DENTON VACUUM, LLC

Infinity™ 26 Coating System

E2O Communications, Inc. Job # 23856

Operating Manual

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EQUIPMENT	**MANUAL**
Computer Control	
Computer High Speed COMPAQ Desk Pro ENLP866 M p/n ENL P866/6/128CV US C P/N CPU001-0033 S/N 6113 DYSZL984	Manual Provided
Monitor 15" FPD Black IBM M p/n 9483-AG1 C p/n CPU001-0031 S/N 66-47831	Manual Provided
PC Anywhere Version 9.2 M p/n SKU017109 C p/n CPU004-0025	Manual Provided
Cimplicity 150 Point run time M p/n IC646TRT150 C p/n CPU004-0016	Manual Provided
Omniserver R/T Lisence M p/n IC646ND300 C p/n CPU004-0015	
MS –office 2000 Pro-fes M p/n SKU47730-00 C p/n CPU004-0030	
Pumping Control	
Mechanical Pump ALCATEL MODEL 2033 SD M p/n 2033 SD C p/n PMP006-0033 S/N 373674	Manual Provided
Temperature Display (Cryopump) Scientific Instruments M p/n 1901 C p/n HTR501-0001 S/N 0749	Manual Provided

EQUIPMENT	**MANUAL**
Cryopump CTI CryoTorr 10 M p/n 8118236 C p/n PMP005-0281 S/N 13H0113251	Manual Provided (*1 manual for pump and compressor)
Water-Cooled CTI -9600 Compressor M p/n 8135900G001 C p/n PMP005-0282 S/N 94D0115164	*
Heater Blanket Kit for CT-10 M p/n 8080003K012 C p/n HTR002-0075	
<u>Vacuum Control</u>	
Chamber Rough Valve M p/n 152-1040K C p/n VAL001-0012 S/N 0110716997	*
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CRYO Regen Valve ACCUCON M p/n C p/n S/N 2696	*
Vent Valve M p/n 152-1016K C p/n VAL001-0010 S/N 0107414423	*
Vacuum Gauge Controller Pfeiffer PiraniTRR265 M p/n PT-R276-750 C p/n VAC001-0059 S/N	Manual Provided
Vacuum Gauge Controller Pfeiffer Full range PBR260 M p/n PT-R27-000 C p/n VAC001-0058 S/N 44033663	Manual Provided

EQUIPMENT	**MANUAL**
Vacuum Gauge Controller Pfeiffer Full range PBR260 M p/n PT-R27-000 C p/n VAC001-0058 S/N 44035950	Manual Provided
<u>Deposition Control</u>	
Deposition Controller w/Sensor XTC/2 system package M p/n 760-500-G1 C p/n RAT001-0177 S/N G1XX31A03433	Manual Provided
<u>Gas Control</u>	
Mass Flow Controller MKS 100 sccm M p/n 2179A12CG1BV C p/n GAS500-0007 S/N 727025	Manual Provided (*1 manual for all)
Mass Flow Controller MKS 100 sccm M p/n 2179A12CG1BV C p/n GAS500-0007 S/N 730301	Manual Provided (*1 manual for all)
Mass Flow Readout Power Supply MKS 250E-1-D M p/n 250E-1-D C p/n GAS500-0014 S/N 000723174	Manual Provided
<u>Electron Beam Control</u>	
Electron Beam Gun ST_6E Telemark Power Controller M p/n 107-0603-2 C p/n SRC001-0080 S/N SRFU30455	Manual Provided (*1 manual for both)

EQUIPMENT	**MANUAL**
Electron Beam Gun Telemark High Voltage Module M p/n 007-0602-2 C p/n S/N NEU62179/NEU61175	Manual Provided (*1 manual for both)
Electron Beam Gun Telemark XY-Sweep M p/n 132-0500-1 C p/n S/N XY10192	*
<u>Ion Source Control</u>	
Ion Source Neutralizer Sorensen Power Supply M p/n DCS33-33EM37 C p/n PWR001-0014 S/N 102B1114	Manual Provided
Ion Source Drive	Manual Provided
Senvac Power Supply M p/n GS20/600 C p/n PWR001-0047 S/N G012970D20	
Water Manifold EMI 6Stage M p/n WFR2-10 C p/n PMP009-01510 S/N DFR-301	
Rotation Motor PM 123 RPM M p/n 33A5BEPM-W2 C p/n MTR0002-0004 S/N 6152BWAF0056	

1. Introduction

The Denton Infinity™ 26 Optical Coating System is a customized vacuum deposition system designed for precision applications. It features a "box coater" design that provides easy access to substrates, sources, and instrumentation while maintaining excellent pumping characteristics. 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 electron beam source, an ion source, and the ability to heat and rotate the substrates, and automatically control the deposition process with a quartz crystal monitor. Automatic layer endpoint detection is implemented through the quartz crystal monitor.

The Infinity™ 26 system is fully automatic and is controlled by a Gateway computer running GE Cimplicity® HMI software combined with a GE9030 programmable logic controller. The computer, keyboard, gauges, and switches are installed in two electrical control cabinets. The cabinets are conveniently located next to the chamber on a unit frame for easy installation, observation and operation.

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.

2. Safety Warnings

This vacuum deposition system is comprised of a number of complex subsystems.

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.

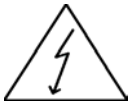
SYSTEM/SOFTWARE INTERLOCKS SHOULD NEVER BE DEFEATED UNLESS SERVICING OF THE SYSTEM REQUIRES TEMPORARY INTERLOCK OVERRIDES. HARDWIRED SAFETY INTERLOCKS MUST NEVER BE DEFEATED.

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.

2.1. 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.

3. System Specification

3.0 SUMMARY SPECIFICATION:
3.1 CHAMBER:

- 38" (high) x 26" (wide) x 30" (deep).
- 304 stainless steel construction; water-cooled via exterior welded 304 stainless steel U-channel.
- Full width opening door, two (2) 100 mm viewports with hinged welding glass holders.
- Internal (multi-piece) evaporation plenum.
- All required ports and feedthroughs.
- Chamber supported by tubular steel frame; (2) horizontal cross members and welded subplate.
- Integral sheet metal door "skin".
- Two complete sets of removable, stainless steel, evaporant shields (multi-piece construction to facilitate removal and reinstallation, with integral handles).
- Removable stainless steel uniformity mask.
- The following chamber penetrations will be provided:
  - i. Baseplate:
    - (32) 1.0" diameter penetration
    - 5.0" view port (optical monitor)
  - ii. Sidewall (water-cooled via exterior welded 304 stainless steel U-channel):
    - (6) 2.75" CF (IG tube, 5 spare)
    - (1) NW-400 pumping port flange
    - (1) 4.75" boss (blank)
  - iii. Pumping Plenum/Elbow (water-cooled via exterior welded 304 stainless steel U-channel):
    - (2) NW-400 pumping port flanges
    - (1) NW-63 (roughing valve)
    - (2) NW-16 (vent valve/bellows safety switches)
    - (1) NW-40 (spare port)
  - iv. Top-plate (water-cooled via exterior welded 304 SS U-channel):
    - 16" diameter penetration (rotation hardware)
    - (4) 1.0" diameter penetration (spare)
  - v. Door (water-cooled via exterior welded 304 stainless steel U-channel):
    - (2) 4.0" diameter viewports with hinged welding glass holders.

3.2 PUMPING SYSTEM:

- CTI Cryogenics CryoTorr® 10 cryogenic pump:
  - i. Digital temperature display,
  - ii. Water-cooled compressor (10' He lines), and
  - iii. Heated thermal blanket for cryopump regeneration.
- Removable, elbow-mounted, stainless steel evaporant baffle assembly (1 spare assembly provided).
- Alcatel 2033 (26 CFM) dual-stage, rotary vane pump.
- ***High Vacuum Valve:*** bellows-sealed poppet valve, straight open/close (double dovetail geometry, 0.375" diameter o-ring cross section). Poppet air cylinder (non-rotating) supplied with integral open/close proximity sensors, integrated to system control and interlocks.

- ***Roughing Valve:*** 40 mm bellows-sealed, right angle, poppet valve (stainless steel), ISO flanging. Valve supplied with integral open/close proximity sensors, integrated to system control and interlocks.
- ***Regen Valve:*** 25 mm bellows-sealed, right angle, poppet valve (stainless steel). Valve supplied with integral open/close proximity sensors, close-coupled metering valve, and, integrated to system control and interlocks.
- ***Vent Valve:*** 19 mm bellows-sealed valve. Valve supplied with integral open/close proximity sensors, integrated to system control and interlocks.
- ***Cryopump Purge Valve:*** VCR-4, bellows-sealed, inline poppet valve (stainless steel). Valve supplied with integral open/close proximity sensors; integrated to system control/interlocks and a close-coupled metering valve to adjust purge gas flowrate.
- ***Ion Gauge (cryopump) Isolation Valve:*** 2.75" conflat-type, bellows-sealed, right angle valve.
- ***Mechanical Pump Vent Valve:*** 0.25" electric valve, slaved to mechanical pump status.
- ***Leak Check Valve:*** Manual ball valve, mounted on foreline.

3.3 VACUUM GAUGING:

- (2) Pfeiffer PBR260 Compact FullRange® combination Bayard-Alpert ionization gauge transmitters (ISO-25 flanging; main chamber and cryogenic pump stub):
  i. Trigger relay on vacuum gauge interfaced to discrete PLC digital inputs (PBR1 trigger relay interfaced to ST-6 electron beam gun power supply "VAC" interlock), and
  ii. Output signal of each gauge transmitter interfaced to discrete computer analog input for process control.
- (2) Pfeiffer TPR265 Pirani gauge transmitters (ISO-16 flanging; system foreline and mechanical pump stack inlet):
  i. Output signal of each gauge transmitter interfaced to discrete computer analog input for process control.

3.4 PRESSURE/FLOW CONTROL:

- (2) MKS 2179 mass flow controllers (100 sccm), integrated to system host computer,
  i. (1) Configured for constant flow (dedicated to the CC-105 ion source):
  ii. (1) Configured for constant flow OR variable flowrate operation (via input from the MKS 250D PID controller); dedicated to the reactive evaporation process:
    - Dedicated to oxygen
- MKS 250C PID controller (auto pressure stabilization via pressure input from PBR260 gauge controller):
  i. Configured for remote setpoint control.

3.5 ELECTRON BEAM EVAPORATION SOURCE:

- (1) Telemark TFI-271-18 (six pockets, 25 cm^3/pocket), electron beam gun:
  i. Off-center mounted source location,
  ii. Dedicated cooling water circuit with integral flow rate sensor; hardwired interlock to ST-6 electron beam gun power supply.
- DVI auto crucible selection.

- Telemark ST-6 (6.0 kW) electron beam gun power supply and Telemark X/Y sweep:
  i. Manual high voltage on/off and filament on/off,
  ii. Interfaced to the XTC/2 deposition rate controller, and
  iii. Hardwired safety interlocks.
- Telemark four-pattern, remote sweep select.
- Rectangular HV feedthrough covers with full access flange.
- Filament transformer located in remote, stand-alone transformer cabinet (NEMA 4) bolted to chamber frame.

3.6 LOW VOLTAGE RESISTANCE EVAPORATION SOURCE:

- None provided.

