DENTON VACUUM, INC.

THE UNIVERSITY OF UTAH
Job #: 18097

SJ/20C
E-BEAM EVAPORATION SYSTEM

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12. EQUIPMENT LISTS, VENDOR MANUALS & SERIAL NUMBERS (cont'd)

Inficon Standard, Compact Sensor	Manual Provided
Inficon XTC/2 Quartz Crystal Monitor Serial #: J6XX21A01245	Manual Provided
KEP KEP Push Button Panel	Manual Provided
MKS Instruments, Inc MKS-290C Ionization Gauge Controller Serial #: 000040403	Manual Provided
MKS Instruments, Inc MKS-286 Convectron Gauge Controller Serial #: 000040403	Manual Provided
Omega CN76000 Microprocessor-Based Temperature/ Process Controller	Manual Provided
TFI-Telemark E-Gun Power Supply Model TT-3 Power Modual Serial #: 3046	Manual Provided
TFI-Telemark E-Gun Power Supply Model TT-3 Control Modual Serial #: 3046	Manual Provided
TFI-Telemark E-Gun Power Supply Model XY Sweep Serial #: 3046	Manual Provided

1. INTRODUCTION

The Denton Vacuum SJ/20C Optical Coating System is designed for either thin film production or research. The SJ/20C configuration provides easy access to substrates, sources, and instrumentation while maintaining excellent pumping characteristics. This system is designed to simplify the geometries necessary for the 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 for the operation of one electron beam gun, a 3 kW substrate heating system, and the ability to rotate the substrate. The SJ/20C is semi-automatic controlled by a General Electric 90-30 Programmable Logic Controller (PLC). The system's power supplies and instrumentation are installed in a control cabinet conveniently located next to the chamber for easy observation and operation.

The system offers the user a myriad of thin film process possibilities. However, it is important to note that with all of this system's potential there exists safety considerations. **Individuals who are to operate, service or maintain this system should familiarize themselves with this manual.**

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.

THE SYSTEM SHOULD BE OPERATED ONLY BY PERSONNEL WITH PROPER TRAINING AND PROCESS EXPERIENCE.

3. SUMMARY SPECIFICATION

3.1 DEPOSITION CHAMBER

The vacuum chamber assembly is constructed entirely of electropolished, 304L stainless steel and measures internally 20" wide x 29" deep x 28" high. The generous internal height facilitates the introduction of substrates and substrate fixturing and minimizes the chance that spatter from an evaporant source will contaminate the substrates surface. All elastomeric seals used throughout the chamber are fabricated from Viton.

The chamber is split on a vertical axis with a full opening door mounted on the front; providing complete, unrestricted access to the substrates and internal chamber components. The chamber door incorporates two-point articulating hinges to protect the door o-ring from scuffing and insure proper sealing.

3.2 PUMPING SYSTEM

The chamber is pumped through a high conductance bellows-sealed poppet valve which is welded to the chamber's baseplate. This valve housing also incorporates the chamber's roughing and venting ports.

All components of the poppet valve are fabricated from 304L stainless steel.

The poppet valve is designed to facilitate maintenance through the incorporation of the following features:

- removable seal plate (o-ring replacement)
- removable seal plate seating disk (customer refurbishment of sealing surface)
- flange mounted bellows and linear actuator (replacement of bellows)

High vacuum pumping is provided by an APD Cryogenics APD-8S cryopump with an HC-4 Displex water cooled compressor. Initial chamber evacuation and cryopump regeneration is accomplished by an Alcatel 2021 (17 cfm) two-stage, rotary vane

pump. An oversized absorption trap and mechanical pump purge (dry N_2) capability has been included in the foreline to effectively reduce backstreaming.

3.3 VACUUM GAUGING

Vacuum measurement and control is affected by the following instrumentation:

- MKS-290C-07 convectron/ionization gauge controller
- Denton Vacuum DV-23 dual-gauge thermocouple readout

The MKS-290B-07 supports two Thermocouple gauge tubes (two programmable setpoints per channel) and two ionization gauge tubes (two programmable setpoint, user-allocatable to either IG channel). The MKS-290B-07 serves as the system's primary vacuum measurement and control instrumentation. Interfaced to the system's automation package, the MKS-290B-07's thermocouple setpoints are used as a:

- trigger for high vacuum crossover in the AUTOPUMP automatic process sequences
- endpoint for the mechanical pump's evacuation of the cryopump during the AUTOREGEN process sequence
- endpoint for intrinsic pressure-rise test performed by the system during the AUTOREGEN process sequence

The two ionization gauges supported by the MKS-290B-07 (emission can be established on only one of the two gauges at any one time) provide the measurement of the system's high vacuum (< 1.0E-3 torr) performance.

A dual-gauge DVI-23 thermocouple gauge readout (switch selectable; reading from selected tube displays) has also been provided for redundant measurement of foreline pressure and mechanical pump performance.

The location of the provided vacuum gauging is as follows:

GAUGE	TYPE	LOCATION
TC-1	Thermocouple (MKS-290B-07)	Chamber
TC-2	Thermocouple (MKS-290B-07)	Between cryopump and purge valve
TC-3	Thermocouple (DVI)	Foreline, between rough valve and foreline trap
TC-4	Thermocouple (DVI)	Foreline, between foreline trap and mechanical pump
IG-1	Bayard-Alpert (MKS-290B-07)	Chamber
IG-1	Bayard-Alpert (MKS-290B-07)	Cryopump side of high vacuum poppet valve

3.4 ELECTRON BEAM SOURCE

The system includes one Telemark electron beam source:

a) Telemark Model 241 electron beam gun (4 x 777 cc crucible) with DVI manual crucible rotation system.

b) The gun is powered by TT-3 3.0 kW power supply and an X-Y sweep controller.

c) The source output is controlled automatically by the XTC/2 quartz crystal controller.

3.5 EVAPORATION SOURCE SHUTTER

A remote operating quick disconnect electropneumatic shutter is included for the evaporation source. This shutter is interfaced to the quartz crystal controller and the PLC system control.

