GENxplor™ MBE SYSTEM

User Manual

P/N 1222036 Rev 02
May 2015

Preface

Scope

The GENxplor Molecular Beam Epitaxy (MBE) system is used to make compound semiconductor materials with great precision and purity. When these semiconductor materials are layered on each other, they form semiconductor devices that are used in a variety of applications, such as fiber-optics, radar systems, solar cells, and display devices.

The preface defines the intended audience and describes how to make best use of the information in is manual. This preface also outlines the document conventions, safety hazards, pertinent technical support information, and a process for the customer to offer any technical feedback that could improve this manual.

Products Covered

This manual covers the following Veeco systems:

- GENxplor MBE System (referred to as GENxplor in this manual)

If you have a different Veeco system, please contact us using the Technical Support information to receive the correct manual.

Intended Audience

This manual is intended for trained molecular beam epitaxy (MBE) professionals, technicians, and persons under the direct guidance of such individuals.

If you are not among these groups, do not attempt to use the information in this manual to operate the equipment.

This manual is written in the English language, regarded as the language spoken and used worldwide, even on the Internet. This manual presents information for persons who understand the English language. If any end user (customer) does not understand the English language, it is the customer’s responsibility to translate the textual content in the manual into their desired language.

CE Marking

Veeco declares that this product (the GENxplor MBE System) conforms to the specifications outlined in the EMC Test Report and the Safety Test Report. The product also meets the requirements of the applicable EC directives.

For the **EMC Directive** 2004/108/EC, the GENxplor MBE System conforms to the following test specifications:

	Test Specifications
Emissions	EN55011: 2009+A1: 2010,
	EN61000-3-2: 2006+A2: 2009, EN61000-3-3: 2013
Immunity:	EN61000-6-2: 2005
	EN61000-4-2: 2009, EN61000-4-3: 2006+A2: 2010,
	EN61000-4-4:2012, EN61000-4-5: 2006, EN61000-4-6: 2009,
	EN61000-4-8: 2010, EN61000-4-11: 2004

For the **Machinery Directive ANNEX I of 2006/42/EC**, the GENxplor MBE System conforms to the following test specification:

	Test Specifications
Safety:	EN 60204-33:2011

TELEMARK Declaration of Conformity

The Electron Beam (E-Beam) source is an optional component on the GENxplor MBE System. Veeco declares that the E-Beam conforms to the specifications outlined in the EMC Test Report and the Safety Test Report. The product also meets the requirements of the applicable EC directives.

TELEMARK

DECLARATION OF CONFORMITY

Telemark
1801 SE Commerce Avenue
Battle Ground, WA 98604, USA

Declares that the products

Product Name:	TT Series High Voltage Power Supply
Model Number(s)	Cheetah TT-3/6/8/10/15 and Cheetah TT-6/8/10/15/20E Incl. Analog X-Y Beam Sweep Module or Digital X-Y Beam Sweep Module and Filament Transformer in protective Metal Enclosure

Conform to the following specifications:

EMC: 61326: 2013

Standard	
EN61326-1	Class A: EMC Requirements
EN50081-2	Electromagnetic Compatibility Emissions
EN50082-2	Electromagnetic Compatibility Immunity
EN61326-1/IES 61000-4-2: 1995	Electrostatic Discharge Immunity
EN61326-1/ENV50140	Radiated Susceptibility Test
EN61326-1/IES 61000-4-4: 1995	Electrical Fast Transit/Bursts Immunity
EN61326-1/ENV50141	Conducted RF Susceptibility
EN61326-1/IEC 61000-4-8: 2001	Power Frequency Magnetic Field Immunity

Safety	
EN61010-1:2010	Safety Requirements: General Requirements

Supplementary Information:

The product described complies with the requirements of the Low Voltage Directive 2006/95/EC and the EMC Directive 2004/108/EC and carries the CE Marking accordingly.

CE

Gerald G. Henderson, President
Battle Ground, WA, August 2014

Using This Manual

To make best use of this manual:

- **Read the entire manual first.** Do not attempt to operate or perform maintenance of any kind on the system before you have thoroughly reviewed this manual.
- **Pay close attention to all safety information!** All MBE applications include inherent hazards and require strict adherence to safety standards. Read *Operator Safety* in this preface for critical safety information. Also see *Safety Hazards* in this preface to learn how safety hazards are indicated in this manual.
- **Use this manual as a tool for putting your own knowledge into practice.** This manual does not cover the theory, principles, or best practices for any particular MBE application. It aims to provide useful information to help you achieve your own objectives.
- **Remember that the GENxplor is highly configurable.** It is not possible to address all aspects of all configurations in a single manual. If you are not finding the information you need, please consult *Additional Resources* in this Preface, or contact us using the *Technical Support* information.
- **Refer to all graphics in context.** The graphics in this manual may not exactly match your system. Graphics are intended to illustrate only the features relevant to the topic at hand. Any optional, configurable, or missing features are identified, if contextually relevant.

Document Conventions

Safety Hazards

The following formats are used to communicate safety hazards. Where applicable, additional hazard-specific symbols may accompany these formats.

WARNING— HAZARD SUMMARY. Indicates a hazard that, if not avoided, may result in injury or death to personnel, or long-term adverse effects on health.

CAUTION— Indicates a hazard that, if not avoided, may result in damage or destruction of equipment.

Notes, Tips, and Important Messages

The following formats are used for various types of information that do not directly pertain to hazards.

NOTE—Indicates additional explanatory information.

TIP—Indicates a suggestion to help you perform a task successfully or understand something better.

IMPORTANT— Indicates essential information that must be considered or acted upon.

Additional Resources

This manual is just one part of a complete documentation package for your system.

Please refer to your system Technical Documentation package for:

- Component user manuals (for sources, electronics, subsystems, and other miscellaneous components)
- Source QAC Specification Sheets
- Electrical diagrams
- System interlock flow charts
- System bill of materials (BOM)

You will find Software Help for the programs listed below on your process control computer, and also on the backup software installation CD provided for the system.

- Molly® Growth Control software

IMPORTANT— For components not manufactured by Veeco (pumps, gauges, valves, etc.), always consult the original equipment manufacturer (OEM) manual.

Technical Support

For technical assistance or questions, please use the contact information below.

Veeco Instruments, Inc.
4875 Constellation Drive
St. Paul, MN 55127
U.S.A

Phone: +1 (651) 482-0800
Fax: +1 (651) 482-0600
Hours: Monday – Friday, 8 a.m. – 5 p.m. CST

Documentation Feedback

Veeco strives to continuously improve its technical publications. If you find errors, omissions, or inconsistencies in this manual, please contact Veeco Technical Support and describe the problem.

Your feedback is appreciated.

Version History

Revision	ECO	Date	Submitter	Description of Changes
01	-	8/13	TEW	Initial draft
02	-	5/15	TC	Second draft

Notices

Veeco has no control over how the system will be used for research or production purposes, and is not responsible for personal injury or damage resulting from such use. It is the sole responsibility of users of the system to comply with all local, state, and federal safety laws and regulations applicable to the system.

The content of this publication is subject to change without notice. Veeco Instruments, Inc. reserves the right to make product-improvement changes which may or may not be reflected in this publication. Veeco Instruments, Inc. is not responsible for any inadvertent omissions or errors. Veeco Instruments, Inc. assumes no liability for damages arising out of, or in connection with, the application or use of any product or application described herein.

This manual does not describe or constitute any commitment, agreement or relationship between Veeco Instruments, Inc. and the customer. Please refer to the sales contract for warranty terms and obligations.

If the customer alters the system, the customer assumes responsibility for safety, installation, and operation issues, and all other items pertinent to conformance to standards.

Veeco accepts no responsibility for failure to follow the safety information included in this manual, or failure to comply with all applicable health, facility, and safety guidelines.

Table of Contents

About This Manual

Chapter 1: Facility Requirements

This chapter establishes the requirements needed to prepare the customer's facility for installation. It is the customer's responsibility to provide an acceptable installation site.

Chapter 2: Safety

This chapter provides the safety precautions to ensure everyone understands the safety guidelines needed to operate the GENxplor MBE system. This chapter also provides the instructions that are needed to work safely in the laboratory, including instructions for appropriate personal protected equipment, safety precautions, and potential hazards, compliance with the Environmental Health and Safety (EHS) guidelines.

Chapter 3: System Description

This chapter provides a brief functional summary of the entire system, followed by more detailed descriptions of the main components. This chapter also contains graphics, tables, and instructions about the GENxplor MBE system. After reading this chapter, the end user will have acquired more knowledge, outside of professional training, while they become acquainted with the system.

Chapter 4: Operation

This chapter defines the procedures for effective operation of the GENxplor MBE system. and covers some of the most common operational procedures for the GENxplor, including system start-up, system shutdown, emergency and restoration, understanding system interlocks, which involves using the system software. This chapter also provides procedures to load and transfer platens into and from the GENxplor system.

Chapter 5: Maintenance

This chapter provides the maintenance procedures that are necessary to prevent a major accident or hazard. The GENxplor MBE system requires scheduled routine, preventive, corrective maintenance procedures that must be completed within applicable regulatory requirements. Included in this chapter are general maintenance and repair procedures, general calibration and test procedures, and a list of approved lockout/tagout (LOTO) devices to ensure personal safety.

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Chapter 1 Facility Requirements

Introduction

NOTE—To view the detailed facility requirements for the GENxplor MBE System, refer to:

Doc Number	Title
1219288, Rev A	MBE Facility Requirements Master

This chapter discusses the installation preparation requirements that must be completed before installing the GENxplor system at the customer's facility. Review the information in this section to ensure the site is prepared prior to installation, which could, but may not require all of the following requirements:

- Transportation and storage
- Installation altitude
- Upon receipt of the GENxplor system
- Power requirements
- Physical environment and operating conditions
- Vibration, shock, and bump
- Provisions for handling

Facility Requirements

Before the GENxplor system can be installed at the customer's facility, the customer must be made aware of several requirements that must be met to avoid unnecessary delay during the installation process.

Transportation and Storage

Each GENxplor system crate is designed to fit through the doorways, hallways, and into their new places properly. Large components are disassembled to make them easier to ship. After testing the equipment, components are emptied of any contents. All boxes and crates are clearly labeled with the customer's name and shipping destination. All hinged doors are taped shut. Cables and hoses are packaged separately.

The installation site for the GENxplor system must be capable of withstanding temperatures from -25 °C to +55 °C and for short periods not exceeding 24 hours, +70 °C, and relative humidity from 10% to 90%.

Installation Altitude

The GENxplor system is a sealed pressurized system All operators and maintenance personnel must be provided with sufficient training on the safety systems of the facility in which the GENxplor is to be operated, including hazard-monitoring equipment, risk mitigation policies, contingency planning, and emergency response protocol.

All operators and maintenance personnel must also be provided with all necessary “right to know” information with regard to hazardous substances used in the facility.

Upon Receipt of the GENxplor System

Before shipment to the customer’s site, each GENxplor system is subjected to demanding factory tests. Carefully inspect the shipping container for damage that may have occurred in transit. Then unpack the shipping containers and carefully inspect the unit for any signs of damage. Save the shipping container for future transport of the GENxplor system.

In the event of damage, please contact and file a claim with the freight carrier involved immediately.

If the equipment is not going to be put into service upon receipt, cover and store the GENxplor system in a clean, dry location. After storage, ensure that the equipment is dry and that no condensation has accumulated on the GENxplor system before applying power.

Power Requirements

The GENxplor MBE electrical rack is equipped with a single electrical distribution panel. This panel distributes power for the process and bake functions of the tool. The distribution panel is equipped with a 200A breaker protected by a low voltage trip circuit and EMO (emergency machine off) interrupt buttons.

Input and output power wiring to the GENxplor system should be performed by authorized personnel in accordance with the local electrical codes and regulations.

Verify that the power source to which the GENxplor system is to be connected is in agreement with the nameplate data on the equipment. A fused disconnect switch or circuit breaker should be installed between the GENxplor system and its source of power in accordance with the local electrical codes and regulations. All equipment must be installed in accordance with the electrical schematics provided by Veeco.

WARNING— Failure to connect the GENxplor system components according to the system wiring diagram could result in equipment damage, injury, or death.

Emergency Backup Power Systems

It is recommended that the customer implement an emergency power backup system to prevent downtime and damage to the MBE system as a result of common power problems including power failures, power sags, power surges, brownouts, line noise, high voltage spikes, frequency variations, switching transients, and harmonic distortion. Power outages can occur when least expected and power quality can be erratic. These power problems have the potential to corrupt critical data and damage hardware, causing hours of lost productivity and expensive repairs.

The MBE system should be connected to a three-phase continuous duty, on-line, solid state uninterruptible power supply (UPS) to safely eliminate the effects of power disturbances and guard the integrity of the equipment. The UPS shall operate in conjunction with the existing building electrical system to provide power conditioning, back-up and distribution to the electronics rack. Where there is a high risk of power outages lasting longer than the UPS battery runtime, it is highly recommended to incorporate a generator into the backup power system to automatically take over the task of float charging the UPS batteries until utility power is restored.

Use of an Isolation Transformer

A site-specific transformer is required in any non 200V three-phase facility. Facilities that do not have nominal 200V three-phase power available are required to provide an isolation transformer.

Electrical Service Disconnect

To ensure ready power hookup to the Veeco system at installation and promote safe maintenance to the tool, an electrical service disconnect is required in the lab within visual range of the tool for each electrical hookup. The electrical service must be installed up to the point of the service disconnect prior to when the system ships such that the customer's electrician need only route the power connections from the service disconnect box to the respective electronics rack distribution panel.

Veeco recommends installing electrical services sized for the full load rating of the equipment panel board as listed below. However, for economical purposes, it is common practice to install the electrical service sized appropriately for the actual equipment loads (using overcurrent factors) versus the full load rating of the equipment panel board. This is allowable per national electric code provided overcurrent protection is made available in the form of line breakers or fused disconnects. For downsized service applications, consult the factory and your electrical contractor for aid in selecting an appropriate electrical service rating for your specific system configuration to ensure the system is not underpowered.

Use of RFI Modules

The electronics has passed conductive and RF radiation CE emissions tests at the factory without the use of RFI filters, but if the customer's utility power is “noisy” then the equipment may not pass the CE emissions requirement. In this case RFI hardware would need to be installed by the facility to provide a clean power source to the electronics.

Electrical Specifications

Electrical Service #1 [Process] electrical service input:

- 208 VAC / 50-60 Hz / 200 A / 3 Ø / ? load / 3 Pole (4-wire grounding; no neutral)
- Voltage range: 208V ± 10%.
- Voltage regulation: nominal input voltage +/- 3%.
- Frequency: 50/60 Hz ± 5%

A site-specific transformer is required in any non 200V 3-phase facility for each electrical service.

Typical Power Consumption (excludes compressors):

- Normal Operation: 15-20 kVA
- Bake Operation: 20-25 kVA

NOTE—the use of (optional) cryopumps adds an additional 2.5 kW load per 8200 compressor and 5 kW load per 9600 compressor.

Compressor Power: Receptacles are provided in the electronics rack for power connection to the compressors. Although the use of a remote power source for the compressors is possible, it is recommended to connect them directly into the rack so that they are on the EMO (emergency off switch), vacuum and safety interlock circuit, and also UPS power (when the rack is supplied with UPS power.) For remote location applications where a remote power source is desired, a 208V, 3-phase, 20-amp service should be provided for each cryopump compressor. A connector should also be provided for each compressor to accept a 24 VDC control signal from the EMO interlock to switch compressor power off upon EMO activation. Additionally, the remote power source to the compressors should be on a UPS to maintain system vacuum during power outages. Connection: A 26 foot [8 m] power cable is provided as standard with the compressors for connection into the rack. For remote location applications where a longer cable is needed, the required must be specified in the purchase order agreement.

Auxiliary Equipment Power: Receptacles are provided in the electronic racks for power connection to auxiliary or optional systems such as the Phosphorous Recovery System and the CBr_4 Gas Delivery System.

Backing/Rough Pump Power: Mechanical backing pump(s) (e.g. Varian dry scroll vacuum pumps) are provided with the system; they are used for rough evacuation purposes and for backing support to the turbo pumps. These pumps are typically located on the lab floor directly beneath their respective hookup point and are powered from the electronics rack.

Fluid Utility Requirement

The GENxplor system requires cooling water, nitrogen gas and compressed gas (air or nitrogen). Fittings with which to terminate the fluid utility drops in the lab are provided by Veeco and are shipped to the customer prior to system shipment. The pre-installation of these utility drops and termination fittings provides ready connection of the system to the fluid utilities at installation, which is necessary to avoid start-up delays. The individual specifications are listed as follows.

Air Supply: uninterruptible

Pressure: regulate to 80-100 psi [5.5-6.9 bar] for gate valve pneumatics.

- (Additional 60 psi [4 bar] regulation is provided on system for source shutter actuators)
- (Additional 10 psi [0.7 bar] regulation is provided on system water purge)

Flow: 2 cubic ft/min [1 L/s] minimum

Particulate: 0.1 micron filter

Purity: dry and oil free

Connection: Customer's facility should be equipped with a 1/4" FNPT fitting to accept the Veeco supplied quick-connect fitting. The system is provided with a 20-foot [6 m] flexible hose with the mating quick-connector.

Ultra High Purity N2

For use as a clean and dry low-pressure backfill gas when returning modules to atmospheric pressure conditions.

Pressure:

- 10-120 psi [0.69-8.3 bar] (3-5 psi [0.21-0.35 bar] regulation is provided on system)
- Flow: 2 cubic ft/min [1 L/s] minimum
- Particulate: 0.1 micron filter
- Purity: 99.99% (Grade 4) or greater
- Connection: Customer's facility should be equipped with a 1/4" FNPT fitting to accept the quick-connect fitting provided by Veeco. The system is provided with a 20-foot [6 m] flexible hose with the mating quick-connector.

General Cooling Water Specifications

Process water is required to cool various components on the Veeco system. A coolant containing corrosion inhibitors and bio-cidal additives to minimize the negative effects of corrosion and prevent the growth of microorganisms should be used. Because certain additives can be detrimental to pump seals, it is highly recommended to use a bath fluid and bio-cidal additive designed specifically for recirculating water-cooled systems (such as the 'Thermal' bath fluids and 'Aqua-Stabil' bio-cide products from Julabo, Inc.). As an alternative, use steam-distilled water as the primary coolant with high quality corrosion inhibitor and bio-cidal additives.

Veeco does not recommend using tap water for filling the water-cooling system. First, the pH of tap water is typically acidic and will accelerate the corrosion processes. Second, dissolved minerals in tap water may precipitate out of the solution and/or combine with other materials in the system to coat wetted heat transfer surfaces leading to reduced heat transfer efficiency or blocked flow. Third, high total ionized solids can accelerate the rate of galvanic corrosion. These contaminants can function as electrolytes, which increase the potential for galvanic cell corrosion and lead to localized corrosion such as pitting, and if excessive can form leaks. Fourth, high water hardness produces scaling (Calcium and Magnesium deposits). Fifth, organic material in the tap water is a food source for algae and other microorganisms. Last, trace quantities of various microorganisms

in tap water may flourish inside the cooling system, eventually leading to bio-fouling and reduced heat transfer or blocked flow and a total water cooling system failure. Higher concentrations of hydrogen ions (acidic solutions) promote oxidation (corrosion). Therefore, we generally want to be on the alkaline side of pH to help minimize corrosion issues. Maintaining a mildly alkaline pH around 8.0 will also help deter the growth of biological organisms, as most bacteria, algae, and fungi prefer slightly acidic growing environments. High quality corrosion inhibitors often contain pH buffers, which help maintain an alkaline pH and prevent the coolant from becoming acidic. Over time, the water will become slowly acidic as the pH buffers in water additives become depleted, and therefore periodically need to be replaced.

CAUTION— Chlorine is particularly corrosive to stainless steel. To prevent aqueous corrosion of the austenitic grades of stainless steel used in the system components by the processes of Chloride Crevice Corrosion and Chloride Stress-Corrosion Cracking, chlorides should not be used in the water-cooling system. Alternate forms of bactericidal water treatment additives should be used. [In cooling applications where bio-fouling has occurred, liquid chlorine bleach may only be used for short periods of time at low concentration to kill algae, bacteria and other microorganisms in the water cooling system, and then the system should be drained and repeatedly flushed until all traces of chlorine bleach have been thoroughly removed.]

CAUTION— Deionized (DI) water is extremely corrosive to metal piping and is not recommended. Never use actively deionized water in the cooling system. (The occasional use of DI water to fill the cooling system is probably okay. The water will immediately strip ions away from the surfaces of all wetted metals, but equilibrium will be shortly attained.)

System Process Cooling Water Specifications

Several components on the MBE system (sources, C.A.R. and TSP shroud) require water-cooling. These components connect to a manifold that distributes water to the various components. A single facility water source is required to supply the manifold with water.

- Supply Pressure: regulate to 25-40 psi [1.72-2.76 bar]
- Return back pressure: 5 psig [0.35 bar] maximum
- Flow Rate: 3-4 gpm [11-15 L/min]
- Temperature: maintain inlet above lab dew point (60°-75°F) [15-25°C].
- Heat Load: 1 kW (this will vary depending on the number of sources in use and the temperatures at which they and the CAR heater are operated)
- Particulate: supply filtered to 10 microns.
- Hardness: 60 ppm maximum (calcium & magnesium carbonates)
- Silica: 60 ppm maximum
- TDS (total dissolved solids): 800 ppm maximum
- pH Value: maintain slightly alkaline solution between 7.5 – 8.5 pH
- Conductivity: less than 2000 Microohms/cm
- Corrosion: use corrosion inhibitors to minimize the negative effects of corrosion. (Nitride Borate or sodium nitride is common.)
- Biocides: use non-chloride based biocidal additives (bacterialcide, algaecide) to kill microorganisms and prevent their growth.
- Supply Connection: Customer’s facility should be equipped with a 1/2” FNPT fitting to accept the quick-connect fitting provided by Veeco. The system is provided with a 20-foot [6 m] flexible hose with the mating quick connector
- Return Connection: Customer’s facility should be equipped with a 1/2” FNPT fitting to accept the quick-connect fitting provided by Veeco. The system is provided with a 20-foot [6 m] flexible hose with the mating quick connector
- Purge Drain Connection: Veeco will provide a 20-foot [6 m] 1/4” I.D. open ended flexible drain hose. The means of connection to facility drain is left to the customer’s discretion.

Source Cryopanel Cooling Water Specifications

In certain growth applications cryogenic cooling of the source cryopanel is not required. In these cases the source cryopanel may be water-cooled. If this option is desired it must be communicated to Veeco and specified in the purchase order agreement.

Contact Veeco before using water as an alternate coolant in the cryopanel.

The source cryopanel may be cooled with house water or chilled water. Normally house water (around 10-15°C) is used to cool the panel, so distilled water along with some corrosion inhibitors and biocidal additives to minimize the corrosion of metal parts and prevent the growth of biological organisms in the cooling system is used.

For applications where cooling below the freezing point of water is desired, some type of antifreeze additive is required to lower the freezing point of the water-based coolant. It is common to use methanol (methyl alcohol) and/or glycol for freeze protection. A mixture of 70% water and 30% methanol will roughly provide freeze protection down to –30°C. An added benefit is that methanol, even in relatively low concentrations, is an effective general purpose biocide. Glycol based coolant also provides good freeze protection. A 50% glycol/water solution provides freeze protection to –30°C.

CAUTION— Do not use automotive antifreeze. Commercial antifreeze is not recommended as it is formulated for a high level of aluminum corrosion protection through the addition of silicates and other supplemental coolant additives (SCA's) that may be detrimental to pump seals in water cooling systems. Instead, it is recommended to use a mixture of pure glycol and water along with corrosion inhibitors and biocide additives.

CAUTION— If there is a loss of coolant flow through the cryopanel, stagnant water remaining in the cryopanel may overheat causing serious damage to equipment and personnel. An overpressure safety relief valve should be installed and directed to a facility drain. Additionally, for safety interlocking purposes, Veeco recommends that a flow switch should be used. Veeco should be contacted for recommendations on incorporating this into the safety interlocking scheme.

- Supply Pressure: regulate to 20-25 psi [1.4-1.7 bar]
- Return Backpressure: 5 psig [0.3 bar] maximum
- Overpressure Safety Relief Valve: 40 psi [2.8 bar]
- Flow Rate: 1-2 gpm [3.8-7.6 L/min]
- Temperature: maintain inlet above lab dew point (60°-75°F) [15-25°C].
- Heat Load: 1 kW (this will vary depending on the number of sources in use and the temperatures at which they and the CAR heater are operated)
- Particulate: supply filtered to 10 microns.
- Hardness: 60 ppm maximum (calcium & magnesium carbonates).
- Silica: 60 ppm maximum

- TDS (total dissolved solids): 800 ppm maximum
- pH Value: maintain slightly alkaline solution between 7.5 – 8.5 pH
- Conductivity: less than 2000 Microohms/cm
- Corrosion: use corrosion inhibitors to minimize the negative effects of corrosion. (Nitride Borate or sodium nitride is common.)
- Biocides: use non-chloride based biocidal additives (bacterialcide, algaecide) to kill microorganisms and prevent their growth.
- Supply Connection: Customer’s facility should be equipped with a 1/2” FNPT fitting to accept the quick-connect fitting provided by Veeco. The system is provided with a 20-foot [6 m] flexible hose with the mating quick-connector.
- Return Connection: Customer’s facility should be equipped with a 1/2” FNPT fitting to accept the quick-connect fitting provided by Veeco. The system is provided with a 20-foot [6 m] flexible hose with the mating quick-connector.
- Purge Drain Connection: Veeco will provide a 20-foot [6 m] 1/4” I.D. open-ended flexible drain hose. The means of connection to facility drain is left to the customer’s discretion.

Cryopump Connection to Compressor

Veeco will provide a set of 25-foot [7.6 m] compressed Helium flex lines and a cold head power cable for each compressor supplied with the system. The standard configuration places the compressors in a service chase directly behind the electronic racks. Longer length requirements (for remote location) must be communicated to Veeco and specified in the purchase order agreement.

Veeco recommends the electrical service input for the cryo compressor:

- 208 VAC / 50-60 Hz / 200 A / 3 Ø / ? load / 3 Pole (4-wire grounding; no neutral)
- Voltage range: 208V ± 10%.
- Voltage regulation: nominal input voltage +/- 3%.
- Frequency: 50/60 Hz ± 5%

The voltage rating is site-dependent (North America or International). The rating plate typically determines the voltage and wattage of the equipment. The cryopump is equipped with a conversion device that enables the customer to convert the compressor to use 208 volts or 220 volts. The electricity frequency for domestic (United States) use is 60 Hz (cycles). The electricity frequency for most foreign countries use 50 Hz (cycles).

The following figure shows the two conversion switches on the cryopump.

Conversion switches
on the cr yo pump

220V/208V Switch on Cry-Compressor

Physical Environment and Operating Conditions

Before the GENxplor system can be installed, the installation site must consider and meet all environmental protection, occupational health and safety standards, which includes, but are not limited, to the following:

- Electrical hazards
- Chemical and biological hazards
- Thermal hazards
- Radiological hazards
- Physical/mechanical hazards
- Pressure/vacuum hazards

- Suffocation hazards
- Personal Protective Equipment (PPE)

It is the customer's responsibility to contract with a support service capable of transporting, handling, and disposal of hazardous material.

Vibration, Shock, and Bump

The floor must be a safe flat surface. Effects of vibration, shock and bump (including those generated by the fabrication equipment and those created by the physical environment) that can result in a hazardous situation shall be avoided by the selection of suitable electrical equipment, by mounting it away from the source of disturbance, or by provision of anti-vibration mountings.