3.7 SOURCE SHUTTERS:

- (1) Dedicated electro-pneumatic source shutter:
  i. Dedicated to the electron beam gun,
  ii. Interfaced to PLC controller for remote open and close operation,
  iii. Interfaced to the Inficon XTC/2 deposition rate controller (via system PLC) for automatic layer termination.

3.8 DEPOSITION CONTROL:

- (1) Leybold-Inficon XTC/2 quartz crystal rate controller; interfaced to system computer via IEEE-488; film program download from system computer and full data logging.
- (1) Maxtek Cool-Drawer®, dual, shuttered sensor head; positioned adjacent to work holder (inside swept volume of work holder).

3.9 SUBSTRATE HEAT:

- (2) 3.0 kW quartz heater arrays (backside reflector/deposition shield); mounted to baseplate plenum with stainless steel screening to protect bulbs from chamber debris.
- 208/110 VAC, step-down/isolation transformer to minimize possibility of spurious glow discharges and feedback from e-beam guns.
- PID temperature control system via GE 90-30 PLC controller.
- (1) Sheathed thermocouple positioned internally in chamber, fastened to central chip changer.
- Remote operation, setpoint and data logging via host system computer.

3.10 ION SOURCE:

- Denton Vacuum CC-105 Cold Cathode Ion Source System:
  i. Senvac GD20/600 drive power supply, and
  ii. Sorensen DCS 33-33 neutralizer power supply.
- Dual-neutralizer filament with automatic filament erosion sense and changeover.

- Baseplate-plenum mounting bracket and all required feedthroughs:
    i. Ion source positioned 15" below the plane of the substrate, offset 8.0" from the centerline of the work holder rotation.
- Remote operation, setpoint and data logging via host system computer.

3.11 SUBSTRATE FIXTURING:

- Gear-driven, hollow rotation assembly, single support bearing rated for continuous loading. Bearing to be mounted on water-cooled hub with central, 5.0" clear area for mounting of temperature thermocouple, TGC-50 chip changer (planned future system upgrade) and Maxtek Cool-Drawer®, dual, shuttered sensor head.
- Flat-rack, pre-machined to accept six (6) solid flip-fixturing paddles (nominal 4.0" Ø per E2O 12/11/00 fax from J. Chen).
- (12) Complete flip-fixture paddles.
- Spring-loaded electro-pneumatic flip actuator.
- High torque, reversible DC, gear motor and controller (0-20 RPM speed range):
    - Interfaced to system host controller for on/off, forward/reverse, and fast/slow speed operation, and
    - Tachometer on fixture drive shaft (atmosphere) with speed display (rotation alarm contact interfaced to control software).

3.12 SYSTEM AUTOMATION:

- Windows NT® operating system; super-VGA, flat-panel display.
- Dual (forced air-cooling) instrumentation cabinets.
- Denton Vacuum ProcessPro® control software configured for specific delivered hardware:
    - Mouse activation of pumps, valves, deposition sources, subsystems, gauging, gas/flow control, setpoints, and automatic process sequence activation.
- GE-Fanuc 9030 programmable logic controller (331-based microprocessor) interfaced to system host computer via RS-232 interface.
- Full remote setpoint capability:
    - Gas 1, and Gas 2 flowrates,
    - Total chamber pressure during PID pressure control,
    - Chamber temperature,
    - CC-105 Ion Source Drive Current,
    - CC-105 Neutralizer Current, and
    - XTC/2 film program.
- Multiple operation modes:
    - Manual, Automatic, Maintenance,
    - Automatic process sequence generation and editing, and
    - XTC/2 film program generation and editing.
- Automatic process sequences delivered:
    - Autopump, Autovent, Autoregen,
    - Ion Pre-cleaning (IPC), and
    - Multi-layer, double-sided depositions (w/IAD & auto substrate flip).

3.13 UTILITY REQUIREMENTS:

- **Electrical:**
  - 208 VAC (+/- 5 %), 60 Hz, 3 phase, 5 wire, 100 A.
  - Panelized control with single entrance protection by a heavy duty disconnect switch with "lockout" provision, provided by DVI.

- **Water:**
  - 10-12 GPM, 60-80 °F, 40-60 psi differential between supply and return (80 psi maximum inlet pressure)
  - Six-circuit water manifold; supply and return metering valves on each circuit with temperature indication on each circuit's return line. Water circuits requiring flow "sense" (hardware interlocks) will be equipped with a proximity switch keyed to the integral brass float on that circuit's sight glass.

  Circuit designation will be as follows:
  1) Cryogenic pump in series with Chamber/door/plenum/top-plate.
  2) Rotation housing/crystal sensor.
  3) Ion source (flow sense).
  4) Spare.
  5) E-beam gun (flow sense).
  6) Spare
- **Air:**
  - Normal dry shop air, 90-110 psi (system valve operation), and
  - Stand-alone air manifold positioned above the water manifold; solenoid valves incorporating removable plug-type electrical connections.

- **Nitrogen:** (Preferentially evaporated from a liquid source)
  - 3-15 psi (chamber venting, optional), and
  - 30 psi (cryopump regeneration), 2-3 CFM flowrate, 400 ft^3 required for regeneration cycle).

- **Oxygen:** (5N purity):
  - 7 psi (reactive evaporation gas makeup, ion source operation).

3.14 HARDWARE REVIEW:

All stated equipment, and subsystems detailed in Summary Specification were present and accounted for.

WITNESS:

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3.15 VACUUM PERFORMANCE:

3.15.1 PUMPDOWN AND ULTIMATE VACUUM:

1.) Clean, dry and empty system pumped overnight (12 hrs minimum).
2.) Chamber to demonstrate ultimate pressure of < 2.0E-7 torr.
3.) Chamber vented to atmosphere with dry N2 gas.
4.) Chamber door opened to room air for 3 minutes (ambient conditions of 21°C and 60% RH).
5.) Chamber door closed and system pumped into high vacuum status using "AUTOPUMP" automatic pumping sequence.
6.) Chamber to reach pressure of 150 mtorr (high van crossover) in < 5 minutes after initiating pumping cycle.
7.) Chamber to reach pressure of 5.0E-6 torr < 15 minutes after reaching hivac crossover (150 mtorr).
8.) All pumpdown data to be recorded on one-minute intervals for a period of ninety minutes.

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3.15.2 SEAL INTEGRITY:

1.) Clean, dry and empty system pumped overnight (12 hrs minimum).
2.) Chamber to demonstrate ultimate pressure of < 3.0E-7 torr.
3.) Helium mass spectrometer leak detector with a usable sensitivity of 1.0E-11 sccm mated to system.
4.) All welds, seals and penetrations exposed to helium gas.
5.) No single leak greater than 5.0E-9 sccm detected.

Note: *Leak detector to be provided by customer during acceptance testing duplicated at customer's location. In the event that no leak detector is available, steps 3-5 of Section 3.15.2 will not be performed.*

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3.15.3 PRESSURE RISE DOCUMENTATION:

1.) Clean, dry and empty system pumped overnight (12 hrs minimum).
2.) Seal integrity demonstrated via protocol outlined in Section 3.15.2.
3.) High vacuum valve and high vacuum bypass valve closed.
4.) Rise in chamber pressure recorded at one-minute intervals for a period of thirty minutes.
5.) Pressure rise from 3.0×10^{-7} torr (overnight ultimate) to 5×10^{-5} torr will not exceed 10 minutes.
6.) Data presented in both a tabular and graphical format.

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3.16 MANUAL SYSTEM CONTROL:
3.16.1 PUMPS AND VALVES:

1.) Main system overview page selected via keypad mouse.
2.) Individual valve and pump icons selected and then enabled (subject to pre-defined manual mode interlocks).

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3.16.2 GAS CONTROL:
3.16.2.1 FIXED FLOWRATE CONTROL (GAS 1 and GAS 2):

1.) High vacuum system status.
2.) Main system overview page selected via keypad mouse.
3.) Gas Control icon selected and enabled.
4.) Fixed flow mode enabled for Gas #1.
5.) Gas flowrate input to setpoint field.
6.) Ionization gauge #1 and/or #2 emission disabled.
7.) Gas Control icon closed; return to main system overview page.
8.) Gas #1 valve icon selected and enabled (subject to pre-defined manual mode interlocks); predefined flowrate established and verified by on-screen data display.
9.) Gas Control icon selected and enabled.
10.) Ionization gauge #1 (chamber) emission enabled.
11.) Steps 2 through 10 repeated for Gas #2.

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3.16.2.2 CLOSED-LOOP PRESSURE CONTROL (GAS 1):

1.) High vacuum system status.
2.) Main system overview page selected via keypad mouse.
3.) Gas Control icon selected and enabled.
4.) PID mode enabled for Gas #1.
5.) Controlling pressure input to setpoint field.
6.) Ionization gauge #1 and/or #2 emission disabled.
7.) Gas Control icon closed; return to main system overview page.
8.) Gas #1 valve icon selected and enabled (subject to pre-defined manual mode interlocks).
9.) Gas Control icon selected and enabled.
10.) Ionization gauge #1 (chamber) emission enabled.
11.) Control at predefined pressure established (+/- 5.0% of setpoint) verified.

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3.16.3 SUBSTRATE HEAT

1.) High vacuum system status.
2.) Main system overview page selected via keypad mouse.
3.) Heat control icon selected and enabled.
4.) Control temperature input to setpoint field (25 to 125 °C).
5.) Heater power enabled.
6.) Heat Control icon closed; return to main system overview page.
7.) Predefined temperature setpoint established and verified by on-screen data display.
8.) System soaked for 1 hour at temperature.

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3.16.4 OPERATION OF ELECTRON BEAM SOURCE:

1.) High vacuum system status.
2.) Main system overview page selected via keypad mouse.
3.) Electron beam gun control icon selected and enabled.
4.) E-gun hearth (1 to 6) input to setpoint field; advance to input hearth demonstrated.
5.) E-gun sweep pattern input to setpoint field, advance to desired sweep demonstrated.
6.) High Voltage energized.
7.) Emission current energized.
8.) E-gun shutter toggled open and closed.
9.) Filament emission de-energized.
10.) High Voltage de-energized.

Note: Depositions from the electron beam gun source are only executed under automatic XTC/2 control (refer to Section 3.17). As a consequence, manual control of the electron beam gun source is limited to basic on/off functionality.

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3.16.5 CC-105 ION SOURCE:

1.) Fixed flowrate of process gas introduced through ion source via gas #2 (refer to Section 3.16.2.3).
2.) Main system overview page selected via keypad mouse.
3.) Ion Source control icon selected and enabled.
4.) Proportional gain input to setpoint field.
5.) CC-105 drive current input to setpoint field.
6.) CC-105 neutralizer current input to setpoint field.
7.) CC-105 drive power energized.
8.) CC-105 neutralizer power energized.
9.) Ion Source control icon closed; return to main system overview page.
10.) Predefined drive and neutralizer setpoints established and verified by on-screen data display.
11.) Stable ion source operation (2.5 A drive current) demonstrated for 30 minutes.
12.) Ion Source control icon selected and enabled.
13.) CC-105 drive power de-energized.
14.) CC-105 neutralizer power de-energized.
15.) Fixed flowrate of process gas introduced through ion source terminated (refer to Section 3.16.2.3).

