Solarus 950
Gatan Advanced Plasma System

Owner's Manual and User's Guide

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Preface

About this Guide

This provides information on operation and basic maintenance of the Solarus 950 Advanced Plasma system.

The following typographical conventions are used for special comments:

NOTE: Recommendations for getting the best performance from the equipment.

CAUTION: Precautionary notes and advice to avoid personal injury or damage to the equipment.

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Returns

If there is a need to return equipment to the factory, please call Gatan to obtain a Returned Merchandise Authorization Number (RMA #). This RMA number must appear on your shipping document, to help in tracking and to ensure that proper actions will be taken to repair or replace your equipment.

Support

Gatan, Inc. provides free technical support via phone, fax, and email. Contact the facility nearest you, or send email to help@gatan.com.

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Overview

Optimal imaging and microanalysis in electron microscopy requires a clean, well-prepared specimen. This is especially important for FEG TEM, because specimen contamination rates tend to increase as probe size decreases and beam current density increases. The high performance now possible with the FESEM underscores the need for eliminating hydrocarbon contamination, especially for those applications involving low voltage, high-resolution operation.

An RF-generated gas plasma cleaning process, originating within the semiconductor industry for wafer cleaning, has been known and available for some time. A version of this technique was adapted for EM applications by Nestor Zaluzek at Argonne National Laboratory and University of Chicago (US Patent 5,510,624, dated April 23, 1996).

The Solarus Advanced Plasma System expands this process to a new level. Solarus is a low power hydrogen and oxygen radical generator producing glow-discharge plasma within the generator housing. The hydrogen and oxygen radicals disperse from the generator by convection, passing over and around the specimen/specimen holder tip to clean hydrocarbons from the surfaces. The process produces H_2O, CO_2, and CO gases that are pumped away by the vacuum system.

Solarus incorporates a multi-stage diaphragm pump backing a turbomolecular drag pump to assure fast, reliable pumping. The pump package enables pump and vent cycles of less than two minutes. With cleaning times of 1-2 minutes, the full Solarus 950 cleaning cycle takes less than four minutes.

ƒigure 1 Gatan Advanced Plasma System, model Model 950

Features

The Solarus 950 is unique in automatically managing all critical plasma parameters, offering a reliable one-touch cleaning solution. With this system, every user can obtain consistent, high quality results.

The Gatan Advanced Plasma System consists of four main elements:

- plasma recipes
- hardware
- electronics
- software

These elements are integrated into a highly flexible system that allows a great deal of control over the sample cleaning process.

Plasma Recipes

Gatan provides cleaning recipes developed to maximize contamination removal rates while minimizing damage to even the thinnest TEM samples. These recipes have been tuned for efficiency using a mass spectrometer and crystal and thickness monitors, tuned for minimal sputtering and sample damage using Langmuir probes, and exhaustively verified with TEM and SEM samples in a wide variety of conditions.

The unique H_2/O_2 recipe prevents or reduces buildup of contamination after about one minute of cleaning. Even the worst burned-on contamination takes less than ten minutes to clean. Holey carbon films have been cleaned in this recipe for more than nine minutes without damage. Alternate Ar/O_2 (Ar 75% - O_2 25%) recipes can also be selected.

The two primary gas chemistries used are H_2/O_2 and Ar/O_2.

H_2/O_2

Gatan has found this chemistry to provide superior cleaning rates, less sputtering damage, and significantly less sample heating than Ar/O_2 over a wide range of samples.

Ar/O_2 (option)

This is the traditionally used process gas combination in electron microscopy.

Gatan has not yet found a processing advantage to Ar/O_2 over H_2/O_2, but some sites may have restrictions on the use of pure H_2 or O_2. An optional third mass flow controller and a supply of Ar 75%/O 25% is required to use this recipe.

The use of this recipe requires optional hardware.

Air

Air can be used as a substitute for Ar/O_2 in a pinch. Some concerns exist about forming C-N compounds that won't volatilize and remain on the sample.

NOTE: Any of the cleaning chemistries can be used to treat carbon films that have become hydrophobic.

Cl_2/Br_2

CAUTION: Do not use Cl2/Br2 with the aluminum Gatan Advanced Plasma System chamber!

Other Gases

Please contact Gatan for compatibility of other gases.

Hardware

The Gatan Advanced Plasma System hardware offers fast cycle times and a broad range of sample cleaning options. Both TEM and SEM samples can be accommodated.

TEM Samples

Two front ports on the Solarus 950 accept TEM adapters compatible with all side-entry TEM or SEM specimen holders. For slightly faster cleaning, use the left port.

SEM Samples

A top-loading chamber accepts multiple SEM stubs and large irregular-shaped samples.

Electronics

The electronics subsystem offers a powerful RF power supply, an auto-tuning RF match network, and mass flow controllers.

RF Source

The Solarus 950 contains a 65 Watt RF power supply (13.56 MHz) with an auto-tuning network to assure effective plasma coupling to the generator and chamber. The RF supply is CE certified to comply with FCC guidelines.

The auto-tuning network is critical for achieving consistent results. It measures the amplitude and phase of the forward and reflected power and automatically minimizes reflected power. This ensures that the power delivered to the plasma is

consistent, even as the impedance varies due to aging, odd sized samples, or changes in gas pressure or species.

Vacuum/Gas Pumping

A two-stage variable-speed diaphragm pump (electronic speed control) backs a 70 liters/second turbo molecular drag pump.

Chamber

The chamber is 3.5” in diameter x 2.0” deep, and includes multiple entry ports. A front viewing port displays plasma when activated. An inline electromagnetic valve isolates the vacuum pump from the chamber, resulting in less than one minute pump down and less than a ten-second vent cycle.

Mass Flow Controllers

Mass flow controllers accurately gauge gas levels to achieve superior and repeatable cleaning results.

Touch Screen User Interface

A touch screen interface to the Solarus 950 software offers one touch operation through user-programmable recipes, providing greater flexibility and repeatability than competitive products.

Simple Four-Step Cleaning

1. **Load a sample**, either from the front (TEM holders) or top (stand-alone TEM/SEM samples)
2. **Select a recipe** for TEM, STEM, SEM or carbon film cleaning using either H_2/O_2 or Ar/O_2 plasma cleaning.
3. **Touch START** to begin the cleaning cycle.
4. **Touch VENT** to vent the chamber and permit sample removal.

Description and Specifications

The Solarus 950 consists of a single self-contained unit as shown in the following photos.

figure 2 ***Gatan Advanced Plasma System, front-accessible components***

The front of the unit contains a touch screen for executing all actions, two TEM holder ports, and a viewing port. The door to the top-loading specimen chamber is on the top of the unit, above the TEM holder ports.

All gas and venting connections are made at the rear of the unit. The rear panel also contains the on/off power switch, connectors for power cable, USB ports and network cable, and a storage area for the DP locking screw mentioned in the unpacking instructions.