Provisions for Handling

The GENxplor system is proportionally large in size. In order to ship the system to the installation site, several components, such as the electronics rack distribution panels, are disconnected from the system and placed inside wooden crates with a skid base, which are liftable flat transport structures. Each crate is designed to eliminate damage while the system is being shipped to the installation site. All crates can be moved with a forklift truck.

Some equipment is placed on a pallet and secured with strapping and/or shrink wrap. The smaller pallets can be lifted by a forklift truck, pallet jack or other jacking device. The largest shipping containers for the GENxplor system must be moved using a forklift truck, which is a powered industrial truck used to lift and move heavy materials short distances.

The physical characteristics of the largest shipping crate for the GENxplor system is:

Table 1: Crate Weight and Dimensions

Weight (Est. max.)	4750 lb (2155 kg)
Dimensions	Length: 99 in. (251.46 cm)
	Width: 94 in. (238.76 cm)
	Height: 103 in. (261.62 cm)

GENxplor System Shipping Crate -- Typical

System Dimensions (Uncrated)

All uncrated items must be able to be moved through an entrance in the laboratory and fit in the space intended for installation. Having enough clearance to move all uncrated items to the install location is the customer's responsibility.

GENxplor System (Front Elevation)

The GENxplor system (front elevation) dimensions are shown in Figure 1-1.

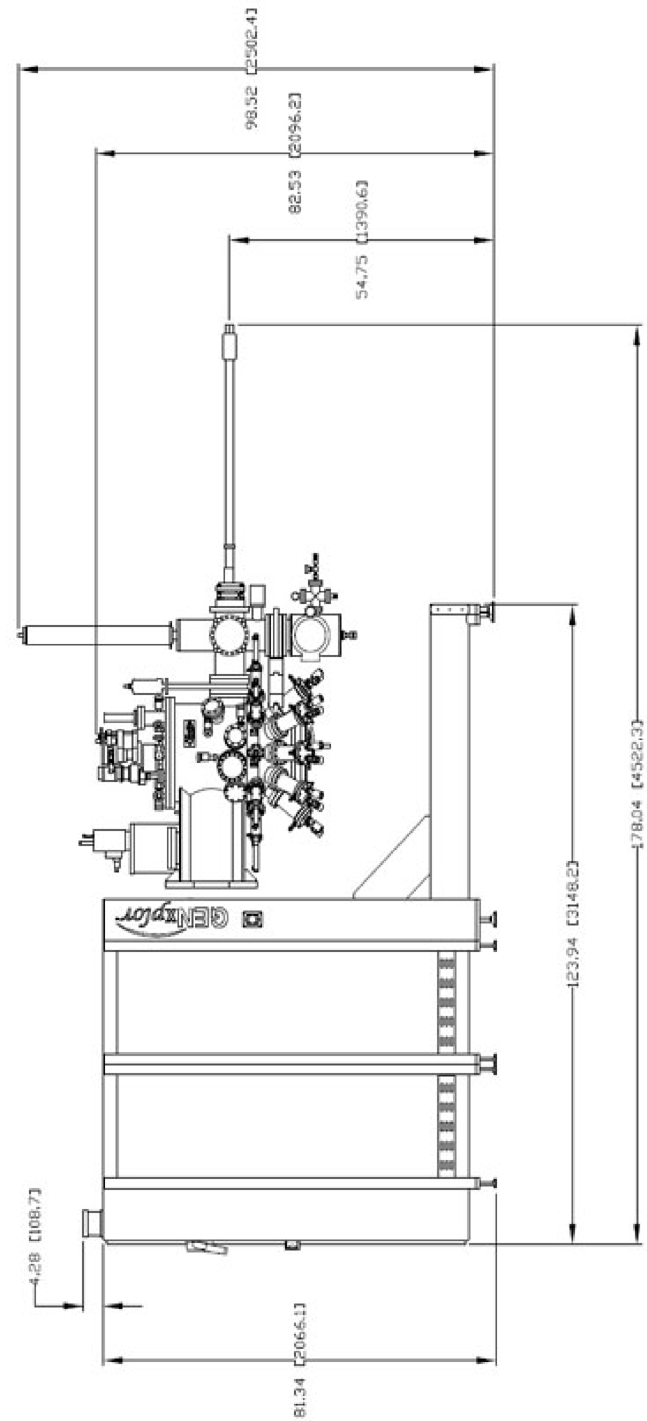


Figure 1-1. GENxplor System (Front Elevation)

For clearance and moving purposes, the two relevant GENxplor system (front elevation) dimensions are specified in the following table:

Table 2: GENxplor System - Front Elevation Dimensions

Specification	Dimension
Length:	178.04 in. (4522.3 mm)
Height:	98.52 in. (2502.4 mm)

GENxplor System (Side View, Manipulator Elevation)

The GENxplor system (side view, manipulator elevation) dimensions are shown in Figure 1-2. and the table below.

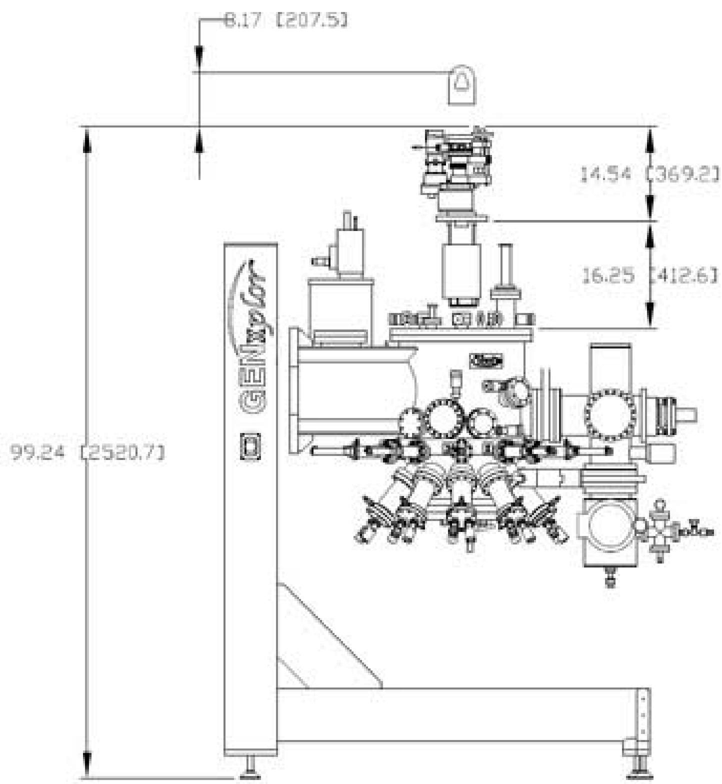


Figure 1-2. GENxplor Dimensions (Side View)

Table 3: GENxplor System - Side View, Manipulator Elevation

Specification	Dimension
Manipulator Height:	31.0 in. (787.4 mm)
Overall Height:	99.24 in. (2520.7 mm)

Cryopump (Side View, Full Elevation)

The GENxplor system is equipped with a cryopump. For clearance, moving, and maintenance purposes, the overhead space (ceiling) requirement to lift and remove the cryopump completely out of its base is shown in Figure 1-3 and the table below.

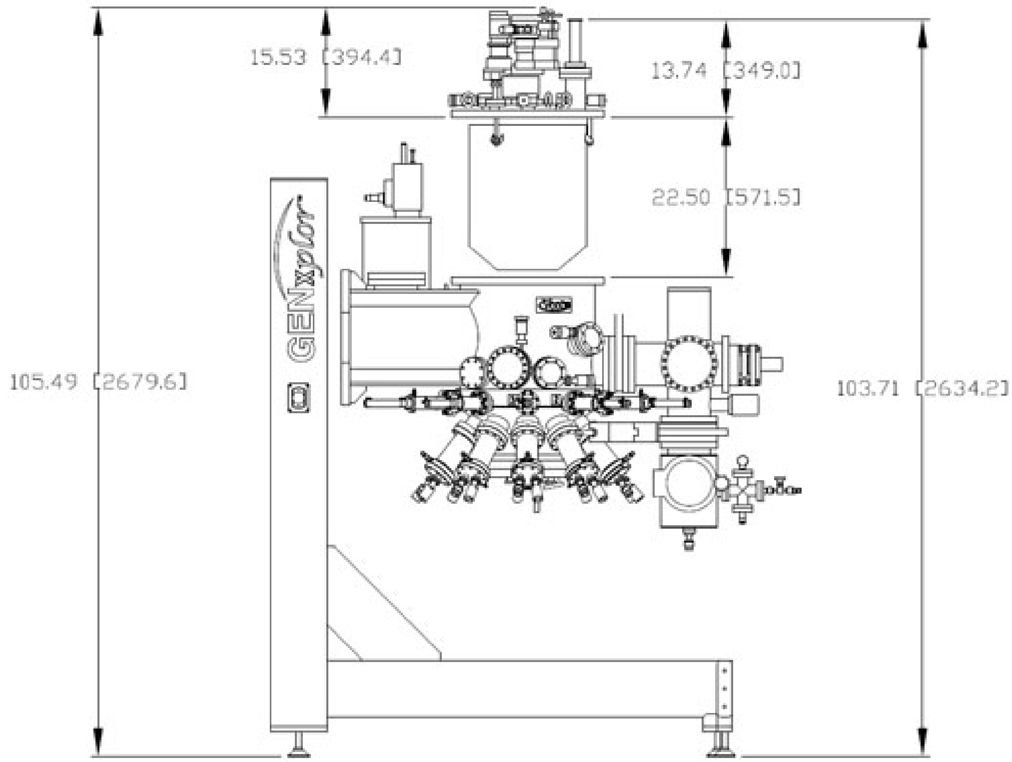


Figure 1-3. Cryopump Dimensions (Side View, Full Elevation)

Table 4: Cryopump - Side View, Full Elevation

Specification	Dimension
Full Cryopump Height:	38.03 in. (966.0 mm)
Overall Height:	105.49 in. (2679.6 mm)

Cryopump (Side View, Half Elevation)

The GENxplor system is equipped with a cryopump. For clearance, moving, and maintenance purposes, the overhead space (ceiling) requirement to lift the cryopump halfway out of its base is shown in Figure 1-4 and the table below.

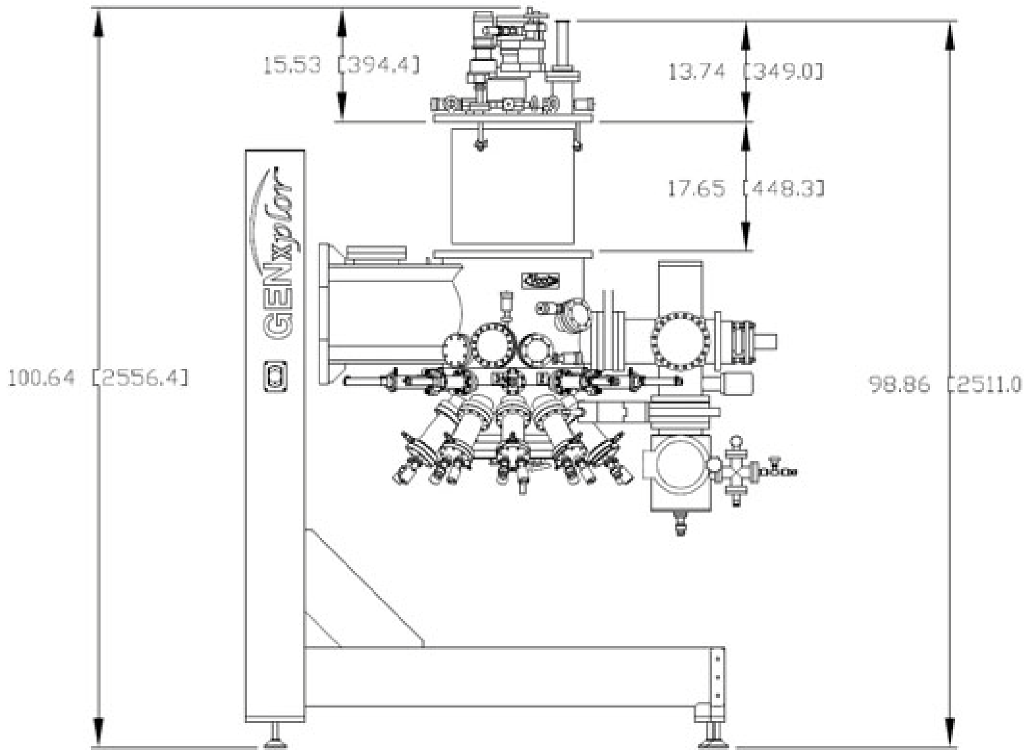


Figure 1-4. Cryopump Dimensions (Side View, Half Elevation)

Table 5: Cryopump - Side View, Half Elevation

Specification	Dimension
Half Cryopump Height:	33.2 in. (843.3 mm)
Overall Height:	100.64 in. (2556.4 mm)

Safety Concerns for Moving Equipment

The safety concerns for transporting The GENxplor system shipping crates from Veeco to the customer's site are specified in the following list.

- Point of Contact - The customer should have one person who is the point of contact on site to direct the movers to where items will be moved to. This person would coordinate the moving with all parties within their department. The mover can notify the customer's contact person prior to the moving date to discuss process and procedures.
- Insurance - Veeco nor the move crew is not responsible or liable for repairing or replacing damaged items. If needed, the customer should obtain a protection policy if they deem it necessary.
- Elevators - All crated items must be able to fit in the elevator of the location they are moving to. Movers will not move things up or down stairways due to safety concerns.
- Chemicals - The department must arrange with Environmental Health & Safety when moving chemicals. If EH&S is required to move chemicals for the department, there may be a charge associated with it.
- Building Space - The customer is responsible for assuring that the items to be moved will fit in the space intended and into the elevators and through the hallways where moving.
- Cleaning - Veeco nor the moving crew is not responsible for cleaning the installation space before the move takes place.
  Customer's Responsibilities
- Label All Items - All shipping crates delivered to the customer's site will be clearly labeled.
- Boxes - Veeco nor the moving crew is not responsible or liable for repairing or replacing damaged items.

Conductors and Cables

It is the customer's responsibility to ensure that all equipment and wiring is properly grounded at the installation site for the GENxplor system in order prevent a serious shock hazard. All control gear, such as switches, circuit breakers, and other control devices, must be mounted in an accessible location, contained in an enclosure, and easily accessible for operation and maintenance.

High voltage system cables should be segregated from cables of other systems and clearly identified for a general safety precaution, as well as for Electromagnetic Interference (EMI) reasons. If a wide separation cannot be achieved some form of protection barrier may be required.

Protection for External Cables

Preferably, all cables and conductors external to the electrical enclosure(s) must be enclosed in ducts or of a type suitable for installation without ducts.

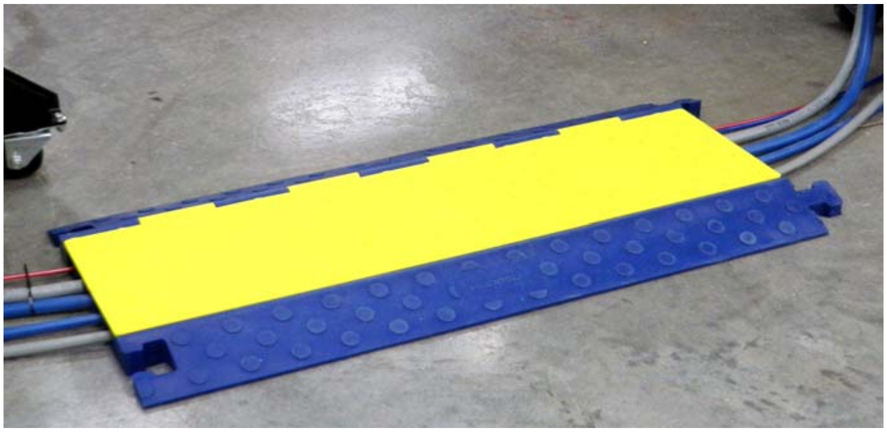
It is the customer’s responsibility to install ducts and/or cable trunks to eliminate the appearance of spaghetti cabling. A cable truck is generally installed under a raised floor structure. Veeco recommends using flexible corrugated plastic tubing to enclosed some of the external cables. Veeco also recommends using plastic wire ties to bundle the cables when it is possible.

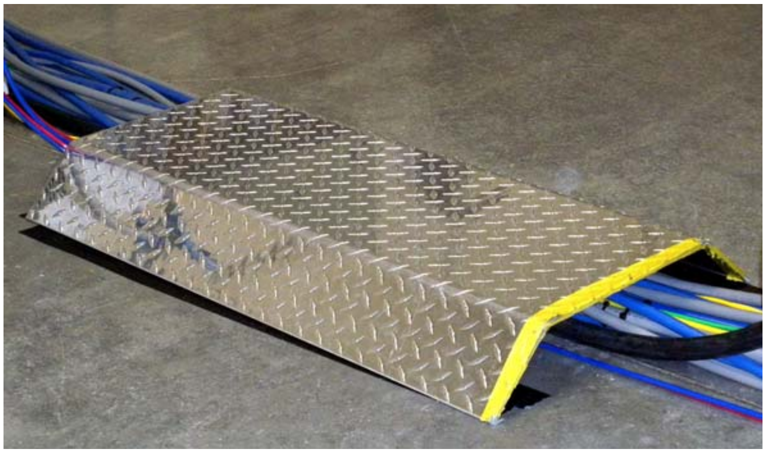
If compartment trunking is used, the barriers (metallic or non-metallic) are also suitable for separating individual power conductors (live, neutral and earth conductors) from high performance cables. These power conductors must be maintained close together for minimizing inductive coupling into the other cables.

The use of surge suppressors in branch circuits can further limit the propagation of electrical surges. These must be installed according to the applicable local/national codes (for equipment safety). The use of fully enclosed metallic trunking or conduit will also limit inductive coupling, but if properly grounded and bonded in accordance with the IEE Wiring Regulations (BS 7671).

On-Floor Cable Covers

For cables and conductors that run across the floor (external to the electrical enclosure), use an on-floor cable cover, which is designed to provide a solution for electrical and data cables without creating a trip hazard.





On-Floor Cable Cover - Examples

To prevent serious injury or death, Veeco recommends that all conductors and cables that are exposed to condensation, moisture, or in the presence of water or corrosive substances be covered and/or insulated to prevent shock, fires, and short circuits. All electrical cords should have sufficient insulation to prevent direct contact with wires.

All copper type cables that are carrying AC electrical currents will have an Electro Magnetic Field (EMF) surrounding the cable, this magnetic field is susceptible to interference from other magnetic fields that are in close proximity. The greater the current being carried then the greater the EMF produced, this therefore will cause an induction effect upon adjacent cables which may well result in induced noise/voltage transients etc. All cables are aerials, thus any adjacent signal cables (data/voice) will very lightly suffer from data corruption in data/Lan cables and line noise in voice circuits.

Safety Considerations for Power Supply Cables

Veeco recommends that the customer use the following guidelines to help ensure personal safety and help protect the GENxplor system and working environment from potential damage.

CAUTION— The power supplies in the GENxplor system may produce high voltages and energy hazards, which can cause bodily harm. Unless the customer is instructed otherwise by Veeco, only trained service technicians are authorized to remove the covers and access any of the components inside the system.

CAUTION— The GENxplor system may have more than one power supply cable. To reduce risk of electrical shock, a trained service technician may need to disconnect all power supply cables before servicing the system.

NOTE—Some equipment may be utilized as a stand-alone device or a rack-mounted system component.

If any of the following conditions occur, shut-down the equipment from its electrical source and contact a trained service provider:

- The power cable, extension cable, or plug is damaged.
- An object has fallen into the equipment.
- The equipment has been exposed to water.
- The equipment has been dropped or damaged.
- The equipment does not operate correctly when you follow the operating instructions.

CAUTION— Opening or removing covers that are marked with the triangular symbol with a lightning bolt may expose you to risk of electrical shock. Components inside these compartments should be serviced only by a trained service technician.

CAUTION— If your equipment gets wet, turn off AC power at the circuit breaker (if possible) before attempting to remove (disconnect) the power cables from the electrical outlet. Use the utmost caution when removing wet cables from a live power source.

Selecting the Proper Overcurrent Protection Devices

NOTE—For detailed fuse replacement information, refer to Replacing Fuses i*n the* Maintenance *chapter of this guide*.

The use of the proper overcurrent protection devices in the GENxplor system is essential to minimize the threats to human life. For the GENxplor system, Veeco uses different types of fuses in the system to protect system equipment against electrical power surges.

Fuses were used in the system equipment due to their increased flexibility in panel use and installation. Fuses were selected because:

- Fuses can be installed in systems with available fault currents up to 200kA or 300kA, which covers the majority of installations.
- Fuses can handle line-to-ground fault currents up to their marked interrupting rating where mechanical devices often have a single pole interrupting capabilities far less than their marked interruption rating.
- Fuses have a straight voltage rating instead of a slash voltage rating.
- Fuses do not vent. Therefore fuses will not affect other components in the panel while clearing a fault.

The electrical distribution system for the GENxplor is complicated. No electrical distribution system is absolutely fail-safe. Circuits are subject to destructive overcurrents, general deterioration, accidental damage, excessive expansion, or overloading of the electrical distribution system are just a few of the factors that contribute to the occurrence of overcurrents. Reliable protective devices prevent or minimize costly damage to transformers, conductors, motors, and the other components and loads that make up the complete distribution system. Reliable circuit protection is essential to avoid losses which can result from power outages and prolonged downtime of facilities. It is the need for reliable protection, safety, and avoidance of fire hazards that has made the fuse a widely used protective device. In addition to fuses, Veeco used some multiple-pole, mechanical overcurrent protective devices, such as circuit breakers, self-protected starters, and manual motor controllers when the equipment warranted using it.

Veeco acknowledges that the supplier of the electrical equipment is not responsible for providing the overcurrent device for the supply conductors to the GENxplor system electrical equipment.

Ducts, Cable Trays, and Cable Supports

It is the customer's responsibility to install and rout the ducts, cable trays, and cable supports at their facility.

- The cabling ducts, where needed, are used to rout and conceal electrical wiring in control panels. Ducts are also used to run in high traffic areas to avoid posing a trip danger.
- Cable trays are used to support insulated electric cables for power distribution and communication. It is recommended that the cable trays used are vented and provide protection from dust, water, mildew, corrosion, excessive moisture, and other elements that damage electrical wire and cable.
- There are a variety of cable/wire supports that assure a safe and reliable electrical system. The cable holding device is designed to distribute stress over a large area so that it can support the cable. It is recommended that the customer use cable straps for bundling wires and wire clamps to assist in securing, joining and running electrical cable from one point to the next.

Cleanroom Classification and Requirements

The cleanroom classification/ requirements for the GENxplor system, which is generally installed in a scientific research environment. Generally, it is important to maintain an environment that has a controlled level of contamination.

Most cleanrooms are free from microbial and particulate contamination and protected from moisture. The customer is expected to maintain a low-level cleanroom, which includes, but is not limited to, the following standards:

- The air entering the cleanroom from outside is filtered to exclude dust
- The air inside the cleanroom is constantly recirculated through high-efficiency particulate air filters to remove internally generated contaminants
- An air conditioner that controls the humidity to low levels, which is necessary to prevent electrostatic discharge problems.
- Low-level cleanroom, such as the type the where the GENxplor system is installed, require special shoes with completely smooth soles that do not track in dust or dirt.
- Access to the cleanroom is usually restricted to those wearing a cleanroom suit, such as a gown, cap, gear to cover your shoes. The manufacturing staff at Veeco abides by this specific practice.

NOTE—To learn more about cleanroom classifications and requirements, refer to:

Doc Number	Title
FS209E	Federal Standard 209E
ISO/TC209	Cleanrooms and associated controlled environments
ISO 14644-1	Airborne Particulate Cleanliness Classes in Cleanrooms and Clean Zones

Chapter 2 Safety

Introduction

This chapter discusses important safety information for the GENxplor. Review this information before operating or performing maintenance of any kind on the system.

Additional safety information may be found in individual user guides for Veeco components, and in manuals for OEM components.

WARNING— Careless or improper operation of the system can result in equipment damage, serious injury, and even death. Users must be aware of all potential hazards when operating or performing maintenance on the system.

Safety Overview

Veeco has designed and manufactured the GENxplor with strict regard for the safety of operators. Safety interlocks, mechanical guards (where needed), and emergency off (EMO) buttons have all been included to provide a safe operating environment.

However, MBE is a field that includes inherent hazards, which are present regardless of the type of system or application. Therefore, safety also depends on proper training, strict adherence to safe practices, and an awareness of all potential hazards.

Please note the following general safety requirements:

- Specific MBE applications must be reviewed and approved by an industrial hygienist or chemical safety engineer.
- Anyone who operates or maintains the system must be thoroughly trained (see *Training Required* on page 42) and fully understand how to reduce or eliminate all potential safety hazards, including those outlined in the *Specific Hazards* section starting on page 43.
- Hazardous materials must be handled safely and in a manner consistent with guidelines provided in the material safety data sheets (MSDS), which are accessible on the Internet. It is the customer’s responsibility to comply with the guidelines specified in the MSDS’s. The disposal process for hazardous and radioactive waste materials generally involves transportation and treatment at a receiving facility.
- The facility must include appropriate materials-safety handling equipment, and an exhaust system with proper filtration and scrubbing capability.
- Chemical by-products must be accounted for, and recycled or disposed of as required by all applicable laws, regulations and codes.

Training Required

General MBE Training

All operators and maintenance personnel must have thorough training in the general field of MBE. This general training should include one or more of the following, as deemed appropriate:

- Official certification (particularly with respect to MBE) through a recognized standards body for semiconductor processing/fabrication
- Significant MBE training or experience within a official research institution
- Thorough in-house training through a controlled program under the guidance of one or more trained MBE professionals

IMPORTANT— Training must include exhaustive coverage of the safety hazards inherent to the practice of MBE.

System Training

Before working on the GENxplor, all operators and maintenance personnel must receive thorough training on the system. Training should be delivered by an MBE professional who is familiar with the GENxplor.

Additionally, prior to working on the system, anyone who will operate or maintain the GENxplor should read the following documentation:

- This GENxplor manual
- All associated Veeco and OEM component manuals provided for the system
- All Veeco software documentation, including the Molly software help.

The procedures in this manual, and in the associated component manuals and software help, should be reserved for individuals with an acceptable level of understanding of the GENxplor. This includes procedures relating to processing substrates, system assembly/ disassembly, software configuration, installation and operation of sources, instrument calibration, system bake, and platen loading and unloading.

Facility Training

All operators and maintenance personnel must be provided with sufficient training on the safety systems of the facility in which the GENxplor is to be operated, including hazard-monitoring equipment, risk mitigation policies, contingency planning, and emergency response protocol.

All operators and maintenance personnel must also be provided with all necessary “right to know” information with regard to hazardous substances used in the facility.

Specific Hazards

Electrical Hazards

WARNING— HIGH VOLTAGE. Many system components and their associated leads run on high voltages that could cause injury or death by electrocution. For the purpose of this manual, high voltage is defined as any voltage equal to or greater that 40 volts (AC or DC). Disconnect any component that operates with high voltage from input power at the component source before servicing. Perform a complete electrical lockout/tagout (LOTO) of the system as outlined in the LOCKOUT / TAGOUT warning that follows.

WARNING— LOCKOUT /TAGOUT REQUIRED. To prevent accidental exposure of operators/technicians to high voltage, perform a complete electrical lockout/ tagout (LOTO) of the system prior to general system electrical maintenance, as part of system de-commissioning, and before servicing any component for which input power cannot be removed by other means. The LOTO must lock out power at ALL main circuit breakers on the system, as identified by the lockout/tagout hazard alert label shown on page 47.

WARNING— MULTIPLE ELECTRICAL SERVICES. Some components may receive power from more than one input. Verify that all sources of input power have been disconnected prior to servicing.