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3.16.6 SUBSTRATE ROTATION AND FLIP FIXTURING:

1.) Main system overview page selected via keypad mouse.
2.) Rotation control icon selected and enabled.
3.) "FWD" rotation direction selected.
4.) "FAST" rotation speed selected.
5.) Rotation power energized.
6.) Rotation control icon closed; return to main system overview page.
7.) Rotation and speed verified by on-screen data display.
8.) Steps 2 through 7 verified for all combinations of direction ("FWD" and "REV") and speed ("FAST" and "SLOW").
9.) Substrate flip-over verified for slow speed and both rotational directions.

Note: "FAST" and "SLOW" speed potentiometers will have been previously calibrated to the desired speed, limited to a maximum rotation speed of 20 RPM.

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3.17 AUTOMATIC PROCESSING:

Automatic processes are constructed by linking recipe Building Blocks in the desired sequence. Once the recipe building blocks are created, the Master Recipe Builder is used to create permanent and accessible recipe files for use in the generation of thin film coating stacks. A Master Recipe can contain a maximum of 120 steps; all recipe functions are accessed through the Recipe system page.
Certain non-Programmable Building Blocks are programmed at the factory and cannot be reprogrammed by the customer. These non-programmable elements are limited to basic system "housekeeping" functions and are limited to:

- Auto Pump: Autopump factory programmed to be the first step in all recipes to pump the system into high vacuum before any other processing.
- Auto Vent: Auto Vent is factory programmed to be the last step in all recipes to vent the system to atmosphere safely. Auto Vent contains one user-accessible parameter, "Cool Down Time".
- Auto Regen: Auto Regen is non-programmable and is used to regenerate the system cryopump. Unlike Auto Pump and Auto Vent, Auto Regen cannot be combined with other Building Blocks; it is programmed to run as a stand-alone recipe.

All programmable Building Blocks require initial data input and are structured as Configuration Pages. In each Configuration Pages the operator can access the various File Option. Accessible options include: starting a New file, Opening an existing file, saving (Save) the displayed settings as a new file, saving (Save As) an existing file, and deleting (Delete) an existing file. All Configuration Pages incorporate both a Close and Cancel function; required when data input is complete. The following Configuration Pages are accessible:

- Autoheat: Auto Heat is used to heat the substrates before deposition (it is typically the second step in a process recipe after Auto Pump) and allows for the follow parameters to be specified:
  - Rotation & speed.
  - Heat Setpoint.
  - Soak time.
  - Minimum Vacuum Required (wait for process pressure, before turning on the heat).
- Ion Preclean: Ion Preclean is used to clean/etch the substrates before deposition with the CC-105 ion source and allows for the following parameters to be specified:
  - Heat Setpoint.
  - Process Gas flowrate (Gas #1 or Gas #2).
  - CC-105 Drive current setpoint.
  - CC-105 Neutralizer current setpoint.
  - Cleaning/etch time.
  - Minimum Vacuum Required (wait for process pressure, before turning on the heat).
- Auto Deposition: Auto Deposition is used to control all aspects of a the available deposition sources and subsystems; allowing for the following parameters to be specified:
  - Rotation & speed.
  - Heat Setpoint (if any).
  - Minimum Vacuum Required (wait for process pressure, before turning on the heat).
  - Inficon XTC/2 configuration (Auto Deposition accesses previously stored XTC/2 deposition configurations).
  - Electron beam source configuration:
    - Crucible #.
    - Sweep Pattern #.
  - Reactive Process Gas Flow Mode (Gas 1):
    - If PID control mode:
    - Process control pressure.
    - If Fixed flow mode:
    - Gas 1 flowrate.
  - Ion Assisted Deposition:
    - Gas 1 and/or Gas 2 flowrate.
    - Neutralizer setpoint.
    - Drive setpoint.
- XTC/2 Configuration: XTC/2 Configuration is used define all aspects of the XTC/2 controller invoked during a single layer deposition controlled by the XTC/2. The XTC/2 Deposition Controller is the device that controls the power applied to the source, the rate at which the evaporants are deposited on the substrate, and the thickness at which the layer deposition is terminated. This Configuration Page also contains data required to maintain accuracy and safety.

The Acceptance Test Protocol for Automatic System operation will focus on the generation and execution of recipes based on the available Configuration Pages and the Master Recipe Builder. These techniques will then be used to generate a V-coat using TiO_2 (e-beam) and SiO_2 (e-beam) with ion assist with a nominal design wavelength of 1550 nm on GaAs substrates (exact design criteria and GaAs test samples to be provided by E2O Communications).

3.17.1 AUTO HEAT CONFIGURATION:

1.) Recipe Page selected via keypad mouse.
2.) Autoheat Configuration Page selected.
3.) Autoheat parameters input to configuration page:
    - Rotation direction ("FWD"),
    - Rotation Speed ("FAST),
    - Heat Setpoint (125 °C),
    - Soak time (60 minutes),
    - Minimum Vacuum Required ("YES")
    - File name (TBD at time of acceptance test)
4.) Autoheat Configuration Page closed.
5.) Master Recipe Configuration Page selected. Master Recipe (File name TBD at time of acceptance test) created using:
    - Auto Pump,
    - Auto Heat,
    - Auto Vent,
6.) Recipe downloaded to system PLC.
7.) System Overview Page selected.
8.) Automatic process sequence initiated and system response verified.

WITNESS:

Denton Vacuum LLC	E2O Communications	Date

3.17.2 ION PRECLEAN CONFIGURATION:

1.) Recipe Page selected via keypad mouse.
2.) Ion Preclean Configuration Page selected.
3.) Ion Preclean parameters input to configuration page:
    - Rotation direction ("FWD"),
    - Rotation Speed ("FAST),
    - Heat Setpoint (25 °C),
    - Drive Setpoint (TBD),
    - Neutralizer Setpoint (TBD),
    - Gas #1 and/or Gas #2 flow (TBD),
    - Precleaning time (10 minutes),
    - Minimum Vacuum Required ("YES")
    - File name (TBD at time of acceptance test)
4.) Ion Preclean Configuration Page closed.
5.) Master Recipe Configuration Page selected.
6.) Master Recipe (File name TBD at time of acceptance test) created using:
    - Auto Pump,
    - Ion Preclean,
    - Auto Vent,
7.) Recipe downloaded to system PLC.
8.) System Overview Page selected.

9.) Automatic process sequence initiated and system response verified.

WITNESS:

Denton Vacuum LLC	E2O Communications	Date

3.17.3 XTC/2 CONFIGURATION:

Note: XTC/2 configuration is verified in Section 3.17.4.

3.17.4 DEPOSITION CONFIGURATION:

3.17.4.1 ION ASSISTED ELECTRON BEAM DEPOSITION OF A DIELECTRIC (Ti_2O_3 @ 0.4 nm/sec):

1.) Recipe Page selected via keypad mouse.
2.) Deposition Configuration Page selected.
3.) Deposition Configuration parameters input to configuration page:
- Rotation direction ("FWD"),
- Rotation Speed ("FAST),
- Heat Setpoint (TBD),
- XTC/2 configuration File number (TBD),
- Electron beam gun crucible # (TBD),
- Electron beam gun sweep pattern (TBD),
- Ion source (Gas #1 and/or Gas #2) flowrate (TBD),
- Ion Source Drive Current (TBD),
- Ion Source Neutralizer Current (TBD),
- Minimum Vacuum Required ("YES")
- File name (TBD)

4.) Deposition Configuration Page closed.
5.) Master Recipe Configuration Page selected.

Master Recipe (File name TBD at time of acceptance test) created using:
- Auto Pump,
- Deposition (using previously established filename),
- Auto Vent,

6.) Recipe downloaded to system PLC.
7.) System Overview Page selected.
8.) Automatic process sequence initiated and system response verified.

WITNESS:

Denton Vacuum LLC	E2O Communications	Date

3.17.4.2 ELECTRON BEAM DEPOSITION OF A DIELECTRIC (SiO_2 @ 1.0 nm/sec):

1.) Recipe Page selected via keypad mouse.
2.) Deposition Configuration Page selected.
3.) Deposition Configuration parameters input to configuration page:
- Rotation direction ("FWD"),
- Rotation Speed ("FAST),
- Heat Setpoint (TBD),
- XTC/2 configuration File number (TBD),
  - Electron beam gun crucible # (TBD),
  - Electron beam gun sweep pattern (TBD),
  - Minimum Vacuum Required ("YES")
  - File name (TBD)

4.) Deposition Configuration Page closed.
5.) Master Recipe Configuration Page selected.
6.) Master Recipe (File name TBD at time of acceptance test) created using:
  - Auto Pump,
  - Deposition (using previously established filename),
  - Auto Vent,

7.) Recipe downloaded to system PLC.
8.) System Overview Page selected.
9.) Automatic process sequence initiated and system response verified.

WITNESS:

_____ _____ _____
Denton Vacuum LLC E2O Communications Date

3.17.5 UNIFORMITY/MASKING:

Inspection of test pieces, coated in the Infinity® 26 under fully automatic control (SiO_2 and TiO_2, Section 3.17.4) with associated masking indicates that uniformity requirements are met (+/- 1.0% thickness non-uniformity) and that DVI responsibility for mask trimming is completed.

Definitions:

$$+/- \text{ Non-Thickness Uniformity} = ((T_{max}-T_{min})/T_{avg}/2) \times 100$$

Where:

T_{max} = Maximum optical thickness recorded within measurement area
T_{min} = Minimum optical thickness recorded within measurement area
T_{avg} = Average optical thickness recorded within measurement area

WITNESS:

_____ _____ _____
Denton Vacuum LLC E2O Communications Date

3.18 MULTILAYER COATINGS:

3.18.1 BROADBAND ANTIREFLECTIVE COATING:

Using the techniques and procedures outlined in Section 3.17.4, a v-coat (TiO_2/SiO_2) stack on GaAs substrates (provided by E2O Communications) will be deposited. This coating will be produced under active automatic optical monitoring with a control strategy developed by Denton Vacuum. This coating will be deposited on both sides of a substrate during a single chamber pumpdown using the automatic flip capabilities of the system.

WITNESS:

_____ _____ _____

Denton Vacuum LLC E2O Communications Date

4. Utility Requirements

- **Electrical:**
  - 208 VAC (+/- 5 %), 60 Hz, 3 phase, 5 wire, 100 A.
  - Panelized control with single entrance protection by a heavy duty disconnect switch with "lockout" provision, provided by DVI.

- **Water:**
  - 10-12 GPM, 60-80 °F, 40-60 psi differential between supply and return (80 psi maximum inlet pressure).
  - Six-circuit water manifold; supply and return metering valves on each circuit with temperature indication on each circuit's return line. Water circuits requiring flow "sense" (hardware interlocks) will be equipped with a proximity switch keyed to the integral brass float on that circuit's sight glass. Circuit designation will be as follows:

    1) Cryogenic pump in series with Chamber/door/plenum/top-plate.
    2) Rotation housing/crystal sensor.
    3) Ion source (flow sense).
    4) Spare.
    5) E-beam gun #1 (flow sense).
    6) Spare.

- **Air:**
  - Normal dry shop air, 90-110 psi (system valve operation).
  - Stand-alone air manifold positioned above the water manifold; solenoid valves incorporating removable plug-type electrical connections.

