

# **DENTON VACUUM**

## **OPERATING MANUAL**

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### **Bench Top Turbo Coating System**

**UNIVERSITY OF NEVADA**

**SO#73543**

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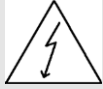
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## SAFETY WARNINGS



**Lethal voltages, high temperatures, high pressures and powerful mechanical drive mechanisms are present throughout the system.**



**Every attempt has been made to safeguard operating and maintenance personnel. Interlocking of subsystems provides a high degree of operator safety.**

**System/software interlocks should never be defeated unless servicing of the system requires temporary interlock overrides. Hardwired safety interlocks must never be defeated.**



**All safety/software interlocks should be returned to operational status when problems have been corrected.**



**Operating and maintenance manuals have been provided and should be thoroughly understood before any operations are contemplated.**



**Only personnel with proper training and process experience should operate the system.**



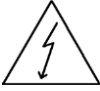


**PLEASE NOTE BEFORE SYSTEM STARTUP**

**Do not attempt to operate this system until you have read this manual completely. Failure to operate the system properly may result in damage to the system.**

**This unit has been shipped with the high vacuum pump section under vacuum. Do not open any vacuum valves until the procedure outlined in the Pumping System Operation section of this manual has been followed. Failure to heed this warning may result in damage to the equipment.**

**Air used for the automatic valves MUST be clean and dry to ensure proper operation of the valves. Failure to comply may result in a voiding of the warranty.**

## SAFETY SYMBOLS

	CAUTION: Risk of Electrical Shock
	CAUTION: This symbol is intended to alert the user to the presence of important operation & maintenance instructions in this manual.
	Protective Conductor Terminal: this symbol indicates where the protective earth ground is connected.

## INTRODUCTION

### GENERAL DESCRIPTION

The Denton Bench Top Turbo is a fast, clean laboratory deposition system. By using state-of-the-art electronic components and an advanced mechanical vacuum design, the system can rapidly and repeatedly cycle from atmosphere to high vacuum.

This system is designed to simplify the geometry necessary for coordination of multiple source depositions.

Because Denton uses the finest available subsystems and components, the system is highly reliable and durable. The system's inherent flexibility allows the operation of an evaporation sources, plasma sources, and gas control.

The Bench Top Turbo system is semi-automatic and is controlled by PLC through a touch screen interface. The controls are contained in the main system cabinet. It can be access through the front or rear door.

The system offers you a myriad of thin film process options. However, it is important to note that with all of this system's potential there exist safety considerations.

**Individuals who are to operate, service, or maintain this system should familiarize themselves with this manual.**

**If this equipment is used in a manner not specified by Denton Vacuum, the protection provided by the equipment may be impaired.**



## **SYSTEM OVERVIEW**

The Denton Vacuum Bench Top Turbo is a fast, clean laboratory deposition system designed to simplify the geometry necessary for the coordination of multiple evaporation/sputter sources.

The unit is equipped with a standard 12" X 12" Pyrex bell jar (a 12"dia X 18" Tall Bell Jar is available upon request) that allows for observation of all aspects of the process. The bell jar seals on a 13" diameter stainless steel collar that attaches to the base plate. An automatic lift assembly is provided for ease of use. The bell jar, collar and base plate assembly is mounted to a space saving cabinet designed to be placed on a laboratory table. All power distribution and system controls are enclosed in the cabinet. The front cabinet panel is hinged, but interlocked. The rear panel is removable. Both panels provide safe and convenient access to internal components for servicing and inspection.

A direct-drive mechanical pump and a turbo molecular pump are directly coupled to the chamber collar to evacuate time the chamber. A larger, dual-stage rotary vane pump and two different dry pumps are available as options.

The optional specimen table can be mounted in the center of the base plate, or raised and inverted for evaporating up. Standard table sizes are 2", 4" and 6" diameter. Special fixtures are available upon request.

Systems can be equipped with 1 KVA or 2 KVA evaporation power supplies switchable for A or B source select. The 1 KVA power supply is available with the following options: filaments, a carbon rod accessory, or a carbon yarn accessory. The 2 KVA power supply uses copper boat holders with water cooled feedthroughs.

The system can be configured with one DC power supply for sputtering applications. The power supply is 100 mAmps, provides Power Control and is integrated into the system control.

A 2.0" diameter internal sputter cathode is available. The system is delivered without targets unless purchased as an option at time of sale.

A manual Gas Control (needle valve) to control pressure in the deposition chamber is available for the sputter and glow options.

A mass flow controller is available as an option.

A Glow supply is available for sample preparation. For additional precision in the control of chamber pressure the system can be equipped with one or more optional mass flow controller.

A Programmable Logic Controller (PLC) controls the system, utilizing a 6" color TFT touch screen, which is interfaced with the PLC. Operator interface is through a graphics program that is running on the touch screen.

System controls are provided for manual operation of all components such as the pumps and valves, the evaporation sources, the shutter and the substrate rotation. Automatic sequences are

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**BENCH TOP TURBO COATING SYSTEM**  
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provided for pumping the system to vacuum as well as venting to atmosphere. An automatic single layer evaporation sequence is also available with the addition of a deposition controller.

Three operating modes are available: Manual, Auto, and Service. Interlocks for safe operation are active in Manual and Auto modes.

## SAFETY WARNINGS



**Lethal voltages, high temperatures, high pressures and powerful mechanical drive mechanisms are present throughout the system.**



**Every attempt has been made to safeguard operating and maintenance personnel. Interlocking of subsystems provides a high degree of operator safety.**

**System/software interlocks should never be defeated unless servicing of the system requires temporary interlock overrides. Hardwired safety interlocks must never be defeated.**



**All safety/software interlocks should be returned to operational status when problems have been corrected.**



**Operating and maintenance manuals have been provided and should be thoroughly understood before any operations are contemplated.**



**Only personnel with proper training and process experience should operate the system.**






**PLEASE NOTE BEFORE SYSTEM STARTUP**

**Do not attempt to operate this system until you have read this manual completely. Failure to operate the system properly may result in damage to the system.**

**This unit has been shipped with the high vacuum pump section under vacuum. Do not open any vacuum valves until the procedure outlined in the Pumping System Operation section of this manual has been followed. Failure to heed this warning may result in damage to the equipment.**

**Air used for the automatic valves MUST be clean and dry to ensure proper operation of the valves. Failure to comply may result in a voiding of the warranty.**

## SAFETY SYMBOLS

	CAUTION: Risk of Electrical Shock
	CAUTION: This symbol is intended to alert the user to the presence of important operation & maintenance instructions in this manual.
	Protective Conductor Terminal: this symbol indicates where the protective earth ground is connected.

## PHYSICAL SPECIFICATIONS

- Dimensions:
  - 56" (142 cm) high x 32" (81 cm) wide x 28" (71 cm) deep with bell jar in the up position.
  - Overall footprint is approximately 40" (101.6 cm) wide x 36" (91 cm) deep including the externally mounted mechanical pump.
- Shipping weight: 420 pounds (191 kg)

## **UTILITY REQUIREMENTS**

### **ELECTRICAL**

The Benchtop Turbo deposition system is available with a variety of options. Electrical requirements vary. Typical requirements are listed here for reference. Check the Power Schematics or contact DVI for final system specifications.

- 110 VAC (+/- 5 %), 50/60 Hz, Single phase, 3 wire, 20 – 30 Amps (SEE POWER SCHEMATIC). Contact DVI for final system specifications.
- 208 VAC (+/- 5 %), 50/60 Hz, Single phase, 3 wire, 20 – 30 Amps (SEE POWER SCHEMATIC). Contact DVI for final system specifications.
- 230 VAC (+/- 5 %), 50/60 Hz, Single phase, 3 wire, 20 - 30 Amps (SEE POWER SCHEMATIC). Contact DVI for final system specifications.

### **WATER**

- Water (needed for 2kVa only): 1-2 GPM (4-8 LPM), 60-80 °F (15-26 °C), 30-45 psig (2.1-3.1 Bar) differential between supply and return (50 psig (3.5 Bar) maximum inlet pressures.
  - 2 KVA Low Voltage Source (OPTION) (Flow sensor)

### **COMPRESSED AIR**

- Normal dry shop air; 80-110 psi (5.5 – 7.5 bar) for system shutter operation.
- Stand-alone air manifold with solenoid valves incorporating removable plug-type electrical connections.

### **ARGON**

- 99.9995 % purity (if equipped); 10-15 psi (0.4-1 Bar) process gas.

### **NITROGEN**

- Optional.
- Preferentially evaporated from a liquid source, and 10-15 psi (0.4-1 Bar) for chamber venting

## **ENVIRONMENTAL CONDITIONS**

The system is designed and intended for use in the following environmental conditions. If all specifications are not met, system components may malfunction and can possibly cause injuries.

- Altitude up to 2000m
- Temperature range from 5 to 40 C
- Maximum relative humidity 80% for temperature up to 31C decreasing linearity to 50% relative humidity at 40C
- Mains supply voltage fluctuations not to exceed +/-5% of the nominal voltage
- Other supply voltage fluctuations as stated by the manufacturer
- Pollution degree 2 in accordance with IEC 664

## INSTALLATION

After ensuring that all utility connections have been made (See Utility Requirements), the installation can be completed.

The vacuum system requires minimal assembly upon installation because most subassemblies are mounted on the unit frame.

**Note: Initial installation completed by Denton Vacuum Technicians only as a paid option.**

There are subsystems not on the unit frame that may require re-installation after the system is operational.

### PLEASE NOTE BEFORE SYSTEM STARTUP



**Do not attempt to operate this system until you have read this manual completely. Failure to operate the system properly may result in damage to the system.**



**This unit has been shipped with the high vacuum pump section under vacuum. Do not open any vacuum valves until the procedure outlined in the Pumping System Operation section of this manual has been followed. Failure to heed this warning may result in damage to the equipment.**

## GENERAL

- This system is for indoor use only. The system must be placed on a flat, sturdy bench. Otherwise, any vibration from the unit could be picked up and amplified by the table. Three feet clearance is required for the operating the system. At least six inches clearance on both sides to leave adequate room for the fan to ventilate the system interior.
- Consumables are generally bulk material, boats or filaments and Vacuum Gauges and require all power supplies to be shut down before venting and exchanging these items.

## MECHANICAL PUMP

- The mechanical pump is shipped pre-filled with oil. Check the oil level in the mechanical pump only after it has been running. The level is misleading when pump is idle.
- A larger, dual-stage rotary vane pump and two different dry pumps are available as options.
- An automatic vent valve is slaved to the mechanical pump. It will automatically open when the Mechanical Pump is turned OFF to vent the chamber to atmosphere. It will automatically close when the Mechanical pump is turned on.

## TURBO PUMP

- The turbo pump is air-cooled.

## COMPRESSED AIR

- An external air supply of 80-110 psi (5.5 – 7.5 bar) is required to operate the source shutter. The connections are located in the rear up right side of the unit.

## MASS FLOW CONTROLLER GAS SELECT

### Optional

Alicat™ mass flow controllers can be programmed for use with up to 150 standard gases and mixes. They can also be programmed to store up to 20 additional gas mixes.

Most Alicat™ mass flow controllers are shipped with a factory default Gas Select setting of Air. This setting must be changed to match the gas that will be used in the system. Please refer to the Alicat™ mass flow controller operating manual for detailed instructions on changing the Gas Select settings.

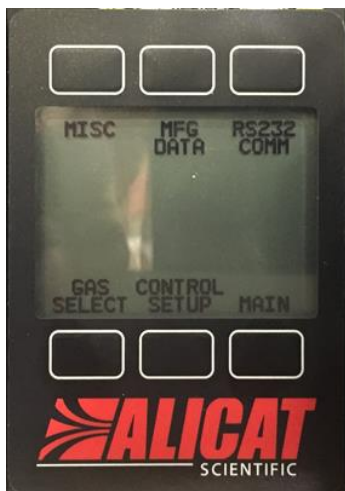


**NOTE! The Gas Select setting of the mass flow controller must match the gas in order to provide accurate flow control. Failure to use the correct Gas Selection will result in inaccurate gas flow.**

Photos of the Alicat™ mass flow controller display are shown here for reference only. Refer to the Alicat™ operating manual for a complete description of the available programming for the Gas Select feature.



Photos of the Alicat™ control screen are shown for reference.



**Alicat™ Mass Flow Controller Main  
Display**



**Alicat™ Mass Flow Controller Gas Select  
Display**

## **HIGH PURITY GAS LINES – OXYGEN, ARGON, NITROGEN**

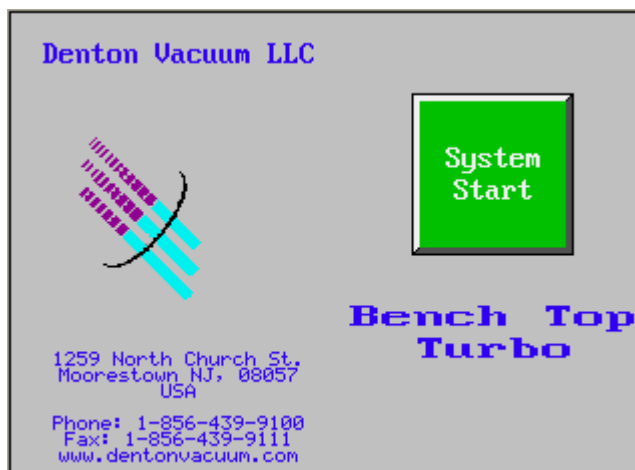
- All pumps must be operational before connecting the high purity gas line.
- All gas supply lines must have an ON/OFF valve between the regulator and the vacuum system.
- Connect the gas supply line to the rear of the machine and close the valve near the pressure regulator.
- Pump the chamber out manually and open the Gas Isolation Valve. Use the gas adjust micrometer valve to increase the gas flow set point to 50%.
  - If the system is equipped with a mass flow controller, then input a gas flow setpoint of 50% of full range.
- Continue pumping out the system until the actual flow in the line decreases or the pressure returns to the original value.
- Increase the flow Set point to maximum.
  - If the system is equipped with a mass flow controller, then input a gas flow setpoint of 100% of the full range.

- Continue pumping until the actual flow in the line decreases or the pressure returns to the original value.
- Reduce the set point to zero or close the micrometer valve and close the Gas Isolation Valve.
  - If the system is equipped with a mass flow controller, then input a gas flow setpoint of zero.
- Open the toggle valve near the pressure regulator and adjust the regulator to 10 -15 psi (0.4 – 1.0) bar.

## **FILAMENT HOLDER**

- The filament holders screw directly onto the threaded 3/8” low voltage feedthroughs, which are mounted in pairs at the left and right of the baseplate. Filaments can be positioned low for low angle rotary shadowing or well over the tilting OMNI for conductive coatings. Make all connections snug for good electrical contact.

## SOFTWARE OVERVIEW



System Start Screen

**This chapter will describe the control screens. An understanding of these screens is required to proceed with operation of the vacuum system.**

## CONTROL SYSTEM

The Bench Top Turbo system is semi-automatic and is controlled by a PLC from Automation Direct. The operator interface is a touch screen with a graphical interface to the PLC. Manual operation of the valves, pumps, low voltage sources, DC sputter sources, and the fixture rotation subsystems is through this graphical interface. Automatic processes are also initiated through this screen.

This software links the operator to the PLC. It provides control input and data display of current status. This software is active whenever the power is applied to the system. Graphical display of the control system is organized onto multiple screens.

Graphic display of the control system is arranged on individual “screens”:

- Start
- Overview
- Pumping
- Rotation
- Gas (if equipped)

- Low Voltage (if equipped)
- Heat (if equipped)
- DC Sputter (if equipped)
- Glow (if equipped)
- Process
- PLC Rack
- Service

Start is the first screen active when power is applied. The “System Start” push button at the top of the screen provides access to the control software from this screen.

Overview is the primary operating screen. A brief description is included here for reference, but this screen is described in detail later in this section of the manual.

- A graphical representation of the vacuum system is displayed on this screen. Individual vacuum component graphics (valves, pumps) change color to indicate ON/OFF condition.
- All current system data is displayed on this screen. The current vacuum pressure, system Mode, and interlock status are displayed on this screen.
- Automatic pumping and venting operations are started from this screen.
- Operation of the bell jar lift is available on this screen.
- The operator can access all subsystem control screens through a push button on this screen.

Pumping – The pumps, vent valve and gauge can be controlled from this screen as long as the safety interlocks are satisfied. The color of the push buttons change color to indicate ON/OFF status. If a button does not change color when pressed, an interlock is not satisfied. Graphic indicators are visible for the Minimum Vacuum and Turbo @ Speed interlocks. Current vacuum pressure is also displayed on this screen.

