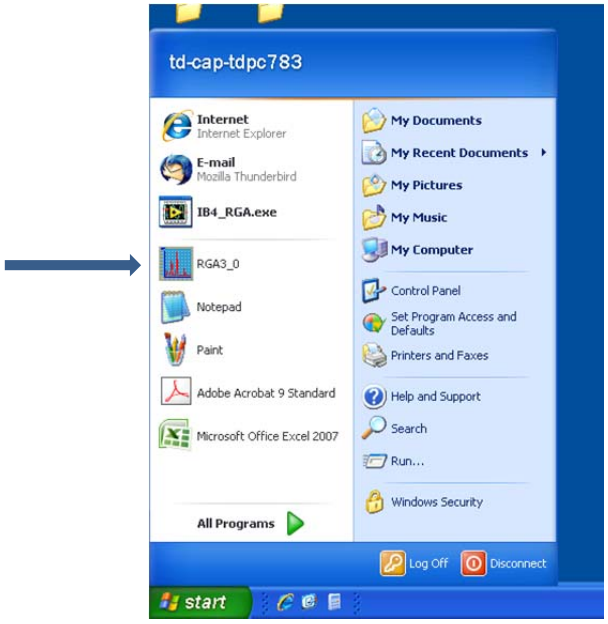
Load the cavity/cavities into the chamber

- ❑ Visually inspect the hot zone, ceramics, and heating elements for any changes.
- ❑ Verify the niobium liner is clean and without damage. Replace if needed.
- ❑ Wipe down all tooling surfaces with ethanol saturated wipers
- ❑ Unload work piece(s) from transport packaging by following approved cavity handling techniques as defined by ICPA Clean Room Area Cavity Handling Procedure OP-464026.
- ❑ Place the work piece(s) on to the hearth
- ❑ Carefully inspect all visible cavity surfaces and note any visible anomaly, including

discoloration, presence of grease or fingerprints, or other markings.
  - Questionable marks or identifiable contamination must be brought to the attention of the engineer responsible for the oven. Do not bake cavity with questionable markings without approval of responsible engineer.
- ❑ Install thermocouples on far and near ends of cavity flanges and in a central location along the length of the workpiece.
- ❑ Open the chamber
  - Unlock the door by simultaneously pressing the "Door Lock" button on the panel to the right of the computer monitor and pressing the button on the door.
  - Open the door.
- ❑ Raise the forks up to the top mechanical stop (on the cart) so that it is just above the rails in the chamber
- ❑ Push the loading cart toward the chamber to bring the hearth into the chamber
  - More sure the thermocouples pass into oven unimpeded
- ❑ Lower the hearth on to the rails by lowering the forks to rest on the lower mechanical stop on the cart
- ❑ Pull the loading cart out of the chamber
- ❑ Plug in thermocouples.
- ❑ Verify that thermocouple wires do not contact any heater elements or the hot zone's thermocouple probes
- ❑ Take photo of hotzone with cavity/cavities and post as attachment in Elog
- ❑ Take photo of shields on door and post as attachment in Elog
- ❑ Close the chamber door

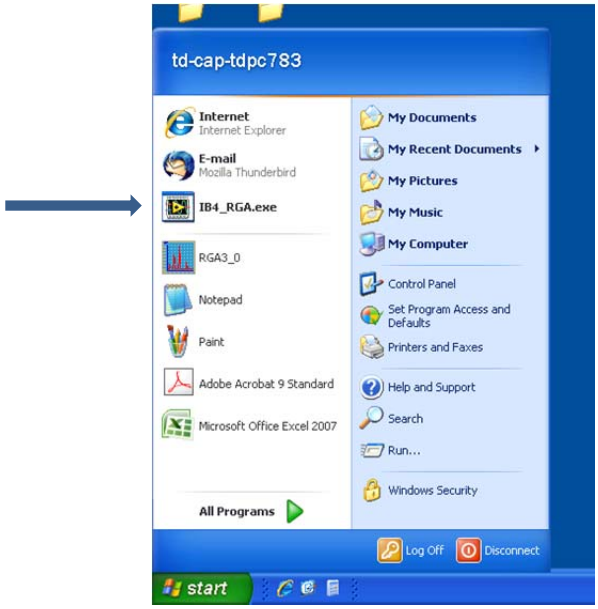
Pump down chamber to high vacuum pressure
- ❑ In the furnace control window, set the control to "Automatic"
  - The status should read "Ready – Automatic"
- ❑ Click on "Auto Pump"

RGA and Data logging startup - Turn on RGA only when chamber vacuum is less than $1x10^{-4}$ torr
- ❑ Confirm that the Baratron gauge reading (line pressure) is less than $1x10^{-5}$ torr or chamber's cold cathode gauge (chamber pressure) is less than $1x10^{-4}$ torr
- ❑ In the furnace control window, Open the RGA Isolation Valve
- ❑ Connect the RGA to the computer.

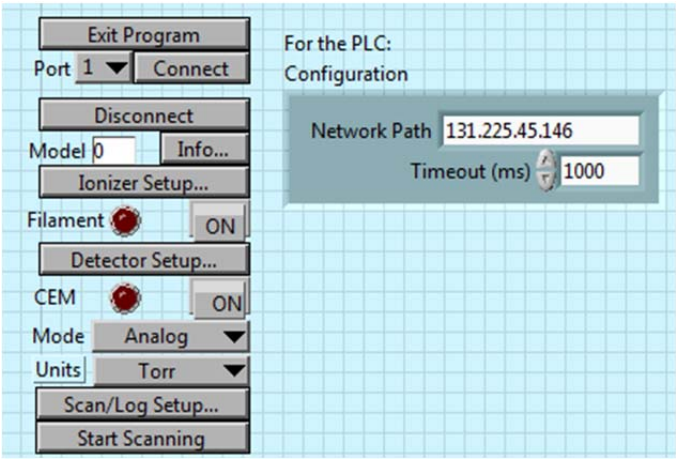


- Go to the Start Menu -> RGA3_0
  - Go to "Head" to pull down a menu
  - Click on "Connector List Setup"
  - Highlight COM1
  - Click "Connect" (upper left hand corner)
  - Click on "Close"
  - Exit the RGA3_0 program

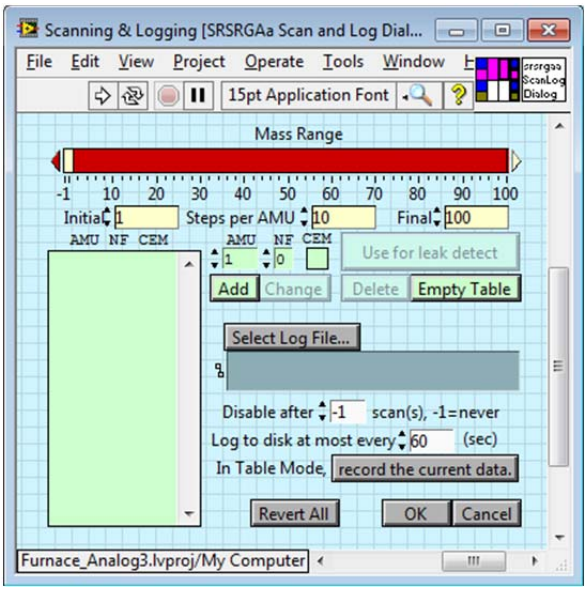
- ❑ Go to the Start Menu and Click on the IB4_RGA.exe to start the LabVIEW program.



- On the LabVIEW main screen (should have buttons such as **Exit Program**, **Connect**, etc.):
  - Select **Connect** to connect to the RGA
  - If blank, enter the proper **PLC IP address** (as shown below).
  - FYI - the **Exit Program** and **Connect** buttons should become grayed and disabled



  - Turn the Filament **ON**.
  - The mode should be **Analog**.
  - The units should be **Torr**.
- Select **Scan/Log Setup…**



  - Type in "100" under the "Final" number of the Mass Range,
  - Select **Select Log File** to choose the location and name the file that the data will be saved in. Verify that the file will be saved on the computer's Desktop.
  - Verify the following: "Disable after **-1** scans."
  - Verify the following: "Log to disk at most every **60** seconds."

- In Table Mode, **record the current data**.
- Select **OK**.

❑ Select **Start Scanning**.

- FYI - Do not change the size of the Analog window as this will rearrange certain objects on the window in an unpleasant manner.
- FYI - It is more than likely that there will be a NaN appearing in one of the cavity temperatures. NaN stands for Not-a-Number. In this case, the NaN simply represents that either the data did not get grabbed by the PLC or, in the special case of the Cavity temperatures, the temperature readings coming in are large enough as to indicate that no thermocouple is being used.
- Colors of the plots may be changed by clicking on the small plot icon >> Color
- Points for the plots may be changed by clicking on the small plot icon >> Point Style

❑ Go to folder where RGA file should be kept and open log file name to verify that it is recording the RGA readings

Bake Cycle

❑ Verify that the cryopumps are on and are at high vacuum pressure
- Each cryopump is colored yellow
- The pressure is < $5x10^{-6}$ torr
- The temperature is <17K

❑ On the computer, login as “Expert”

❑ Set control to “Automatic”

❑ Click on the “Cycle Start”

❑ For details of the procedure, refer to section 4.2 of the furnace’s operating manual (Appendix A).

❑ Once the cycle is complete, the furnace status will read “Ready – Automatic”

Screen shots during the Bake Cycle

- ❑ During the soak segment, upload an image of the Main Operator Interface Screen to the Elog (to record the power output of the heaters)
- ❑ Record an RGA spectrum image at the soak temperature to the appropriate Q:\ICPA Furnace data\Bake Cycles folder
- ❑ Upload the RGA spectrum image at the soak temperature to the Elog
- ❑ At the end of the bake cycle, record an RGA spectrum image to the appropriate Q:\ICPA Furnace data\Bake Cycles folder
- ❑ At the end of the bake cycle, upload the RGA spectrum image to the Elog

During cooldown period

- ❑ The operator can click on "Reset" to prematurely end the program
  - o Verify that the operator is logged in as "Expert"
  - o Click on "Manual"
  - o Click "Hold"
  - o Click "Reset"
  - o Verify that the High Vacuum Valves are still open and the chamber pressure continues to reduce

At the end of the bake cycle

- ❑ In the RGA display graph, when done scanning, select **STOP** on the graph screen.
- ❑ Turn the filament **OFF**.
- ❑ Select **Disconnect** from the main screen. When it is properly disconnected, the previously disabled buttons should appear enabled again.
- ❑ Select **Exit Program**.
- ❑ In the furnace's Main Window, close the "RGA isolation valve"
- ❑ FYI - At the end of the bake cycle, the "Cycle Stop" button will flash. The system will hold until operator clicks "Cycle Stop". When "Cycle Stop" is clicked, the chamber will automatically be vented.

General rules of thumb:

- Other recipes include "800C – 3 hrs" (baking the workpiece at 800°C for 3 hours) and "Burnout 1000C" (baking the chamber at 1000°C for 2 hours)
- The cavity can be handled when cooled to less than 50°C
- When not in use, store molybdenum hearth and niobium liners inside the empty vacuum chamber
- When furnace not in use, pump the vacuum chamber to -29-inHg
- Bake out the empty chamber at 1000°C after every 6-8 uses.
- Regenerate the cryopumps every 1000 hours of operation

Shut down sequence

Shut down the power to the furnace during maintenance of the furnace or its utilities (such as water chiller system).

- ❑ Verify that you are logged in as "Expert"
- ❑ Verify that chamber is in rough vacuum (20-torr)
- ❑ Turn off roughing pump
- ❑ Verify that all valves to the chamber are closed
- ❑ Purge cryopumps with nitrogen
    - o Turn to Manual mode
    - o Turn off cryopumps
    - o While cryopumps are warming up, open the Purge Valves
    - o Verify that the nitrogen is flowing through the cryopumps by checking the flow meters labeled "Purge Lines 1 and 2"
    - o When the cryopumps reach 290°K, close the Purge Valves
- ❑ From the Main screen, click on "Utilities"
- ❑ In the Utilities screen, click on "Exit"
- ❑ Close the RSView window by clicking on the window's X
- ❑ Use the "Start" button to shut off the computer
- ❑ Power down the computer monitor
- ❑ Move the breaker switch on the furnace's electrical control box to the "OFF" position
- ❑ Remove the furnace side panel to access the UPS
- ❑ Hold the UPS power button down until the alarm sounds off. It will take a few seconds for the UPS to power off.
- ❑ Replace the furnace side panel.

Scheduled Maintenance

Monthly Maintenance

1. Visually inspect all electrical switches and contacts and repair as required.
2. Inspect vacuum chamber O-rings for proper sealing.
3. Inspect air, inert gas, and water lines for leaks.
4. Check for oil level in roots pump. Fill as necessary. Refer to Section 5.1 – "Standard Maintenance – Oil Level – Procedure" of the Adixen RSV 151 / 301 / 601 Roots Pump User's Manual
5. Burnout cycle
   - ❑ Follow bakeout cycle steps using the "Burnout 1000C" (baking the chamber at 1000°C for 2 hours) recipe
6. Regenerate cryopumps – Plan for 2-4 hours to regenerate cryopumps
   - ❑ Verify that all valves leading to the chamber are closed
   - ❑ Verify that the furnace is in "Manual" mode
   - ❑ Click on "Cryo Regen" For a list of detailed steps that take place during the process, see Section 6.1 in the furnace operating manual (Appendix A).
   - ❑ When regeneration is completed, the cryopumps will begin pumping down the chamber automatically.
7. Cleanroom maintenance
   - ❑ Refill PPE as needed
   - ❑ Wipe down surfaces in cleanroom
   - ❑ Remove items that do not belong permanently in the cleanroom (boxes, trash, etc.)
   - ❑ Dry or wet mop floor as needed
8. Tabulate rates of rise for each cycle in the month for signs of leaking or dirty system.
   - ❑ Open a blank MS Excel worksheet
   - ❑ For each day a bake out occurred, open the data that the furnace logs, located in the folder C:\RSView\09-1274 fermilab ss12-72-13mcx\DLGLOG\D7162 (file name example "2011 06 07 0000 09-1274 Data (Wide).dbf")
   - ❑ Go to the beginning of the data within Segment 2 of the recipe (column title "5")
   - ❑ Write down the time from the column titled "Time"
   - ❑ Write down the negative voltage signal representing the pressure reading in the column titled "35"
   - ❑ Go the end of the data within Segment 2 of the recipe
   - ❑ Write down the time
   - ❑ Write down the negative voltage signal representing the pressure reading
   - ❑ Convert the voltage signals to vacuum pressure readings (for example, the reading is -4.72):
     - o Take the number to the left of the decimal point and subtract 1. This will give the exponent (in the example, the -4 converts to 10^{-5})
     - o Subtract the two digits to the right of the decimal from 100 and then divide by 100 (in the example, 72 converts to 2.8)

- Combine the two numbers to result in the vacuum pressure reading in torr (for example, 2.8×10^{-5} torr)

- ❑ Calculate rate of rise of chamber pressure (difference in pressure divided by difference in time). To convert torr/minute to microns/minute, multiply by 1000
- ❑ Record in MS Excel worksheet
- ❑ Repeat for all bake out cycles
- ❑ Add MS Excel worksheet to E-Log.

9. Check the count level for the MKS Baratron Transducer when the chamber is at ultra-high vacuum.
   - ❑ Verify that the chamber pressure is less than 5×10^{-7} torr
   - ❑ Click on the pressure reading of the chamber (in between the cryo pumps) to view the "Chamber Vacuum Setpoints" window
   - ❑ If the "Raw Pressure" reads greater than ±20 counts, adjust the ZERO pot of the MKS Baratron transducer
10. Lift maintenance
    - ❑ Grease wheels and casters
    - ❑ Check chain tension. The chain should be tight enough so that it does not come off the roller assembly
    - ❑ Lubricate chain with a rust inhibitive lubricant
    - ❑ Clean and lubricate all roller bearings and cam followers
    - ❑ Check battery terminals. Clean if required.
    - ❑ Check hydraulic cylinder. Clean if required.
    - ❑ Check all welds. Clean if required.
    - ❑ Check wheels for wear and damage.
11. Verify that the cryopump's compressor helium supply pressure is within the range of 240 – 380 psig when the cyropump is in operation.

Annual Maintenance

1. Test the interlock sequence of all safety equipment. Manually make each interlock fail, noting that the related equipment shuts down or stops as required.
   - ❑ Verify that gate valves and the RGA isolation valve shut during unexpected power interruption
     - o Start with cryopumps in normal operating mode and vacuum chamber at a pressure less than $1x10^{-6}$ torr
     - o Set furnace control to "Manual"
     - o Open the cryopumps to the chamber
     - o Open the RGA valve
     - o Turn the furnace's power disconnect (under the printer) to "Off"
     - o Turn the furnace's power disconnect to "On"
     - o Turn computer on
     - o Run furnace's program
     - o Push the "Alarm Reset" button
     - o Verify that the gate valves and RGA isolation valve are closed
   - ❑ Verify the overtemperature interlock
     - o Start with cryopumps in normal operating mode and vacuum chamber at a pressure less than $1x10^{-6}$ torr
     - o On the
   - ❑ Verify that the closing of the water flow switch triggers safety interlocks
     - o Start with cryopumps in normal operating mode and vacuum chamber at a pressure less than $1x10^{-6}$ torr
     - o Run program "InterlockTest" (which runs the oven temp to 100°C for an hour)
     - o Set furnace control to "Manual"
     - o Open the cryopumps to the chamber
     - o Open the RGA valve
     - o Close the hand valve of the water supply line
     - o Open the hand valve of the water supply line
     - o Push the "Alarm Reset" button
     - o Verify that the heaters shut off and the valves closed
2. Test pressure relief valves and clean if necessary.
   - ❑ Start with the vacuum chamber at atmospheric pressure
   - ❑ Verify that all valves closed
   - ❑ Switch to Unsafetied mode
   - ❑ Run program "ReliefValveInterlockTest" (in parameter window, backfill pressure setpoint at 890-torr = 2.5-psig)
   - ❑ Open backfill valve
   - ❑ Allow argon to purge through the relief valve for 3 minutes
   - ❑ Close backfill valve
   - ❑ Vent chamber by opening manual valve on roughing line (behind furnace) until chamber is at atmospheric pressure
3. Operate all valves once a month to insure proper opening and closing

Other Periodic Maintenance

1. Change oil in Roots Blower every 5000 operating hours. Operating hours are logged by the furnace and displayed in the Preventative Maintenance Timers window of the furnace's OIT (Operator Interface Terminal on the computer monitor). Refer to Section 5.1 – "Standard Maintenance – Oil Level – Procedure" of the Adixen RSV 151 / 301 / 601 Roots Pump User's Manual.
2. For the Dry roots pump, complete pump maintenance which includes oil draining and replacement, bearing replacement, and seal replacement every 22,000 operating hours or 4 years. Operating hours are logged by the furnace and displayed in the Preventative Maintenance Timers window of the furnace's OIT (Operator Interface Terminal on the computer monitor). Following the Maintenance Instructions in Chapter D of the Adixen ACP 15 / 28 / 40 Series 2 Dry Primary Pumps User's Manual, the complete maintenance must be performed by the manufacturer's trained personnel.
3. Check the vacuum chamber vessel for evidence of hot spots indicating improper water cooling by looking for discoloration inside the chamber.
4. Examine furnace internals in detail for heating element, heat shield, work support, or mechanism deterioration or failure.
5. Lubricate motors, drives, valves, blowers, compressors, pumps, etc., as required.
6. With brush or other device remove major build up of oxides and contamination from the hot zone and accessible areas of the cold wall chamber. Blow out contamination with dry air or nitrogen.
7. Clean anode of cold cathode gauges as needed. Refer to Televac electronic document "7FC SPECIFICATION CLEANING SHEET.pdf"
8. For the Compressors of the Cryopumps, the compressor adsorber must be changed every 30,000 operating hours. Contact the Service Center of Sumimoto (SHI) Cryogenics for field service (refer to the Operating Manual for the F-70H Helium Compressors for CP Series Cryopumps).
9. For the Compressors of the Cryopumps, if the helium supply pressure during operation falls below 240 psig, charge helium supply line:
    a. Turn off cryopump that is connected to the compressor that will be charged
    b. Items needed:
        i. Adapter fitting with valve, Sumitomo P/N 253757B
        ii. Helium supply, 99.999% pure
        iii. Regulator and charge line for helium supply cylinder
        iv. Open end wrenches
    c. Connect the adapter fitting to the line coming from the helium gas cylinder
    d. Attach the adapter fitting to the helium supply port on the compressor
    e. Charge the system with helium gas to the equalization pressure of 140 – 220 psig
    f. Close the valves on the adapter fitting and on the gas cylinder
    g. Disconnect the adapter fitting from the compressor
    h. Disconnect the charge line from the adapter fitting

10. For the Cold Heads of the Cryopumps, if the cryopump is operating at 15K, the cold head must be serviced. Contact the Service Center of Sumimoto (SHI) Cryogenics for field service (refer to the Marathon CP-16 Cryopump - Technical Manual of Sumitomo (SHI) Cryogenics).
11. Every 2-3 years, or as needed, replace the

Note: Operating manuals for all systems of the furnace are kept in the binders at the furnace. Electronic copies of all manuals are stored on the server:

Q:\Vacuum_furnace_for_SCRF_cavities\Small-oven\operating_instructions \Vendor_Manuals

Material Restrictions

Here is a list of materials that are allowed in the furnace:

- Niobium – ultrasonically cleaned, rinsed with distilled water, dried with clean inert gas or air; chemically polishing after the ultrasonic cleaning and rinsing is acceptable
- Titanium – Grade 1 or grade 2 commercially pure titanium; alloys of grade 1 or grade 2 titanium (e.g. Nb55Ti); grade 5 (Ti6Al4V) and grade 9 (Ti3Al2.5V) titanium in small quantities less than a total mass of 1-kg
- Threaded material – only in short lengths of no more than 1.5-inches

Here is a list of materials that are NOT allowed in the furnace unless explicitly permitted by the responsible engineer:

Metals:
- Steels, Stainless steels, Carbon steels, tool steels
- Nickel alloys, Chrome alloys
- Parts containing cobalt, or manganese
- Copper or copper alloys (brasses, bronzes)
- Silver or silver alloys
- Aluminum or aluminum alloys
- Any materials (e.g. fluxes, brazing agents) containing tin, lead, bismuth, gallium, cadmium, mercury, Alkali metals, or Alkaline Earth metals

Forms of materials:
- Powders or sponge (i.e. pressed and lightly sintered powders)
- Long threaded rods (lengths greater than 1.5-inch)
- Expanded metal
- Materials with un-welded seams (bolted flanges, press-fits, etc.)
- Surfaces with deep gouges
- Rough or discolored surfaces

Non-metals of any kind, including:
- Ceramics
- Glasses
- Boron or boron nitride
- Graphite

Appendix A

INSTALLATION AND OPERATING INSTRUCTIONS

SUPER SERIES VACUUM FURNACE

MODEL SS12/72-10MCX
SERIAL No. 09-1274

Manual No. D-7162_02 April, 2011

T- M Vacuum Products Inc.
Cinnaminson, NJ 08077
(856) 829-2000
FAX: (856) 829-0990
E-mail: info@tmvacuum.com

SAFETY CONSIDERATIONS

This instruction manual is designed to aid you throughout the working life of the unit. How well it aids you depends on how thoroughly you read and make reference to it. Since the warranty does not cover damage resulting from abuse, or errors in installation, set-up, or operation, it is to your advantage to read this manual, in addition to all provided component manuals, as comprehensively as possible. Observe all Warnings and Cautions to minimize serious hazards involved. Carelessly or improperly operated equipment can cause serious injury or death to personnel and damage to the equipment and/or facilities.

This system is a complex piece of equipment composed of several different fully integrated mechanical, electrical, pneumatic, and vacuum systems. This system has its own unique requirements regarding power, gases, water, air, and vacuum services. Specific safeguards and safety features are engineered into the system. Do not defeat or override these safety devices in any way. T-M Vacuum Products, Inc has no control over the use of the equipment and is not responsible for injury or damage resulting from its misuse.

The safety and emergency procedures in this manual are provided to help suitably trained users, and other qualified personnel, to install, operate, and service the unit safely. It is the responsibility of the user to maintain safe operating conditions at all times. The consequences of unskilled, improper, or careless operation of the equipment can be serious, even deadly.

It is the sole responsibility of the user of the equipment to comply with all local, state, and federal safety requirements, laws, and regulations applicable to the system. The safe use and disposal of hazardous or potentially hazardous materials, of any kind, is the responsibility of the user.

All users of this system should be alert to several levels of hazard presented in this manual, identified as follows:

WARNING!!!

Warnings indicate situations where failure to observe instructions or procedures may cause injury or death to operating personnel.

CAUTION!!!

Cautions indicate situations where failure to observe instructions could result in significant damage to equipment and/or facilities.

SAFETY SUMMARY

The following are general safety precautions that are not related to any specific procedures. They are recommended precautions that personnel must understand and apply during many phases of operation and maintenance.

WARNING!!!
High voltage is used in this equipment, high enough to kill through electrical shock. Always break the primary circuit to the power supply before working on the system. Do not attempt to replace components or make adjustments on the unit with the high voltage turned on.

WARNING!!!
Do not service or adjust this equipment alone under any circumstance. Always have someone present who is capable of offering assistance and rendering aid.

WARNING!!!
Under no circumstance should personnel enter the vacuum chamber without first guarding against accidental entrapment inside the chamber (securing the door in the open position).

WARNING!!!
Do not use flammable or explosive liquids, solids, or gases, or any material with the potential to become flammable or explosive, in or around the equipment.

WARNING!!!

Use only safety approved equipment. When cleaners or primers are being applied, use explosion proof lights, blowers, and other equipment. Keep cleaners in approved containers in minimum quantities. Discard soiled cleaning cloths into safety cans. Insure that firefighting equipment is readily available and in working order.

WARNING!!!

This vessel and its components are designed for vacuum and limited pressure service. It is not designed to be over-pressurized for testing or any other purpose. This could cause the vessel or its components to burst, possibly expelling sharp pieces at deadly speeds.

WARNING!!!

Water used to cool the system can reach scalding temperatures. Touching or rupturing the cooling system can cause serious burns.

CAUTION!!!

Acetone and other solvents degrade O-ring material, reducing its ability to hold a vacuum. Do not use any solvent on the O-rings. If it is necessary to clean an O-ring, wipe with a clean, lint free cloth, mild detergent and water, or a small amount of pump oil.