- **Nitrogen:** (Preferentially evaporated from a liquid source)
  - 3-15 psi (chamber venting, optional).
  - 30 psi (cryopump regeneration), 2-3 CFM flowrate, 400 ft^3 required for regeneration cycle).

- **Oxygen:** (5N purity):
  - 7 psi (reactive evaporation gas makeup, ion source operation).

5. Installation

After ensuring that all utility connections have been made (See section 4, 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 is completed by Denton Vacuum Technicians.

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

5.1. Mechanical Pump

5.1.1.  Attach the pump to the vacuum lines that connect it to the rear of the vacuum chamber and cryo-pump. All vacuum fittings and clamps are included with the system.

5.1.2. Connect the pump electrically to the power distribution box on the rear of the system. The Pump is supplied with a "twist-lock" plug that mates with an outlet in the power distribution box. The outlet is labeled "Mechanical Pump" and sized to fit the plug.

5.2. Cryo-Pump Compressor

5.2.1.  The instructions for connecting the Cryo-Pump compressor to the Cryo-pump are outlined in detail in the Cryo-Pump manual. **Read this manual before proceeding with the installation.**

5.2.2. Water lines supplied with the vacuum system are connected from the water manifold to the Cryo-Pump Compressor**. Be certain to connect Input and Output lines correctly.**

5.2.3. Connect the compressor electrically to the power distribution box on the rear of the system. The compressor is supplied with a "twist-lock" plug that mates with an outlet in the power distribution box. The outlet is labeled "Cryo-Pump Compressor" and sized to fit the plug.

5.2.4. The Cryo-pump can be started in accordance with the startup instructions contained in the Cryo-pump manual. **Read the Cry-pump manual before proceeding with the startup.**

5.2.5. Open the nitrogen supply for the Cryo-pump purge and adjust the pressure regulator to 0.75 bar. Bleed nitrogen through the line up to the vacuum system before connecting the nitrogen line to the vacuum system.

5.2.6. The system computer will start the Cryo-pump automatically. Use the AutoRegen recipe.

5.3. High Purity Gas Lines – Oxygen, Argon, Nitrogen

5.3.1. All pumps must be operational before connecting the high purity gas line.

5.3.2. All gas supply lines must have an ON/OFF valve between the regulator and the vacuum system.

5.3.3. Connect the gas supply line to the rear of the machine and close the valve near the pressure regulator.

5.3.4. Pump the chamber out manually and open the Gas Isolation Valve. Use the on-screen Gas Status & Control screen to increase the gas flow setpoint to 40 SCCM. Continue pumping out the system until the actual flow in the line decreases.

5.3.5. Increase the flow Setpoint to maximum. Continue pumping until the actual flow is approximately zero (0).

5.3.6. Reduce the setpoint to zero and close the Gas Isolation Valve. Open the toggle valve near the pressure regulator and adjust the regulator to 0.75 bar.

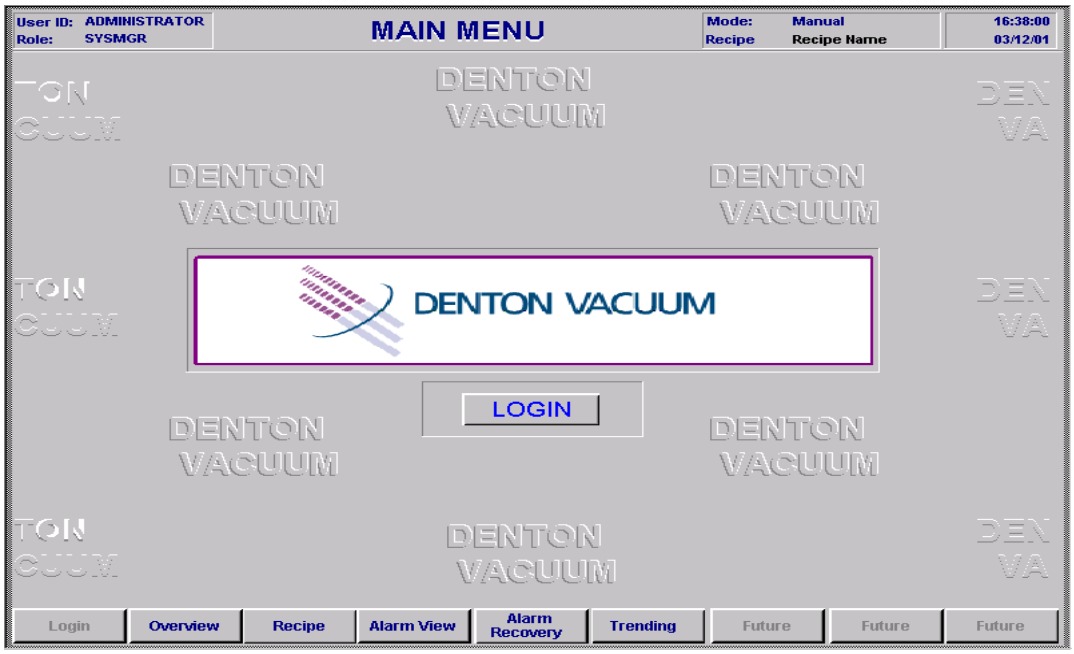
5.4. Vacuum Gauge Tubes.

5.4.1. Install (2) full range tubes and (2) pirani tubes into the feedthroughs and attached the electrical control unit to the tubes. Attach the control cables to the control unit.

5.5. Chamber Thermocouple

5.5.1. Connect the chamber thermocouple using the supplied two-conductor connector. The thermocouple is located in a feedthrough at the top of the vacuum chamber.

6. Software Overview



6.1. Control System

The control system for the vacuum system is GE Cimplicity® HMI (Human Machine Interface). Cimplicity® runs on a Windows NT operating system. This should make the interface between operator and machine familiar and easy to learn.

This software links the operator to the PLC. It allows for data input and data display. Operators can use a mouse to select on-screen graphics by clicking on any active element on a screen. Data is input by pushing on-screen buttons or using the keyboard.

Security is implemented through the Login Panel. Multiple levels of security are available to control access to critical information. The System Administrator has complete access to the entire control system. The System Operator can access everything except the heat PID settings, Service Mode and the Configuration Screens in the Recipe Builder. System Security is described in detail in the System Security section of this manual.

This software is active when power is applied to the system.

Graphic display of the control system is arranged on six "screens":

- Main Menu (Login)
- Overview
- Recipe
- Alarm View
- Alarm Recovery
- Trending

Main Menu (Login) is the first screen active when power is applied. It gives the operator access to the other screens through push buttons at the bottom of the screen. Access to the Login software is through this screen.

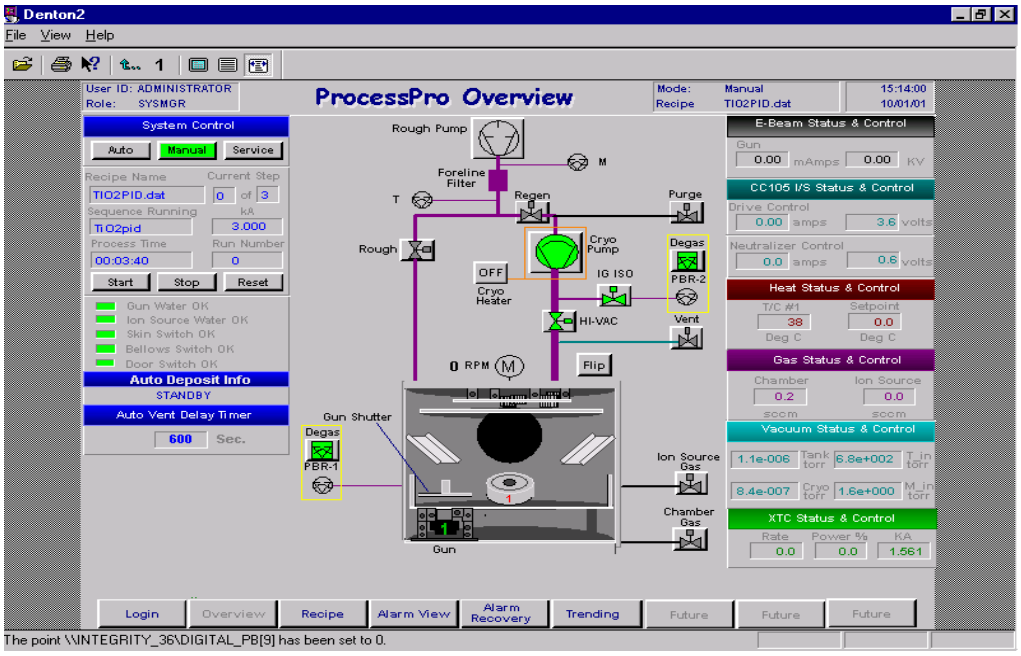
Overview is the primary operating screen. All current system data is displayed on this screen. The operator can access all subsystems through this screen. The Auto, Manual, and Service Modes are selected on this screen. Automatic sequences are Started, Stopped and Reset on this screen. This screen is described in detail in this section of the manual.

Recipe screens are used to develop, store, and download recipes for automated processes. Recipe screens are fully described in the Recipe Builder section of this manual.

Alarm View is the screen used to display, acknowledge, and clear system alarms. Alarm View is fully described in the Alarm section of this manual.

Alarm Recovery is the screen that displays the data captured when an automatic process is interrupted. This information is used to continue a recipe that has been stopped. Alarm Recovery is fully described in the Alarm section of this manual.

Trending is the screen where system data is graphically displayed.



6.2. Overview Screen

The Overview screen is used to display current system data and provide manual control of subsystems. The system data and security access level are displayed across the top and down the left side of the screen. The current state of the vacuum chamber and the pumping system are graphically displayed in the center of the screen. Subsystem control boxes are accessible on the right side of the screen. Push buttons across the bottom are used to switch to Login, Recipe, Alarm View, Alarm Recovery and Trending screens.

Pushbuttons change color to indicate the state of the switch. Valves, pumps, and interlocks change color to indicate current state. Graphic indicators are displayed on the vacuum system graphic when evaporation sources, heaters or ion sources are active. The electron beam gun pocket indicators and neutralizer filament selection are displayed on the vacuum system graphic.

All operations are familiar Windows operations. All graphics that are accessible to the operator will display a white "lasso" when the cursor is near the graphic. The valves, pumps, timers, and individual control boxes are activated by a single click on the mouse. Data is input into a data box by clicking on the data box, typing in the data, and pressing the ENTER key.

6.3. Top Overview Bar

Displays current security data (User ID & Role), mode of operation (MODE), Recipe name, time of day and date. The User ID and Role are factory set in the control system software. The current Login name is displayed here.

The time and date can be adjusted in the Windows Control Panel.

6.4. Left Overview Screen

The left side of the Overview screen is used for System Control, Interlocks, and XTC/2 data display and control.

6.4.1. System Control

The System pushbuttons at the top select the mode of operation: Auto, Manual, & Service.

6.4.1.1. Auto

Auto mode is used to run automatic recipes. The Start, Stop, and Reset buttons are active in this Mode. The current Recipe Running, Current Step, Sequence Running, Final Thicknesses, and Total Process Time will advance as the automatic recipe is running.

The Run Number is incremented every time the Start button is pressed. This feature can be customized to match customer run numbering. Contact Denton Vacuum for more information.