Rotation - Substrate Rotation ON/OFF and speed setpoint input are available on this screen. Rotation MUST be ON when operating LV Power Supply.

Gas - The Gas Power ON/OFF buttons are on this screen. Current vacuum pressure is also displayed on this screen.

Gas Control – (Optional Mass flow controller) Manual control of the optional mass flow controller is available on this screen. The gas isolation valve can be operated On/Off and a gas flow setpoint (SCCM) can be entered. Current vacuum pressure is also displayed on this screen.

Low Voltage (If equipped) - All low voltage source functions are displayed on this screen. Power On/Off, power setpoint input, source selection are available on this screen. Low Voltage Source current is displayed on this screen as well as the overview screen. The Source Shutter button is on this screen.

Heat (if equipped) - The Heat power supply ON/OFF button is on this screen with displays for feedback temperature as well as PID functions.

DC Sputter (If equipped) - All sputter source functions are displayed on this screen. Power On/Off, power setpoint input, source selection are available on this screen. DC Setpoint is displayed on this screen as well as the overview screen.

Glow (if equipped) - The Glow power supply ON/OFF button is on this screen.

Process - Controls are available on this screen to initiate automatic sequences that are programmed into the PLC.

- Auto Pump and Auto Vent are available.
- An Abort button is available to stop an automatic sequence.
- Interlock and system status are displayed on the screen. Current vacuum pressure is also displayed on this screen.

PLC Rack – A graphic display of the I/O of the PLC module is provided to aid in troubleshooting.

Service - Access to the Service Mode is through the hidden buttons on this screen.

## MODES OF OPERATION

### AUTO

Auto mode is used to run automatic sequences. All interlocks are active in this mode. The Abort button is active in this mode.



**Note: Access to all other on-screen controls are denied in the Auto mode. This interlock is built in to avoid manual operation of a subsystem in the Auto Mode.**

### INTERLOCKS

Interlock messages are displayed on the control screens. Unsatisfied interlocks are displayed as a text message on the Overview screen. The word “Satisfied” is displayed when all interlocks are satisfied. A complete listing of the system interlocks is included in the Interlock section of this manual.

Lift interlocks prevent unsafe operation of the bell jar lift mechanism. A text message is displayed on the Overview screen to show the current state of the lift interlock.

### MANUAL

The operator can safely run the system from the touch screen in the Manual mode. All interlocks are active in Manual mode.

All on-screen control systems are available. The state of the valves, pumps, low voltage source, DC sputter sources, and fixture rotation can be changed on the touch screen.

### SERVICE



**CAUTION: Interlocks are inactive in service mode. Caution must be taken to safely operate the vacuum system**

**NOTE: Service Mode is not accessible to System Operators. Service Mode is only accessible by activating the hidden Service key buttons.**

Use Service Mode only for maintenance. Software interlocks are inactive in this mode. Hardwired interlocks are active in service mode. All control systems are active as in Manual mode.

## OVERVIEW SCREEN

<p>The screen displays a vacuum gauge at the top with a scale from 1 to 9. Below it is a schematic of the chamber with 'A' and 'B' ports. The 'Low Voltage Current' is shown as 0 AMPS. 'Vent Delay' is 0 Sec. The 'Auto Pump' status is 'Running'. The 'Auto Vent' status is 'Running'. The 'Auto Process' status is 'Running'. The 'Interlocks' section shows 'Lift Interlock Not Met' in red and 'Lift Down' in yellow. At the bottom are buttons for 'Screens', 'Lift Up' (Lifting), 'Lift Down' (Lowering), and 'Abort'.</p>	<p>The screen displays a vacuum gauge at the top with a scale from 1 to 9. Below it is a schematic of the chamber with '1' and '2' ports. The 'Gas' is shown as 0 AMPS. 'Low Voltage DC Sputter Current' is 0 mAMPS. 'Vent Delay' is 0 Sec. The 'Auto Pump' status is 'Running'. The 'Auto Vent' status is 'Running'. The 'Auto Process' status is 'Running'. The 'Interlocks' section shows 'Lift Interlock Not Met' in red and 'Lift Down' in yellow. At the bottom are buttons for 'Screens', 'Lift Up' (Lifting), 'Lift Down' (Lowering), and 'Abort'.</p>
<p style="text-align: center;">Typical Overview Screen (Low Voltage)</p>	<p style="text-align: center;">Typical Overview Screen (Sputter)</p>

<p>The screen displays a vacuum gauge at the top with a scale from 1 to 9. Below it is a schematic of the chamber with 'A' and 'B' ports. The 'Low Voltage Current' is shown as 0 AMPS. 'Vent Delay' is 0 Sec. 'Heat Temperature' is 0 Deg C. The 'Auto Pump' status is 'Running'. The 'Auto Vent' status is 'Running'. The 'Auto Process' status is 'Running'. The 'Interlocks' section shows 'Lift Interlock Not Met' in red and 'Lift Down' in yellow. At the bottom are buttons for 'Screens', 'Lift Up' (Lifting), 'Lift Down' (Lowering), and 'Abort'.</p>	<p>The screen displays a vacuum gauge at the top with a scale from 1 to 9. Below it is a schematic of the chamber with 'A' and 'B' ports. The 'Gas' is shown as 0 AMPS. 'Low Voltage DC Sputter Current' is 0 AMPS. 'Vent Delay' is 0 Sec. The 'Auto Pump' status is 'Running'. The 'Auto Vent' status is 'Running'. The 'Auto Process' status is 'Running'. The 'Interlocks' section shows 'Lift Interlock Not Met' in red and 'Lift Down' in yellow. At the bottom are buttons for 'Screens', 'Lift Up' (Lifting), 'Lift Down' (Lowering), and 'Abort'.</p>
<p style="text-align: center;">Typical Overview Screen (Heat)</p>	<p style="text-align: center;">Typical Overview Screen (Gas)</p>

This screen is used to display current system status, the vacuum level in the vacuum chamber, the pumping system and sources. Operation of the bell jar Lift (up/down) is available on this screen. Access is provided on the lower left to the Screens display.

## DISPLAYS

Graphics change color to indicate current state: **GREEN** = ON/OPEN, **RED** = OFF/CLOSED. Valves, pumps, rotation motor, and interlocks change color to indicate current state (**GREEN** = ON/OPEN; **RED** = OFF/CLOSED). Graphic indicators are displayed on the vacuum system graphic when sources are active.

The Chamber Pressure (from the full range gauge in Torr), Low Voltage Current (Amps), Sputter Current (mAmps), Vent Delay Timer (seconds), Heat Temperature (°C) and Rotation Setpoint (0-100%) are displayed on this screen.

The Lift Interlock Status is also displayed on this screen. The interlock will be “Met” or “Not Met”.



**Note: A pressure interlock is in place to prevent operating the lift while the chamber is under vacuum!**

The various interlocks that will appear will be Bellows (BL), Skins (SK), and the chamber Door (DR). If all interlocks are met, the system will display SATISFIED. If an interlock is not met, the system will read unsatisfied and the name of the interlock will appear on the interlock message. Clearing this interlock will allow continuation of process.

## LOW VOLTAGE

Low Voltage (LVA or LVB) graphics change color to indicate current state (ON/OFF; OPEN/CLOSED). Low Voltage Current (amps) is displayed on the screen.

## SPUTTER

Cathode and Gas graphics change color to indicate current state (ON/OFF). The DC Current (mAmps) is displayed.

## HEAT

The Heat graphic changes color to indicate current state (ON/OFF). The Heat Temperature (°C) is displayed.

## GAS

The Gas graphic changes color to indicate current state (ON/OFF).



## LIFT



**Note: A pressure interlock is in place to prevent operating the lift while the chamber is under vacuum!**

The chamber pressure must be greater than  $6 \times 10^{-2}$  Torr for one (1) minute before the Lift can be operated. This is a safety feature intended to protect the lift mechanism from damage. This interlock is not active in Service mode. A text message will display to indicate the current state of the Lift Interlock.



**Caution: Extreme care must be taken to insure safe operation of the Lift in Service Mode. The Lift must only be operated when the chamber is not under vacuum. Damage to the lift or the system resulting from improper operation of the lift voids the warranty protection.**



**Caution: Extreme care must be taken to insure safe operation of the Lift. Keep hands and other foreign objects away from the bell jar sealing surface when operating the lift to prevent lowering the lift and damaging your hand or the sealing surface.**

The Lift Up button is only available when the “LIFT UP” Sensor is NOT satisfied, and the Lift Down button is only active when the “LIFT DOWN” Sensor is NOT satisfied. These buttons must be pressed and held to operate the lift. If you release the button the lift will stop at the position it is currently at. Either button will not operate if the chamber pressure is not at or above  $6.0 \times 10^{-2}$  for at least 2 minutes



Text will display on the Lift Up and Down buttons to indicate movement of the lift.



Text messages are displayed to indicate the current state of the Lift (up/down) and the current condition of the Lift Interlock.

## AUTO BUTTONS



Automatic operation of the vacuum system is instantiated from this screen.

AUTO PUMP is an automatic sequence that safely pumps the vacuum system into high vacuum.

AUTO VENT is an automatic process that safely vents the vacuum chamber to atmospheric pressure.

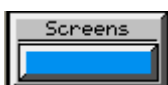
The ABORT button stops an automatic sequence with all valves returning to a safe condition. The ABORT button will also change the System Status from Automatic to Manual Mode.

The Auto Process button is active only for systems that are built with the optional Deposition Controller (evaporation only). See the Process Configuration and Deposition Controller sections of the operating manual for further information on this feature.

**NOTE: AUTO PROCESSES WILL AUTOMATICALLY START ROTATION. SYSTEM VENTING WILL AUTOMATICALLY STOP ROTATION.**

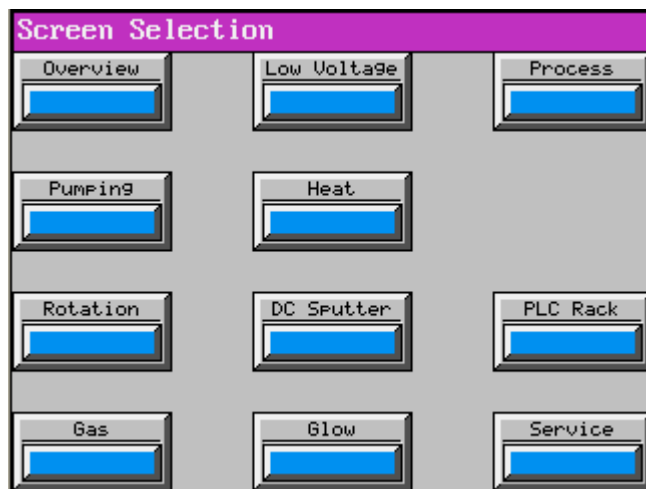
**NOTE: Selection of either button will cause the system to switch from Manual to Auto Mode. Manual operation of subsystems is NOT available in Auto Mode. Manual operation of subsystems is available ONLY in Manual Mode.**

## SCREENS BUTTON



Screens Push button is used to switch to the Screen menu. Overview button is used to switch back to the Overview screen.

## SCREEN SELECTION

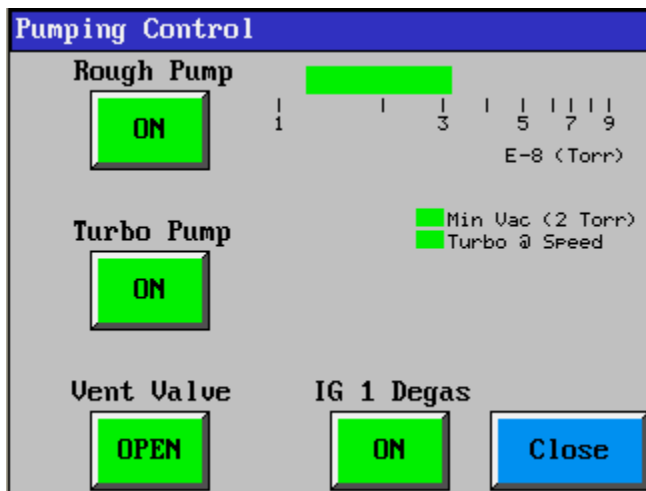


Screen Selection (typical)

Access to all subsystem control screens is available through this menu screen. Press any button to open the control screen for the desired subsystem operation.

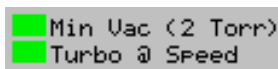
**Screens will NOT be displayed when a button is pressed unless the Benchtop Turbo system is equipped with the corresponding subsystem.**

## PUMPING CONTROL



Buttons change color to indicate current state: **GREEN** = ON/OPEN, **RED** = OFF/CLOSED.

The Chamber Pressure (from full range gauge in Torr) is displayed continuously on this screen.



Min Vac and Turbo @ Speed interlock indicators are visible on this screen. **GREEN** = Satisfied, **RED** = Open.

- The Min Vac interlock functions to protect the operator from accidental operation of a subsystems (i.e Turbo Pump, power supply, etc.) when the chamber is open.
- Turbo@ Speed interlock provides feedback from the turbo molecular pump to indicate that it has reached operating speed.

The vacuum pumps, vent valve and gauge can be operated from this screen.

- Rough Pump ON/OFF.
  - An automatic vent valve is slaved to the mechanical pump. It will automatically open when the Mechanical Pump is turned OFF to vent the chamber to atmosphere. It will automatically close when the Mechanical pump is turned on.



**NOTE: The Vent Valve button can only be operated from this screen in Service Mode. Care must be taken to activate the Vent Valve only when the pumps are off.**

- Turbo Pump ON/OFF
- The degassing of the Ion gauge can be controlled from this screen.
  - When the Chamber Degas button is pressed, the gauge will be degassed for three (3) minutes. Degassing of the Ion gauges requires the system to be under vacuum with all vacuum interlocks met.



**NOTE: The system must be in Service Mode and the chamber pressure must be below 5.4e-6 Torr before activating the Degas feature. Read the gauge manual before attempting to degas the gauge tube.**

Current System Mode and Interlock Status are also displayed on this screen. The System Status will be Manual, Auto, or Service. The various interlocks that will appear will be Bellows (BL), Skins (SK), and the chamber Door (DR).

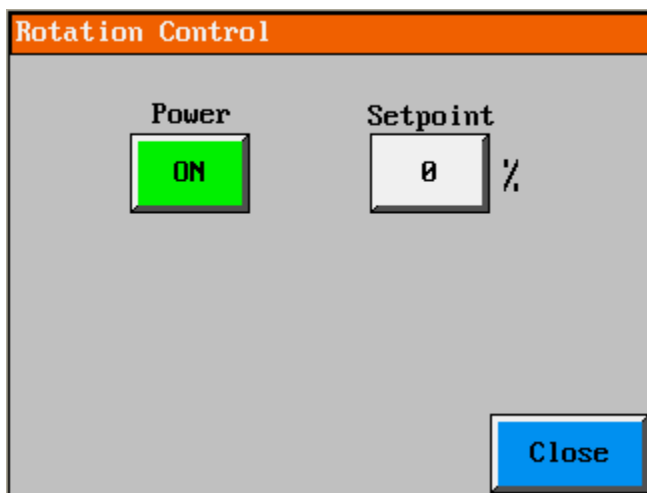
If all interlocks are met, the system will display SATISFIED. If an interlock is not met, the system will read unsatisfied and the name of the interlock will appear on the interlock message. Clearing this interlock will allow continuation of process.

The Close push button at the bottom is used to switch back to the “Overview” screen.

Operation of the Pumps and Valves is described in detail in the Pumping System section of this manual.

## ROTATION CONTROL

(If Equipped)



Buttons change color to indicate current state: **GREEN** = ON/OPEN, **RED** = OFF/CLOSED.

The substrate Rotation drive motor can be turned ON/OFF on this screen.

The rotation Set Speed (%) can be input on this screen. Press the Setpoint entry box and a digital keypad will pop-up for data entry.

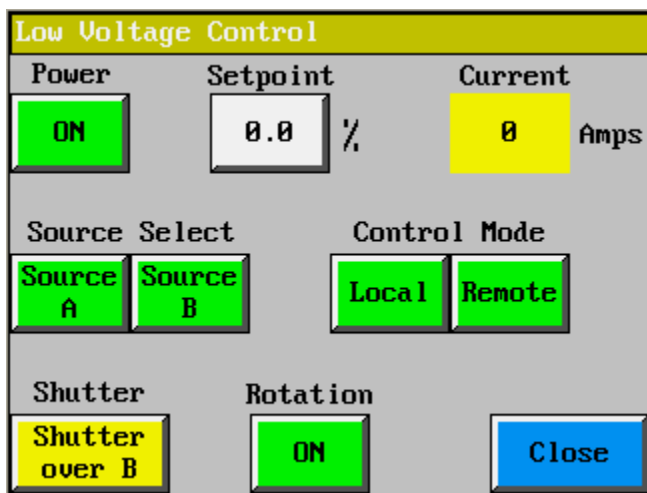
The Close push button at the bottom is used to switch back to the “Overview” screen.