WARNING— HAZARDOUS VOLTAGE WITH SYSTEM POWER OFF. Turning a main circuit breaker off does not remove hazardous voltage on the main (line side) power leads to the circuit breaker.

WARNING— POTENTIAL ARC FLASH. If the facility transformer that supplies power to the system exceeds a capacity of 125 kVA, there is an arc flash hazard on the line side (facility side) of the system circuit breakers. To prevent the possibility of an arc flash, which could result in severe burns or death, keep conductive objects safely away from the area upstream of the main system circuit breakers. Follow the applicable safety protocol during service, and apply the arc flash safety labels that are supplied with the electronics rack in the proper locations.

WARNING— UPS POWER. Power from an uninterruptible power supply (UPS) is not cut off when the main circuit breaker is turned off. If an uninterruptible power supply is installed on the system, UPS power must also be turned off prior to servicing the affected components.

Chemical Hazards

WARNING— TOXIC SUBSTANCES. Deposition materials have varying degrees of toxicity. Observe all warnings listed on the original material container. Carefully review the material safety data sheets (MSDS) for the substances involved. Wear appropriate personal protective equipment (PPE) when handling these substances.

WARNING— FLAMMABLE SUBSTANCES. Certain deposition materials are flammable. Phosphorus may cause fire and explosion resulting in death or serious injury. Do not use phosphorus in the system unless the system has been explicitly designed for it. Review all safety information in the Veeco Phosphorus Recovery System User Manual. Some source gases are also flammable. Review the MSDS and wear appropriate personal protective equipment (PPE) whenever working with a flammable substance.

Thermal Hazards

WARNING— HOT SURFACES. Some surfaces on the system may exceed 60º C (140ºF). Avoid contact with exposed system appendages or bake-enclosure surfaces that develop high temperatures during bake. These metal parts could cause burns to bare skin.

WARNING— CRYOGENIC HAZARDS (DANGEROUSLY COLD). Some sections of the system are cooled with liquid nitrogen (LN_2), which can cause severe burns. All dewars, plumbing connections, and LN_2 supply and return lines must be properly handled, insulated, and maintained to prevent serious operator injury. Wear appropriate personal protective equipment (PPE) when servicing any cryogenically cooled part of the system.

Radiation Hazards

WARNING— X-RAY RADIATION. The reflected high-energy electron diffraction (RHEED) system operates with voltages greater than 10 kV. Impingement of the RHEED high-energy electron beam on the surface of a wafer during characterization may generate X-ray radiation inside the growth module. Never operate the RHEED gun without the supplied RHEED-screen/viewport assembly installed, which includes leaded glass to protect operators from any generated radiation.

Physical/Mechanical Hazards

WARNING— PINCH POINTS. The system includes pivoting, sliding, and rotating parts that could present a pinch hazard if mechanical guards are removed or if components are operated negligently. These components include, but are not limited to: servo motor couplers, load-lock doors and hinges, bolted flanges, quartz crystal monitor (QCM) assembly (if installed), and pneumatic actuators for platen stages/shelves, shutter-assemblies and beam flux monitor (BFM).

WARNING— TRIP HAZARD. Raised flooring, cable assemblies, or components extending out from the system could result in falls and injury. Use caution when walking around or near the system.

WARNING— SLIP HAZARD. Water leaks or spills from system water-cooling lines may result in slippery floors and possible falls. Immediately clean up any spills in the area of the equipment.

WARNING— HEAVY OBJECTS. Many system components weigh in excess of 40 lbs (18 kg). To avoid personal injury and equipment damage, always use a hoist and sling when removing or installing these components, and have more than one person assisting.

Pressure/Vacuum Hazards

WARNING— PRESSURIZED GASES. Parts of the system contain pressurized gases (compressed dry air [CDA], high-purity nitrogen vent gas, source gases), even when the entire system is electrically de-energized. An accidental breach of a gas line or pressurized container could result in forceful expulsion of gas and particulates, causing injury to operators.

WARNING— PNEUMATICS DO NOT DE-ENERGIZE. Pressing the emergency off (EMO) button, or otherwise electrically de-energizing the system, does not de-energize the system pneumatics. Pneumatic components could still actuate, injuring personnel, if an operator alters the air lines or overrides the solenoids.

WARNING— MODULE OVER-PRESSURIZATION. Having the high-purity N_2 pressure set to greater than 3 psi during module venting could result in over-pressurization of modules and possible harm to operators or equipment.

WARNING— **VACUUM BREACH HAZARD**. Applying excessive external force to system appendages, or operating certain sources too hot, could result in a breach of the vacuum chamber walls, resulting in an implosion and possible injury to operators. Use caution when moving and working around the system. Refer to the applicable source manuals for safe operating temperatures.

Suffocation Hazard

WARNING— **SUFFOCATION HAZARD.** If excessive amounts of LN_2 evaporate into a poorly ventilated facility, the N_2 could displace O_2, resulting in a suffocation hazard. Ensure adequate ventilation and avoid unnecessary evaporation of LN_2.

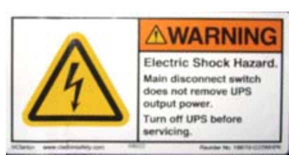
Hazard Alert Labels on Equipment

Hazard alert labels are applied to various locations on the GENxplor.

The table below shows labels that may appear on the system, and describes how to interpret them.

IMPORTANT— Hazard alert labels are applied to *both* Veeco and OEM components. Refer to the OEM manuals for further information on common labels, or for explanations of labels not included in the table below.

Hazard Alert Label	Specific Hazard Indicated	Explanation
  	High voltage.	See HIGH VOLTAGE warning on page 43.

Hazard Alert Label	Specific Hazard Indicated	Explanation
(current label)  ***(obsolete label)*** 	Potential arc flash.	See POTENTIAL ARC FLASH warning on page 43.
	Multiple electrical services.	See MULTIPLE ELECTRICAL SERVICES warning on page 43.
	Lockout / tagout required.	See LOCKOUT / TAGOUT REQUIRED warning on page 43.
	Hazardous voltage present with machine power off.	See HAZARDOUS VOLTAGE WITH SYSTEM POWER OFF warning on page 43.
	UPS power.	See UPS POWER warning on page 43.
	Flammable substances.	See FLAMMABLE SUBSTANCES warning on page 44.
 	Toxic substances.	See TOXIC SUBSTANCES warning on page 44.

Hazard Alert Label	Specific Hazard Indicated	Explanation
	Hot surfaces.	See HOT SURFACES warning on page 44.
	Cryogenic hazards (dangerously cold).	See CRYOGENIC HAZARDS (DANGEROUSLY COLD) warning on page 44.
	Pinch points.	See PINCH POINTS warning on page 45.
	Heavy object.	See HEAVY OBJECTS warning on page 45.
	Trip hazard.	See TRIP HAZARD warning on page 45.
	Slip hazard.	See SLIP HAZARD warning on page 45.
	X-ray radiation.	See X-RAY RADIATION warning on page 44.
	Pneumatics do not de-energize.	See PNEUMATICS DO NOT DE-ENERGIZE warning on page 49.
	Suffocation hazard.	See SUFFOCATION HAZARD warning on page 46.

Hazard Alert Label	Specific Hazard Indicated	Explanation
	General warning.	This is a general warning label that draws attention to a serious hazard for which no specific warning graphic exists, or adds emphasis to other hazard alert labels. May be used in conjunction with other hazard alert labels.
	Read this manual.	This is a general warning label that reminds operators to read the manual to understand all safety hazards that are present. May be used in conjunction with other hazard alert labels.

Using the Emergency Off (EMO) Button(s)

There are multiple EMO buttons on the system. The EMO buttons interrupt the main power to the system, completely powering the system down.

Figure 2-1: EMO Button Near Circuit Breaker Panel

You only need to press one EMO button to power down the entire system.

Each EMO button is latching, which means that it stays activated (no power to the system) until an operator manually resets it.

To reset an EMO button, manually rotate the button until it pops back out.

WARNING— PNEUMATICS DO NOT DE-ENERGIZE. Pressing the emergency off (EMO) button, or otherwise electrically de-energizing the system, does not de-energize the system pneumatics. Pneumatic components could still actuate, injuring personnel, if an operator alters the air lines or overrides the solenoids.

Personal Protective Equipment

Appropriate personal protective equipment (PPE) is mandatory whenever there is a possibility of exposure to:

- Toxic or flammable substances
- LN_2
- Electrical hazards

Please consult all applicable industrial safety guidelines for the specific substances involved. Thoroughly review the applicable material data safety sheets (MSDS). Contact an industrial hygienist if you have questions regarding the type or category of PPE required for a specific operation.

WARNING— PERSONAL PROTECTION EQUIPMENT (PPE) REQUIRED. Failure to use appropriate personal protective equipment could result in severe injury or death.

Electrical Grounding

The GENxplor includes a comprehensive electrical grounding system. This allows for the safest possible discharge path in the event of failed electrical insulation or unexpected power surges. It also helps to mitigate the effects of electromagnetic interference (EMI).

Connection points of the grounding system are identified by the following symbol:

To view the grounding paths, ground cables, and termination points of the grounding system, please refer to the system cabling diagrams.

When replacing any part of the grounding system, be sure to use cables of the correct type and size, as specified in the system cabling diagrams or bill of materials (BOM).

WARNING— ELECTRICAL GROUNDING REQUIRED. To maintain electrical safety, always maintain the connections of the electrical grounding system!

Lockout/Tagout Procedure

During the servicing and maintenance of the GENxplor, an unexpected startup or release of stored energy could cause personal injury to an operator or maintenance personnel.

With the exception of the computer software, the entire GENxplor system will be shutdown during a maintenance activity when it is deemed appropriate. Adding additional disconnecting devices, such as more circuit breakers, to the current electrical configuration is unnecessary.

The lockout/tagout (LOTO) tags are used to avoid an accident or injury when a component or assembly is being repaired or replaced. This practice applies to all electrical, mechanical, hydraulic, pneumatic, chemical, thermal, and other equipment that can be hazardous to workers. Moreover, it is the customer's responsibility to train each worker to ensure that they know, understand, and are able to follow the LOTO practices.

- Proper lockout/tagout (LOTO) practices and procedures safeguard workers from the release of hazardous energy.
- The OSHA standard for The Control of Hazardous Energy (Lockout/Tagout) (29 CFR 1910.147) for general industry, outlines specific action and procedures for addressing and controlling hazardous energy during servicing and maintenance of machines and equipment.
- The customer is required to train each worker to ensure that they know, understand, and are able to follow the applicable provisions of the hazardous energy control procedures.
- Workers must be trained in the purpose and function of the energy control program and have the knowledge and skills required for the safe application, usage and removal of the energy control devices.
- All employees who work in the area where the energy control procedure(s) are utilized need to be instructed in the purpose and use of the energy control procedure(s) and about the prohibition against attempting to restart or reenergize equipment that is locked or tagged out.
- All employees who are authorized to lockout equipment and perform the service and maintenance operations need to be trained in recognition of applicable hazardous energy sources in the workplace, the type and magnitude of energy found in the workplace, and the means and methods of isolating and/or controlling the energy.
- Specific procedures and limitations relating to tagout systems where they are allowed.
- Retraining of all employees to maintain proficiency or introduce new or changed control methods.

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Chapter 3 System Description

Introduction

The GENxplor is a research-scale MBE system with a manual platen transfer system. It can be used to grow a wide variety of thin crystalline films on substrates up to 3.0 inches (7.6 cm) in diameter. Common applications for the GENxplor include Groups III–V, Groups II–VI, oxides, and nitrides. Other applications may also be possible.

As shipped, each GENxplor is typically customized for a particular MBE application. The basic GENxplor platform, however, is flexible enough to allow changes in application.

The System Description that follows begins with a brief functional summary of the entire system, followed by more detailed descriptions of some of the main subsystems.

Functional Summary

TIP—Refer to Figure 3-1 to identify the specific components mentioned in this summary.

Although the number and arrangement of system modules may vary based on the specific configuration, operation of the GENxplor generally occurs as follows:

The user places up to three loaded platens (defined here as either standard gravity substrate holders or non-bonded Veeco Uni-Block® substrate holders) into the load-lock cassette, which gets inserted into the load-lock module (8) through the opened load-lock door (7). The user then pumps down the load-lock module using the attached turbo pump.

With the load-lock module under vacuum, the user opens the manual load-lock/buffer gate valve (6) and lowers the hand-cranked elevator (1) with attached storage-shelf cassette in order to pick up the load-lock cassette. When the two cassettes are coupled, the user raises them into the buffer module (3).

At this point, the user closes the load-lock/buffer gate valve and performs the necessary combination of movements using the elevator and horizontal transfer arm (5) to do several things:

- transfer the platens from the load-lock cassette to one of the four shelves in the storage cassette directly above it;
- transfer a platen back to the optional heated station (4) for outgassing; in this case, the user lifts the platen up off the horizontal transfer arm using the hand-crank for the heated-station stage (2), which brings the substrate into proximity with the heater; or
- transfer a platen from either cassette (or from the optional heated station) directly to the growth module (11) to initiate growth; note that this requires that the manual buffer/growth gate valve (13) be opened first.

When a platen is on the growth stage of the substrate manipulator (12), the user starts a growth recipe in the Molly® Growth Control Software, which governs the growth process by: controlling temperatures of the substrate heater and sources (9); regulating the flow of gas from gas sources (if applicable); and opening or closing the source shutters (10) and the main shutter as needed. This produces the required number, order, and composition of epitaxial material layers on the substrate.

After growth, the user transfers the platen from the growth stage back to the load-lock cassette, or optionally to the storage cassette for interim storage. Finally, to remove the platens that now hold processed substrates, the user lowers the load-lock cassette back down into the load-lock module, isolates and vents the load-lock module, and removes the load-lock cassette through the load-lock door. The platens can now be removed from the cassette for material characterization and/or further processing.

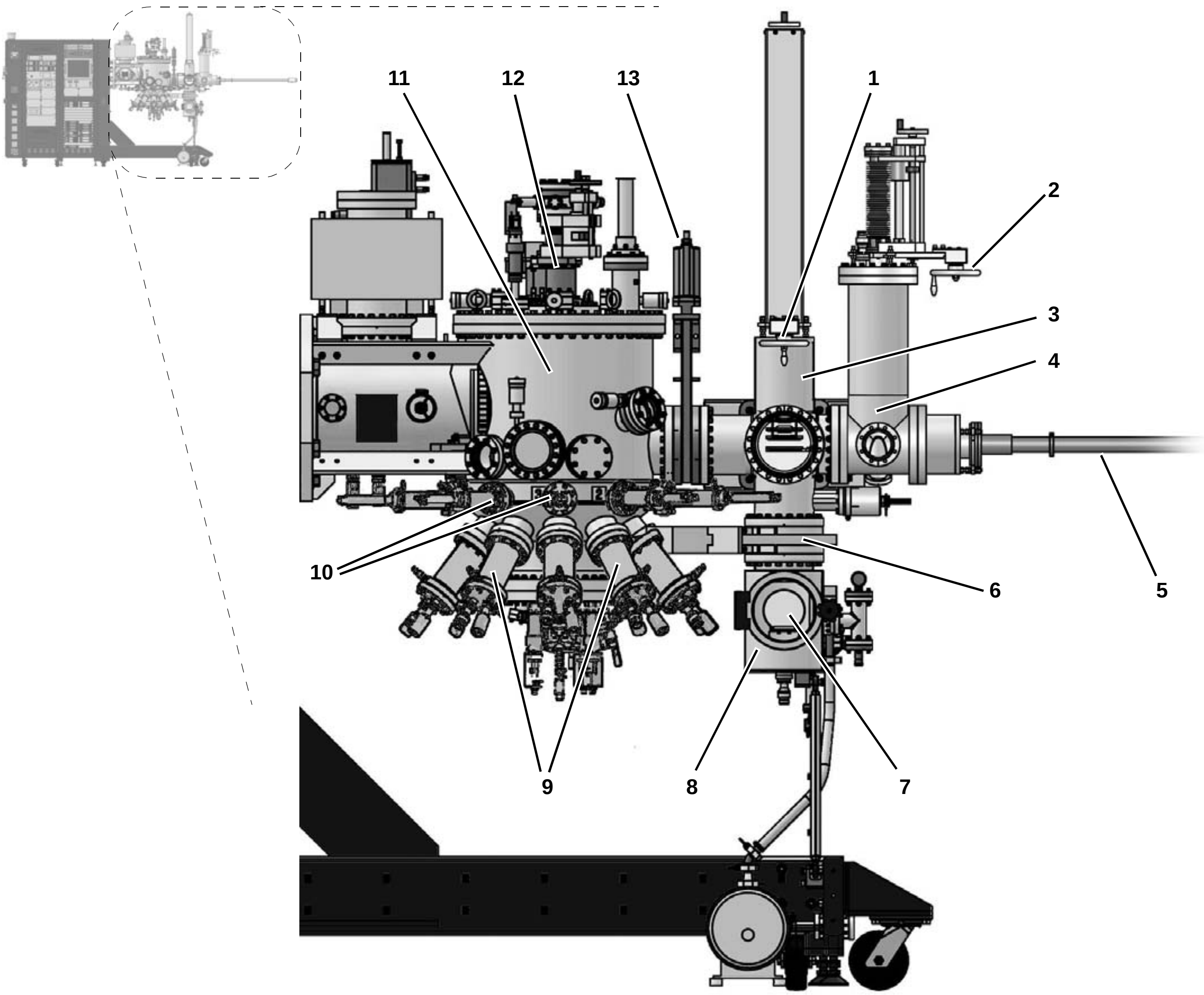


Figure 3-1: GENxplor Functional Diagram

#	Description	#	Description
1	Hand-crank for elevator	8	Load-lock module
2	Hand-crank for prep stage (up/down)	9	Sources
3	Buffer module	10	Source shutter actuators
4	Optional heated station	11	Growth module
5	Horizontal transfer arm	12	Substrate manipulator

#	Description	#	Description
6	Manual load-lock/buffer gate valve	13	Manual buffer/growth gate valve
7	Load-lock door	–	–

System Modules

About System Modules

System modules are the vacuum chambers in which substrates are loaded, transferred, stored, and processed. System modules are the basic building blocks of the GENxplor.

Three types of modules are standard on the system: load-lock, buffer, and growth. A non-isolated heated station may optionally be attached to the buffer module. The figure and table below describe the function of each module.

Load-Lock Module

Overview

The load-lock module enables the user to move platens and substrates into and out of the system while maintaining the ultra-high vacuum (UHV) levels of the buffer and growth modules. A manual gate valve between the load-lock module and buffer module above it provides isolation, ensuring that the load-lock module is the only one normally exposed directly to atmosphere. Four quartz-lamp heaters are included for removing water vapor or other contaminants introduced through the load-lock door. A turbo pump provides load-lock pumping.

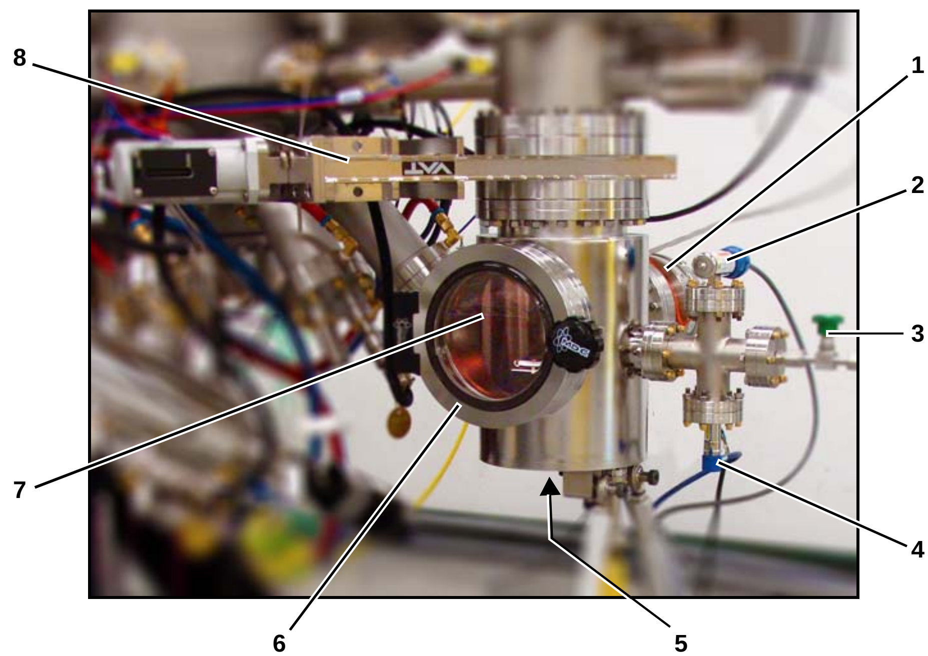


Figure 3-2: Load-Lock Module

#	Description	#	Description
1	Turbo pump	5	Magnetic handle (hidden in photo)
2	Convectron gauge	6	Load-lock door

#	Description	#	Description
3	Nitrogen vent valve	7	Quartz lamp (1 of 4)
4	Micro ion gauge	8	Manual load-lock/buffer gate valve

Buffer Module

Overview

The buffer module provides a UHV zone between the load-lock and growth modules, preventing direct exposure of the growth module to potentially higher levels of contaminants in the load-lock module. Manual gate valves isolate the buffer module from both the load-lock and growth modules, and an ion pump typically provides module pumping. Within the buffer module, the axes of the elevator and horizontal transfer arm intersect. This allows platens to be removed from the vertically stacked load-lock and storage cassettes, and transferred either forward to the growth module, or backward to the optional heated station (see next section).

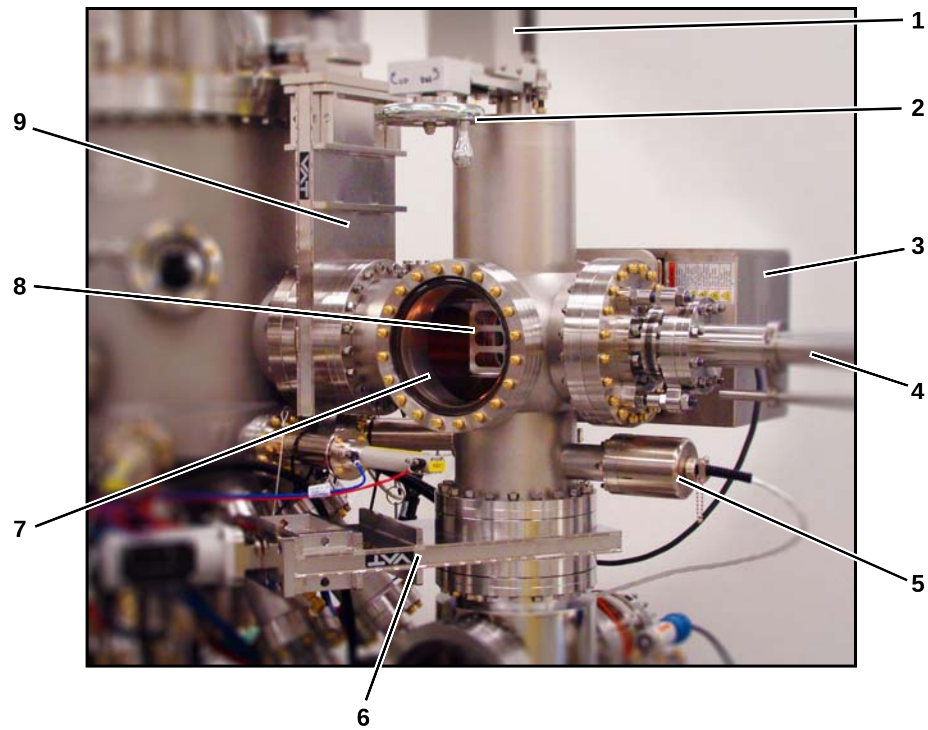


Figure 3-3: Buffer Module

#	Description	#	Description
1	UHV bellows for elevator	6	Manual load-lock/buffer gate valve
2	Hand crank for elevator	7	Viewport
3	Ion pump	8	Load-lock platen cassette
4	Horizontal transfer arm	9	Manual buffer/growth gate valve
5	Ion gauge	–	–

Heated Station (Optional)

The heated station is an optional unit attached to the buffer module. This is where substrates are conditioned through outgassing and/or hydrogen plasma cleaning before transfer to the growth module for epitaxial processing. The heated station includes a hand-cranked non-rotating stage, heater assembly, thermocouple, and ion gauge. If a heated station is included, it shares pumping with the buffer module; no isolation gate valve is included.

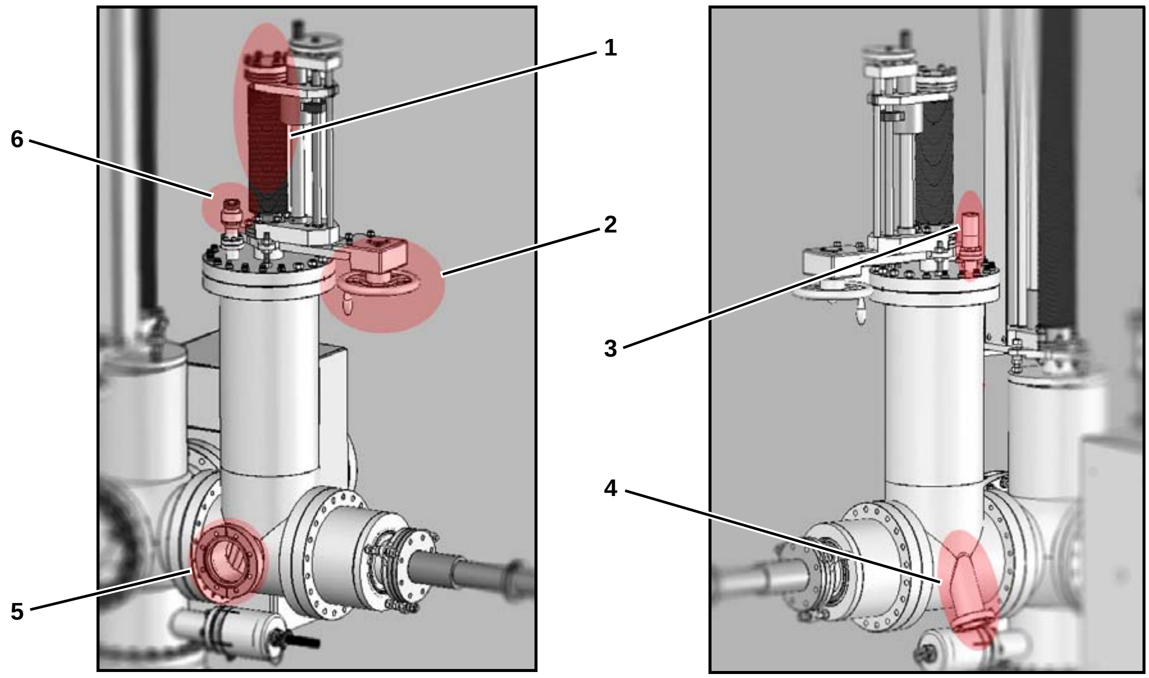


Figure 3-4: Prep Module

#	Description	#	Description
1	UHV bellows for prep stage	4	Port for hydrogen source
2	Hand crank for heated-station stage	5	Viewport
3	Thermocouple connector	6	Prep heater power connector

Growth Module

Overview

The growth module is where the sources are located and epitaxial growth occurs. It is equipped with both processing equipment, including application-specific sources, substrate manipulator with integral heater, cryo panel, and pump options as well as a variety of monitoring and analysis instruments. These include a standard chamber ion gauge, beam flux monitor (BFM) ion gauge, reflective high-energy electron diffraction (RHEED) screen, residual gas analyzer (RGA), optical pyrometer, and (optionally) instrumentation for band-edge thermometry.