3.6 SUBSTRATE HEATER

a) One Denton 3.0 kW heater array.

3.7 SUBSTRATE FIXTURE AND STAGE ROTATION

The SJ/20C is supplied with a single rotation, bearing-supported, rotary fixture support. The shaft will be directly driven by a DC gear motor and attain a variable speed of 0 to 27 rpm, via a potentiometer.

3.8 SYSTEM CONTROL AND AUTOMATION

- General Electric 90-30 programmable logic controller (PLC) with membrane-type operator interface.
- EEPROM memory backup.
- Valve control/sequencing, pump operation, and "soft" system interlocks (i.e., non-safety related) controlled by the PLC.
- The following operating modes provided:
  - AUTOPUMP (automatic loadlock and chamber pumpdown to high vacuum conditions),
  - AUTOVENT (automatic loadlock and chamber venting to atmospheric pressure),
  - MANUAL (permits manual (front panel) system operation and interruption of in-process automatic system sequences), and
  - MAINTENANCE MODE (key-switch selectable from MANUAL mode; permits all MANUAL MODE functionality, "soft" system valve interlocks disabled. All "hard" safety interlocks remain operational).

3.9 UTILITIES

Electrical:	208 VAC, 3-phase, 60 Hz, 5-wire, 75 amps.
Water:	15-20 l/min, 15-25 C, 3-4 bar differential between supply and return.
Nitrogen:	0.5 bar (Chamber venting) 2.0 bar (Cryopump regeneration)

3.10 SAFETY STANDARDS

3.10.1 SAFETY INTERLOCKS

- The system is equipped with a hardwired safety interlock system which fully protects operators and maintenance personnel from personal injury. The following hardwired interlocks will be provided:
  - E-Gun Power Supply: Vacuum safety bellows switch, chamber door, chamber thermocouple gauge setpoint and water flowswitch.
  - Heat Power: Vacuum safety bellows switch and chamber door.

- All hardwired safety interlock status are displayed to the system operator(s) at all times.

- All hardwired safety interlocks are duplicated by system controller "software" interlocks. In addition, all digital system events (eg., valve closure) are protected by "software" interlocks.

3.10.2 MOVING PARTS

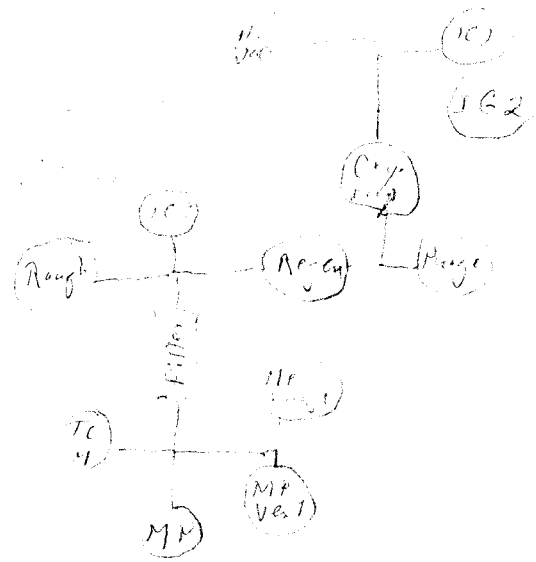
- Sliding surfaces and pinch points are fully guarded to prevent injury to operators and maintenance personnel.

- In the event of a power failure, all moving parts come to a complete stop. Upon initiating a restart cycle, all moving parts proceed to their home position without damage to the equipment or injury to operations and/or maintenance personnel.

3.10.3 POWER SYSTEMS

- In the event of an interlock dropout or power failure, all power to internal sources of energy (heater and sputter power supply) are interrupted. When power is restored, or an interlock is satisfied, a hard, manual reset of the affected subsystem is required.

- High voltage devices, vacuum feedthroughs and inter-connecting cabling will be enclosed in water-tight enclosures (NEMA 4 rating or better).



4. SYSTEM OPERATION

4.1 COLD START-CRYOPUMP REGENERATION

4.1.1 COLD START-CRYOPUMP REGENERATION - MANUAL MODE

1. Ensure that all utilities and process gases are installed and operational. Turn ON the main system disconnect which is located on rear of the system's instrumentation cabinet.

2. Push the green START button located near the top of the instrumentation cabinet. At this point, power to the system will be applied.

3. Power-up the following subsystems and instrumentation:
   - MKS 290-07 ionization/thermocouple gauge controller,
   - ~~MKS 247C power supply/readout,~~
   - ~~TFI~~ Telemark electron beam gun power supply.

4. Select (instrument front panel) the following configuration on the following subsystems and instrumentation:
   - Turn on each channel on the MKS 247C flow controller,
   - " FLOW" mode on the MKS 247C flow controller for each channel,
   - Set up Channels 1-4 displays: (Full scale flowmeter rating)x(GCF).

   Please refer to the MKS 247C manual on the proper procedure to display and alter gas correction factors and setpoints.

5. Ensure that the following setpoints are entered into the MKS 286 thermocouple gauge controller:
   - Channel 1 setpoint B (Chamber): 1.5E-1 torr (Isolation Valve Crossover),
   - Channel 2 setpoint A (Cryopump): 5.0E-2 torr,
   - Channel 2 setpoint B (Cryopump): 1.0E-1 torr.

   Please refer to the MKS 286 manual on the proper procedure to display and alter setpoints.

6. Ensure that the system keyswitch is set in the Manual Mode position.

7. Ensure that the chamber door is closed.

8. Ensure that 20-40 psi dry nitrogen gas has been supplied to the cryopump purge valve.

9. Open the cryopump purge valve (key pad labeled "PURGE ~~VALVE~~"); wait 3 hours.

10. Close the cryopump purge valve (key pad labeled "PURGE ~~VALVE~~").

11. Turn on the mechanical pump (key pad labeled "MECH PUMP"); wait 60 seconds and open the cryopump regen valve (key pad labeled "REGEN VALVE"); until the pressure indicated on MKS 286 thermocouple gauge channel 2 is less than 50 millitorr.