7	8	9	Demo Numeric Entry	
4	5	6	<input type="text"/>	
1	2	3	MINIMUM 0	
0	Clear		MAXIMUM 9999	
			CURRENT 0	
			Cancel	Enter

Numeric Keypad

## LOW VOLTAGE CONTROL

(If Equipped)



Buttons change color to indicate current state: **GREEN** = ON/OPEN, **RED** = OFF/CLOSED.

The low voltage Power supply can be turned ON/OFF on this screen. The Rotation **MUST** be ON (Green).

Source A or Source B selection is available on this screen. Power is directed to either source with this selection.

The Low Voltage (LV) Shutter can be switched between sources on this screen.

The Power Level (%) of the Low Voltage Source can be input on this screen. Press the Setpoint box and a digital keypad will pop-up for data entry. The Low Voltage Current (Amps) is displayed on this screen.

The Rotation can be switched ON/OFF from this screen.

Low Voltage Control Mode can be switched from Local to Remote.

- Local Control of the source is from this screen.
- Remote Control of the source is from the optional deposition controller. See the Deposition Control section of this manual for detailed instructions of this feature.
  - The Deposition Controller button will switch power control to the deposition controller. This will disable the power Setpoint input from this screen. The Power button must be ON before activating the Deposition Control button.



**NOTE: Read the deposition controller operating manual before proceeding to operate the sputter source through the deposition controller!**

- All deposition parameters must be programmed into the deposition controller. The deposition controller will control the power supply.
- Power ramp and soak settings are programmed into the deposition controller. The shutter will open when the deposition controller enters the Deposit state and close when the Final Thickness is reached.

The Close push button at the bottom is used to switch back to the “Overview” screen.

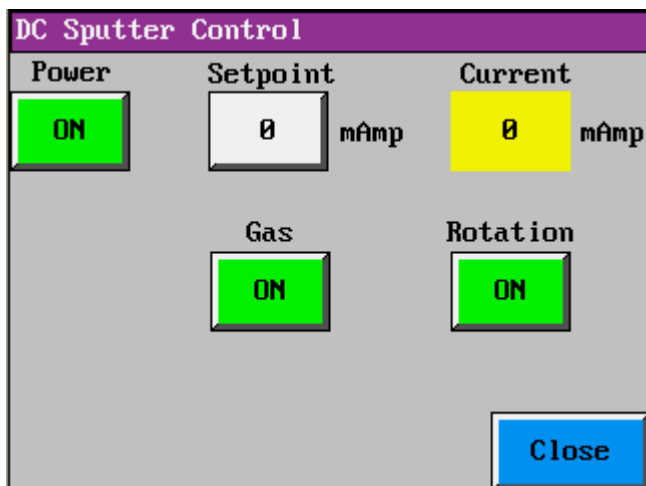
7	8	9	Deno Numeric Entry	
4	5	6	<input type="text"/>	
1	2	3	MINIMUM 0	
0	Clear		MAXIMUM 9999	
			CURRENT 0	
			Cancel	Enter

Numeric Keypad



## SPUTTER CONTROL

(If Equipped)



**WARNING: Maximum operating time for the sputter head is ten (10) minutes. A minimum of ten (10) minutes cool down time is required between each operating session. Failure to follow this recommendation will result in damage to the equipment.**

Buttons change color to indicate current state: **GREEN** = ON, **RED** = OFF

The DC Power on/off can be controlled on this screen. Maximum operating time is ten (10) minutes.

Gas Power on/off can be controlled on this screen. **GREEN** = ON, **RED** = OFF

The DC Setpoint (mAmps) can be input on this screen. Press the Setpoint box and a digital keypad will pop-up for data entry. The Low Voltage Current (Amps) is displayed on this screen.

The DC Current is also displayed on the Overview screen.

The substrate Rotation can be controlled on/off from this screen. **GREEN** = ON, **RED** = OFF

The Close push button at the bottom is used to switch back to the “Overview” screen.

7	8	9	Demo Numeric Entry <input type="text"/> MINIMUM 0 MAXIMUM 9999 CURRENT 0
4	5	6	
1	2	3	
0	Clear		
			Cancel    Enter

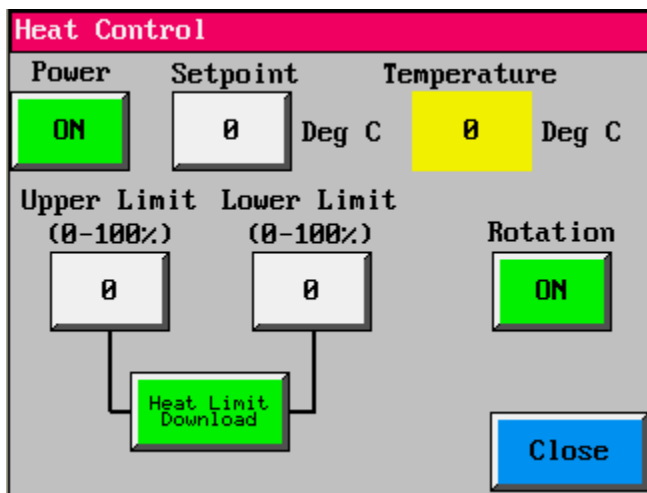
Numeric Keypad



**WARNING:** Maximum operating time for the sputter head is ten (10) minutes. A minimum of ten (10) minutes cool down time is required between each operating session. Failure to follow this recommendation will result in damage to the equipment.

## HEAT CONTROL

(If Equipped)



Buttons change color to indicate current state: **GREEN** = ON, **RED** = OFF

The Heat Power on/off can be controlled on this screen.



**Chamber MUST be under vacuum to activate Heat Power.**

Rotation on/off can be controlled on this screen. **GREEN** = ON, **RED** = OFF.



**Rotation MUST be ON to activate Heat Power.**

The Heat Setpoint (0 - 100°C) can be input on this screen. Press the Setpoint box and a digital keypad will pop-up for data entry.

The Upper and Lower Limits (0 – 100%) can be input on this screen. Press the Setpoint box and a digital keypad will pop-up for data entry.



**Heat Limit Down Load button MUST be pressed to enter the new limit set points.**

- Upper and Lower Limits control the minimum and maximum power output available from the Heat power supply.

- Heat Limit Down Load button **MUST** be pressed to enter the new limit set points.

The substrate Rotation can be controlled on/off from this screen. **GREEN** = ON, **RED** = OFF.

Actual Heat Temperature is displayed on this screen and the Overview screen.

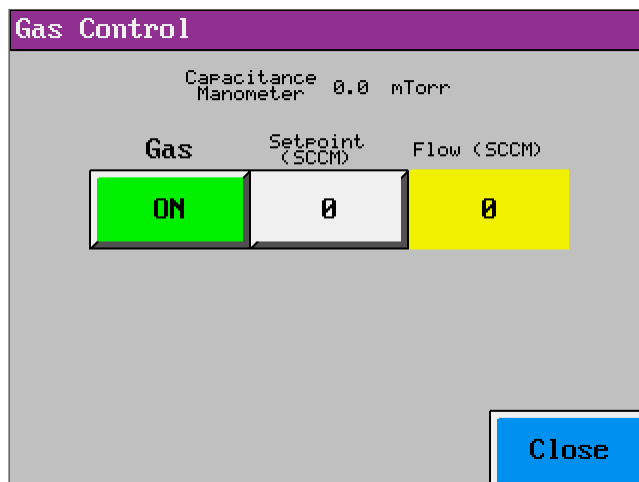
The Close push button at the bottom is used to switch back to the “Overview” screen.

7	8	9	Demo Numeric Entry	
4	5	6	<input type="text"/>	
1	2	3	MINIMUM 0	
0	Clear		MAXIMUM 9999	
			CURRENT 0	
			Cancel	Enter

**Numeric Keypad**

## GAS CONTROL

(If Equipped)



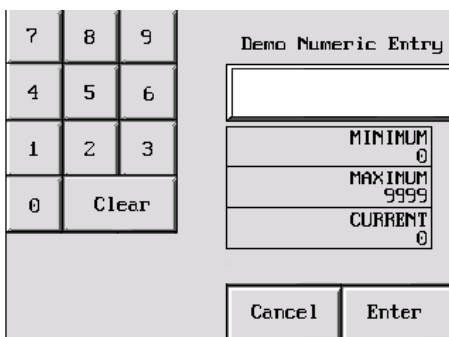
The Gas Control screen features a purple header bar with the text "Gas Control". Below the header, the text "Capacitance Manometer 0.0 mTorr" is displayed. The main area contains three columns: "Gas", "Setpoint (SCCM)", and "Flow (SCCM)". The "Gas" column has a green button labeled "ON". The "Setpoint (SCCM)" column has a white input box containing "0". The "Flow (SCCM)" column has a yellow button labeled "0". A blue "Close" button is located in the bottom right corner.

Graphics change color to indicate current state: **Green** = ON/OPEN, **Red** = OFF/CLOSED.

The chamber vacuum pressure (mTorr) is displayed on this screen via the Capacitance Manometer. If system is not equipped with a Capacitance Manometer, vacuum pressure will be displayed using a bar graph similar to the one on the Overview screen.

Gas On/Off can be selected. Flow setpoint(s) can be input from this screen by pressing the white input box(es) and entering settings using the digital keypad.

The CLOSE button will switch to the Overview screen.

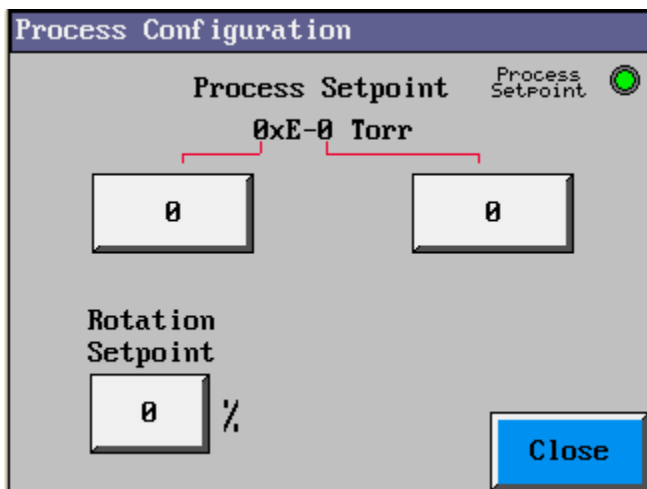


The Numeric Keypad interface consists of a 4x3 grid of buttons. The first three rows contain digits 7-9, 4-6, and 1-3 respectively. The fourth row contains a "0" button and a "Clear" button. To the right of the grid is a "Demo Numeric Entry" section with a white input box, and three rows labeled "MINIMUM", "MAXIMUM", and "CURRENT", each with a corresponding input box. At the bottom right are "Cancel" and "Enter" buttons.

Numeric Keypad

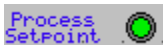
## PROCESS CONFIGURATION

(If equipped with Low Voltage Source and optional Deposition Controller)



The Process button will activate a screen that provides access to program the Process Setpoint.

This setpoint is used as an interlock for the start of an automatic deposition process. Process Setpoint indicator will indicate current state of the pressure interlock. **GREEN** = Satisfied, **RED** = Not Satisfied.



The Process Setpoint indicator is also visible on the Overview screen.

A programmed evaporation process will not begin until this setpoint is satisfied.

The programmed evaporation Auto Process is enabled from the Overview screen.

## PROGRAMMED EVAPORATION EXAMPLE

**NOTE: A Rotation Setpoint and a Process Setpoint must be entered on the Process screen.**



**NOTE: Read the deposition controller operating manual before proceeding to operate the sputter source through the deposition controller!**

All deposition parameters must be programmed into the deposition controller. The deposition controller will control the power supply in the Auto Process.

Power ramp and soak settings are programmed into the deposition controller. The shutter will open when the deposition controller enters the Deposit state and close when the Final Thickness is reached.

The programmed evaporation Auto Process is enabled from the Overview screen. **GREEN** = ON, **RED** = OFF. The programmed evaporation procedure is as follows:

- System will pump down to reach the programmed Process Setpoint.
- Substrate Rotation will turn ON.

**NOTE: AUTO PROCESSES WILL AUTOMATICALLY START ROTATION. SYSTEM VENTING WILL AUTOMATICALLY STOP ROTATION.**

- When the Process Set Point is satisfied:
  - The Low Voltage source power will turn ON.
  - The Deposition Controller will ramp and soak the Low Voltage power as programmed.
  - The Shutter will open.
  - Deposition will proceed as programmed in the deposition controller until the programmed Final Thickness setpoint is reached.
  - The shutter will close and the source power will turn OFF.
- The ABORT button stops an automatic sequence with all valves returning to a safe condition. The ABORT button will also change the System Status from Automatic to Manual Mode.
  - Pressing the Abort button during an Auto Process procedure will end the Auto Process and switch the System Status from Automatic to Manual.

## SERVICE MODE



Access to the SERVICE screen is available on this screen. Two hidden buttons must be pressed in sequence to activate the Service Screen. These hidden buttons are in the top corners of this screen.

The Close push button at the bottom is used to switch back to the “Overview” screen.



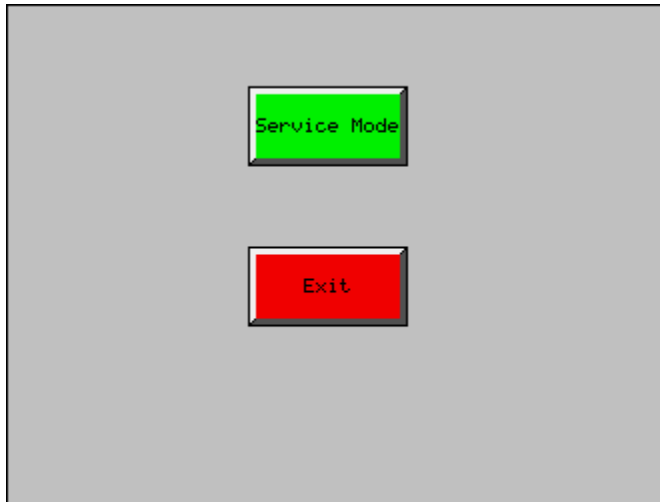
**Caution! ALL Interlocks are deactivated in Service Mode. Use caution when operating the system in Service Mode.**



**LETHAL VOLTAGES ARE AVAILABLE ON THIS VACUUM SYSTEM. EXTREME CAUTION MUST BE TAKEN TO OPERATE THE SYSTEM SAFELY IN SERVICE MODE.**



## SERVICE



**Caution! ALL Interlocks are deactivated in Service Mode. Use caution when operating the system in Service Mode.**



**LETHAL VOLTAGES ARE AVAILABLE ON THIS VACUUM SYSTEM. EXTREME CAUTION MUST BE TAKEN TO OPERATE THE SYSTEM SAFELY IN SERVICE MODE.**

Buttons change color to indicate current state: **GREEN** = ON/OPEN, **RED** = OFF/CLOSED.

Activate Service Mode on this screen by pressing the Service Mode button.

To switch from Service Mode to Auto Mode:

- Start an Auto Pump or Auto Vent process from the Auto screen.
- Start an Auto Process from the Auto Process screen.

To switch from Service Mode to Manual Mode:

- Start an Auto Pump or Auto Vent process from the Auto screen and then abort.
- Start an Auto Process from the Auto Process screen and then Abort.
- Deactivate Service Mode from the Service Mode screen.

The Exit push button is used to switch back to the “Service Mode” screen.

## PLC RACK

Main Rack								Slot 1	Slot 2
<b>Y Outputs</b>								<b>Inputs</b>	
0	1	2	3	4	5	6	7	U2001	
●	●	●	●	●	●	●	●	0	
10	11	12	13	14	15	16	17	U2002	
●	●	●	●	●	●	●	●	0	
<b>X Inputs</b>								<b>Outputs</b>	
0	1	2	3	4	5	6	7	U2051	
●	●	●	●	●	●	●	●	0	
10	11	12	13	14	15	16	17	U2052	
●	●	●	●	●	●	●	●	0	
20	21	22	23						
●	●	●	●						

Close

Indicators change color to indicate current state: **GREEN** = ON/OPEN, **RED** = OFF/CLOSED.

Input and Output values are displayed as raw digital values.