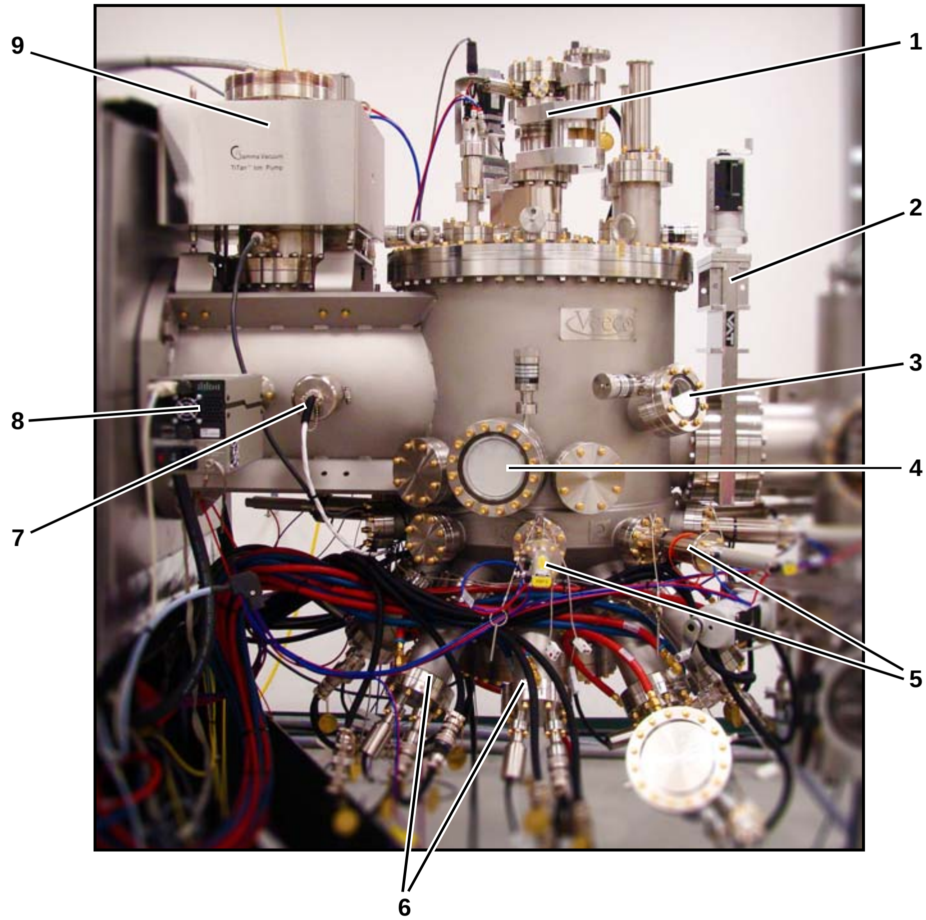


Figure 3-5: Growth Module

#	Description	#	Description
1	Substrate manipulator	6	Sources
2	Manual buffer/growth gate valve	7	Ion gauge
3	Viewport	8	RGA
4	RHEED screen	9	Main pump (1 of 2; ion pump shown)
5	Source shutter actuators	–	–

Platen Transfer System

Overview

The platen transfer system is responsible for moving platens through and within the system to the various processing locations. All platen transfers in the system are completely manual.

The key components of the platen transfer system include:

- Elevator
- Horizontal Transfer arm
- Platen cassettes (load-lock and storage)
- Platen stages (growth and prep)

Elevator

The **elevator** moves platens between the load-lock and buffer modules. The elevator is housed within a UHV bellows affixed to the top of the buffer module, and is moved up and down via a hand-cranked lead screw (see Figure 3-6).

A storage cassette is permanently attached to the bottom of the elevator. The storage cassette can be coupled to the load-lock cassette below it, which allows the two cassettes to be transferred together between modules.

To move the elevator up or down, the user operates a hand-crank. Rotating the hand-crank clockwise (as viewed from above) moves the elevator upward; rotating the hand-crank counterclockwise moves it downward.

Horizontal Transfer Arm

The **horizontal transfer arm** moves platens between the buffer, growth, and prep modules. It consists of a magnetically coupled assembly affixed to the side of the buffer module, or alternatively to the side of the prep module if included (see Figure 3-6). An “end effector” at the end of the horizontal transfer arm carries a single platen at time during transfers.

To use the horizontal transfer arm, the user slides the assembly forward or backward into the desired position. When ready for a platen pick-up or drop-off, the user rotates the magnetically-coupled handle. Rotating the handle counter-clockwise (as viewed from the end of the horizontal transfer arm) raises the end effector; rotating the handle clockwise lowers the end effector. In this way, the end effector can pick up or drop off a platen.

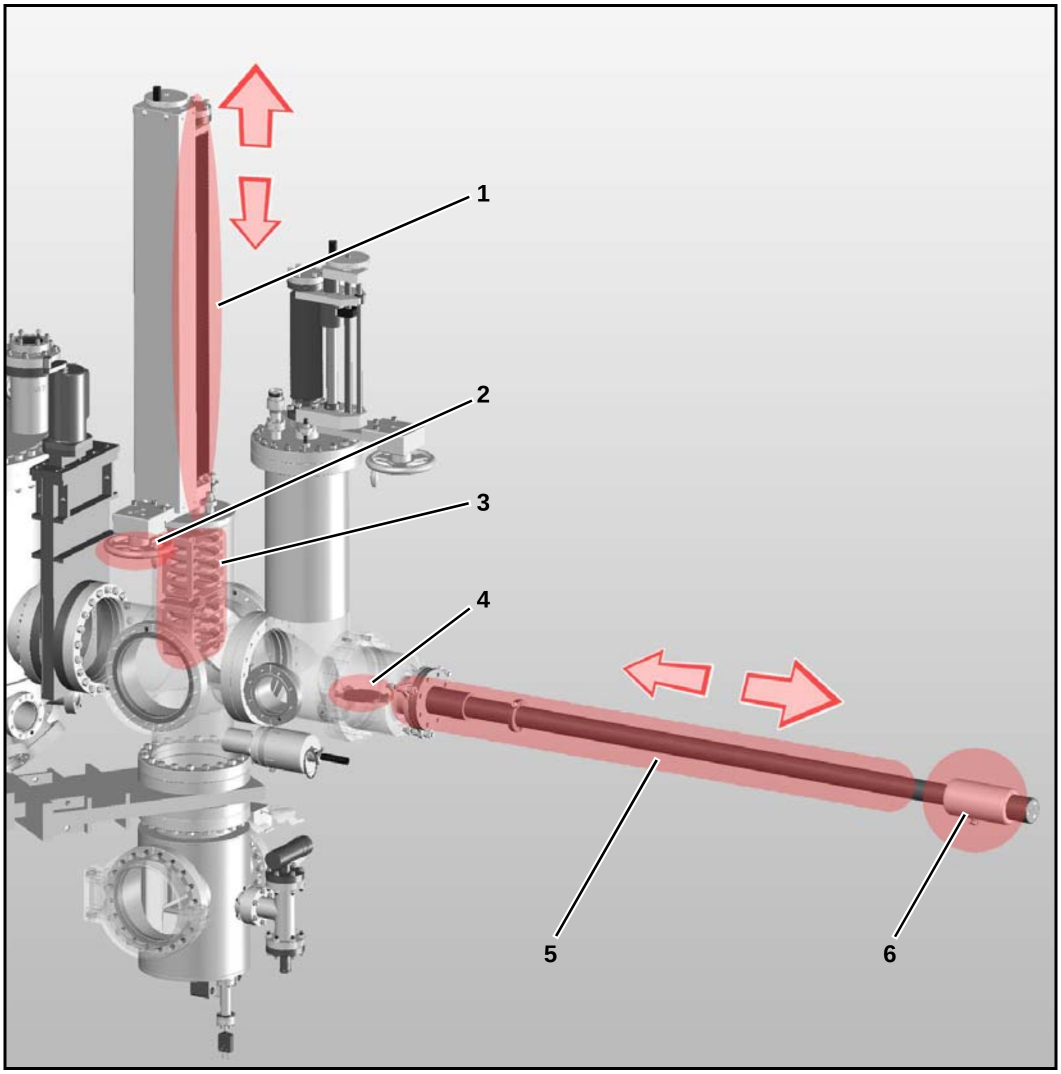


Figure 3-6: Vertical (Left) and Horizontal (Right) Transfer Arms

#	Description	#	Description
1	UHV bellows for elevator	4	End effector
2	Hand crank for elevator	5	Horizontal transfer arm
3	Storage (top) and load-lock (bottom) cassettes	6	Magnetically coupled handle

Platen Cassettes

The **load-lock cassette** is where the user loads new platens, and removes platens containing substrates that have undergone growth. The load-lock cassette holds up to three platens at time, which the user loads or unloads outside the system.

When the load-lock cassette is in the load-lock module, a magnetic knob on the bottom of the module allows the user to move the cassette forward or backward to couple it to, or de-couple it from, the lowered **storage cassette** on the elevator. The storage cassette, which holds up to four platens at time, stays permanently affixed to the elevator inside the system.

When the two cassettes are properly coupled, the holes of the load-lock cassette engage the pins of the storage cassette (see Figure 3-7). This engagement allows the load-lock cassette to “hang” below the storage cassette while the two cassettes are transferred up or down between the load-lock and buffer modules.

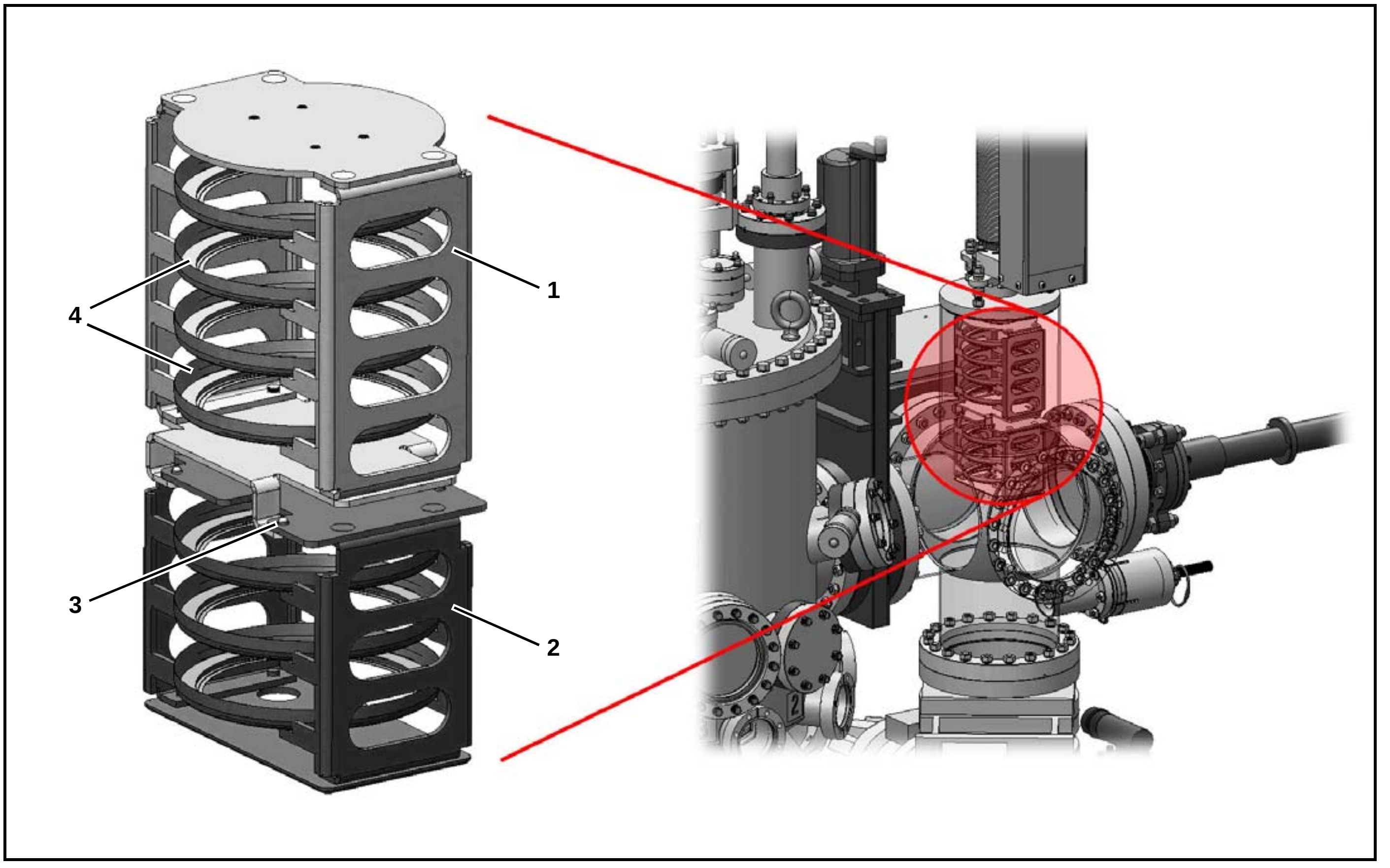


Figure 3-7: Storage Cassette (Top) and Load-Lock Cassette (Bottom), Coupled

#	Description	#	Description
1	Storage cassette	3	Hole/pin engagement
2	Load-lock cassette	5	Platens

Platen Stages

Growth Stage

The growth stage holds a single platen during epitaxial growth. Platens are placed onto, and removed from, the growth stage through the z-axis motion of the end effector on the horizontal transfer arm. The growth stage itself has no z-axis motion.

Growth stage rotation is automated and under the direct control of a Veeco SMC controller in the electronics rack. Growth stage rotation helps to minimize any thermal gradient across the substrate and optimize the deposition uniformity. For further information on the SMC controller, please refer to the appropriate Veeco user manual.

Heated-Station Stage (Optional)

The heated-station stage holds the platen during pre-growth conditioning. It is included only if the system has the optional heated station. The heated-station stage has no rotation, but does have manual (hand-cranked) z-axis motion. This z-axis motion allows for platen transfers between the end effector on the horizontal transfer arm and the heated-station stage.

Molly Growth Control Software

The Molly Growth Control Software runs on the computer built into the system electronics rack. Molly automates the growth process by allowing you to author and execute recipe files, which describe the desired epitaxial layer structure to be grown. In addition to recipe execution, Molly provides manual control and override capabilities, data trending and logging to disk, as well as simple but comprehensive system configuration and calibration. Please refer to Molly Help (accessible through the Molly software) for comprehensive information.

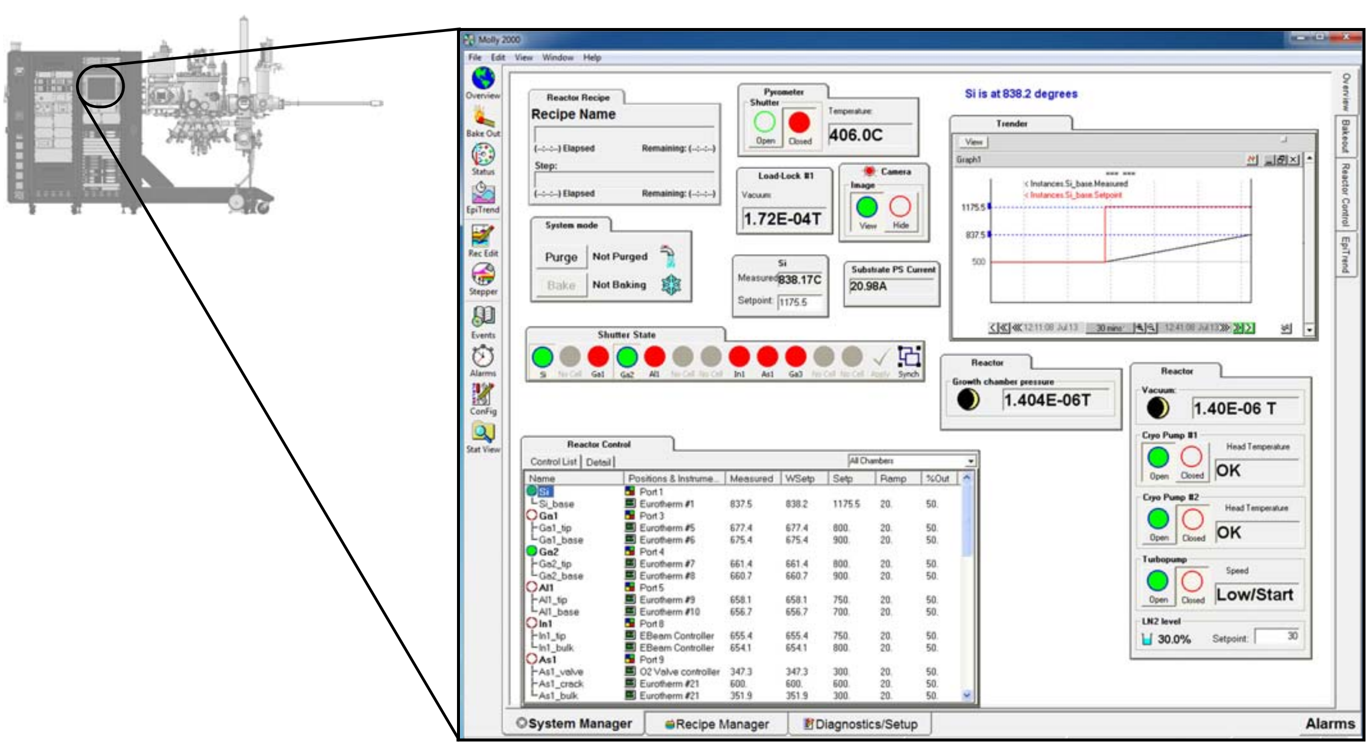


Figure 3-8: Molly Growth Control Software

Chapter 4 Operation

Introduction

This chapter covers some of the most common operational procedures for the GENxplor.

System Start-up Procedure

Overview

This procedure takes into account that most experienced operators and technicians who have performed tasks on a system similar to the GENxplor are familiar with the start-up process and understand how to start-up the system. However, it is important to have a basic startup process that a novice can understand. This start-up process ensures that the system is activated properly. The objective of the start-up procedure is to prevent a physical hazard and/or damage to equipment.

Tools and Parts Required

None.

Procedure

NOTE—The start-up procedure is intended for trained molecular beam epitaxy (MBE) professionals, technicians, and persons under the direct guidance of such individuals. If you are not among these groups, do not attempt to operate the equipment.

IMPORTANT— The procedure below is for a complete system start-up. Performing this procedure applies power and utility service to the system, including the subcomponents.

WARNING— HAZARDOUS VOLTAGE WITH SYSTEM POWER ON. Turning a main circuit breaker on applies voltage on the main power leads to the circuit breaker.

1. Turn on the power supply (main power circuit breaker), located outside the electronics rack (E-rack).
2. Press the system Reset button.

NOTE—Step 3 requires a time period of 12 hours (minimum) for system preparation.

3. Connect the pump down line between the load-lock turbo and cryo-pump. This key step prepares the system for operation.

4. Start the cyro-compressor. Wait 2 to 3 hours until the temperature on the cryo compressor reads 15 °K (-258.15 °C).

NOTE—The turbo pump controls the load-lock module.

5. While waiting for the cyro-compressor to reach the prescribed operating temperature, stop the turbo pump, which controls the load-lock module.

6. Open all gate valves at the transfer connection on the system, including the:

    - Load-lock module
    - Buffer module
    - Growth module

7. Re-start the turbo pump to pump-down the load-lock module. This process will take approximately 20 minutes to complete.

    - For turbo pumps: 1) press the Start button at the controller, 2) wait for the rotor to start spinning, 3) power on the controller, and 4) verify that the backing pump (typically a scroll pump) also starts.

8. At the turbo pump, visually check the vacuum pressure reading.

    - If the reading is less than 1.0E-5 Torr (133.322 Pa), system operation is normal.
    - If the cryo compressor is cold [15 °K (-258.15 °C) or less], use the Molly interface software to open valve to the chamber.

NOTE—At this point in the process, the GENxplor is operational.

Operating Modes

Overview

The three main operating modes for the GENxplor are:

- growth state,
- bake state, and
- idle state.

The sections that follow describe the three modes of operation.

Growth State Operation Mode

An operator can initiate the growth state at the HMI computer. The objective is to purify the substrate and reduce the impurities below the parts-per-billion level.

There is no simple rule for determining an optimum bake temperature for a growth module.

For most MBE applications, growth module bake temperatures typically fall somewhere in the range of 120–200ºC. Growth module bake temperatures must be hot enough to ensure that contaminant gases are desorbed to the pumps, without being so hot as to overload the growth module pumps with excess pressures.

As a rule, always maintain the substrate manipulator heater, and any source heating zone that extends into the growth module, at a slightly higher temperature than the growth-module bake zone. In general, cooler surfaces within a bake zone allow condensation of gases which could be released during subsequent growth processes.

WARNING— FLAMMABLE SUBSTANCES. Systems containing phosphorus should not be baked too hot. The growth-module bake temperature should be between 120°C and 150°C to prevent the conversion of red phosphorus to white phosphorus, which burns on contact with air presenting serious safety hazards during maintenance. Phosphorus recovery is a unique kind of bake that requires special equipment. Refer to the Phosphorus Recovery System User Guide for more information.

Bake State Operation Mode

An operator can initiate the bake state at the HMI computer. This mode starts the etching process and applies heat to the substrate for an indeterminate number of hours.

The system bake process includes procedures for preparing for bake, performing a bake, and returning to growth after a bake.

During bake, heat is used to drive off molecules that have adsorbed onto module interior surfaces, fixtures, and equipment. After these molecules have been driven off (desorbed), they are pumped away by the system pumps, improving the system vacuum level.

Baking the system allows system modules to be pumped back down more quickly after being vented for maintenance work or for loading of sources.

Low base pressures can be achieved after a system bake and subsequent cool-down to ambient temperature.

There are different bake zones on the system that are controlled with a Proportional-Integral Derivative (PID) controller device through the Molly software. The PID bake controller is embedded in the electronics rack.

During system bake, the Molly software provides remote control of the different bake zones. Each bake zone must be incorporated into a Molly bake schedule, that is generally stored in a Molly recipe file.

For each bake zone, the Molly bake schedule specifies the temperature control parameters (bake setpoint and ramp rate) and bake duration. Additionally, it includes zone-specific pressure bounding parameters (maximum module pressure and maximum pressure rate-of-change). If a pressure bounding parameter is exceeded, Molly temporarily turns off the corresponding bake heater to allow the affected pumps to “catch up” before a bake over-pressure interlock is triggered.

Returning to Growth after Bake

1. Make sure that:
   - The bake heaters are powered off.
   - The system has cooled for a minimum of 24 hours after power was shut off to the bake heaters
   - The sources, substrate manipulator heater, and prep heater (if included) have been safely ramped down (1°C/min maximum) to below 100°C.

WARNING— HOT SURFACES. Be careful to avoid burns. Never remove bake equipment until the system has adequately cooled.

CAUTION— Opening the bake enclosures too soon after bake may stress system seals and components, resulting in damage.

CAUTION— Damage to sources can occur during cooling. Some materials may crack the source crucible when they freeze unless the cooling rate is carefully controlled near the freezing point. Valved sources may need to have the valve opened before certain heating zones are cooled. Refer to appropriate source user manuals and material properties documentation.

2. Remove all peripheral bake equipment and store it for future use.
3. Set the bake-enable switches to the OFF position on the sub-cluster and growth-module electronics racks.
4. Perform a helium leak-check on the system using the RGA to ensure integrity of flanges and view ports following the bake.
5. Lubricate the substrate manipulator bearings.

6. Re-install all non-bakeable components that you removed for bake.

CAUTION— Be sure to color-match the cable connections for the position sensors on the storage-shelf assembly! If these connections are mixed up, the robot could collide with the storage-shelf assembly resulting in system damage.

7. Restore normal flow to the main water-cooling circuits.
8. Restore normal flow to any peripheral water-cooling circuits.
9. On the Molly Overview screen, exit Bake mode for the growth and cluster modules.
10. Re-fill the cryo panel.
11. Prepare the platen transfer system.
    a. Power on all motion controllers.
    b. Re-home the various axes of motion. (See the applicable Veeco user manuals for homing instructions.)
    c. Re-teach platen transfer positions.

Idle State Operation Mode

An operator can set the GENxplor system to the idle state at the HMI computer. This mode starts a hard stop of a running process. The system goes into idle mode without going through the usual pump and purge cycles.

Operating the Sources

The proper method for operating the sources depends on the source design, choice of materials, source configuration, and specific growth application. Each MBE source on the system has unique power specifications and material compatibilities.

Source temperatures are directly controlled by a Veeco Temperature Controller (8-loop or 16-loop versions) via manipulation of the appropriate power supply output. The Molly software provides the interface for remote control and monitoring of source temperatures.

Please refer to the following publications for information pertaining to source operation:

- Veeco source user manuals
- Molly Software Help
- Veeco Temperature Controller User Manuals (8-loop and 16-loop versions)
- OEM power supply manuals

IMPORTANT— The system includes two important safety interlocks pertaining to source operation: the growth module vacuum interlock and water-cooling low flow interlock. Carefully review the purpose and mechanism for each of these interlocks before attempting to operate the sources!

Controlling Component States

The alarms panel allows you to control certain system components. For example, you can open or close gate valves and shutters, and start or stop turbo pumps.

Any component for which the alarms panel provides control capability has a control box. Control boxes are located on module/subsystem screens only.

As an example, the control box below has all features identified.

Component Name Tab

Lists the component to which the controls apply.

Status Bar

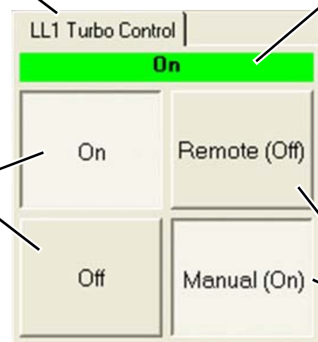
Shows the current state of the component.

Green = On or Open

Red = Off or Closed

Orange = Ajar (no indication signal present)

Yellow = Invalid (both indication signals present)



Manual Command Buttons

When a button is depressed, the component goes to the state listed on the button itself, provided the control mode is set to Manual.

Control Mode Buttons

Button depressed = active control mode

Button "popped out" = inactive control mode

Remote = from Molly

Manual = from the alarms panel or EpiMove

In parentheses is the current command for that control mode, which takes effect when the control mode is active.

Understanding System Interlocks

Overview of System Interlocks

The system is configured with a set of interlocks that help to ensure the safety of equipment and operators.

Interlocks are designed to put the system into a safe state, or disallow certain operations, upon detection of unfavorable or dangerous conditions. Interlocks may be PLC based or software based, as described in the following sections.

IMPORTANT— The GENxplor is a manual system, and as such does not prevent against all unsafe actions on the part of operators. Anyone who operates the system must be fully aware of the system interlocking behavior in order to know which conditions to avoid and how to restore the system to an operational state should interlocks become active.

WARNING— Some interlocks include editable input conditions, or may be defeated through manual overrides. Either action could potentially result in system damage, poor performance, or even harm to operators.

PLC-Based Interlocks

System PLCs embedded in the electronics racks continuously monitor signals from one or more input devices on the system (ion gauges, pump controllers/monitors, water flow switches, etc.). If the received signals conform to the input conditions defined for the interlock, the system PLCs command the output devices to a safe output condition.

Typically, the input conditions for standard PLC-based interlocks also result in active alarms on the alarms panel and in the Molly software. However, not all active alarms are associated with interlocking behavior.

PLC-based Interlocks may be latching or non-latching, as described in the following sections.

Latching PLC-Based Interlocks

Latching PLC-based interlocks require operator intervention to be manually reset (cleared) after the input conditions (triggers) have been eliminated.

PLC-based interlocks are configured to be latching when automatic clearing of the interlock could have undesired consequences.