12. Close the cryopump regen valve (key pad labeled "REGEN ~~VALVE~~") and turn off the mechanical pump (key pad labeled "MECH PUMP").

13. If the channel 2 pressure reading does NOT rise above 100 mtorr in 60 seconds the pump is ready to be turned on. In this case please continue to operational procedure 14. Likewise, if the channel 2 pressure reading does rise above 100 mtorr in 60 seconds the pump is NOT ready to be turned on. In this case please close the regen valve and return to operational procedure 10 but only purge the cryopump for 1 hour. If the cryopump fails this "60 second pressure rise test" 3 times consecutively it is most likely a vacuum leak and should be leak tested before continuing.

14. Turn on the cryopump (key pad labeled "CRYOPUMP") ; wait 3 hours and select the cryopump ionization gauge tube (key pad labeled "IG 1/2 SELECT"; Note when the led is on IG1 is selected) and turn on the gauge emission (turn off and then turn on the power to the MKS 290).

4.1.2 COLD START-CRYOPUMP REGENERATION - AUTOMATIC MODE

1. Turn ON the main system disconnect which is located on rear of the system's instrumentation cabinet; ensure that all utilities and process gases are installed and operational.

2. Push the green START button located near the top of the instrumentation cabinet. At this point, power to the system will be applied.

3. Power-up the following subsystems and instrumentation:
   - MKS 290-07 ionization/thermocouple gauge controller,
   - MKS 247C power supply/readout,
   - TPI Telemark electron beam gun power supply.

4. Select (instrument front panel) the following configuration on the following subsystems and instrumentation:
   - Turn on each channel on the MKS 247C flow controller,
   - "FLOW" mode on the MKS 247C flow controller for each channel,
   - Set up Channels 1-4 displays: (Full scale flowmeter rating)x(GCF).

   Please refer to the MKS 247C manual on the proper procedure to display and alter gas correction factors and setpoints.

5. Ensure that the following setpoints are entered into the MKS 286 thermocouple gauge controller:
   - Channel 1 setpoint B (Chamber): 1.5E-1 torr (Isolation Valve Crossover),
   - Channel 2 setpoint A (Cryopump): 5.0E-2 torr,
   - Channel 2 setpoint B (Cryopump): 1.0E-1 torr.

   Please refer to the MKS 286 manual on the proper procedure to display and alter setpoints.

6. Ensure that the system keyswitch is set in the Manual Mode position.

7. Ensure that the chamber door is closed.

8. Depress the "SHIFT" and then "AUTOREGEN" softkey to initiate the automatic chamber pumping process. At the completion of this automatic pumping sequence the "AUTOREGEN" LED indicator will be extinguished and the cryopump will be in high vacuum status.

4.2 SYSTEM PUMPING AND VENTING

4.2.1 MAIN CHAMBER PUMPING - AUTOMATIC MODE

1. Ensure that steps 1 through 16 of the Cold Start Procedure (Section 4.1) have been successfully completed.

2. Depress the "SHIFT" and then "AUTOPUMP" softkey to initiate the automatic chamber pumping process. At the completion of this automatic pumping sequence the "AUTOPUMP" LED indicator will be extinguished and the chamber will be in high vacuum status.

   NOTE: If the "AUTOPUMP" softkey is depressed before the completion of the automatic cycle (i.e., the autocycle LED is still lit when the key is depressed) then the automatic cycle will be terminated and the machine will remain in the valve state at which the termination was initiated!

4.2.2 MAIN CHAMBER PUMPING - MANUAL MODE

1. Ensure the Cold Start Procedure (Section 4.1) has been successfully completed.

2. Ensure that the system keyswitch is set in the Manual Mode position.

3. Ensure that the all system valves are closed and turn off the gauge emission (turn off the power to the MKS 290).

4. Turn on the mechanical pump (key pad labeled "MECH PUMP"); wait 60 seconds.

5. Open the chamber rough valve (key pad labeled "ROUGH VALVE"). Pump the main chamber until the pressure indicated on MKS 286 channel 1 is less than 1.5E-1 torr (150 mtorr).

6. Close the chamber rough valve (key pad labeled "ROUGH VALVE").

7. Open the chamber hivac valve (key pad labeled "HIVAC VALVE").

8. Select the chamber ionization gauge tube (key pad labeled "IG 1/2 SELECT"; Note when the led is on IG1 is selected) and turn on the gauge emission (turn off and then turn on the power to the MKS 290).

4.2.3 MAIN CHAMBER VENTING - AUTOMATIC MODE

1. Ensure that the system keyswitch is set in the Manual Mode position.

2. Turn off all internal sources of energy (RF power, DC power, and heat).

3. Depress the "SHIFT" and then "AUTOVENT" softkey to initiate the automatic chamber venting process. At the completion of this automatic venting sequence the "AUTOVENT" LED indicator will be extinguished and the chamber will be vented to atmospheric pressure.

   NOTE: If the "AUTOVENT" softkey is depressed before the completion of the automatic cycle (i.e., the autocycle LED is still lit when the key is depressed) then the automatic cycle will be terminated and the machine will remain in the valve state at which the termination was initiated!

4.2.4 MAIN CHAMBER VENTING - MANUAL MODE

1. Ensure that the system keyswitch is set in the Manual Mode position.

2. Turn off all internal sources of energy (DC power, gun high voltage and filament power, AC glow power, and low voltage power).

3. Close (if open) the hivac valve (key pad labeled "HIVAC VALVE").

4. Close (if open) the chamber rough valve (key pad labeled "ROUGH VALVE").

5. Close (if open) the gas #1 isolation valve (key pad labeled "GAS VALVE").

6. Select the cryopump ionization gauge tube (key pad labeled "IG 1/2 SELECT"; Note when the led is ON, IG1 is selected).

7. Open the chamber vent valve (key pad labeled "VENT VALVE"). When chamber is fully vented and the chamber lid seal is broken, close the chamber vent valve (key pad labeled "VENT VALVE").