The Start button starts the Recipe that is displayed. The Stop button stops the recipe at the **end** of the current Sequence Running. The Reset button stops the automatic process immediately and resets the recipe back to the beginning and resets the Total Process Time.

All buttons change to green when active or ON

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

6.4.1.2. Manual

The operator can safely run the system from the Overview screen in the Manual mode. All interlocks are active in Manual mode. Recipes are not active in Manual mode.

All on-screen control systems are available. The state of the valves, motors and fixture rotation can be changed by clicking on the graphic for that item. Clicking will change the state of simple on/off, open/closed devices or open control boxes for more sophisticated controls. The Status & Control boxes on both sides of the screen are all activated by double-clicking. Pop-up boxes are displayed for operator input.

The Total Process Time will not advance and the Start and Stop buttons are inactive in Manual mode. The Reset button is inactive in the Manual mode.

6.4.1.3. 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 to System Administrator. See System Security for complete details*

Use Service Mode 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.

6.4.2. Interlocks

The Electron Beam gun interlocks are displayed on the left side of the Overview screen. The graphic is green if the interlock is satisfied and gray if it is open. The Electron Beam Gun will not operate if any interlock is open. These are hardwired interlocks.

6.4.3. Auto Deposit Info

Step-by-step information is provided during the deposition of a layer. "Standby" is displayed at all other times. These messages are intended to provide the operator with information on the set-up and deposition of a layer.

Typical messages:

Standby – displayed at all times except during deposition of a layer.

Step 2 – Minimum Vacuum – displayed when the system is waiting for the minimum vacuum setpoint to be achieved before proceeding.

Step 3 – Heat – displayed when the vacuum system is waiting for the heat setpoint to be achieved before proceeding.

Step 4 – Gas - displayed when the vacuum system is waiting for the gas flow setpoint to be achieved before proceeding.

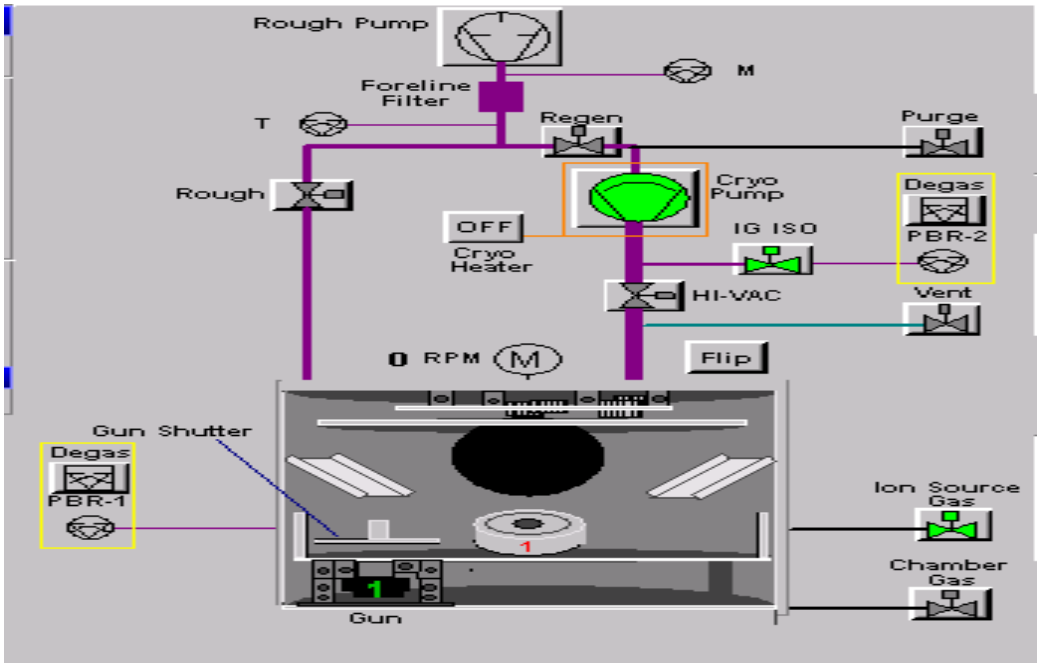
"Step 5 – IAD wait for Beam Good - displayed when the vacuum system is waiting for the ion source to stabilize before proceeding.

Step 6 – LV or EB Select - displayed when the vacuum system is waiting for the source selection to be completed before proceeding.

Step 7 – Start XTC & Wait Final Thick - displayed when the deposition controller has been started for the deposition of a layer. This message will continue until the deposition controller reaches the Final Thickness setpoint.

6.4.3.1. Auto Vent Delay Timer

The current value of the AutoVent time delay is displayed. This default value is set from the AutoVacuum Configuration screen. The value in this box can be changed at any time by highlighting, changing value and enter.



6.5. Center Overview Screen

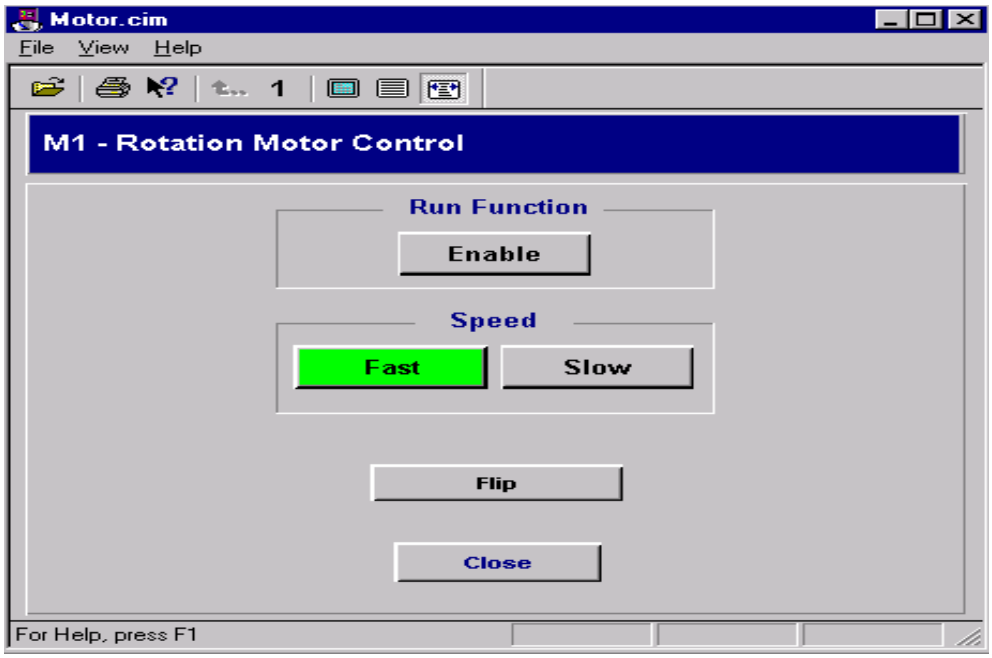
NOTE: *All relevant interlocks must be satisfied before a subsystem will respond. See the Interlock section of this manual.*

A graphic representation of the vacuum chamber, fixture rotation, and pumping system is displayed on the center of the Overview screen. All components of the pumping system are accessible in Manual or Service modes. Double-click on a component to change the state (on/off, open/closed) of the component or double-click on a component and a control box will pop-up for operator control input. The fixture rotation control box is accessed by double-clicking on the motor graphic **(M)** above the vacuum chamber graphic.

NOTE: *Access to the status & control boxes is denied in Auto mode*.

Vacuum chamber graphics are used to display the current condition of major subsystems.

The Heaters will change from gray to orange when the heaters are active in the chamber. Evaporation indicator is visible when material is evaporated from the electron Beam Gun in the chamber. An Ion Source indicator is visible when the Ion Source is active in the chamber. The fixture rotation speed, ion source filament selection and e-gun pocket selection are displayed.



6.5.1. Rotation Motor Control

NOTE: *All relevant interlocks must be satisfied before a subsystem will respond. See the Interlock section of this manual.*

The only manual control located in the center of the Overview screen is for the fixture rotation The control box for the rotation motor is accessed by double-clicking on the graphic of the rotation motor (the **(M)** in the circle above the chamber in the center of the Overview screen).

The control box for the Rotation Motor Control allows manual control of the fixture rotation motor.

Run Function: Enable/Disable (power switch)

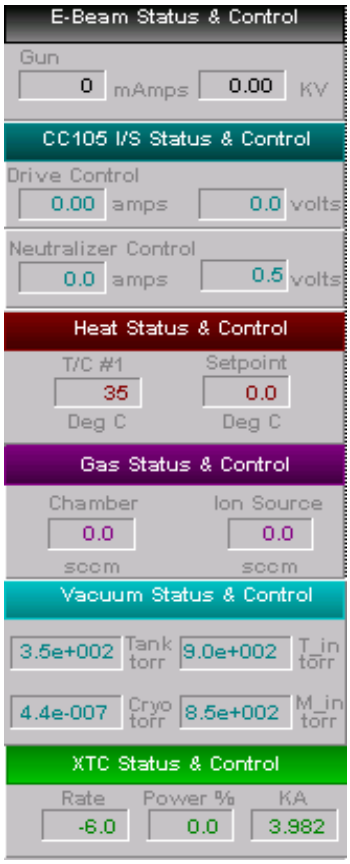
Speed selection: Fast / Slow (factory preset)

Flip: Lowers or raises flip actuator arm. (for flip testing and alignment)

Note: The Fast and Slow rotation speeds are selectable. The default values are programmed at the factory. Denton Vacuum can reprogram the pre-programmed speeds through the Remote Connection feature of the software. See the Remote Connection section of this manual.

All buttons change to green when active or ON.

Note: Press CLOSE button to close the Status & Control screen



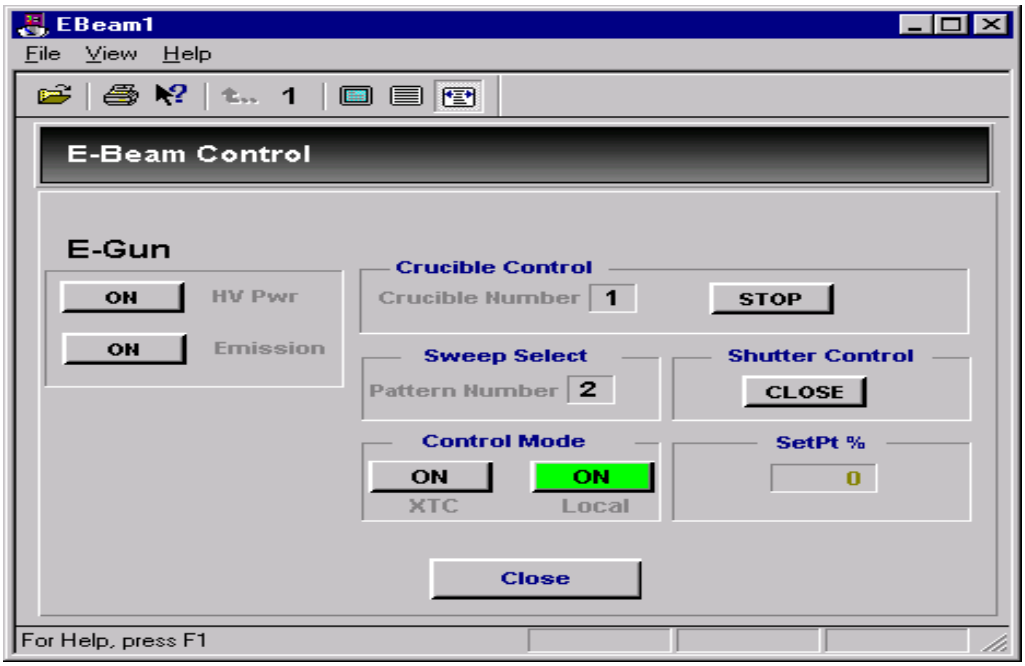
6.6. Right Overview Screen

The control boxes for all major subsystems are displayed on the right side of the Overview screen. The current condition of the subsystems is continuously displayed on the right side of the Overview screen in data boxes. Double-clicking on the Status & Control box accesses the subsystems. Control boxes will pop-up with input boxes for operator interface with the subsystem.