Examples of standard latching PLC-based interlocks include:

- Growth module vacuum interlock
- Cryo pump over-temperature interlock

For information on resetting a latching PLC-based interlock, see *Resetting Latching PLC-Based Interlocks* on page 72.

Non-Latching PLC-Based Interlocks

Non-latching PLC-based interlocks are automatically reset (cleared) when the input conditions (triggers) have been eliminated.

PLC-based interlocks are configured as non-latching when automatic clearing is desirable.

Examples of non-latching PLC-based interlocks include:

- Bake over-pressure interlocks
- Water-cooling low flow interlock

Table of Standard PLC-Based Interlocks

The table below lists **standard** PLC-based interlocks, which are included on most systems.

▶ **IMPORTANT—** For a complete description of all PLC-based interlocks on the system, refer to the interlock flow charts for the system.

Interlock Name	Type	Input Devices	Input Conditions	Output Devices	Output Conditions
Bake over-pressure, growth module	Non latching	Growth-module ion gauge / ion gauge controller	Pressure > SP2	PID bake controller for the growth-module bake zone	Bake power output disabled
Bake over-pressure, cluster module	Non latching	Cluster-module ion gauge / ion gauge controller	Pressure > SP2	PID bake controller for the cluster-module bake zone	Bake power output disabled
Bake over-pressure, load-lock module	Non latching	Load-lock ion gauge / ion gauge controller	Pressure > SP2	PID bake controller for the load-lock module bake zone	Bake power output disabled
Growth module vacuum	Latching	Growth-module ion gauge / ion gauge controller Devices relating to growth-module pump statuses (vary by system config.)	Pressure > SP2 AND Pump status = not OK (composite signal based on several conditions)	Power supplies for all heat-producing devices in growth module	Output = 0
Water-cooling low flow	Non latching	Water flow switches	Water flow switch open (indicates low flow)	Veeco Temperature Controller (8-loop or 16-loop version)	2nd setpoint = active setpoint for all control loops
Cryo pump over-temperature interlock (one instance included for each cryo pump)	Latching	Cryo pump temperature monitor	Cryo pump temp. > Low Setpoint (when Molly module mode = Normal) OR > High Setpoint (when Molly module mode = bake)	Cryo pump gate valve	Closed

Bake Over-Pressure Interlocks

Summary

If the second pressure setpoint (SP2) is reached or exceeded on the ion gauge controller for a particular module, the bake power output for the corresponding bake zone is disabled until the vacuum level recovers to an acceptable level. When the vacuum level again becomes acceptable, the output is automatically re-enabled to allow the bake to continue. Note that there is one bake over-pressure interlock for each bake zone.

Purpose

Cutting power to the bake zones reduces the rate of desorption from in-vacuum surfaces, allowing the pumps to “catch up.” This protects the module pumps to a degree (see “Notes” below) against potential damage caused by excessive gas loads.

Type

The bake over-pressure interlocks are non-latching. As such, they auto-reset when the input conditions are eliminated. These interlocks must be non-latching because the system bake process takes a relatively long time, and the bake heaters must be allowed to resume operation after the vacuum level recovers. If the bake heaters were latched, the bake would be terminated at the first instance of P > SP2 on the applicable ion gauge controller.

Notes

Do not rely upon the bake over-pressure interlocks to limit the bake heaters during system bake. When these interlocks activate, bake power output is abruptly disabled until the pumps “catch up,” resulting in repeated on/off cycles of the bake heaters and a jagged heating curve. Instead, use the MaxP (maximum pressure) setting available in the Molly bake recipe. The MaxP should be approximately 0.5 - 1.0 orders of magnitude lower (better vacuum) than SP2 on the ion gauge controller. This keeps bake temperatures under proper PID control and results in a more stable heating curve.

CAUTION— The bake over-pressure interlocks do not prevent a severe overshooting of the safe module maximum pressure during bake, in which case material continues to desorb off of module interior surfaces despite no additional heat being supplied. Such overshooting can damage the pumps; to avoid it, make sure that the ramp rate, PID values, and pressure bounding parameters are set properly in Molly for each bake zone.

Growth Module Vacuum Interlock

Summary

If a system PLC determines that the pressure in the growth module has exceeded a safe level, all power supplies for devices that draw current in the growth module have their output disabled. These devices (sources, substrate manipulator heater, heated view ports, etc.) remain without power, even if the pressure drops back down below SP2, until the operator manually resets the interlock.

Purpose

Cutting power to all devices that draw current in the growth module serves several purposes. First, for heat-producing devices (most importantly sources) it eliminates the possibility of a runaway pressure increase in the growth module. A runaway pressure increase could result in damage to equipment and/or a dangerous over-pressurization of the growth module. (Note that for gas sources, in addition to cutting power to the filaments, the growth module vacuum interlock turns off flow from the corresponding mass flow controller [MFC)]). Second, it protects heater filaments from burning out by being run at atmosphere. Finally, it reduces the potential for exposure of personnel to electrical hazards when the growth module is being vented to atmosphere.

WARNING— HIGH VOLTAGE. If the growth module must be opened up for maintenance, do not rely upon the growth module vacuum interlock to electrically de-energize all devices. For maximum safety, always power off each device at the appropriate power supply.

Type

The growth module vacuum interlock is latching. As such, a manual reset is required. The latching behavior of this interlock serves two important functions: 1) It protects filaments from damage from repeated power-cycling (on/off) in the event that the pressure is hovering right around SP2, and 2) It allows the operator to assess the consequences of the over-pressure incident on past or future material growth before deciding to re-apply power to the heaters.

Notes

The input devices and conditions for this interlock may vary by system configuration. A system PLC uses various inputs to calculate a composite “growth module vacuum” signal, which determines whether the interlock is active. Typically, the input conditions include: 1) the second setpoint (SP2) being reached or exceeded on the growth-module ion gauge controller; and 2) one or more pump statuses being “not OK”. (Note that pump status is itself a composite signal based on several input conditions.)

Water-Cooling Low Flow Interlock

Summary

If a water flow switch opens up on a main water-cooling circuit, this indicates that the minimum flow is no longer being supplied, a system PLC sends an interlock signal to the Veeco Temperature Controller, which starts ramping all temperature loops down to their 2nd setpoint. Note that the 2nd setpoint is a safely lower value that requires careful selection and attention. (See Notes section below.)

NOTE—This interlock pertains only to the main water-cooling circuits. Refer to the interlock flow charts for the system for details on interlocks pertaining to peripheral water-cooling circuits (for example, e-beam and RF plasma sources).

Purpose

Ramping down the sources and substrate manipulator heater when water flow is inadequate serves several important functions: 1) it minimizes the amount of heat that requires dissipation; 2) it reduces the chances of a steam rupture in the water-cooling lines or within water-cooled components; and 3) it prevents equipment damage caused by excessive temperatures.

Type

The water-cooling low flow interlock is non latching. As such, it safely auto-resets when the input condition has been eliminated. All temperature loops automatically start ramping back up to their normal setpoint when the flow switch closes, indicating adequate water flow. Nonetheless, any instance of an active water-cooling low flow interlock may indicate a larger facility water-supply issue that requires due attention.

Notes

The water-cooling low flow interlock is necessarily ignored when the system mode is set to Bake for the growth module (GM) in the Molly software. If it were not ignored, purging the water lines before bake would cause the 2nd setpoint to become active for each temperature loop, preventing the sources and substrate manipulator heater from being set to an appropriate temperature for bake (typically slightly hotter than the bake temperature for the growth-module bake zone).

IMPORTANT— For this interlock to function as intended, it is critical that an appropriate 2nd setpoint value be in place for each temperature loop on the Veeco Temperature Controller. The 2nd set points must be sufficiently low so that the system will be protected if water flow to the system is lost. Normally, the 2nd set points are low temperatures such as room temperature or 100ºC, depending on the properties of the material (melting point, expansion/contraction upon freezing, etc.). In some cases, such as for a melted aluminum source, it makes sense for the 2nd setpoint to be just above the melting point of the material so that the crucible is not destroyed by sudden freezing of the material. However, you should typically keep the 2nd setpoint at a safe (sufficiently low) value in the event of a water failure.

WARNING— Failure to use an appropriate 2nd setpoint value for each temperature loop could result in crucible failure and/or system damage in the event that water cooling is lost. Moreover, deliberately setting the 2nd setpoint high in order to operate sources hot without adequate cooling may result in equipment damage and/or hazards to operators.

Cryo pump Over-Temperature Interlock

Summary

If a cryo pump temperature monitor reads a cryo pump temperature above the applicable setpoint (Setpoint Low or Setpoint High), the isolation gate valve to the cryo pump automatically closes.

Purpose

Closing the gate valve to the cryo pump isolates the pump from the module. During system bake, this isolation prevents excessive heat loads from reaching the cryo pump. During normal operation, isolation prevents any back-streaming of lighter gases from the pump to the system in the case where the cryo pump arrays have become saturated.

Type

The cryo pump over-temperature interlock is latching. As such, a manual reset is required. The latching behavior of this interlock prevents rapid on/off firing of the gate valve solenoid in situations where the cryo pump temperature is hovering right around the cryo pump temperature setpoint. Rapid firing could damage the solenoid and gate valve mechanisms.

Notes

Setpoint Low is used for this interlock during normal operation. Setpoint High is used during system bake. Setpoint High is intentionally higher, because baking the system generates large amounts of heat, so there must be a slightly higher tolerance to keep the cryo pump actively pumping out the gases that are generated during bake.

Any cryo pump on the system may include two other features designed to limit cryo pump over-temperature conditions. These features must be well understood in order to troubleshoot the cause of an active cryo pump over-temperature interlock. First, there may be a water-cooled adapter between the cryo pump and the system. Water cooling in this region dissipates heat during both normal operation and bake, and must be maintained at all times to prevent cryo pump temperatures from rising too high. Second, there may be a throttling device on the isolation gate valve for a cryo pump. This device can be used to limit conductance to the pump during bake.

Software Interlocks

The Molly and Lot Manager software both include a variety of interlocks to prevent equipment damage or poor material growth.

Software interlocks are typically designed to prevent one of the following when unfavorable conditions are detected:

- Platen transfers
- Molly recipes
- Manual operations that could otherwise be performed through the software interface

Like PLC-based interlocks, software interlocks may be latching or non-latching. For a complete description of software interlocks, refer to Molly or Lot Manager Help.

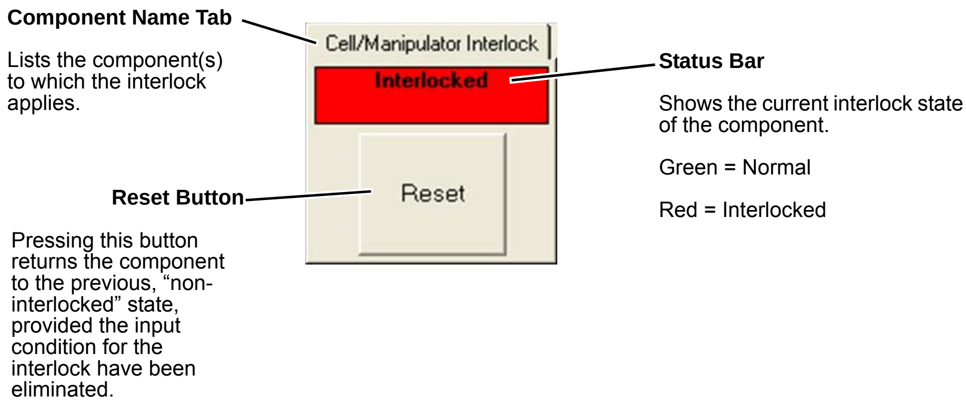
Resetting Latching PLC-Based Interlocks

The alarms panel includes an interlock reset box for latching PLC-based interlocks. When active, these interlocks put one or more output devices into an “off” or “closed” state until the operator manually resets the interlock.

To reset this type of interlock:

1. Eliminate the input conditions that have resulted in the active alarm/interlock.
2. On the alarms panel, reset the interlock by pressing **Reset** on the applicable interlock reset box. This turns control back over to the process control system, which has the same effect as restoring the component to the previous, non-interlocked state, provided the input conditions for the interlock have been eliminated.

As an example, the interlock reset box below has all features identified.



Loading Platens

Overview

The three main procedures required to load platens into the GENxplor are

- mounting the substrates;
- filling the load-lock cassette; and
- loading the cassette into the load-lock module.

The sections that follow cover each of these procedures.

Mounting the Substrates

Because the GENxplor keeps the installed substrates in a horizontal position throughout the transfer and epitaxy process, no snap rings or spring plates are needed to mount the substrates if you are using standard gravity substrate holders. Simply place the cleaned substrate onto the substrate holders, using backing rings if needed.

If you are using Veeco Uni-Block® substrate holders with retaining rings and special plates, refer to the Veeco Uni-Block user manual for instructions on using a variety of different Uni-Block configurations.

You will need to determine the required cleanliness level of the facility and the equipment needed (gloves, wafer-handling instruments, etc.) during substrate mounting. Your process will likely dictate the exact procedures needed.

Filling the Load-Lock Cassette

You can fill the load-lock cassette with up to three 3” platens. These can be either standard gravity substrate holders or non-bonded Veeco Uni-Block® substrate holders.

Each platen should be centered and level on its shelf in the load-lock cassette.

Loading the Cassette into the Load-Lock Module

1. Note the following assumed starting conditions:
   - The load-lock module is vented.
   - All substrates to be loaded have been mounted on platens.
   - The three shelves of load-lock cassette are filled with platens containing substrates.
2. Make sure that you have the following equipment:
   - Cleanroom gloves (nitrile, latex or vinyl)
3. Open the load-lock door by loosening the screw mechanism and swinging the door open.
4. Place the load-lock cassette into the load-lock module so that the four holes in the bottom of the cassette engage the four screws on the cassette support.

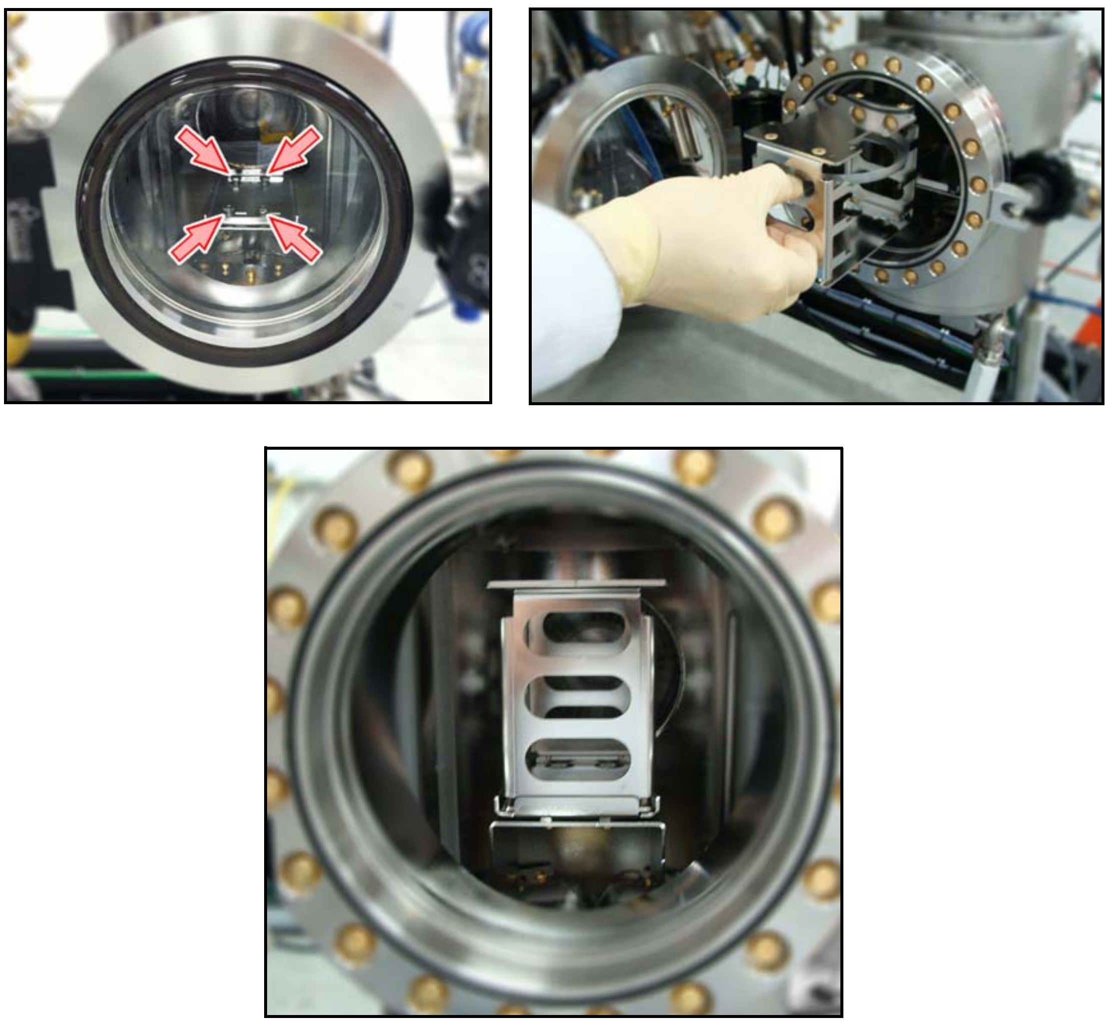


Figure 4-1: Placing the Load-Lock Cassette into the Load-Lock Module

5. Close and latch the load-lock door.

6. Screw the locking mechanism until it is hand-tight.

CAUTION— Do not overtighten the locking mechanism. It should be hand-tight only. Overtightening could damage the O-ring seal.

You are now ready to pump down the load-lock module.

Transferring Platens

Transfer Basics

Overview

The first step in learning to manually transfer platens within the system is to understand the basic types of platen movement that are possible. The following sections show how to perform each type of movement.

After you understand how to move each component, you can progress to the specific point-to-point transfer procedures (see page 79). These procedures typically involve a sequence of two or more basic operations.

IMPORTANT— Be sure to review *Transfer Safety Rules* on page 78 before practicing any of these transfer basics.

Coupling and De-coupling the Platen Cassettes

Before executing a series of platen transfers as part of your overall process, you first need to couple the load-lock cassette (loaded with platens) to the storage cassette. Later, after you have executed all necessary transfers and growth is complete, you need to de-couple the load-lock cassette from the storage cassette in order to remove the load-lock cassette from the system.

Raising and Lowering the Elevator

You need to raise or lower the elevator in order to transfer the platen cassettes between the load-lock and buffer modules, and during transfers of individual platens between specific cassette shelves and the end effector. The required direction (up or down) depends on which step you are at in a specific point-to-point transfer procedure (see page

79 for details). Figure 4-2 shows how to rotate the hand crank to move the elevator up or down.

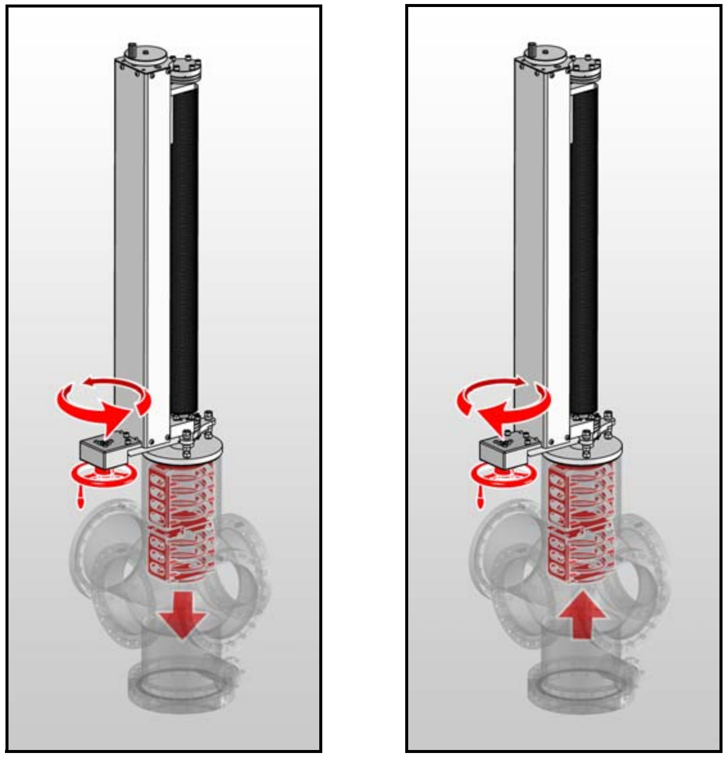


Figure 4-2: Moving the Elevator Up or Down

Sliding the Horizontal Transfer Arm to Different Positions

You slide the horizontal transfer arm forward or backward to bring the end effector to critical positions with respect to platen transfers. The horizontal transfer arm includes two permanent, clamp-style stops and up to four optional stops. Each stop is intended to correspond to one of these critical positions of the end effector.

The optional stops are recommended, but not required, for correct positioning of the end effector. Careful and experienced users may be able to transfer platens without using the optional stops.

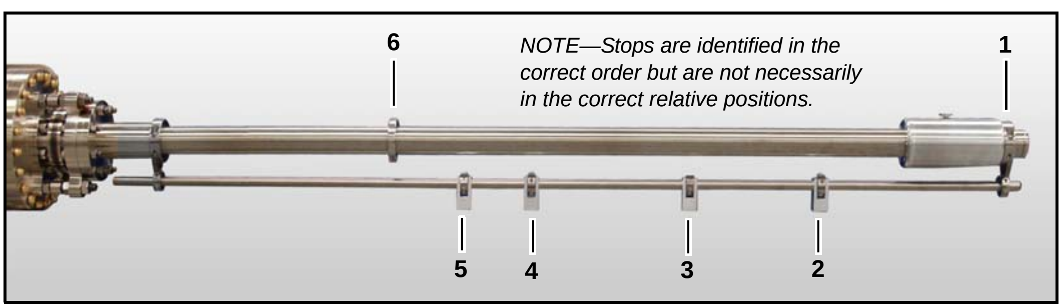


Figure 4-3: Stops for Critical End Effector Positions

#	Description	#	Description
1	Standby for cassette (Standby for heated-station stage if heated station included)	4	Not used (Cassette transfer if heated station included)

#	Description	#	Description
2	Cassette transfer (Heated-station transfer if heated station included)	5	Standby for growth stage
3	Not used (Standby for cassette if heated station included)	6	Growth stage transfer

To use a permanent stop, slide the handle horizontally toward the stop until the two meet. To use an optional stop, rotate the block upward and then slide the handle toward it until the two make contact.

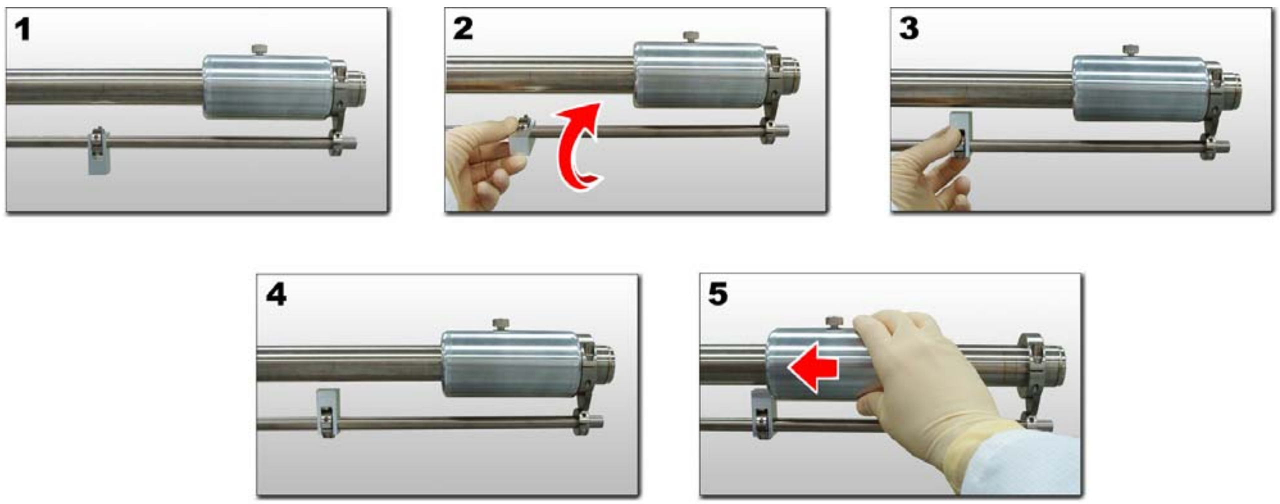


Figure 4-4: Using an Optional Stop

Moving the End Effector Up or Down

When the end effector has a platen that you want to transfer to the growth stage, you move the end effector up just before the actual transfer. You also move the end effector up as a means of picking up a transfer before transferring a platen from the end effector to the growth stage. You move the end effector down all the way down

Figure 4-5 shows which direction to rotate the handle to move the end effector up or down.

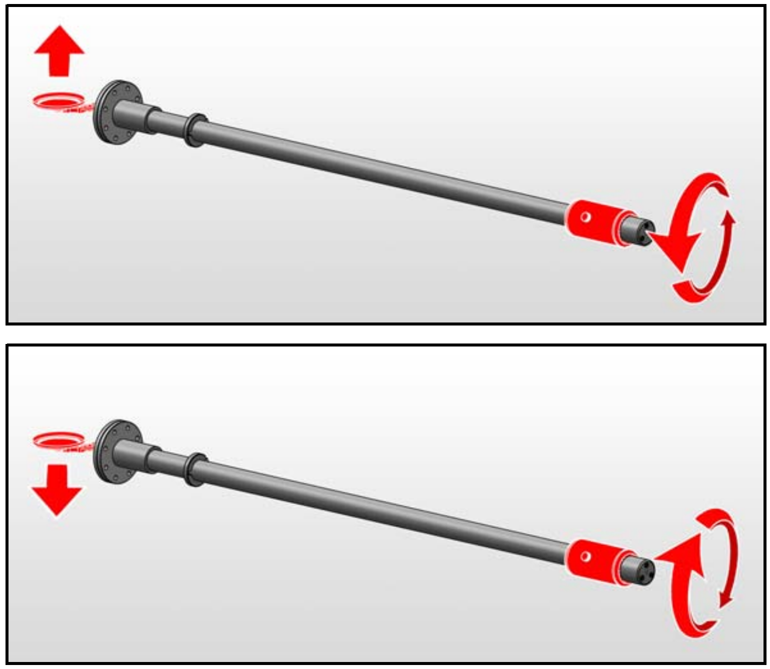


Figure 4-5: Moving the End Effector Up or Down

Transfer Safety Rules

CAUTION— Failure to follow these rules could result in dropped platens or damage to system equipment.

- Always know the open/closed position of the manual gate valves. Other than operator awareness, there is nothing on the system to prevent an open gate valve from being closed onto an extended transfer arm, or a transfer arm from being rammed into a closed gate valve.
- Never move the horizontal transfer arm, elevator or heated station stage unless the buffer/growth gate valve is closed. The purpose is to protect the growth environment from any debris generated by moving parts, or from an exceedingly-rare-but-possible vacuum breach (for example, in the bellows for the elevator or heated-station.
- Use extra caution to prevent bumping different components of the transfer system into one another. Careless operation could result in contact between the horizontal transfer arm and the platen stages or cassettes. During transfers, closely observe the motion of each moving component to gauge the correct stopping point.
- Before any transfer to or from the growth stage, make sure that the growth stage is rotated to a safe angle, that is: one at which the three vertical arms supporting the growth stage cannot interfere with the end effector. The proper technique is to first home the growth stage using the Veeco SMC-GSR Controller, then make a visual confirmation through the growth module viewport.
- Never initiate growth stage rotation until the horizontal transfer arm is fully retracted from the growth module and the buffer/growth gate valve is closed.

- Before opening the manual gate valve between different modules prior to an inter-module transfer, make sure that the pressure differential between modules is not too great.