4.3 SUBSTRATE HEAT CONTROL

1. Ensure that the chamber is in a state of high vacuum.

2. Turn ON the substrate rotation (key pad labeled "ROTATION POWER").

3. Set the temperature setpoint on the Omega temperature controller. Refer to the Omega manual for detailed instruction.

4. Turn ON the substrate heat power (key pad labeled "HEAT POWER").

4.4 ELECTRON BEAM SOURCE OPERATION

4.4.1 GUN CONTROL/XTC/2 SETPOINT CONTROL

1. Ensure that main chamber has been pumped to a state of high vacuum and that an appropriate charge of material(s) has been loaded into the Telemark 271 electron beam gun.

2. Turn ON main power push-button on the TT-3 and let the power supply warm up for a minimum of 2 minutes before continuing. To turn on the high voltage before may cause damage to the power supply.

3. Ensure that the Telemark TT control module has been configured for "REMOTE" filament current regulation mode. This configuration allocates emission control to the XTC/2. If the Telemark TT is configured for "manual" emission regulation, the XTC/2 is totally disabled and emission control is through the TT's front panel potentiometer. LOCAL

4. Select the appropriate crucible pocket manual crucible control for the Telemark 241 electron beam gun.

5. Manually input the program directly into the XTC/2. **Ensure that "Source 1" is input into the XTC/2 parameter!**

6. Enable substrate rotation (key pad labeled "ROTATION POWER").

7. CLOSE the Gun Shutter (key pad label "SHUTTER"). GUN

8. Select the chamber ionization gauge tube (key pad labeled "IG SELECT"; Note when the led is on, IG1 is selected) and turn on the gauge emission (turn off and then on the power to the MKS 290).

(REMEMBER: THE ST'S HIVAC INTERLOCK IS TIED TO THE IG1 SETPOINT!) TT-3

OF THE "VOLTAGE ADJUST" TO DESIRE LEVEL @ (6 KV)

9. Turn ~~ON the "Gun High Voltage/ "Filament"~~ located on the TT-3 power supply; ensure that the bias (refer to ~~ST~~ manual) is properly set.

TT-3/6

10. Manually (via START the XTC/2 via its' front panel, membrane-type, pushbutton) initiate the XTC/2 film program:

    - If XTC/2 rate control is desired, simply START the film program.

    - If Manual source setpoint control is desired, plug XTC/2 hand controller into the XTC/2 and place it in Manual mode (Remember: Placing the XTC/2 in manual mode will cause the source shutter to open immediately. To defeat this press the override feature (key pad labeled "XTC/2 SHUTTER ~~"OVERRIDE"~~).

OVERRIDE
VOLTAGE EMISSION

11. After the deposition has been completed turn OFF the "~~Gun High Voltage/Filament~~" located on the TT-3 power supply. Let the power supply cool down for a minimum of 2 minutes before turning OFF the main power push-button on the TT-3. To turn off the power supply before it is cooled down may cause damage to the power supply.

TURN THE "VOLTAGE ADJUST" KNOB TO ZERO. (COUNTER CLOCKWISE)

4.5 SERVICE MODE

To place the system into service mode (i.e., disable all software interlocks), position front panel keyswitch so the key cannot be removed.

~~XTC/2 SHUTTER~~

~~XTC/2 BYPASS~~

5. I/O LIST

INPUT

Number	Name	Description
%I0033		NOT USED
%I0034		NOT USED
%I0035		NOT USED
%I0036		NOT USED
%I0037		NOT USED
%I0038		NOT USED
%I0039	VACBEL	VACUUM BELLOWS SWITCH INPUT
%I0040	DOOR	CHAMBER DOOR SWITCH INPUT
%I0041	SKINS	SKIN SWITCHES INPUT
%I0042	GWATER	GUN WATER SWITCH INPUT
%I0043		NOT USED
%I0044		NOT USED
%I0045	XTCSHUT	XTC GUN SHUTTER CONTROL INPUT
%I0046	XTCBYIN	XTC SHUTTER BYPASS INPUT
%I0047	MAINT	MAINTENANCE MODE
%I0048		NOT USED
%I0049		NOT USED
%I0050		NOT USED
%I0051		NOT USED
%I0052		NOT USED
%I0053		NOT USED
%I0054		NOT USED
%I0055		NOT USED
%I0056		NOT USED
%I0057	TC1A	TC 1A SETPOINT INPUT
%I0058	TC1B	TC 1B SETPOINT INPUT
%I0059	TC2A	TC 2A SETPOINT INPUT
%I0060	TC2B	TC 2B SETPOINT INPUT
%I0061	IG1	IG 1 SETPOINT INPUT
%I0062	IG2	IG 2 SETPOINT INPUT
%I0063		NOT USED
%I0064		NOT USED

OUTPUT

Number	Name	Description
%Q0001	CP	CRYO PUMP OUTPUT
%Q0002	MP	MECH PUMP OUTPUT
%Q0003	CPPURGE	CRYO PUMP PURGE VALVE OUTPUT
%Q0004	CPREGEN	CRYO PUMP REGEN VALVE OUTPUT
%Q0005	HVAC	HIGHVAC VALVE OUTPUT
%Q0006		NOT USED
%Q0007	VENT	VENT VALVE OUTPUT
%Q0008	ROUGH	ROUGHING VALVE OUTPUT
%Q0009	MPPURGE	MECH PUMP PURGE VALVE OUTPUT
%Q0010		NOT USED
%Q0011		NOT USED
%Q0012		NOT USED
%Q0013		NOT USED
%Q0014	ROTPWR	ROTATION POWER OUTPUT
%Q0015	IGPWR	IG EMISSION POWER OUTPUT
%Q0016	GSHUT	GUN SHUTTER OUTPUT
%Q0049	TC	TC 3/4 SELECT OUTPUT
%Q0050		NOT USED
%Q0051	IGSEL	IG TUBE SELECT OUTPUT
%Q0052		NOT USED
%Q0053		NOT USED
%Q0054	MAINLED	MAINTENANCE MODE LED
%Q0055	HEATPWR	HEAT POWER OUTPUT
%Q0056		NOT USED
%Q0057		NOT USED
%Q0058		NOT USED
%Q0059		NOT USED
%Q0060		NOT USED
%Q0061		NOT USED
%Q0062		NOT USED
%Q0063		NOT USED
%Q0064	XTCBY	XTC SHUTTER BYPASS LED OUTPUT