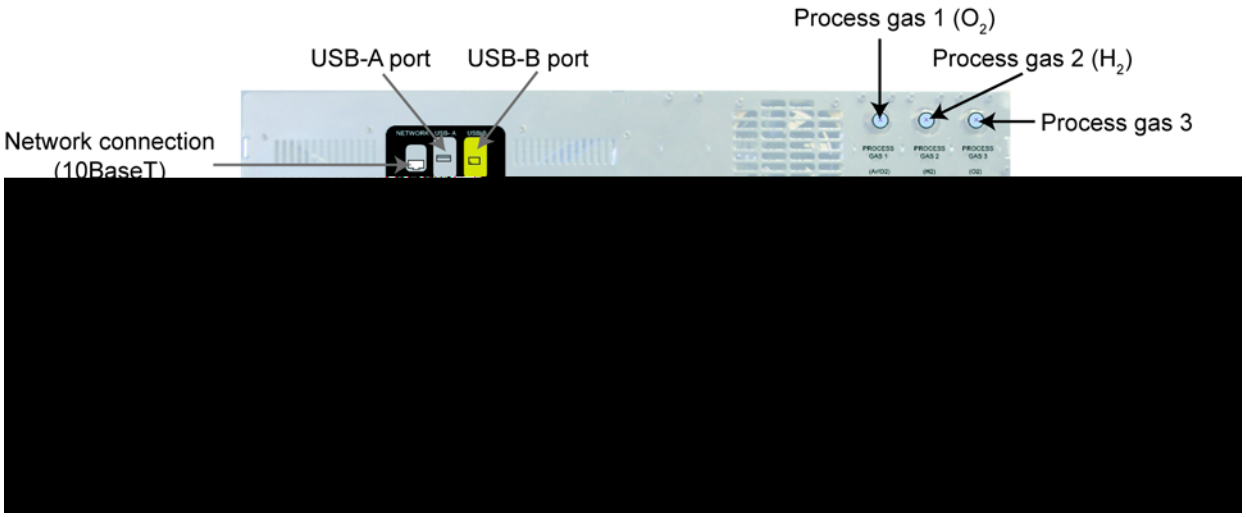


figure 3 Gatan Advanced Plasma System, rear panel

Physical Specifications

SPECIFICATION	VALUE
Weight	145 lbs/65 kg (see Note)
Dimensions	The system requires a stable bench with a surface area of: ● 39 inches (1m) in length ● 24 inches (62cm) in depth ● 18 inches (46cm) in height
Clearance	Allow clearance on both sides for ventilation, and to the rear for gas line connections and ventilation. **Do not block the fan vents.**
Power	100-240 VAC, 50/60 Hz, 1000 Watts A molded power cord is supplied to fit the local standard power socket. Be sure to use a properly grounded AC outlet.
Maximum Ambient Temperature	35 degrees Celsius

NOTE: Although the instrument is a compact bench-top system, it is relatively heavy and should not be lifted by a single individual.

Gas Requirements

GAS	PURITY	PSI
O_2	Grade = 4.5	25 psi (1.7 bar)
H_2	Grade = 4.5	25 psi (1.7 bar)
Ar (option)	Grade = 4.5	25 psi (1.7 bar)

NOTE: All gas connections are compression fittings (1/8 inch OD Tube), 4.5 grade is 99.995% pure (50 PPB).

Gas Used During Cleaning (Standard Gatan Recipes)

GAS	USAGE
H_2/O_2	H_2 = 6.4 sccm*
	O_2 = 27.5 sccm
Ar/O_2	Ar = 35.0 sccm
	O_2 = 11.5 sccm

NOTE: * sccm = standard cubic centimeters per minute

For example, a 2 cubic foot (~57 liter) lecture bottle of H_2 will last for ~147 hours of continuous use. An 80 cubic foot (~2265 liter) bottle of O_2 will last for ~1373 hours of continuous use.

Safety and Serviceability

Cautionary Notes

CAUTION: Unplug the AC mains cable before opening the system, to avoid electric shock. Dangerous high voltages and currents may be present inside the case during operation. Do not reach your hands inside the system while the power is on or if the AC mains cable is plugged in.

CAUTION: High pressure cylinders can be dangerous when not properly secured. Be sure all cylinders are secured according to applicable safety codes..

CAUTION: The RF power supply can generate 85 Watts of power, which can cause burns if the live conductors are touched. Do not operate the unit unless the RF cables are plugged in properly. Do not defeat the safety mechanisms and touch the RF antenna when the system is attempting to generate a plasma.

CAUTION: Hydrogen and Oxygen are combustible gasses. During normal operation these gasses are fully combusted in the plasma and are not a danger. If the gas supply connections or lines leak into an enclosed space, it is possible for a dangerous concentration to accumulate. It is important to install and maintain these connections properly in order to prevent leaks.

Servicing

The turbo-molecular drag pump and diaphragm pumps require periodic maintenance. Please see the individual operator manuals of these instruments (included in the shipping crate) for instructions. See the maintenance section in this manual for instructions to remove these pumps from the instrument.

Installation Recommendations for Gatan Customers—Flammable and Oxidizing Gases

Hydrogen Guidance

- ***Enclosure/Cabinet:*** Store a lecture bottle of hydrogen within a one hour fire barrier such as a “semiconductor type” rated lecture bottle gas cabinet. Secure the compressed gas cylinder inside cabinet.
- ***Seismic Bracing and Mechanical Integrity:*** Ensure that the enclosure is seismically braced in accordance with applicable Building Codes and that the distribution line is properly braced between the cabinet and the Solarus 950.
- ***Gas Detection:*** Install listed and/or approved hydrogen gas monitoring for the lecture bottle gas cabinet providing both local and remote alarm annunciation.
- ***Distribution System:*** Piping, tubing, valves, and fitting shall be compatible with flammable gases and be of adequate strength and durability to withstand the pressure expected.
- ***Grounding and Bonding:*** Provide for appropriate grounding and bonding to minimize the potential for static electricity buildup.
- ***Maintenance and Inspections:*** Place safety critical equipment such as flammable gas detection and grounding on a periodic calibration and test schedule.

Oxygen Guidance

- ***Compressed gas cylinder:*** Secure oxygen compressed gas cylinders to a fixed object with one or more restraints stored upright with valve end up. Protect compressed gas cylinder valves from physical damage, by using valve caps and ensure compressed gas cylinder caps are in place when not in use
- ***Distribution System:*** Ensure oxygen piping is free from oil residues and foreign material. Oil-free and noncombustible materials must be used for leak testing oxygen lines.
- ***Segregation:*** Store oxygen compressed gas cylinder separately from incompatible materials, such as hydrogen gas. Note: If hydrogen gas cylinder is located within a 1-hour rated fire barrier such as a semiconductor type gas cabinet, then adequate segregation is provided. If no enclosure is used for hydrogen, then the oxygen compressed gas cylinder shall be located at least 20 feet away.

Oxygen Guidance Applicable to both Hydrogen and Oxygen

- ***Leak Testing:*** Conduct pressure leak testing of delivery piping and associated fittings prior to introducing hydrogen to the Solarus 950.

- ***Emergency shut-off:*** Provide approved emergency shutoff valves on supply piping at the cylinder.
- ***Labeling:*** All piping and tubing should be labeled in accordance with ASME A13.1
- ***Signage:*** Install NFPA 704 hazard or similar identification placards, along with “No Smoking” signage at the entrance to the area where the sources of hydrogen and oxygen are located.
- ***Documentation:*** Document operating and emergency procedures in a site and/or lab Emergency Plan.
- ***Training:*** Train in-house emergency response team (ERT) members on how to respond to flammable and oxidizing gas leak emergencies during both operating and off-hour work shifts. In addition, provide employee training on proper compressed gas cylinder inspection, handling, hookup and deinstallation procedures.

Additional Guidance for the Solarus 950 Installation

- ***Seismic Bracing:*** Ensure that the Solarus system is properly secured to a table top surface and the table top/lab bench or other location is seismically braced to minimize stress to the hydrogen line connection at the back of the Solarus 950 system.
- ***Clearance:*** Ensure that there is adequate clearance provided around the Solarus so that the heat exhaust fans are not blocked.
- ***Exhaust:*** Gatan recommends that the effluent from the vacuum pump is connected to the customer’s house exhaust system so that small quantities of hydrogen and oxygen gas as well as plasma chamber contaminants are not introduced into the work area.

Installation and Setup

Unpacking and Inspection

Before continuing, you should have already followed the *Unpacking Instructions* that accompanied the packing crate.

NOTE: Do not discard packing crate. Keep all packing materials.

Connections

Rear Panel Gas Line Connections

NOTE: All gas line pressure regulator valves should remain closed until the Solarus 950's internal purging process cycle has been completed.

The clearly labeled gas inputs are located on the rear panel (Figure 4) and connect directly to the input of the mass flow controllers. From left to right these lines are Gas 1 (O_2), Gas 2 (H_2), Gas 3 (Ar). Gas inlet 3 can be configured to accept Ar (default) or a mixture of 25% O_2, 75% Ar. If a gas other than Ar is connected, the system configuration must be changed correspondingly. See page 16.