TABLE OF CONTENTS

1. INTRODUCTION 9

1.1 GENERAL DESCRIPTION 9

1.2 SPECIFICATIONS 9

2. INSPECTION & INSTALLATION 11

2.1 INSPECTION 11

2.2 INSTALLATION & ASSEMBLY 11

2.2.1 Positioning and Leveling 11

2.2.2 Removal of Shipping Bolts 12

2.3 SERVICE CONNECTIONS 12

2.3.1 Power 12

2.3.2 Air 12

2.3.3 Water 12

2.3.4 Drain 14

2.3.5 Water Jacket Relief Drain 14

2.3.6 Inert Gas 14

2.3.7 Vent 14

3. START UP 15

3.1 INITIAL START UP 15

3.1.1 Pump Rotation 15

3.1.2 Instrument Configuration 15

3.2 NORMAL START UP 16

3.2.1 Automatic 16

3.2.2 Manual 16

3.3 PURGING OF INERT GAS LINES 16

3.3.1 Auto Purge 17

3.3.2 Manual Purging 17

3.4 QUICK START 19

4. NORMAL OPERATION 20

4.1 PRECAUTIONS 20

4.2 AUTOMATIC 20

4.2.1 Preparation 20

4.2.2 Operation 21

4.2.3 Power Failure Recovery 22

4.2.4 Auto Pump and Auto Vent 22

4.3 STANDBY 22

4.4 MANUAL 22

4.4.1 General 22

4.4.2 Safetied Manual 22

4.4.3 Auto Manual 23

4.4.4 Unsafetied Manual 24

5. SHUT DOWN 25
6. CRYO REGENERATION 26
6.1 GENERAL 27
7. ALARMS 27
7.1 POWER 28
7.2 AIR 28
7.3 WATER 28
7.4 BACKFILL GAS SOURCE LOW 29
7.5 BATTERY LOW IN THE PLC 29
7.6 FAILURE OF VACUUM GAUGE 29
7.7 FAILURE OF BARATRON PRESSURE TRANSDUCER 29
7.8 FAILURE OF THE HEAT'S SCR 29
7.9 THERMOCOUPLE FAILURE 30
7.10 OVER TEMPERATURE ALARMS 30
7.10.1 Furnace Over Temperature Controller 30
7.10.2 Over Temperature Of The Chamber Shell 31
7.10.3 Over Temperature Of The Power Feedthrus 31
7.10.4 Over Temperature Of The Control Thermocouples 31
7.10.5 Over Temperature Of The Work Thermocouple 31
7.11 VACUUM ALARMS 31
7.11.1 Rough Pump Failed to Reach Vacuum 31
7.11.2 Vacuum In Cryo Pump 32
7.11.2.1 Time To Pressure 32
7.11.2.2 Rise In Pressure 32
7.11.3 Vacuum In Chamber 32
7.11.3.1 Time To Rough Vacuum 32
7.11.3.2 Time To High Vacuum 32
7.11.3.3 Rise In Pressure 32
7.11.4 Leak Rate Test 32
7.12 CHAMBER OVER PRESSURE 33
7.13 ROUGH PUMP 33
7.14 BLOWER 33
7.15 CRYO PUMP 33
7.16 THE CHAMBER DOOR IS OPEN 33
7.17 HIGH VACUUM VALVE FAILED TO OPEN OR CLOSED 33
7.18 PREVENTATIVE MAINTENANCE ALARMS 34
8. PUMP & VALVE INTERLOCKS 35
8.1 ROUGH PUMP 35
8.2 BLOWER 35
8.3 CRYO PUMP 1 35
8.4 CRYO PUMP 2 35
8.5 CRYO 1 REGEN VALVE 35
8.6 CRYO 1 PURGE VALVE 36
8.7 CRYO 1 HIGH VACUUM VALVE 36

8.8 CRYO 2 REGEN VALVE 36
8.9 CRYO 2 PURGE VALVE 36
8.10 CRYO 2 HIGH VACUUM VALVE 37
8.11 ROUGH VALVE 37
8.12 VENT VALVE 38
8.13 HEAT 38
8.14 BACKFILL VALVE 38
8.15 GAS BLEED VALVE 39
8.16 RGA ISOLATION VALVE 39
8.17 DOOR LOCKS 39
OPERATOR INTERFACE SCREENS 41
9.1 T-M LOGO SCREEN 41
9.2 MAIN 41
9.2.1 Pop Up Screens 43
9.2.1.1 Rough Pump Setpoints 43
9.2.1.2 Blower Setpoints 44
9.2.1.3 Cryo Pump Setpoints 45
9.2.1.4 Cryo Pump Vacuum 47
9.2.1.5 Cryo Pump Port Setpoints 47
9.2.1.6 Chamber Vacuum Setpoints 48
9.2.1.7 Vent Setpoints 50
9.2.1.8 Backfill Setpoints 50
9.2.1.9 Heat Setpoints 51
9.2.1.10 Heating Zone Controllers 52
9.2.1.11 Water System 53
9.2.1.12 Work Thermocouples 54
9.2.1.13 RGA Isolation Setpoints 54
9.2.1.14 Auto Purge Setpoints 54
9.2.1.15 Operator Input 55
9.3 TREND SCREEN 57
9.4 SURVEY SCREEN 58
9.5 UTILITIES 59
9.5.1 View Furnace Programs 60
9.5.1.1 File Options 60
9.5.1.2 View Options 61
9.5.2 Edit Furnace Programs 61
9.5.2.1 File Options 61
9.5.2.2 Edit Options 62
9.5.2.3 Segment Editing 62
9.5.2.4 Parameters 1 65
9.5.2.5 Parameters 2 68
9.5.3 Edit Program Defaults 68
9.5.4 Furnace Data 69
9.5.5 Auxiliary Setpoints 72
9.5.6 Preventive Maintenance Timers 74
9.5.7 Thermocouple Input Calibration 75
9.5.8 Thermocouple Calibration Offsets 76
9.5.8.1 Thermocouple Calibration Offsets 1 76
9.5.8.2 Thermocouple Calibration Offsets 2 77
9.5.9 Alarm Screens 77

9.5.9.1 Alarm Summery 78
9.5.9.2 Alarm Viewer 79
9.6 SECURITY 80
10. TROUBLE SHOOTING AND MAINTENANCE 82
10.1 VACUUM SYSTEM 82
10.1.1 General 82
10.1.2 Mechanical Vacuum Pumps 82
10.1.3 Cryo Pumps 82
10.1.4 Vacuum Valves 83
10.2 POWER SUPPLY 83
10.3 SENSORS 83
10.3.1Thermocouples 83
10.3.2Vacuum Gauge Tubes 83
10.4 INSTRUMENTATION 84
10.5 INTERLOCKS AND ALARMS 84
10.6 COOLING 84
10.7 CONTINUOUS MAINTENANCE CHECK LIST 84
10.8 SHIFT MAINTENANCE CHECK LIST 84
10.9 WEEKLY MAINTENANCE CHECK LIST 85
10.10 MONTHLY MAINTENANCE CHECK LIST 85
10.11 PERIODIC MAINTENANCE CHECK LIST 85
11. REQUIRED DRAWING 87
12. EXAMPLE TEMPERATURE PROGRAMS 88
12.1TYPICAL CYCLE 88
12.2BURN OUT 90
13. INSTRUMENT CONFIGURATION 92
13.1UDC120L #DC120L-1-0-0-0-1-0-0-0 FURNACE OVER TEMPERATURE 92

1. INTRODUCTION

1.1 General Description

The T-M Vacuum Products' Super Series X Vacuum Furnace System is a current, state of the art furnace having the optimum in control, temperature uniformity, work zone utilization, program conformance, and cool down. The furnace is complete in every respect, incorporating vacuum furnace, vacuum pumping system, programmable microprocessor based controls and instrumentation, current proportioning power supply, and quick cool system.

The SS12/72-10CM X furnace has a usable work zone of 12 × 12 × 72 inches surrounded by six layers of molybdenum reflective insulation, backed by a stainless steel containment. The molybdenum hearth is capable of supporting a maximum evenly distributed workload of 200 pounds. With 180,000 watts of heating power, the furnace is capable of a maximum operating temperature of 1000 degrees C (1832ºF) in vacuum. Actual heating is done by 18 low voltage molybdenum strip heaters. The entire hot zone is removable to facilitate maintenance.

The chamber and door are double walled for the circulation of cooling water and are constructed of stainless steel to avoid corrosion.

Pumping System

Vacuum for the unit is achieved and maintained by means of a dry mechanical roughing pump and a cryogenic pump. Also included in the pumping system are all necessary valves and piping. The system is helium mass spectrometer leak checked at a sensitivity of 2×10^{-9} std. cc/sec. until there is no indication of inleakage.

Controls

The entire system can be operated from a single control panel. The heart of the controls is a Allen-Bradley SLC 500™ programmable controller that is replacing the equivalent of some 1000 relays, timers, and counters. Connected to this are all the various pushbuttons, switches, status lights, valves, and sensors for pressure, temperature, and flow. The temperature profile programs for the system are entered and monitored on the Operator Interface Terminal (OIT). Also included are five Honeywell UDC-120L over temperature controllers that will automatically shut down the heat should the furnace exceed some user preset temperature.

1.2 Specifications

Vacuum Furnace Hot Zone:

- **Hot Zone Size:** 12" wide × 12" high × 72" deep. Cylindrical, horizontally oriented, front-loading. Total zone is usable and uniform in temperature.
- **Maximum Operating Temperature (continuous):** 1000°C (1832°F), in vacuum or backfilled to 1 Torr.
- **Workload Capacity At Maximum Temperature:** 200 pounds

- **Heating Elements:** 2" wide molybdenum strips completely surrounding the zone. Provides low watt density for optimum temperature uniformity.
- **Hot Zone Thermal Insulation:** Six layers of molybdenum reflective shields, backed by a stainless steel containment.
- **Hearth:** Rugged molybdenum rails running front to back. Work dimensions are 12" wide × 72" long.

Vacuum Pumping System:

- 16" ASA pump port flange on chamber.
- High Vacuum Valve: HVA 16" gate valve.
- Cryo Pump: Sumitomo, Inc. Marathon CP-16. Net pumping speed is 4800 l/s air.
- Roughing Pump: Alcatel Model ACP 120 (66 cfm).

Operating Pressure Range:

- High vacuum to 2 psig (860 Torr).
- Working pressure at maximum temperature: high vacuum to 1 Torr.

2. INSPECTION & INSTALLATION

2.1 Inspection

Every effort is made to insure that the system is packed properly. However, rough and/or careless handling in transit occasionally results in shipping damage. In such cases, the carrier is responsible for the damages. First, carefully inspect the outside of all shipping containers for shipping damage. If shipping damage is found, stop and immediately contact the carrier. Save the shipping container and the packing materials if making a damage claim.

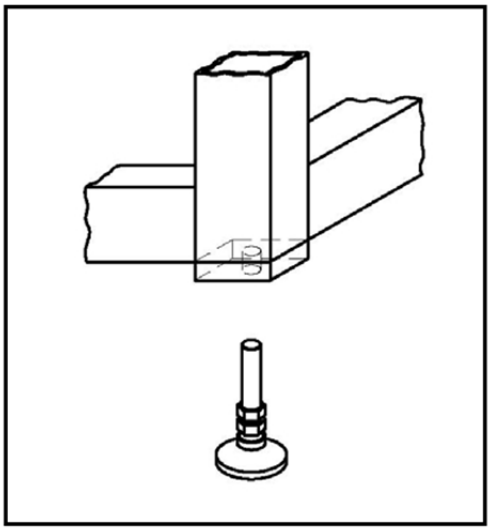
2.2 Installation & Assembly

WARNING!!!

This equipment and its parts are big and heavy. Always use power assisted equipment and trained moving / installing personnel to avoid dropping, slipping or overturning which could kill or seriously injure the inexperienced worker.

2.2.1 Positioning and Leveling

To remove the system from the skid, first take out the six shipping bolts located under the skid. Once this is done, the system may be removed and located in the desired position. Note that the chamber side of the unit is the heavier side, so if using a fork lift, pick the system up from the chamber side. Insert the six leveling legs into the threaded sockets located in the base of the unit, and level it using the top as a reference surface.



2.2.2 Removal of Shipping Bolts

The swivel control cabinet has been bolted down for shipment and should be freed at this time. To do so, first open the back of the control cabinet, and then remove the shipping bolt and packing material holding the cabinet in place. All other packing material found in the cabinet may also be removed at this time.

2.3 Service Connections

2.3.1 Power

WARNING!!!
This equipment operates at **HIGH VOLTAGES** that are high enough to kill through electrical shock. Always break the primary circuits of the power supply when direct access to an electrical cabinet is required.

A source of electrical power for the system should be brought into the top of the high voltage cabinet located on the lower right hand side of the system. Connect power to the top of the circuit breaker located within this cabinet. Consult the electrical schematic (drawings #D-7162 sheets 1 - 12) for power requirements and wiring details.

2.3.2 Air

A source of compressed air is required by the system to operate the various pneumatic valves and cylinders. Connect a supply of air to the coupling provided on the lower left hand side of the system cabinet. Air should be supplied at a pressure between 80 and 100 psig with a minimum capacity of 2 cfm. Consult the piping schematic (drawings #D-7163) for air requirements and piping details.

2.3.3 Water

WARNING!!!
The water used to cool the system can reach scalding temperatures. Touching or rupture of the cooling system can cause serious burns.

Water is required by the system to cool its various components. These water system requirements are for general example only to accommodate:

1. Furnace cooling during heating cycle and quick cooling if applicable an andy pumps or additional equipment requiring water cooling.

2. Heat removal capacity required: T-M Vacuum can provide specific requirements for sizing.

3. Water temperature to furnace: 60-80°F. Exit temperature will vary according to flow and heat load, flow requirement is based on nominal 40°F delta T. Inlet temperature can be higher if the high vacuum pump is on a separate circuit to provide 60-80°F nominal water.

4. See piping schematic for specific flow requirements. Flow will vary from zero gpm to maximum during cycle. A water system must be designed to accommodate zero flow with a bypass system or other means to prevent harm to water system or furnace.

5. Pressure: 40-50 psig nominal to furnace, with little or no pressure at drain with vented collection tank to allow steam to escape from quick cool system. Cooling water heat removal is an estimate based on an average during the cool down time period. Actual rate could spike considerably above average. It is recommended that a large enough collection tank be provided to prevent overload of cooling system and asorb this additional heat.

6. Maximum static pressure: 50 psig nominal at the furnace. A minimum of 30 psig dileta P normal is required so back pressure should not exceed 10 psig.

7. Water should be clean and free of sediments. T-M provides a strainer of 20 mesh (.034"). The water supplied to the system should have a pH value of between 6.0 and 8.0 and a calcium carbonate concentration of less than 75 paerts per million (typical municipal drinking water quality). A non-automotive ethylene glycol up to 50% mix is permissible (use minimum required). Propylene glycol can also be used if low toxicity is desired. De-ionized water is desirable but not required.

8. Heat to room: for standard units it is minimal since system is water cooled. However if HVAC heat load is critical each system should be considered individually.

9. Type of water cooling systems: air to water, water to water, water tower evaporative or similar is recommended. Refrigerated systems are not recommended unless able to tolerate high return water temperatures.

10. It is recommended that before a cooling system is designed all operating conditions related to a particular furnace be considered. These can be obtained from the information provided on assembly and piping diagram when furnace design is finalized.

11. It is strongly recommended that a backup cooling system be provided.

12. Piping to and from the furnace must properly sized and be of a non corrosive material.

13. This is general information only and specifics for each unit must be considered for water system design.

Connect a source of cooling water to the two couplings provided on the lower left-hand side of the system cabinet. Water for the furnace should be supplied at a minimum flow rate of 32 gpm, a pressure of 40 to 50 psig, and a temperature of between 60 and 80°F. Consult the piping schematic (drawing #D-7163) for piping details.

2.3.4 Drain

CAUTION!!!
Back pressure in the drain line can cause rupture of the cooling lines and/or the chamber shell.

Connect a water drain line to the coupling provided for the furnace. This drain should be free and open with little or no back pressure. If a valve is desired to control the water flow, it should be incorporated in the water inlet line. **Under no circumstance should a valve be put in the drain line.**

2.3.5 Water Jacket Relief Drain

The furnace chamber water jacket is equipped with a 50 psig pressure relief valve to protect the chamber from collapse. This valve has been plumbed to a coupling located next to the water inlet and drain couplings. This drain must be free and open. **Under no circumstance should this coupling be connected to a closed water system.**

2.3.6 Inert Gas

CAUTION!!!
High pressure and/or unregulated gas sources can cause damage to the valves and/or gas lines. Under no circumstances should a high pressure or unregulated gas source be connected to the system.

Connect a supply of inert gas to the couplings provided for Backfill, Gas Bleed, Sieve Trap Bleed and Regen Gas. Consult the piping schematic (drawing #D-7163) for gas requirements and piping details.

2.3.7 Vent

If it is desired to vent the furnace chamber with inert gas, a coupling has been provided for this purpose. Gas connected to this coupling should be supplied at a maximum pressure of ½ psig, with a flow rate of approximately 21 cfm. Consult the piping schematic (Drawing #D-7163) for vent requirements and piping details.

3. START UP

3.1 Initial Start Up

To start up the system for the first time, first turn on all service connections, i.e. power, water, air, etc., at their source. Next, turn on the power by turning on the main power disconnect switch, located on the lower right hand side of the system cabinet. Then turn on the system's uninterruptable power supply (UPS) located behind the control cabinet by pressing its power button. Turn on the computer's monitor with its pushbutton. Once the computer has booted it should automatically run the RSView32 application. If it does not, RSView32 can be started manually by double clicking the desktop icon labeled "09-1274 fermilab ss12-72-13mcx" and then clicking on the Run Project button once RSView32 starts. Finally pull out the Emergency Stop button and press the System Power button. Within one second of doing this, the alarm bell will begin to ring and the OIT's Alarm Banner will display the message "The main power was off". To reset the alarm condition, simply depress the pushbutton marked ALARM RESET.

3.1.1 Pump Rotation

CAUTION!!!

The rough vacuum pump is equipped with a **THREE PHASE MOTOR** and its direction of rotation must be considered. Operating this pump in the wrong direction for prolonged periods can cause severe damage to the pump.

At this time the mechanical vacuum pump should be checked for proper rotation according to their owner's manuals. To do so, first put the system into the MANUAL mode, then turn on the Rough Pump with its button and observe the pump motor's direction of rotation. If it is incorrect, shut off the main power disconnect switch, open the door of the high voltage cabinet, and exchange any two of the wires leaving the motor starter connected to the pump in question. After the change has been made, repeat the above procedure to confirm that rotation is correct.

3.1.2 Instrument Configuration

Check that the Honeywell UDC120L Over Temperature controller is configured per section 13.1.

Once these steps have been taken the system is ready for normal Start Up.

3.2 Normal Start Up

3.2.1 Automatic

To start the system up, first put the mode selector in either the MANUAL or AUTOMATIC position, and then click the button marked START UP. Upon doing so the Start Up button will light up, the message "The System Is In Start Up" will be displayed, and the Rough Pump will come on. After the Rough Pump reaches its Ready Vacuum level (200 microns, section 9.2.1.1), the Regen Valves will open to evacuate the Cryo Pump to its Cryo Pump Base Vacuum level (50 microns, section 9.2.1.2). If the Cryo pressure cannot reach 50 microns two hours after the Regen Valve opens, the alarm bell will sound and the start up sequence will halt. Once the Cryo Pump reaches 50 microns, the Regen Valve will close and the rate of rise of the vacuum level will be monitored for thirty seconds. If the rate of rise is more than 10 microns/minute, the Cryo will be pumped to 50 microns again followed by another rate of rise test. Once the rate of rise test has been passed the Cryo Pump will turned on. When the pump's temperature drops below 17°K the Start Up light will go out, and the display will read Ready - Manual or Ready - Automatic depending on which mode the system is in.

Note: If the system is in the manual mode while Start Up is in progress, pressing any of the manual buttons on the graphic panel will abort Start Up and leave the system in the MANUAL MODE.

3.2.2 Manual

To start the system up manually, proceed as follows:

1. Put the system into the manual mode by clicking on the MANUAL button (a security level of "K" is required for this).
2. Depress the pushbutton marked ROUGH PUMP to turn on the Rough Pump.
3. Open the REGEN VALVE with its pushbutton. Observe the Cryo Pump pressure.
4. Allow the Cryo Pump's vacuum level to go below 50 microns then close the Regen Valve and monitor the leakup rate. The cryo pressure should not rise above 100 microns in five minutes.
5. When the leakup rate of the Cryo Pump is acceptable, turn on the CRYO PUMP with its button and allow time for it to cool down below 17° Kelvin.

After the Cryo Pump has cooled down the system is ready to be operated manually or automatically.

3.3 Purging Of Inert Gas Lines

The following instructions cover the purging of the inert gas backfill lines. This must be done before the initial use of the furnace, and whenever a new source of gas is connected. Failure to do so could result in severe damage to the furnace hot zone due to oxidation.

CAUTION!!!
Purging of the backfill lines should never be done while the furnace is hot. Failure to do so could result in severe damage to the furnace hot zone due to oxidation.

3.3.1 Auto Purge

Located on the control panel is a button marked AUTO PURGE that can be used to automatically purge the gas backfill lines with a minimum amount of operator interaction. If pushed while in the Ready - Automatic or Ready - Manual mode, the Auto Purge will be initiated and the message "Establishing A Base Pressure" will be displayed. At this time the furnace chamber will be pumped down to 10 Torr (Auto Purge Base Pressure, section 9.2.1.11). Once this vacuum level is achieved, the Backfill and Gas Bleed valves will open, the message "Checking If The Gas Source Is On" will be displayed, and furnace pressure will be monitored for five minutes to insure that the gas source has been shut off. If the chamber exceeds 100 Torr during this time, the Backfill and Gas Bleed valves will close, and the operator will be directed to shut the gas source off and press the "Auto Purging Of Gas Lines In Progress" will appear and the chamber and the gas lines will be pumped to the current Program Start Vacuum level (section 9.5.2.4). When this pressure is reached, the High Vacuum Valve will close, and the operator will be directed to turn the gas source on. When a pressure of 100 Torr is reached (Auto Purge Fill Pressure, section 9.2.1.11), the Auto Purge cycle is complete.

3.3.2 Manual Purging

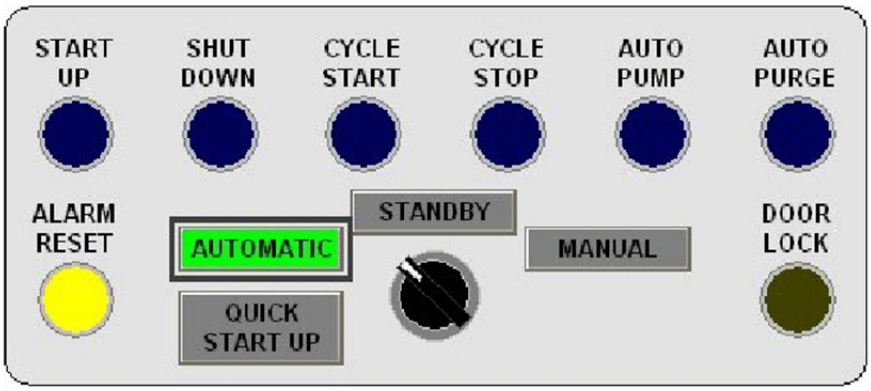
Manual purging of the gas lines should only be attempted by qualified personnel since improper manual operation could be harmful to the furnace's pumping system.

1. All gas supplies should be valved off at their source.
2. With the chamber door closed, and the system in the Ready - Manual condition, open the
3. ROUGH VALVE by pressing its pushbutton.
4. Enter the Unsafetied Manual mode (see section 4.4.4 for discussion of Unsafetied Manual)
5. Open the BACKFILL VALVE by clicking its buttons.
6. Open the GAS BLEED VALVE and open its needle valve.
7. At this point the furnace and all the inert gas lines are being evacuated by the Rough Pump.
8. When the unit reaches a pressure of about 100 microns (1.0×10^{-1} Torr), close the ROUGH VALVE, allowing approximately two seconds for it to do so.

9. Open the HIGH VACUUM VALVE.
10. When a pressure of 5.0×10^{-5} Torr is reached, close all the gas valves by again pressing their respective pushbuttons. If this pressure cannot be reached in a reasonable amount of time (one hour), check for possible leaks in the gas lines to the system.
11. Return to the safetied manual mode (Ready - Manual). Close the HIGH VACUUM VALVE.
12. Turn on the inert gas source.

3.4 Quick Start

In the event of a power failure, or for purposes of maintenance, it may be necessary to bring the system up to a READY condition without the time delays. To do so, first put the mode selector in the AUTOMATIC position, and then click on the QUICK START button on the OIT's main screen. Note that this can only be done if he logged in user has the proper security code. At this point the system may be operated normally in the automatic mode. Keep in mind that this procedure does not guarantee that the Cryo Pump will be at its normal operating temperature, or even that it has been properly evacuated. For this reason, the Quick Start procedure should only be used by qualified personnel.



Note: The logged in user must have a security code of "L" to use this mode.

4. NORMAL OPERATION

This system should normally be operated in the automatic mode. Only qualified personnel should do operating in the manual mode since improper manual operation could be harmful to both the workload and the system.

4.1 Precautions

1. The unit should never be operated without all services being connected and on.
2. Be sure the rotation of the mechanical vacuum pumps is correct per the pump owner's manuals.
3. The unit should be left under vacuum when not in use.
4. Turning on the Heat with room air in the chamber should never be attempted.
5. The furnace hot zone should not be exposed to atmosphere if its temperature is above 150 degrees C (300°F).
6. Be sure that a supply of inert gas is connected to the proper inlet coupling and that the gas lines have been purged. Failure to do so could result in severe oxidation of the furnace hot zone and the workload.
7. Purging of the inert gas lines should not be done if the furnace temperature is above 150 degrees C (300°F).
8. All materials placed in the furnace should be carefully checked for vapor pressure at maximum operating temperature. Failure to do so could result in the severe contamination of the system.
9. All materials placed in the furnace should be thoroughly degreased and cleaned.
10. Type 'K' thermocouples should not be used in a temperature cycle exceeding 1093 degrees C (2000°F) due to their tendency to lose calibration above this temperature.

4.2 Automatic

Since all aspects of an automatic cycle are either user adjustable through Auxiliary Setpoints (see section 9.5.5), or programmable through the OIT, the system is extremely flexible. The following describes the preparation for and operation of an automatic cycle.

4.2.1 Preparation

1. Enter a temperature profile program at the Furnace Programs screen on the OIT. The system supports an unlimited number of programs, each with a maximum length of 63 segments. Programs are made up of six basic components: Ramp Rates, Ramp Times, Soaks, Guaranteed Soaks, Work Guaranteed Soaks, and Events. Profiles may start with either a Soak or a Ramp but must end with a Soak. Ramp Ramps are entered in the range of 1.0 to 3276.7 deg/min or deg/hr. Soaks are in the range of 0 to 1000 degrees C, with durations in the range of 0.1 to 3276.7 minutes or hours. The time base may be toggled by the Hours/Minutes buttons (default

is minutes). Events can be used to control various aspects of an automatic cycle as described in section 9.5.2.3. Note that all Events take place in the first one second of the segment that they are in and that a Guaranteed Soak or a Work Guaranteed Soak will prevent the Event until the Soak Band is reached. Refer to section 12 for example programs.

2. If necessary, reset the Program by pressing RESET.

3. Adjust the Over Temperature controller to a temperature 10 to 20 degrees above the highest soak setpoint programmed. If necessary, reset this controller by pressing the RESET button located on its face.

4. Be sure that the sources of inert gas used by the Backfill and Gas Bleed are sufficient to complete a cycle. Keep in mind that some alarm conditions call for backfill gas, so gas should always be available when the furnace is to be heated.

4.2.2 Operation

After all preparations have been made, press the pushbutton marked CYCLE START to initiate the automatic cycle. Actual initiation of a cycle is dependent on the following conditions:

- A valid Program has been selected.
- The Cryo Pump is on and at temperature.
- The Over Temperature controller has been reset.
- The chamber door is closed and locked.
- No alarm conditions exist.