In normal operation the following data is continuously displayed on the Overview screen:

- Current and Voltage from E-Beam Gun (Amps, kV)
- Ion Source drive current & voltage (Amps, Volts)
- Ion Source neutralization current & voltage (Amps, Volts)
- Actual substrate temperature and current heater Setpoint. (Deg. C)
- Gas flow through mass flow controllers; Ion Source & Chamber (SCCM)
- Pressure in the vacuum chamber: Tank (mbar)
- Pressure in the cryo-pump: Cryo (mbar)

- Pressure above the mechanical pump: T & M (mbar)
- XTC Status (rate, power, and thickness)



6.6.1. E-Beam Status and Control

NOTE: *All relevant interlocks must be satisfied before a subsystem will respond. See the Interlock section of this manual*

The control box for the E-Beam Status & Control allows manual control of the E-Beam Evaporation Sources. HV Power and Emission buttons are provided to operate the E-Beam power supply. They are designed to replace the buttons on the front panel of the E-Beam power supply.

Crucible Control (Crucible selection): Click on the box; enter a number (1 - 6); press Enter.

Select the sweep pattern. Click on the box; enter a number (1 - 4); press Enter.

Turn the HV Power ON; turn the filament Emission ON.

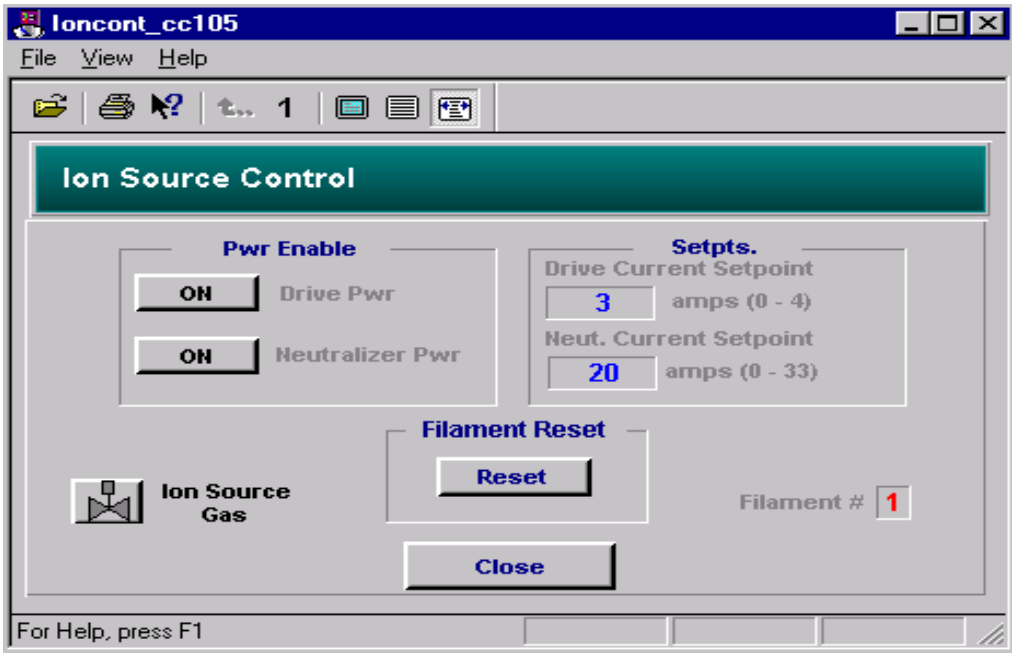
Set the output setpoint if in the Local mode. Click on the box; enter a number (max. 100%); press Enter. This Setpoint input operates like a potentiometer to control the power to the e-beam power supply

The setpoint can also be controlled from the XTC Deposition Control when in the XTC control mode. Individual layers can be deposited semi-automatically or full manual operation can be implemented from the XTC controller.

The evaporation source shutters can be opened and closed manually from this control box.

All buttons change to green when active or ON.

NOTE: *Press CLOSE button to close the Status & Control screen*



6.6.2. CC-105 Ion Source Status & Control

NOTE: *All relevant interlocks must be satisfied before a subsystem will respond. See the Interlock section of this manual*

The Ion Source electrical power supplies can be manually controlled from this box. Gas Flow **must** be initiated before attempting to operate the Ion Source power supplies. The Isolation Valve must be opened on the Overview screen and gas flow must be initiated. See Gas Status & Control for information. Also see the Ion source Operating Manual for gas flow requirements.

CAUTION: *The Ion Source must not be operated without a gas flow. Attempting to operate the Ion Source without gas flow may result in damage to the Ion Source. See the Ion Source Manual.*

Input a Drive Setpoint Current: Click on the box; enter a number (0 - 5); press Enter.

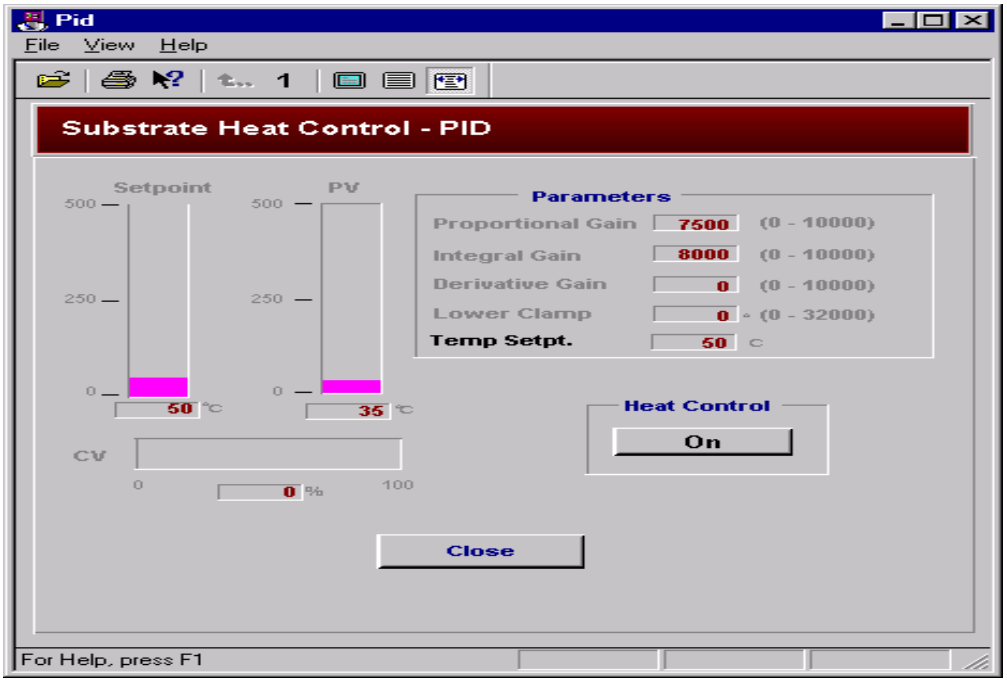
Input a Neutralization Setpoint Current: Click on the box; enter a number (0 - 33); press Enter. (**20 Amps recommended**)

Turn the Neutralization Power Supply ON **before** turning the Drive Power Supply ON.

NOTE: *The **Filament Reset** button **must** be pressed after an automatic crossover alarm has occurred. The software is programmed to change from the primary filament to the secondary filament before it breaks. This will cause an audible alarm. Change the filaments at the next chamber opening and Reset the filament at that time.*

All buttons change to green when active or ON.

Note: Press CLOSE button to close the Status & Control screen



6.6.3. Heat Status & Control

NOTE: *All relevant interlocks must be satisfied before a subsystem will respond. See the Interlock section of this manual.*

The Substrate heaters are operated manually from this control box. Enter a heat setpoint: Click on the box; enter a number; press Enter.

CAUTION: *The PID parameters are factory set. Changing the PID parameters will affect the temperature control. PID settings are not accessible to System Operators. System administrators can access the PID parameters. See System Security for details.*

Turn the Heat Control ON. The graphic displays will show the Setpoint, Present temperature Value (PV), and the Current power output Value (CV). The setpoint will be reached and held until it is changed.

In Manual Mode, a constant power output (CV) can also be held by entering a value into the '%' data box: Click on the box; enter a number (max. 100); press Enter.

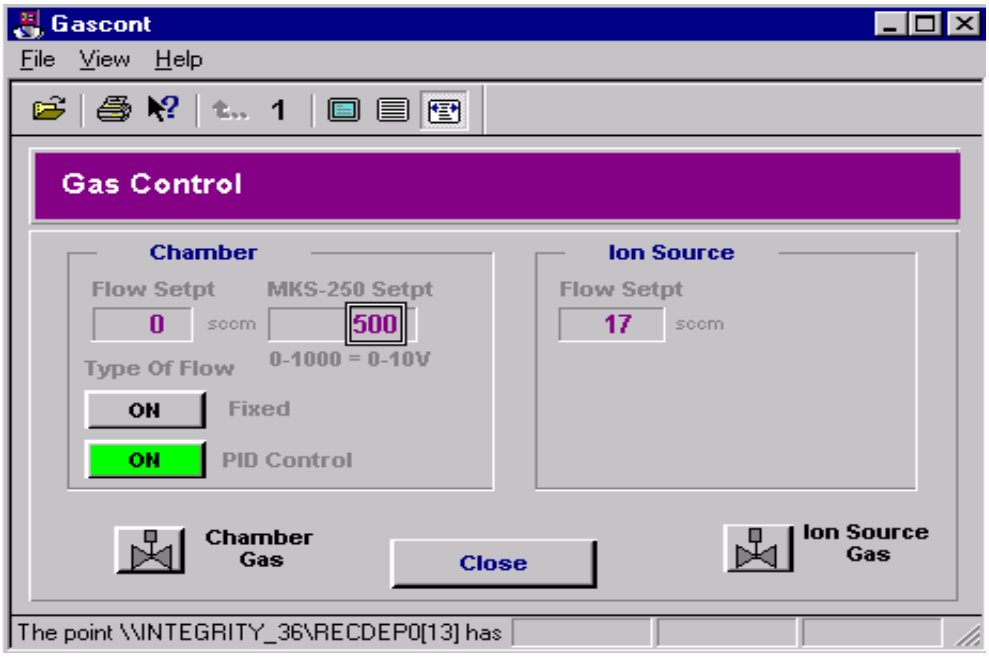
CAUTION: *The temperature will not be controlled with the system in a constant output mode. Dangerous high temperatures can result.*

In Auto Mode, a constant power output (CV) can be held by entering a value into the **Lower Clamp** data box. The range of input is 0 – 100%. This represents the *minimum* power output. This value can be set in addition to the PID parameters to improve temperature control at high temperature setpoints.