Transfer Procedures

Overview

The following “point-to-point” transfer procedures assume that you are already familiar with the transfer basics (see page 79). These procedures typically involve a sequence of two or more basic operations.

IMPORTANT— Be sure to review *Transfer Safety Rules* on page 78 before attempting any of these transfer procedures.

Load-Lock to Buffer Module

1. Note the following assumed starting conditions:
   - The load-lock cassette has been filled with platens and loaded into the load-lock module.
   - The load-lock module has been pumped down.
   - Any load-lock outgassing recipe in Molly has finished running.
2. Make sure that the pressure differential between the load-lock and buffer modules is safe for the manual load-lock/buffer gate valve to be opened.
3. Open the manual load-lock/buffer gate valve.
4. Using the hand crank, lower the elevator all the way down until the bottom of the storage cassette is near, but not touching, the load-lock cassette.
5. Using the magnetic knob below the load-lock module, pull the load-lock-cassette slightly toward the load-lock door and hold it there, out of the way of the storage cassette.
6. Lower the elevator a little further until its four lower pins are just below the top plate of the load-lock cassette.
7. Using the magnetic knob, push the load-lock cassette forward to allow the four pins of the storage cassette to engage the four holes in the top plate of the load-lock cassette.
8. Release the knob when the pins and holes are engaged.
9. Raise the elevator (with cassettes coupled together) safely above the manual load-lock buffer gate valve.
10. Close the manual load-lock buffer gate valve.

    The procedure is complete.

Between Cassette Shelves

NOTE—Use the following procedure to transfer a platen from its current cassette shelf to any empty cassette shelf.

1. Note the following assumed starting conditions:
   - The elevator is in the buffer module, with the two platen cassettes coupled together.
   - All inter-module gate valves are closed.
2. Make sure that:
   - The horizontal transfer arm is in the “standby for cassette” position (see Figure 4-3 on page 76); and
   - The end effector is in the Down position.
3. While looking through the buffer viewport, refine the height of the elevator by rotating the hand crank in the appropriate direction. The goal is to position the elevator so that the end effector while still in the Down position can be slid forward to a point just below the platen that you wish to transfer, without contacting any platen below it.

   TIP—You may need to move the end effector slightly closer to the cassettes in order to gauge the correct elevator height.
4. When the elevator height is correct, carefully slide the horizontal transfer arm forward until the end effector is directly below the platen to be picked up.
5. Slowly lower the elevator until the platen is fully resting on the end effector, but no more than 1/8” (3.2 mm) beyond that point.
6. Slide the horizontal transfer arm back to the “standby for cassette” position.
7. Adjust the height of the elevator by rotating the hand crank in the appropriate direction. This time, the goal is to position the elevator so that the end effector now holding a platen and still in the down position can be slid to just above the empty cassette shelf to which you wish to transfer it, without contacting any platen or cassette top-plate above it.

   TIP—You may need to slide the end effector slightly closer to the cassettes in order to gauge the correct elevator height.
8. When the elevator height is correct, carefully slide the horizontal transfer arm forward until the end effector is directly above the empty shelf.
9. Slowly raise the elevator until the platen is fully resting on the cassette shelf, but no more than 1/8” (3.2 mm) beyond that point.
10. Slide the horizontal transfer arm back to the “standby for cassette” position.

    The procedure is complete.

Buffer to Heated Station

Stage and end effector must be all the way down. Stage picks up off of end effector.

Heated Station to Buffer

Stage and end effector must be all the way down. Stage sets platen down onto end effector.

Buffer to Growth Module

1. Note the following assumed starting conditions:
    - The elevator is in the buffer module, with the two platen cassettes coupled together.
    - All inter-module manual gate valves are closed.
2. Perform steps 2–6 in *Between Cassette Shelves* on page 80. You should now have a platen that is ready for growth on the end effector.
3. Raise the elevator up all the way, so that the platen cassettes cannot interfere with the horizontal transfer arm when you slide the arm forward in a later step.
4. Make sure that the substrate manipulator heater is in the Up position (see Figure 4-16 on page 108).
5. Make sure that the pressure differential between the buffer and growth modules is safe for the manual buffer/growth gate valve to be opened.
6. Open the manual buffer/growth gate valve.
7. Slide the horizontal transfer arm forward to the “standby for growth stage” position.
8. Raise the end effector to the Up position.
9. Slide the horizontal transfer arm forward to the “growth stage transfer” position.
10. While looking through the growth viewport, carefully lower the end effector to the Down position. The platen is transferred from the end effector to the growth stage.
11. Slide the horizontal transfer arm back to the “standby for cassette” position.
12. Close the manual buffer/growth gate valve.

    The procedure is complete.

Growth to Buffer Module

1. Note the following assumed starting conditions:
    - A platen is on the growth stage, and growth is complete.
    - All inter-module manual gate valves are closed.
2. Raise the substrate-manipulator heater all the way.
3. Make sure that:
    - The elevator is raised up all the way; and
    - The end effector is in the Down position.
4. Make sure that the pressure differential between the buffer and growth modules is safe for the manual buffer/growth gate valve to be opened.
5. Open the manual buffer/growth gate valve.
6. Slide the horizontal transfer arm forward to the “growth stage transfer” position.
7. While looking through the growth viewport, carefully raise the end effector to the Up position. The platen is transferred from the growth stage to the end effector.

8. Slide the horizontal transfer arm back to the “standby for cassette” position.
9. Close the manual buffer/growth gate valve.

   The procedure is complete.

Buffer to Load-Lock Module

1. Note the following assumed starting conditions:
   - The elevator is in the buffer module, with the two platen cassettes coupled together.
   - The load-lock module is still pumped down.
2. Make sure that the pressure differential between the load-lock and buffer modules is safe for the manual load-lock/buffer gate valve to be opened.
3. Open the manual load-lock/buffer gate valve.
4. Using the hand crank, lower the elevator until the load-lock cassette lands on the cassette support at the bottom of the load-lock module. The four holes on the base of the load-lock cassette should engage the four nuts on the cassette support.
5. If necessary, continue lowering the elevator slightly to fully disengage the pins of the storage cassette from the four holes in the top plate of the load-lock cassette.
6. Using the magnetic knob below the load-lock module, pull the load-lock-cassette slightly toward the load-lock door and hold it there, out of the way of the pins on the storage cassette.
7. Raise the elevator enough to fully clear the top plate of the load-lock cassette.
8. Using the magnetic knob below the load-lock module, push the load-lock cassette forward to its natural position.
9. Raise the elevator safely above the manual load-lock buffer gate valve.
10. Close the manual load-lock buffer gate valve.

    The procedure is complete.

Pumping Down System Modules

Pumping Down the Load-Lock Module

Use this procedure to pump down the load-lock module.

1. Note the following assumed starting conditions:
   - Substrates are on platens in the load-lock cassette, and the load-lock cassette is in the load-lock module.
   - The load-lock turbo and scroll pumps are off.
   - The load-lock module is currently vented to atmospheric pressure.
   - The manual load-lock/buffer gate valve is closed.

2. If the load-lock door is open, close and lock the door using the locking mechanism.

CAUTION— Do not overtighten the locking mechanism. It should be hand-tight only. Overtightening could damage the O-ring seal.

3. Start the load-lock turbo pump and its backing scroll pump simultaneously by pressing the “Start/Stop” button on the turbo pump controller in the electronics rack.

   The load-lock scroll pump and turbo pump start at the same time. Initially, the speed of the turbo pump is very low. As the scroll pump removes more vent gas from the load-lock module, the turbo pump speed increases.

   At the beginning of the pump-down process, the Convectron gauge on the load-lock turbo-pump isolation space measures the pressure inside the module. When the vacuum improves below 1.0×10^{-3} Torr, the filament on the load-lock ion gauge automatically turns on and continues to monitor the module pressure.

   NOTE—The Convectron and ion gauge readouts are shown on the load-lock ion gauge controller in the electronics rack.

4. After the pressure drops to below 1.0×10^{-3} Torr, unscrew the door lock and swing it out to avoid over-pressurization in the load-lock module for any reason.
5. Monitor the speed of the load-lock turbo pump at the turbo pump controller in the electronics rack. When the turbo pump reaches normal operating speed, the active alarm for turbo pump speed goes away, as indicated on the Alarms screen in the Molly software.
6. Continue to monitor the load-lock module pressure on the appropriate ion gauge controller.
7. You may now start a load-lock outgassing recipe in the Molly software.

Pumping Down the Buffer Module

If the buffer module is vented, you should pump it down through the load-lock module below it. The buffer module cannot be individually pumped down.

Use this procedure to pump down the buffer module.

NOTE—If the optional heated station is included, it will be pumped down along with the buffer and load-lock modules as you perform this procedure.

1. Note the following assumed starting conditions:
   - The buffer module and load-lock module are both currently vented to atmosphere.
   - The load-lock turbo and scroll pumps are off.
   - The manual load-lock/buffer gate valve is open.
   - The manual buffer/growth gate valve is closed.
   - The buffer-module ion pump is powered off.
2. Perform all steps starting at step 2 in *Pumping Down the Load-Lock Module*. The buffer module is pumped down along with the load-lock module.

3. Turn on the filament for the buffer-module ion gauge when the load-lock module pressure is less than 1.0×10^{-3} Torr. You can now monitor pressure directly on the buffer-module ion gauge controller.
4. Power on the buffer-module ion pump when the buffer-module pressure is less than 1.0×10^{-5} Torr.
5. Continue to monitor the buffer-module pressure on the appropriate ion gauge controller.

Pumping Down the Optional Heated Station

To pump down the optional heated station after it has been vented, follow the procedure for pumping down the buffer module on page 82. Because there is no isolation gate valve between the buffer module and heated station, the heated station will be pumped down along with the buffer module.

Pumping Down the Growth Module

If the growth module is vented, you must pump it down through the buffer and load-lock modules using the load-lock turbo pump. The growth module cannot be individually pumped down.

WARNING— FLAMMABLE SUBSTANCES. If the system is being used with phosphorus, you must pump down the growth module using the turbo pump and scroll pump included in the Veeco Phosphorus Recovery System. Using any other pumping method may cause white phosphorus (which burns on contact with air) to travel to other parts of the system, exposing maintenance personnel to possible fires or explosions if the system is opened to air.

WARNING— TOXIC SUBSTANCES. Ensure that the growth module is free of chemicals or contaminants before pumping it down through the buffer and load-lock modules. Failing to do this could lead to operator exposure to toxic substances and migration of contaminants to other parts of the system.

Use this procedure to pump down the growth module.

NOTE—The buffer and load-lock modules (and the optional heated station, if included) will also be pumped down as you perform this procedure.

1. Note the following assumed starting conditions:
   - The growth, buffer, and load-lock modules are all currently vented to atmosphere.
   - The cryo-panel is empty of cooling liquid.
   - The manual load-lock/buffer gate valve is open.
   - The manual buffer/growth gate valve is open.
   - The load-lock turbo and scroll pumps are off.
   - The buffer-module ion pump is powered off.

2. Verify that the growth-module primary pumps are in the correct initial state:

   For an ion pump:

   - The ion pump may be powered off, with the isolation gate valve to the pump open (pump off and vented).

     OR

   - The ion pump may be running, with the isolation gate valve to the ion pump closed (pump running and under vacuum).

   For a cryopump:

   - The cryopump should be running. (Refer to the OEM manual for the cryopump for startup instructions if necessary.)
   - The isolation gate valve to the cryopump should be closed.

   For a turbo pump:

   - The turbo pump should be at operating speed (no active alarm shown on the Alarms screen in the Molly software for turbo pump speed).
   - The isolation gate valve to the turbo pump should be closed.

3. Perform all steps starting at step 2 in *Pumping Down the Load-Lock Module*. The growth and buffer modules are pumped down along with the load-lock module.
4. When the vacuum improves below 1.0×10^{-3} Torr, turn the filament on at the growth-module ion gauge controller to continue to monitor the growth-module pressure.
5. Wait for the growth-module pressure to drop to 1.0×10^{-5} Torr.
6. Close the manual gate valves between modules:
   - Load-lock/buffer gate valve
   - Buffer/growth gate valve
7. Use the growth-module primary pumps to further pump down the growth module:
   - For an ion pump that was off and vented in step 2 (above), power on the ion pump.
   - For a cryo pump or turbo pump, or an ion pump that was running and under vacuum in step 2 (above), open the isolation gate valve to the pump.
8. Continue to monitor the growth-module pressure on the appropriate ion gauge controller.
9. To power off the load-lock turbo pump, press the “Start/Stop” button on the turbo pump controller in the electronics rack.

Preparing a Cryopump for Use

During initial system installation, a Veeco technician prepares any cryopumps on the system. If a cryopump is ever powered off, you must properly prepare it for use again before pumping down the module to which it is attached.

CAUTION— Running a cryopump at or near atmospheric pressure is ineffective and results in pump failure.

Generally, cryopump preparation involves:

- Rough-pumping the cryopump with the isolation gate valve closed between the cryopump and the module.

  NOTE—An all-metal valve is attached to the rough-pumping port on the back side of the cryopump, allowing the cryopump to be opened up to a rough-pumping line.

- Cooling the cryopump to the appropriate operating temperature using the attached cryo-compressor.

IMPORTANT— Refer to the OEM manual for the cryopump and cryo-compressor for complete startup instructions.

Venting System Modules

Overview

During module venting, high-purity dry N_2 gas is used to backfill the module. Properly venting a module before it is exposed to air limits surface oxidation, adsorption of water vapor, and general contamination of interior surfaces, fixtures, and equipment.

The following sections include instructions for venting different system modules.

WARNING— MODULE OVER-PRESSURIZATION. Having the high-purity N_2 pressure set to greater than 3 psi during module venting could result in over-pressurization of modules and possible harm to operators or equipment.

Venting the Load-Lock Module

In order to load or unload the load-lock platen cassette, you must first vent the load-lock module. Venting the load-lock module is also required when the load-lock module must be opened for maintenance purposes.

Use this procedure to vent the load-lock module.

1. Note the following assumed starting conditions.
   - The load-lock module is currently under vacuum.
   - The load-lock/buffer gate valve is closed.

2. Make sure that the door locking mechanism on the load-lock module has been loosened and swung open.

3. Stop the load-lock turbo pump by pressing the “Start/Stop” button on the turbo pump controller in the electronics rack.

4. Wait for the turbo pump to spin down to a safe speed before proceeding.

   TIP—Check the blade rotation of the turbo pump by looking through viewport on the load-lock door.

WARNING— Do not begin to open the vent valve unless the turbo pump has spun down to a safe speed! Doing so could result in equipment damage or harm to operators. Refer to the OEM manual for the turbo pump for further guidance.

5. When ready to vent, very slowly open the manual N_2 vent valve on the side of the load-lock module.

6. Gradually open the manual N_2 vent valve until fully opened.

7. Monitor the pressure rise on the appropriate ion gauge controller. When the load-lock module pressure reaches 760 Torr, venting is complete and the load-lock door may be opened.

8. Close the manual N_2 vent valve.

Venting the Buffer Module

Venting the buffer module is required when the buffer module must be opened for maintenance purposes.

The buffer module must be vented through the load-lock module below it. The buffer module cannot be individually vented.

Use this procedure to vent the buffer module.

NOTE—If the optional heated station is included, it will be vented along with the buffer and load-lock modules as you perform this procedure.

1. Note the following assumed starting conditions:
   - The buffer and load-lock modules are both under vacuum.
   - All inter-module manual gate valves are closed, including the load-lock buffer gate valve and buffer/growth gate valve.
   - There are no platens in the load-lock module.

2. At the buffer-module ion gauge controller, make sure that the ion-gauge filament is off.

3. Open the buffer/load-lock gate valve.

4. Perform all steps starting at step 2 in *Venting the Load-Lock Module*. The buffer module is vented along with the load-lock module.

Venting the Optional Heated Station

Venting the optional heated station is required when the heated station must be opened for maintenance purposes.

Venting the heated station requires the same basic procedure as venting the buffer module. Because there is no isolation gate valve between the buffer module and heated station, the latter will be vented along with the buffer module.

However, before starting the procedure on page 87, it is critical that you first perform these additional steps:

1. Power off all electrical instruments attached to, or within, the heated station chamber including:
   - heated station heater;
   - sources (RF plasma or Atomic Hydrogen Source);
   - ion gauge (if present); and
   - any other powered equipment.

WARNING— HIGH VOLTAGE. Failure to power off all heated-station instruments prior to starting to vent the module presents electrical hazards to operators or maintenance personnel when the heated station is opened following vent, and may result in equipment damage.

2. Purge the water-cooling circuit for any source installed on the heated station. For an atomic hydrogen source, this is a main water-cooling circuit; for an RF Plasma source, this is a peripheral water-cooling circuit serviced by a separate OEM chiller/circulator (refer to OEM manual for purge instructions).

   NOTE—During vent, water may condense on any surfaces that remain cool. This increases the time required to pump down the buffer module and heated station after venting.

3. Proceed with the procedure for venting the buffer module (see page 87).

Venting a Growth Module

You must vent a growth module before re-loading sources with material or before performing growth-module maintenance.

The growth module must be vented through the load-lock and buffer modules. The growth module cannot be individually vented.

The complete procedure for venting the growth module (below) includes preparatory steps that must be performed before actual venting begins. The overall procedure could take over 24 hours.

WARNING— TOXIC SUBSTANCES. Venting and opening the growth module exposes operators to substances with varying degrees of toxicity. Observe all warnings listed on the original material containers. Carefully review the material safety data sheets (MSDS) for the substances involved. Wear appropriate personal protective equipment (PPE) when handling these substances.

Use this procedure to vent a growth module.

NOTE—The buffer and load-lock modules (and the optional heated station, if included) will also be vented as you perform this procedure.

1. Note the following assumed starting conditions:
   - The growth, buffer, and load-lock modules are all under vacuum.
   - The manual buffer/growth gate valve is closed.
   - There is no platen on the growth stage.
2. If phosphorus has been used in the system and the growth module will be opened to air following the vent procedure, make sure that you have performed a phosphorus recovery. (See the Phosphorus Recovery System User Guide for instructions.)

WARNING— FLAMMABLE SUBSTANCES. If phosphorus (which burns on contact with air) has been used as a source material in the system, failure to perform a phosphorus recovery before venting the growth module may result in exposure of maintenance personnel to fires or explosions when the system is opened to air.

3. Cool all sources to room temperature.

CAUTION— Use caution when cooling sources that contain particular materials. Some materials expand as they freeze and may crack the crucible unless the cooling rate is carefully controlled near the freezing point. Other materials must be cooled to very low temperatures before they can be exposed to air.

   NOTE—Cooling sources takes at least 4 hours. More time may be required depending on the thermal conductivity of the crucible material and the mass and properties of deposition material in the crucible.

4. Empty the cryo-panel. (See *Emptying the Cryo-panel* on page 92.)
5. Power off the substrate manipulator heater.
6. At the appropriate controllers or power supplies in the growth-module electronics rack, power off all instruments attached to, and within, the growth module, including:
   - sources;
   - ion gauges;
   - RHEED gun;
   - RGA;
   - heated view ports;
   - titanium sublimation pump; and
   - any other powered equipment.

WARNING— HIGH VOLTAGE. Failure to power off all growth-module instruments presents electrical hazards to operators or maintenance personnel when the growth module is opened following vent.

7. Purge the required water-cooling circuits:

   NOTE—During vent, water may condense on any surfaces that remain cool. This increases the time required to pump the growth module back down after venting.

   a. Purge all main water-cooling circuits for the growth module, and allow the growth module to warm to ambient temperature.

   b. Purge any peripheral water-cooling circuits for components on the growth module. For instructions, refer to the OEM manual for the separate chiller/circulator for these components.

   c. Maintain normal flow in the auxiliary water-cooling circuits.

8. Close the isolation gate valves (if present) to the growth-module primary pumps.

9. If the growth module includes an ion pump with no isolation gate valve, power off and secure the ion pump.

10. After again verifying that the buffer and load-lock modules are under vacuum, open the manual inter-module gate valves:

    - Buffer/growth gate valve
    - Load-lock/buffer gate valve

CAUTION— Opening the manual inter-module gate valves without the buffer and load-lock modules already being under vacuum could result in equipment damage.

11. Perform all steps starting at step 2 in *Venting the Load-Lock Module*. The growth and buffer modules are vented along with the load-lock module.

12. When the growth-module pressure reaches 760 Torr, close the all-metal valve on the growth-module venting/pumping port. The growth module can now be opened.

    TIP—There is typically no instrument included on the growth module to monitor pressures in this range. You may use time as a guide: 20 minutes of venting is usually adequate.

Filling & Emptying the Cryo-panel

Safety Considerations

Cryo-panels are designed for use with liquid nitrogen (LN_2), which can be dangerous. Please review the following warnings.

WARNING— CRYOGENIC HAZARD (DANGEROUSLY COLD). LN_2 can cause severe burns. Always wear appropriate personal protective equipment (PPE) when filling or emptying the cryo-panel.

WARNING— SUFFOCATION HAZARD. If excessive amounts of LN_2 are allowed to evaporate into a poorly ventilated facility, the N_2 could displace O_2, resulting in a suffocation hazard. Ensure adequate ventilation and avoid unnecessary evaporation of LN_2. Also, backflow of cold N_2 gas from a disconnected LN_2 exhaust line could cause a suffocation hazard if the exhaust line is left uncapped. Always cap the exhaust line after disconnecting (applies to cryo-panels connected a phase separator).

Filling a Cryo-panel

Overview

After the growth module has reached a suitable base pressure through use of the attached primary pumps, you can fill the cryo-panel with LN_2 to further reduce the pressure in preparation for epitaxial growth. The cryo-panel works by trapping molecules on its cold surface.

General Recommendations

Here are general recommendations for filling and using a cryo-panel:

- Before filling a cryo-panel, make sure that:
    - There is water flowing in all water-cooling circuits.
    - The growth module has reached a suitable base pressure through use of the primary pumps. Veeco recommends a base pressure of 5.0×10^{-8} Torr or lower.
    - You have taken appropriate measures to minimize thermal stress on the cryo-panel. (See *Minimizing Thermal Stress* on page 91).
- When filling a cryo-panel:
    - Do not use any cooling liquid other than LN_2.
    - Attach the LN_2 supply and exhaust lines to the appropriate cryo-panel ports. Pay close attention to any “Supply” and “Exhaust” labels included, or contact Veeco if you have questions about the purpose of each cryo-panel port.
- At all times (during filling and maintaining the LN_2 liquid level), avoid supplying LN_2 intermittently. This can cause pressure bursts in the growth module. It can also cause thermal stress on the cryo-panel, shortening its lifetime. (See *Minimizing Thermal Stress*.)

Minimizing Thermal Stress

All cryo-panels have a limited lifetime due to the extreme temperature range that they experience during different stages of MBE system operation. The most common failure mode is a vacuum leak at a weld joint in the cryo-panel. Vacuum leaks are typically the result of thermal stress.

Thermal stress can be classified as either *baseline* and *operator-induced*.

- *Baseline* thermal stress is caused by a temperature change of approximately 220ºC, and is the simple result of cycling the cryo-panel between room temperature (empty cryo-panel) and -196ºC or lower (full cryo-panel). Baseline thermal stress is unavoidable.
- *Operator-induced* thermal stress is caused by temperature changes greater than 220ºC, or by uneven heating. This type of thermal stress occurs when you fill a cryo-panel while maintaining sources or other heat-producing devices above room temperature. Operator-induced thermal stress can typically be minimized or avoided altogether (see procedure below).

Use this procedure before filling the cryo-panel to minimize operator-induced thermal stress on the cryo-panel.

1. If possible, cool all sources, the substrate heater and any other heat-producing devices (for example, titanium sublimation pump) to ambient temperature before introducing any LN_2 into the cryo-panel.

CAUTION— Use caution when cooling sources that contain particular materials. Some materials may crack the crucible when they freeze unless the cooling rate is carefully controlled near the freezing point.

2. If it is not possible to cool all heat-producing devices to ambient temperature, take the following actions:

CAUTION— The steps below do not guarantee against excess thermal stress on the cryo-panel, possibly resulting in leaks. Veeco provides these steps as suggestions only; proceed at your own risk.

   a. Use the lowest possible temperature for each heat-producing device. Use only the amount of heat needed to achieve the desired effect, and no more.
   b. Connect a supply of 30 psi compressed dry air (CDA) to the Supply port on the cryo-panel.
   c. Allow the air to flow through the cryo-panel for a minimum of six hours to distribute cryo-panel temperatures evenly, minimizing hot and cold spots.
   d. After six hours, disconnect the supply of CDA and immediately proceed to fill the cryo-panel. (See *General Recommendations* on page 91).

Emptying the Cryo-panel

Here are general recommendations for emptying the cryo-panel:

- Completely empty the cryo-panel before baking the system, and before venting the growth module for source loading or system maintenance.
- To remove all LN_2, simply terminate the supply and allow the LN_2 to evaporate away through the exhaust port. This could take more than 24 hours.

- If the cryo-panel is connected to a phase separator, you may need to disconnect the exhaust line to prevent backflow of cold N_2 gas from entering the cryo-panel. Be sure to cap the exhaust line after disconnecting to prevent a suffocation hazard.
- To expedite the evaporation process, you may ramp the substrate manipulator heater up to a low temperature (400ºC maximum), while keeping all sources and other heat-producing devices cool.
- After emptying the cryo-panel, always allow it to warm to ambient temperature before venting the growth module.

3. circuits are now filled.
4. Restore normal flow to both circuits by connecting the supply line (blue) and return line (grey) for each circuit to their normal connectors.

Baking the System

Purpose of System Bake

During bake, heat is used to drive off molecules that have adsorbed onto module interior surfaces, fixtures, and equipment. After these molecules have been driven off (desorbed), they are pumped away by the system pumps, improving the system vacuum level.

Baking the system allows system modules to be pumped back down more quickly after being vented for maintenance work or for loading of sources.

Low base pressures can be achieved after a system bake and subsequent cool-down to ambient temperature.

Bake Zones and Control

Standard Bake Zones

Bake zones are defined as “standard” if they use a dedicated Eurotherm bake PID temperature controller and are listed as bake zones in the Molly software. (See “Add bakeout schedule dialog box” in the Molly software help.)

The system includes one standard bake zone for the load-lock module, and a second standard bake zone that encompasses the growth module, buffer module, optional heated station, and horizontal transfer arm. For simplicity, this second standard bake zone is referred to simply as the “growth bake zone” or “main bake zone”. Therefore, a typical system with one load-lock module, one buffer module, and one growth module has two standard bake zones.

The critical control hardware for each standard bake zone includes:

- A dedicated Eurotherm bake PID temperature controller
- Power-control electronics (power supply, PLC, solid-state relay [SSR], etc.)
- One or more AC bake heaters
- A thermocouple for temperature feedback
- The module ion gauge for pressure feedback

The distribution of this hardware varies by bake zone. For the growth bake zone, the Eurotherm bake PID temperature controller is in the power distribution panel on the side of the electronics rack (see Figure 4-6), and the power-control electronics and AC bake heaters are in the growth bake cart assembly (see Figure 4-7).