The PLC Rack screen is provided for reference only. It is intended to be used as a troubleshooting aid if a problem arises. If technical support is required, the operator may be asked to observe and record information from this screen and report on the status of each item displayed to help in the identification of the cause of a problem.

The Close push button at the bottom is used to switch back to the “Overview” screen.

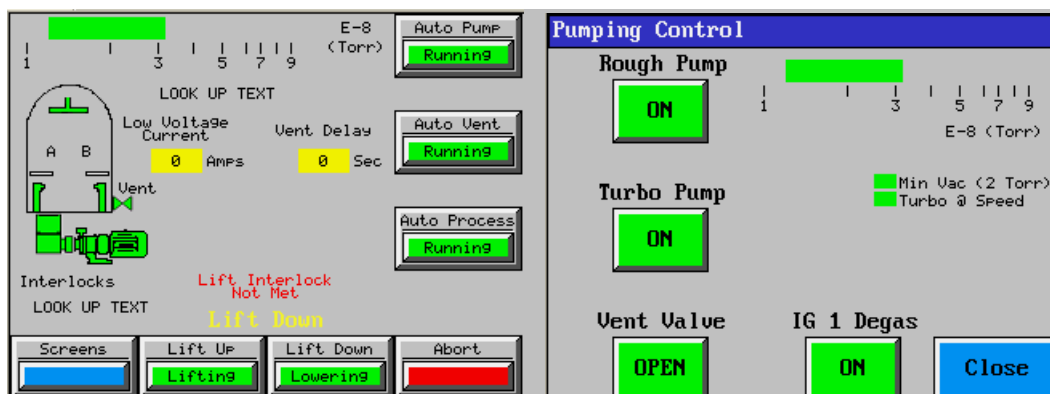
## PUMPING SYSTEM OPERATION



**Warning! Do not remove the vacuum system skins or defeat the door or skin switches. Do not attempt to bypass them. This is for your safety.**

The Bench Top Turbo vacuum system provides fully automated pumping processes. Auto Pump and Auto Vent are automatic sequences that provide safe operation of the pumps and valves to pump the system into high vacuum and vent the chamber to atmosphere.

System startup is either manual operation or auto operation. And system shutdown is manual operation. These sequences are fully outlined in this section of the manual.



## START UP

- Turn ON main electrical power and verify proper air pressure (80 –100 psi), and cooling water, if required.

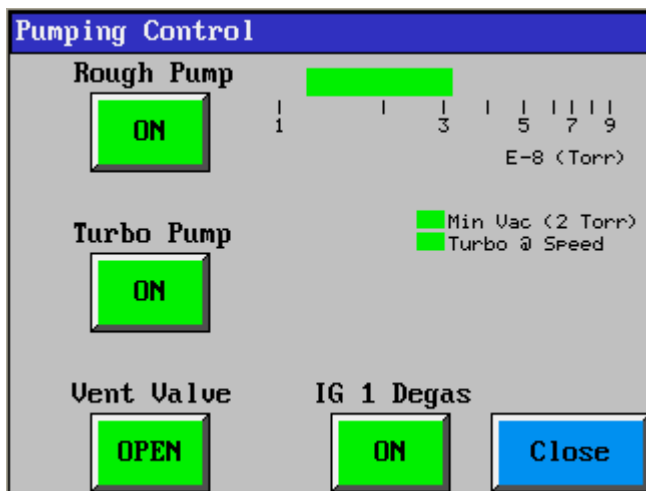


**NOTE: Verify that the Emergency Stop button is in the OUT position. Twist it to pull it out.**

- Press the Green power button on the front door of the cabinet to apply power to the control system. Verify that all interlocks are satisfied. See the Interlock section of this manual for further details.
- Begin with all valves closed and all pumps OFF.

- Turn ON the Rough Pump. Run the Rough Pump until the Minimum vacuum 2 Torr indicator turns **Green**.
- Turn ON the Turbo Pump. Wait until the turbo speed reaches normal speed. The Turbo @ Speed indicator will be Green. The Turbo Pump will be ready for operation at this time.
- The vacuum system is now in high vacuum status.

## MANUAL MODE SHUTDOWN



**NOTE:** This Shutdown sequence must be performed whenever the vacuum system will not be used or for cleaning or maintenance. The chamber can be left at atmosphere if cleaning or maintenance will be performed.

- Turn OFF the Turbo pump.
- Wait ten minutes.
- Turn the Rough Pump OFF.
- Turn OFF Main Electrical Power, Compressed Air, and cooling water.

## AUTO PUMP SEQUENCE



**Note: The Auto Pump sequence is used to safely and automatically evacuate the chamber. All interlocks are active to safely operate the pumping system. The glass bell-jar must be in place.**

The pumping system on the Bench Top Turbo system is designed to deliver quick, easy evacuation of the vacuum chamber. The pumping system is versatile and is delivered with many interlocks to provide for safe operation under most production conditions. The pumping system can be operated in the Automatic Mode.

All graphics on the Overview screen will change from red to green as they are cycled ON and OFF. Chamber pressure is displayed on the Overview screen. Auto Pump will proceed as follows if the pumping system is ready:

- Upon initiating the Auto Pump Sequence. The system will automatically verify that the lift is down. The Rough Pump will start and the System will pump until the Minimum vacuum 2 Torr indicator turns **Green**.
- The Turbo Pump will activate and continue until the Turbo @ Speed indicator is green. The pumps will continue to operate until an Auto Vent process is run. The chamber will be in high vacuum status.
- An automatic vent valve is slaved to the mechanical pump. It will automatically open when the Mechanical Pump is turned OFF to vent the chamber to atmosphere. It will automatically close when the Mechanical pump is turned on.

## AUTO VENT SEQUENCE

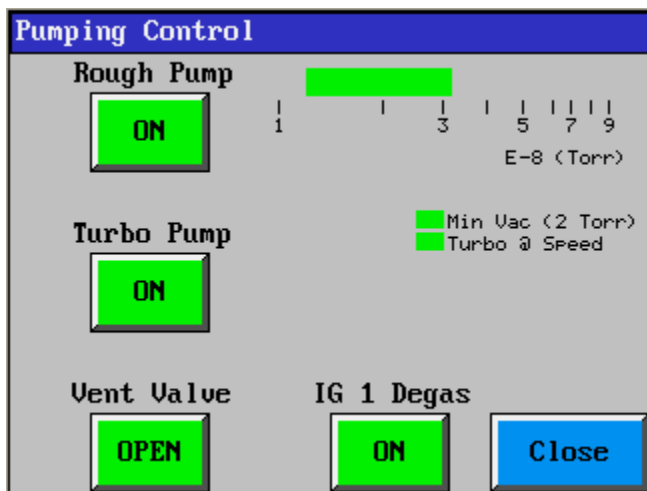
**Note: The Auto Vent sequence is used to safely and automatically vent the chamber to atmosphere. All interlocks are active to safely operate the pumping system.**

The pumping system is versatile and is delivered with many interlocks to provide for safe operation under most production conditions. The pumping system can be operated in the Automatic Mode.

All graphics on the Overview screen will change from red to green as they are cycled ON and OFF. Chamber pressure is displayed on all screens. Auto Vent will proceed as follows:

- The Turbo Pump will shut off.
- Five minutes later the rough Pump will shut off and the Vent Valve will open and remain open until the chamber is at atmospheric pressure.
- An automatic vent valve is slaved to the mechanical pump. It will automatically open when the Mechanical Pump is turned OFF to vent the chamber to atmosphere. It will automatically close when the Mechanical pump is turned on.

## MAIN CHAMBER PUMPING – MANUAL MODE



**NOTE: All manual operations are carried out from the Pumping Control Screen on the touch screen.**

- Lower the bell jar until the lift down switch is satisfied.
- Turn ON the Rough Pump. Run the Rough Pump until the Minimum vacuum 2 Torr indicator turns **Green**.
  - An automatic vent valve is slaved to the mechanical pump. It will automatically open when the Mechanical Pump is turned OFF to vent the chamber to atmosphere. It will automatically close when the Mechanical pump is turned on.
- Turn ON the Turbo Pump. Wait until the turbo speed reaches normal speed. The Turbo @ Speed indicator will be Green. The Turbo Pump will be ready for operation at this time.
- The Vacuum Chamber is now in High Vacuum.

## MAIN CHAMBER VENTING – MANUAL MODE

- Turn OFF the Turbo pump.
- Wait ten minutes.
- Turn the Rough Pump OFF.



- An automatic vent valve is slaved to the mechanical pump. It will automatically open when the Mechanical Pump is turned OFF to vent the chamber to atmosphere. It will automatically close when the Mechanical pump is turned on.

## PROCESS GAS START-UP (IF EQUIPPED)

- All pumps must be operational before connecting the high purity gas line.
- All gas supply lines must have an ON/OFF valve between the regulator and the vacuum system.
- Connect the gas supply line to the rear of the machine and close the valve near the pressure regulator.
- Pump the chamber out manually and open the Gas Isolation Valve. Use the gas adjust micrometer valve to increase the gas flow set point to 50%.
  - If the system is equipped with a mass flow controller, then input a gas flow setpoint of 50% of full range.
- Continue pumping out the system until the actual flow in the line decreases or the pressure returns to the original value.
- Increase the flow Set point to maximum.
  - If the system is equipped with a mass flow controller, then input a gas flow setpoint of 100% of the full range.
- Continue pumping until the actual flow in the line decreases or the pressure returns to the original value.
- Reduce the set point to zero or close the micrometer valve and close the Gas Isolation Valve.
  - If the system is equipped with a mass flow controller, then input a gas flow setpoint of zero.
- Open the toggle valve near the pressure regulator and adjust the regulator to 10 - 15 psi (0.4 – 1.0) bar.



**NOTE: This procedure MUST be followed whenever a gas tank is replaced or a gas line is opened to atmosphere.**

## SYSTEM INTERLOCK



**Interlocks are provided to insure operator safety. Operation of the vacuum system with bypassed interlocks is unsafe and may cause damage to the system.**

**Please verify interlock status before assuming that a repair is necessary. This list is provided for reference. Please check this list before proceeding with troubleshooting or repair.**

## HARDWARE INTERLOCKS

Hardware interlocks are standard in all Bench Top Turbo systems. These interlocks protect the operator from unsafe operating conditions (high voltages, high temperatures, dangerous pressure differentials, etc.). Subsystems will not operate when hardware interlocks are not satisfied.

The status of all hardware interlocks is displayed on the touch screen at all times. These messages are described in the following list:

ON-SCREEN INTERLOCK MESSAGES	DESCRIPTION
Skins (Sk)	Electrical Cabinet Door Open
Bellows (Bl)	Minimum Vacuum Sensor Open (in Chamber)
Water (Wt)	Cooling Water Sensor Open
All Satisfied	All Hardware Interlocks Satisfied
Lift Down Switch	Lift Down
COMBINATIONS WILL BE DISPLAYED AS FOLLOWS:	
Sk	Skin
Bl	Bellows
Bl-Sk	Bellows-Skin
Bl-Sk-Wt	Bellows-Skin-Water

**DENTON VACUUM, LLC**  
**BENCH TOP TURBO COATING SYSTEM**  
**1-856-439-9100**

	To Turn ON	To turn OFF
Mechanical Pump	Lift Down Switch Satisfied	None
Turbo Pump	None	None
Vent Valve	None	None
Gas Valves	None	None
Heat Power	Vacuum switch Satisfied	None
DC Power Supply	Vacuum switch Satisfied	None
Low Voltage Power	Vacuum switch Satisfied	None
	Water Switches Satisfied (for 2kVA only.)	
Low Voltage Select	None	None
Glow Discharge	Vacuum switch Satisfied	None
Rotation	None	None
Shutters	None	None
Degas 1	None	None
Auto Pump	Lift Down Switch Satisfied	None

## SOFTWARE INTERLOCKS

Software interlocks are standard in all Bench Top Turbo systems. These interlocks protect the operator from unsafe operating conditions (high voltages, high temperatures, dangerous pressure differentials, etc.). Subsystems will not operate when software interlocks are not satisfied.

Verify that all software interlocks are satisfied before troubleshooting a subsystem. Software interlocks are listed below for each subsystem.

	To Turn ON	To turn OFF
Mechanical Pump	Lift (Down) Sensor Satisfied	Turbo Pump off
Turbo Pump	Min. Vacuum Satisfied	None
Chamber Vent Valve	In Service Mode only	In Service Mode only
Gas Valves	Vacuum switch Satisfied	None
	Turbo Pump ON	
Heat Power	Rotation ON	None
	Vacuum switch Satisfied	
	Skin Switches Satisfied (Cabinet)	
DC Power Supply	Rotation ON	None
	Vacuum switch Satisfied	
	Gas Valve On	
Low Voltage Power	Rotation ON	None
	Vacuum switch Satisfied	
	Low Voltage A or B Selected	
	Water Switches Satisfied (for 2kVA only.)	
Low Voltage Select	Low Voltage Power Off	Low Voltage Power Off
Glow Discharge	Vacuum switch Satisfied	None
	Turbo Pump OFF	

**DENTON VACUUM, LLC**  
**BENCH TOP TURBO COATING SYSTEM**  
**1-856-439-9100**

	To Turn ON	To turn OFF
Rotation	None	None
Shutters	None	None
Degas 1	Vacuum at or below 1.0E-4	None
Auto Pump	Lift Down Sensor satisfied	None
Auto Vent	System under vacuum	None
Auto Process	Lift Down Sensor satisfied	None

## SYSTEM SETPOINTS

### PRESSURE SETPOINTS

All system pressure set points are programmed into the PLC. They are factory set. They are not displayed in the software.

The set points should not be changed. They are an integral part of the software and PLC program.

The pressure set points are provided here for verification and as a backup record in the event a setpoint must be changed.

SETPOINT #	ASSIGNMENT	PRESSURE	PURPOSE
1	Process Set Point	vary	Process Setpoint; customer adjustable (functional only if system is equipped with Auto Process).
2	Min. Vacuum	2.0E-0 Torr	Crossover Point for Turbo Pump.

## OPERATING PROCEDURE



**NOTE: IF THE UNIT HAS JUST BEEN DELIVERED, OR IF THE CHAMBER HAS BEEN OPEN TO ATMOSPHERE FOR SEVERAL DAYS AND HAS PICKED UP WATER VAPOR ON THE SURFACES, IT WILL BE NECESSARY TO PUMP THE SYSTEM FOR MANY HOURS (even overnight) TO FULLY CLEAN IT OUT.**

## BELL JAR LOADING

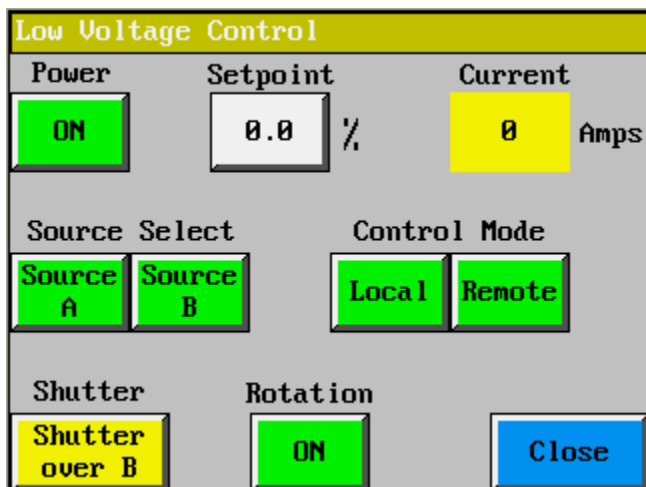
- Open the CHAMBER vent valve and bring the bell jar to atmosphere. (Necessary only if bell jar was left under vacuum previously.)
- Lift the bell jar.



**NOTE See the Lift section of this manual for specific instruction for operating the chamber Lift.**

- Load filament and/or carbon sources. Adjust sources to desired position.
- Position samples in bell jar.
- Lower the bell jar until the lift down sensor is satisfied and the jar is resting on the collar flange.

## EVAPORATION



(If Equipped)

When the bell jar reaches the necessary vacuum:

- Open the Low Voltage control screen
- Select the appropriate filament holder electrode (Low Voltage A/B Select).
- Check that the Power Level is set at 0%.
- Turn ON Rotation (OPTION).
- Turn the Low Voltage POWER button ON.
- Increase the Power Level to bring the filament to red color. Hold at this power level. Check HIGH-VACUUM gauge to see if vacuum is holding. Check ammeter to obtain ampere reading. This is out gassing the filament and the evaporant. Do this for about 20 seconds or until the pressure starts dropping again. Raise power to the appropriate level to complete the evaporation. The Power Level is adjustable from 0 – 100%.
- Depending on the resistance of the carbon rod or filament wire used, different power levels will be drawn. If you are unable to draw 40 amps with the SCR on full scale, you must use a wire of larger diameter. If you can draw 55 amps, but nothing is evaporating, then:
  - FOR FILAMENT WIRE:
    - Use smaller diameter wire.
    - Check melting point of material.