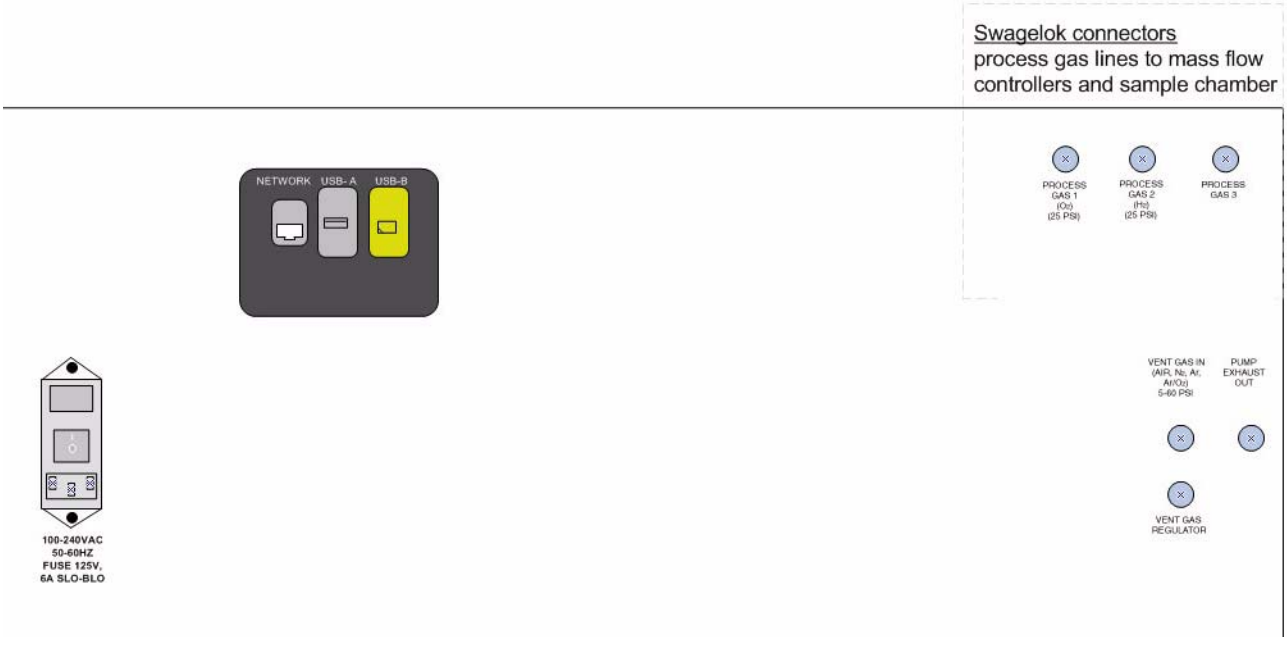


figure 4 ***Solarus 950 rear panel gas connection detail***

NOTE: The optional Gas 3 line can be configured to accept several different gasses:

- Default is Ar

- Mixture (25% O_2, 75% Ar)
- Air

If a gas other than Ar is connected, the system configuration must be changed accordingly. If air is being used, the port is left unconnected but the system configuration must still be changed. See instructions for configuring Gas 3 later in this chapter.

Attaching Gas Lines

Attach each of the gas lines to the appropriate connector (Swagelock compression fitting for 1/8” OD tube) and leave the cylinder bottle valves closed until **after** the gas line purging process has been completed.

The gas lines may be connected using either the gas lines and adapters supplied with the unit, or a customer-supplied 1/8” OD tube gas line.

The Gas 2 (H_2) inlet has an 0.5 micron filter attached via a short length of stainless steel tubing. The gas line from the H_2 regulator should be connected to the inlet of this filter as shown in the picture below.

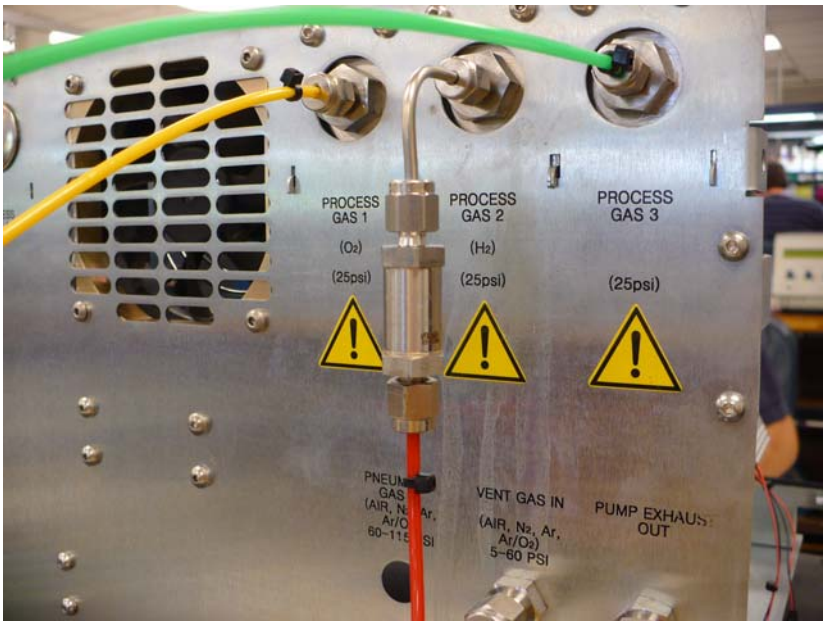


figure 5 ***Gas line to filter connection***

Using a Gas Line Shipped with the Unit

To attach a gas line that is shipped with the unit:

1. Remove the blanking plug from the Swagelok gas connector on the rear panel.
2. Install one end of the supplied gas line to the connector. Screw on the Swagelok nut finger tight; tighten the nut with a wrench 3/4 turn to tighten.
3. Remove the Swagelok to NPT adapter on the other end of the line and install the NPT side to the gas regulator using Teflon tape (not supplied).
4. Connect the second end of the gas line to the adapter, and tighten as above.

Using a Customer-Supplied Metal Gas Line

The Swagelok fitting is ready for a 1/8-inch metal tube to be connected. To attach a customer-supplied gas line:

1. Make sure the nut is finger tight.
2. Insert the gas tubing into the fitting, making sure the tubing is pressed firmly into the shoulder of the fitting.
3. Tighten the nut 3/4 turn clockwise using a wrench.

Cleaning Configurations

H_2/O_2 Plasma Cleaning Configuration

For this (standard) configuration, two gas connections are required, H_2 and O_2, as shown in the following diagram.

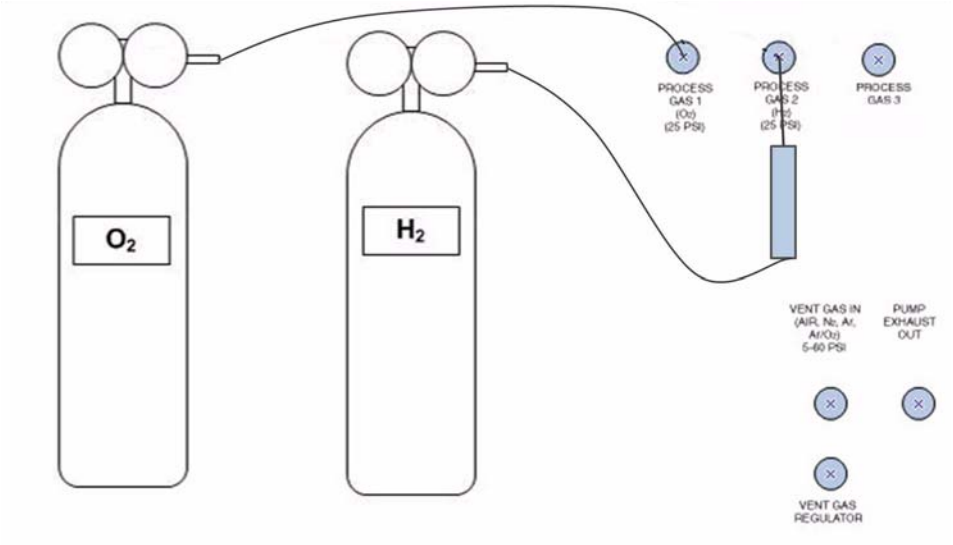


figure 6 ***Two-tank cleaning configuration***

H_2/O_2 and Ar (optional) Plasma Cleaning Configuration

For this optional configuration, three gas connections are required: H_2, O_2, and Ar. See the following diagram for locations of the gas inlet ports.