If any one of these conditions is not met, an appropriate message will appear on the display when CYCLE START is pressed to alert the operator why nothing happened. Once the cycle has started, the Rough Valve will open to begin evacuation of the chamber. The display will show the message "Rough Pumping To 100 Microns" at this time. When the pressure in the furnace chamber reaches 100 microns, the Rough Valve will close, the Foreline and High Vacuum Valves will open, and the message "High Vacuum Pumping To < 5 x10 -5 Torr" will be displayed. Once the Program Start Vacuum (section 9.5.2.4) level is reached, the Program will start.

Note: While an automatic cycle is in progress, as indicated by the CYCLE START light being on, pressing any button, except CYCLE STOP, will have no effect on the system. Pressing CYCLE STOP for less than one (1) second will abort the cycle and put the Program into hold. Pressing CYCLE STOP for more than one second will also cause the chamber to vent to atmosphere (provided that the furnace temperature is below 150 degrees C). If it is desired to go to the manual mode, simply turn the key switch to the MANUAL position.

When the event for Cycle Complete comes on, or if the last segment times out, the alarm bell will sound for three seconds, the messages "The Automatic Cycle Is Complete" and "Press Cycle Stop" will alternate and the Program will go into hold. At this time the CYCLE STOP button will be flashing and may be used to reset the Program and vent the furnace chamber to atmospheric pressure. If the CYCLE STOP button has not been pushed after sixty (60) minutes of Cycle

Complete (Cycle Complete Pumpout, section 9.5.5), and the chamber is not already in high vacuum, the system will automatically pump itself down.

4.2.3 Power Failure Recovery

Recovery from a power failure during an automatic cycle is dependent on the temperature of the Cryo Pump when power returns. If it is below the Power Fail Recovery temperature (25°K, section 9.2.1.2) the system will restart and the automatic cycle will continue from where it left off. If the temperature is above 25°K when power returns the alarm bell will sound, the message The Main Power Was Off will be displayed, and the rest of the system will be off. At this point it will be up to the operator to reset the alarm and restart the system by pressing START UP. Once instrument power returns, the operator can assess whether or not to continue the cycle by checking the vacuum gauges and the Program status (the Program will be in Hold at the point the power went out). After the Ready - Automatic condition is reached, restart the cycle by pressing CYCLE START. At this point it may be necessary for the operator to turn on the last function that had been turned on by the Program's Events. This is done by holding in the ALARM RESET button and pressing the button of the required function. For example, if the Heat was on when power failed, after restarting the cycle the operator would hold in the ALARM RESET button and press HEAT. After doing this the cycle will continue normally.

4.2.4 Auto Pump and Auto Vent

The furnace is capable of being simply evacuated or vented while in Ready - Automatic by pressing either AUTO PUMP or CYCLE STOP. AUTO PUMP will automatically close all conflicting valves, and then cause the system to pump down and crossover into high vacuum. Pushing CYCLE STOP for a duration of a least 1 second will also close all conflicting valves, and open the Vent Valve until the chamber door opens.

4.3 Standby

The Standby mode can be entered by turning the key switch to the center position. Selecting this mode will disable all the pushbuttons on the control panel, thus preventing any unauthorized tampering of the unit. If the system has been shut down, it cannot be started up nor can any valves be operated. Likewise, if the system is in the Ready condition, it cannot be shut down and again none of the valves can be operated. If the chamber pressure is below crossover the High Vacuum Valve will open to maintain pressure in the chamber.

4.4 Manual

4.4.1 General

This system incorporates three manual modes. The normal "Safetied Manual" is indicated on the display as either Manual Mode or Ready - Manual. The second mode is "Auto Manual" and is indicated by the display as Auto - Manual. The third mode is "Unsafetied Manual" and is indicated by the message "Unsafetied Manual" flashing. In both the Safetied and Unsafetied Manual modes, the system is operated by the lighted buttons located on the graphic panel. The Auto Manual mode is operated by the buttons marked AUTO PUMP and CYCLE STOP.

Note: None of the Events programmed will have any effect on any of the manual modes. Also, the Program will not go into Hold or Run mode due to furnace pressure.

Note: The logged in user must have a security code of "K" to use this mode.

4.4.2 Safetied Manual

The mode reached by simply turning the key switch to the MANUAL position is the safetied manual and is indicated on the display as either Manual Mode or Ready - Manual. In this mode the system will observe proper time delays between valves opening and closing, regardless of how fast the operator selects them. Situations such as having the Vent Valve and the High Vacuum Valve open at the same time are disallowed. All disallowed states are indicated by a flashing light and a relevant message on the display.

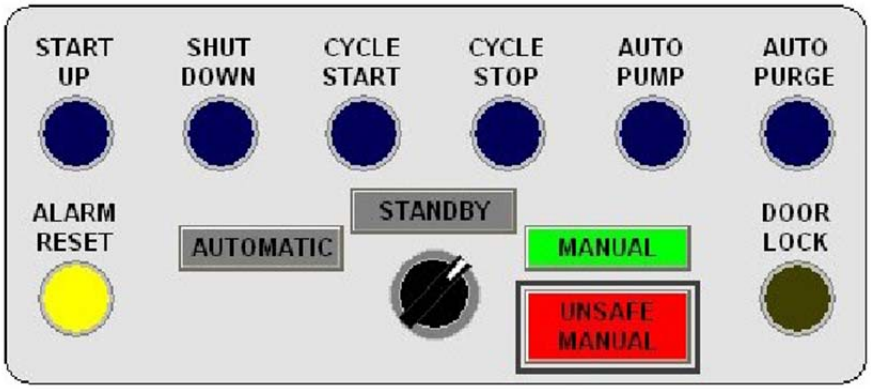
4.4.3 Auto Manual

The Auto - Manual mode is reached by pressing either AUTO PUMP or CYCLE STOP for a duration of at least 1 second while in Ready - Manual. AUTO PUMP will automatically close all conflicting valves, and then cause the system to pump down and crossover into high vacuum. Pushing CYCLE STOP will close all conflicting valves and open the Vent Valve until the chamber door opens. Pushing any of the manual buttons except Heat, or going to the Unsafetied Manual mode will abort the Auto - Manual mode.

4.4.4 Unsafetied Manual

CAUTION!!!
Only qualified personnel should operate the system in the **UNSAFETIED MANUAL** mode. In this mode the system will not observe proper time delays and/or disallowed states. Damage to the system and/or workload can occur if proper time delays and/or sequencing are not observed.

The safeties of the normal manual mode can be over ridden by going into the Unsafetied Manual mode. This is done by clicking on the UNSAFE MANUAL button on the OIT's main screen while in the manual mode. Note that this can only be done if he logged in user has the proper security code. Once this is done the CYCLE START and CYCLE STOP lights will flash and the message "Unsafetied Manual" will flash on the OIT. Repeating this process or changing the modes will abort this mode.



Note: The logged in user must have a security code of "L" to use this mode.

5. SHUT DOWN

Whenever the unit is not to be used for some prolonged time or if maintenance is to be done, the system should be shut down. To do so, first put the system in either the AUTOMATIC or the MANUAL mode, close the chamber door, and then click the button marked SHUT DOWN. Upon doing so the Cryo Pump will shut off. When the temperature of the Cryo Pump rises above the Cryo Pump Ready Temperature (17°K, section 9.2.1.3), the Cryo Purge Valve will open. When the pump's temperature rises above 290°K (Cryo Pump Warm Temperature, section 9.2.1.3) the Rough Valve will open to evacuate the chamber. Once the cross oven vacuum level is reached the Rough Valve will close and the Rough Pump will shut off.

6. CRYO REGENERATION

6.1 General

At an interval to be determined with use, the Cryo Pump will require regeneration. Regeneration is manually initiated by the button marked CRYO REGEN. Once the regeneration cycle is started no other operation interaction is required. The cryo regeneration cycle consists of the following:

1. Shut down the Cryo Pump.
2. Allow the Cryo Pump to warm up. After the cryo temperature rises above 17 degrees K it will be purged with dry inert gas at a flow rate of 50 - 100 scfh. When the temperature reaches 290°K (Cryo Warm Temperature, section 9.2.1.3), the pump will continue to be purged for the Cryo Extended Purge Time (section 9.2.1.3).
3. When purging is complete, open the Regen Valve and evacuate the Cryo Pump to its base pressure (50 microns).
4. Close the Regen Valve. If the Cryo Pump's rate of rise is more than 10 microns/minute return to step 3.
5. Turn on the Cryo Pump and allow it to reach its normal operating temperature (Cryo Pump Ready Temperature, 17°K). When this is done the regeneration cycle is complete and the system is again ready for normal operation.

7. ALARMS

Incorporated into the system are several independent alarm mechanisms designed to protect the furnace system and the workload. They are as follows:

- loss of power
- loss of compressed air
- loss of cooling water
- backfill gas source is low
- battery low in the PLC
- failure of the Heat's SCRs
- over temperature of the furnace hot zone
- over temperature of the chamber shell
- vacuum in the pumps
- vacuum in the chamber
- vacuum pumps off
- failure of the High Vacuum Valve to open or close

In the event that any of these alarms are triggered, the alarm bell will sound, the Program will go into Hold, and the OIT's alarm banner will indicate the nature of the trouble. The alarm bell can be silenced by pressing the ALARM RESET button. Once the problem has been rectified, the alarm system may have to be reset as indicated by the ALARM RESET light flashing. Besides the above, the system will take appropriate action, dependent on the nature of the alarm, to preserve the integrity of the system and/or the workload. If any alarm is not acknowledged within fifteen minutes, the system will automatically shut itself down (refer to section 9.5.5, Alarm Shut Down Time).

7.1 Power

There are six alarms associated with power. They are:

- Complete power failure (The main power was off.)
- Loss of PLC input power (Power for the PLC's inputs has failed. Check circuit breaker 7CB.)
- Loss of PLC output power (Power for the PLC's outputs has failed. Check circuit breaker 8CB.)
- Loss of instrument power (Power for the instruments has failed. Check circuit breaker 9CB.)
- Main power phase loss (One of the phases of the incoming power has failed. Check circuit breaker 1CB.)
- Emergency Stop (The System Power is off. Pull out the Emergency Stop and press System Power to reset.)

Any of these alarms occurring will disable all other alarms and cause the immediate shut down of the system. Correcting the alarm condition usually requires turning off the main power and resetting the appropriate circuit breaker.

In the event of a complete power failure, the system will revert to the pre Start Up conditions. When power returns, the alarm message "The main power was off" will be displayed. Once the alarm is reset, the unit may be restarted with the START UP button.

7.2 Air

An air supply is required to operate the various pneumatic valves and cylinders in the system. This air supply must be at a minimum pressure of 60 psig as measured by a pressure switch (I1609PS). Should the pressure drop below 60 psig, the air alarm will be triggered and the message "The pressure of the air for pneumatics is low. Check the air supply and pressure switch I1609PS" will be displayed and all open pneumatic valves will close. Upon the return of air pressure, the valves will resume their previous status, and the alarm will have to be reset

7.3 Water

Water is required to cool various components of the furnace system. Water alarms are armed whenever water is required, i.e. chamber and power feed thru water is required whenever the Heat is on or if the furnace temperature is above the Chamber Water Required temperature (see section 9.2.1.11). If water to the system fails, as determined by a flow switch, the alarm will be triggered, appropriate action will be taken, and one of the following messages will be displayed:

- The chamber water supply has failed. Check the water supply and flow switch I1610FLS.
- The power feed thru water supply has failed. Check the water supply and flow switch I1611FLS.
- The power feed thru water supply has failed. Check the water supply and flow switch I1612FLS.
- The power feed thru water supply has failed. Check the water supply and flow switch I1613FLS.

When water returns, the alarm will have to be reset by the ALARM RESET button.

7.4 Backfill Gas Source Low

If, during a backfill, the backfill pressure is not satisfied and the valve remains open for more than the Backfill Alarm Time (see section 9.2.1.8), this alarm will be triggered. The Backfill Valve will close and the message "The gas source failed to backfill the chamber in 7 minutes. Check the gas supply" will be displayed depending on the gas being used. Pressing ALARM RESET will reset the timer and backfilling will continue.

7.5 Battery Low In The PLC

If the battery is found to be low in the programmable logic controller, the alarm bell will ring and the message "The PLC's battery is low" will be displayed. When this happens the system will have to be shut off and the battery will have to be replaced per the Allen-Bradley *Installation Instructions* for *SLC 5/03™, SLC 5/04™, and SLC 5/05™ Modular Processors*.

7.6 Failure Of Vacuum Gauge

If either of the vacuum gauges fails to come on after the instrument power is turned on, "The vacuum gauge is off" alarm will occur. Since the PLC depends on information from these gauges for the safe operation of the system, all vacuum operations will be disabled.

7.7 Failure Of Baratron Pressure Transducer

There are two alarms associated with the Baratron pressure transducer. The first possible failure is a "Baratron pressure reading for atmosphere is invalid" alarm. This will occur if the Baratron Pressure Transducer fails to determine a valid pressure for atmosphere when the chamber door is open. The second is "The Baratron pressure transducer requires Zero calibration". This alarm is triggered if the Chamber Raw Pressure (see the Chamber Vacuum Setpoint popup screen) is less than -250 or greater than +250 (section 9.2.1.6.1) when the furnace is less than 10^{-4} Torr. Since the PLC depends on information from this sensor for the safe operation of the system, all gas backfill operations will be disabled if either of these alarms is triggered.

Either of these alarms is an indication that the Baratron sensor needs calibration or replacement. To calibrate the transducer, it will first be necessary to evacuate the furnace to less than 10^{-4} Torr. Once below this vacuum range, adjust the Zero pot on the rear of the Baratron transducer until the Chamber Raw Pressure is as close to zero as possible.

7.8 Failure Of The Heat's SCR

The heat's SCR power supply is capable of two alarmed fault conditions. The messages generated for these alarms are "The Heat's SCR is shorted" and "The Heat's SCR is over current". The SCRs are reset for these conditions when the Heat is first turned on and when the ALARM RESET button is pressed. Either of these alarms is usually an indication that a heating element is shorted to ground.

7.9 Thermocouple Failure

If any of the thermocouples connected to the PLC fail an alarm message will be displayed as follows:

- Front Zone 1 thermocouple 1T/C has failed.
- Zone 2 thermocouple 2T/C has failed.
- Zone 3 thermocouple 3T/C has failed.
- Zone 4 thermocouple 4T/C has failed.

- Zone 5 thermocouple 5T/C has failed.
- Zone 6 thermocouple 6T/C has failed.
- Zone 7 thermocouple 7T/C has failed.
- Zone 8 thermocouple 8T/C has failed.
- Rear Zone 9 thermocouple 9T/C has failed.
- Cryo Pump 1 port thermocouple 15T/C has failed.
- Cryo Pump 2 port thermocouple 16T/C has failed.
- Chamber side thermocouple 17T/C has failed.
- Work thermocouple 18T/C is open.
- Work thermocouple 19T/C is open.
- Work thermocouple 20T/C is open.
- Work thermocouple 21T/C is open.

Note: Alarms for work thermocouples will only occur if the number of valid work is less than the Minimum Number Of Work T/Cs Required (section 9.5.2.4) when the chamber door is closed. At this time "An insufficient number of work thermocouples are valid" alarm will also be displayed.

7.10 Over Temperature Alarms

7.10.1 Furnace Over Temperature Controller

In the event that the Over Temperature controller sensing furnace temperature drops out while the Heat is on, or during an automatic cycle, power to the heating elements will drop out, and one of the following messages will be displayed:

- Zones 1-2 Over Temperature controller has dropped out.
- Zones 2-3 Over Temperature controller has dropped out.
- Zones 4-5 Over Temperature controller has dropped out.
- Zones 6-7 Over Temperature controller has dropped out.
- Zones 8-9 Over Temperature controller has dropped out.

To reset the alarm the temperature in the furnace must first drop below the controller's setpoint, and then the reset button on the controller's face must be pushed.

7.10.2 Over Temperature Of The Chamber Shell

Mounted on the chamber's side are two temperature switches (`I1514TAS` & `I1515TAS`) set to 125 degrees F (52°C). If the outer shell of the furnace chamber exceeds this temperature, the effect will be the same as if the over temperature controller had tripped out, with the exception that the display will show one of the following messages:

- The front chamber shell is too hot. Reset 1514TAS.
- The Rear chamber shell is too hot. Reset 1515TAS.

To reset this alarm, the upper left-hand side panel must be removed and the temperature switch must be manually reset.

7.10.3 Over Temperature Of The Power Feedthrus

Mounted on the water return lines from the power feedthrus are three temperature switches (`I1600TAS - I1602TAS`) set to 125 degrees F (52°C). If the water from the feedthrus exceeds this temperature, the effect will be the same as if the over temperature controller had tripped out, with the exception that the display will show one of the following messages:

- The power feedthrus for zones 1-3 are too hot. Reset I1600TAS.
- The power feedthrus for zones 4-6 are too hot. Reset I1601TAS.
- The power feedthrus for zones 7-9 are too hot. Reset I1602TAS.

To reset this alarm, the upper left-hand side panel must be removed and the temperature switch must be manually reset.

7.10.4 Over Temperature Of The Control Thermocouples

In the event that any of the thermocouples used to control the furnace rises above the Furnace Over Temp Setpoint (see section 9.5.2.4), power to the heating elements will drop out and a message indication which zone is over temperature will be displayed. To reset the alarm, the temperature of the furnace must first drop below the setpoint.

7.10.5 Over Temperature Of The Work Thermocouple

In the event that the thermocouple sensing work temperature rises above the Work Over Temp Setpoint (see section 9.5.2.4), power to the heating elements will drop out and a message indication which thermocouple is over temperature will be displayed. To reset the alarm, the temperature of the work must first drop below the setpoint.

7.11 Vacuum Alarms

The PLC monitors the vacuum level of all vacuum pumps and the furnace chamber through analog outputs from the vacuum gauge. If the vacuum gauge fails or if the system is in the Unsafe Manual mode, all vacuum alarms are disabled. Possible vacuum alarms are as follows:

7.11.1 Rough Pump Failed To Reach Vacuum

Whenever the Rough Pump is on and blanked off, i.e. the Rough and Foreline Valves are closed, the pump's vacuum level must drop below 100 microns (Rough Pump Ready Vacuum, section 9.2.1.1) in under two minutes (Rough Pump Vacuum Alarm Time, section 9.2.1.1). If it fails to do so, this alarm will be triggered and the message "The Rough Pump failed to reach 100 microns in 2 minutes" will be displayed. Adjusting the Rough Pump Ready Vacuum setpoint to 1000 microns will disable the alarm.

7.11.2 Vacuum In Cryo Pump

There are two conditions that will cause a cryo vacuum alarm.

7.11.2.1 Time To Pressure

Whenever pumping down from above 200 microns, the Cryo Pump pressure must reach 30 microns (Cryo Pump Base Vacuum, section 9.2.1.2) in less than 120 minutes (Cryo Pump Vacuum Alarm Time, section 9.2.1.2). If this condition cannot be met, the Cryo Pump will not be turned on, and the alarm bell will sound and the message "The Cryo Pump failed to reach 30 microns in 120 minutes" will be displayed. This alarm is disabled it the system is in the Unsafetied Manual mode.

7.11.2.2 Rise In Pressure

After the Cryo has been pumped to 30 microns and if the Cryo Pump is at its operating temperature, the pressure must not rise above 200 microns (Cryo Pump High Vacuum, section 9.2.1.2). If it does the Cryo Pump will be shut off and the message "The Cryo Pump's foreline has exceeded 200 microns" will be displayed.

7.11.3 Vacuum In Chamber

There are three conditions that will cause a Chamber Vacuum Alarm.

7.11.3.1 Time To Rough Vacuum

Starting when the Rough Valve opens, the chamber must reach the Crossover Vacuum level (section 9.2.1.4) in less than the Rough Alarm Time (section 9.2.1.4). If this vacuum level cannot be reached, the cycle will be halted until the alarm is reset, and the message "The chamber failed to reach 100 microns in 20 minutes" will be displayed. This alarm is disabled when the Gas Bleed is on.

7.11.3.2 Time To High Vacuum

Once the High Vacuum Valve opens during an automatic cycle, the chamber must reach the Program Start Vacuum level (section 9.5.2.4) in less than the High Vacuum Alarm Time (section 9.2.1.4). If this vacuum level cannot be reached, the alarm message "The chamber failed to reach 5 x10 -5 Torr in 120 minutes" will be displayed.

7.11.3.3 Rise In Pressure

If, after reaching the Program Start Vacuum level (section 9.5.2.4), the chamber pressure rises above the Vacuum Alarm Pressure (section 9.2.1.4) while the High Vacuum valve is open, the alarm message "The chamber pressure has risen above 50 microns" will be displayed. If the furnace is hot, the chamber will be backfilled with inert gas to 2 psig. To reset the alarm the furnace must either be below the Vent Safe Temperature (section 9.2.1.7), in high vacuum, or the mode switched to Manual.

7.11.4 Leak Rate Test

If a leak rate test, initiated by Leak Test event in an automatic cycle, fails the second attempt (see section 9.5.2.3 for a description of the leak rate test), this alarm will be triggered and the message "The leak rate test failed" will be displayed. After acknowledging the alarm, it is up to the operator to press Run to continue the cycle, or Reset to abort the cycle.

7.12 Chamber Over Pressure

If the chamber pressure rises above its maximum safe limit this alarm will be triggered. All gas valves will close, the Vent Valve will open to relieve the pressure, and the message "The furnace chamber has exceeded its maximum pressure" will be displayed.

7.13 Rough Pump

Should the Rough Pump's motor starter drop out due to overload, the Rough and Foreline valves will close, the ROUGH PUMP light will flash, and the message "The Rough Pump is off. Check circuit breaker 3CB and O1000MS" will be displayed. To reset the alarm, the main power must be shut off, the high voltage cabinet must be opened, and the motor starter (O1000MS) must be reset.

7.14 Blower

Should the Blower's motor starter drop out due to overload, the BLOWER light will flash, and the message "The Blower is off. Check circuit breaker 4CB and motor starter O1001MS" will be displayed. To reset the alarm, the main power must be shut off, the high voltage cabinet must be opened, and the motor starter (O1001MS) must be reset.

7.15 Cryo Pump

There are two alarms for the Cryo Pump. If either occurs, the High Vacuum valve will close and the CRYO PUMP light will flash. The first alarm is triggered if the pump's compressor drops out. If this happens, the message "The Cryo Pump is off. Check its circuit breaker" will be displayed.

The second alarm is triggered if the Cryo Pump's temperature fails to reach Cryo Pump Ready Temperature (section 9.2.1.2) in less than the Cryo Pump Ready Time (section 9.2.1.2). If this happens, the message "The Cryo Pump failed to reach 17°K in 120 minutes. Check its compressor" will be displayed.

7.16 The Chamber Door Is Open

If the chamber door opens (as determined by I901PRS) during an automatic cycle, this alarm will be triggered. If this alarm occurs, the Rough and Backfill Valves will close, the Heat will shut off and the message "The chamber door has opened" will be displayed. Normal operation will resume once the door has been closed and the alarm is reset.

7.17 High Vacuum Valve Failed To Open Or Closed

If the High Vacuum Valve cannot open within its time limit as determined by I810LS, this alarm will go off and the message "The High Vacuum Valve failed to open" will be displayed.

If the valve cannot close in the required time as determined by I809LS, the system's reaction will be to close all conflicting valves and display the message "The High Vacuum Valve failed to close".

7.18 Preventive Maintenance Alarms

The accumulated time that the pumps, heat, and quick cool fan have been on and the number of automatic cycles started and completed is monitored. These can be setup on the Preventive Maintenance Timers screen to alarm after some time to alert the operator that maintenance needs to be done. The alarms that can be triggered are as follows:

- The Rough Pump Requires Maintenance.
- The Blower Requires Maintenance.
- Cryo Pump 1 Requires Maintenance.
- Cryo Pump 2 Requires Maintenance.
- The Heat Requires Maintenance.
- Number Of Cycle Starts Requires Maintenance.
- Number Of Cycle Completes Requires Maintenance.

To disable any of these alarms simply adjust the setpoint to 0 (section 9.5.5). Note that these alarms are considered non critical and will only occur if an automatic cycle is **not** in progress.

8. PUMP & VALVE INTERLOCKS

The system is interlocked by various means to help avoid improper operation. Some of these interlocks can be overridden by entering the Unsafetied Manual mode as indicated by an♦. The interlocks are as follows:

8.1 Rough Pump

For the Rough Pump to be on, the following must be true:
- The control system is enabled and all power is on.
- An alarm for Rough Pump off is not in progress.

8.2 Blower

For the Blower to be on, the following must be true:
- The control system is enabled and all power is on.
- The Rough Pump is on.
- An alarm for Blower off is not in progress.
- The chamber vacuum level is below 750 Torr (Blower Cutin Pressure, section 9.2.1.2).

8.3 Cryo Pump 1

For the Cryo Pump to be on the following must be true:
- The control system is enabled and all power is on.
- The Cryo 1 Purge Valve is closed.
- An alarm for Cryo Pump 1 off is not in progress.
- An alarm for Cryo 1 High Vacuum Valve is not closed is not in progress.
- Cryo Pump 1 pressure has been below 50 microns.
- Cryo Pump 1 pressure remains below 100 microns.

8.4 Cryo Pump 2

For the Cryo Pump to be on the following must be true:
- The control system is enabled and all power is on.
- The Cryo 2 Purge Valve is closed.
- An alarm for Cryo Pump 2 off is not in progress.
- An alarm for Cryo 2 High Vacuum Valve is not closed is not in progress.
- Cryo Pump 2 pressure has been below 50 microns.
- Cryo Pump 2 pressure remains below 100 microns.

8.5 Cryo 1 Regen Valve

For this valve to open all the following must be true:
- ♦ The Rough Pump is on and has reached its Ready Vacuum (section 9.2.1.1).
- ♦ If Cryo Pump 1 is less than 25°K its pressure must be > 100 microns.
- ♦ The Cryo 1 Purge Valve is closed.
- ♦ The Cryo 1 High Vacuum Valve is closed.

♦ The Rough Valve is closed.
♦ The air supply for pneumatics is above 60 psig (`I1609PS`).

8.6 Cryo 1 Purge Valve

For this valve to be open the following must be true:
• The control system is enabled and all power is on.
♦ Cryo Pump 1 is off.
♦ The Cryo 1 Regen Valve is closed.
♦ The Cryo 1 High Vacuum Valve is closed.
♦ Cryo Pump 1 is above its Ready Temperature (section 9.2.1.3).

8.7 Cryo 1 High Vacuum Valve

For this valve to open, all the following must be true:
♦ The chamber pressure is below 100 microns (Crossover Vacuum section 9.2.1.4).
♦ An alarm for Cryo Pump 1 vacuum is not in progress.
♦ Cryo Pump 1 is on and below its Ready Temperature (section 9.2.1.3).
♦ The Cryo 1 Regen Valve is closed.
♦ The Cryo 1 Purge Valve is closed.
♦ The Rough Valve is closed.
♦ The Vent Valve is closed.
♦ The Backfill Valve is closed.
♦ The Gas Bleed Valve is closed.
♦ The chamber door is closed and locked.
♦ The air supply for pneumatics is above 60 psig (`I1609PS`).

Note: The interlocks for the Backfill and Gas Bleed valves are overridden in an Auto Purge cycle once it has been determined that the gas source is off.