The current input from the thermocouple is displayed on this screen. This is the process value (PV). It is input to the PID controller for temperature control.

All buttons change to green when active or ON.

Note: Press CLOSE button to close the Status & Control screen.



6.6.4. Gas Status & Control

NOTE: *All relevant interlocks must be satisfied before a subsystem will respond. See the Interlock section of this manual.*

NOTE: The Ion Source or Chamber Gas Isolation Valves *must be open before adjusting gas flow on this screen. Gas Valve controls are accessed on the Overview Screen. If gas flow is initiated before gas valves are opened, pressure interlocks may drop out when the gas valve is opened due to the inrush of gas.*

Control of the mass flow controllers is implemented through this screen. There are two mass flow controllers: one connected directly to the chamber and one connected to the ion source.

The two mass flow controllers will operate in a constant flow configuration:

Enter a Flow Setpoint: Click on the Flow Setpoint box; enter a number (0-100); press Enter. The actual gas flow through the Mass Flow Controller will be displayed on the Overview screen. Flow is measured in Standard Cubic Centimeters per Minute (SCCM).

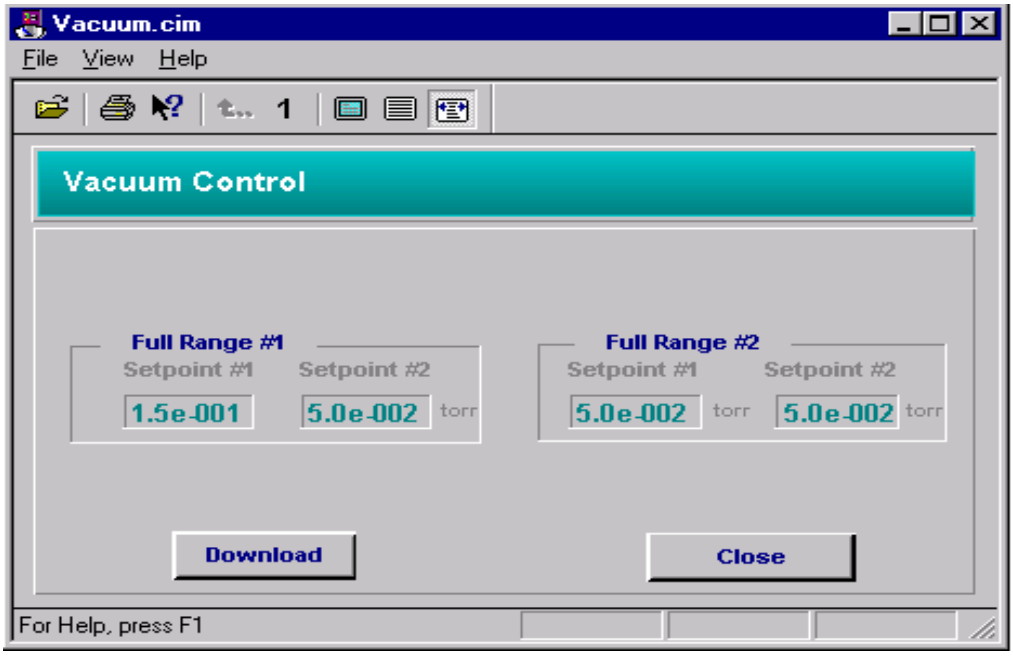
The mass flow controller connected directly to the chamber has selectable control: constant flow or variable flow. Variable flow control is implemented through the MKS 250 PID controller. The MKS 250 controller operates via pressure input from the full range vacuum gauge in the chamber. Actual flow will be displayed on the Overview screen.

Select PID control and input a percentage. This percentage is proportional to the pressure in the chamber as indicated from the Tank gauge. This analogue pressure signal is displayed on the front of the MKS 250 controller.

Gas flow through the mass flow controller will vary to maintain a constant pressure setpoint in the chamber.

All buttons change to green when active or ON.

Note: Press CLOSE button to close the Status & Control screen.



6.6.5. Vacuum Status & Control

NOTE: *All Vacuum Setpoints have been programmed at the factory for safe operation of the vacuum system.* ***It is recommended that NO vacuum setpoints be changed without assistance from Denton Vacuum*** *(856-439-9100). See the Setpoint section of this manual for the factory values.*

NOTE: *New values are not saved unless the Download button is pressed before leaving this screen.*

Two Vacuum Setpoints can be programmed for each full range Gauge.

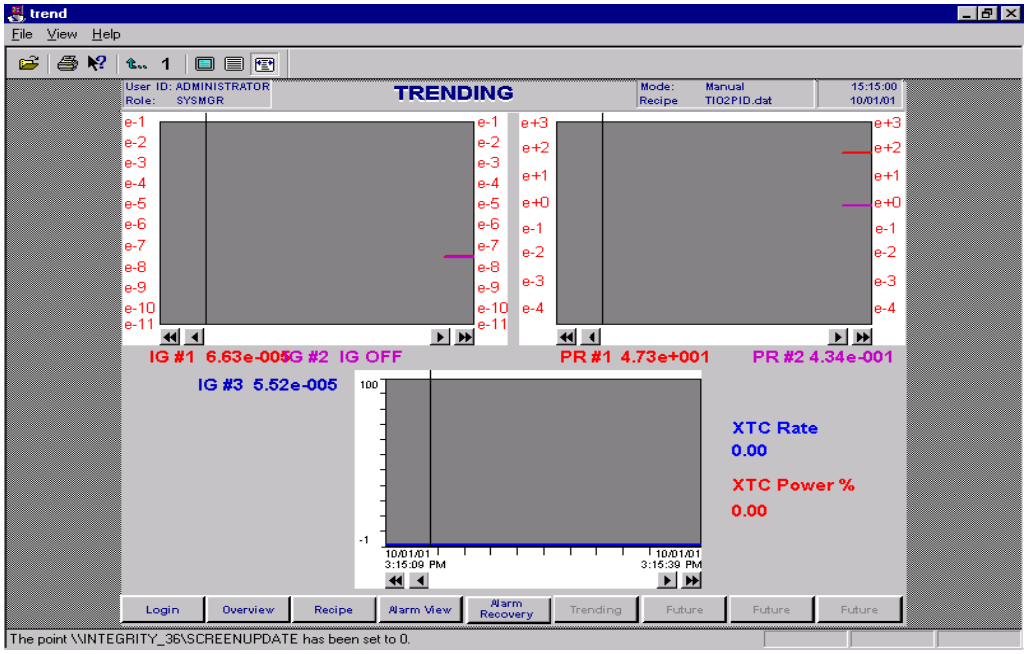
The current value of all Vacuum Setpoints is displayed on this screen.

To change a setpoint click on the setpoint box. Enter a new value and press the Download button.

All setpoints are not accessible at the Operator level (see the Security section of this manual).

All buttons change to green when active or ON.

Note: Press CLOSE button to close the Status & Control screen.



6.7. Trending Screen

Access to this screen is possible at any time through the buttons at the bottom of any screen.

This screen is used to graphically display current data from the Overview Screen. This data is displayed as a function of time. The display is programmable and data can be selected from any displayed values on the Overview screen.

Most systems are shipped with the following data displayed graphically: Full range gauges, PBR1 & PBR2, Pirani gauges T & M, XTC/2 Rate, and XTC/2 Power.

7. Pumping System Operation

7.1. Automatic CryoPump Protection

NOTE: *This protection is only applicable when power to the vacuum system has been interrupted for short (less than 20 minutes) periods of time.*

Automatic cryopump protection is built in to the Infinity vacuum systems to protect the cryopump during power outages. If power to the vacuum system is interrupted for short periods of time (less than 20 minutes), the cryopump will not require regeneration because of the automatic cryopump protection. Automatic cryopump protection is described below.

7.1.1. When power is interrupted to the vacuum system, all valves default to safe positions (CLOSED). All pumps and subsystems default to OFF. The control system turns OFF.

7.1.2. When power is restored to the vacuum system, all valves remain CLOSED. All pumps and subsystems remain OFF. The control system remains OFF. Power to the system remains OFF.

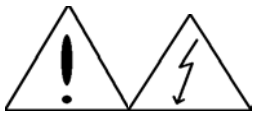
7.1.3. The Cryo Compressor will come ON automatically and the cryo will continue at operating temperature if the power outage was brief (less than 20 minutes). The Cryo Compressor will remain ON even if the control system is still OFF. (Overnight if the power outage occurs after hours.)

7.1.4. The control system remains OFF until the green START button near the view screen on the cabinet front is pressed. At this time the computer will power up and the software will take over the control of the vacuum system. **The default condition on software start-up for the Cryo Compressor is OFF.**

7.1.5. **The CryoPump will turn OFF automatically and must be turned ON through the Overview screen.**

This protection is included to protect the Cryo Pump from accidental regeneration caused by power outages. The Cryo Compressor will turn ON immediately after a power failure to protect the CryoPump if no one is there to turn the system ON. *The Cryo Compressor must be restarted after the control system is turned ON*

7.2. Automatic System Startup – *Use if CryoPump has been OFF more than 24 hours.*



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.

After ensuring that all utility connections have been made (See Section 4, Utility Requirements), and the vacuum system has been installed (See Section 5, Installation), The system can be turned on.

NOTE: *This procedure can only be run if the Cryo-pump was successfully shutdown, i.e. the cryo-pump was properly purged with nitrogen gas when turned OFF.*

7.2.1. Turn ON the main NEMA power breaker and push the green Power switch located on the door of the computer cabinet ON. The system will power up and the Menu screen will be displayed on the computer screen.

7.2.2. Power up the following instrumentation located in the system's electrical cabinet:

- MKS 250 PID Controller
- Ion Source Neutralizer, Drive and DC Glow power supplies
- E-Beam Power supply (keyed switch and pushbutton)
- XTC/2 Deposition Controller

7.2.3. Ensure that the Vacuum Setpoints are set to the values listed in Section 10 (Vacuum Setpoint) of this manual.

7.2.4. Open the Recipe Screen on the computer screen and download the Autoregen program into the PLC. Select the Overview Screen.

7.2.5. Start the AutoRegen program. A complete description of this program is in the Autoregen chapter of this manual.

7.2.6. In approximately 6 hours the Cryo-pump will have reached operating temperature. If the program fails to regen the Cryo-pump, an audible alarm will sound. If the regen is complete, an "End of Cycle " Alarm will sound.

7.3. Manual System Startup – *Use if CryoPump has been OFF more than 24 hours.*

Note: This procedure must only be run if the Cryo-pump was successfully shutdown, i.e. the cryo-pump was properly purged with nitrogen gas when turned OFF.

NOTE: *Use manual regeneration only in emergency situations. Otherwise use the AutoRegen program*

7.3.1. Turn ON the main NEMA power breaker and push the green Power switch located on the door of the computer cabinet ON. The system will power up and the Menu screen will be displayed on the computer screen.

7.3.2. Power up the following instrumentation located in the system's electrical cabinet:

- MKS 250 PID Controller
- Ion Source Neutralizer, Drive and DC Glow power supplies
- E-Beam Power supply (keyed switch and pushbutton)
- XTC/2 Deposition Controller

7.3.3. Ensure that the Vacuum Setpoints are set to the values listed in Vacuum Setpoint section of this manual.

7.3.4. Ensure that a supply of dry nitrogen has been connected to the Purge Gas input of the vacuum system (see Utility section of this manual for nitrogen requirements).