Figure 4-6: Eurotherm Bake PID Temperature Controllers

#	Description
1	Load-lock bake PID temperature controller
2	Growth (main) bake PID temperature controller

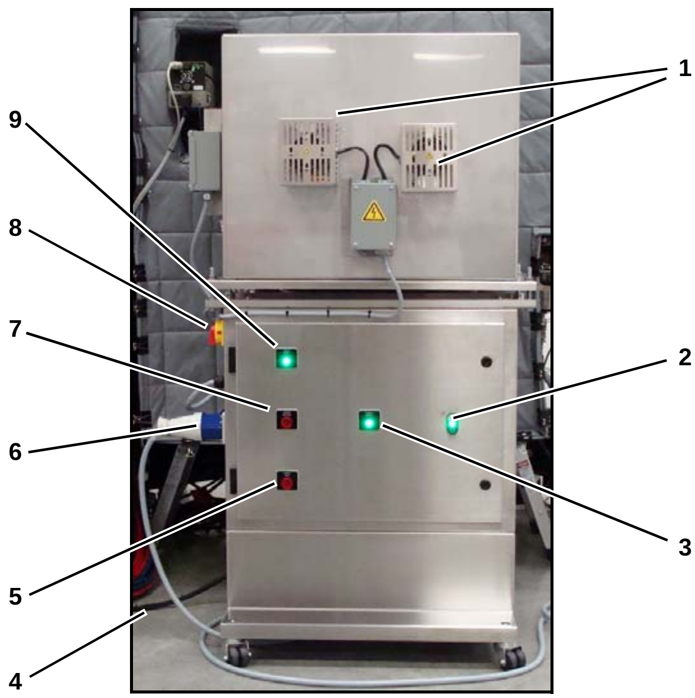


Figure 4-7: Growth Bake Cart Assembly

#	Description	#	Description
1	Stir fans	6	Power connector
2	Bake heater ON/OFF switch	7	CHAMBER OVER TEMP indicator (see *PLC-Based Interlocks* on page 67)
3	SYSTEM ENABLED indicator	8	Power enable switch
4	Control/feedback cable	9	HEATER ACTIVE indicator
5	STIR FAN FAULT indicator	–	–

Heated Station Bake Zone

The optional heated station is defined as a non-standard bake zone because it is baked both externally and internally, has no dedicated Eurotherm PID temperature controller for bake (the control loop for the heated-station heater in the Veeco 8-loop or 16-loop Temperature Controller is used), and is not listed as a bake zone in the Molly software. (See “Add bakeout schedule dialog box” in the Molly software help.)

External heat is supplied by the growth bake zone. During bake, the optional heated station is incorporated into the growth bake zone along with the buffer module and horizontal transfer arm through the use of shared bake insulation blankets.

Internal heat is supplied by the heated-station heater. Power to the heated-station heater comes from a DC power supply under the control of a Veeco Temperature Controller (8-loop or 16-loop version).

IMPORTANT— To achieve the internal heat required for the heated station during bake, be sure to add the heated-station heater to your Molly bake schedule, using the buffer module ion gauge for pressure feedback. This allows you to precisely control the heated-station heater output based on pressure feedback from the buffer module ion gauge, preventing the buffer-module pump from being overloaded or the bake over-pressure interlock from being triggered by excess gas loads. Refer to the Molly Software help for instructions.

Remote Control of Bake Zones

During system bake, the Molly software provides remote control of the different bake zones. Each bake zone must be incorporated into a Molly bake schedule (a Molly recipe file).

For each bake zone, the Molly bake schedule specifies the temperature control parameters (bake setpoint and ramp rate) and bake duration. Additionally, it includes zone-specific pressure bounding parameters (maximum module pressure and maximum pressure rate-of-change). If a pressure bounding parameter is exceeded, Molly temporarily turns off the corresponding bake heater to allow the affected pumps to “catch up” before a bake over-pressure interlock is triggered.

For an explanation of why and how to use the pressure bounding parameters in a Molly bake schedule to avoid triggering the bake over-pressure interlocks, see the “Notes” section within *PLC-Based Interlocks* on page 67.

For further information on bake control through Molly, refer to the Molly software help.

IMPORTANT— Molly may display all zeros for the PID values for the load-lock bake zone (see Detail tab of the Status screen) if the PID bake controller for the load-lock quartz lamps is power-cycled. You do NOT need to enter new PID values to achieve proper functioning of this zone. After power-cycling, a script in the controller automatically resets the PID values to the functional defaults (P=2, I=200, D=0). However, because these values are not actively polled by Molly, zeros continue to be displayed. For correct display, re-enter only these default values in Molly!

Bake Temperatures

Load-Lock Bake Zone

The recommended bake temperature for load-lock bake zone is **200ºC**.

Heated Station Bake Zone

If an optional heated station is included on the system, the recommended internal bake temperature for the heated-station heater is **400ºC**. The recommended external bake temperature is the same as for the growth bake zone, which encompasses the optional heated station.

Growth Bake Zone

There is no simple rule for determining an optimum bake temperature for the growth bake zone.

For most MBE applications, growth-module bake temperatures typically fall somewhere in the range of 120–200ºC. Growth-module bake temperatures must be hot enough to ensure that contaminant gases are desorbed to the pumps, without being so hot as to overload the growth-module pumps with excess pressures.

Review the variables and guidelines below.

<u>Variables</u>

- Vapor pressure curve of the most volatile material in the growth module.
  The more volatile the material, the lower the bake temperature must be.
- Pumping configuration on the growth module.
  The pumping configuration includes the type, capacity, and number of pumps. Certain pumps can handle higher partial pressures of specific gases.

<u>Guidelines</u>

- Use published vapor-pressure data to estimate the evaporation rates of the materials at various temperatures, and then select a temperature that will not overload the system pumps or vaporize a significant fraction of the source loads.
- Understand the limits of your pumps. Consult the OEM manual for the pump or contact the manufacturer to determine safe upper limits for partial pressures of specific gases.
- Regardless of the temperature chosen, approach the ultimate bake temperature slowly and incrementally to avoid pressure spikes that could damage pumps or trigger the bake over-pressure interlock for the growth bake zone. Remember, it is easy to modify the bake setpoint and bake duration in the Molly software while a bake is in progress. (See Molly Help for instructions.)
- Always maintain the substrate manipulator heater, and any source heating zone that extends into the growth module, at a slightly higher temperature than the growth-module bake zone. In general, cooler surfaces within a bake zone allow condensation of gases which could be released during subsequent growth processes.

WARNING— FLAMMABLE SUBSTANCES. Systems containing phosphorus should not be baked too hot. The growth bake zone temperature should be between 120°C and 150°C to prevent the conversion of red phosphorus to white phosphorus, which burns on contact with air presenting serious safety hazards during maintenance. Phosphorus recovery is a unique kind of bake that requires special equipment. Refer to the Phosphorus Recovery System User Guide for more information.

Interlocks Pertaining to Bake

Three important interlocks are included in system PLCs to protect equipment during a system bake:

- Bake over-pressure interlocks
- Cryo pump over-temperature interlock
- Bake temperature runaway interlock

For more information, refer to the subheadings under *PLC-Based Interlocks* on page 67.

IMPORTANT— Carefully review the purpose and mechanism for each of these interlocks before attempting to bake the system!

Equipment Required for Bake

The following peripheral equipment is required for bake:

- Growth bake cart assembly includes bake heaters, power-control electronics, fans, etc.
- Support frame for growth bake zone (includes poles and connectors)
- Thermal blankets (various sizes and shapes)
- Aluminum foil
- Binder clips
- Acetone or isopropyl alcohol and a lint-free cloth
- Step ladder (customer supplied; used for accessing the top of modules during bake preparation and setup)

Summary of the Bake Process

The overall process of baking the system includes the following tasks:

1. Preparing for a bake (page 98)
2. Starting the bake (page 105)
3. Returning to growth after bake (page 106)

Preparing for Bake

WARNING— FLAMMABLE SUBSTANCES. If phosphorus (which burns on contact with air) has been used as a source material in the system, you must bake the growth module into the attached Veeco Phosphorus Recovery System instead of through open gate valves to the growth-module primary pumps. Refer to the Phosphorus Recovery System User Guide for system bake instructions. Do NOT proceed with the instructions below.

1. Note the following assumed starting conditions:
   - Modules are all pumped down to less than 1.0×10^{-6} Torr.
   - All platens are removed from the system.
   - All inter-module gate valves are closed.
   - Gate valves are open to all primary pumps and pumps are running.
   - All standard sources, the substrate manipulator heater, and heated-station heater (if included) are powered off or idling at low temperatures (less than 200ºC).
   - E-beam and plasma sources (if installed) are powered off and cooled to ambient temperature.
2. Prepare the cryo-panel for bake.
   a. Empty the cryo-panel. (See *Emptying the Cryo-panel* on page 92.)
   b. Make sure that the cooling-liquid supply and return lines are removed from the "Supply" and "Exhaust" connections on the cryo-panel.
3. Purge the required water-cooling circuits.
   a. Purge all main water-cooling circuits.
   b. Purge any peripheral water-cooling circuits for Veeco RF Plasma sources or OEM E-beam sources.
   c. Maintain normal water flow for all auxiliary/facility water-cooling circuits.
4. Remove and set aside all non-bakeable parts from the substrate manipulator.
   a. Remove the drive-belt shield.
      i. Remove the six screws that secure the drive-belt shield to the servo motor mount.
      ii. Remove the two pieces of the drive-belt shield.

b. Remove the servo motor assembly as follows.

   i. Remove the two inner screws indicated.

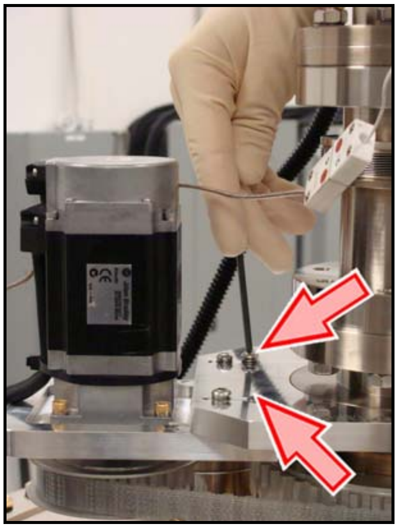


Figure 4-8: Removing the Two Inner Screws

   ii. Slide the servo motor inward. The drive belt loosens up.

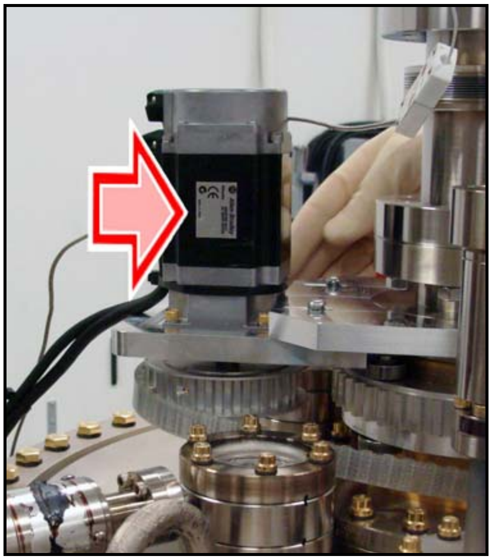


Figure 4-9: Sliding the Servo Motor Inward

iii. Disengage the drive belt from the center gear teeth, and rest the drive belt on the substrate manipulator flange.

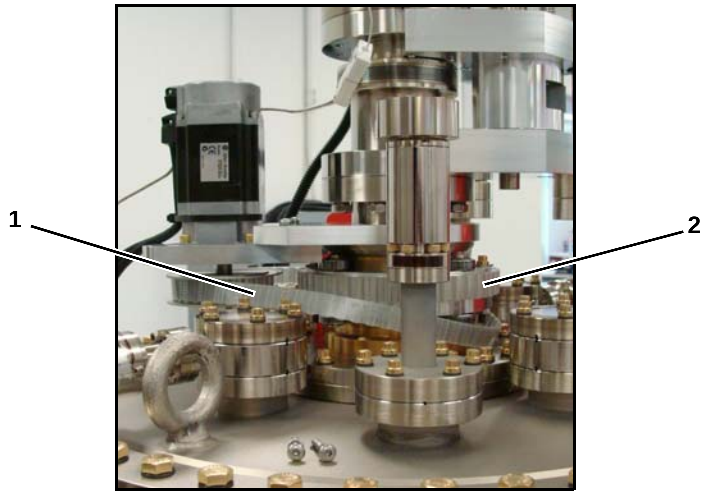


Figure 4-10: Drive Belt Disengaged from the Gear Teeth

#	Description
1	Drive belt
2	Center gear teeth

iv. Remove the servo motor assembly by loosening the two clamp screws, pulling the halves apart and setting them safely outside the bake zone.

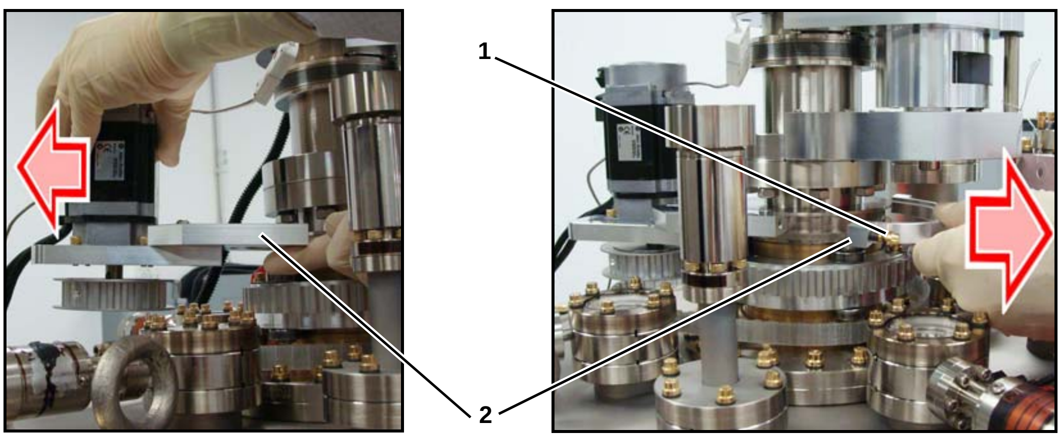


Figure 4-11: Removing the Servo Motor Assembly

#	Description
1	Clamp screw (1 of 2)
2	Two halves of clamp

c. Remove the drive belt.

   i. Disconnect the thermocouple and power cables from the substrate manipulator to allow the drive belt to be removed.

   ii. Lift the drive belt upward. If you encounter a narrow gap between the substrate manipulator and the flange of the LN_2 supply tube, carefully work the drive belt through this gap.

Figure 4-12: Removing the Belt

   iii. Set the drive belt safely aside outside the bake zone.

   iv. Reconnect the thermocouple and power cables to the substrate manipulator to allow the substrate heater to be run during the bake.

d. Remove the magnetic center gear.

   i. Loosen the two coupling screws on opposite sides of the center gear. This allows the two halves of the gear to be de-coupled.

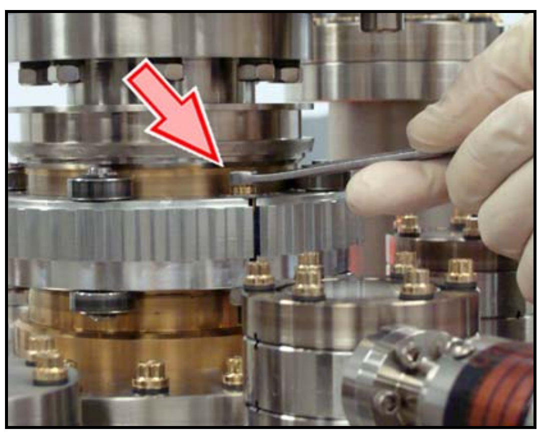


Figure 4-13: Loosening the Two Coupling Screws on the Center Gear

ii. De-couple the two halves of the center gear by manually pulling each away from the substrate manipulator.

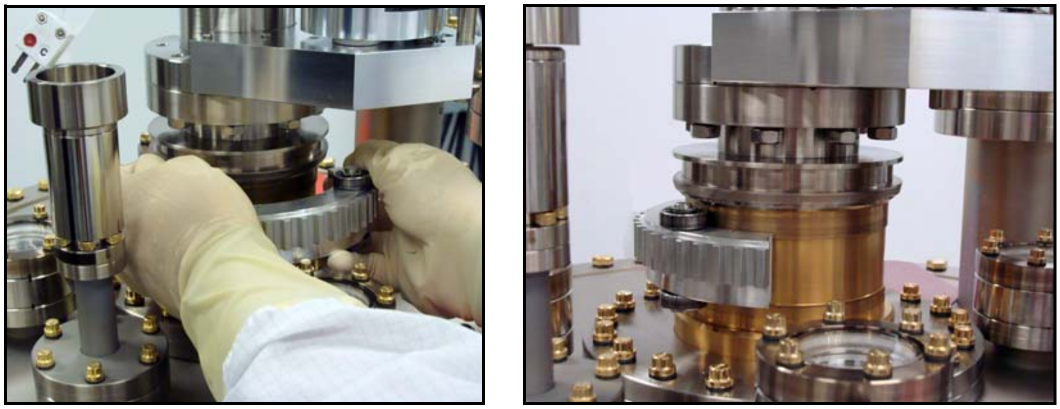


Figure 4-14: De-coupling the Two Halves of the Center Gear

iii. Set the two halves of the center gear safely aside outside of the bake zone, making sure to separate the halves with a soft barrier to prevent the strong magnets from collapsing together.

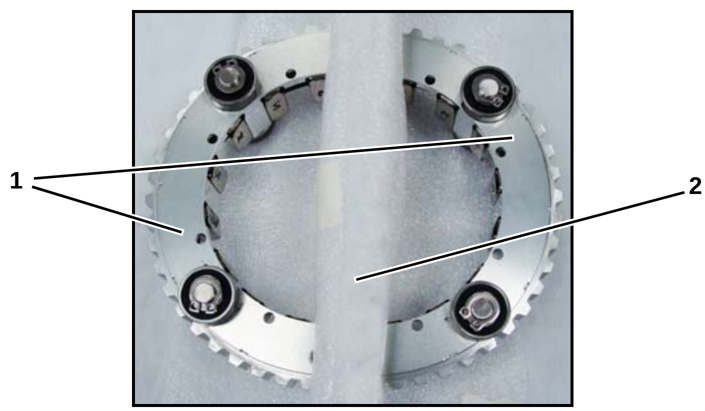


Figure 4-15: Separation of Center Gear Halves

#	Description
1	Center gear halves
2	Soft barrier (bundled packing foam shown)

5. Remove and set aside all other non-bakeable components (typically marked with yellow tape) from the system, including the components listed below:

WARNING— HIGH VOLTAGE. Do not remove any non-bakeable component that draws power without first verifying that it is powered off and the power cable is disconnected.

CAUTION— The following list of steps is extensive but may not cover all non-bakeable equipment on the system. As a rule, non-bakeable components are marked with yellow tape; however, this marking method provides general guidance only and is not exhaustive. Do not bake any component if you are not certain that it can withstand the heat of bake. When in doubt, refer to the OEM manual for the component.

- Supply hoses (blue) and return hoses (grey) for the main water-cooling circuits. The hose disconnection points are listed below:

  * Main water manifolds (on the growth-module H-frame support)
  * Sources
  * Substrate manipulator
  * Growth-module cooling jacket
  * Growth-module base flange (in some cases)
  * Quartz crystal monitor assembly (if installed)

- Servo motors and motor couplers for:

  * Substrate manipulator
  * Valved Cracker sources (if installed)
  * Automated linear positioner for quartz crystal monitor assembly (if installed)

- Pneumatic actuators for:

  * Source shutters (including E-beam source shutters, if installed)
  * Growth-module main shutter
  * Base flange shutters

  TIP—For easier re-installation, leave the pneumatic air lines attached when possible.

- Gate valve position indicators (except for gate valves to growth-module primary pumps, which are outside the bake zone)

- E-beam assemblies (if installed):

  * Shutter assembly
  * Power connector assembly

  NOTE—Refer to the OEM manual for the E-beam source for details on preparing for system bake.

- Flexible drive belts

- Illumination lamps and lamp power supplies (if installed)

- RHEED camera (if installed)

- RHEED gun components (if installed; see OEM manual)

- Growth-stage camera and camera shutter (if installed)

- BandiT light source and detector (if installed)

- Piezo ceramic stack (if a piezoelectric valve is installed for control of background oxygen pressures)

- Non-bakeable power and data cables to system equipment

- Tape, cable ties, and non-bakeable affixing equipment

6. Make sure that the source shutters are secured in the retracted (open) position with the attached shutter pins.
7. Prepare any Veeco gas-delivery subsystems for bake, including:
    - CBr_4 Gas Flow Control System (if installed)
    - Gas Source Delivery System (if installed)

    Refer to the user guides for these subsystems for bake preparation instructions.
8. Perform any additional specific steps required to prepare each source for bake. Refer to the appropriate source user guides for instructions.

CAUTION— Failure to properly prepare each source for bake could result in equipment damage. Some sources, particularly RF Plasma, Valved Cracker, and Valved Mercury sources, may require additional bake-preparation steps.

9. Using acetone or isopropyl alcohol with a lint-free cloth, remove residues, marks and fingerprints from module surfaces.

    NOTE—If not cleaned in this way, module surfaces could be etched during bake.
10. Install all bake equipment for the growth bake zone.
    a. Cover all view ports to be baked with aluminum foil to minimize viewport stress due to thermal gradients during bake.
    b. Inspect the following connection points for the primary and secondary bake thermocouples:
        - on the growth module weldment; and
        - near the entry of the thermocouple cable run into the electronics rack.

        All connections must be secure.
    c. Erect the support frame for the thermal blankets around the growth module using the poles and connectors provided.
    d. Cover the support frame with the main thermal blanket.
    e. Use binder clips to secure the seams between thermal blanket seams.
    f. Roll the growth bake cart assembly into place. The open end of the bake cart assembly should fit over one of the open gaps of similar size in the main growth-module thermal blanket.
    g. If applicable, make sure that any empty spaces in the main growth-module thermal blanket are covered with the supplied thermal-blanket “patches”.
    h. Inspect all joints and seams in the thermal blankets, and cover any gaps using pieces of aluminum foil.
    i. Separate temperature-sensitive materials (wires, tubing) from hot thermal blankets using aluminum foil.

j. For now, on the bake cart assembly, make sure that the red power enable switch (side of cart) and the bake heater ON/OFF switch (front of cart) are both turned off (O).

k. Connect the power cables from the facility power outlet to the IEC connector on the growth bake cart assembly.

l. Connect the bake-control/secondary-TC-feedback cable from the electronics rack to the growth bake cart assembly.

11. Set the SYSTEM BAKE switch on the electronics rack to the ENABLE position. This enables the bake function.

12. If necessary and included, set the throttle device for any cryo pumps on the system. (See *Throttling a Cryopump During Bake* on page 107 for instructions.)

Starting the Bake

1. On the bake cart assembly, make sure that the red power enable switch (side of cart) and the bake heater ON/OFF switch (front of cart) are both turned ON (I).

2. On the Overview screen in the Molly software, enter Bake mode using the appropriate status panel.

3. Power on all heated viewports (if included).

4. Using the Molly software, ramp up the substrate manipulator heater temperature. The following values are recommended:

   - Ramp rate = 5–10ºC/min.

   - Target setpoint = 300ºC, or approximately 100ºC above the temperature for the growth module (main) bake zone.

CAUTION— Never exceed 400ºC in any event. There is no water cooling to the substrate manipulator during bake. Excess heat could damage surrounding components.

5. Ramp up the individual heating zones for each source to an appropriate temperature for bake. (See individual source User Guides for recommendations. Also see *Bake Temperatures* on page 96 for relevant information.)

6. In the Molly software, verify that an appropriate system bake recipe has been set up. If a system bake schedule has not yet been set up, see Molly Help for instructions.

   The following guidelines may be used for the various bake zones:

   - Ramp rate: 1ºC/min

   - Temperature set points: see *Bake Temperatures* on page 96.

   - Max P (maximum pressure [Torr]): Set to approximately 0.5 - 1.0 orders of magnitude lower pressure (better vacuum) than the “hard” bake over-pressure interlock, which is triggered when P exceeds SP2 on the applicable ion gauge controller. This keeps bake temperatures under proper PID control and results in a more stable heating curve.

- Max P’ (maximum rate-of-change for pressure [%/min]): Material/pump dependent; typically 250 – 500.

7. If desired, set up graphs to track system bake data using the EpiTrend feature in the Molly software. (See Molly Help for instructions.)
8. Set up and start any desired residual gas analysis (RGA) graphing on the RGA computer.
9. Run the Molly bake recipe.

   TIP—Refer to Molly Help for information on how to run bakeouts, including how to stop the bake or adjust values (Bake setpoints, Maximum pressure, Time Left, etc.) during the bake.

Returning to Growth after Bake

1. Make sure that:
   - The bake heaters are powered off.
   - The system has cooled for a minimum of 24 hours after power was shut off to the bake heaters
   - The sources, substrate manipulator heater, and prep heater (if included) have been safely ramped down (1°C/min maximum) to below 100°C.

WARNING— HOT SURFACES. Be careful to avoid burns. Never remove bake equipment until the system has adequately cooled.

CAUTION— Opening the bake enclosure too soon after bake may stress system seals and components, resulting in damage.

CAUTION— Damage to sources can occur during cooling. Some materials may crack the source crucible when they freeze unless the cooling rate is carefully controlled near the freezing point. Valved sources may need to have the valve opened before certain heating zones are cooled. Refer to appropriate source user manuals and material properties documentation.

2. On the bake cart assembly, make sure that the red bake power enable switch (side of cart) and the bake heater ON/OFF switch (front of cart) are both turned off (O).
3. Remove all bake equipment and store it for future use. (See list on page 93.)
4. Set the SYSTEM BAKE switch to the OFF position on the electronics rack. This disables the bake function.
5. Perform a helium leak-check on the system using the RGA to ensure integrity of flanges and viewports following the bake.
6. Re-install all non-bakeable components that you removed for bake.
7. Restore normal flow to the main water-cooling circuits.
8. Restore normal flow to any peripheral water-cooling circuits.

9. On the Molly Overview screen, exit Bake mode for the growth module.
10. Re-fill the cryo-panel. (See *Filling & Emptying the Cryo-panel* on page 90.)
11. Power on and re-home the SMC controller for growth stage rotation. (See the applicable Veeco user manual for homing instructions.)

Throttling a Cryopump During Bake

About the Cryopump Throttle Device

The optional cryopump throttle device provides a means of limiting conductance to the cryopump during system bake. This device is included only on specific system configurations.

The purpose of the cryopump throttle device is to maintain pump effectiveness while preventing overheating.

If a cryopump overheats, the cryopump over-temperature interlock is triggered causing the pneumatic gate valve to the cryopump to close in order to protect the cryopump from further temperature increases. If the gate valve closes during bake, module pressures increase and may trigger the bake over-pressure interlock, which disables bake power output. If this happens, the bake is effectively terminated.

For a description of these and other PLC-based interlocks, see *PLC-Based Interlocks* on page 67.

Procedure for Throttling a Cryopump

Use this procedure to throttle a cryopump.

1. Close the pneumatic gate valve to the cryopump.
2. Remove the throttle bolt from its holder on top of the pneumatic gate valve.
3. If desired, unscrew the bottom nut on the throttle bolt to achieve a set distance from the bolt head.

   NOTE—Setting the distance in this way is optional but allows for throttling repeatability. The shorter the distance from the bottom nut to the bolt head, the greater the throttling action.

4. Snug the lock nut against the bottom nut so that both are held firmly in place.
5. Screw the throttle bolt all the way (until it stops) into the cylinder that protrudes from the top of the pneumatic gate valve. The “open” position for the pneumatic gate now provides some obstruction to molecules entering the cryopump.
6. Open the isolation gate valve to the cryopump.

   NOTE—The gate valve will no longer read Open.

Operating the Sources

The proper method for operating the sources depends on the source design, choice of materials, source configuration, and specific growth application. Each MBE source on the system has unique power specifications and material compatibilities.

Source temperatures are directly controlled by a Veeco Temperature Controller (8-loop or 16-loop versions) via manipulation of the appropriate power supply output. The Molly software provides the interface for remote control and monitoring of source temperatures.