8.8 Cryo 2 Regen Valve

For this valve to open all the following must be true:
♦ The Rough Pump is on and has reached its Ready Vacuum (section 9.2.1.1).
♦ If Cryo Pump 2 is less than 25°K its pressure must be > 100 microns.
♦ The Cryo 2 Purge Valve is closed.
♦ The Cryo 2 High Vacuum Valve is closed.
♦ The Rough Valve is closed.
♦ The air supply for pneumatics is above 60 psig (`I1609PS`).

8.9 Cryo 2 Purge Valve

For this valve to be open the following must be true:
• The control system is enabled and all power is on.
♦ Cryo Pump 2 is off.
♦ The Cryo 2 Regen Valve is closed.

- The Cryo 2 High Vacuum Valve is closed.
- Cryo Pump 2 is above its Ready Temperature (section 9.2.1.3).

For this valve to open, all the following must be true:

8.10 Cryo 2 High Vacuum Valve

- The chamber pressure is below 100 microns (Crossover Vacuum section 9.2.1.4).
- An alarm for Cryo Pump 2 vacuum is not in progress.
- Cryo Pump 2 is on and below its Ready Temperature (section 9.2.1.3).
- The Cryo 2 Regen Valve is closed.
- The Cryo 2 Purge Valve is closed.
- The Rough Valve is closed.
- The Vent Valve is closed.
- The Backfill Valve is closed.
- The Gas Bleed Valve is closed.
- The chamber door is closed and locked.
- The air supply for pneumatics is above 60 psig (`I1609PS`).

Note: The interlocks for the Backfill and Gas Bleed valves are overridden in an Auto Purge cycle once it has been determined that the gas source is off.

8.11 Rough Valve

For this valve to open, all the following must be true:

- The Rough Pump is on and has reached its Ready Vacuum (section 9.2.1.1).
- The chamber pressure is less than 100 Torr above atmospheric pressure (Vent Excess Gas Above Atm, section 9.5.5).
- An alarm for Cryo Pump 1 vacuum is not in progress.
- An alarm for Cryo Pump 2 vacuum is not in progress.
- The Cryo 1 Regen Valve is closed.
- The Cryo 2 Regen Valve is closed.
- The Cryo 1 High Vacuum Valve is closed.
- The Cryo 2 High Vacuum Valve is closed.
- The Vent Valve is closed.
- The Backfill Valve is closed.
- The chamber door is closed and locked.
- The air supply for pneumatics is above 60 psig (`I1609PS`).

In an automatic cycle, the following also must be true:

- The chamber pressure is above 100 microns (Crossover Vacuum section 9.2.1.4).

Note: The interlock for the Backfill Valve is overridden in an Auto Purge cycle once it has been determined that the gas source is off.

8.12 Vent Valve

For this valve to open, all the following must be true:

- The control system is enabled and all power is on.
- The hot zone temperature is below 100°C (Vent Safe Temperature, section 9.2.1.7).
- The furnace Heat is off
- ♦ The chamber door is closed.
- ♦ The Cryo 1 High Vacuum Valve is closed.
- ♦ The Cryo 2 High Vacuum Valve is closed.
- ♦ The Rough Valve is closed.
- ♦ The Backfill Valve is closed.
- ♦ The Gas Bleed Valve is closed.
- ♦ The RGA Isolation Valve is closed.
- ♦ The air supply for pneumatics is above 60 psig (`I1609PS`).

Note: The interlocks for hot zone temperature and furnace Heat are overridden if the chamber pressure is more than 100 Torr above atmospheric pressure (Vent Excess Gas Above Atm, section 9.5.5). This allows for venting excess gas out of the chamber.

8.13 Heat

For the Heat to be on, all the following must be true:

- The control system is enabled and all power is on.
- The Heat's SCRs are not shorted.
- The Heat's SCRs are not over current
- The over temperature controllers (`1OT` – `5OT`) are reset.
- Chamber thermal switches (`I1514TAS`, `I1515TAS`) are not over temperature.
- Feedthru water thermal switches (`I1600TAS` – `I1602TAS`) are not over temperature.
- The chamber door is closed.
- The chamber has been pumped to 50 microns (Heat Safe Vacuum, section 9.2.1.9).
- No alarm conditions exist.

8.14 Backfill Valve

For this valve to open all, the following must be true:

- The control system is enabled and all power is on.
- The chamber pressure is less than its maximum allowable.
- ♦ The chamber pressure is below the highest pressure setpoint for Backfill as set in the Program Parameters for the currently select program.
- ♦ The Cryo 1 High Vacuum Valve is closed.
- ♦ The Cryo 2 High Vacuum Valve is closed.
- ♦ The Rough Valve is closed.
- ♦ The Vent Valve is closed.
- ♦ The Gas Bleed Valve is closed.
- ♦ The RGA Isolation Valve is closed.

♦ The chamber door is closed and locked.
♦ The air supply for pneumatics is above 60 psig (`I1609PS`).
♦ An alarm for backfill gas is not in progress.
♦ An alarm for the Baratron pressure transducer is not in progress.

Note: The interlocks for the Rough, High Vacuum and Gas Bleed Valves are overridden in an Auto Purge cycle once it has been determined that the gas source is off.

8.15 Gas Bleed Valve

For this valve to open, the following must be true:
• The control system is enabled and all power is on.
• The chamber pressure is less than its maximum allowable.
♦ The Cryo 1 High Vacuum Valve is closed.
♦ The Cryo 2 High Vacuum Valve is closed.
♦ The Vent Valve is closed.
♦ The Backfill Valve is closed.
♦ The RGA Isolation Valve is closed.
♦ The chamber door is closed and locked.
♦ The air supply for pneumatics is above 60 psig (`I1609PS`).

Note: The interlocks for the Rough, High Vacuum and Backfill Valves are overridden in an Auto Purge cycle once it has been determined that the gas source is off.

8.16 RGA Isolation Valve

For this valve to open, the following must be true:
• The control system is enabled and all power is on.
• The chamber pressure is less than its maximum allowable.
♦ The chamber pressure is less than 10 microns (RGA Safe Vacuum, section 9.2.1.7).
♦ The Vent Valve is closed.
♦ The Backfill Valve is closed.
♦ The Gas Bleed Valve is closed.
♦ The chamber door is closed and locked.
♦ The air supply for pneumatics is above 60 psig (`I1609PS`).

8.17 Door Locks

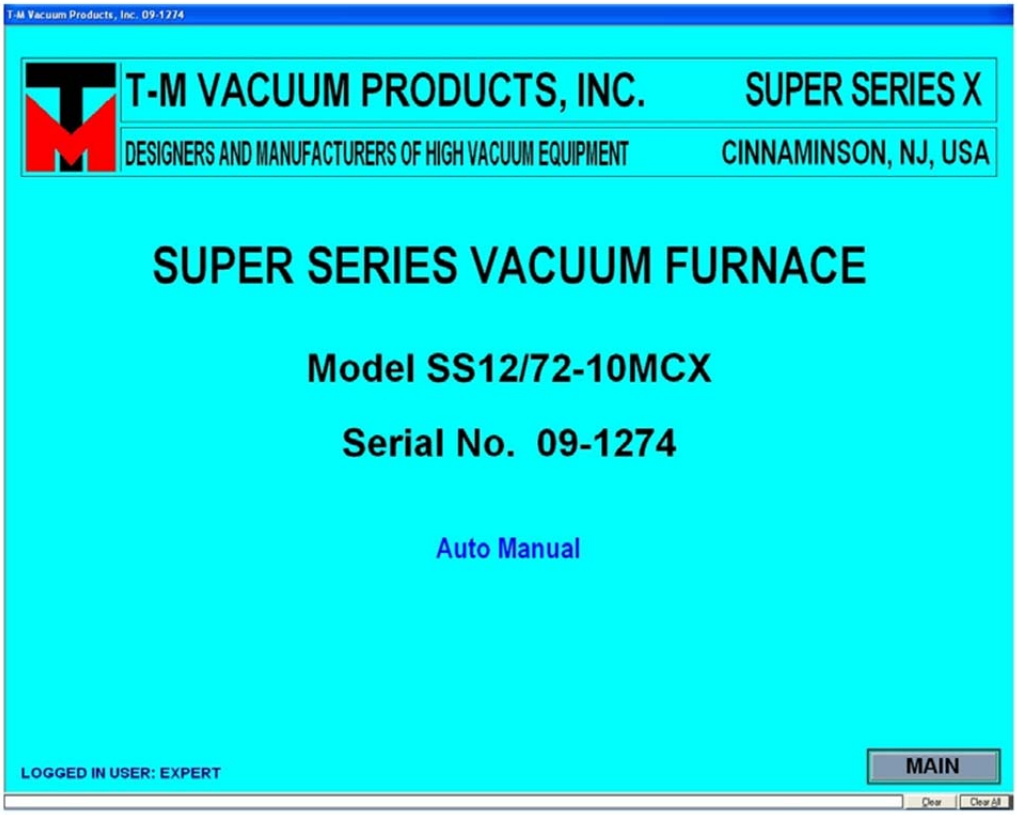
For the door locks to open, all the following must be true:
• The hot zone temperature is below 100°C (Vent Safe Temperature, section 9.2.1.7).
• The chamber pressure is less than 100 Torr above atmospheric pressure (Vent Excess Gas Above Atm, section 9.5.5).
• The system is not in the Standby mode.
• The furnace is not in an automatic cycle.
• The Cryo 1 High Vacuum Valve is closed.

- The Cryo 2 High Vacuum Valve is closed.
- The Rough Valve is closed.
- The furnace Heat is off.
- The Backfill Valve is closed.
- The Gas Bleed Valve is closed.

9. OPERATOR INTERFACE SCREENS

9.1 T-M Logo Screen

This is the screen that is first presented when power is applied to the system. Displayed on this screen is a brief description of the system, and the system's model and serial numbers. The operator can access other screens by clicking on the MAIN button.

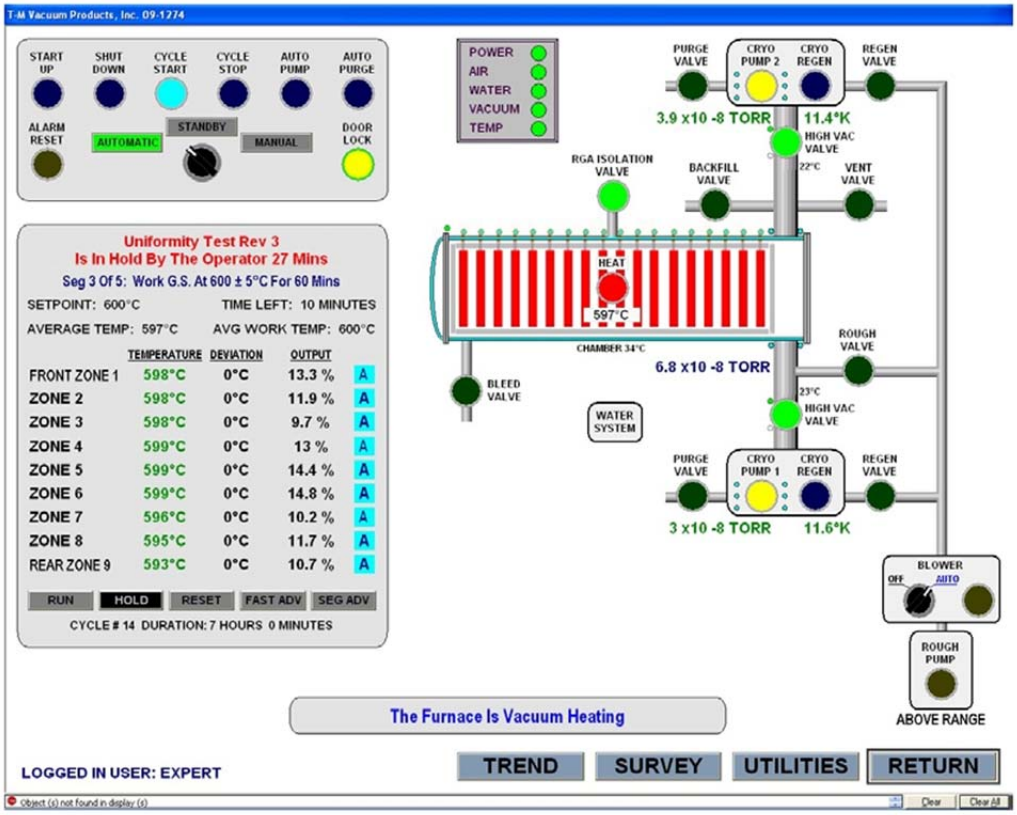


9.2 Main

This screen is used to view the normal operation of the furnace system and is divided into several areas depending on function. The first area in the upper left corner has buttons for the automatic control of the system, Alarm Reset, and Door Locks. The position of the mode key switch is also displayed. If the system is in the manual mode and the logged in user has the proper security code, a button for Unsafe Manual will also be present.

The area just below that is used to view and control the progress of a furnace temperature program. The heading of this area of the screen displays the currently selected program and its condition. Below this are the currently active program segment number, a description of that segment, current temperature setpoint, and time remaining in the segment. Also displayed is an average of the control and over temperature thermocouples, the average temperature of the work thermocouples, the control zone temperatures, their deviation from setpoint, and the percent output to the heaters. The

A or M to the right of the percent output indicates whether the zone's PID loop is in automatic or manual.



This area also allows the operator to control the execution of the currently selected program, when appropriate, through the following buttons:

RUN	Will start the program if it is Reset or allow the program to continue if it is in Hold.
HOLD	Will halt the program at its current temperature Setpoint and Time Left. Note: The logged in user must have a security code of "F" to use this button.
RESET	Will halt execution of the program and reset it back to the beginning of segment one.
FAST ADV	This will increase speed at which the program executes by the multiplier set by the Program Fast Advance Rate (section 9.5.5).
SEG ADV	Will advance the program to the beginning of the next segment.

Note that whenever one of these keys is active, it is displayed on the screen in reverse video.

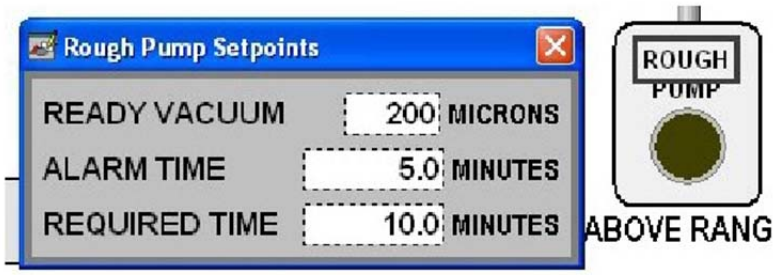
Below that area is a message display that will indicate either the Mode (e.g. Automatic, Manual) of the system, the current operation being performed in an automatic sequence, or an explanation of possible operator error.

To the right of these areas is an animated graphic of the system indicating the condition of all of the pumps, valves, etc. Also shown here are the vacuum, pressure, temperatures levels, etc. of the various components of the system. There are also buttons here that the operator can use to move to other screens as described below.

9.2.1 Pop Up Screens

The operator can access a series of pop up windows to view details or adjust parameters of the system by clicking on the various components on the main screen.

9.2.1.1 Rough Pump Setpoints



Setpoint	Range	Default Setting
Rough Pump Ready Vacuum	10 - 1000 Microns	100 Microns
Rough Pump Vacuum Alarm Time	0.1 - 3276.7 Minutes	20.0 Minutes
Rough Pump Required Time	0.0 - 3276.7 Minutes	15.0 Minutes

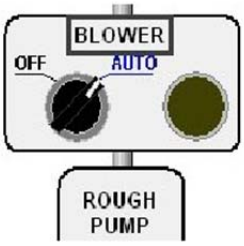
Rough Pump Ready Vacuum: Whenever the Rough Pump is blanked off, i.e. the Rough and Foreline Valves are closed, the pump's vacuum level must drop below this setpoint in less than the Alarm Time. If it fails to do so, a "The Rough Pump failed to reach 100 microns in 20 minutes" alarm will be triggered. Adjusting the setpoint to 1000 microns will disable this alarm.

Rough Pump Vacuum Alarm Time: Whenever the Rough Pump is on and blanked off, i.e. the Rough and Foreline Valves are closed, it must reach the Ready Vacuum level in less than this time. If this time is exceeded, "The Rough Pump failed to reach 100 microns in 20 minutes" alarm will occur. Adjusting the setpoint to 0 will disable this alarm.

Rough Pump Required Time: If the Rough Pump is not required during an automatic operation (i.e. the Rough Valve, Foreline Valve, or Bleed Valve is not being used) it will shut off after this period of time. Setting this value to 0.0 will allow the Vacuum Pump to stay on all the time.

Note: The logged in user must have a security code of "G" to modify parameters on this screen.

9.2.1.2 Blower Setpoints



Setpoint	Range	Default Setting
Blower Cutin Pressure	1 - 760 Torr	750 Torr
Blower Cutin Alarm Time	0.1 - 3276.7 Minutes	20.0 Minutes
Required Time	0.0 - 3275.7 Minutes	1.0 Minutes

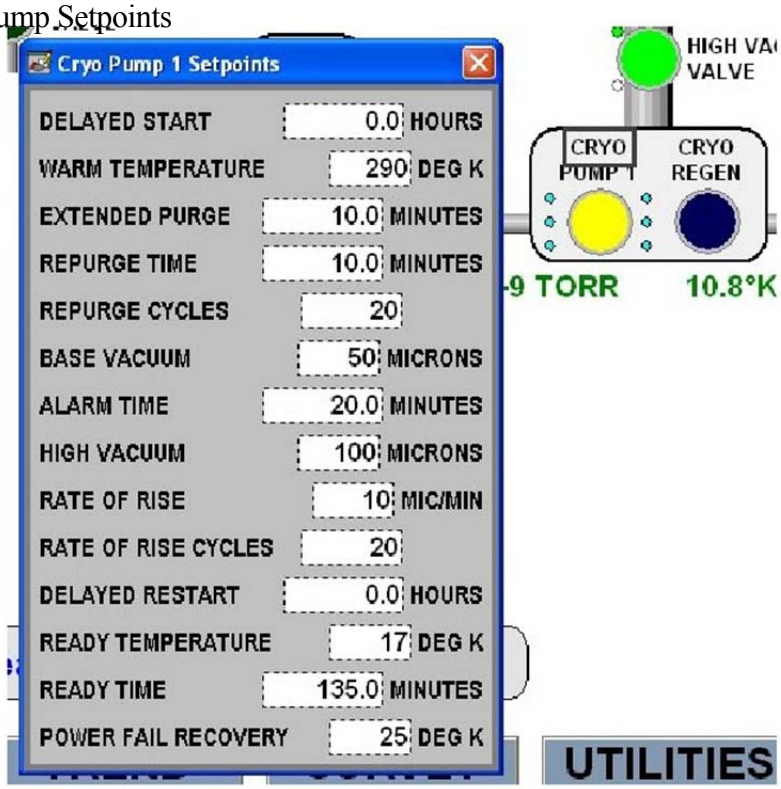
Blower Cutin Pressure: This vacuum level must be reached before the vacuum Blower can be turned on.

Blower Cutin Alarm Time: Whenever the Rough Valve opens, the chamber must reach the Cutin Pressure level in less than this time. If this time is exceeded, The chamber failed to reach 30 Torr in 5 minutes alarm will occur.

Required Time: If the Blower is not required during an automatic operation (i.e. the Rough Valve and Foreline Valve are not being used) it will shut off after this period of time. Setting this value to 0.0 will allow the Blower to stay on all the time.

Note: The logged in user must have a security code of "G" to modify parameters on this screen.

9.2.1.3 Cryo Pump Setpoints



Setpoint	Range	Default Setting
Delay Start Time	0.0 - 3276.7 Hours	0.0 Hours
Warm Temperature	280 - 310 Deg K	290 Deg K
Extended Purge Time	0.0 - 3276.7 Minutes	10.0 Minutes
Repurge Time	0.0 - 3276.7 Minutes	10.0 Minutes
Repurge Cycles	0 - 20 Cycles	20
Base Vacuum	25 - 200 Microns	50 Microns
Alarm Time	0.0 - 3276.7 Minutes	20.0 Minutes
High Vacuum	25 - 200 Microns	100 Microns
Rate Of Rise	0 - 200 Microns/Min	10 Microns/Min
Rate Of Rise Cycles	0 - 40 Cycles	20
Delayed Restart	0.0 - 3276.7 Hours	0.0 Hours
Ready Temperature	10 - 80 Deg K	17 Deg K
Ready Time	0.0 - 3276.7 Minutes	135.0 Minutes
Power Fail Recovery	10 - 80 Deg K	25 Deg K

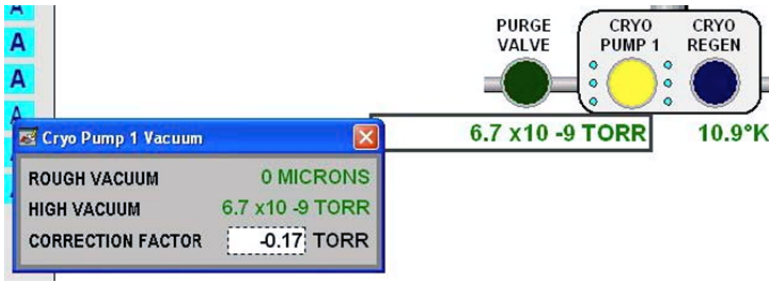
Delayed Start Time:	If a value other than zero is selected the start of a full Cryo regeneration cycle will be delayed by this amount of time.
Warm Temperature:	If the Cryo Pump is below this setpoint when Start Up, Cryo Regen or Shut Down is selected, the pump will be purged until this temperature is reached before continuing the cycle.
Extended Purge Time:	This parameter will extend the purge time during a full regeneration to ensure the pump has been purged of all contaminants.
Repurge Time:	When the Cryo Pump is being evacuated in Start Up or Cryo Regen, the pressure must decrease at a rate of at least 2% per minute. If this rate cannot be met, the Regen Valve will close and the pump will be repurged for this period of time.
Repurge Cycles:	This parameter is used to determine the number of repurge cycles allowed before a "The Cryo Pump failed to reach 50 microns in 120 minutes" alarm is generated.
Base Vacuum:	This vacuum level must be reached before the Cryo Pump can be turned on.
Alarm Time:	Whenever the Cryo Pump is being evacuated it must drop below one Torr in less than this time. If this time is exceeded, a "The Cryo Pump failed to reach 50 microns in 120 minutes" alarm will occur.
High Vacuum:	Once the Cryo Pump Base Vacuum level is reached, the foreline pressure must not rise above this setpoint. These setpoints define the maximum safe vacuum range that the Cryo Pump can be operated within and allow for normal fluctuation in foreline pressure during a typical cycle.
Rate Of Rise:	This setpoint is used to establish the micron/minute rate for the Rate Of Rise (ROR) test performed during a Start Up or Cryo Regen cycle.
Rate Of Rise Cycles:	The number of Rate Of Rise cycles cannot exceed this parameter or a "The Cryo Pump's foreline has exceeded 100 microns" alarm will be generated.
Delay Restart:	After the Rate Of Rise test passes, and if this parameter is greater than zero, the Cryo Pump will be backfilled with purge gas and the system will wait for this time to expire. At the end of this time the pump will roughed out, the Rate Of Rise test will be repeated, and then the pump will turn on.
Ready Temperature:	Once the Cryo Pump is turned on, it must reach this temperature in less than the Cryo Pump Ready Time. If this temperature cannot be reached in time the alarm "The Cryo Pump failed to reach 17°K in 135 minutes. Check its compressor" will be triggered.

Ready Time: Once the Cryo Pump is turned on, it must reach the Cryo Pump Ready Temperature in this period of time. If this temperature cannot be reached in time the alarm "The Cryo Pump failed to reach 17°K in 135 minutes. Check its compressor" will be triggered.

Power Fail Recovery: If the Cryo Pump remains belows this temperature during a short duration power failure it will automatically turn back on when power returns. If an automatic cycle was in progress at the time it will continue.

Note: The logged in user must have a security code of "G" to modify parameters on this screen.

9.2.1.4 Cryo Pump Vacuum



Setpoint	Range	Default Setting
Cold Cathode Correction	-1.00 – 1.00 Torr	0.00 Torr

Cold Cathode Correction: This correction factor can be used to make the high vacuum reading on the OIT agree with the reading on the vacuum gauge.

Note: The logged in user must have a security code of "H" to modify parameters on this screen.

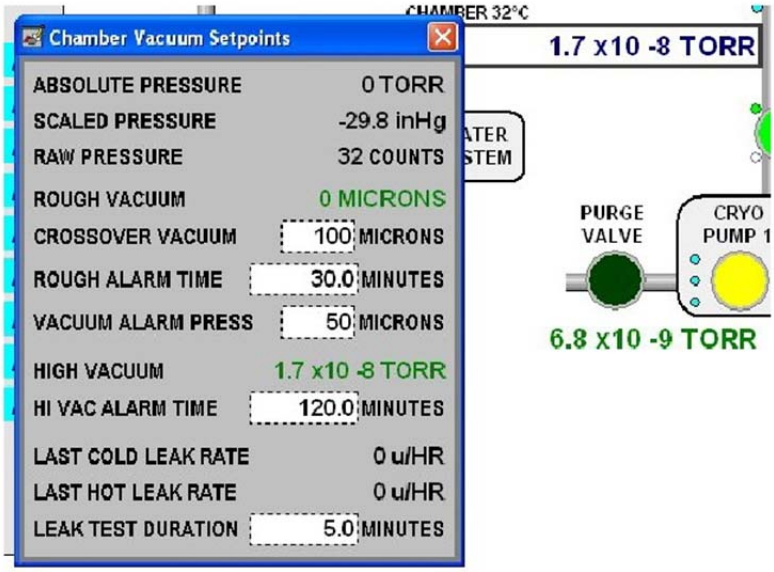
9.2.1.5 Cryo Pump Port Setpoints

Setpoint	Range	Default Setting
Over Temperature	0 – 100 Deg C	60 Deg C

Over Temperature: The temperature in the pumping port above the High Vacuum Valves must be below this temperature for the Cryo Pumps to operate properly. If this temperature is exceeded the alarm "Cryo Pump 1 port thermocouple 15T/C is above 60°C" will be triggered.

Note: The logged in user must have a security code of "G" to modify parameters on this screen.

9.2.1.6 Chamber Vacuum Setpoints



Setpoint	Range	Default Setting
Crossover Vacuum	10 - 200 Microns	100 Microns
Rough Vacuum Alarm Time	0.1 - 3276.7 Minutes	20.0 Minutes
Vacuum Alarm Pressure	10 - 200 Microns	50 Microns
High Vacuum Alarm Time	0.1 - 3276.7 Minutes	120.0 Minutes
Leakup Test Duration	5.0 - 60.0 Minutes	5.0 Minutes

Crossover Vacuum: This is the pressure where during an automatic pump down the Rough Valve closes and the Foreline and High Vacuum Valves open.

Rough Vacuum Alarm Time: Starting when the Rough Valve opens, the chamber must reach the Crossover Vacuum level in less than this time. If this time is exceeded, "The chamber failed to reach 100 microns in 20 minutes" alarm will occur. Fifteen minutes is usually adequate if the parts placed in the furnace are relatively clean. If water or glycol based cleaners are used on the parts, or some operations, such as brazing, may require significantly longer times. Adjusting the setpoint to 0 will disable this alarm.