- You may require an evaporation power supply with lower voltage and higher amp output.
- FOR CARBON RODS:
  - Check purity of carbon rods. Use only highest purity rods that have the highest resistance.
  - Check diameter of reduced section. It MUST be .040" or less to have appropriate resistance.

## AC GLOW DISCHARGE

### (If Equipped)

When a bell jar high-vacuum evaporator is equipped with a glow discharge cleaning circuit, carbon support films and grids may be cleaned in vacuum to remove the molecular layers of oil and water. All materials exposed to our atmosphere tend to accumulate molecular layers of oil and water on the surface. These few molecular layers cause the surface to repel water. Carbon films so contaminated will cause aqueous solutions to bead rather than to spread over the surface. Contaminated grids will not pick up replicas readily. The AC Glow Discharge will clean the carbon support films and grids in vacuum of the molecular layers of oil and water.

The Denton AC Glow Discharge apparatus consists of a 4000V, 30MA high-voltage transformer, two high-voltage baseplate feedthroughs, and a bellows activated safety switch.

This apparatus should be installed in the evaporator when being built, but it can be added in the field by using three spare baseplate holes for the safety switch and the two antennae.

To set up for glow cleaning, two pure aluminum wires, connected to two high-voltage feedthroughs, are brought about above and below the sample area.



**WARNING! MAKE SURE GLOW WIRES ARE COMPLETELY ISOLATED FROM FIXTURING (FOIL SHUTTERS, ETC.) TO PREVENT IT FROM SHORTING.**

Rough out the bell jar to high vacuum and back fill with a gas inlet valve to  $5 - 9 \times 10^{-3}$  Torr. Open the Low Voltage & Glow screen. Turn the Glow Power button ON. A glow or plasma should be visible between the aluminum wires. The material to be cleaned should be just below the visible glow. Little or no glow should be evident below the port cover. (To see the glow it may be necessary to shadow the bell jar from bright room lighting.) Hold for 2 to 15 minutes. All surfaces are being bombarded with ions formed in the high-voltage field.

Reducing the chamber pressure will result in less gas to be ionized. Visible glow is hardly visible below  $3 \times 10^{-3}$  Torr. At this pressure the rate of cleaning is very slow. At pressures between  $5 - 9 \times 10^{-3}$  Torr, the glow fills the bell jar and the cleaning rate is best.

After cleaning, turn the Glow Power button OFF, vent the chamber and remove cleaned material. It should stay visibly clean for a day or so.

## CARBON ROD EVAPORATION SOURCE

(If Equipped)

The carbon evaporation unit is designed to use high-purity nominal 1/8" (.120") diameter carbon rods. It will fire the .040" reduced diameter, as supplied. The fixed carbon must have the contact end flat, smooth, and square to the moving carbon. The height is adjustable by loosening a screw holding the unit to the mounting post.



**NOTE: DO NOT permit the mounting post to touch the pump out cover, which is at baseplate ground. This would short the filament current directly to ground.**

## LOADING CARBON RODS:

Two carbon rods are positioned in the center of the "yoke" to do the coating. One rod will have a reduced section; the other will have a full diameter section that has been carefully flattened on the end touching the point (or reduced section) of the other rod. A metal or emery board nail file is useful for this task.

Both carbon rods should be inserted, one after another, through the outside end of the fixed rod holder. First, the flattened rod should be inserted and pushed through with another rod or a 1/16" wooden stick into the moving rod holder. Tighten the rod when the flat end is exposed approximately 1/4" from the holder. Push the holder against the spring and deflect approximately 3/8" by hand. Insert the second rod (point first) and push it up against the flattened rod. Tighten the thumb screw holding the pointed carbon in the fixed holder. When using a reduced section carbon rod, the spring should be moved out a little more than the length of the reduced section.

When properly loaded, the reduced section goes from a solid to a gas (sublimes) with no liquid phase. When unloading, allow time for mandrels to cool as they get quite hot, especially when firing carbon for 30 seconds or longer. The screws holding the guide sleeve and the carbon rod need only be finger tight. The screw for the power lead should be tightened snugly. **NOTE: EXCESSE TIGHTENING OF CARBON LOCKING SCREW WILL BREAK THE ROD.**

## EVAPORATION:

The chamber should first be pumped to  $2 \times 10^{-5}$  Torr or less. Denton Vacuum supplies a hard carbon rod of excellent quality. With the reduced diameter (.040") section, we suggest using a filament power setting of about 15 amps to degas the carbon; about 40 to 45 amps to evaporate. Degas the carbon (bright red) for 5 to 10 seconds. (Watch the chamber pressure rise and then start to fall back.) Carbon should be evaporated slowly. Normally, after degassing, the filament power is increased to where the carbon starts lightly sparking, then backing off 5 percent on the power setting. Length of evaporation time will depend on desired thickness of carbon film. It should take from 30 seconds to two minutes to totally evaporate the carbon rod.

A carbon rod with a .040" reduced section heats up and stabilizes more quickly. The rate of evaporation remains fairly constant. Thickness of the deposited film may be controlled by the length of the reduced section.

To check the carbon evaporation technique before coating samples, do the following: Coat a glass cover slip with gold. The gold color will change to copper when the cover slip is over-coated with 100 angstroms of carbon, to orange with 150 angstroms of carbon, and to purple with 200 angstroms.



**WARNING! USE DARK GLASS TO OBSERVE CARBON EVAPORATION. INTENSE BRIGHTNESS IS HARMFUL TO EYES WHEN VIEWED DIRECTLY.**

## EVAPORATION TIPS:

If you cannot evaporate your carbon at 40 amps in 10 seconds, then you need to:

- Check your carbon's purity. Use only the highest purity carbon with high internal resistance.
- Check the diameter of the reduced section. It should be .040" x .125" long. Current required to evaporate is dependent on the square of the diameter. A small difference in diameter can make a big difference in power required.

## CARBON YARN EVAPORATION SOURCE

(If Equipped)

The Carbon Yarn Evaporation Source is adjustable and is designed to provide carbon films for support, replication or conduction. The mounting posts are drilled and tapped to screw onto one of a pair of low-voltage feedthroughs. The rectangular extension block connects the upper post to the lower post. Two blocks clamp the carbon evaporation unit to the upper post. This arrangement gives flexibility to locate the source as desired.



**NOTE: DO NOT PERMIT THE MOUNTING POST TO TOUCH THE PUMPOUT COVER, WHICH IS AT BASEPLATE GROUND. THIS WOULD SHORT THE FILAMENT CURRENT DIRECTLY TO GROUND.**

The carbon yarn evaporation unit is designed to use high-purity carbon yarn. The height is adjustable by loosening the screw holding the unit to the mounting post.

### LOADING THE CARBON YARN:

The carbon yarn is placed across two spring-loaded electrode posts. Carbon sublimates, i.e., it goes from solid to a gas with no liquid phase. When reloading, allow time for mandrels to cool as they get quite hot, especially when firing carbon for 30 seconds or longer.

### EVAPORATION:

The chamber should first be pumped to  $2 \times 10^{-5}$  torr or less.

Denton Vacuum supplies a carbon yarn of excellent quality. It is suggested that a low power setting, to degas the carbon, be used; slowly raise to evaporate. Degas the carbon (bright red) for 5 to 10 seconds. (Watch the chamber pressure rise, and then start to fall back.)

Carbon may be evaporated slowly or rapidly. Normally, after degassing, the power is increased to where the carbon starts depositing. Length of evaporation time will depend on the desired thickness of carbon film. It should take from 30 seconds to totally evaporate the carbon. DO NOT take power too high for more than one minute. NEVER EXCEED 50 AMPS.

A rapid evaporation (flashing) may be utilized by presetting the control to 75 percent and then turning on the power. The flash will last from 1 to 2 seconds and help reduce heat damage.

Carbon vaporizes due to localized heat caused by resistance to flow of electric current. Carbon resistance lowers as carbon heats up, but will stabilize.

To check the carbon evaporation technique before coating samples, do the following: Coat a glass cover slip with gold. The gold color will change to copper when the cover slip is over-coated with

100 angstroms of carbon; to orange with 150 angstroms of carbon; and to purple with 200 angstroms.



**WARNING! USE DARK GLASS TO OBSERVE CARBON EVAPORATION. INTENSE BRIGHTNESS IS HARMFUL TO EYES WHEN VIEWED DIRECTLY.**

## SHADOW CASTING, REPLICATION, CONDUCTIVE FILMS

The Denton High Vacuum Evaporators are designed to deposit thin films on specimens for transmission and scanning electron microscopes, and for electron microprobe analyzers.

A thin film of carbon, in the order of 50 to 150 angstroms, is used to support specimens. A thicker film of carbon, in the order of 200 angstroms, will form a replica of a specimen surface. Metal evaporated in a high vacuum, i.e.  $10^{-5}$  Torr, will deposit a thin coating on specimen surfaces that can see the source of metal vapor. Surfaces that do not see the source receive little or no vapor. Shadow casting with heavy metal increases specimen contrast. Shadowing at a known angle also provides a means to estimate heights from the length of the shadow.

To shadow with platinum, wrap about 2.5 cm of .005" diameter platinum wire at the point of a "V" shaped in a single .020" diameter tungsten filament. Set the angle between source and specimen. Degas the filament at 10-12 amps for 10 seconds, and then increase the filament power to melt the platinum. Hold until the platinum evaporates completely. At a source to specimen distance of 10 cm, 2.5 cm of .005" diameter platinum wire will deposit a coating of about 30 angstrom units. Vary the thickness of the platinum coating by using more or less wire. The bell jar should be pumped to at least  $2 \times 10^{-5}$  Torr for sharp shadows. At higher pressures, molecular collisions may blur the shadows.

Carbon replication is done with the specimen facing the carbon source. To form a continuous coating, it is preferred that the specimen change angles as the carbon film forms. Rocking the specimen will expose irregular surfaces. In extreme cases, we have a rotating, tilting table that exposes all irregular surfaces to the carbon source.

Carbon is evaporated from a special fixture using a fixed 1/8" diameter carbon rod with a flat end and a moving pointed carbon. The moving arm is spring loaded to maintain point contact. Our carbon fixture will work with either a carbon sharpened to a long point or a carbon with a section reduced to .040" diameter. The point is sturdier and easier to use. The reduced section is more precise as to reproducibility.

To evaporate carbon rod with the 1 mm reduced section, degas the carbon at red heat with a power setting of 20 amps for a few seconds; evaporate at 28 to 34 amps. As power is increased to

evaporate carbon, it will tend to spark. Careful power adjustment will hold this to an occasional visible spark. With a source to specimen distance of about 10 cm, a

3 mm length of the 1 mm diameter carbon section will deposit about 140 angstroms of carbon on a specimen.

Carbon support films mounted on grids may cause water suspensions to bead. The support film may be cleaned so that it will set, by exposure to a high voltage glow discharge. Glow cleaning is done at about 100-150 microns bell jar pressure with about 2000 V applied for several minutes. Two aluminum glow rings provides a means of adjusting the glow area.

All connections in the filament circuit must be making good contact. For proper firing, the filament must be the highest resistance in the circuit.

For scanning electron microscopy, non-conducting specimens should be coated to prevent electron accumulation. For irregular surfaces, the conductive coating should get down into the pockets and crevices. We use a tilting rotating table with a vapor source about 15° from directly over the specimen. This rotating, tilting motion bathes the specimen at all angles in the conductive metal vapor. Gold or gold-palladium is generally used. About 10 cm of .008" diameter gold wire will deposit about 200 angstroms of gold at a source to specimen distance of about 12 cm. For very difficult surfaces, a combination of carbon plus gold is used.

Highly polished specimens, as used for an electron probe, may need a very uniform conductive coating of carbon. The tilting, rotating table will hold the thickness of the carbon deposition within +/-5%. The film deposition of all evaporated materials varies in thickness inversely as the square of the source to specimen distance. Film thickness at 4 inches distance is more than double what it would be at 6 inches distance. Consequently, specimen rotation tends to even out the variations in coating thickness that a stationary specimen might receive.

Tungsten filaments tend to embrittle with use. They oxidize readily if exposed to atmosphere while hot. It is good practice to allow 2 or 3 minutes cooling time before venting the system. Denton high vacuum evaporators have filament cooling time designed into its automatic cycle.

To clean apertures, use a .001" thick tantalum or molybdenum boat about 6 mm wide with a dimple. Mount boat in place of tungsten filament. Place aperture in boat dimple. Pump bell jar to 10<sup>-5</sup> Torr. Bring filament power up sufficient to turn the boat bright red. Hold at high vacuum until the aperture is the same color as the boat. Contamination will vaporize and be pumped away. Cut off filament power and allow to cool for 5 minutes or so before venting the system.

Tungsten filaments and carbon rods reach a white heat at the evaporating temperature. The brilliant white light should not be stared at without eye protection, such as a piece of dark glass or plastic.

## DSM-10 COLD SPUTTER MODULE

(If Equipped)

### ASSEMBLY:

The sputtering module mounts on a standoff on the baseplate of the bell jar evaporator. Two 1/2" diameter holes are required in the baseplate - one for the negative high-voltage feedthrough; one for the gas bleed. The high-voltage feedthrough and leads in the bell jar are shielded to prevent sputtering except from the cathode target.

Connect the cable from the target head to the H.V. feedthrough in the baseplate. Connect the cable from the grid to the chamber base plate.

The sputtering module removes from the bell jar by unscrewing the leads at the high-voltage feedthroughs and baseplate.

Although sputtering is possible using room air as the bleed gas, it is not recommended. The composition of room air varies with water and oil vapor as contaminants.

Argon, recommended as the ionized gas, is an efficient, repeatable sputter medium. Connect a cylinder of argon equipped with pressure reducing valves to the micrometer bleed valve (or optional mass flow controller).

### OPERATION:

When the sputtering module is in position and all the connections are made, it is ready to operate. Use the following procedure:

- On initial startup of the system or whenever the gas line has been disconnected from the gas inlet fitting, it is necessary to purge the gas lines between the gas cylinder or wall supply to the inlet of the system.
  - Refer to the High Purity Gas section of this manual for instructions on purging the gas supply line.
- Be sure the cathode is centered over the specimen holder with 3 3/4" between cathode and specimens. Lower bell jar and pump to  $10^{-5}$  torr to outgas specimens and remove moisture.
- Turn gas ON. Adjust micrometer valve to obtain  $5 \times 10^{-3} - 10 \times 10^{-2}$  Torr in bell jar as read on Chamber Pressure display.
  - Adjust the gas flow setpoint (SCCM) on the Gas Control screen if equipped with the optional mass flow controller.

- Input a Power setpoint (mAmps) on the touch screen. Turn on power supply. Do not exceed 100 milliamps current. The rate of deposition relates to the distance from the cathode to the substrate, gas pressure, target material, and voltage.

**NOTE: A STABLE GAS FLOW IS ESSENTIAL TO PRODUCE REPEATABLE COATINGS.**

Approximate rates for gold with the sputter head 3 3/4" above the substrate table are:

RATE A/sec.	CURRENT Ma.
6.2	50
4.4	40
3.1	30
1.7	20
.7	10



**WARNING: Maximum operating time for the sputter head is ten (10) minutes. A minimum of ten (10) minutes cool down time is required between each operating session. Failure to follow this recommendation will result in damage to the equipment.**

Manual (ON/OFF) operation is also available.

- With desired coating deposited, input Power Level of zero. Turn off power supply. Close toggle valve. Close main valve of vacuum system. Vent the bell jar and remove specimens.

A casual check of the thickness of the gold coating can be made by placing a glass cover slip at the same level as the specimen. With about 50A of gold, glass will transmit a light blue-gray coloring agent against a piece of white paper. A 100A gold coating is blue-green against white and has a faint gold reflection. At 200A the green is deeper and the gold reflection is obvious.