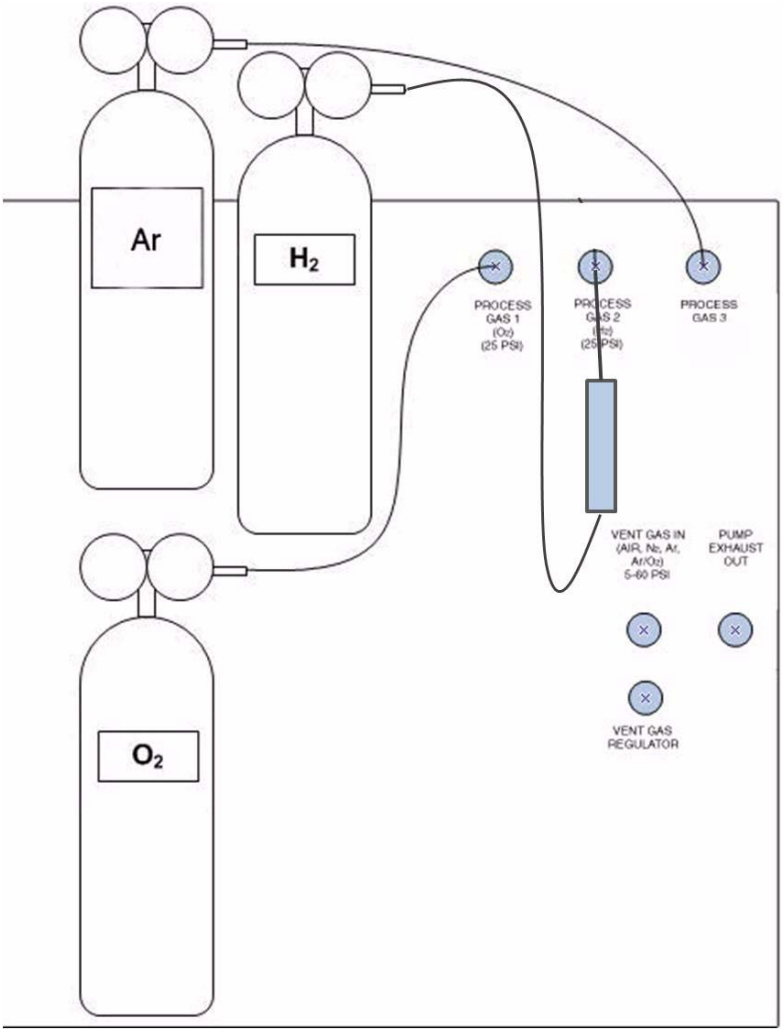


figure 7 Three-tank cleaning configuration

Configuring Gas 3

If a gas other than Ar is connected to the Gas 3 inlet, the system configuration must be changed. When a mass flow controller is operated on a gas other than the gas it was calibrated with, a scale shift will occur in the flow reading. If the orifice size is appropriate, a new gas can be used, and scaling the flow reading results in a reasonably accurate flow rate (+/- 5%). The Gas 3 mass flow controller is factory calibrated for O_2 with a full scale value of 40 sccm. The Gas 3 mass flow controller has been setup for Ar using the multiplier 1.412. The following conversion factors (multipliers) can be used with Gas 3:

- Air = 1.012
- Ar = 1.412
- Ar(75%)/O_2(25%) = 1.280
- N_2 = 1.012

To configure Gas 3 for other gas types:

1. Touch **Options**. The options screen should be displayed.
2. Touch **Configuration**. The configuration screen should be displayed.
3. Be sure that **Gas Line 3 Enable** is set to **Yes**.
4. Touch **Gas Line 3 Name**, touch **Clear**. Enter the name of the gas, e.g., **A r / O 2**. Touch **Apply**. This sets the name.
5. Touch **Gas Line 3 Multiplier**, touch **Clear**. Enter the multiplier for the gas you have connected, e.g., **1 . 2 8**, touch **Apply**. This sets the MFC multiplier, which compensates for using a gas other than the Ar gas the MFC was calibrated for at the factory.
6. Touch **Done**.

NOTE: These multiplier values can be used with Gas 1 (O_2), but do not use them with Gas 2 (H_2).

Purging the Gas Lines

After the gas lines have been connected and tightened, they should be purged to eliminate contamination and maintain gas purity **before** opening the valves. This process is controlled by system software. In most cases, this step will only need to be performed once, unless the gas lines are removed and reattached or otherwise opened to atmosphere.

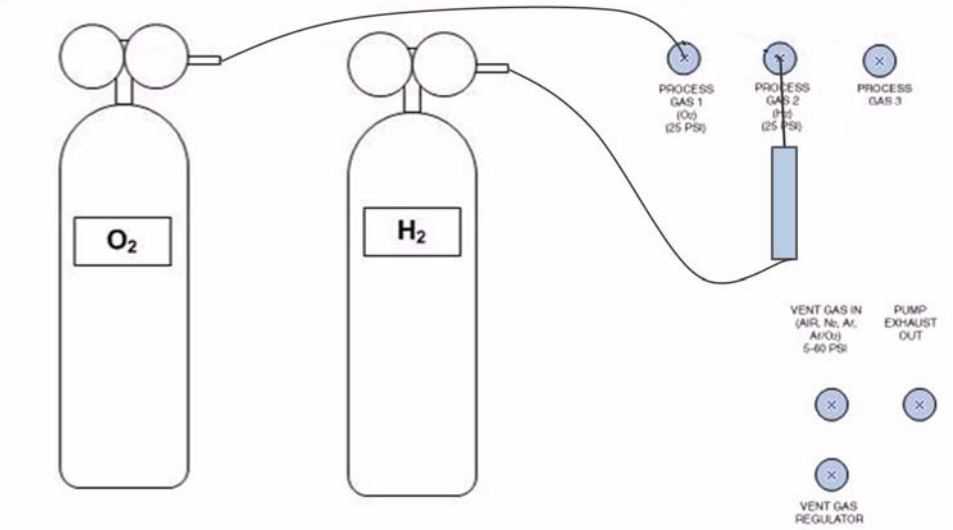


figure 8 ***Two-tank purging configuration***

To purge the gas lines, follow these steps.

1. Attach gas lines as described in the previous sections.
2. Close the valves on the gas cylinders of all gas lines to be purged.
3. Turn on the mains power by pressing the upper portion of the power switch located on the rear panel.
4. Touch **Options** on the lower right of the display panel touch screen.
5. Touch **Service** on the left of the display.
6. Touch **Clear Gas Lines** near the top of the display.
7. **Select the gas lines** that need purging. You may check as many lines as you have installed, but remember that the gas cylinder valve of each line selected must be closed, or the purging process will never complete. You may purge all the installed gas lines at the same time, or purge the lines individually one after the other by repeating this process.
8. Select **Yes** to confirm, and follow the instructions on the screen.
9. The gas purging cycle takes about 20 minutes to complete. The selected lines will be evacuated to a high vacuum state to remove all remaining gases. If there are any leaks in these gas lines, the flow rate for that gas line will not reach the target value and the purging cycle will not complete successfully. If needed, press **Cancel** and correct the gas line setup before trying again.
10. When the purge cycle is complete, the screen will indicate that it is time to **open the gas valve on the cylinder** of those gas lines that have been purged.
11. Touch **Done** to complete the purging process.
12. Touch **Done** again on the next screen, when it appears, to return to the main menu.

13. Open the valves on the cylinders of newly attached gas lines.
14. Set the gas pressure regulators on the cylinders to ~25 PSI (~ 1.7 bar).

The system is now ready for use.

Connecting Exhaust Lines

The common by-products of plasma cleaning with H_2/O_2 or Ar/O_2 chemistries are unlikely to be harmful in small quantities, but Gatan recommends connecting the exhaust line to a vent connection that removes the processed gases from the room to the outside. The exhaust line connection is Swagelok.

CAUTION: If the samples being processed contain toxic materials, it is **critical** that the exhaust gas is also treated as toxic and appropriate measures are taken to remedy the situation.

NOTE: When H_2 and O_2 are used with Gatan recipes, the H_2 is combusted and is not present in meaningful (harmful or combustible) quantities. If users create their own recipes using H_2 (particularly when the concentration is much greater than O_2), H_2 may exist in the exhausted gas. In such gases, venting the gas from the room is important.

To properly connect the exhaust lines:

1. Attach the exhaust line to the connector labeled **Pump Exhaust Out** on the rear panel of the cabinet (Swagelok compression fitting for 1/4” OD tube). The Swagelok fitting is ready for a tube to be connected.
2. Make sure the nut is finger tight.
3. Insert the gas tubing into the fitting, making sure the tubing is pressed firmly into the shoulder of the fitting.
4. Tighten the nut 3/4 turn clockwise using a wrench.