6. "SOFTWARE" INTERLOCK STRATEGY

6.1 MKS 286 CONVECTRON SETPOINTS:

TC1A (Chamber):	User Defined
TC1B (Chamber):	1.5E-1 torr
TC2A (Cryopump):	1.0E-1 torr
TC2B (Cryopump):	5.0E-2 torr

6.2 MECHANICAL PUMP:

To turn on:	No interlocks
To turn off:	No interlocks

6.3 CRYO PUMP:

To turn on:

Cryo Pump Purge	CLOSED
Cryo Pump Regen	CLOSED
TC2B Setpoint	SATISFIED

To turn off:	No interlocks

6.4 CHAMBER ROUGH VALVE:

To open:

Chamber Door	CLOSED
Chamber Vent Valve	CLOSED
Mech Pump	ON
Chamber Hivac Valve	CLOSED
~~Chamber Hivac Bypass Valve~~	~~CLOSED~~
~~Gas 1 Valve~~	~~CLOSED~~
~~Gas 2 Valve~~	~~CLOSED~~
~~Gas 3 Valve~~	~~CLOSED~~
~~Gas 4 Valve~~	~~CLOSED~~
Cryo Pump Regen	CLOSED
"AUTOVENT"	OFF

To close:	No interlocks

6.5 CHAMBER VENT VALVE:

To open:

Chamber Door	CLOSED
Chamber Rough Valve	CLOSED
Chamber Hivac Valve	CLOSED
~~Chamber Hivac Bypass Valve~~	~~CLOSED~~
~~Gas 1 Valve~~	~~CLOSED~~
~~Gas 2 Valve~~	~~CLOSED~~
~~Gas 3 Valve~~	~~CLOSED~~
~~Gas 4 Valve~~	~~CLOSED~~
"AUTOPUMP"	OFF
"AUTOVENT"	OFF

To close: No interlocks

6.6 MECH. PUMP PURGE:

To turn on:

Mech. Pump ON

To turn off: No interlocks

6.7 CRYO PUMP PURGE:

To turn on:

Cryo Pump	OFF
Cryo Pump Regen	CLOSED
High Vacuum valve	CLOSED
~~High Vacuum Bypass valve~~	~~CLOSED~~

To turn off: No interlocks

6.8 CRYO PUMP REGEN:

To turn on:

Cryo Pump	OFF
Mech. Pump	ON
Cryo Pump Purge	CLOSED
High Vacuum valve	CLOSED
~~High Vacuum Bypass valve~~	~~CLOSED~~
Rough valve	CLOSED

To turn off: No interlocks

6.9 CHAMBER HI-VAC VALVE:

To open:

Chamber Door	CLOSED
Cryo Pump	ON
Cryo Pump Purge	CLOSED
Cryo Pump Regen	CLOSED
Chamber Vent Valve	CLOSED
Chamber Rough Valve	CLOSED
Mechanical Pump	ON
Vacuum Safety Bellows	SATISFIED
TC1B Setpoint	SATISFIED
TC2B Setpoint	SATISFIED

To close: No interlocks

6.10 ROTATION:

To turn on:

"AUTOVENT" OFF

To turn off: No interlocks

6.11 HEAT POWER:

To turn on:

Cryo Pump	ON
Rotation	ON
TC1B Setpoint	SATISFIED
Vacuum safety(*)	SATISFIED
Chamber door(*)	CLOSED
Gun Water Flowswitch(*)	SATISFIED
Heat Water Flowswitch(*)	SATISFIED
"AUTOVENT"	OFF

To turn off: No interlocks

6.12 SHUTTER:

To open:

"AUTOVENT" OFF

To close: No interlocks

6.13 SHIFT FUNCTION:

To turn on:

"AUTOPUMP"	OFF
"AUTOVENT"	OFF
"AUTOREGEN"	OFF

To turn off: No interlocks

6.14 AUTOREGEN:

To turn on:

"AUTOPUMP"	OFF
"AUTOVENT"	OFF
"MAINTENANCE"	OFF

To turn off: No interlocks

6.15 AUTOPUMP:

To turn on:

"AUTOREGEN"	OFF
"MAINTENANCE"	OFF
Chamber Door	CLOSED
"AUTOVENT"	OFF

To turn off: No interlocks

6.16 AUTOVENT:

To turn on:

"AUTOREGEN"	OFF
"MAINTENANCE"	OFF
"AUTOPUMP"	OFF

To turn off: No interlocks

7. TROUBLESHOOTING

7.1 INTRODUCTION

WARNING!

DUE TO THE NATURE OF HOW A VACUUM SYSTEM OPERATES, THERE ARE MANY TYPES OF VOLTAGES ON A VACUUM CHAMBER.

BEFORE ATTEMPTING ANY TYPE OF TROUBLE-SHOOTING ON THE VACUUM SYSTEM OR ANY SUBSYSTEM, REFER TO PROPER SECTION OF THE OPERATING MANUAL FIRST TO CHECK IF THE SYSTEM IS BEING OPERATED IN THE PROPER MANNER. THERE MIGHT BE AN INTERLOCK PARAMETER BEING OVERLOOKED, RATHER THAN A SYSTEM FAILURE.

7.2 BASIC TOOL REQUIREMENTS

NOTE ON JEWELRY

When working around a vacuum system,
there is one good practice,

DO NOT WEAR ANY JEWELRY!

AN ARC MAY BE DRAWN FROM A HIGH VOLTAGE SOURCE!

REQUIRED TOOLS	
DESCRIPTION	**USE**
Multimeter (Analog or Digital)	A - To Read A.C. or D.C. Voltage B - To Read low A.C. or D.C. current C - To Read OHMs of resistance
Hand-held Current Meter (Amp probe)	Clamps around an A.C. line to read current
H.V. Probe	Attaches to a multimeter so that very high voltages can be measured
Screw Drivers (Both +/- types)	For disassembly and assembly
Wrenches (Box type)	For disassembly and assembly 3/8" to 1" for most items
Allen Wrenches	For disassembly and assembly 1/16" to 3/8" for most items

7.3 VACUUM SYSTEM CONTROL RACK

Problem: No panel lights displayed, or no activation of subsystems when switch is toggled.