**NOTE: THE DSM-10 SPUTTER UNITS ARE SAFETY INTERLOCKED. THEY WILL NOT OPERATE IF THE BELL JAR IS AT ATMOSPHERE.**



## PROCESS RECOMMENDATIONS

### GAS LINES

To be able to sputter aluminum, chromium or other metals that form oxides, it is necessary to eliminate virtually all oxygen from the system. Therefore, the vacuum chamber as well as the gas inlet line must be fully leak checked. This can be done in the following manner:

- The sputtering gas (typically argon) must be supplied from a tank, not a house line. The tank should be connected to a two stage regulator, with the final pressure into the system being 5-10 psig.
- There must be a positive cutoff valve (customer supplied) after the regulator. This is normally a ball valve or a toggle valve.
- With the toggle valve closed, open the tank valve to pressurize the line to full tank pressure and then close it. Observe the pressure reading. Allow the system to sit for several hours and observe the pressure again. If it has not dropped, then the system is leak tight from the tank to the cutoff valve.
- Leaving the toggle valve closed, open the gas inlet valve and needle valve (or mass flow controller) completely. Pump your vacuum system to high-vacuum and observe how low the ultimate pressure goes. It SHOULD go to the same ultimate as with the gas inlet valves closed (although slower). It MUST go lower than  $1 \times 10^{-5}$  torr if you are to have any hope of sputtering aluminum.

Having ensured that your gas inlet line is leak tight, you can proceed to operation of the DSM-10.

### DEPOSITION

- Pump system down to less than  $1 \times 10^{-5}$  Torr. If this is the first time you have run system (or sputter head), allow at least a two-hour period to pump out contaminants from the sputter head.
- Open gas valve. Allow thirty seconds for a pulse of gas to work its way through system, and for pressure to stabilize.
- Adjust needle valve (or mass flow controller) to bring pressure to desired setting (generally 5 m. torr).
  - The lower the pressure, the less scattering losses there will be. The higher the pressure, the easier it is to develop plasma.
  - A recommended starting pressure is  $5.0 \times 10^{-3}$  Torr (or 5 mTorr). A turbo pumped system can estimate a low mTorr reading within the chamber by having

a 100 - 150 mTorr pressure on the foreline. If in doubt as to exact pressure, go to a higher pressure before trying to light off the sputter head.



**WARNING: Maximum operating time for the sputter head is ten (10) minutes. A minimum of ten (10) minutes cool down time is required between each operating session. Failure to follow this recommendation will result in damage to the equipment.**

- When you have reached the desired thickness on your substrate, the power should be turned off, the argon turned off and the chamber vented.



**NOTE: TARGET CONDITIONING**

**WHEN STARTING TO SPUTTER A NEW TARGET, OR IF THE VACUUM SYSTEM HAS NOT BEEN OPERATED FOR A LONG TIME, POWER TO THE SPUTTERHEAD MUST BE BROUGHT ON AT A LOW POWER LEVEL, AND THEN GRADUALLY RAISED TO HIGHER POWER LEVELS AS THE TARGET ARCING DECREASES OVER THE COURSE OF SEVERAL MINUTES. THIS WILL ALLOW CONTAMINANTS TO OUTGAS AND FOR THE TARGET TO PROPERLY PREPARE ITSELF FOR SPUTTERING GOOD QUALITY FILMS.**

## MAXIMUM POWER SETTINGS



**WARNING: Maximum operating time for the sputter head is ten (10) minutes. A minimum of ten (10) minutes cool down time is required between each operating session. Failure to follow this recommendation will result in damage to the equipment.**

- For DSM-10 systems with 100 Watt supply:

**Do not exceed 100 mAmps.**

## TARGET CHANGEOUT

The DSM-10 sputter head is internally mounted in the chamber on an adjustable base. The base is mounted to a standoff on the baseplate.

To change the target:

- Remove the sputter head assembly.
  - Loosen the two #6-32 screws holding the Cathode Holder Strap and remove it.
  - The head assembly can be picked up and removed.
- Remove the four #4-40 flat head screws holding the Target Retaining Ring.
- Remove and replace the target material.
  - Ensure good thermal and electrical contact.



**WARNING: Do not overtighten the screws.**

- Foil target size is 2.375" (60 mm) outside diameter.

## OMNI & TILTING OMNI ROTARY FIXTURES

### (If Equipped)

These rotary fixtures provide variable speed rotation for specimens under high-vacuum. The Tilting Omni causes the angle between the source and the specimen to vary continuously during rotation. The Tilting Omni can also rotate at a fixed angle for cone shadowing simply by substituting a sleeve and screw, provided with the fixture, in place of the Teflon pin. The Omni Rotary Fixture remains in a fixed horizontal position.

A 0-60 rpm gear motor mounts in a "C" bracket below the baseplate. Power is driven through a flexible coupling to a 1/4" rotary motion feedthrough, which is also the vacuum seal at the baseplate. The gear motor is shipped mounted to the bracket. The 1/4" rotary motion device installs through the baseplate from the vacuum side. The long threaded end under the large hex nut clamps the bracket firmly to the baseplate; the open side of the bracket faces out.

The 1/4" rod should move freely in the rotary motion feedthrough. Install the Teflon washer, the thrust clamp, and the upper part of the flexible coupling on the 1/4" rod. Lower the rod assembly so the bar on the motor shaft and the bar on the rod fit snugly into the nylon insert. Tighten the rod thrust clamp and the upper and lower part of the flexible connector.

Plug in the gear motor and test the rotation. The vacuum end of the rotary motion device should rotate smoothly and the nylon insert should turn evenly with no play where it meshes with the drive and driven bars.

The rotating table assembly mounts through a 25/32" hole in the port cover with two 6/32" x 3/8" long flat head screws, which thread into holes with centers 19/32" from mounting hole center. The cover port must be firmly positioned. The table is drilled to accept 12 specimen mounts with .128" pins or 8 mounts 13/32" in diameter. The standard table is 2 1/2" in diameter, but larger tables may be used. The Omni Rotary Fixture is also available with a microscope slide.

The pulley ratio for rotation is 1:1. Mount the driving pulley on the 1/4" rod in the same plane as the driven pulley. The small gear drives the tilting cam. The chain drive for the tilt cam is fitted after the table assembly and the rotary motion feedthrough are installed.

Wrap the chain around the driving and driven gear. Mark the length carefully. Use long-nosed pliers to open the chain. Make certain that the link ends are bent evenly. Properly assembled, the joined links will look exactly like the rest of the chain. The Omni Rotary Fixture uses a rubber belt in lieu of a chain. Wrap the belt around the pulley on the drive shaft and the pulley on the rotary motion shaft. All bearings in the vacuum space run dry. The rotary motion feedthrough uses a lubricated sleeve plus two spring-loaded o-rings for a vacuum seal. Use a high quality lubricating vacuum grease such as our Moly-lube. Do not use silicon-based grease.

To lubricate the rotary motion feedthrough, loosen the upper end of the flexible connector, loosen the thrust clamp, and remove the hex nut. All these parts are within the "C" bracket below the baseplate. The motion feedthrough will now lift from the baseplate. Loosen the hex nut on

the vacuum side of the motion feedthrough. Inspect lower end of 1/4" rod for burns. Rod should lift out easily bringing the o-ring, spring, and o-ring assembly with it. Wipe spacers, o-rings, and spring clean. Lubricate o-rings lightly. Lubricate 1/4" rod lightly. As you reassemble, pack grease into the spring area. This will act as a lubricant reservoir.

The Omni and Tilting Omni may be adapted to any evaporator with a 10" diameter or larger bell jar. At additional cost we can supply a mounting plate or a motion feedthrough flanged for baseplate holes larger than 33/64" diameter.

## **1 KW RADIANT HEAT WITH CONTROL**

### **(If Equipped)**

The radiant heat source is supplied by two 500 watt G.E. lamps operated in parallel up to 120V.

Backside heaters are thin, disc-like in shape and have a central hole for rotation fixturing. The heaters are clamped into a ring to maintain good thermal and electrical performance.

The Omega Miniature Microprocessor Controller is designed for accurate precise temperature control. It features high accuracy and reliability, as well as sophisticated PID or Auto tune PID with approach control (PDPI) for optimal control during start-up and steady-state operation.

The controller utilizes input from a "K" type thermocouple and reads out in °C temperature.

Refer to the temperature controller manual for detailed operating instructions.

## EVAPORATION PROCESSES

(If Equipped)

### METAL EVAPORATION:

For shadowing, increase the filament power sufficient to melt the evaporant. Platinum melts at 1769° C and evaporates readily at 1800° C. Watch the evaporant through dark glasses to avoid eye damage. Increase power to evaporate quickly without causing evaporant to fly off in chunks. Molten platinum dissolves tungsten. A slow platinum evaporation usually will stop due to the filament breaking. The diameter of filament wire is limited to a size that will heat above 1800° C with not more than 50 amperes current. We suggest MULTISTRAND .015" filament wire for maximum heat surface. Do not operate above 40 amps for more than one minute as this will exceed 1 KVA.

For low angle rotary shadowing, use a straight length of multi-strand .015" filament with a 1" length of .005" diameter platinum wrapped along the filament. Position the source out from the sample 10 cm and up 1 cm above the plane of the sample for the shadow angle of 9 degrees. Rotate sample 100 rpm while evaporating platinum vapor evenly for a period of 10 to 15 seconds. Shadowing is usually done at 1 or  $2 \times 10^{-5}$  Torr.

To shadow without rotation the V-shaped filament is often used with the platinum wire wrapped at the point of the "V." It melts to form a drop. Evaporate rapidly just below the temperature causing spitting. It is a race between evaporation and dissolution. Seldom can a "V" filament be used a second time, as it will show thinning from the first use. Shadowing is done at a 45° angle to provide a height to shadow length of one to one. Smoother samples require a shallower angle for the shadow to be discernable - as low as 6° has been used with careful setup.

Conductive coating uses the same techniques with differences. A conductive coating provides an electrical path to dissipate electrons from the beam. A gold coating of 100Å will increase secondary emission, provide a measure of heat dissipation, and, to a degree, provide radiation protection for the sample. To aid in making the coating continuous, the samples are rotated and tilted during deposition. This gets a conductive coating into the hills and valleys avoiding shadows.

If sufficient gold is evaporated to deposit 100Å on a smooth surface, the exposure determines how much of a material deposits on any given spot. If the bottom of a depression is exposed 10 percent of the time, it will receive only 10Å of gold. The sample may need extra coating to become conductive. Use only the coating needed to prevent charging.

If gold wire .008" diameter of a measured length is used and the wire is completely evaporated, the conductive coating is repeatable; however, for each sample, the thickness of the coating for an area is determined by its exposure to the metal vapor.

At the completion of the evaporation allow the filament to cool for several minutes before venting when evaporating metals that do not dissolve the tungsten filament. With care, a filament will last for 15 to 20 evaporations. Venting immediately will cause the tungsten to oxidize.

## **CARBON EVAPORATION:**

Carbon is used in a thin film to support samples as they stretch over the grid openings. This supporting film can be as thin as 30Å to 35Å. A drop of diffusion pump oil placed on a piece of white porcelain and carbon coated will show a discernable gray at about 30Å carbon. The porcelain stays white under the oil and is carbon coated elsewhere. Thicker carbon films are used for replicas. Replicas usually are 100Å to 150Å. Carbon is used for conductive coatings ranging in thickness from 50Å to several hundred angstroms.

A useful carbon thickness monitor can be made by gold coating cover slips. Place the gold cover slip with the samples to be carbon coated. The gold will change to a copper color when 100Å of carbon is deposited, to orange with 150Å carbon, to purple with 200Å carbon.

The Denton Carbon Evaporation Source uses a nominal 1/8" carbon rod that is .120" in diameter. A fixed rod holder and a spring loaded moving rod holder combine to maintain contact during evaporation. The current is adjusted to approximately 40 amps to achieve the sublimation temperature of the carbon.

Three millimeters of reduced section can be evaporated when a rod is reduced in cross section to .040" diameter. The carbon rods are supplied with reduced sections. A reduced section will continue to evaporate at a gen power level. Reduced sections are used when carbon deposits of 150Å to 200Å are desirable. Automatic carbon evaporation is easier to control using reduced sections instead of points. Incidentally, evaporation is not the proper description for carbon going from solid to vapor. Carbon sublimates when heated.

The Denton Carbon Evaporation Source also uses carbon yarn for quick loading and easy evaporation.

High pressure (1 to 10 millitorr) evaporation of gold, gold/palladium or carbon can improve conductivity of coatings on SEM specimens having very irregular or porous surfaces difficult to penetrate with straight line ( $2 \times 10^{-5}$  Torr) evaporation pressures. High-pressure evaporation will produce somewhat larger grain size, but only rarely will this increase be objectionable.

This high-pressure technique may also be adapted to protect heat sensitive specimens from filament or carbon source thermal radiation. Because thermal radiation is essentially straight line at all pressures, inserting a shield 25 mm to 30 mm diameter between the filament and specimen about 2.5 cm from the filament will block the radiant heat, but will permit the evaporant to diffuse around the shield and coat the specimen.

At 10 millitorr some coating thickness is lost, but the diffuse nature of the coating permits conductivity and penetration to remain excellent. If evaporating carbon by this method, expect some loss to oxygen when bleeding air. Bleeding an inert gas would eliminate this loss.

## SPUTTERING OPERATION



**NOTE: THE SPUTTER UNITS ARE SAFETY INTER- LOCKED. THEY WILL NOT OPERATE IF THE CHAMBER IS AT ATMOSPHERE.**



**WARNING: Maximum operating time for the sputter head is ten (10) minutes. A minimum of ten (10) minutes cool down time is required between each operating session. Failure to follow this recommendation will result in damage to the equipment.**

To be able to sputter aluminum, chromium or other metals that form oxides, it is necessary to eliminate virtually all oxygen from the system. Therefore, the vacuum chamber as well as the gas inlet line must be fully leak checked. This can be done in the following manner:

- The sputtering gas (typically argon) must be supplied from a tank, not a house line. The tank should be connected to a two stage regulator, with the final pressure into the system being 10-15 psig.
- There must be a positive cutoff valve (customer supplied) after the regulator. This is normally a ball valve or a toggle valve.
- With the toggle valve closed, open the tank valve to pressurize the line to full tank pressure and then close it. Observe the pressure reading. Allow the system to sit for several hours and observe the pressure again. If it has not dropped, then the system is leak tight from the tank to the cutoff valve.
- Leaving the toggle valve closed, open the gas inlet valve and needle valve completely. Pump your vacuum system to high vacuum and observe how low the ultimate pressure goes. It SHOULD go to the same ultimate as with the gas inlet valves closed (although slower). It MUST go lower than  $1 \times 10^{-5}$  Torr if you are to have any hope of sputtering aluminum.
- Having ensured that your gas inlet line is leak tight, you can proceed to operation of the sputter head.

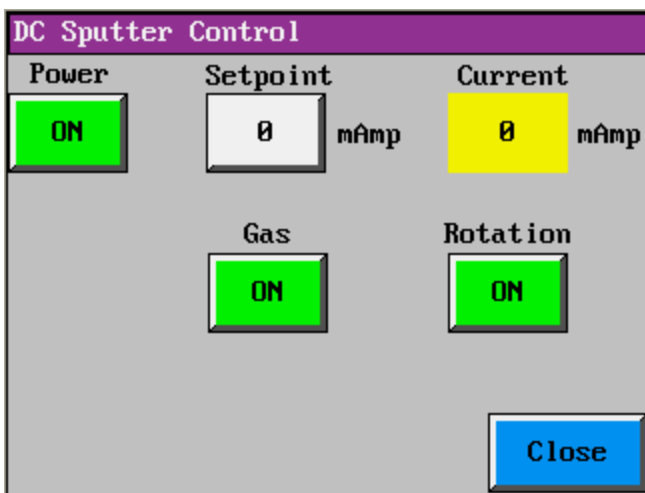


## SPUTTER PROCESSING



**NOTE: TARGET CONDITIONING!** When starting to sputter a new target, or if the vacuum system has not been operated for a long time, power to the sputter head must be brought on at a low power level, and then gradually raised to higher power levels as the target arcing decreases over the course of several minutes. This will allow contaminants to outgas and for the target to properly prepare itself for sputtering good quality films.

## MANUAL DC SPUTTERING



**NOTE:** All manual operations are carried out from the DC Sputter Control Screen.

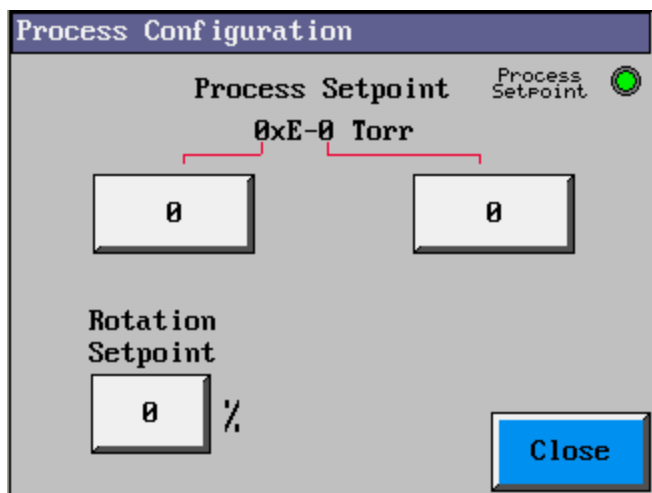


**WARNING:** Maximum operating time for the sputter head is ten (10) minutes. A minimum of ten (10) minutes cool down time is required between each operating session. Failure to follow this recommendation will result in damage to the equipment.