Please refer to the following publications for information pertaining to source operation:

- Veeco source user manuals
- Source QAC specification sheet (one provided for each source)
- Molly Software Help
- Veeco Temperature Controller User Manuals (8-loop and 16-loop versions)
- OEM power supply manuals

IMPORTANT— The system includes two important safety interlocks pertaining to source operation: the growth module vacuum interlock and water-cooling low flow interlock. For information, see the subheadings under *PLC-Based Interlocks* on page 67. Carefully review the purpose and mechanism for each of these interlocks before attempting to operate the sources!

Operating the Substrate-Manipulator Heater

Moving the Heater Up and Down

The substrate-manipulator heater must be up all the way during any platen transfers between the horizontal transfer arm and the growth stage. The heater should be lowered down all the way for substrate heating during growth. To move the heater up, rotate the hand crank clockwise (as viewed from above) until you reach the stop; to move the heater down, rotate the hand crank counter-clockwise until you reach the stop (see Figure 4-16).

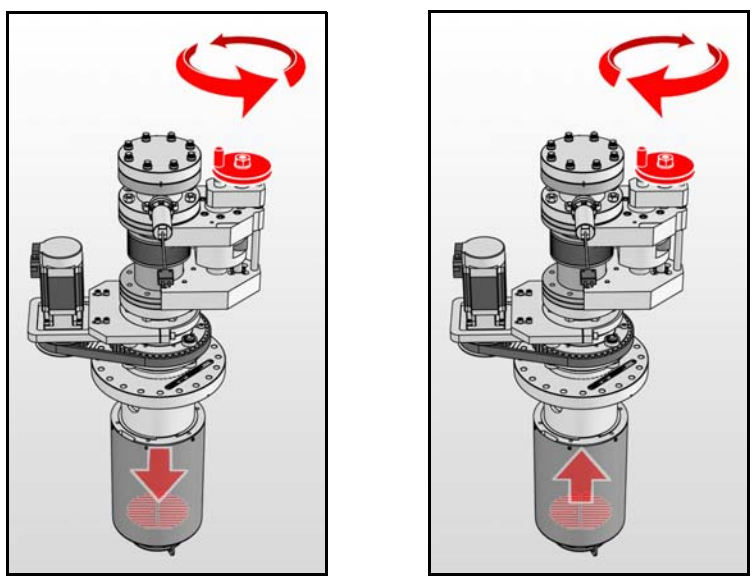


Figure 4-16: Movement of Substrate-Manipulator Heater With Crank Rotation

Powering the Heater

The substrate manipulator includes a single-zone heater for outgassing substrates and achieving appropriate substrate temperatures during epitaxial growth. Heater type and temperature range are specified at the time of the system order based on the desired growth application(s).

The substrate-manipulator heater is set up as a standard zone in the Molly software. This allows it to be controlled either manually or incorporated into a Molly growth recipe.

The proper method for operating the substrate-manipulator heater is highly dependent on the growth application(s) and heater type.

Please refer to the following publications for information pertaining to substrate-manipulator heater operation:

- Molly Software Help
- Veeco Temperature Controller User Manuals (8-loop and 16-loop versions)
- OEM power supply manuals

IMPORTANT— The system includes two important safety interlocks pertaining to operation of the substrate-manipulator heater: the growth module vacuum interlock, and water-cooling low flow interlock. For information, see the subheadings under *PLC-Based Interlocks* on page 67. Carefully review the purpose and mechanism for each of these interlocks before attempting to operate the substrate-manipulator heater!

Chapter 5 Maintenance

Introduction

The information in this chapter is organized into individual procedures, each covering a single maintenance-related task. In practice, you will likely want to perform several maintenance procedures simultaneously or consecutively to reduce system down time.

Due to the complexity of an MBE system, it is not possible to address all potential maintenance issues in a single chapter. Please contact Veeco for assistance if a maintenance issue arises with your system that is not covered here.

IMPORTANT— Be sure to consult the appropriate OEM manuals for service-related information on components not manufactured by Veeco.

Emergency System Recovery

Overview

Occasionally, an MBE system will undergo a power interruption. This may be due to a facility power interruption, or a localized outage resulting from a current surge and breaker shut-off.

If the system is not backed up with an uninterrupted power supply (UPS) system, the operator must quickly interact with the system to restore power. The goal is to minimize the deterioration of system status.

The rate of system-status deterioration upon loss of power will depend upon the system parameters and conditions at the time of the power interruption.

Generally, if the power outage is brief (< three minutes), the system can be brought back to the operational state that it was in just prior to the power interruption. Any actual epitaxial growth will likely be defective, but the pumping and system status will recover.

In a power outage lasting more than three minutes, any molten aluminum source material will have likely solidified too quickly and resulted in a broken source crucible. Outages beyond five minutes may also require regeneration of cryo pumps.

Tools and Parts Required

No special tools or parts are required.

Procedure

IMPORTANT— The procedure below is for outages lasting less than three minutes. It assumes that there are no UPS systems installed.

1. In the electronics rack(s), make sure that all of the following are powered off:
   - RHEED power supply
   - All titanium-sublimation-pumps (TSPs)
   - All DC power supplies
   - All Veeco SMC controllers

CAUTION— Failure to power off these components could result in equipment damage during system power up.

2. Power on the main circuit breaker, if it has shut off. This circuit breaker is located on the end of the electronics rack.

   TIP—For circuit breakers that have shut off, the low-voltage interruption, which is a safety feature, will likely need to be reset by toggling the breaker arm fully down and then back up.

3. At the appropriate ion gauge controllers, turn on the ion-gauge filaments for any module that should still be under vacuum.

   NOTE—This step is necessary because the module vacuum alarms become active (resulting in interlock conditions) when the ion gauge filaments are without power. These alarms remain active regardless of the actual pressure in the module.

4. Make sure that the pumps are actively pumping.

   a. Make sure that the pumps are on.
      - Cryo pumps are “on” if the corresponding cryo-compressors are on.
      - Turbo pumps and ion pumps may need to be re-started at the pump controller unless they have been configured for automatic re-start on power up.

   b. Make sure that the pumps are operating normally.
      - Cryo pumps should register a temperature under 28K on the corresponding cryo pump monitor. This indicates that the pump is operating normally and can be expected to recover.
      - Turbo pumps should be at operating speed. This is indicated by no active alarm for turbo speed on the alarms panel.
      - Ion pumps should be under set point 1. This is indicated by no active alarm for ion pump set point #1.

   c. Reset any active interlocks pertaining to pumps using the Alarms screen in Molly. If you cannot reset an interlock, attempt to troubleshoot the cause of the interlock. (See *Table of Standard PLC-Based Interlocks* on page 68, and the interlock flowcharts provided for the system.)

   d. Open the isolation gate valves to all pumps. This should be possible if there are no active interlocks pertaining to pumps.

5. Ensure that the system utilities are functioning as required.

   a. On the Alarms screen in Molly, verify that there is no active alarm for cooling-water flow.

   b. Verify that all gauge pressures for utilities (CDA, N_2) fall within the recommended ranges:

IMPORTANT— Be sure to fix any problems with utilities before proceeding.

6. Confirm that the sources and substrate heater are recovering.

   a. Turn on the 1U full-rack system computer (at upper right on the front of the electronics rack) and re-start the Molly software.

      NOTE—This step allows you to view temperatures in Molly, which is recommended when confirming recovery of the sources and substrate heater. However, you can also view temperatures directly on the applicable temperature controller.

   b. Reset the growth-module vacuum interlock by pressing the blue reset button on the front left side of the electronics rack, below the Veeco SMC-GSR controller.

      NOTE— When active, this interlock prevents heater operation.

   c. Power on any DC power supplies for sources and the substrate heater, if powered off.

   d. Make sure that:

      - Temperatures for sources and the substrate-manipulator heater have ramped back up to their last instructed operating set point, and are within the required operating range.

        NOTE—If the water-cooling system turned off during the power interruption, the Water-Cooling Low Flow Interlock likely became active, causing the 2nd set point (which should be safely lower) to become the active control point for all temperature loops. (See Water-Cooling Low Flow Interlock on page 70.*)*

      - The temperature controller(s) show a reasonable measured temperature for each temperature loop, given the temperature at power interruption and the duration of the outage. Refer to the user guide for the temperature controller for information on any possible error messages.

   e. If there are any aluminum sources on the system that show a temperature below 680°C, the aluminum has likely turned solid. In this case:

      i. Shut off power to the affected aluminum source.

      ii. Vent the applicable growth module.

      iii. Inspect the crucible for damage out of vacuum.

CAUTION— Never heat an improperly cooled aluminum source before inspecting the crucible for breakage. Damage will likely occur.

7. Recover motion control and test moving components.

   a. If you have not done so already, turn on the system computer and start the Molly software.

   b. Make sure that all SMC Controllers are powered on. The system includes one SMC-GSR Controller (growth stage rotation) on the front left of the electronics rack, and may include one or more SMC-AVP Controllers (automated valve positioners) in the main bays of the electronics rack.

   c. For any valved source on the system, perform the following procedures at the appropriate SMC-AVP controller.

      - Verify that the correct source configuration is loaded.

      - Home the valve.

      (See the SMC Automated Valve Positioner user manual for instructions).

   d. Test the functions of all:

      - Pneumatic gate valves
      - Substrate manipulator
      - Pneumatic cylinders
      - Shutters
      - Any other moving components

System Shutdown and Lockout/Tagout (LOTO)

Overview

During periods of overall maintenance, or in situations where the system must be taken out of service, it is important that the different parts of the system be shut down in the proper sequence. This will ensure that the system is de-energized, preventing a physical hazard and/or damage to equipment.

Tools and Parts Required

Approved lockout/tagout (LOTO) devices.

Procedure

▶ **IMPORTANT—** The procedure below is for a complete system shutdown. Performing this procedure removes all power and utility service to the system and subcomponents.

---

1. Remove any platens from the system.

2. Safely ramp down all temperature loops for sources and substrate heaters to room temperature.

CAUTION— For an aluminum source, ramp down no faster than 1°C/minute to prevent damage.

3. Turn off the power supplies for all sources and substrate heaters.
4. Make sure that the SYSTEM BAKE switch on the electronics rack is set to the OFF position.
5. Empty the cryo-panel of LN_2. (See *Emptying the Cryo-panel* on page 92.)

   TIP—You may proceed with this procedure before all LN_2 has evaporated, but should not perform step 13 (venting system modules) until the cryo panel is completely empty.

6. Purge all water-cooling circuits.
7. Move all motor axes to the home (0) position. You may do so directly at the front panel of the motion controllers, or through the Lot Manager software.
8. Close all viewport shutters.
9. Secure the system pneumatics in the appropriate position using the pins provided:
   - BFM should be retracted
   - Source shutters should be retracted (open)
   - Growth stage should be up
10. Make sure that all ion-gauge filaments are powered off.
11. Lock and tag out any Veeco Gas Delivery Systems, if included. (See the appropriate user guide for instructions.)
12. Power off all pumps:
    - For turbo pumps: 1) press the Stop button at the controller, 2) wait for the rotor to stop spinning, 3) power off the controller, and 4) verify that the backing pump (typically a scroll pump) has also stopped.
    - For ion pumps, power of the pump at the respective controller.
    - For cryo pumps, power off the respective cryo-compressor.
13. Vent all system modules (see *Venting System Modules* on page 86.)

IMPORTANT— Any cryo panel must be completely empty of LN_2 before the growth module is vented. Otherwise, water vapor will freeze on the cryo panel resulting in a “frost ball” condition.

14. When the system is vented, turn off all utility sources (N_2, compressed dry air, and cooling water).
    - Close all regulators and valves at the supply connection on the system.
    - Shut off the facility supply lines.
    - Lock and tag out the facility supply lines, or disconnect the connections at the standard utility box or the utility panel (if included).
15. Close all software programs, in this order:
    - Molly server

      TIP—In the Molly interface, Select View > Molly Controller, and click ***Shut down Molly Server****.*
    - Molly interface
    - RGA software
    - Any other programs that are running
16. Power off all electrical components in the electronics racks that have not yet been powered off.
17. Power off the system computer.
18. Electrically isolate the system.
    a. Remove power supplied by any UPS system, if applicable.
       i. Isolate and shut off the UPS system. (Refer to the OEM manual for instructions.)
       ii. Switch off the UPS circuit breaker in the applicable system electronics rack.
       iii. Using a voltmeter, verify that there is no voltage on the line side of the UPS circuit breaker in the applicable system electronics rack.

    b. Remove facility power.
       i. Turn off the main circuit breaker on the electronics rack.

          To turn off a main circuit breaker, pull the main breaker arm all the way down as shown in the figure below.

WARNING— HAZARDOUS VOLTAGE WITH SYSTEM POWER OFF. Turning a main circuit breaker off does not remove hazardous voltage on the main (line side) power leads to the circuit breaker.

       ii. Shut off, lock and tag out all facility electrical service to the system.
       iii. Using a voltmeter, verify that there is no voltage on the line side of the circuit breaker panels.

          NOTE—The circuit breaker panels are inside the electronics rack, adjacent to the breaker arms.
       iv. Secure each main breaker arm in the OFF position (down) using an approved lockout/tagout device.

IMPORTANT— The lockout/tagout device must pass through the holes on both the breaker arm and frame!

At this point the GENxplor is locked in its de-energized state.

Regenerating a Cryo Pump

Any cryo pump on the system requires periodic regeneration to maintain pumping effectiveness. Regeneration involves isolating the cryo pump and gradually warming it so that solids trapped in the arrays of the pump can evaporate and be removed through the all-metal valve on the backside of the pump.

Refer to the OEM manual for the cryo-pump for guidelines on when and how to regenerate a cryo pump.

Replacing the RHEED Screen

Overview

Although the RHEED screen has a shutter that protects it from unintentional deposition during epitaxial growth, over time the brightness and resolution of RHEED screen will be diminished. When the display is no longer satisfactory, a new screen must be installed.

Tools and Parts Required

- Replacement RHEED screen
- New metal gasket
- Wrench
- Isopropyl alcohol
- Lint-free wipes

Procedure

1. Vent the growth module. (See *Venting a Growth Module* on page 88.)
2. Remove any auxiliary hardware for RHEED monitoring equipment.
3. Remove the RHEED viewport flange.
    a. Remove the flange bolts.
    b. Remove the flange from the growth module.
    c. Remove and discard the metal gasket.
4. Remove the RHEED-screen assembly from the viewport by lifting it away from the viewport glass.
5. Using isopropyl alcohol and a lint-free wipe, clean all sealing surfaces on the following:
    - The RHEED viewport flange

- The growth-module port flange
- The new metal gasket

6. Place the clean new gasket onto the port flange on the growth module.
7. Install a new RHEED-screen assembly into the RHEED viewport flange.

IMPORTANT— Make sure the phosphor side (dull in appearance) faces away from the viewport glass.

CAUTION— To avoid damaging the RHEED screen, never touch the phosphor surface, even with gloved hands.

8. Install the RHEED viewport flange.
   a. Line up the holes on the RHEED viewport flange and growth-module port.
   b. Install four flange bolts finger tight in a square pattern.
   c. Insert the remaining flange bolts and tighten all bolts serially and evenly around the flange perimeter.
9. Re-install any auxiliary hardware for RHEED monitoring equipment.

Replacing a Water Hose Assembly

Use this procedure to replace a damaged or leaking rubber water hose assembly.

IMPORTANT— Water cooling is critical to MBE system performance. A leaking or damaged water hose may activate safety interlocks on the system, with serious consequences for any process being run. The procedure here covers the basic process of replacing a hose assembly. Keep in mind that significant additional effort may be required to restore the system to its previous state.

1. Take all necessary measures to ensure that replacement of the damaged or leaking rubber water hose will not adversely affect system components.

   Steps that may be required include:

   - Valving off, or shutting off, the supply and return for the affected water-cooling circuit (to avoid gushing water)
   - Ramping down any heated components on the affected water-cooling circuit to a safe temperature for operation without cooling water (ideally, less than 200ºC)
   - Purging the affected water-cooling circuit
   - For pumps with water-cooled adapters, isolating the pump with the isolation gate valve (refer to the applicable OEM manual)

2. Address any immediate problems caused by the damaged or leaking hose.

WARNING— **SLIP HAZARD**. Water leaks or spills from system water-cooling lines may result in slippery floors and possible falls. Immediately clean up any spills in the area of the equipment.

3. Remove the damaged or leaking rubber water hose.
4. Identify which part of the hose has failed:
   - Quick-disconnect water fittings
   - Rubber hose
5. Based on 4, order replacement parts from Veeco or the manufacturer as needed. Refer to the labels on the components or the system Bill of Materials.
6. Rebuild the hose assembly using the new parts.
7. Re-install the hose assembly as before.
8. Restore flow to the affected water-cooling circuit.

Adjusting the Horizontal Transfer Arm and Vertical Elevator (Single Configuration)

There is only rotational adjustment on the growth stage to ensure that the sample holder (block) on the end of the transfer arm clears two of the three support arms on the stage during transfer to/from the stage. The transfer arm provides a clamp collar on the transfer arm housing to limit the linear travel of the sample holder into the stage drop-off point (position #6 on the transfer arm photo below). The centering of the sample holder on the stage can be observed by slowly rotating the sample stage while observing the block on the stage arms. Each of the landing pads on each stage arm should be engaged on the sample block approximately the same amount.

The transfer arm itself has a three-point adjustment mounting flange where the arm is attached to the buffer chamber.

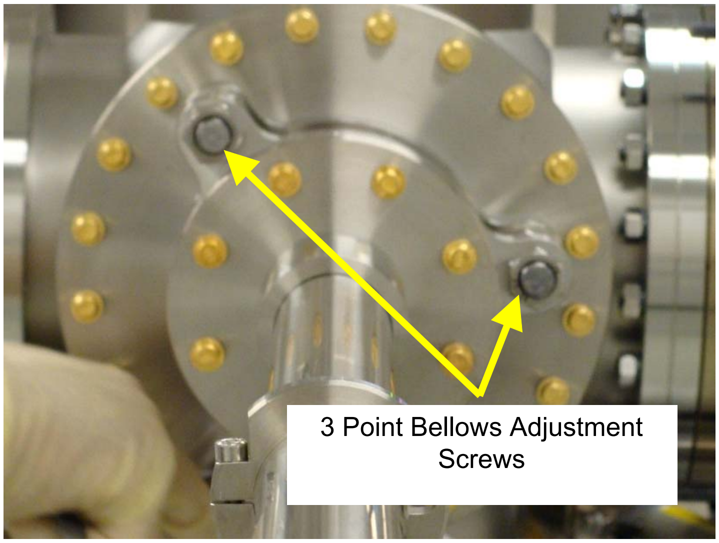


Figure 5-1: Bellows Adjustment Screws

Use these screws to adjust the transfer arm side-to-side and up-down. The overall adjustment will be a compromise between the transfer to/from the growth stage and the vertical elevator. Since there is no adjustment on the growth stage, this stage/transfer arm interaction should be performed first. The arm is at its full extension during this adjustment so minor tweaks on the adjustment flange will greatly impact the long lever arm of the extended transfer arm.

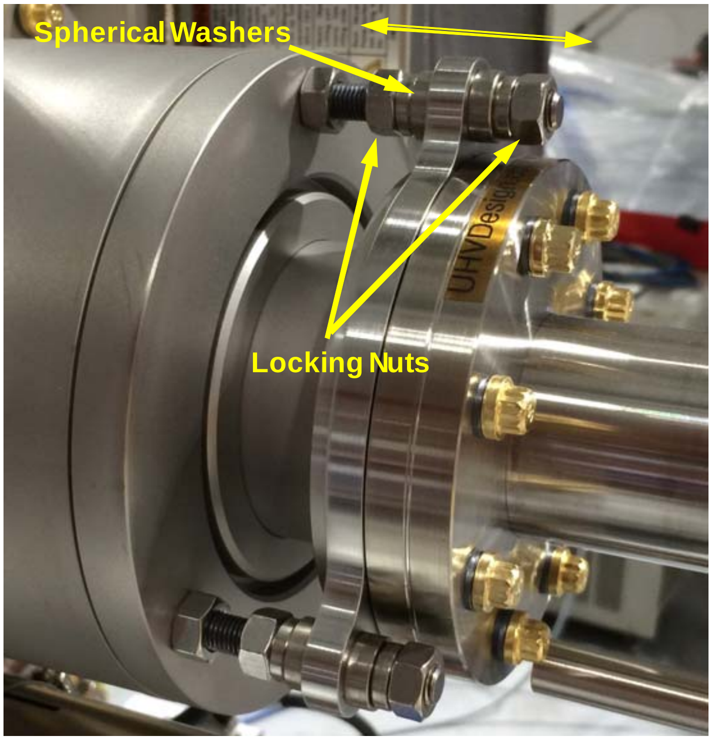


Figure 5-2: Adjusting the Nuts and Washers

Each ear of this three point adjuster will "tip" the transfer arm back and forth as the locking nuts are first loosened and tightened down in the desired direction. To fully realize an overall transfer arm motion, usually more than one ear will require adjustment. The process is an iterative procedure between adjustment points to achieve final desired location of the transfer arm end effector. (Do not loosen the nuts next to the chamber wall these simply provides lock-downs for the studs holding the adjustment nuts/washers).

The spherical washers provide cleaner movement of the adjustment nuts, so that the operator is not fighting the binding that would result from using flat washers. Use small incremental adjustments, observing the direction and how much movement is imparted by each adjustment point. Once the final adjustment has been made, tighten the locking nuts completely and verify this last tightening has not moved the final end effector position from the desired location at any of the transfer positions.

Ensure the collar stop or the "flip" stop (photo below) for the particular linear engagement to the transfer position is also still valid. Adjust these as necessary by loosening and tightening the clamping feature of the collar or flip stop.

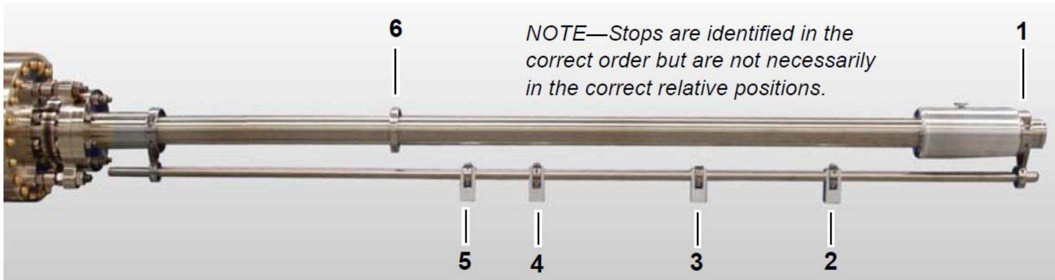


Figure 5-3: Stops for Critical End Effector Positions

A similar three-point adjustment flange is provided for the elevator bearing the cassette.

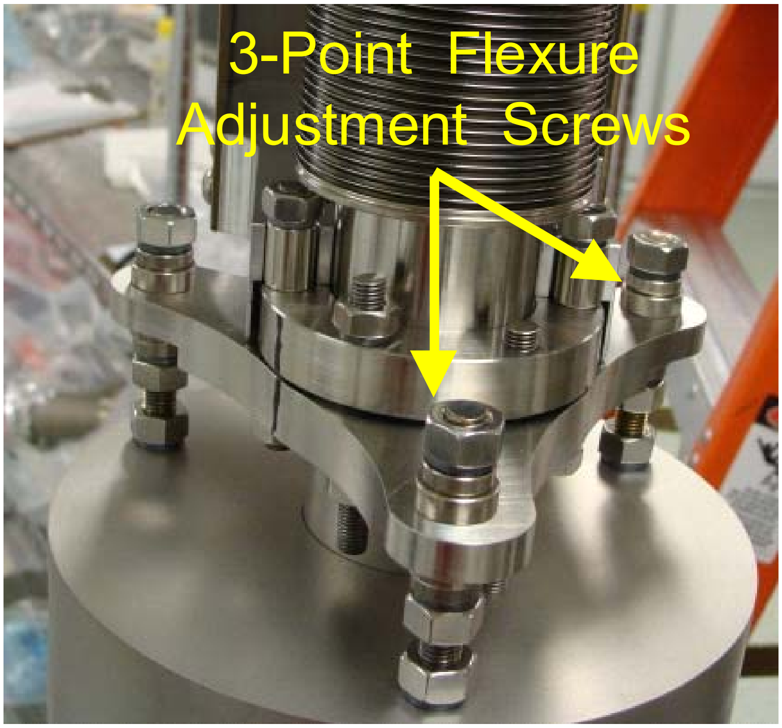


Figure 5-4: Flexure Adjustment Screws

Use these adjustment screws in a similar manner as described above for the transfer arm. Again compromise will be required for transfers between the transfer arm and the vertical moving cassette(s), as well as, final Load Lock cassette positioning within the Load Lock chamber.

General System Cleaning Procedure

The customer must use the proper cleaning procedure in accordance with guidelines provided in the material safety data sheets (MSDS), which are accessible on the Internet. When cleaning components, wear the appropriate personal protective equipment (PPE) and comply with the hazardous materials safety requirements. It is the responsibility of the customer to determine the required cleanliness level of the system equipment. Since each system is application specific, the MSDS will likely dictate the exact cleaning procedures required.

For cleaning the equipment, make sure you have acetone or isopropyl alcohol and a lint-free cloth.

1. Make sure that you wear cleanroom gloves (nitrile, latex or vinyl).

WARNING— HIGH VOLTAGE. Do not remove any component that draws power without first verifying that it is powered off and the power cable is disconnected.

CAUTION— The following step may not cover all components on the system. As a rule, this procedure provides general guidance only and is not exhaustive. Do not clean any component if you are not certain that it can withstand the cleaning process. When in doubt, refer to the OEM manual for the component.

2. Using acetone or isopropyl alcohol with a lint-free cloth, remove residues, marks and fingerprints from module surfaces.

   NOTE—If not cleaned in this way, module surfaces could be etched during bake.

CAUTION— Failure to properly clean surfaces each could result in equipment damage.

Replacing Fuses

Use the information in the tables below when replacing fuses on the system.

IMPORTANT— The Electronics Rack (E-rack) is open and accessible to technicians to perform maintenance activities. The e-rack is fitted with an earthing/ grounding strap to prevent static shocks to a person performing maintenance in the E-rack, which contains sensitive electronic equipment. All maintenance personnel must wear an antistatic wrist strap while performing service in the E-rack.

Fuses - Growth Module Electronics Rack

Manufacturer	Manufacture Part Number	Description	Rating	Label / Location on System
LittleFuse	0217004.vxp	5x20mm glass tube fast acting	250VAC 4A	None / see fuses 1-4 on growth module PLC panel
LittleFuse	KLDR020	Class CC time-delay fuse, 20 A	300VDC / 600VAC 20A	FU1, FU2 / growth module circuit breaker panel
LittleFuse	KLDR005	Class CC time-delay fuse, 5 A	600VAC / 300VDC 5A	FU 3, FU4 / growth module circuit breaker panel

Fuses - Sub-Cluster Electronics Rack

Manufacturer	Manufacture Part Number	Description	Rating	Label / Location on System
LittleFuse	0217004.vxp	5x20mm glass tube fast acting	250VAC 4A	None / see fuses 9-13 on cluster module PLC
LittleFuse	KLDR015	Class CC time-delay fuse, 15 A	300VDC / 600VAC 15A	FU1, FU2 / cluster module power subsystem
LittleFuse	KLDR006	Class CC time-delay fuse, 6 A	300VDC / 600VAC 6A	FU5, FU6 / cluster module power subsystem
LittleFuse	KLDR005	Class CC time-delay fuse, 5 A	300VDC / 600VAC 5A	FU3, FU4 / cluster module power subsystem
LittleFuse	KLKR005	Class CC fast-acting fuse, 5 A	300VDC / 600VAC 5A	FU7, FU8 / cluster module power subsystem

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GENxplor™ MBE SYSTEM
User Manual

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