Vacuum Alarm Pressure:	If this setpoint is exceeded after the Program Start Vacuum level has been reached and while the High Vacuum Valve is open, an alarm for chamber rise in pressure will be triggered.
High Vacuum Alarm Time:	Once the High Vacuum Valve opens during an automatic cycle, the chamber must reach the Program Start Vacuum (section 9.5.2.4), in less than this amount of time. If this time is exceeded, "The chamber failed to reach 5 x10^{-5} Torr in 120 minutes" alarm will occur. This time should be determined based on the vacuum level to be reached and the cleanliness of the work. Adjusting the setpoint to 0 will disable this alarm.
Leakup Test Duration:	This is the interval between the first and second vacuum reading from which the leak rate is calculated.

Note: The logged in user must have a security code of "G" to modify parameters on this screen.

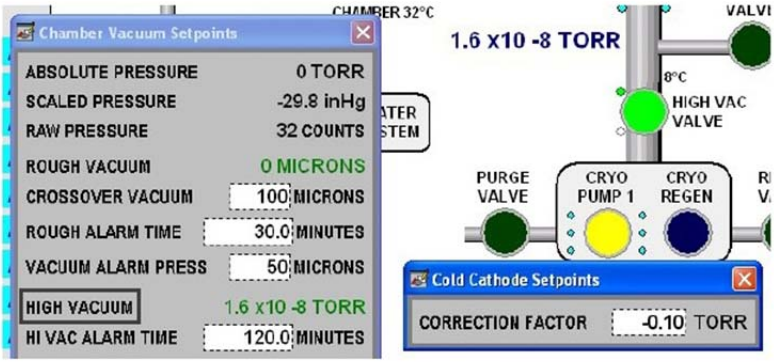
9.2.1.6.1 Chamber Baratron Setpoints

Setpoint	Range	Default Setting
Baratron Safe Negative	-32768 - 0 Counts	-250 Counts
Baratron Safe Positive	0 - 32767 Counts	250 Counts

Baratron Safe Negative:	This is the negative side of the valid range of the Baratron pressure transducer in proportional counts (see section 7.12).
Baratron Safe Positive:	This is the positive side of the valid range of the Baratron pressure transducer in proportional counts (see section 7.12).

Note: The logged in user must have a security code of "H" to modify parameters on this screen.

9.2.1.6.2 Cold Cathode Setpoints

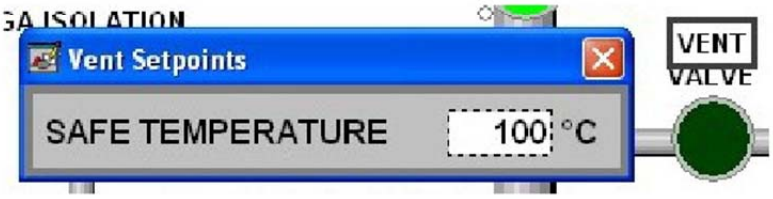


Setpoint	Range	Default Setting
Cold Cathode Correction	-1.00 - 1.00 Torr	0.00 Torr

Cold Cathode Correction: This correction factor can be used to make the high vacuum reading on the OIT agree with the reading on the vacuum gauge.

Note: The logged in user must have a security code of "H" to modify parameters on this screen.

9.2.1.7 Vent Setpoints



Setpoint	Range	Default Setting
Safe Temperature	0 - 260 Deg C	100 Deg C

Safe Temperature: The furnace's average temperature must be below this temperature before an attempt is made to vent the chamber to atmosphere and open the chamber door.

Note: The logged in user must have a security code of "G" to modify parameters on this screen.

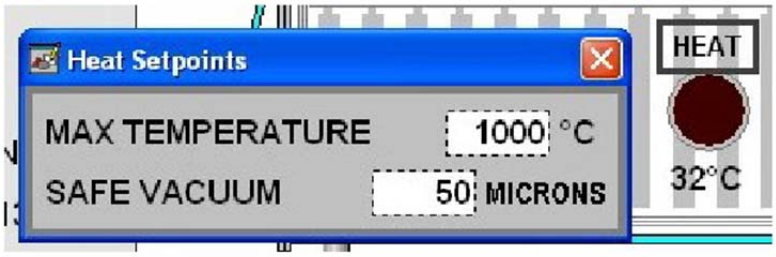
9.2.1.8 Backfill Setpoints

Setpoint	Range	Default Setting
Backfill Alarm Time	0.1 - 3276.7 Minutes	7.0 Minutes

Backfill Alarm Time: This is the maximum amount of time that the backfill valve can be open without one of the backfill pressure setpoints being satisfied. If backfilling exceeds this time "The gas source failed to backfill the chamber in 5 minutes. Check the gas supply" alarm will occur. This time should be selected based on the actual time required to backfill the chamber when the user's gas source is in good working order.

Note: The logged in user must have a security code of "G" to modify parameters on this screen.

9.2.1.9 Heat Setpoints



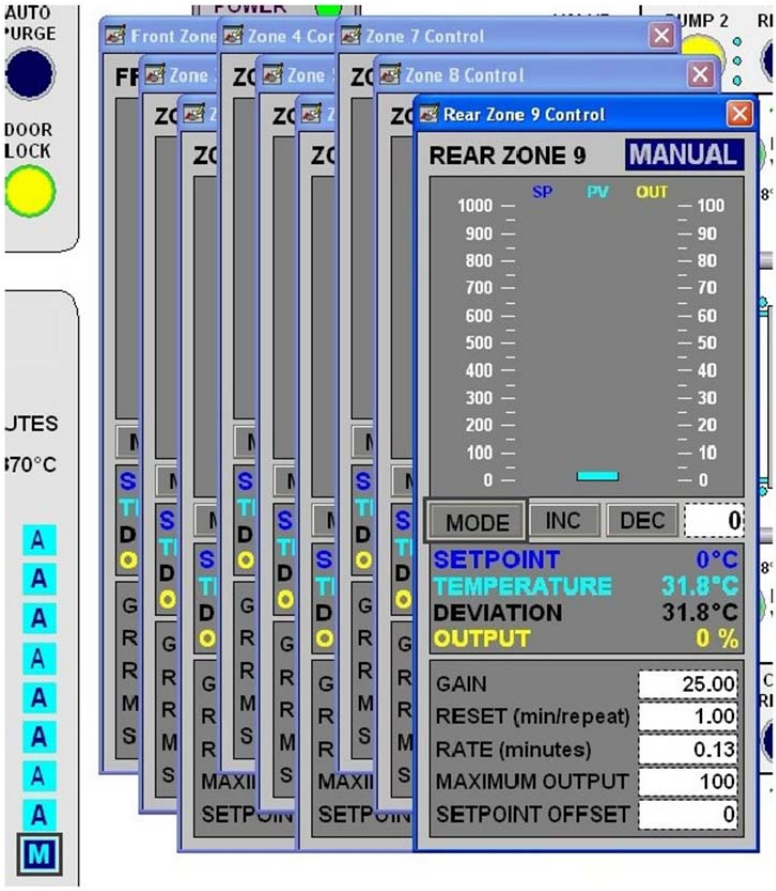
Setpoint	Range	Default Setting
Maximum Temperature	0 - 1000 Deg C	1000 Deg C
Safe Vacuum	10 - 900 Microns	50 Microns

Maximum Temperature: This is the highest temperature Setpoint that the furnace will control at regardless of what is set in a program.

Safe Vacuum For Heat: The furnace must have been pumped below this setpoint before the Heat can be turned on.

Note: The logged in user must have a security code of "G" to modify parameters on this screen.

9.2.1.10 Heating Zone Controllers



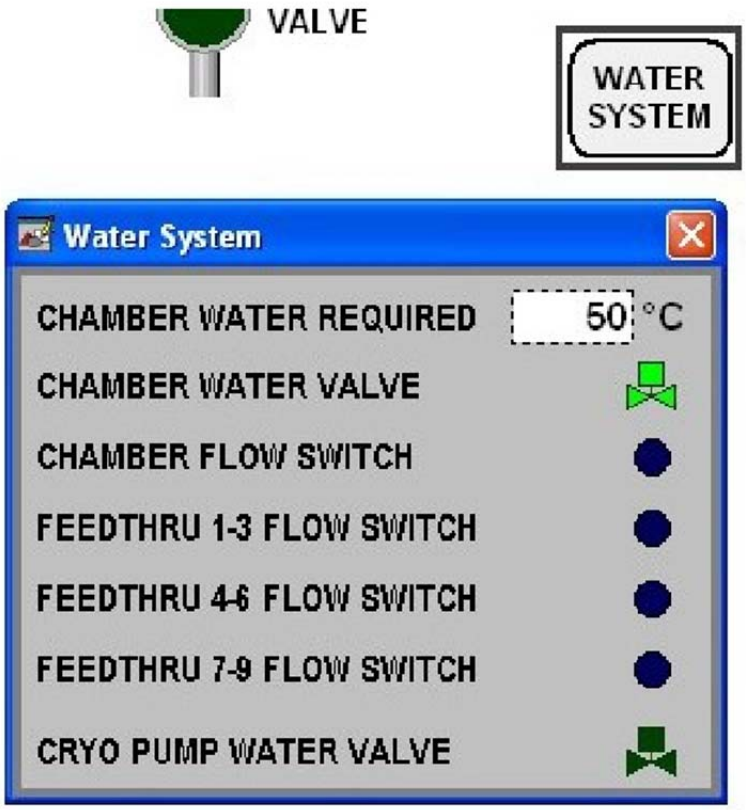
These screens are provided to allow adjustment of the PID and other parameter for the three zones of temperature control. Provisions are also made for the operator to take manual control of the output to the SCR for each zone. Refer to the *Allen-Bradley SLC 500™ Instruction Set Reference Manual* for an explanation of the parameters and tuning procedures. The allowable ranges and factory defaults for the PID parameters are as follows:

Parameter	Range	Default Setting
Gain	0 - 327.67	25.00
Reset	0 - 327.67 Mins/Repeat	1.00
Rate	0 - 327.67 Minutes	0.13
Maximum Output	0 - 100 % Power	100
Setpoint Offset	-99 - +99 Degrees	0

Note: Any adjustments to these parameters are replaced by the programs PID 1 parameters (section 9.5.2.5) when a program is selected or if an event to change to a new set of PID parameters is encountered.

Note: The logged in user must have a security code of "F" to modify parameters on these screens.

9.2.1.11 Water System



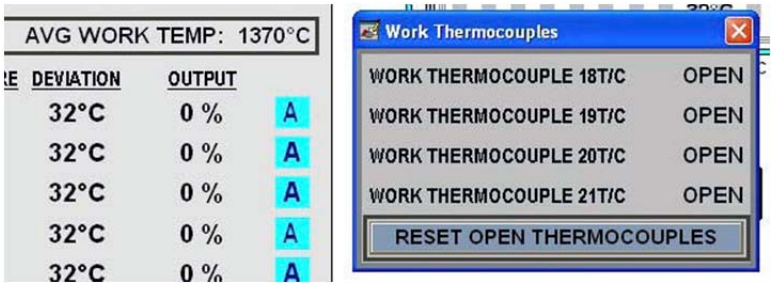
This screen shows the condition of the water systems valves and flow switches.

Setpoint	Range	Default Setting
Chamber Water Required	0 - 260 Deg C	50 Deg C

Chamber Water Required: If the furnace is above this temperature, the furnace water will be on and the water alarm will be armed.

Note: The logged in user must have a security code of "G" to modify parameters on this screen.

9.2.1.12 Work Thermocouples



This screen is provided to allow the operator to easily view the individual work temperatures.

9.2.1.13 RGA Isolation Setpoints

Setpoint	Range	Default Setting
Safe Vacuum	0 – 100 Microns	10 Microns

Safe Vacuum: The furnace's vacuum level must be below this setpoint before the RGA Isolation Valve can be opened.

Note: The logged in user must have a security code of "G" to modify parameters on this screen.

9.2.1.14 Auto Purge Setpoints

Setpoint	Range	Default Setting
Auto Purge Base Pressure	10 - 99 Torr	10 Torr
Auto Purge Fill Pressure	100 - 760 Torr	100 Torr

Auto Purge Base Pressure: This is the vacuum level that the chamber will be pumped to when Auto Purge is first initiated. While pumping to this level the message "Establishing A Base Pressure" will be displayed. Once this vacuum level is achieved, the Backfill and Gas Bleed valves will open, the message "Checking If The Gas Source Is On" will be displayed, and furnace pressure will be monitored for five minutes to insure that the gas source has been shut off.

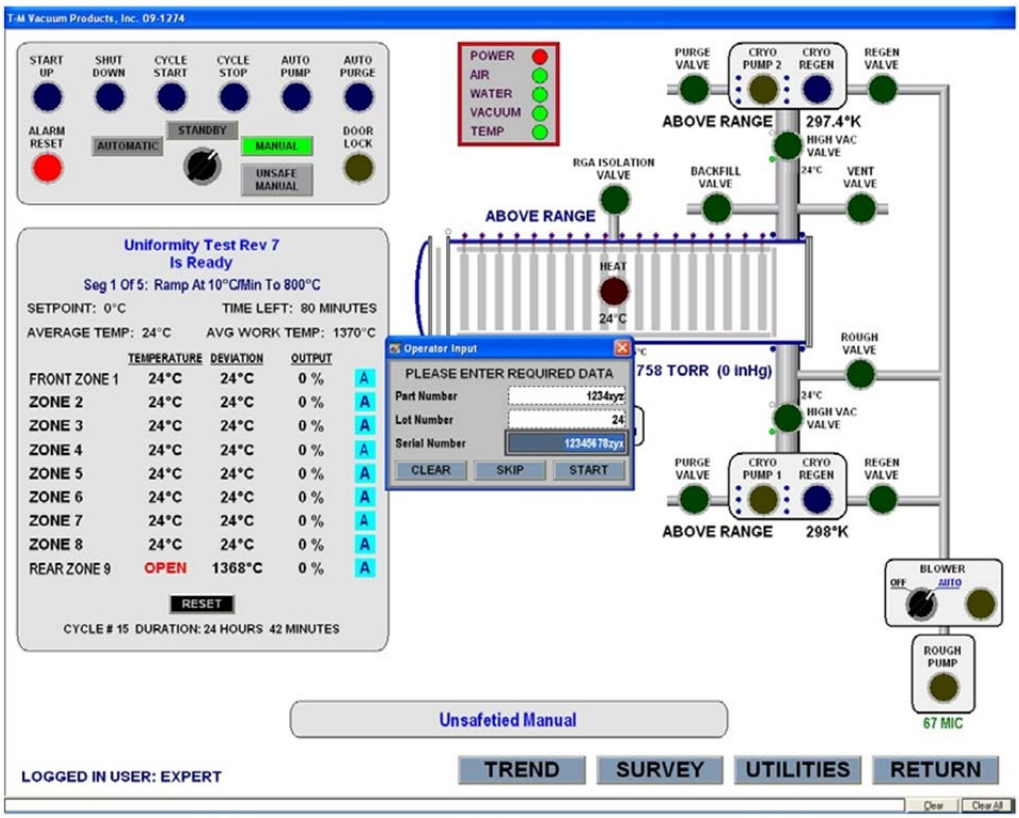
Auto Purge Fill Pressure: While the system is checking if the gas source is on, if the chamber exceeds this pressure, the gas valves will close and the operator will be directed to shut the gas source off and press the AUTO PURGE button a second time. Once the system is satisfied that the gas source is off, the message "Auto Purging Of Gas Lines In Progress" will appear and the chamber and the gas lines will be pumped to the current Program Start Vacuum (section 9.5.2.4). When this pressure is reached, the High Vacuum Valve will close, and the operator will be directed to turn the gas source on. When the Auto

Purge Fill Pressure is reached, the Auto Purge cycle is complete.

Note: The logged in user must have a security code of "H" to modify parameters on this screen.

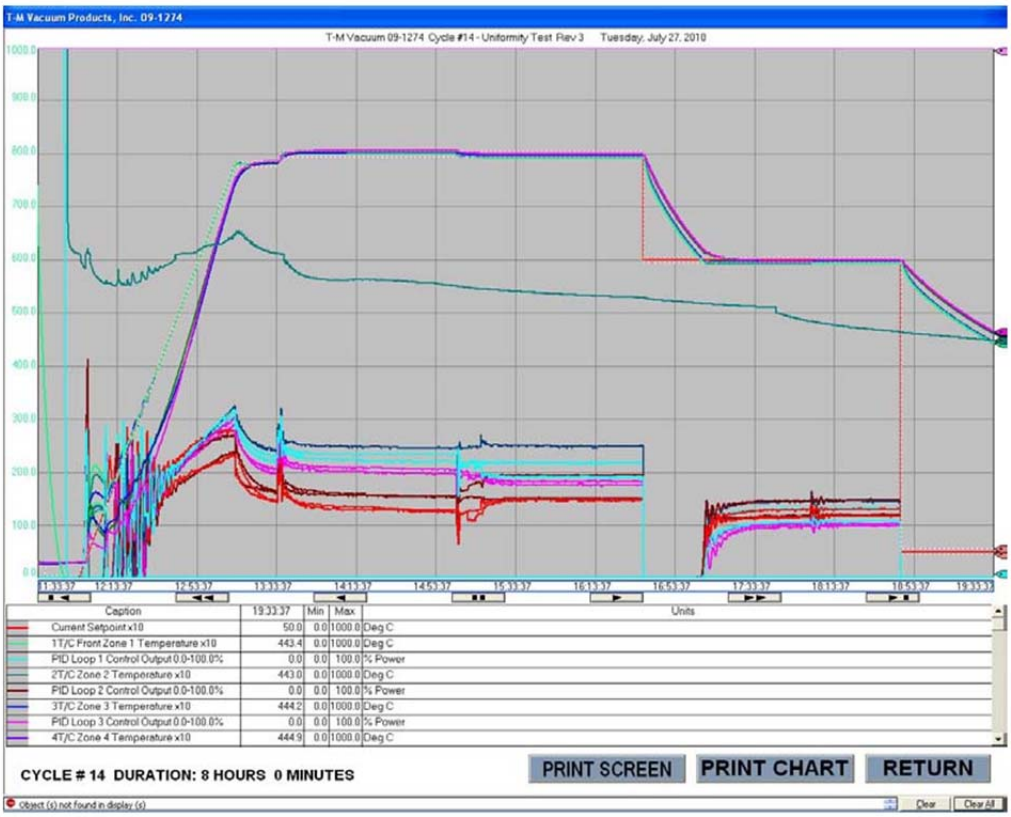
9.2.1.15 Operator Input

When enabled this screen is displayed whenever an automatic cycle is started. It allows the operator to enter information into up to 8 data fields. Each field will except up to a maximum of 16 characters. The entered data is then saved to the "C:\RSView32\09-1274 fermilab ss12-72-13mcx\DLGLOG\OPERATOR" data log file. If the operator has a security code of "D" or "L" a SKIP button in displayed allowing the operator to start the cycle without entering any data. The labels for each field can be changed from the Auxiliary Setpoints Screen (section 9.5.5).


T-M Vacuum Products, Inc. 09-1274
START UP
SHUT DOWN
CYCLE START
CYCLE STOP
AUTO PUMP
AUTO PURGE
ALARM RESET
AUTOMATIC
STANDBY
MANUAL
UNSAFE MANUAL
DOOR LOCK
POWER
AIR
WATER
VACUUM
TEMP
PURGE VALVE
CRYO PUMP 2
CRYO REGEN
REGEN VALVE
ABOVE RANGE
297.4°K
HIGH VAC VALVE
RGA ISOLATION VALVE
BACKFILL VALVE
VENT VALVE
ABOVE RANGE
HEAT
24°C
Uniformity Test Rev 7
Is Ready
Seg 1 Of 5: Ramp At 10°C/Min To 800°C
SETPOINT: 0°C
TIME LEFT: 80 MINUTES
AVERAGE TEMP: 24°C
AVG WORK TEMP: 1370°C
TEMPERATURE DEVIATION OUTPUT
FRONT ZONE 1 24°C 24°C 0 % A
ZONE 2 24°C 24°C 0 % A
ZONE 3 24°C 24°C 0 % A
ZONE 4 24°C 24°C 0 % A
ZONE 5 24°C 24°C 0 % A
ZONE 6 24°C 24°C 0 % A
ZONE 7 24°C 24°C 0 % A
ZONE 8 24°C 24°C 0 % A
REAR ZONE 9 OPEN 1368°C 0 % A
RESET
CYCLE # 15 DURATION: 24 HOURS 42 MINUTES
Operator Input
PLEASE ENTER REQUIRED DATA
Part Number 1234xyz
Lot Number 24
Serial Number 12345678zyx
CLEAR
SKIP
START
758 TORR (0 inHg)
ROUGH VALVE
HIGH VAC VALVE
PURGE VALVE
CRYO PUMP 1
CRYO REGEN
REGEN VALVE
ABOVE RANGE
298°K
BLOWER
OFF
AUTO
ROUGH PUMP
67 MIC
Unsafetied Manual
LOGGED IN USER: EXPERT
TREND
SURVEY
UTILITIES
RETURN
Clear
Clear All

9.3 Trend Screen

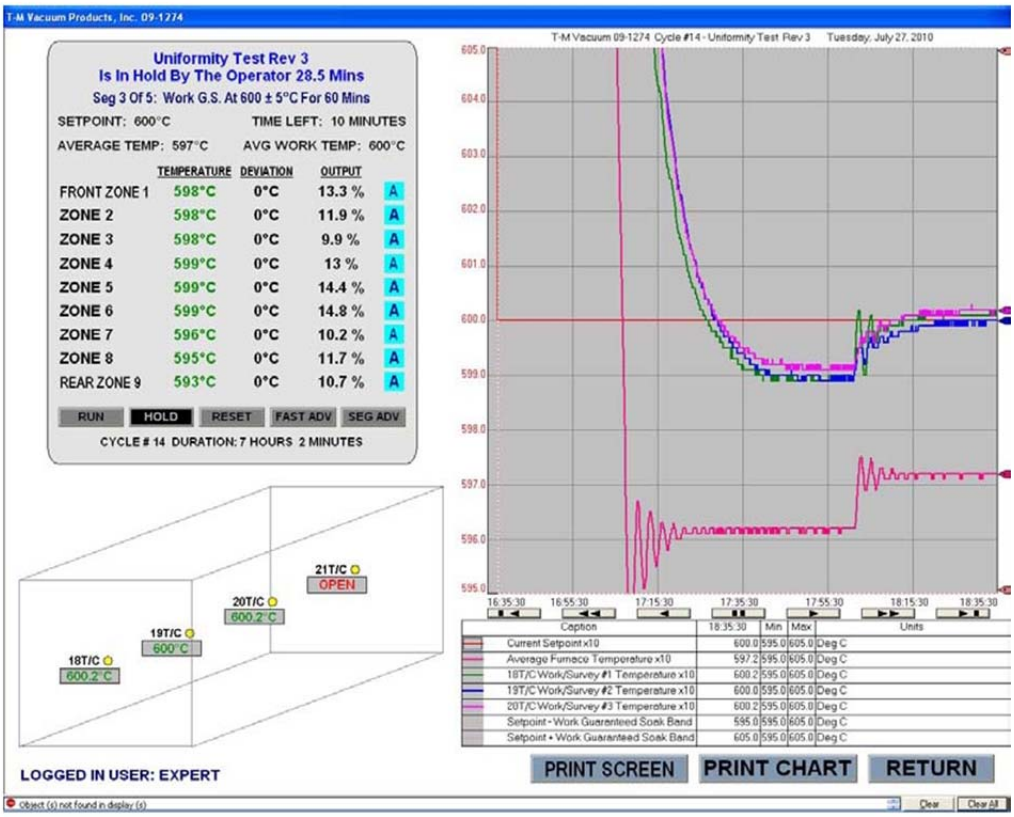
This screen is used to view real time or historical trends of any or all data collected by the furnace system. This screen can be easily reconfigured by the operator at any time to show whatever is required at the time. Pens can be turned on or off, the time scale can be changed, the y-axis can be rescaled, etc. Also at any time the chart can be printed out for a hard copy.



Note: The trend data is stored on the computer's hard drive as DBF files in the directory "C:\RSView32\09-1274 fermilab ss12-72-13mcx\DLGLOG\D7162".

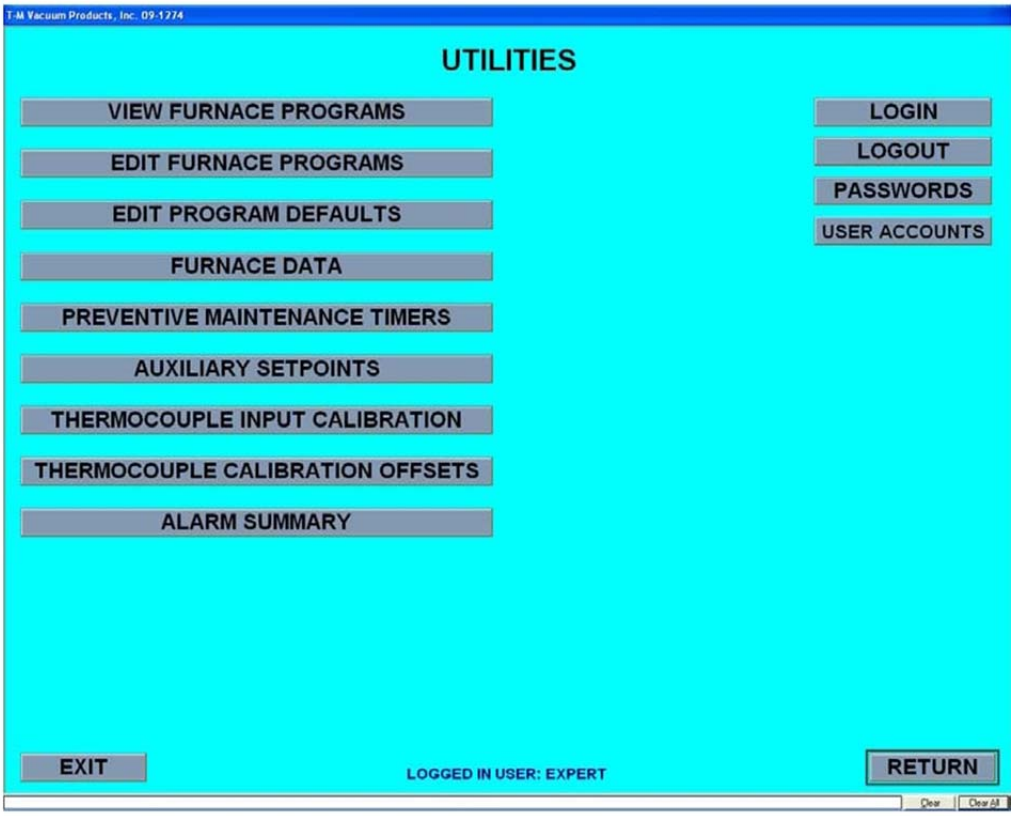
9.4 Survey Screen

This screen is provided as an aid to performing temperature uniformity studies of the furnace hot zone. Up to four thermocouples can be monitored for temperature at their relative position in the hot zone. Real time trending of the temperatures is also available with the ability to zoom in and scroll the Y-Axis to enhance readability.