- Abort any Automatic process to switch to Manual mode.
- Pump system down to less than  $1 \times 10^{-5}$  Torr. If this is the first time you have run system (or sputter head), allow at least a two-hour period to pump out contaminants from the sputter head.

- Open gas valve. Allow thirty seconds for a pulse of gas to work its way through system, and for pressure to stabilize.
- Adjust gas flow to bring pressure to desired setting (generally 5 millitorr). The sputter head is capable of sputtering between  $6 \times 10^{-4}$  Torr and  $1 \times 10^{-2}$  Torr (10 millitorr) pressure in the chamber. (The lower the pressure, the less scattering losses there will be. The higher the pressure, the easier it is to develop plasma.) A recommended starting pressure is  $10 \times 10^{-3}$  Torr (or ten millitorr).
- Turn on sputter power and bring up to desired power setting. 100 milliamps is sufficient to sputter Al, Cr, Ta, W, Ni and any other DC Magnetron sputterable material.
- After a suitable pre-sputter, open the shutter to deposit the coatings.
- Power Supply will be in current regulation.
- Final deposition rate will be dependent on material being sputtered, power setting, pressure, distance and time.
- When you have reached the desired thickness on your substrate, the power should be turned off, the shutter should be closed, the argon turned off and the chamber vented.

## DEPOSITION CONTROLLER



(OPTIONAL)

**NOTE: All deposition parameters are programmed into the deposition controller. Read the operating manual for the deposition controller before proceeding.**

- Pump system down to less than  $1 \times 10^{-5}$  Torr. If this is the first time you have run system allow at least a two-hour period to pump out contaminants.
- Program a Process Pressure and Rotation Set Points.
- Program the deposition controller for the desired material and thickness.
- Select the Remote Control Mode on the Low Voltage Control screen.
- Press the Auto Process button on the Overview screen.
- System will automatically pump down to reach the programmed Process Pressure setpoint before starting the rotation and deposition controller.
- The deposition controller will begin to control the Low Voltage power supply as programmed for the layer.
- The shutter will open when the deposition controller enters the Deposit state and close when the final thickness is reached.
- Final deposition rate will be dependent on material being evaporated, power setting, pressure, distance and time.

- When you have reached the desired thickness on your substrate, the power and rotation will be turned off.
- Vent the chamber using the Auto Vent process.

## DEPOSITION MONITOR

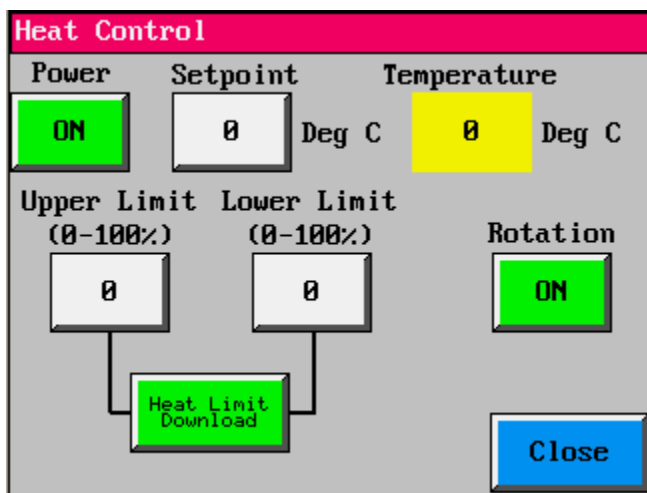
(OPTIONAL)

**NOTE: All deposition parameters are programmed into the deposition monitor. Read the operating manual for the deposition monitor before proceeding.**

- Abort any Automatic process to switch to Manual mode.
- Program the deposition monitor for the desired material and thickness.
- Operate the Low Voltage source power manually as previously described.
- When you have reached the desired thickness on your substrate, the power should be turned off, rotation stopped and the chamber vented.

## HEAT CONTROL

(If Equipped)



Buttons change color to indicate current state: **GREEN** = ON, **RED** = OFF

The Heat Power on/off can be controlled on this screen.



**Chamber MUST be under vacuum to activate Heat Power.**

Rotation on/off can be controlled on this screen. **GREEN** = ON, **RED** = OFF.



**Rotation MUST be ON to activate Heat Power.**

The Heat Setpoint (0 - 100°C) can be input on this screen. Press the Set Point box and a digital keypad will pop-up for data entry.

The Upper and Lower Limits (0 – 100%) can be input on this screen. Press the Set Point box and a digital keypad will pop-up for data entry.



**Heat Limit Down Load button MUST be pressed to enter the new limit set points.**

- Upper and Lower Limits control the minimum and maximum power output available from the Heat power supply.

- Heat Limit Down Load button **MUST** be pressed to enter the new limit set points.

The substrate Rotation can be controlled on/off from this screen. **GREEN** = ON, **RED** = OFF.

Actual Heat Temperature is displayed on this screen and the Overview screen.

The Close push button at the bottom is used to switch back to the “Overview” screen.

7	8	9	Demo Numeric Entry <div style="border: 1px solid black; height: 20px; width: 100%;"></div> <div style="border: 1px solid black; padding: 2px;">MINIMUM 0</div> <div style="border: 1px solid black; padding: 2px;">MAXIMUM 9999</div> <div style="border: 1px solid black; padding: 2px;">CURRENT 0</div>	
4	5	6		
1	2	3		
0	Clear			
			<div style="border: 1px solid black; padding: 2px; display: inline-block;">Cancel</div> <div style="border: 1px solid black; padding: 2px; display: inline-block; margin-left: 10px;">Enter</div>	

**Numeric Keypad**

## HEAT OPERATION



**Chamber MUST be under vacuum to activate Heat Power.**



**Rotation MUST be ON to activate Heat Power.**

To operate the heat, first pump the system into high vacuum and activate the Rotation.

- Enter a Heat Setpoint (0 - 100°C).
- Enter an Upper and Lower Limit Set Point (0 – 100%).
  - Down load the new limits if they have been changed.
    - Setting a Lower Limit is recommended when a high temperature setpoint is desired.
    - Setting the Lower Limit greater than 0% will maintain heater power ON constantly at the Lower Limit value.
    - Setting an Upper Limit is recommended when a low temperature setpoint is desired.

- Setting the Upper Limit less than 100% will prevent the heat power from reaching its maximum level.
- Turn Heat Power ON.
  - Built-in software PID controller will control heat power within the Upper and Lower Limits to reach and maintain the Heat Setpoint.
  - The actual Heat Temperature is displayed on the Heat Control and the Overview screens.

## SYSTEM MAINTENANCE

A clean vacuum evaporator will more likely be a good operating evaporator. It is essential to keep the unit clean. A total system cleanup is recommended every six months. Scale build-up on the baseplate should be scraped off weekly and the surface cleaned with acetone or alcohol using a lint free cloth or paper and solvent. Be sure all debris is vacuumed away.

Should a need for spare parts occur, see the "Spare Parts" section of this manual. **BE SURE TO REFER TO THE JOB NUMBER WHEN ORDERING SPARE PARTS.**

## BELL JAR

- Clean coating build-up from the bell jar with a metal polish. "Wenol" or "Pol" is recommended. These polishes clean off the coating deposit and polish the glass. Use Acetone and the Isopropanol Alcohol to clean the surfaces after the polish is wiped off.
- To ensure a proper vacuum seal, inspect the bell jar gasket for nicks, cracks, and other foreign material. Apply a thin coat of vacuum grease to the gasket. Immediately wipe off the grease to prevent excessive grease build-up. Inspect the sealing surface for nicks or scratches. These must be smoothed out with emery and polished with fine emery or Scotchbrite. Any deposit build-up must be similarly removed and the entire surface wiped clean with alcohol or acetone. Vacuum the baseplate to remove all debris and powder deposits.

## VACUUM GAUGE TUBES

- Degas gauge tubes for 3 minutes periodically after system is at or below  $1.0E-4$ .
- Replace gauge tubes when filaments fail. Do Not remove gauge tube when under vacuum. Vent chamber before changing gauge tube.
- Loosen vacuum flange clamp around gauge tube and remove failed tube. Remove electrical connector.
- Install new gauge tube, clean O-ring and sealing surfaces. Re-install flange clamp. Reconnect electrical connector.
- Degas tube according to the guidelines in the subsystem operating manual.



**CHECK AND RECORD THE OPERATING PRESSURES MONTHLY.**



## **TURBO PUMP**

- The turbo pump is equipped with ceramic bearings and requires greasing every 16,000 hours. See the enclosed vendor manual for details.

## **ROTARY FEEDTHROUGHS (IF EQUIPPED)**

- Fixture Drive, and Shutter Drive, should be disassembled and inspected every 6 - 12 months.
- Replace all damaged, brittle, or worn seals. Clean and lubricate all seals before reassembly.

## **HEATER ASSEMBLY (IF EQUIPPED)**

- Disassemble heater assembly every 6 - 12 months. Bead blast all metal components.
- Heater tubes can be cleaned if over coated. Use Pol brand metal polish (or equal) and rinse with alcohol before reassembly.

## **LOW VOLTAGE SOURCES (IF EQUIPPED)**

- Clean low voltage sources periodically. Do not allow excess coating material to build up on the copper blocks and feedthroughs.
- Vacuum up loose particulate and scrub copper blocks with Scotchbrite and isopropyl alcohol.
- Remove blocks periodically and bead blast to remove all coating material.

## **DC SPUTTER SOURCES (IF EQUIPPED)**

- DSM-10 sputter heads:
- Clean screen grids, dark space shields and target surfaces of loose debris using bead blaster or Scotchbrite.
- Check targets for usage. If the center has fallen, change to a new target.

## OVERALL SYSTEM MAINTENANCE



**Refer to instrument manuals.**

## MAINTENANCE SCHEDULE

### DAILY TO ONCE A WEEK

- Clean inside of Bell Jar using lint free wipes and IPA. If needed use fine 3M Scotch Bright pads with IPA to remove excess build up.
- Once a week compare overnight pump value, and pump down value to that of system when originally started. This is a good way to tell if there may be a vacuum leaks or that the system needs to be cleaned.

### MONTHLY

- All of the above.
- Inspect Bell Jar Gasket for wear and dirt as well as the bottom edge of the jar for chips or cracks. Keeps the gasket lubricated with Vacuum Grease, only making the gasket shinny with no excess grease on the surface.
- Check oil level in mechanical pump and add oil if necessary to bring level to approx.  $\frac{3}{4}$  of the sight glass using pump manufacturer recommended oil.
- While system is at high vacuum status operate any and all rotary motions for shutters and rotations (if equipped) and observe the vacuum reading for the chamber. If you notice the vacuum level fluctuating (rising and dropping) this is an indication that the rotary motion is leaking and needs servicing.

**Denton Vacuum offers onsite or at factory PM service for the Bench Top Turbo.**

**Please call us at 856-439-9100 for information.**

### EVERY 6 MONTHS

- All of the above.
- Thoroughly clean all interior surfaces of vacuum chamber, cleaning base plate and all parts that are exposed to vacuum.

- Clean all bearings that are within vacuum chamber using an ultra-sonic cleaner or alcohol and lint free wipes. After cleaning, re-apply vacuum compatible lubricant (i.e.; Dow Corning Vacuum Grease) to the bearing before re-installing.

## **ONCE A YEAR**

- All of the above.
- Disassemble all rotary motions (if equipped). Clean shaft, bearings, O-rings and inside of feedthrough. Inspect all surfaces for wear and damage. Lubricate bearings and O-rings with vacuum grease (Dow Corning). Re-assemble feedthrough parts on shafts and install in feedthrough. After high vacuum status is achieved activate rotaries and verify vacuum stability.
- Remove power feedthroughs for resistive sources and inspect O-rings and insulators. Clean buildup of evaporated materials from feedthrough using fine 3M Scotch Bright pad being careful not to remove the nickel plating from the feedthrough. Replace O-rings and/or insulators if necessary.
- Inspect and clean all remaining O-rings replacing if necessary.
- Change oil in vacuum pump using pump manufacturer recommended oil.
- Lubricate Turbo Pump to manufacturer recommendations.

**Denton Vacuum offers onsite or at factory PM service for the Bench Top Turbo.**

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## TROUBLESHOOTING

### SAFETY WARNINGS



**Warning!** Due to the nature of the subsystems, there are many types of voltages on a vacuum system.



**WARNING!** Lethal high voltages are present!



**Caution!** Read the operating manuals supplied with the system before attempting any type of troubleshooting on the vacuum system. Refer to the proper sections of the operating manuals to verify that the system is being operated in the proper manner.

Interlocks are built in to the control system. Rather than assuming a system failure, verify the problem is not an interlock intended to prevent unsafe operation.



**Note on jewelry!** When working around a vacuum system, there is one good practice:

**Do not wear jewelry!**

**An arc may be drawn from a high voltage source!**

## REQUIRED TOOLS

TOOL	USE
Multimeter  (Analog or Digital)	To read AC or DC Voltages  To read low AC or DC Current  To read resistance (Ohms)
Hand-held Current Meter  (Amp Probe)	Clamps around an AC line read current.
Screwdrivers  (Flat & Phillips)	For disassembly and assembly.
Wrenches  (Box Type)	For disassembly and assembly: 3/8" to 1"
Allen Wrenches	For disassembly and assembly: 1/16" to 3/8"

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## ELECTRICAL PROBLEMS

### VACUUM SYSTEM CONTROL RACK

Problem: No activation of subsystems when the main switch is toggled.

Cause: No +24V DC power from DC power supply.

Solution:

Check to see if there is proper supply voltage being supplied to the system as per the system specifications

Turn ON main breaker.

Press green “START” button. If system will not start proceed to next step. If system does start proceed to the relays section of this guide

Check the fuse for the AC Input of the 24 VDC Power Supply. Replace if blown.

Check the fuse for the DC Output of the DC power supply. Replace if blown.

Check the DC Output Voltage of the 24vdc power supply

Check the input of the DC power supply to ensure that the input voltage as per the schematics is present.

If there is AC input power, but no 24V DC output, replace the power supply.

If there is no AC power at this point, call Denton Vacuum Service at (856-439-9100) or by e-mail at ( [Support@dentonvacuum.com](mailto:Support@dentonvacuum.com) ).

**Problem:**        Subsystems activated, but no control of pumps, valves, and subsystems.

**Cause:**            **24V Relays.**

**Solution:**

Be sure all relevant interlocks are satisfied before proceeding. ( See Interlocks section of this manual)

Pumps, valves, and subsystems are controlled through the PLC by relays. Each relay is numbered. Identify the correct relay according to the schematic and check correct position (OPEN/CLOSED) of the relay. Visually verify the proper operation of the relay against the schematic.

If the relay fails to operate, remove it and use an Ohmmeter to read the resistance of the coil. Verify that the coil is not shorted.

Verify that the contacts are not fused and preventing movement.

If there is a problem with a relay, replace it.

Use a voltmeter to determine if a signal is going to the relay.

If the relay is not receiving a signal to open or close, contact Denton Vacuum Service at (856-439-9100) or by e-mail at( [Support@dentonvacuum.com](mailto:Support@dentonvacuum.com) ).

## VALVES & SHUTTERS

The source shutter and all vacuum valves (IF EQUIPPED) on the vacuum system are pneumatically controlled. The valve opening procedure is as follows:

- The Pneumatics of the system are operated using air pressure set to 80 to 100 psi. In troubleshooting valve and shutter issues 1<sup>st</sup> verify that the system is connected to and receiving 80 to 100 psi of dry compressed air.
- Verify that the air is dry and that there is NO water condensate present in the pneumatics system.
- The valve functions of the system are protected by both hard and soft interlocks. Verify that the specific interlock(s) for the valve(s) you are having problems with are being satisfied. (See interlocks section of this manual)
- If the valves on the system have position indicators, the graphics on the computer screen will indicate green if the valve is open and gray (Red on Touch Screen Systems) if the valve is closed. These indications are an accurate way to know if the valve you are using is actually opened or closed. In systems with no position indicators, the graphics change with the software command and are not indicators that the valves are truly opened or closed.
- The system has a main compressed air manifold generally located within the frame enclosure. The manifold consists of several individual solenoids. Each solenoid controls an individual valve or shutter. When activated from the computer or Touch Screen, an LED will illuminate on the solenoid for that valve. Verify that the solenoid(s) are being activated by actuating the valve from the computer or touch screen. If the screen indicates that the valve is open the LED on the specific solenoid will be illuminated.
- Go to any specific valve or shutter and remove the air line by depressing on the RED collar at the top of the Press Lock fitting while pulling out the airline. Toggle the valve or shutter on the computer or Touch Screen and check to see if the air is flowing out of the disconnected airline.