Connecting Vent Gas Line

The system typically vents the chamber with ambient air, through a carbon filter. A connection is available so that a customer-supplied gas such as dry nitrogen may be used. When the vent button is pressed, this gas connection is opened to the chamber (through a regulator) for a pre-set length of time (default 30 seconds).

A regulator controls the speed at which the system vents. The regulator adjustment is accessible on the rear panel just below the vent gas connection, and is adjusted with an Allen key. You may need to adjust this regulator to maintain the proper vent timing. We have determined that 5 seconds is optimal, in that free-standing samples are not disturbed by the vent gas. This timing may be adjusted by the user if desired. There is a system timer that should be changed if this time is significantly different than 5 seconds.

The Pirani gauge is calibrated for Nitrogen gas. If you use another gas to vent with, the pressure reading will be inaccurate while the system is vented. For

example, if you use Ar as the vent gas, the system will read much lower than 750 Torr when it is vented. This does not significantly affect normal operation of the Solarus, and should not be a concern unless the turbo is slowing below ~ 600 Hz while the system is pumping down.

To properly connect the vent gas line:

1. Attach the vent gas line to the connector labeled **Vent Gas In** on the rear panel of the cabinet (Swagelok compression fitting for 1/4" OD tube). The Swagelok fitting is ready for a tube to be connected.
2. The acceptable range of gas pressure is 5 – 60 psi (0.34 – 4.1 bar).
3. Make sure the nut is finger tight.
4. Insert the gas tubing into the fitting, making sure the tubing rests firmly on the shoulder of the fitting.
5. Tighten the nut 3/4 turn clockwise.
6. Turn on the vent gas.
7. Touch **Vacuum**, wait for the system to pump down.
8. Touch **VENT**.
9. Lift up gently on the specimen chamber lid. While the chamber is under vacuum the lid should not move. Count the time between touching the **VENT** button, and when the lid releases.
10. If the time was significantly different than 5 sec (i.e., +/- 2 sec), adjust the regulator and repeat the test.

Testing With Air as a Plasma Gas

For situations when all of the necessary process gas cylinders are not yet available, an initial system test can be performed to confirm proper system operation. This test uses air to ignite a pink colored plasma which is visible through the chamber viewing window.While this plasma is not recommended for cleaning samples, it does provide an easy method to confirm the operation of the system.

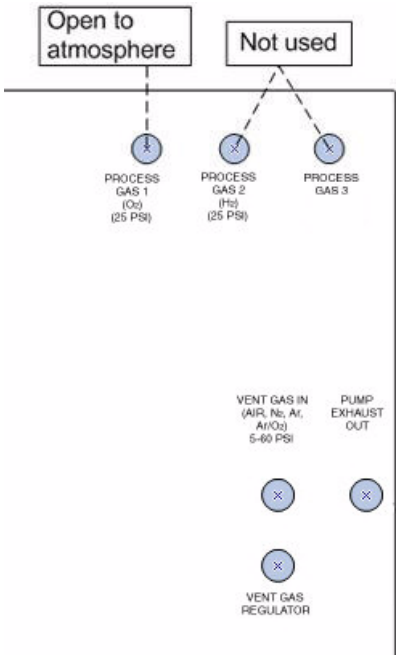


figure 9 ***Air testing configuration***

Standard Configuration

To use air as a plasma gas for testing:

1. Leave the process gas 1 port (O_2) open to allow for passive airflow to the mass flow controller.
2. Turn on the mains power by pressing the upper portion of the power switch located on the rear panel.
3. Create a custom recipe. Set the H_2 flow rate to zero and the O_2 rate at 33.3. See the Creating Custom Recipes section for instructions.
4. Select the custom recipe on the touch screen panel and touch **START**. Note that the custom recipe is added to the end of the list and may be on the next page. It will not be automatically selected after editing.
5. Touch **VENT** when complete.

3rd Process Gas Option

To use air as a plasma gas for testing:

1. Leave the process gas 3 port (Ar/O_2) open to allow for passive airflow to the mass flow controller.
2. Turn on the mains power by pressing the upper portion of the power switch located on the rear panel.
3. Create a custom recipe. Set process gas 3 flowrate to 33.3 sccm, all other rates to 0. See “Creating Custom Recipes” for instructions.

4. Copy item 4 above.
5. Touch **VENT** when complete.

NOTE: At high elevations, the air pressure may not be sufficient to meet the required gas flow rate. A simple solution (if a gas cylinder is not available) is to pressurize a balloon with air and fit the end over the gas inlet connector.

Loading Samples in the Solarus 950

Loading TEM Samples

When working with TEM samples, first insert the TEM holder adapter in place in the unit. Then add the TEM specimen to the TEM specimen holder, and insert the holder into the adapter, as shown in the following photos. A light coating of Krytox vacuum grease may be added to the o-ring on the outside of the holder-adapter so that it is easily inserted and removed.

NOTE: TEM samples must be protected by a sample shield to minimize sample damage.

figure 10 ***Loading TEM holder, holder adapter, and plug***

figure 11 ***TEM holder and adapter in place***

Loading SEM Samples

When working with SEM samples, open the top of the unit by lifting up on the lid to reveal the top-loading chamber. Insert the specimen table and specimen as shown in the following photos.

NOTE: If there is resistance, the system may not be vented. Press the **VENT** button and wait until the touch screen indicates that the system is vented.

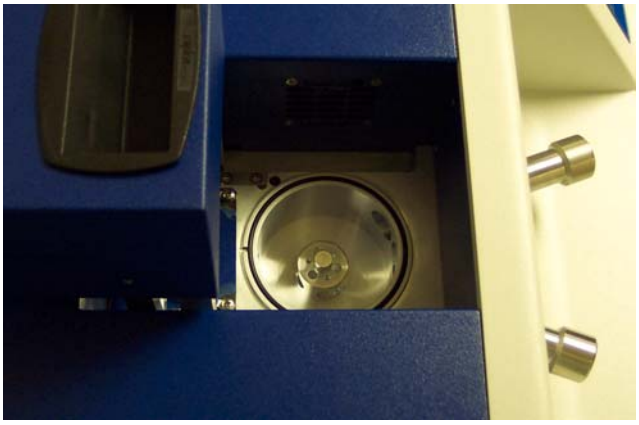


figure 12 Top-loading SEM chamber, side view

NOTE: No part of the sample should extend higher than 1 cm below the chamber ceiling. Never allow any part of the sample to enter the antenna chamber.

figure 13 Sample loaded in SEM chamber

Removing the Ion Shield

When cleaning a TEM holder that does not have a sample installed, you may remove the ion shield in order to increase the cleaning speed (although it is not necessary). This should not be done if a sample is installed or the sample may experience ion damage. To remove, unscrew the ion shield (counter clock wise).

figure 14 TEM holder-adapter with ion shield removed

Operating the Gatan Advanced Plasma System

Theory of Operation

The actual Sample cleaning times depend on the amount and type of contamination as well as the sample material. It is generally recommended to start with short cleaning times (15-30 seconds) and increase only if necessary.

The primary difference between recipes for different gas mixtures is the time of plasma ignition (i.e., TEM and SEM H_2/O_2 recipe is for 1 minute at 50 watts while the TEM and SEM Ar/O_2 recipe is for 2 minutes at 50 watts). Current recipes are based on results obtained at Gatan.

A plasma cleaner is more effective in cleaning samples before they are exposed to an electron beam. Hydrocarbons are much easier to remove before they are cracked or carbonized.

Most fresh or new EM samples can be cleaned in less than 1 minute. Samples previously imaged and having carbonized contamination will require additional cleaning time. Two minute cleaning intervals are recommended to determine the correct length of time for removing carbonized contamination.

Experience with STEM samples has shown that the current 2-minute preset for STEM H_2/O_2 is generally enough time to clean silicon samples for LAB_6 STEM. For FEG STEM, more time may be recommended.

Carbon films can be cleaned in the Gatan Advanced Plasma Cleaner. Please note that not all carbon films are equivalent. Carbon films are volatilized and removed during plasma cleaning, however, pure carbon films will be removed at a slower and consistent rate. In such cases, the films will decrease in thickness evenly across the film and EM imaging will not be adversely affected. If carbon films have high levels of contaminants such as O and H, those areas will be preferentially removed, resulting in uneven C film thickness which may be observed in EM imaging. Hydrocarbon contamination will be removed much faster than C films, especially pure C films. Gatan recommends testing of C film plasma cleaning prior to cleaning important samples. Once a particular C film type has been qualified for a given cleaning recipe and time, it should be safe to use with samples.