7.3.5. Open the Overview Screen on the computer screen.

7.3.6. Select Manual Mode.

7.3.7. Open the Purge Valve to the Cryo-pump and allow the nitrogen to fill the Cryo-pump. Continue for 15 minutes.

7.3.8. Turn ON the Mechanical Pump, wait one minute and open the Regen Valve. Continue for 15 minutes while the nitrogen is feeding into the Cryo-pump.

CAUTION: *Running the Mechanical Pump with the Regen Valve open for extended periods of time will cause damage to the Cryo-pump*

7.3.9. Close the Purge Valve and open the regen valve. Wait until the pirani gauge reaches 5.0 x 10^{-2} Torr. Continue for 5 more minutes.

7.3.10. If the pressure setpoint is not made within fifteen minutes, return to step 7.3.7 and increase the time to 30 minutes.

7.3.11. If the pressure setpoint is reached within fifteen minutes, close the Regen Valve and wait 1 minute.

7.3.12. If the pressure rises above 1 x 10^{-1} Torr during the minute, return to step 7.3.7 and increase the time to 30 minutes.

7.3.13. If the pressure stays below 1 x 10^{-1} Torr during the minute: turn the Mechanical Pump OFF; turn the Cryo-pump compressor ON; Turn the Cryo-pump ON.

7.3.14. Wait approximately 3 hours. When the temperature on the Cryo-pump thermocouple is approximately 10 Kelvin, Turn ON PBR1 AND PBR2.

7.4. Automatic Cryo-Pump Regeneration (*system operational*)

7.4.1. On The recipe Builder Screen, download the Autoregen program. On the Overview Screen press the Auto and Start buttons.

7.4.2. The Cryo-pump will be regenerated in approximately 6 hours. An End of Cycle Alarm will sound when the cycle is complete. An Alarm will sound if the regen failed.

7.5. Manual Cryo-Pump Regeneration (*system operational*)

NOTE: *Use manual regeneration only in emergency situations. Otherwise use Autoregen program*

7.5.1. Open the Overview Screen on the computer screen and select Manual Mode.

7.5.2. Open the Purge Valve to the Cryo-pump and allow the nitrogen to fill the Cryo-pump. Turn the Cryo Heater ON. Continue for 1 hour until Cryo-pump warms up to room temperature (approximately 300 Kelvin). Turn Cryo Heater OFF. Continue Purging for an additional 30 minutes.

7.5.3. Turn ON the Mechanical Pump, wait one minute and open the Regen Valve. Continue for 30 minutes while the nitrogen is feeding into the Cryo-pump.

CAUTION: *Running the Mechanical Pump with the Regen Valve open for extended periods of time will cause damage to the Cryo-pump*

7.5.4. Close the Purge Valve and open the regen valve. Wait until the pirani reaches 5.0 x 10^{-2} Torr. Continue for 15 more minutes.

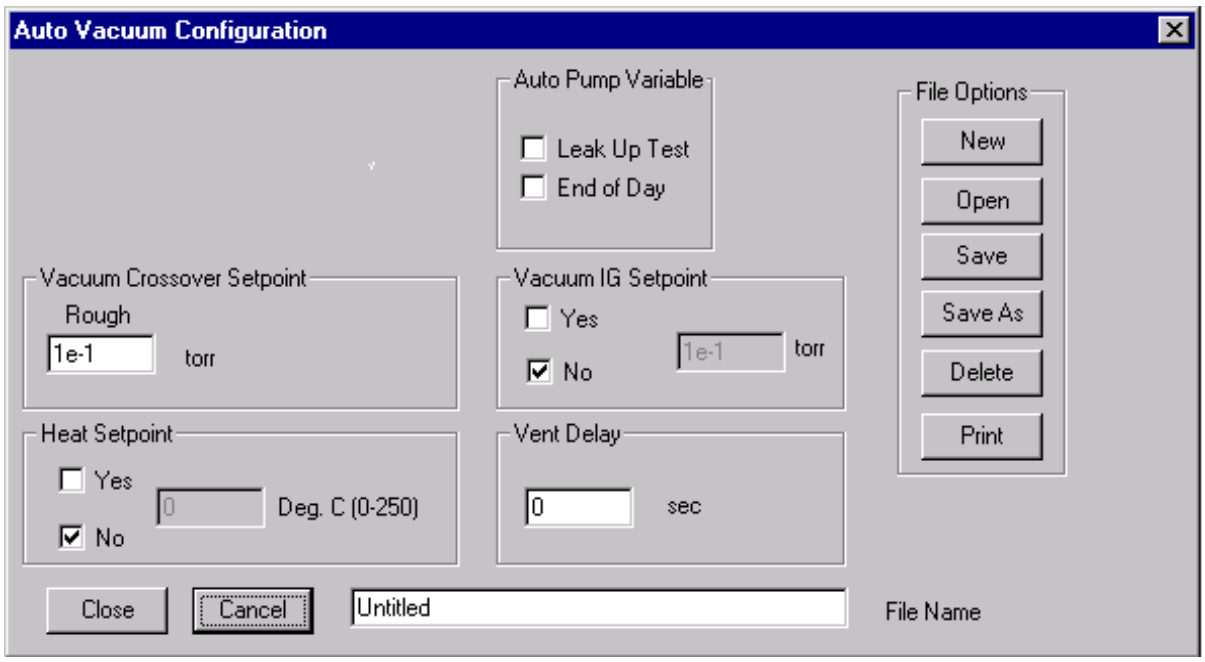
7.5.5. If the pressure setpoint is not made within fifteen minutes, return to step 7.5.2 decrease the purge time to 1 hour and do not turn the Cryo Heater ON.

7.5.6. If the pressure setpoint is reached within fifteen minutes, close the Regen Valve and wait 1 minute.

7.5.7. If the pressure rises above 1 x 10^{-1} Torr during the minute, return to step 7.5.2 decrease the time to 1 hour and do not turn the Cryo Heater ON.

7.5.8. If the pressure stays below 1 x 10^{-1} Torr during the minute: turn the Mechanical Pump OFF; turn the Cryo-pump compressor ON; Turn the Cryo-pump ON.

7.5.9. Wait approximately 3 hours. When the temperature on the Cryo-pump thermocouple is approximately 10 Kelvin, Turn ON PBR1 AND PBR2



7.6. Auto Vacuum Configuration

Note: *The Auto Vacuum recipe blocks are used to automatically evacuate the chamber. All interlocks are active to safely operate the pumping system. The interlocks on the pumping system ARE NOT active in Service Mode. The Auto Vacuum step will END when the Vacuum IG Setpoint is made. An Auto Vacuum step is usually followed by another recipe step. If there is no other recipe step after the Auto Vacuum step, an End of Cycle Alarm will sound when the Vacuum IG Setpoint is reached.*

The pumping system on the Infinity™ 26 vacuum 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. A number of options are available during any pump-down cycle. The Auto Vacuum Configuration screen in the Recipe Builder is used to develop recipe building blocks. The automatic pump-down building blocks can then be run separately or incorporated into Master Recipes (see the Recipe section of this manual).

Rotation Speed, **Heat Setpoint** (if required), **Vacuum PR Crossover Setpoints** can be programmed into an Auto Pump recipe step. The **Vacuum IG Setpoint** is the setpoint that ENDS an Auto Pump recipe step. If no setpoint is selected, the Auto Pump recipe step will end as soon as the IG pressure gauge is turned ON. This is 60 seconds after the High Vac Valve opens.

The **Vent Delay** is a delay timer active during the Auto Vent recipe step. The Vent Valve will not open until the Vent Delay setpoint is exceeded.

Auto Vacuum Configuration allows the operator to program many different auto-pump cycles. This section of the operating manual will cover three specific applications of the Auto Vacuum Configuration: **Polycold, Leak Up Test,** and **End of Day**. The Auto Vacuum recipe blocks will end when the "Vacuum IG Setpoint" is satisfied. The vacuum system will NOT advance without another recipe step.

7.6.1. Leak Up Test

7.6.1.1. The Leak Up Rate Test is a completely programmed pump down cycle. The Leak Up Test option is programmed to perform for a short leak up rate test on the vacuum chamber.

7.6.1.2. The heat setpoint is programmed to hold 100°C.

7.6.1.3. After the high vacuum valve opens, there is a delay of 30 minutes. Pumping of the chamber continues with the heaters set at 100°C during the 30-minute delay.

7.6.1.4. The heaters shut off after the delay. After a brief delay, the high vacuum valve closes.

7.6.1.5. PBR1 stays on for 30 minutes after the high vacuum valve closes. The pressure rise can be recorded during this 30-minute period.

7.6.1.6. After an additional 5minute delay, the cycle is complete.

Note: Press CLOSE button to close the configuration screen

7.6.2. End of Day

7.6.2.1. The End of Day cycle is a completely programmed pump down cycle. The End of Day option is programmed to place the vacuum chamber under vacuum during idle periods.

7.6.2.2. The End of Day cycle contains an Auto Pump sequence.

7.6.2.3. The Auto Pump cycle will run until the crossover pressure is reached.

7.6.2.4. The high vacuum valve will NOT open at crossover. Instead, the cycle will end. The vacuum chamber will remain under vacuum until an Auto Vent cycle is run or the chamber is vented manually.

NOTE: *This process should be run whenever the vacuum camber will not be used for long periods of time. It is recommended that the vacuum chamber be kept under vacuum whenever it is not being used.*

Note: Press CLOSE button to close the configuration screen

7.7. Ion Source & Chamber Gas Start-up

7.7.1. All pumps must be operational before connecting the high purity gas line. Connect the line to the rear of the machine and close the toggle valve near the pressure regulator.

7.7.2. Pump the chamber out manually and open the Ion Source Gas valve. Use the on-screen Gas Control to increase the gas flow setpoints to 40 sccm. Continue pumping out the system until the actual flow begins to decrease.

7.7.3. Increase gas flow setpoints to maximum. Continue until the actual flow reduces to zero (0).

7.7.4. Reduce the setpoints to zero and close the Ion Source & Chamber Gas Valves. Open the toggle valves near the pressure regulator and adjust the regulator to 0.75 bar.

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

7.8. Main Chamber Pumping - Automatic Mode

7.8.1. Ensure that the Cryo-pump is cold and operational.

7.8.2. Download an AutoPump program on the Recipe Screen. Close the chamber door.

7.8.3. On the Overview Screen press the Auto and Start buttons. This will initialize the automatic pump down cycle.

7.8.4. The End of Cycle Alarm will sound when the cycle is complete.

7.9. Main Chamber Pumping - Manual Mode

7.9.1. Ensure that the Cryo-pump is cold and operational.

NOTE*: All manual operations are carried out from the Overview Screen on the computer screen.*

7.9.2. Turn the mechanical Pump ON and wait 1 minute.

7.9.3. Close the chamber door and open the Roughing Valve.

7.9.4. Wait until chamber Vacuum is less than 1.5×10^{-1} Torr (crossover pressure).

7.9.5. Close the Roughing Valve, wait 15 seconds and open the Hi-Vac Valve.

7.9.6. Wait 1 minute before turning PBR1 AND PBR2 ON.