9.5 Utilities

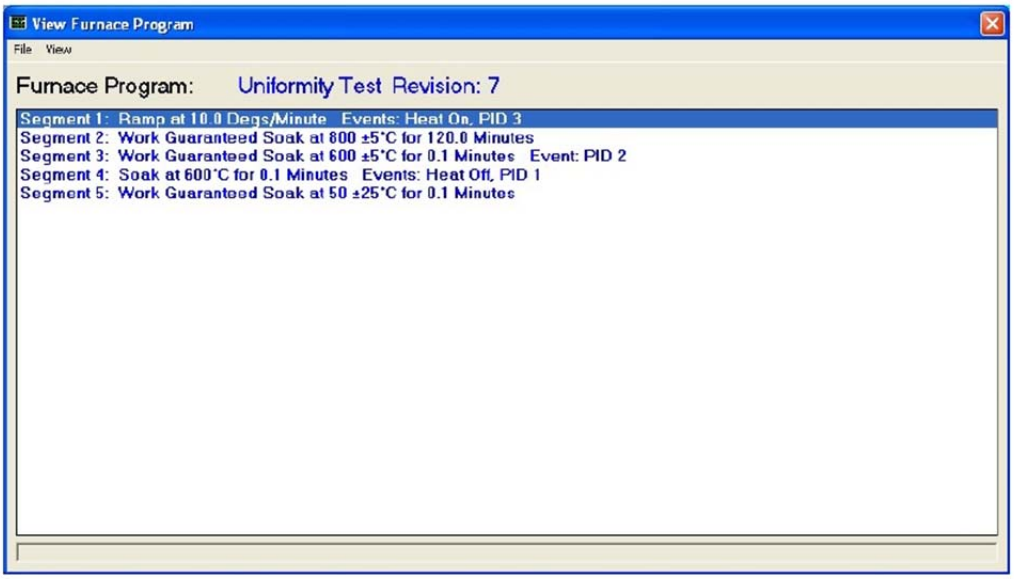
As a convenience for the setup and maintenance of the system, a series of utility screens are provided. These screens are useful for selecting and maintaining temperature programs, setting furnace parameters, viewing raw furnace data, etc. Available utility screens are as follows:



9.5.1 View Furnace Programs

From this screen any operator can open a furnace program file for viewing, save it to the PLC so that it can be run in an automatic cycle, or print out a hard copy of it.

Note: The logged in user must have a security code of "A" to use this screen.



9.5.1.1 File Options

The following options are available from the File pull down menu:

Open Program	This option allows the operator to select a furnace program to view or run from a list of available program.
Save To PLC	Selecting this option will down load the currently selected program to the PLC so that it will run when an automatic cycle is started. Note that this option is unavailable if another program is running.
Load From PLC	Selecting this option will upload the program stored in the PLC allowing it to be edited and/or saved on the computer. Note that any unsaved changes made to a program open in the editor will be lost.
Verify	Selecting this option will open the Program Verification window. When verification is run, the open program will be checked against the program stored in the PLC for any discrepancies.
Print Program	This option will print the currently selected furnace program along with its parameters.
Exit	Will close the View Furnace Program window.

9.5.1.2 View Options

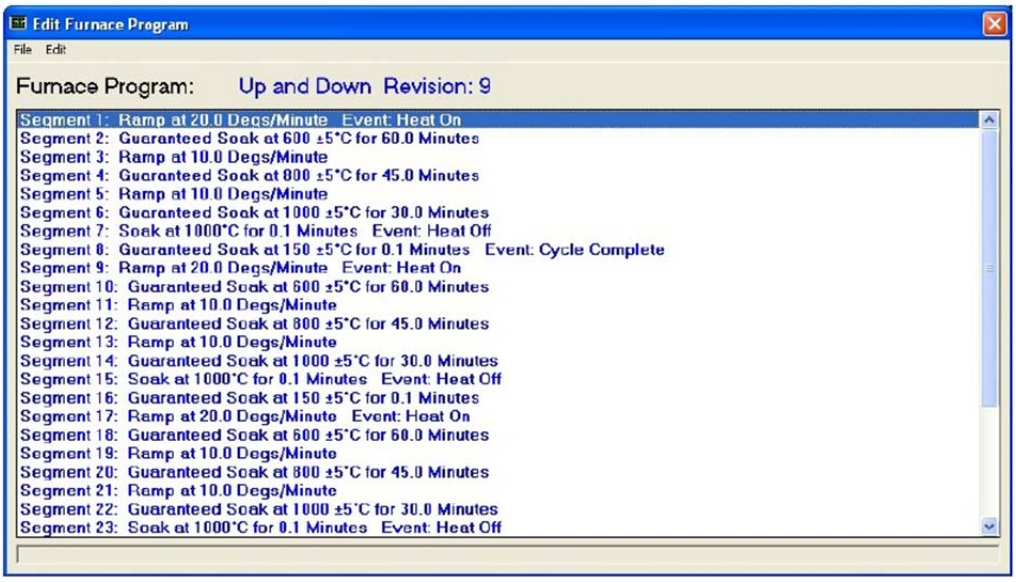
The following options are available from the View pull down menu:

Parameters	This option allows viewing of the parameters for the selected program.

9.5.2 Edit Furnace Programs

From this screen the operator can do everything listed above plus have the ability create, edit, and copy program.

Note: The logged in user must have a security code of "B" to use this screen.



9.5.2.1 File Options

The following options are available from the File pull down menu:

New Program	This option is used to create a new program.
Open Program	This option allows the operator to select a furnace program to view, run, or edit from a list of available program.
Save Program	This option is used to save any changes to the furnace program to the computer's hard drive.
Save Program As	This can be used to save the program under a different file name
Save To PLC	Selecting this option will download the currently selected program to the PLC so that it will run when an automatic cycle is started. Note that this option is unavailable if a different program is running.
Load From PLC	Selecting this option will upload the program stored in the PLC allowing it to be edited and/or saved on the computer. Note that any unsaved changes made to a program open in the editor will be lost.

Verify	Selecting this option will open the Program Verification window. When verification is run, the open program will be checked against the program stored in the PLC for any discrepancies.
Print Program	This option will print the currently selected furnace program along with its parameters.
Exit	Will close the View Furnace Program window.

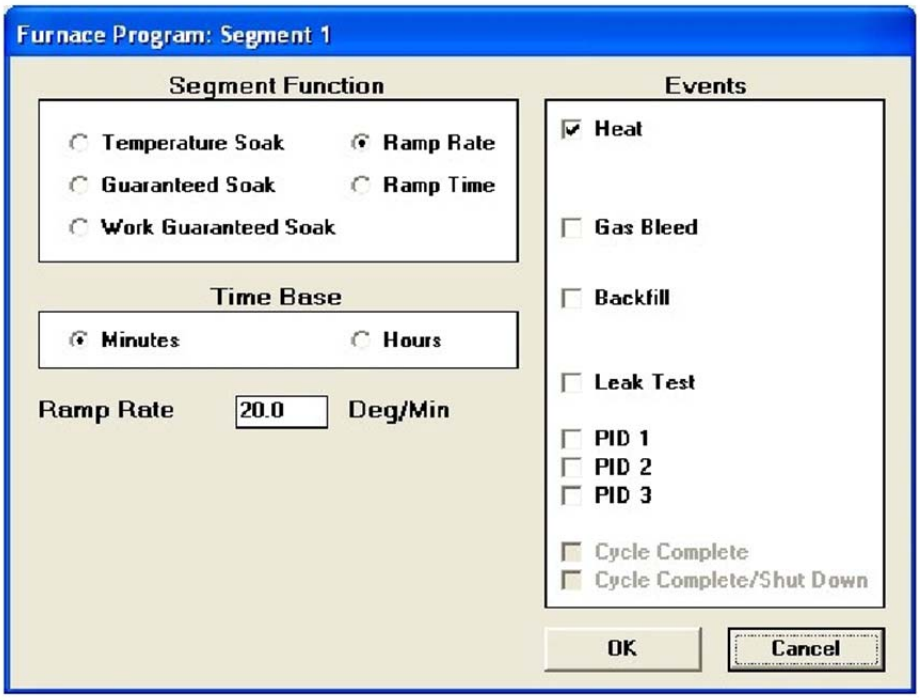
9.5.2.2 Edit Options

The following options are available from the Edit pull down menu:

Parameters	This option allows viewing and editing of the parameters for the selected program. See sections 9.5.2.4 and 9.5.2.5 for a listing and description of the program parameters.
Current Segment	This option allows editing of the selected segment. Note that simply double clicking on a segment will also open the segment editing window.
New Segment	This option will create a new segment at the end of the program.
Insert Segment	This will insert a new segment before the currently selected segment.
Delete Segment	This will delete the currently selected segment from the program.

9.5.2.3 Segment Editing

If a new segment is created by either the New Segment or Insert Segment options, or if Current Segment is used on a selected segment, the following window will open.



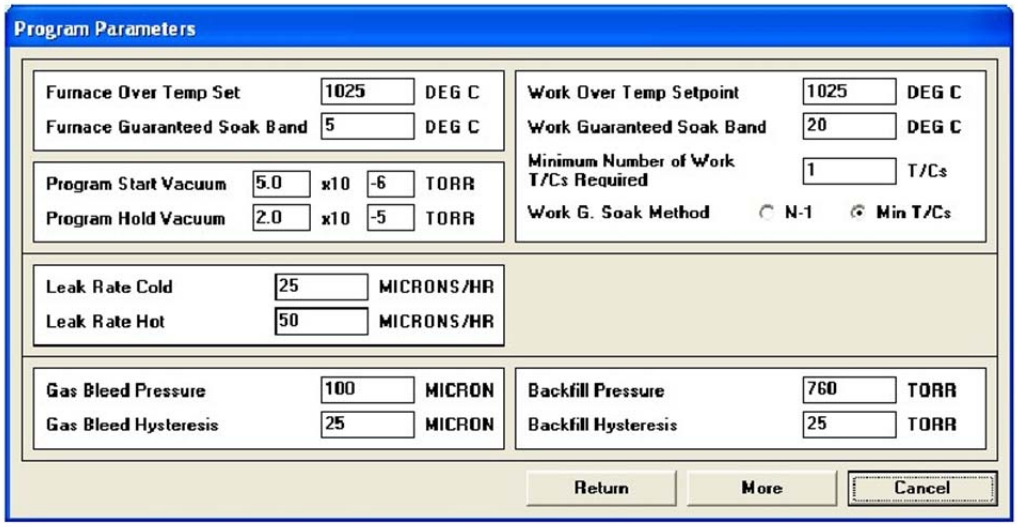
Temperature Soak	Is for a basic Soak where a Setpoint is entered, along with the soak Duration required at that temperature. Any type of segment may follow a Soak.
Guaranteed Soak	A Guaranteed Soak is the same as a basic Soak except that the average furnace temperature must be within the Furnace Guaranteed Soak Band before the soak Duration will begin to time out. Note that any Events programmed will have no effect until this condition is met.
Work Guaranteed Soak	A Work Guaranteed Soak is the same as the Guaranteed Soak described above except that the temperature of the work thermocouple must be within the Work Guaranteed Soak Band.
Ramp Rate	Will make the new segment a Ramp Rate. Once the segment is defined, Ramp Rate can be used to enter a rate in the range of 1.0 to 3276.7 Deg/Min or Deg/Hr. Note that a Soak, Guaranteed Soak, or Work Guaranteed Soak must follow a Ramp Rate.
Ramp Time	Is for a Ramp Time where a Setpoint to be reached is entered, along with the Duration required to do so. A Ramp Rate, another Ramp Time, or any of the Soaks may follow a Ramp Time.
Minutes	Sets the time base of the segment to minutes.
Hours	Sets the time base of the segment to hours.
Heat	This event is used to toggle the furnace Heat on and off. The first time it is used the Heat will be turned on, and the second time turns it off. The Heat will also be turned off if the Quick Cool is turned on with a Fan Speed > 0, or if the cycle is complete.
Gas Bleed	This event is used to toggle Gas Bleed 2 on and off. Once initiated, the High Vacuum Valve will close, the Gas Bleed 2 Valve will open, and the Program will go into hold until the Bleed Pressure is reached. If initiated while backfilled, the Rough Valve will open, and the Program will go into hold until the gas bleed pressure is reached. Once the gas bleed pressure range is reached, the Gas Bleed 2 and Rough Valves will open and close as required to maintain the range. If the Gas Bleed 2 is toggled off by setting its pressure to zero, the chamber will be automatically pumped down, and the Program will go into hold until high vacuum is reached. Turning on the Quick Cool, a Backfill, Gas Bleed 1 or Cycle Complete will turn Gas Bleed 2 off.
Backfill	This event is used to toggle Backfill 1 on and off. Once initiated the Backfill 1 Valve will open and the Program will go into hold until the Backfill Pressure is reached. If Backfill 1 is toggled off by setting its pressure to zero, the chamber will be automatically pumped down, and the Program will go into hold until high vacuum is reached. Turning Backfill 1 on will turn off the Quick Cool, a Gas Bleed, or Backfill 2 if

it was on. Turning on the Quick Cool, a Gas Bleed, Backfill 2 or Cycle Complete will turn off Backfill 1.

Leak Test	This event will initiate an automatic leak rate test. Once started, the program will go into hold and the High Vacuum Valve will close. Thirty seconds later a vacuum reading will be recorded. Five minutes after that (see section 9.2.1.4 to adjust this time) a second vacuum reading will be taken. This reading will be compared with the first and the leak rate will be calculated. If the leak test passes, the chamber will return to high vacuum then the program will continue. If it fails, the High Vacuum Valve will open and the chamber will be pumped on for an additional ten minutes. After this the leak rate test will be tried again. If the test fails a second time, an alarm will sound and it will be up to operator whether or not to continue the cycle.
PID 1, PID 2, PID 3	These events will load the associated PID constants for the current and subsequent segments. If none of these events are used in a program the system will default to the values of PID 1.
Cycle Complete/Regen	This event will signal that the cycle is complete, but will also initiate the automatic Cryo Regeneration sequence. The event should be programmed in the final soak of the program. The final soak must be guaranteed with a setpoint of less than 100 degrees C to prevent oxidation of the hot zone and/or the workload.
Cycle Complete	This event will signal to the system that the cycle is complete, thus allowing the operator to vent the chamber by means of the CYCLE STOP pushbutton. The event should be programmed in the final soak of the program. The final soak must be guaranteed with a setpoint of less than 100 degrees C to prevent oxidation of the hot zone and/or the workload.

9.5.2.4 Parameters 1

These parameters establish various setpoints for temperature, vacuum, pressure, etc. used over the course of a furnace program.



Setpoint	Range	Default Setting
Furnace Over Temp Setpoint	0 - 1050 Deg C	1050 Deg C
Furnace Guaranteed Soak Band	1 - 999 Deg C	5 Deg C
Work Over Temp Setpoint	0 - 1050 Deg C	1050 Deg C
Work Guaranteed Soak Band	1 - 999 Deg C	20 Deg C
Min # Of Work T/Cs Required	0-5	0
Work G. Soak Method	N-1 or Min T/Cs	Min T/Cs
Program Start Vacuum	1.0×10^{-8}-9.9×10^{-3}	5.0×10^{-6} Torr
Program Hold Vacuum	1.0×10^{-8} - 9.9×10^{-3}	2.0×10^{-5} Torr
Leak Rate Cold	1 - 999 Microns/Hr	25 Microns/Hr
Leak Rate Hot	1 - 999 Microns/Hr	50 Microns/Hr
Gas Bleed Pressure	0 - 1000 Microns	300 Microns
Gas Bleed Hysteresis	1 - 100 Microns	25 Microns
Gas Backfill Pressure	0 - 1520 Torr	760 Torr
Gas Backfill Hysteresis	1 - 100 Torr	25 Torr

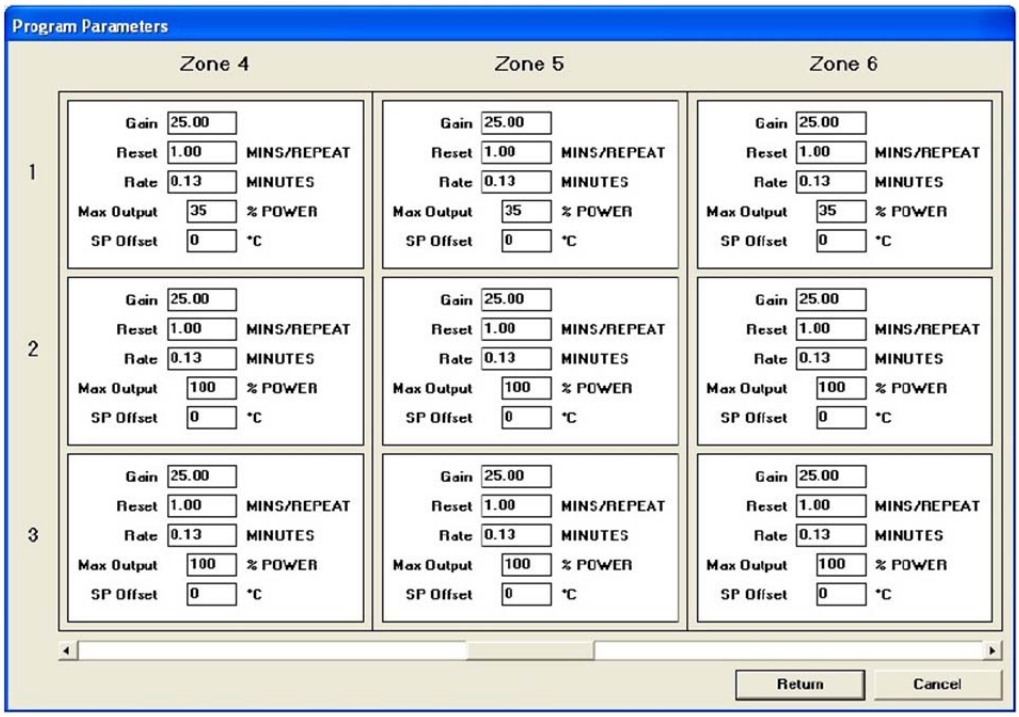
Furnace Over Temp Setpoint: The furnace control or Over Temperature controller's T/C exceeding this temperature will cause a Control T/C Is Over

	Temperature or a Over Temperature T/C Is Over Temperature alarm.
Furnace Guaranteed Soak Band:	When a Guaranteed Soak is encountered, the average furnace temperature must be within the setpoint + or - this band before the soak duration begins timing out. Note that any Events programmed in this segment will not take effect until the soak band is satisfied.
Work Over Temp Setpoint:	The work T/C exceeding this temperature will cause a Work Thermocouple Is Over Temperature alarm.
Work Guaranteed Soak Band:	When a Work Guaranteed Soak is encountered, the work temperature must be within the setpoint + or - this band before the soak duration begins timing out. Note that any Events programmed in this segment will not take effect until the soak band is satisfied.
Min # Of Work T/Cs Required	This the minimum number work thermocouples that must be valid when the chamber door is closed. If less than this number of T/Cs is valid when the door is closed, an alarm will be triggered. Note: any T/C that is considered invalid when the chamber door is closed will be considered faulty regardless of its condition until the door is reopened.
Work G. Soak Method	This selects the method used to determine how many work thermocouples are needed to satisfy a Work Guaranteed Soak. The N-1 method requires that one less than the total number of valid work T/Cs have reached the soak band before the segment will begin timing. The Min T/Cs method uses the number set by the Min # Of Work T/Cs Required parameter.
Program Start Vacuum:	This is the vacuum level that must be reached to start the execution of a program during an automatic cycle. This is also the level that must be reached in less than the High Vacuum Alarm Time (section 9.2.1.4) to avoid The Chamber Failed To Reach High Vacuum In Time alarm. Note that this setpoint must be lower than the Program Hold Vacuum level.
Program Hold Vacuum:	The Program Hold Vacuum setpoint is used in conjunction with the Program Start Vacuum setpoint to define the range to be maintained during a high vacuum heating cycle. After the furnace has been pumped below the Program Start Vacuum level and the program has started, if the pressure rises above this setpoint, usually due to normal outgassing, the program will go into hold until the Program Start Vacuum level is again reached.
Leak Rate Cold	When a leak rate test is initiated by the Leak Test event and the Heat is off, the leak rate must be less than or equal to this setting.

Leak Rate Hot	When a leak rate test is initiated by the Leak Test event and the Heat is on, the leak rate must be less than or equal to this setting.
Gas Bleed Pressure:	This is the partial pressure setpoint (± Bleed Hysteresis) used when the Bleed Gas event is used in an automatic cycle.
Gas Bleed Hysteresis:	Below the Bleed Pressure Setpoint plus the Bleed Hysteresis, the Bleed Valve will be open. For Gas Bleed 1, above the Bleed Setpoint, the High Vacuum Valve will open and stay open unless the chamber pressure drops below the Crossover Vacuum (section 9.2.1.4). For Gas Bleed 2, above the Bleed Setpoint, the Rough Valve will open and stay open unless the chamber pressure drops below the Bleed Setpoint minus the Bleed Hysteresis. If the Bleed needle valve is adjusted properly, the Bleed and Rough Valves will both be open between the Bleed Setpoint plus the Bleed Hysteresis and the Bleed Setpoint minus Bleed Hysteresis, with little cycling of either valve.
Gas Backfill Pressure:	This is the pressure setpoint to which the chamber is backfilled when the Gas Backfill event is used in an automatic cycle. Once this pressure is reached the Backfill Valve will close.
Gas Backfill Hysteresis:	If the pressure drops below the Gas Backfill Pressure minus the Gas Backfill Hysteresis the Backfill Valve will open again to restore the chamber to the Gas Backfill Pressure. If the pressure rises above the Gas Backfill Pressure plus the Gas Backfill Hysteresis the Rough Valve (or the Vent Valve if the chamber pressure is above 2 PSIG) will open to reduce pressure.

9.5.2.5 Parameters 2

These parameters establish the PID constants for the three zones of temperature control and for controlled cooling used by a program. There are three sets of PID constants for heat control that can be called by using the PID events where required in the program.



Parameter	Range	Default Setting
Gain	0 - 327.67	25.00
Reset	0 - 327.67 Mins/Repeat	1.00
Rate	0 - 327.67 Minutes	0.13
Max Output	0 - 100 % Power	100
SP Offset	-99 - 99 Deg C	0

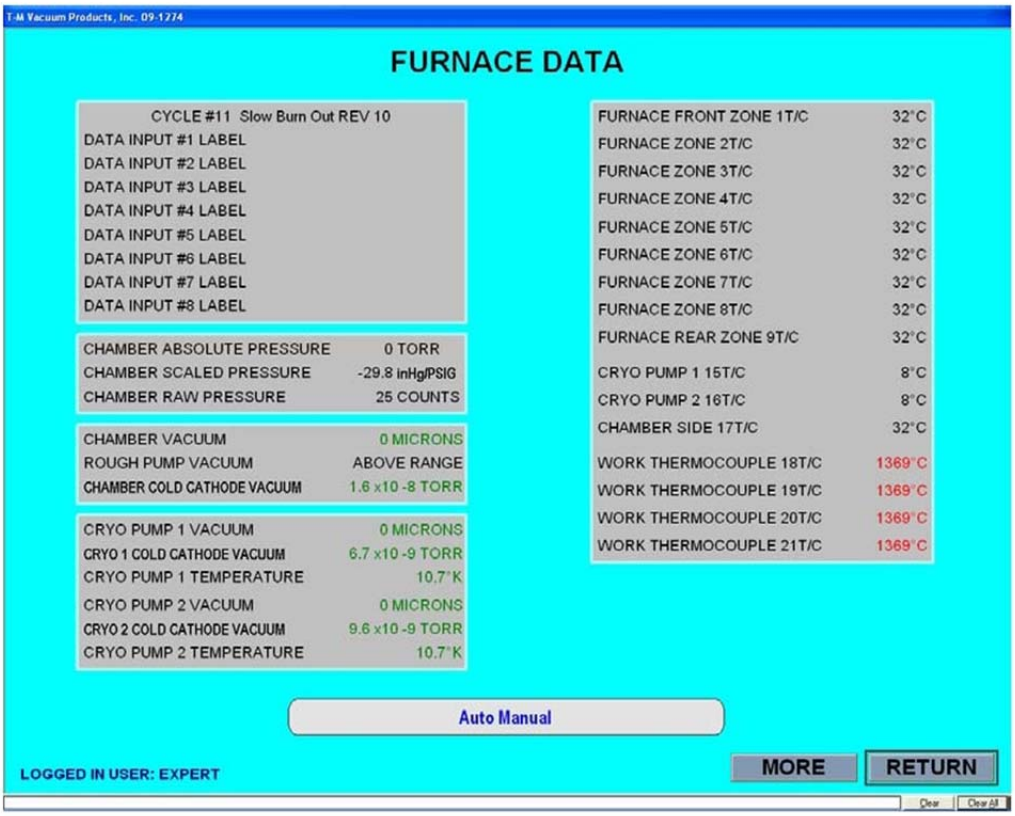
9.5.3 Edit Program Defaults

When a new program is created, default values for all of the program parameters are loaded into it. These defaults can be accessed by clicking on the Edit Program Defaults button. This will present screens as described above for the program parameters. Actual values for these default parameters should be selected to suit the needs of the majority of the programs to be run on the system. The values used by the individual programs can be modified by selecting Parameters from the Edit pull down menu on the Edit Furnace Program screen. Save and Exit will save the default values to a file on the computer's hard drive. Cancel will close this window without saving any changes.

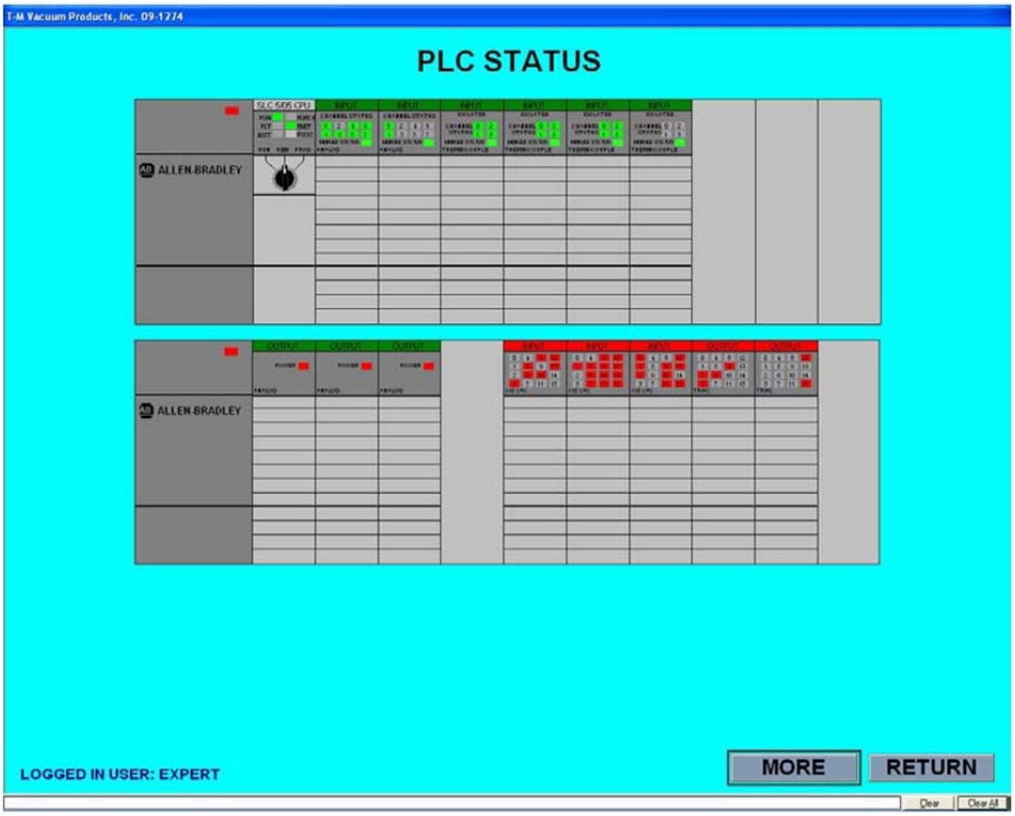
Note: The logged in user must have a security code of "C" to use this screen.