Support structures such as Formvar are polymers and thus are removed quite effectively by the plasma cleaner. Short cleaning times of Formvar films will create a roughness of the Formvar that may interfere with imaging small particles. Carbon films with Formvar or similar support films should be tested in the plasma cleaner in order to determine if plasma cleaning is appropriate. If possible, remove the Formvar films prior to depositing your sample on the C film.

Internal Mass Flow Controllers (MFC) accurately control flow rates for the gas mix chosen. H_2/O_2 is the preferred gas recipe, offering improved cleaning performance, lower sample temperature, less sample damage, and faster cleaning times.

The amount of H_2 gas used is less than 10 sccm (standard cubic centimeters per minute) and is fully combusted in the formation of the cleaning plasma. Ar/O_2 is an optional choice for those installations where flammable gases are restricted.

Significant contamination removal occurs in as little as 15 seconds. However, experience shows that contamination less than 1-2 nanometers thick is removed at a much lower rate than bulk contamination.

Recommended Cleaning Times for Various Samples

SAMPLE	CLEANING TIME	TOTAL CYCLE TIME
CLEANING USING H_2/O_2 RECIPE		
● TEM, prevent C buildup	1:00	1:40
● TEM, remove built-up C	2:00	2:40
● TEM, holey carbon film	0:30	1:10
● TEM holder, slight contamination	2:00	2:40
● TEM holder, gross contamination	10:00	10:40
● TEM, make C film hydrophylic	0:15	0:55
● SEM, prevent C buildup	1:00	1:40
● SEM, remove built-up C	5:00-10:00	5:40-10:40
CLEANING USING Ar/O_2 RECIPE		
● TEM, prevent C buildup	2:00	2:40
● TEM, remove built-up C	4:00	4:40
● TEM, holey carbon film	0:30	1:10
● TEM holder, slight contamination	2:00	2:40
● TEM holder, gross contamination	10:00	10:40
● TEM, make C film hydrophylic	0:15	0:55
● SEM, prevent C buildup	2:00	2:40
● SEM, remove built-up C	5:00-10:00	5:40-10:40

Operating Instructions

The operation of the Solarus 950 consists of the following basic steps. Each step is described in more detail in the remainder of this section.

1. Turn on the mains power by pressing the upper portion of the power switch located on the rear panel.
2. Place the sample in the chamber, using either the SEM table or TEM holder as applicable.
3. Select the appropriate recipe for your sample type and available gas setup. Presets are available by gas type, time and sample type (TEM, STEM, SEM or Carbon Film).

4. If necessary, the cycle time can be adjusted by highlighting the particular timing digit and touching the plus or minus symbol to the right.
5. Touch **START** to automatically run the recipe selected and stop on completion.
6. At the end of the cycle the vacuum chamber will remain under vacuum until manually vented. Samples can thus be stored under vacuum.

NOTE: It is recommended that the system be left on when not in use.

Setting Up the Sample

1. Turn on the mains power by pressing the upper portion of the power switch located on the rear panel. This brings up the operating system and vacuum pumps.The chamber will remain in the idle/vented state.

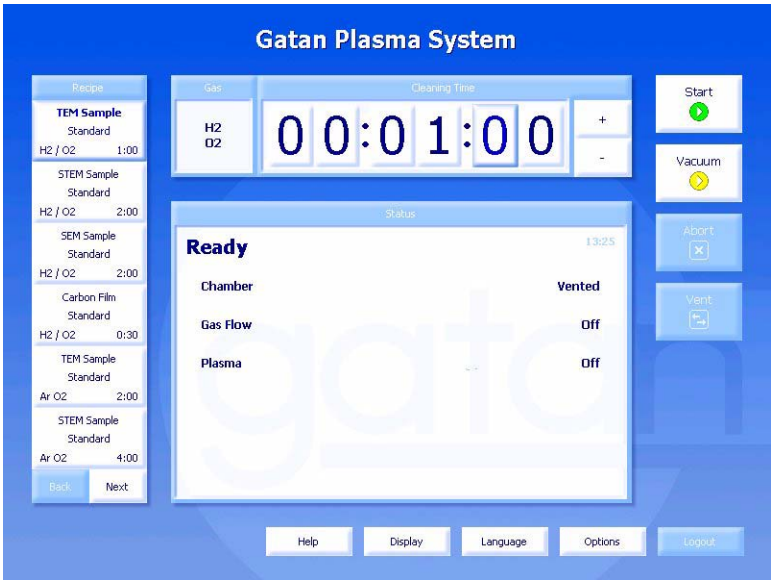


figure 15 System in idle state

2. Place a sample in the chamber using the appropriate SEM stand or TEM holder. See the previous section “Loading Samples in the Solarus 950” on page 22 for more information.
3. Select the appropriate recipe for your sample type and available gas setup. The programmed parameters include gas type, cycle time and sample type (TEM, STEM, SEM or Carbon Film).

   NOTE: To reset the cycle time, highlight the particular timing digit and touch the plus or minus symbol to the right. This change does not permanently alter the preset recipe.

4. Following are the preset gas flow parameters used:
   - H_2/O_2 parameters:

- H_2 flow rate = 6.4 sccm
- O_2 flow rate = 27.5 sccm
- RF Power = 50 Watts

- Ar/O_2 (optional) parameters:
  - Ar flow rate = 35.0 sccm
  - O_2 flow rate = 11.5 sccm
  - RF Power = 50 Watts

Cleaning the Sample

1. Touch **START** to initiate the automatic cleaning cycle. The cycle goes through the following states:
   - Rough vacuum state
   - High vacuum state
   - Gas flow stabilization
   - Plasma cleaning state
   - Cleaning cycle completion

NOTE: Touching the Display button at the bottom of the screen at any time during a cleaning cycle will switch the screen between a graphical and numeric display, providing information on system operating conditions.

Rough Vacuum State

2. After touching **START** the system initiates a rough vacuum state, in which the following events occur.
   - The chamber vent valve closes, isolating the chamber from atmosphere.
   - The three-way roughing valve activates, connecting the diaphragm pump to the chamber for pre-pumping. The diaphragm pump is temporarily out of the backing line for the turbo pump.
   - The system remains in the pre-pump state until the chamber reaches a pre-set level of 20 Torr.

NOTE: Errors in this state may occur if the 20 Torr preset value is not achieved within the allowable time limit. This is most likely due to a leak in the chamber caused by the chamber lid not seating properly, or by not inserting the blanking plugs in the front chamber ports.

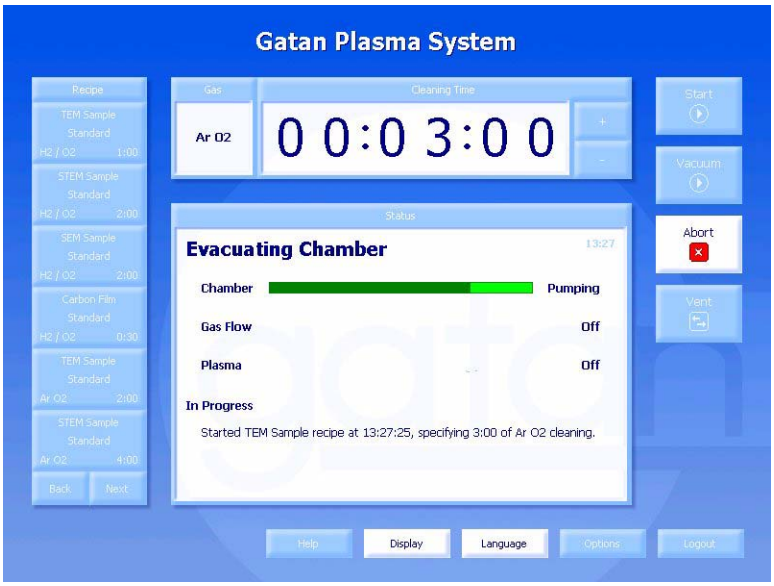


figure 16 System initiating vacuum state

Vacuum State

3. When the cleaning chamber reaches 20 Torr, the system initiates the vacuum state, in which the following events occur.