If all of the above have been verified and tested and you are still experiencing problems, contact Denton Vacuum Service at 856-439-9100 or by e-mail at ([Support@dentonvacuum.com](mailto:Support@dentonvacuum.com)).

## ROTATION

Problem: When rotation is powered ON it does not rotate, or it stops rotating in the middle of a run.

**Cause:**

- Fuse blown.
- SCR or Motor Controller
- Refer to your system schematics for your specific system to determine which type of rotation circuit you have.
- Check to see if there is a physical obstruction to the rotation fixturing within the chamber. Clear the obstruction and verify smooth operation of the rotation.

**Possible Solutions:**

- Check the fuses for the Rotation Motor Controller if equipped. Replace if blown.
- Check the fuses for the input of the SCR Controller if equipped. Replace if blown.
- If your system has the SCR Controller, check the fuse(s) for the input and output of the 24vac control transformer. Replace if blown.
- If the fuses are good for the 24vac transformer, verify the input and output voltages. If there is no input voltage, verify the input connections. If there is no output, verify output connections and replace transformer if needed.

On systems equipped with the SCR Controller, going by the schematics, locate the analog output module on the Direct Logic PLC and locate the rotation set point output wire. Using a Multimeter set to DC Volts, measure between that wire and Ground. The set point operates on a 0 to 10 vdc scale. For example, if the set point is set to 50% you should be seeing 5 vdc at this point. If the voltage is low this would be an indication the Analog Module needs to be replaced. Contact Denton Vacuum Service at 856-439-9100 or by e-mail at ([Support@dentonvacuum.com](mailto:Support@dentonvacuum.com)).

- On Systems with the motor controller, use the schematics to locate the Set Point wire on the controller. Verify the scaling DC voltage for the set point as per the controller on your system. Contact Denton Vacuum Service at 856-439-9100 or by e-mail at ([Support@dentonvacuum.com](mailto:Support@dentonvacuum.com)).



- Verify at the power connection for the motor that the proper voltage is being established. If not check connections between the SCR or the Motor Controller and the motor.
- If all of the above have been checked and verified and you are still experiencing and issue, contact Denton Vacuum Service at 856-439-9100 or by e-mail at ([Support@dentonvacuum.com](mailto:Support@dentonvacuum.com)).

## **MECHANICAL PUMP**

Denton Vacuum system are designed and built within the customers specifications. Some systems are equipped with Oil Vane Rotary Mechanical Pumps and others are equipped with Dry Pumps. Confirm which pump your system is equipped with before proceeding with the following troubleshooting steps.

**Problem:** Rough out times are increasing, crossover vacuum not being achieved, foreline vacuum not concurrent to ultimate vacuum of mechanical pump.

### **Probable Causes:**

- (A) Leak on Vacuum System foreline
- (B) Oil in pump low, old or contaminated
- (C) Dry Pump exposed to excessive water vapor
- (D) Mechanical Pump seals are bad

### **Possible Solutions:**

#### **Cause (A)**

- Verify that all connections on vacuum foreline are tight and secure. Check connection seals if several years have passed since last service, replace any seals that are worn or damaged.
- On systems with an Oil Vane pump the foreline will be equipped with a normally open foreline vent valve. Verify that the valve is receiving 24vdc when the mechanical pump is running. If no 24vdc is present at the valve solenoid refer to the system schematics to troubleshoot missing voltage. If 24vdc is present, but the valve is leaking while pump is running you will need to replace the foreline vent valve. Contact

Denton Service at 856-439-9100 for assistance or by e-mail at ([Support@dentonvacuum.com](mailto:Support@dentonvacuum.com)).

### **Cause (B)**

- With oil vane pumps it is necessary to fill pump reservoir with a specific type of vacuum pump oil. It is very IMPORTANT to refer to the pump manual and/or the original system specifications to ascertain what type of oil your systems pump requires. Failure to do this will result in complete pump damage and failure if the wrong oil is used.
- On the end of the pump housing is a sight glass that shows the pumps oil level. As per the pump manufacture manual, the oil level should be between the 2 level indicators on the sight port or approximately 75% of the sight port. If the oil level is too low either add additional oil or do a complete oil change.
- Generally speaking, the oil in an oil vane pump should be changed at least once per year. If the oil has not been changed for an extended period of time or if the oil looks discolored or non-transparent, refer to the pump manual and system specifications for oil change procedure and type of oil to use. Contact Denton Service at 856-439-9100 or by e-mail at ([Support@dentonvacuum.com](mailto:Support@dentonvacuum.com)).
- If the oil in the sight port looks milky in appearance, this is an indication that excessive water vapor was introduced into the pump. You will 1<sup>st</sup> need to verify the source of the excessive water vapor. You may have a minor water leak on an internal water cooled device within the chamber. Correct this issue if present. Once corrected the pump will need to be ballasted to help dry the water out of the oil. Follow the vendor manual for the pump for the specific ballasting procedure for your pump. In cases of extreme water contamination it may be necessary to drain the oil from the pump and follow the flushing procedure for the specific pump before refilling with new oil.

### **Cause (C)**

- When Dry Pumps become exposed to excessive water or over an extended period of time the pump begins to become saturated with water vapor, it will be necessary to ballast the pump to dry the water

vapor from the internal portions of the pump. Follow pump manufactures instructions for proper ballasting procedures.

- If the ballasting fails to produce normal pumping speed or vacuum level, it may be necessary to replace the tip seals within pump. Follow pump manuals instructions for replacement or contact Denton Service at 856-439-9100 or by e-mail at ([Support@dentonvacuum.com](mailto:Support@dentonvacuum.com)).

### **Cause (D)**

- If your system is equipped with an oil vane pump and you notice that there is oil leaking from around the base of the pump, this is an indication that the shaft seals of the pump have begun to fail and the pump will need to rebuilt or replaced.
- On dry pumps it will be necessary to install an external vacuum gauge and readout to the intake port of the pump. Refer to the operating manual of the pump for the ultimate vacuum capability of the pump. With the gauge only on the intake, the pump should achieve this ultimate vacuum. If not this would indicate that the pump module seals are failing and the pump requires service and rebuild.

## **SUMMARY**

Steps for troubleshooting should follow a logical order.

Vacuum systems are constructed from many different vendor parts and subassemblies. Each subsystem is supplied with a manual of operation. Familiarize yourself with all the operating manuals supplied with the vacuum system. Refer to these manuals for troubleshooting procedures on the individual equipment in question.

This manual reviews the most common problems experienced with similar vacuum systems. Possible causes are described and solutions are presented in a step-by-step procedure. Most problems can be identified and corrected with a similar approach.

If after a reasonable time the problem cannot be identified, call Denton Vacuum Service at (856-439-9100) or by e-mail ( [support@dentonvacuum.com](mailto:support@dentonvacuum.com) ) to assist with troubleshooting and repair. We can also provide system training to facilitate system maintenance and reduce downtime.

## SPARE PARTS LIST

SPARE PARTS LIST				
BENCHTOP TURBO				
	PART NO.	DESCRIPTION	LOCATION	QTY
1	GSK001-0016	GASKET – VITON A – 12”	12” DIAMETER BELL JAR	
2	ORG004-0114	O-RING – VITON, .75” ID	KF16 CENTERING RING	
3	ORG004-0117	O-RING – VITON, 1.13” ID	KF25 CENTERING RING	
4	ORG004-0215	O-RING – VITON, 2.88” ID	ISO63 CENTERING RING	
5	FTG010-0012	GASKET – VCR 4	VACUUM PIPING	
6	VAL004-0081	VALVE – 1/8” NPT	VENT VALVE	
7	PMP007-0049	OIL MIST FILTER, KF25	PUMP EXHAUST	
8	PMP007-0050	FILTER ELEMENT	OIL MIST FILTER, KF25	
9	OIL001-0028	OIL	MECHANICAL PUMP	
10	ORG001-0045	O-RING – BUNA, .75” ID	.50” BASEPLATE FEEDTHRU	
11	FED001-0007	FEEDTHRU BLANK ASSY - .50”	BASEPLATE	
12	ORG001-0048	O-RING – BUNA, .93” ID	1.00” BASEPLATE FEEDTHRU	
13	FED001-0010	FEEDTHRU BLANK ASSY - 1.0”	BASEPLATE	
14	SRC002-0001	.38” LV FEEDTHRU ASSEMBLY	SOURCE ASSEMBLY	
15	ORG004-0049	O-RING – VITON, .75” ID	.38” LV FEEDTHRU	1
16	BUS002-0010	INSULATING BUSHING	.38” LV FEEDTHRU	2

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SPARE PARTS LIST				
BENCHTOP TURBO				
	PART NO.	DESCRIPTION	LOCATION	QTY
17	CAR001-0014	LAVA BUSHING	CARBON ROD FIXTURE	2
18	SPR001-0024	COMPRESSION SPRING	CARBON ROD FIXTURE	
19	CAR001-0026	BOX OF 10 CARBON RODS	CARBON ROD FIXTURE	
20	CAR001-0024	BOX OF 100 CARBON RODS	CARBON ROD FIXTURE	
21	ORG004-0057	O-RING – VITON, 1.25” ID	.38” ROTARY FEEDTHRU	1
22	ORG004-0005	O-RING – VITON, .43” ID	.38” ROTARY FEEDTHRU	1
23	ORG004-0004	O-RING – VITON, .38” ID	.38” ROTARY FEEDTHRU	3
24	BRG003-0016	BALL BEARING, .38” ID	.38” ROTARY FEEDTHRU	2
25	ORG004-0049	O-RING – VITON, .75” ID	.25” ROTARY FEEDTHRU	1
26	ORG004-0003	O-RING – VITON, .25” ID	.25” ROTARY FEEDTHRU	2
27	BRG003-0021	BALL BEARING, .25” ID	.25” ROTARY FEEDTHRU	2
28	BRG008-0001	FLANGED BEARING	INVERTED OMNI ROTATION	1
29	BRG017-0004	LADDER CHAIN	OMNI ROTATION	16”
30	ORG004-0079	O-RING – VITON, 3.88” ID	TILTING OMNI ROTATION	
31	BRG003-0007	BALL BEARING, .25” ID	OMNI ROTATION	
32	SPR002-0002	EXTENSION SPRING	TILTING OMNI ROTATION	
33	PLT007-0003	2.00” SPECIMEN TABLE	TILTING OMNI ROTATION	
34	PLT007-0022	2.00” TABLE	OMNI ROTATION	

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SPARE PARTS LIST				
BENCHTOP TURBO				
	PART NO.	DESCRIPTION	LOCATION	QTY
35	PLT007-0023	3.00" TABLE	OMNI ROTATION	
36	PLT007-0024	4.00" TABLE	OMNI ROTATION	
37	PLT007-0025	6.00" TABLE	INVERTED OMNI ROTATION	
35	FED001-0126	FEEDTHRU – 30A, .50" HOLE	GLOW & DSM ASSEMBLY	
36	SRC002-0121	FEEDTHRU – 30A, 3 WIRE	HEATER ASSEMBLY	
37	LMP001-0071	LAMP – QUARTZ, 500W	HEATER ASSEMBLY	
38	HDR001-0236	QUARTZ LAMP HOLDER	HEATER ASSEMBLY	
50	VAC001-0085	Inficon Replacement Sensor		
51	ACC502-0023	PYREX BELL JAR CHAMBER	12" DIAM. X 12" HIGH	

## FUSE LIST

All fuses are Slo-Blow type, midget class.

Fuse	Rating Amps	Circuit	Denton Vacuum Part Number
FU1	20	Main Power	FUS001-0025
FU2	20	Main Power	FUS001-0025
FU3	2	24VDC Power Supply-Primary	FUS001-0092
FU4	2	24VDC Power Supply-Primary	FUS001-0092
FU5	10	24VDC Power Supply-Secondary	FUS001-0022
FU6	0.25	Signal Transformer-Primary (T1)	FUS001-0089
FU7	0.25	Signal Transformer-Primary (T1)	FUS001-0089
FU8	1	Signal Transformer-Secondary (T1)	FUS001-0091
FU9	10	Low Voltage Power	FUS001-0022
FU10	10	Low Voltage Power	FUS001-0022
FU11	10	Mechanical Pump	FUS001-0022
FU12	10	Mechanical Pump	FUS001-0022
FU13	5	Turbo Pump	FUS001-0023
FU14	2	Rotation Power	FUS001-0092
FU15	1	PLC Power	FUS001-0091
FU16	1	PLC Power	FUS001-0091
FU17	2	PLC Touch Screen	FUS001-0092
FU22	5	Auto Lift	FUS001-0023
FU23	2	DC Sputter	FUS001-0092

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<b>Fuse</b>	<b>Rating Amps</b>	<b>Circuit</b>	<b>Denton Vacuum Part Number</b>
FU24	2	DC Sputter	FUS001-0092
FU27	0.25	Exhaust Fan 1	FUS001-0089
FU28	0.25	Exhaust Fan 1	FUS001-0089
FU29	0.25	Exhaust Fan 2	FUS001-0089
FU30	0.25	Exhaust Fan 2	FUS001-0089
FU31	0.25	Turbo Fan	FUS001-0089

## LIST OF MECHANICAL DRAWINGS

<b>DESCRIPTION</b>	<b>DRAWING NUMBER</b>
Feedthru Assy.- 38"	0024-001-002
Feedthru Assy. Rotary - .38"	0041-011-008
Cooling Assy.	0075-024-040
Bell Jar & Lift Assy.	0079-010-024
Feedthru Assy. Blank	0092-001-001
1" Blank Plug Assy.	0092-003-041
Water Piping Assy.	0131-410-012
General Arrangement & Floor Plan	0131-446-002
Vacuum Piping Assy.	0131-446-013
Base Plate Arrangement	0131-446-100
Coupling Modification	0131-446-104

## EQUIPMENT LIST – SERIAL NUMBERS & VENDOR MANUALS

<b>EQUIPMENT</b>	<b>VENDOR</b>	<b>MODEL NUMBER</b>	<b>SERIAL NUMBER</b>
Full Range Gauge	INFICON	BPG400-353-500	149819
Mechanical Pump	NAVAC	NRD4	AT119-461



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EQUIPMENT	VENDOR	MODEL NUMBER	SERIAL NUMBER
Turbo Pump	EDWARDS	NEXT87D-B8G210B01	180182725
Deposition Controller	INFICON	SQM160-S-2-R	70119714
Touch Screen	AVG	EZ3-T6C-E	E1748401246

## ELECTRICAL SCHEMATICS

DESCRIPTION	DRAWING NO.
Cover Page	BTT0101-73543.DWG
Power Distribution	BTT0201-73543.DWG
Power Distribution	BTT0202-73543.DWG
Power Distribution	BTT0203-73543.DWG
Heat Control	BTT0204-73543.DWG
Heat Control	BTT0301-73543.DWG
Low Voltage Control	BTT0401-73543.DWG
Low Voltage Control	BTT0402-73543.DWG
Vacuum Control Gauging	BTT0501-73543.DWG
Vacuum Control Gauging	BTT0502-73543.DWG
Spare	BTT0601-73543.DWG
Substrate Rotation Control	BTT0701-73543.DWG
Pumping Control	BTT0801-73543.DWG
Pumping Control	BTT0802-73543.DWG
Pumping Control	BTT0803-73543.DWG
Gas Control	BTT0901-73543.DWG
Gas Control	BTT0902-73543.DWG
Source Control	BTT1001-73543.DWG
Source Control	BTT1002-73543.DWG
Source Control	BTT1003-73543.DWG
Source Control	BTT1004-73543.DWG
Deposition Control	BTT1101-73543.DWG
Deposition Control	BTT1102-73543.DWG
Spare	BTT1201-73543.DWG
Glow Discharge Control	BTT1301-73543.DWG
Glow Discharge Control	BTT1302-73543.DWG

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DESCRIPTION	DRAWING NO.
Spare	BTT1401-73543.DWG
PLC Control	BTT1501-73543.DWG
PLC Control	BTT1502-73543.DWG
PLC Control	BTT1503-73543.DWG