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

Solutions:

1. Check to see if there is 208V AC, 3 phase power at main breaker of vacuum system.
2. Turn on main breaker.
3. Turn on aux breaker.
4. Press green "START" button.
5. Check the fuse F2 for the 24 volt DC supply located in the Nema enclosure. Replace if blown.
6. Check the fuse F1 for the AC power to the DC power supply located in the Nema enclosure. Replace if blown.
7. Pull out 24 volt fuse from panel. Then, with voltmeter, check output terminals of +24 volts at power supply. These terminals can be found on the 24 volt supply P.C. board.
8. Check AC input on transformer of DC power supply to see if 120V AC power is present.
9. If there is 120V AC input power, but no 24V DC output, replace power supply.
10. If there is no AC power at this point, call Denton Vacuum (609-439-9100).

Problem: Panel light on, but no control of switches to pumps, valves and subsystems.

Causes: 24V DC Relay.

Solutions: Pumps, valves and subsystem are controlled by relay through PLC controller. Each relay is numbered. Check the relay according to the schematic so it is in position.

7.4 PLC CONTROLLER INPUT/OUTPUT

The program (software) installed into the PLC controller is set up so that when a key is toggled, it will send a signal to the PLC controller. And, if all interlock parameters are satisfied, the PLC controller will prompt a particular output. When the output is turned on it will activate the valve or subsystem which it is intended to turn on.

Problem: When a switch is toggled but the output assigned does not activate.

Causes:

1. Unsatisfied interlocks are stopping the outputs from activating.
2. No +24 volts DC to the relay.

Solutions for Cause 1:

1. If the key being pressed is to a subsystem, such as heat, make sure the interlocks are all satisfied and rotation is on.
2. If it is a valve key being pressed, make sure that the proper items are on and the proper items are off. For example, to activate the ROUGH valve, the MECH PUMP should be on and the HI-VAC and VENT valves should be off.

Solutions for Cause 2:

1. Using a multimeter, check to see if there is +24V DC present on the coil of 24V relay.

NOTE

KEEP IN MIND THAT THIS PART OF THE TROUBLESHOOTING MANUAL ASSUMES THAT THE POWER SUPPLIES ARE GOOD, BECAUSE THE FRONT PANEL LEDs ARE LIT AND THE INPUTS ARE RECEIVING A SIGNAL TO ACTIVATE THEM.

IF THIS IS NOT TRUE, THEN REFER TO THE FIRST PART OF THE TROUBLE-SHOOTING MANUAL FIRST TO DETERMINE IF THE POWER SUPPLIES ARE GOOD.

2. Check relay.

7.5 VALVES AND SHUTTERS

All the pumping valves and the source shutter on the vacuum system are pneumatically controlled.

The valve operation procedure is as follows:

There is a 24V DC signal from an output relay that feeds into a DC solenoid (electromagnetic) coil. The electromagnetic field created by the coil pulls up a "plunger valve" mounted to the air flow manifold. When this "plunger" is pulled up it permits air pressure (80 to 100 psi) to pass through the manifold into an air operated cylinder. The air pressure going into the air cylinder becomes greater on one side of the cylinder than on the other side. The side of the cylinder with the greater air pressure will move a "diaphragm" the opposite way. Depending on which way the "diaphragm" is travelling the valve is being opened or closed.

Problem: When the assigned output is activated the valve or shutter associated with it does not respond. But the panel indicator light turns green.

Causes:

1. No air pressure to the air manifold.
2. No power at valve or shutter solenoid.
3. Valve or shutter solenoid burnt out.

Quick Test: Before going on to the solutions for the above causes there is a quick way of diagnosing if an inappropriate valve has +24V DC and the solenoid is active:

Place a common size screw driver on top of the solenoid with the valve output on. If the screw driver is slightly magnetized to the top of the solenoid, the coil is good and there is most likely a mechanical problem such as no air or a stuck plunger. Remember this is only a quick test, **it is not 100% foolproof.**

Solutions for Cause 1:

A. 1. Check to see if there is 80 to 100 psi of air pressure to the vacuum system.

2. Check to see if the air lines are free of any water.

B. 1. Prove that there is air to the valve in question:

a. Each valve has two (white vinyl) air lines attached to it, one for air in and one for return. These air lines are attached by a special fitting that makes it easy to detach or reattach an air line. These special fittings are called "LEGRIS" fittings.

b. While holding one of the air lines firmly in your hand, push in the red collar on the Legris fitting, pull out air line while pushing the red collar of the Legris fitting inward.

NOTE: There might be 80 to 100 psi of air pressure on the air line. Make sure that you have a firm grip on it so it does not "whip" out of your hand.

c. While holding air line, activate and deactivate power to solenoid.

d. Air should flow out of the Legris fitting mounted in the air manifold when power is at one state, and air should stop flowing when the power to the solenoid is in the other state. " State" being ON or OFF.

e. Repeat steps 3, 4 and 5 for the second air line to see if it operates the same way.

f. If both Legris fittings operate with alternating air on and off, the problem is in the valve assembly itself.

2. Disassemble valve in question to see if there is any foreign matter lodged in it or if a seal is broken.

3. If the air flow coming out of the Legris fittings did not change from one port to the other, when the valve switch was activated or deactivated, then disassemble the Humphry solenoid attached to the top of the air manifold to see if that assembly is intact.

Solutions for Cause 2:

1. Locate the Humphry valve, attached to the air manifold, that is in question.

2. Open the black plastic enclosure that holds the wires connecting to the solenoid.

3. When the wires have been located, expose the connectors that join the power wires to the solenoid.

4. Place a volt meter across the wires at the crimp connectors.

5. Also disconnect the solenoid from the output leads and try to read +24V DC power at the ends of the two wires.

6. If there is NO power at the solenoid when the output is high, using the subsystem schematic and volt meter, trace the lines to see if there is a break in the signal path.