- The three-way roughing valve de-activates, restoring the vacuum path between the turbo pump and diaphragm pump.
- The system pumps until the chamber reaches a preset value of 70 mTorr. The pumping combination is designed to reach a pressure of about 20 mTorr in the specimen chamber.

NOTE: Errors in this state may occur if the 70 mTorr preset value is not achieved within the allowable time limit. This could be due to a vacuum leak in the chamber.

Gas Flow Stabilization State

4. When the cleaning chamber reaches a pressure less than 70 mTorr, the system turns ON the mass flow controllers (MFC) to fix the preset flow rate for the specified recipe. The rate should stabilize within about 5 seconds.

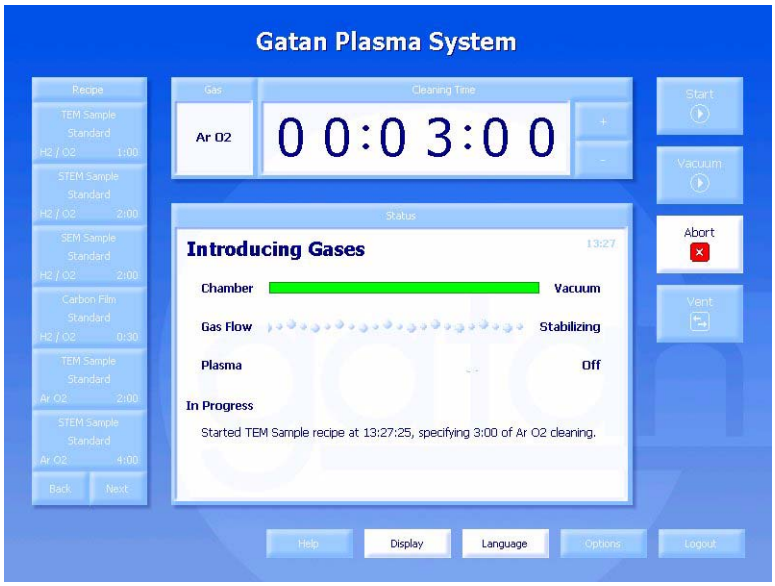


figure 17 ***System introducing gases***

NOTE: The system will report an error if the MFC cannot stabilize the gas flow. Errors are typically caused by a closed gas cylinder valve, empty gas cylinder, or improper gas pressure.

Plasma Cleaning State

5. When the gas flow has been stabilized, the system enters the plasma cleaning state, which delivers RF power (13.56 MHz) to the RF generator chamber, igniting the plasma.

figure 18 ***Applying RF power to the unit***

6. The RF reaches its preset level and the system monitors the power (both forward and reflected) to ensure a matched RF state has been achieved.

7. The timer begins counting down as the system continues to monitor power, gas flow, and vacuum levels to detect errors (such as running out of gas).

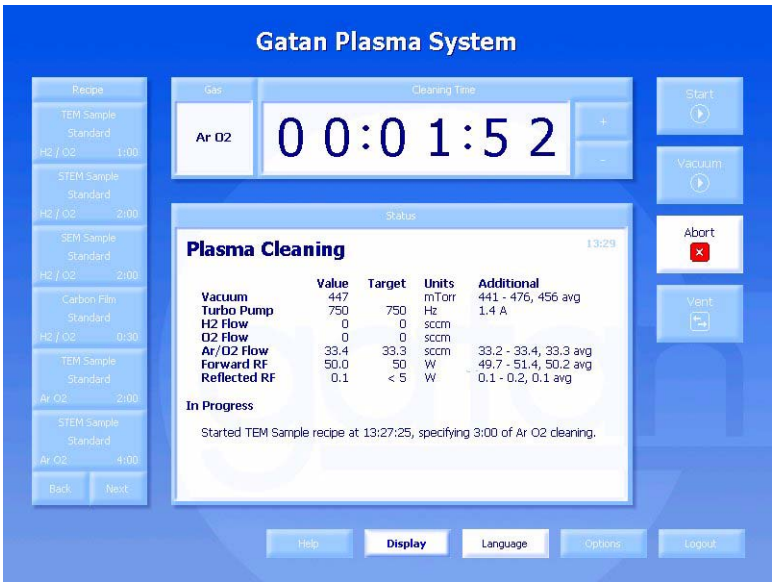


figure 19 ***Cleaning in process***

NOTE: Touch Display to show this screen. The standard display screen will be automatically displayed at the end of the cleaning cycle.

8. The cleaning cycle runs until the preset time limit has been reached.

   NOTE: Should the RF match not be reached due to the forward power or reflected power being out of range, the system will report an error and stop the cleaning cycle.

Cleaning Cycle Completion

9. At completion of the cleaning cycle, the gas flow and RF power are automatically switched off.

figure 20 ***Plasma cleaning complete***

NOTE: Chamber is under vacuum and ready to be vented

10. The cleaning chamber will remain under vacuum until manually vented by the user. This keeps the sample isolated from the environment until it is removed.

NOTE: The system will automatically abort the cycle if any error conditions exist. The user should notify the lab manager to correct the cause of the error. Any uncorrectable issues should be reported to Gatan.

Removing the Sample

1. Touch **VENT** to vent the chamber to atmospheric pressure for removal of the sample. This initiates the following actions:

- The right angle valve between the turbo pump and chamber is closed.
- The turbo continues to be backed by the diaphragm pump and the entire pumping system is isolated from the chamber.
- The vent valve is opened, allowing the chamber to come up to atmospheric pressure.

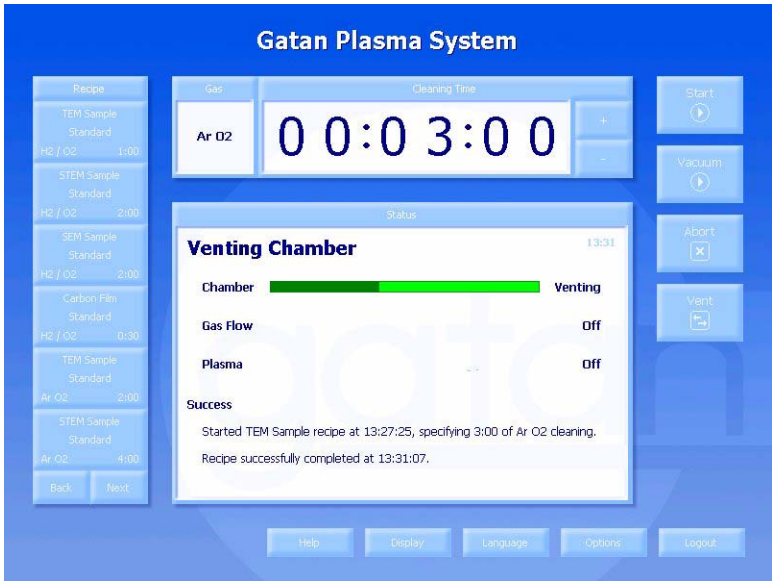


figure 21 ***Venting the chamber***

2. After ~5 seconds the display will indicate that the system is vented, and samples may be removed from the chamber. The vent valve will remain open for ~30 seconds more before closing.

NOTE: It is important that this valve not remain open indefinitely, since a vent gas cylinder could be emptied in this state.

The chamber will now remain in the idle state, ready for insertion of another sample.

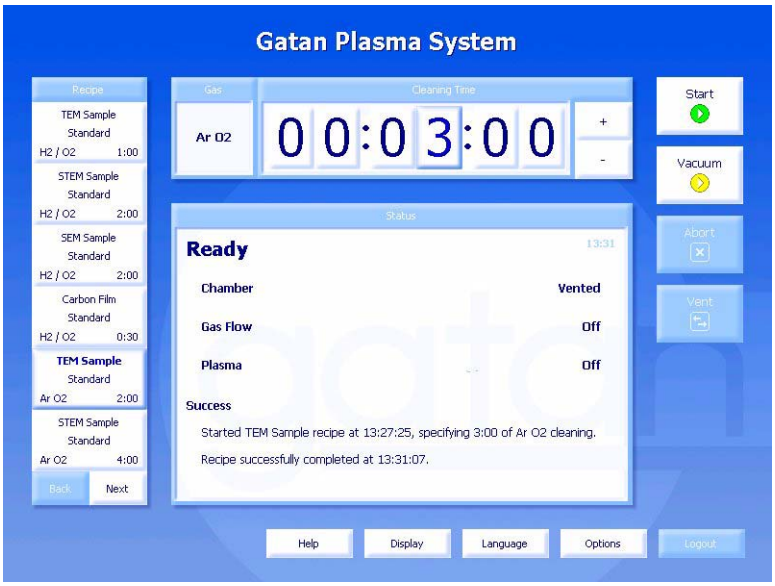


figure 22 ***System ready for next sample***

Creating Custom Recipes

Advanced users have the option of creating custom recipes.