9.5.4 Furnace Data

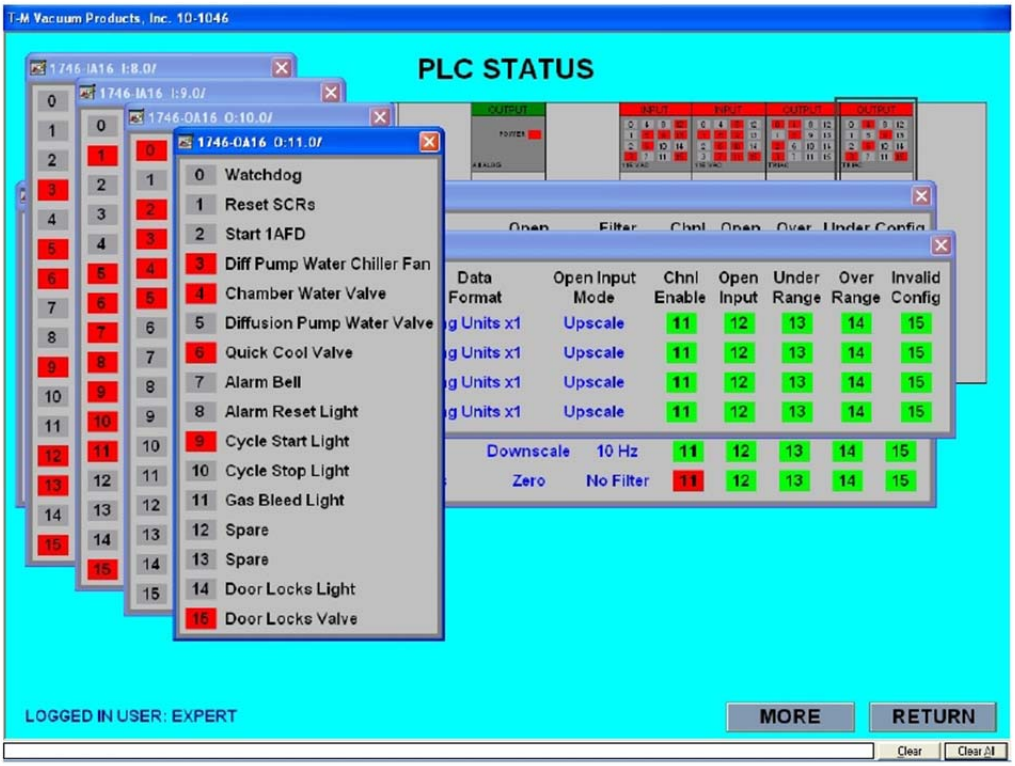
This screen can be used to view all of the data coming into the control system. This includes data from vacuum gauges, pressure transducers, thermocouples, etc.



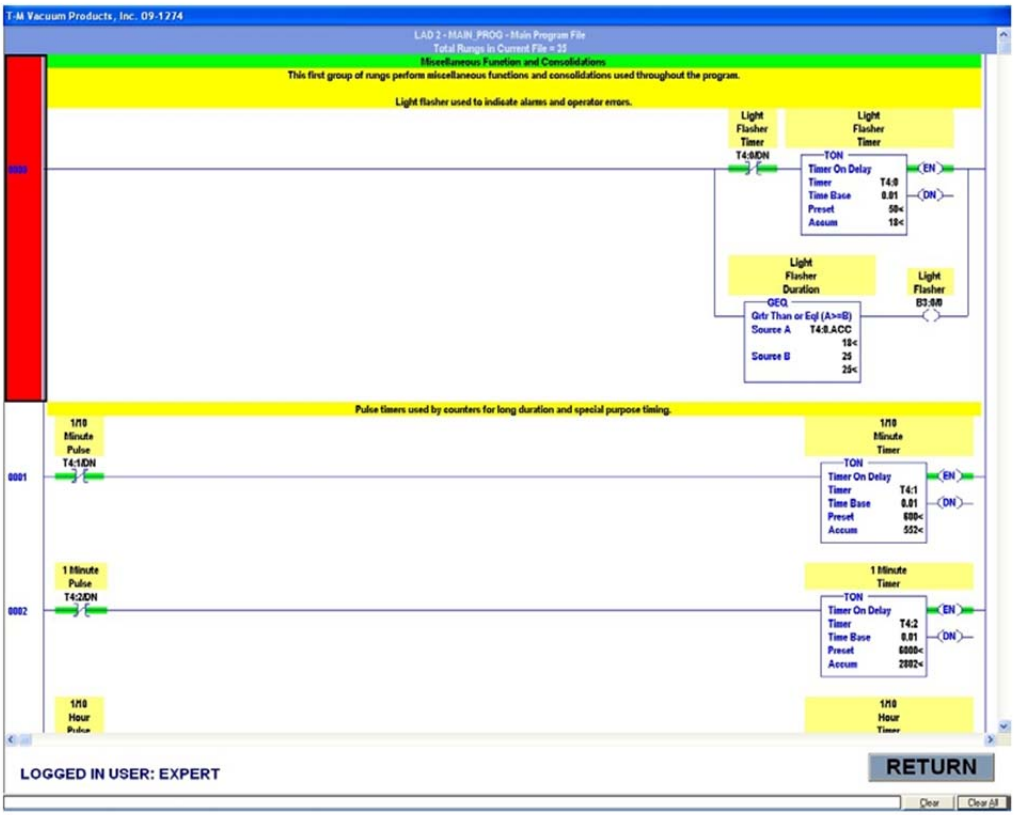
Clicking on the MORE button on this screen will take the user to a screen showing the status of the PLC and its I/O.



Clicking on any I/O module will popup an expanded view of that module. For example:



By pressing the "MORE" button the operator can view the PLC ladder logic.

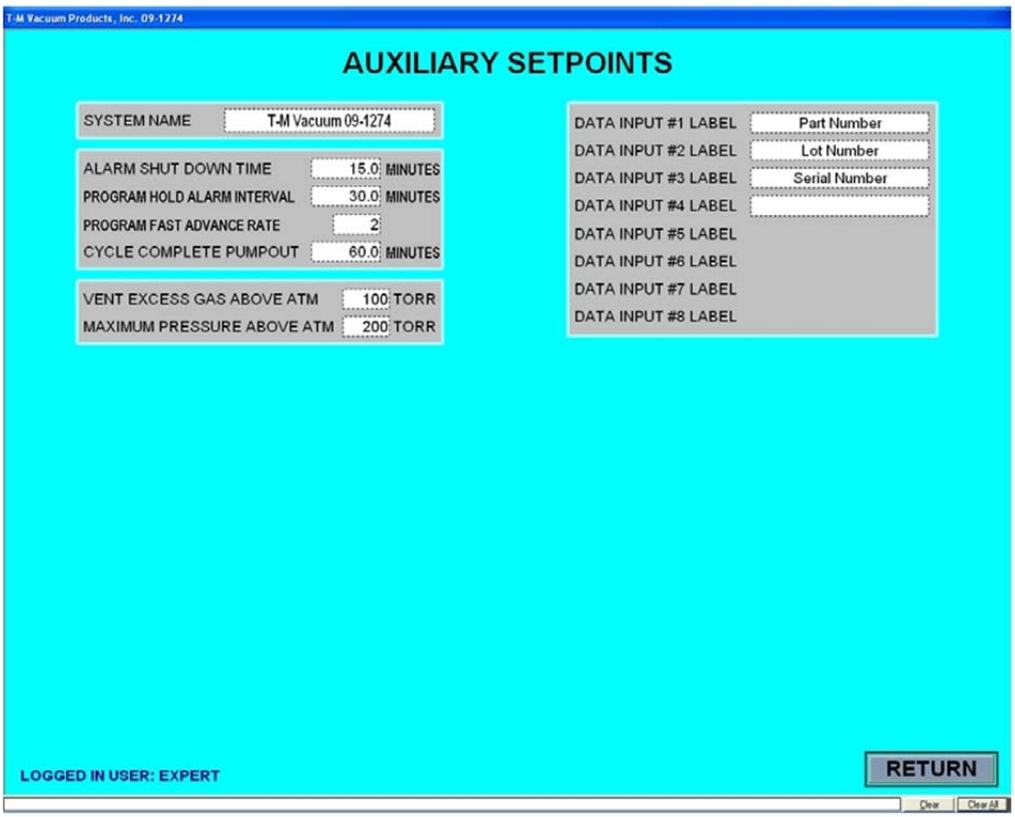


Note: The logged in user must have a security code of "L" to use this screen.

9.5.5 Auxiliary Setpoints

These screens are provided to allow adjustment of the various auxiliary setpoints used by the control system. The allowable ranges and factory defaults for the parameters are as follows:

Note: The logged in user must have a security code of "H" to use this screen.

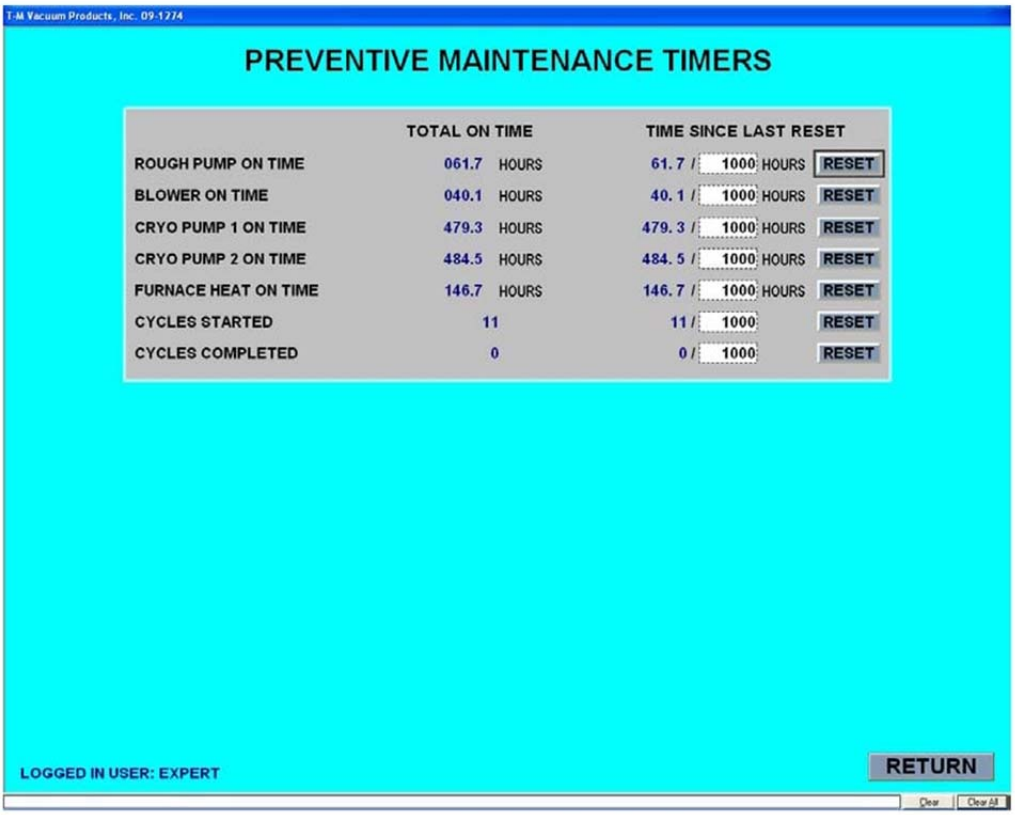


Setpoint	Range	Default Setting
System Name	24 Characters	T-M Vacuum 09-1274
Alarm Shut Down Time	0.0 - 3276.7 Minutes	15.0 Minutes
Program Hold Alarm Interval	0.0 - 3276.7 Minutes	30.0 Minutes
Program Fast Advance Rate	1 - 10 X	2X
Cycle Complete Pumpout	0.0 - 3276.7 Minutes	60.0 Minutes
Vent Excess Gas Above Atm	0 - 250 Torr	100 Torr
Maximum Pressure Above Atm	0 - 250 Torr	200 Torr
Data Input Labels	16 Characters	

System Name:	This is user defined name that is used at the beginning of a trend description.
Alarm Shut Down Time:	If an alarm occurs and it is not acknowledged before this time, the system will automatically shut down. Setting this value to 0.0 will disable this function.
Program Hold Alarm Interval:	Whenever the program goes into hold during an automatic cycle, the alarm bell will ring for three seconds at this interval to alert the operator of a possible problem.
Program Fast Advance Rate:	This is the multiplier used when FAST ADV is pressed on the Furnace Variables screen to speed up the program.
Cycle Complete Pumpout Time:	When an automatic cycle completes and if the High Vacuum Valve is closed, the furnace chamber will be evacuated after this time. Setting this value to 0.0 will disable this function.
Vent Excess Gas Above Atm:	After the furnace chamber has been backfilled to a pressure greater than atmospheric, the excess gas must be vented from the chamber to below this setpoint before the system can be evacuated or the Door Locks can be opened.
Maximum Pressure Above Atm:	This is the maximum pressure above atmospheric that the furnace chamber safely withstand. If this pressure is exceeded an alarm will occur (see section 7.12).
Data Input Labels:	These are user defined labels of up to 16 alpha-numeric characters used to prompt the operator to enter cycle or product information before an automatic cycle can be run. If all label fields are blank, the operator is not required to enter any data.

9.5.6 Preventive Maintenance Timers

This screen displays the accumulated time that the pumps and heat have been on and the number of automatic cycles started and completed.

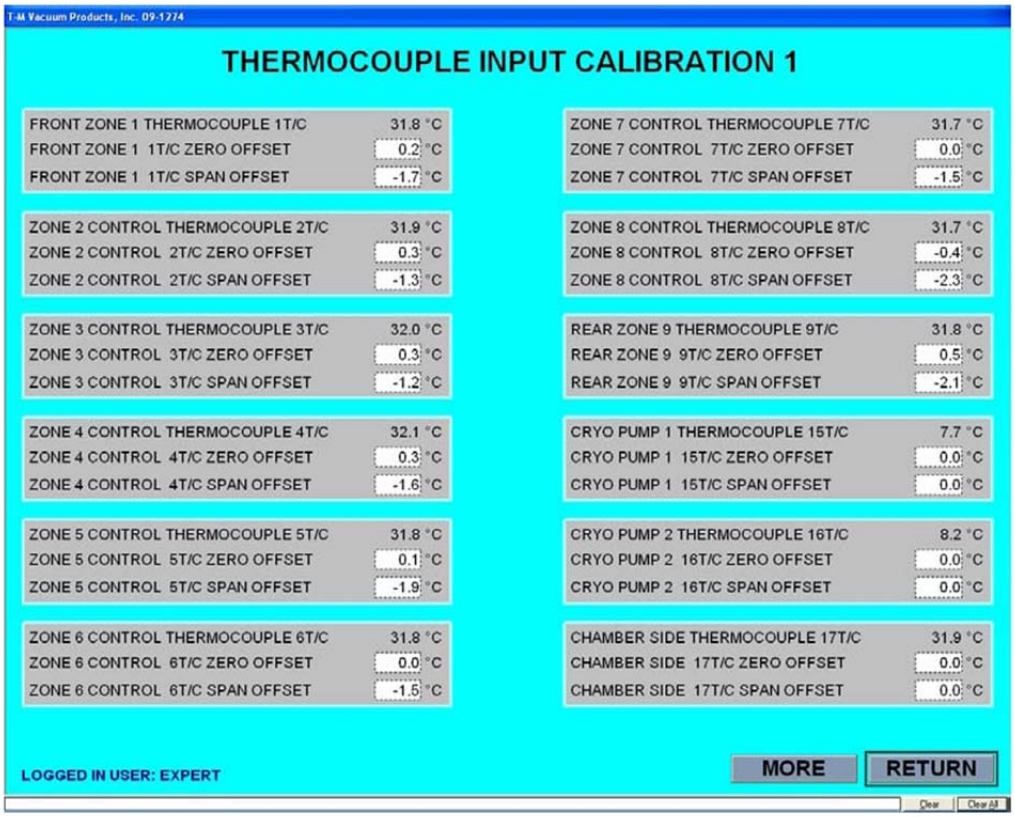


Note: The logged in user must have a security code of "H" to use this screen.

9.5.7 Thermocouple Input Calibration

This screen can be used to apply an offset to the zero and span of each thermocouple's range. This can be useful in compensating for variations in thermocouples and their lead wires. The allowable ranges and factory defaults for the parameters are as follows:

Note: The logged in user must have a security code of "I" to use these screens.



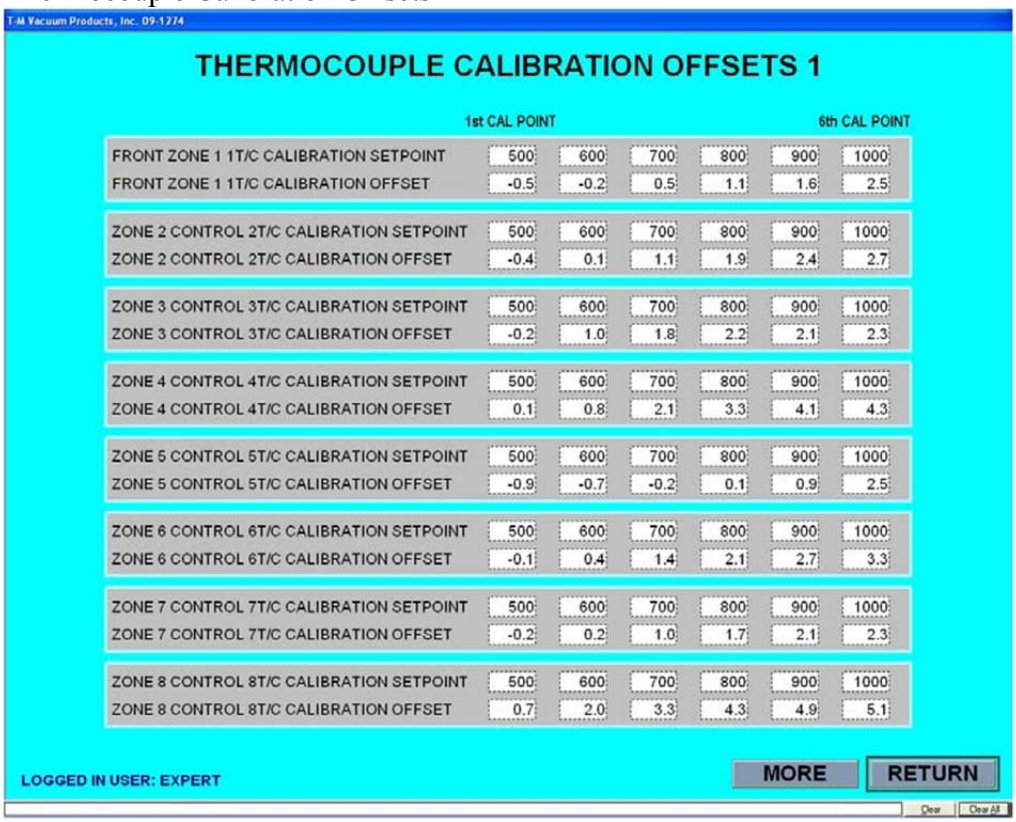
Setpoint	Range	Default Setting
T/C Span Offset	-99 - 99 Degrees C	0 Degrees C
T/C Zero Offset	-99 - 99 Degrees C	0 Degrees C

9.5.8 Thermocouple Calibration Offsets

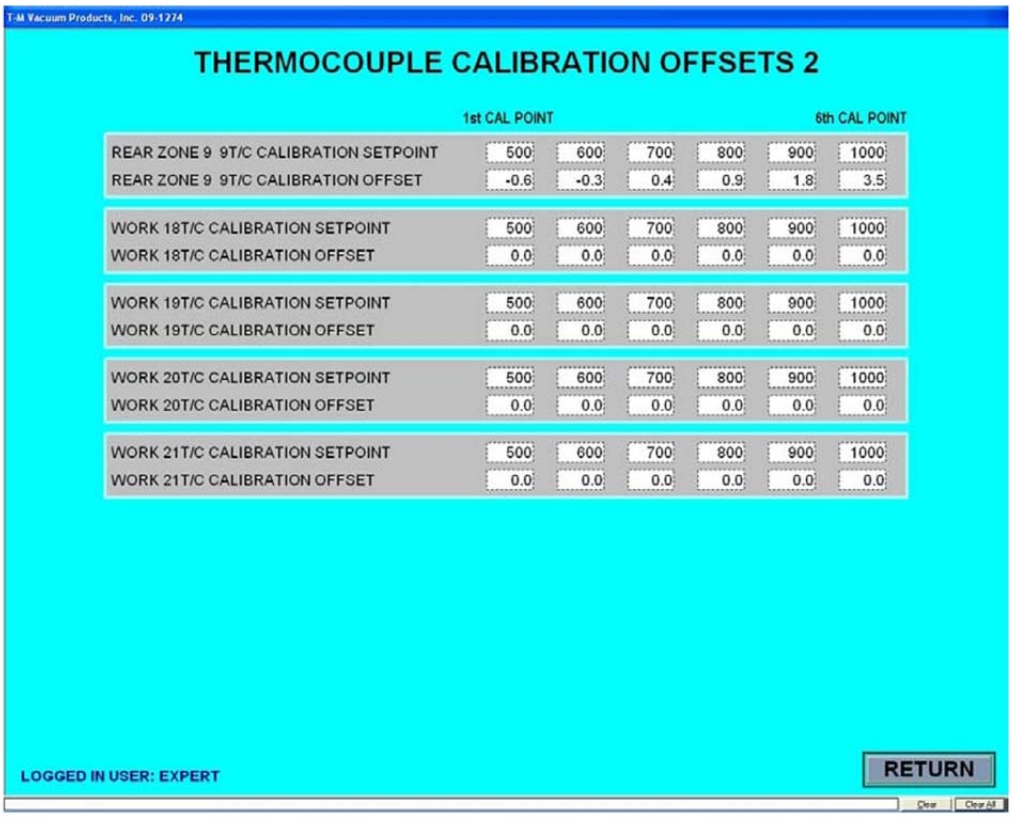
These screens can be used to apply an offset to each thermocouple at up to six known temperatures. This should be done when calibrated thermocouples are being used.

Note: The logged in user must have a security code of "I" to use these screens.

9.5.8.1 Thermocouple Calibration Offsets 1

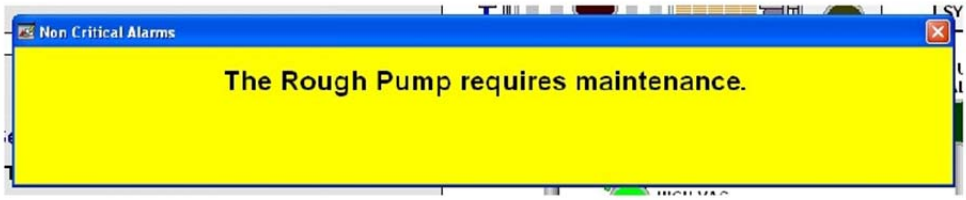


9.5.8.2 Thermocouple Calibration Offsets 2



9.5.9 Alarm Screens

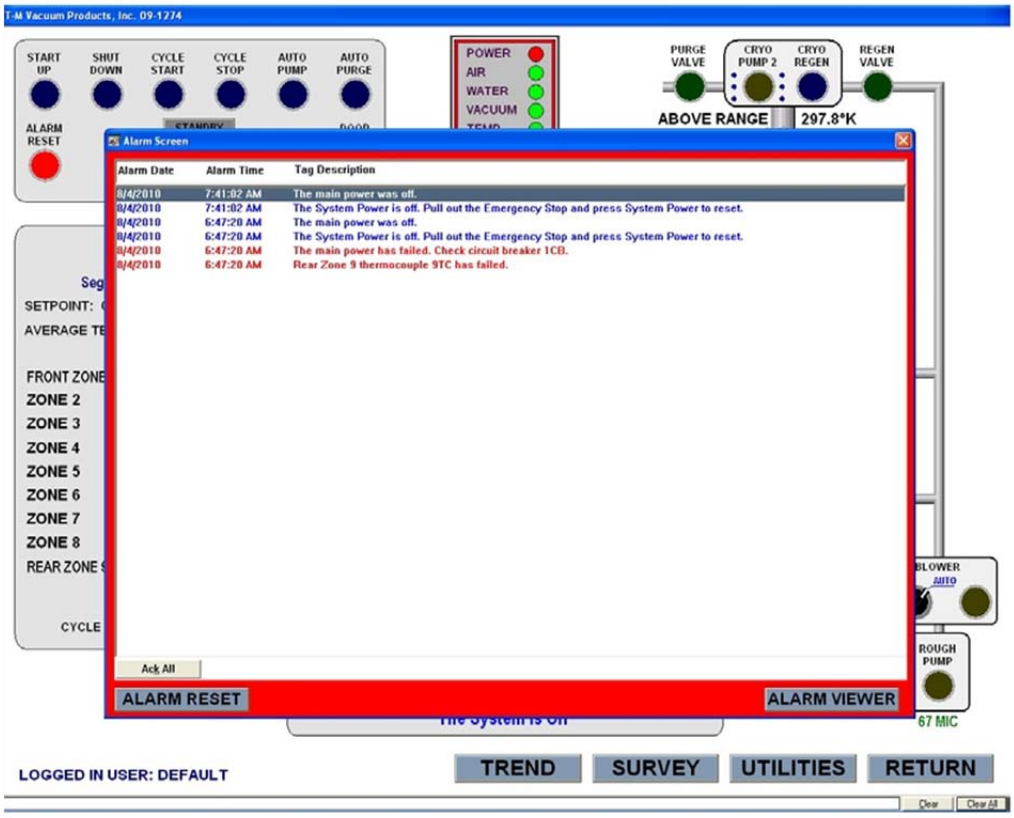
When an alarm first occurs a popup box will appear to indicate the problem regardless of the screen the operator is currently viewing. Non critical warning alarms will display a popup box with a yellow background, but will not affect an automatic program being run.



Critical alarms will display a popup box with a red background, which will put any program running into Hold, shutting off the heater power and taking action as required for the particular alarm.