7. If there is power now that the solenoid is not attached, then the solenoid is shorted out.

8. Using an ohm meter, read the resistance of the solenoid. If the resistance is 00.0, then the solenoid is shorted out.

9. Replace solenoid, then try valve.

Solutions for Cause 3:

1. Disconnect solenoid from power leads.

2. Using an ohm meter, read the resistance of the coil.

3. If the coil is good, it should have a resistance of about 65 to 85 ohms ±10 percent.

4. If the coil reads infinity, then it is burnt out.

5. Replace the coil and try valve.

7.6 ROTATION

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

Causes:

1. Fuse blown.

2. Power to and/or from the motor controller is not active.

3. Mechanical jam-up.

Solutions for Cause 1:

1. Located in the power distribution enclosure, on the frame of the vacuum system, is an SCR Controller.

2. Shut power before step 3 is executed.

3. There is a fuse holder with a 1 amp fuse (FU-6).

4. Remove the fuse, check it. If blown, replace.

Solutions for Cause 2: A 1. Using a volt meter, measure the 120V AC power going into the controller.

2. If no power is present, trace the circuit using the rotation schematic and a volt meter.

Solutions for Cause 3: A 1. Check to see if the chain is too loose or too tight. If too loose, the motor will turn but the chain will not hold onto the gear so as to turn the planetary.

2. If the timing belt is too tight, the motor will not have enough torque to overcome the tension of the chain.

7.7 SUBSTRATE HEAT

7.7.1 SCR Controller

The silicon control rectifier (SCR) controller is a solid state device designed to control a large AC power level with a small DC control signal.

The input of the SCR has a 208 VAC input protected by circuit breakers to limit the current that will be seen by the SCR controller. As the DC signal to the gate of the SCR increases so does the output of the SCR controller. The SCR controller is about 95% efficient. This means for a given input the output voltage will achieve 95% of the actual input voltage. An SCR has a preset gain and span set on it. If these parameters are readjusted, it will limit the control range of the SCR either at the low end or the high end.

Beside being able to control the SCR with an external 0 to 10 Volt DC source, it can be controlled by an internal signal from its own source of power. This is done by removing the 0 to 10 DC signal from the "W" and "CCW" terminals, then attaching a (1 K ohm) pot to the "CW, W, CCW" terminals of the SCR. An SCR controller has one unusual property. If there is no "LOAD" attached to the output, the SCR will pass full voltage no matter where the DC control voltage is set.

Problem: No output from SCR.

Causes:

1. No control signal.
2. SCR device defective.
3. 24 VAC control transformer does not output 24 VAC.

Solution for Cause 1:

1. Measure control signal and check if it is 0 to 10 VDC.

Solutions for Cause 2:

1. With all wiring attached to the SCR, read the 0-10 VDC control signal to the SCR.
2. Prove that input control voltage is present.
3. Prove that the AC power voltage is present.
4. With heater coils connected to the output, place a voltmeter across the output terminals of the SCR.

> **NOTE**
>
> Insure that chamber is under vacuum to prevent coil embrittlement.

5. a. If there is a constant high voltage present, of 190 VAC, with very little or no change when the setpoint is changed, then the SCR is shorted out.
   b. Replace SCR module mounted to the heat sink.
6. a. If there is no voltage present at all, the SCR is burnt out and "open."

b. Replace SCR module.

Solutions for Cause No. 3

1. Check input voltage to 24 VAC transformer. It. shoud be 208 VAC.
2. If input voltage is present, check output voltage. It should be 24 VAC.
3. If output voltage is not present, substitute transformer.

7.8 SUMMARY

Troubleshooting procedures are the same whether it is a vacuum system, your home audio/visual system or an automobile.

Steps for troubleshooting are to be done in a logical order.

This manual reviews the most vulnerable parts of a vacuum system's operation. If a vacuum system is maintained properly, it will give many years of uninterrupted service.

When a vacuum system is constructed, there are many different vendor parts used in the vacuum system, everything from the pumps to the gas flow controllers. Each sub system is supplied with a manual of operation. Refer to these manuals for troubleshooting procedures on the individual equipment in question.

If after a reasonable time the problem cannot be found, call Denton Vacuum (609-439-9100) to help with the problem and help reduce down time.

11. PREVENTIVE MAINTENANCE

11.1 MECHANICAL PUMP

1. Check oil level daily.
   DO THIS WHEN PUMP IS OPERATING. However, do not add oil while the pump is operational.

2. Check the color of the oil monthly. Compare it with a sample of new oil. **IF THE OIL IS BROWN OR BLACK, IT HAS DETERIORATED. DRAIN THE PUMP AND CHANGE THE OIL.** See Troubleshooting section of the operating manual.

11.2 DEPOSITION CHAMBER

Ensure that no build-up of deposition material(s) occurs on the chamber walls and baseplate. Line chamber with disposable foil (degreased, heavy-gauge aluminum foil works well) and replace on a periodic (dependent on system use) basis.

11.3 CRYOPUMP COMPRESSOR

1. Check the pressure gauge on the compressor daily.
   Pressure needs to be 195 to 205 psig at ambient temperature. Check manual.

2. Check the cooling water temperature. The inlet should be a minimum of 40° F. (100° F. maximum) 2.5 gpm flow.

3. Replace compressor absorber every 4,500 hours. See Troubleshooting section of the operating manual.

11.4 CRYOPUMP

1. Check the temperature gauge daily.

   The reading should be 20K or less. Any temperature reading more than 20K is an indication of abnormal operation or that the pump requires regeneration. See Troubleshooting section of the operating manual.

11.5 PUMPING SYSTEM

1. Check the poppet valve assembly monthly.
   a) Bellows should be straight, not twisted.
   b) Movement of the poppet plate must be smooth and firm. If jagged, replace supporting bushing.

2. Check the soft connection between the mechanical pump and piping daily for damage.

3. Check all piping connections for looseness or damage weekly.

4. Check all air lines connected to the pneumatic valves for leaks or damage weekly.

SECTION 8

SPARE PARTS LIST

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SPARE PARTS LIST

VACUUM CHAMBER

JOB # **18097**

PART NO.	DESCRIPTION	LOCATION	QTY.	PRICE EA.
5015-453	O-RING	TOP FLANGE	1	$42.00
5015-347	O-RING	DOOR VIEWPORTS	2	14.95
5015-010	O-RING	DOOR SHUTTER ROTARY MOTION	4	1.00
5015-210	O-RING	DOOR SHUTTER ROTARY MOTION	2	1.00
5015-517	O-RING	DOOR	1	100.85
5015-218	O-RING	1.00 BLANK PORTS	10	1.00
G-275	COPPER GASKET	CHAMBER 2.75 CONFLAT PORTS	4	3.50
5106-004	SIGHT GLASS	DOOR VIEWPORT	1	82.55
5094-008	COMPRESSION SPRING	DOOR SHUTTER ROTARY MOTION	2	4.10

ALL PRICES SUBJECT TO CHANGE **MINIMUM ORDER $25** **FOB MOORESTOWN, NEW JERSEY** **02/97SW**

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PUMPING SYSTEM

JOB # **18097**

PART NO.	DESCRIPTION	LOCATION	QTY.	PRICE EA.
5015-466	O-RING	CHAMBER TO BASEPLATE	1	$62.50
5013-240	O-RING	VALVE BODY PORT	1	4.20
5013-257	O-RING	POPPET PLATE	1	1.60
5013-227	O-RING	POPPET VALVE	1	1.00
5015-326	O-RING	FLANGES - NW40	2	2.50
5015-116	O-RING	ION GAUGE TUBE COMPRESSION SEAL	2	1.00
5015-314	O-RING	FLANGES - NW16	4	2.00
5015-320	O-RING	FLANGES - NW25	6	2.25
5013-012	O-RING	1.12" VALVES	2	1.00
5013-215	O-RING	1.12" VALVES	2	1.00
5013-226	O-RING	1.12" VALVES	2	1.00
5015-172	O-RING	8.00" CRYOPUMP	1	27.50

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SPARE PARTS LIST

E-BEAM SOURCE & SHUTTER

JOB # **18097**

PART NO.	DESCRIPTION	LOCATION	QTY.	PRICE EA.
5015-218	O-RING	3/8" ROTARY FEEDTHROUGH	1	1.00
5015-012	O-RING	3/8" ROTARY FEEDTHROUGH	3	1.00
5015-013	O-RING	3/8" ROTARY FEEDTHROUGH	1	1.00
5015-216	O-RING	HIGH-VOLTAGE FEEDTHROUGH	2	1.00
5015-220	O-RING	DUAL WATER FEEDTHROUGH	1	1.15
5015-021	O-RING	OCTAL HEADER FEEDTHROUGH	1	1.00
B10-1	BEARING	3/8" ROTARY FEEDTHROUGH	2	36.50
A7-120	BEARING SHAFT	3/8" ROTARY FEEDTHROUGH	1	26.20
LC-063H-6-SS	COMPRESSION SPRING	3/8" ROTARY FEEDTHROUGH	1	5.25
5000-75	RETAINING RING	3/8" ROTARY FEEDTHROUGH	2	1.00

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HEATER

JOB # **18097**

PART NO.	DESCRIPTION	LOCATION	QTY.	PRICE EA.
2608	CERAMIC STANDOFF	HEAT FIXTURE	10	2.40
5103-007	QUARTZ LAMP	HEAT FIXTURE	1	115.00
9924006	IN-LINE CONNECTOR	HEAT FIXTURE	2	9.85

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SPARE PARTS LIST

ROTATION ASSEMBLY

JOB # **18097**

PART NO.	DESCRIPTION	LOCATION	QTY.	PRICE EA.
5015-252	O-RING	1.00 ROTARY FEEDTHROUGH	1	6.95
005-137000A	U-CUP SEAL	1.00 ROTARY FEEDTHROUGH	2	16.85
1641DC	BEARING - RADIAL	1.00 ROTARY FEEDTHROUGH	2	28.50
5000-200	RETAINING RING	1.00 ROTARY FEEDTHROUGH	1	1.00
5000-250	RETAINING RING	1.00 ROTARY FEEDTHROUGH	1	1.90
5100-100	RETAINING RING	1.00 ROTARY FEEDTHROUGH	1	1.00

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SPARE PARTS LIST

ELECTRICAL

JOB # **18097**

PART NO.	DESCRIPTION	LOCATION	QTY.	PRICE EA.
TC-1A	THERMOCOUPLE TUBE	PUMPING SYSTEM	1	130.00
5083-002	TUBE-ION	CHAMBER & CRYO PUMP	2	170.33
5108-004	TUBE-T/C DV-23	PUMPING SYSTEM	1	117.13
SH125	MOTOR CONTROLLER	CONTROL/POWER CABINET	1	322.76
MDA-5	FUSE 5 AMPS	CONTROL/POWER CABINET	10	2.60
BC6C-Y	CONTACTOR-24 VDC COIL	CONTROL/POWER CABINET	1	55.48
BZE6-2RN	SWITCH-MICRO	FRAME	1	93.81
1022FC	CIRCUIT-FIRING, SCR	CONTROL/POWER CABINET	1	141.44
G480D90R	RELAY-SOLID STATE	CONTROL/POWER CABINET	1	126.88
FNW-15	FUSE 15 AMPS	CONTROL/POWER CABINET	10	5.28
Bil5U-CP40-VP4X2	SENSOR (U-PROX)	FRAME (WATER CIRCUIT)	1	318.24
MDA-10	FUSE 10 AMPS	CONTROL/POWER CABINET	5	5.85
B6C-1	CONTACTOR 120VAC	CONTROL/POWER CABINET	1	45.55

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9. ELECTRICAL SCHEMATICS

LOCATED IN BINDER

10. MECHANICAL DRAWINGS

LOCATED IN BINDER