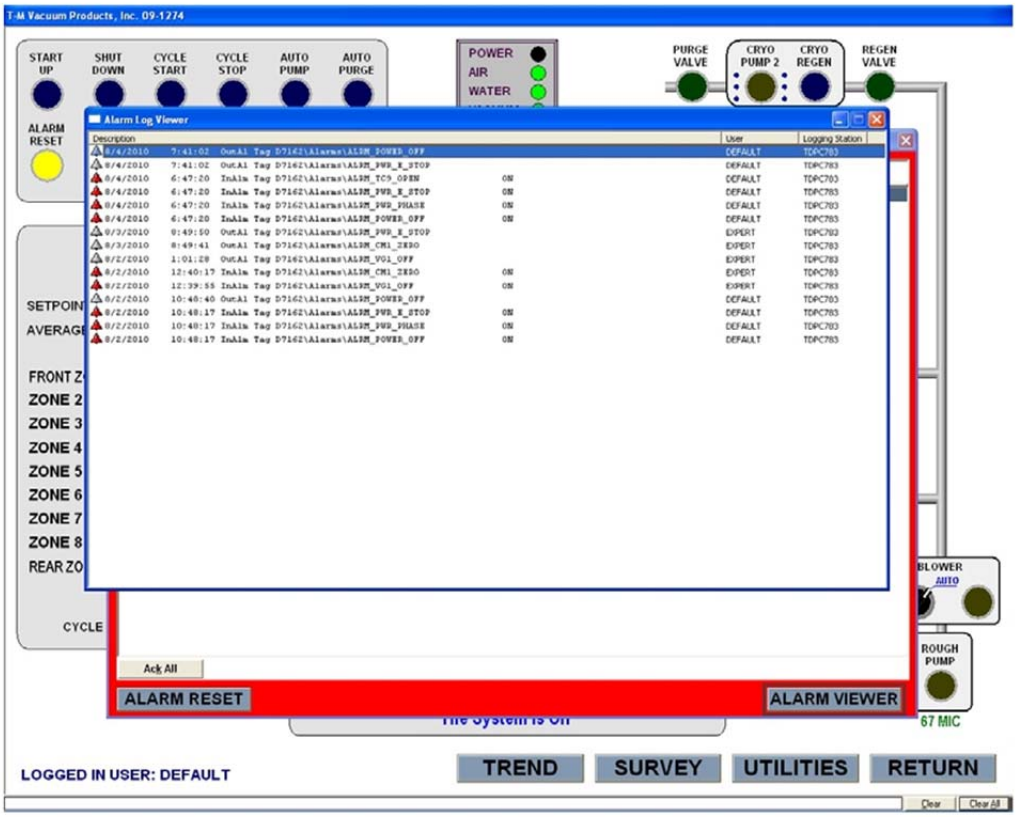
9.5.9.1 Alarm Summery

The alarm summery screen displays all of the currently active alarms. While on this screen, the operator can use the Ack All button to acknowledge and clear all non active alarms from the screen.



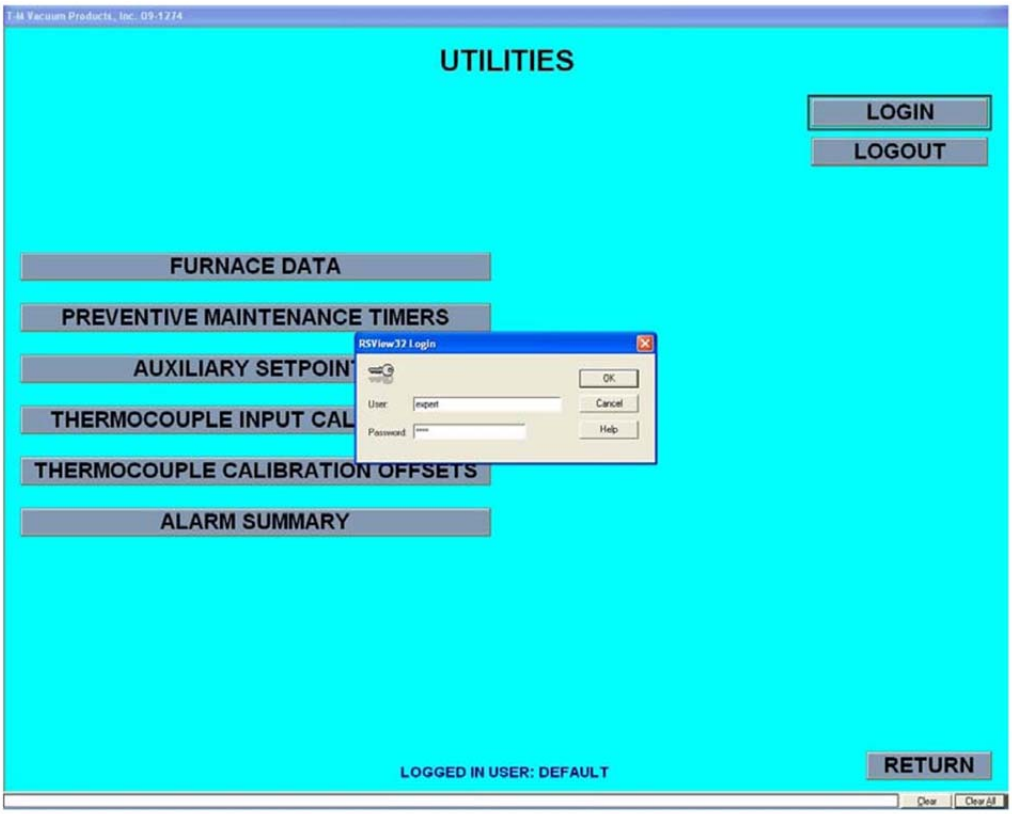
9.5.9.2 Alarm Viewer

The alarm viewer can be used to display a list of the alarm messages that occurred in the last week. Along with each message is the date and time the alarm occurred.

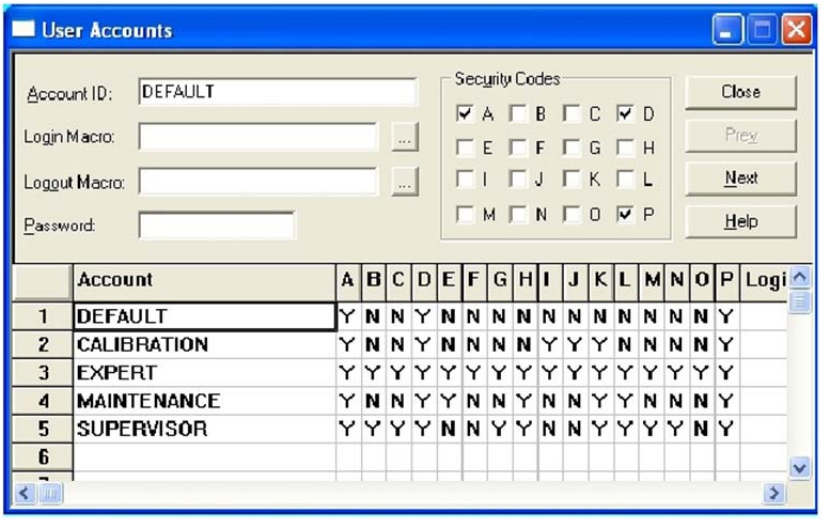


9.6 Security

The system supports up to 16 levels of security (A thru P) with up to 255 users. To utilize features of the system requiring security an operator must Login at the Utilities screen.



New operators can be added or deleted as required by means of the User Accounts window.

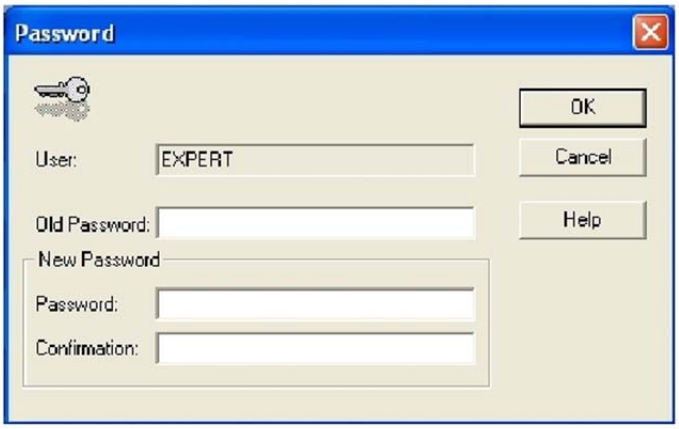


	Account	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Logi
1	DEFAULT	Y	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	Y	
2	CALIBRATION	Y	N	N	Y	N	N	N	N	Y	Y	Y	N	N	N	N	Y	
3	EXPERT	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
4	MAINTENANCE	Y	N	N	Y	Y	N	N	Y	N	N	Y	Y	N	N	N	Y	
5	SUPERVISOR	Y	Y	Y	Y	N	N	Y	Y	N	N	Y	Y	Y	Y	N	Y	
6																		

Use the Help function on this window for details on user accounts and passwords. Security Codes are used to allow access to screens and functions as follows:

- A Automatic Mode
- B View Programs
- C Edit Program / Edit Program Defaults
- D Program Hold Button / Reset Open Work T/Cs
- E View PLC Logic
- F PID Loops
- G Auxiliary Setpoints 1
- H Auxiliary Setpoints 2 / Skip Operator Input Screen
- I Preventive Maintenance Timers
- J Thermocouple Calibration / Reset Open Work T/Cs
- K Manual Mode
- L Unsafe Manual Mode
- M Passwords
- N User Accounts
- O Exit System
- P Default User

Once user accounts for the operators have been setup, Passwords can be used to change their passwords at any time.



Note: The logged in user must have a security code of "M" to setup user accounts and change passwords. The factory default users and passwords are as follows:

- Maintenance: 123
- Calibration: 12345
- Supervisor: 1234
- Expert: 1224

10. TROUBLE SHOOTING AND MAINTENANCE

All maintenance and service procedures should be followed per the supplementary instructions supplied with this manual.

A program of regular inspection and maintenance of the vacuum furnace is essential to the safe and continuous operation of the equipment and should be instituted and followed rigorously.

10.1 Vacuum System

10.1.1 General

Numerous stationary and moving vacuum seals, O-rings and other rubber gaskets are associated with the main vacuum vessel. These seals should be inspected regularly to insure cleanliness, freedom from cracks or gouges, and elasticity retention. The main door where work regularly passes should receive particular attention.

The vacuum chamber and all associated plumbing should be kept clean and free of contamination. If cleaning is required it should be done with a lint free cloth dampened with a solvent consistent with the contaminant. Acetone or alcohol should be used for final cleaning. If the contamination is severe, the vacuum piping and valves should be dismantled and cleaned separately.

The condition and level of oil in the mechanical vacuum pumps and the Cryo pump is critical for their proper operation. Since the effect of the user's process on the oil is unknown at this writing, the condition and level of the pump oil should be checked after every cycle until the required frequency of oil change is determined.

10.1.2 Mechanical Vacuum Pumps

Mechanical vacuum pumps should be checked and repaired as required. A partial check list follows:

1. Mounting bolts are tight
2. Vacuum lines and vibration couplings are tight

10.1.3 Cryo Pumps

Cryo Pumps should be checked and repaired as required. A partial check list follows:

1. Correct water flow for cooling

10.1.4 Vacuum Valves

Vacuum valves should be checked and repaired as required. A partial check list follows:

1. Air supply filter is drained and operating
2. Air supply oiler is filled to the correct level and is operating
3. Pilot valves are not leaking excess air
4. Moving O-ring seals cleaned or changed where indicating excess wear

10.2 Power Supply

The furnace power supply should be inspected and corrected as required. A partial check list follows:

1. Primary and secondary wiring and cables tight and free from overheating
2. Proper ventilation and air cooling or proper water flow
3. Relays and contactors should be free of contact pitting or arching, which could result in contact welding
4. Power supply voltage and current should be monitored to ensure that design limits are not exceeded

10.3 Sensors

The condition of the various pressure, vacuum, and temperature sensors is critical for the safe and consistent operation of the system.

10.3.1 Thermocouples

A regular replacement program should be established for all thermocouples.

Note: The effective life of thermocouples varies depending on their type, the process, and temperature and vacuum levels. These factors must be considered in setting up a replacement schedule.

10.3.2 Vacuum Gauge Tubes

A regular replacement program should be established for all vacuum gauge tubes.

Note: The effective life of gauge tubes varies depending on their type and the process. These factors must be considered in setting up a replacement schedule.

10.4 Instrumentation

All the various instrumentation for temperature, vacuum, etc., should be set up on a regular test and calibration schedule.

Batteries for retaining RAM memory in such devices as programmable logic controllers, message centers, operator interface terminals, etc., should be tested and replaced on a regular schedule.

10.5 Interlocks and Alarms

Periodic checks of all safety interlocks and alarms should be performed. Particular attention should be given to over temperature safety devices, low air pressure, insufficient cooling water, vacuum, oil temperature, and low oil alarms (as applicable to the system).

10.6 Cooling

Many components of the vacuum furnace require water cooling. Drain lines should be inspected for proper flow and temperature of the cooling water. Pressure regulators, strainers, and safety vents should be inspected for proper setting and be maintained free from dirt and contamination.

If an evaporative cooling tower is integral to the furnace system, the tower should be cleaned, the motor and bearings greased, and the water strainers cleaned on a regular basis.

10.7 Continuous Maintenance Check List

1. Review auxiliary vacuum instrumentation for proper indication of system performance, i.e. Rough Pump, and Cryo Pump operating pressure and temperature.
2. Review power instrumentation and trim or zone control settings.
3. Check instrumentation for "on condition".
4. Check chart recorder for paper and active operation.
5. Check mechanical vacuum pumps, blowers, gas fans, oil pumps, etc., for unusual noise or vibration.
6. Check the quench gas pressure and available capacity.
7. Check for proper operation of ventilation equipment if required in the particular installation.

10.8 Shift Maintenance Check List

1. Review auxiliary vacuum instrumentation for proper indication of system performance, i.e., foreline, Rough Pump and Cryo Pump operating pressure and temperature.
2. Review power instrumentation and trim or zone control settings.
3. Check instrumentation for "on condition".

4. Check chart recorder for paper and active operation.
5. Check mechanical vacuum pumps, blowers, gas fans, oil pumps, etc., for unusual noise or
6. vibration.
7. Check the backfill gas pressure and available capacity.
8. Determine and record the furnace chamber vacuum leak rate, and the blank off pressure of the Rough Pumps.

Weekly Maintenance Check List

1. Review hot zone for normal conditions of heating elements, heat shields or retainers, insulators, and work support or mechanisms.
2. Test thermocouples and their lead wires for broken insulators, shorts, and loose connections.
3. Test visible and audible alarms for proper operation.

10.10 Monthly Maintenance Check List

1. Test the interlock sequence of all safety equipment. Manually make each interlock fail, noting that the related equipment shuts down or stops as required.
2. Inspect all electrical switches and contacts and repair as required.
3. Test all temperature instrument fail-safe devices, making certain that the control instrument or recorder drives in the proper direction.
4. Clean all water, gas compressor and pump strainers.
5. Test pressure relief valves and clean if necessary.
6. Inspect air, inert gas, and water lines for leaks.

10.11 Periodic Maintenance Check List

Note: Frequency of maintenance of the following will depend on furnace use and the recommendation of the individual equipment manufacturers.

1. Inspect vacuum chamber O-rings and other gaskets for proper sealing.
2. Check the vacuum chamber vessel for evidence of hot spots indicating improper water cooling.
3. Examine furnace internals in detail for heating element, heat shield, work support, or mechanism deterioration or failure.
4. Lubricate motors, drives, valves, blowers, compressors, pumps, etc., as required.

5. With brush or other device remove major build up of oxides and contamination from the hot zone and accessible areas of the cold wall chamber. Blow out contamination with dry air.
6. Run furnace to near maximum design temperature and maximum vacuum to boil out furnace contamination.
7. Install new valve springs and discs and clean and flush oil from the mechanical vacuum pumps. Replace spring and O-ring in the gas ballast valves (see pump instructions).
8. Run blankoff test for the mechanical vacuum pumps to insure meeting process parameters.

11. REQUIRED DRAWING

1. SS12-72-13MC-X Furnace System..... D-7143 Sheets 1-4
2. SS12-72-13MC-X Furnace..... D-7156 Sheets 1-2
3. SS12-72 Fork Loader..... D-7159 Sheets 1-2
4. Right Control Panel, Modif SS-X ..... D-7160 Sheet 1
5. Left Control Panel, Modif SS-X ..... D-7161 Sheet 1
6. Electrical Schematic..... D-7162 Sheets 1-12
7. Piping Schematic - Special SS12_72-13MC-X..... D-7163
8. SS12_72-X Pumping System..... D-7181 Sheets 1-4
9. SS12_72-X Tank Shields ..... D-7230 Sheets 1-3
10. Air Clamp D-3855
11. SS-12_72-13MC-X Door Shield Ass'y..... C-8154
12. SS-12_72-13MC-X Rear Shield Ass'y..... C-8156
13. 4 Survey TC Assembly..... C-8159
14. Sight Port Assembly..... B-7975
15. Power Feedthru Ass'y B-7976

12. EXAMPLE TEMPERATURE PROGRAMS

12.1 Typical Cycle

```
Program Name:       run1
Revision Number:    24
Segments Used:      7
9/2/2009 10:10:31   AM


Program run1 Segments
   Segment 1:  Ramp at 50.0 Degs/Minute
       Event:  Heat On
   Segment 2:  Guaranteed Soak at 1050 ±5°C for 10.0 Minutes
  Segment 3:  Ramp at 50.0 Degs/Minute
  Segment 4:  Work Guaranteed Soak at 1100 ±5°C for 5.0 Minutes
  Segment 5:  Soak at 1100°C for 0.1 Minutes
       Event:  Heat off
   Segment 6:  Work Guaranteed Soak at 900 ±7°C for 0.1 Minutes
       Event:  Quick Cool 700 Torr Gas 2
   Segment 7:  Work Guaranteed Soak at 50 ±5°C for 0.1 Minutes

Program run1 Parameters

Furnace Over Temperature Setpoint:     1110 Deg C
Furnace Guaranteed Soak Band:          5 Deg C
Work Over Temperature Setpoint:        1110 Deg C
Work Guaranteed Soak Band:             5 Deg C
Minimum Number of Work T/Cs:           2 T/Cs
Work Guaranteed Soak Method:           Min T/Cs

Program Start Vacuum Level:            2.0 x10 -5 Torr
Program Hold Vacuum Level:             5.0 x10 -4 Torr

Quick Cool Pressure:                   800 Torr
Quick Cool Hysteresis:                 25 Torr
Quick Cool Fan Speed:                  100%

Gas Bleed  1 Pressure Setpoint:        0.05 Microns
Gas Bleed  1 Hysteresis:               0.025 Microns
Gas Bleed  1 Flow Rate:                3 SCCM
Gas Bleed  2 Pressure Setpoint:        300 Microns
Gas Bleed  2 Hysteresis:               25 Microns

Backfill  1 Pressure:                  600 Torr
Backfill  1 Hysteresis:                25 Torr
Backfill  2 Pressure:                  700 Torr
Backfill  3 Hysteresis:                25 Torr

Maximum Leak Up Rate Cold:             25 u/Hr

Maximum Leak Up Rate Hot:              50 u/Hr

Front Zone 1st Gain:                   25.00
```

Front Zone 1st Reset:	1.00 Minutes per Repeat
Front Zone 1st Rate:	0.13 Minutes
Front Zone 1st Maximum Output:	100% Power
Front Zone 1st Setpoint Offset:	5 Deg C
Center Zone 1st Gain:	25.00
Center Zone 1st Reset:	1.00 Minutes per Repeat
Center Zone 1st Rate:	0.13 Minutes
Center Zone 1st Maximum Output:	100% Power
Center Zone 1st Setpoint Offset:	-3 Deg C
Rear Zone 1st Gain:	25.00
Rear Zone 1st Reset:	1.00 Minutes per Repeat
Rear Zone 1st Rate:	0.13 Minutes
Rear Zone 1st Maximum Output:	100% Power
Rear Zone 1st Setpoint Offset:	3 Deg C
Front Zone 2nd Gain:	25.00
Front Zone 2nd Reset:	1.00 Minutes per Repeat
Front Zone 2nd Rate:	0.13 Minutes
Front Zone 2nd Maximum Output:	100% Power
Front Zone 2nd Setpoint Offset:	0 Deg C
Center Zone 2nd Gain:	25.00
Center Zone 2nd Reset:	1.00 Minutes per Repeat
Center Zone 2nd Rate:	0.13 Minutes
Center Zone 2nd Maximum Output:	100% Power
Center Zone 2nd Setpoint Offset:	0 Deg C
Rear Zone 2nd Gain:	25.00
Rear Zone 2nd Reset:	1.00 Minutes per Repeat
Rear Zone 2nd Rate:	0.13 Minutes
Rear Zone 2nd Maximum Output:	100% Power
Rear Zone 2nd Setpoint Offset:	0 Deg C
Front Zone 3rd Gain:	25.00
Front Zone 3rd Reset:	1.00 Minutes per Repeat
Front Zone 3rd Rate:	0.13 Minutes
Front Zone 3rd Maximum Output:	100% Power
Front Zone 3rd Setpoint Offset:	0 Deg C
Center Zone 3rd Gain:	25.00
Center Zone 3rd Reset:	1.00 Minutes per Repeat
Center Zone 3rd Rate:	0.13 Minutes
Center Zone 3rd Maximum Output:	100% Power
Center Zone 3rd Setpoint Offset:	0 Deg C
Rear Zone 3rd Gain:	25.00
Rear Zone 3rd Reset:	1.00 Minutes per Repeat
Rear Zone 3rd Rate:	0.13 Minutes
Rear Zone 3rd Maximum Output:	100% Power
Rear Zone 3rd Setpoint Offset:	0 Deg C
Cooling Fan Gain:	25.00
Cooling Fan Reset:	1.00 Minutes per Repeat
Cooling Fan Rate:	0.1 Minutes
Cooling Fan Maximum Output:	100%
Cooling Fan Minimum Output:	0%

12.2 Burn Out

CAUTION!!!
Furnace hot zone warranty is void if bake outs exceeding 1315 degrees C (2400ºF) are used.

```
Program Name: Burn Out
Revision Number: 17
Segments Used: 8
9/2/2009 10:25:24 AM

Program Burn Out Segments

   Segment 1:  Ramp at 25.0 Degs/Minute
       Event:  Heat On
   Segment 2:  Guaranteed Soak at 730 ±10°C for 30.0 Minutes
   Segment 3:  Ramp at 25.0 Degs/Minute
   Segment 4:  Guaranteed Soak at 1000 ±5°C for 30.0 Minutes
  Segment 5:  Ramp at 25.0 Degs/Minute
   Segment 6:  Guaranteed Soak at 1315 ±5°C for 120.0 Minutes
  Segment 7:  Soak at 1315°C for 0.1 Minutes
       Event:  Heat Off
   Segment 8:  Guaranteed Soak at 50 ±5°C for 0.1 Minutes

Program Burn Out Parameters


Furnace Over Temperature Setpoint:        1330 Deg C
Furnace Guaranteed Soak Band:             10 Deg C
Work Over Temperature Setpoint:           1330 Deg C
Work Guaranteed Soak Band:                10 Deg C
Minimum Number of Work T/Cs:              3 T/Cs
Work Guaranteed Soak Method:              Min T/Cs

Program Start Vacuum Level:               5.0 x10 -5 Torr 2.0 x10 -4 Torr
Program Hold Vacuum Level:
                                          760 Torr
Quick Cool Pressure:                      25 Torr
Quick Cool Hysteresis:                    100%
Quick Cool Fan Speed:                     1330 Deg C

Gas Bleed 1 Pressure Setpoint:            0.05 Microns
Gas Bleed 1 Hysteresis:                   0.015 Microns
Gas Bleed 1 Flow Rate:                    3 SCCM
Gas Bleed 2 Pressure Setpoint:            300 Microns
Gas Bleed  2 Hysteresis:                  25 Microns

Backfill 1 Pressure:                      600 Torr
Backfill 1 Hysteresis:                    25 Torr
Backfill 2 Pressure:                      700 Torr
Backfill 2 Hysteresis:                    25 Torr
Maximum Leak Up Rate Cold:                25 u/Hr
```

Maximum Leak Up Rate Hot:	50 u/Hr
Front Zone 1st Gain:	25.00
Front Zone 1st Reset:	1.00 Minute per Repeat
Front Zone 1st Rate:	0.13 Minutes
Front Zone 1st Maximum Output:	100% Power
Front Zone 1st Setpoint Offset:	0 Deg C
Center Zone 1st Gain:	25.00
Center Zone 1st Reset:	1.00 Minute per Repeat
Center Zone 1st Rate:	0.13 Minutes
Center Zone 1st Maximum Output:	100% Power
Center Zone 1st Setpoint Offset:	0 Deg C
Rear Zone 1st Gain:	25.00
Rear Zone 1st Reset:	1.00 Minute per Repeat
Rear Zone 1st Rate:	0.13 Minutes
Rear Zone 1st Maximum Output:	100% Power
Rear Zone 1st Setpoint Offset:	0 Deg C
Front Zone 2nd Gain:	25.00
Front Zone 2nd Reset:	1.00 Minute per Repeat
Front Zone 2nd Rate:	0.13 Minutes
Front Zone 2nd Maximum Output:	100% Power
Front Zone 2nd Setpoint Offset:	0 Deg C
Center Zone 2nd Gain:	25.00
Center Zone 2nd Reset:	1.00 Minute per Repeat
Center Zone 2nd Rate:	0.13 Minutes
Center Zone 2nd Maximum Output:	100% Power
Center Zone 2nd Setpoint Offset:	0 Deg C
Rear Zone 2nd Gain:	25.00
Rear Zone 2nd Reset:	1.00 Minute per Repeat
Rear Zone 2nd Rate:	0.13 Minutes
Rear Zone 2nd Maximum Output:	100% Power
Rear Zone 2nd Setpoint Offset:	0 Deg C
Front Zone 3rd Gain:	25.00
Front Zone 3rd Reset:	1.00 Minute per Repeat
Front Zone 3rd Rate:	0.13 Minutes
Front Zone 3rd Maximum Output:	100% Power
Front Zone 3rd Setpoint Offset:	0 Deg C
Center Zone 3rd Gain:	25.00
Center Zone 3rd Reset:	1.00 Minute per Repeat
Center Zone 3rd Rate:	0.13 Minutes
Center Zone 3rd Maximum Output:	100% Power
Center Zone 3rd Setpoint Offset:	0 Deg C
Rear Zone 3rd Gain:	25.00
Rear Zone 3rd Reset:	1.00 Minute per Repeat
Rear Zone 3rd Rate:	0.13 Minutes
Rear Zone 3rd Maximum Output:	100% Power
Rear Zone 3rd Setpoint Offset:	0 Deg C
Cooling Fan Gain:	25.00
Cooling Fan Reset:	1.00 Minutes per Repeat
Cooling Fan Rate:	0.1 Minutes
Cooling Fan Maximum Output:	100%
Cooling Fan Minimum Output:	0%

13. INSTRUMENT CONFIGURATION

13.1 UDC120L #DC120L-1-0-0-0-1-0-0-0 Furnace Over Temperature

Refer to the Honeywell *UDC120L Micro-Pro Universal Limit Controller Product Manual* for access procedures and a detailed description of the parameters listed below.

CONFIGURATION MODE

Lower Display	Upper Display	Description
SLCt	ConF	Configuration Mode
CLoc	20	Unlock Code Display
inPt	kC	Input Type
ruL	1373	Scale Range Upper Limit
rLL	-240	Scale Range Lower Limit
OFFS	0	Process Variable Offset
CtrL	Hi	Limit Action
SPuL	1050	Setpoint Upper Limit
SPLL	0	Setpoint Lower Limit
ALA1	nonE	Process High Alarm
ALA2	nonE	Process Low Alarm
diSP	EnAb	Display Enable
CLoc	20	Lock Code

SET UP MODE

Lower Display	Upper Display	Description
SLCt	SEtP	Set Up Mode
SLoc	10	Unlock Code Display
SP	1050	Limit Setpoint
hYSt	1	Hysteresis
Filt	2.0	Digital Filter Time Const.
SLoc	10	Set Up Lock Code