> **CAUTION:** Altering certain parameters can create situations which could result in damage to samples and/or the plasma system.Custom recipes should be created and used with care.
>
> If you wish to use the duty cycle feature, you must create a custom recipe. This feature might be used for temperature sensitive samples.

To create a custom recipe:

1. Touch **Options** near the bottom of the touch screen.
2. Choose an existing recipe which is similar to the recipe you will be creating. Use the **Next** button at the bottom of the screen to cycle through the recipes until you find one that is suitable.
3. Touch **Copy**. A new recipe page appears with a list of parameters matching the recipe you selected. These parameters are editable, and include the following options.

PARAMETER	DESCRIPTION AND EDITING STEPS
Title	The name you want to call your recipe. Touch **Clear** and use the keypad to enter a new title.
Visible	Allows you to hide existing recipes that are not being used. For example, if you don't have a Gas 3 (Ar) configured, the visibility on all Ar/O_2 recipes will automatically be set to **No**.
Cleaning Time	Touch the digit you want to change and use the **+** and **-** buttons to adjust the time. Set the **duty cycle** by touching the appropriate duty cycle value (100%, 50%, 25%, 10%, or 5%). The default is 100%, which means the cleaning is uninterrupted. Set the **clean on time** by touching the appropriate button (60 s, 30 s, 15 s, 10 s, or 5 s). For example, if you choose 50% duty cycle and 60 s cleaning period, the system will cycle the RF Power 60 s on and 60 s off until the total cleaning time is reached.
Vacuum Target	Most users should not adjust this value. This adjusts the depth of vacuum that must be achieved before a plasma can be initiated. This setting does not actively attempt to change the pressure, it only monitors the pressure. The pressure is set by the combination of gas flow and turbo speed.
Vacuum Range	Most users should not adjust this value. This sets the acceptable range of deviation from the vacuum target.
Pumping Switchpoint	Most users should not adjust this value. This sets the vacuum level at which the turbo pump begins a deeper evacuation of the sample chamber.

PARAMETER	DESCRIPTION AND EDITING STEPS
Turbo Pump Speed	Most users should not adjust this value, as it can affect cleaning efficiency and damage production of the plasma.
Pumping Timeout	Most users should not adjust this value. This limits the amount of time the system is allowed to achieve the target vacuum state before canceling the process. Adjusting this value can be helpful to set up special functions such as purging gas lines, however, the default purging process under the options section is the preferred method.
Repeat	This function allows for a plasma cycle to be run over and over on the same sample without interruption. The preferred method would be to simply increase the cleaning time.
O_2 Gas Flow, H_2 Gas Flow, Ar Gas Flow	After extensive testing, the default gas flow recipes have been found to be optimum for sample cleaning. However, there will be users who will want to explore their own gas ratios. **CAUTION:** Reducing the gas flow rate may increase the heat generated on the antenna in the plasma chamber and on the sample. Low gas flow rates combined with raising the RF power level above 50 watts for prolonged cleaning time can cause damage to samples and components internal to the chamber such as the RF antenna.
Gas Flow Timeout	This function limits the amount of time any of the gas flow rates are allowed to fall outside the selected range before the RF process shuts down.
Forward RF Target	50 watts of RF power is sufficient (and, in fact, optimum) for cleaning EM samples. The RF power level can be set as high as 65 watts. Additionally, there is a thermal relationship between power and gas flow. Lowering the gas flow also raises the energy per particle and correspondingly the temperature on the antenna.
Forward RF Range	This setting controls how much deviation from the target value is allowed before an RF power shutdown is triggered.
Maximum Reflected RF	This setting should generally not be altered. **CAUTION:** Setting reflected RF to a high value enables the generation of RF energy for prolonged periods with high reflected RF power, which can stress the internal components and cause internal heating. This condition can lead to automatic thermal shutdown. If the system is repeatedly exceeding the default reflected RF limits, it may need service.
RF Timeout	This function limits the amount of time that any of the above three power parameters (Forward RF Target, Forward RF Range, and Maximum Reflected RF) can fall outside the selected range before the RF process is shut off.
RF Tuning Attempts	This function allows the system to retry if a match is not found during the first attempt. The default is 3 attempts.

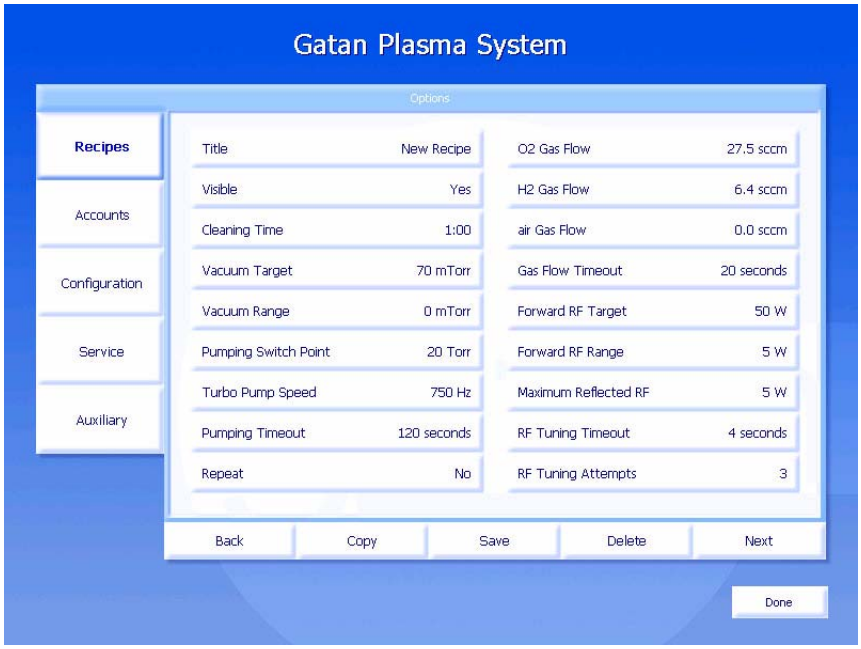


figure 23 ***Recipe options***

Example 1, using air as a test gas:

When no process gases are available, the O_2 process gas connection may be left open to air in order to test the operation of the unit. (note that this may not work at high altitude due to the lower pressure)

1. Select **TEM Standard H_2/O_2 1 Min**.
2. Touch **Options**. The options screen should be displayed.
3. Touch **Copy**. This makes a copy of the recipe that can be modified.
4. Touch **Title**, touch **Clear**, touch **A i r**, touch **Apply**. This sets the title to Air.
5. Touch **O2 Gas Flow**, touch **Clear**, touch **3 3 . 3**, Touch **Apply**. This sets the O_2 gas flow to 33.3 sccm.
6. Touch **H2 Gas Flow**, touch **Clear**, touch **Apply**. This sets the H_2 gas flow to zero.
7. Touch **Cleaning Time**, set the desired time, touch **Apply**.
8. If you want this recipe to be saved in the case of a power failure, touch **Save**.
9. Touch **Done**.

Example 2, using premixed gasses of 75% Ar, 25% O_2 as process gas 3

If you wish to use Ar/O_2 instead of Ar for gas 3, you must create a custom recipe that uses Ar/O_2 (process gas 3) with a flow rate of 45.0. After creating this recipe, you should make the preset recipes for Ar/O_2 not visible, so users will not use the wrong ones. Do this for all the preset Ar/O_2 recipes.

First check to be sure Gas 3 is configured for Ar(75%)/O_2(25%).

1. Touch **Options**. The options screen should be displayed.
2. Touch **Configuration**. The configuration screen should be displayed.
3. Be sure that **Gas Line 3 Enable** is set to **Yes**.
4. Touch **Gas Line 3 Name**, touch **Clear**, touch **A r / O 2**, touch **Apply**. This sets the name.
5. Touch **Gas Line 3 Multiplier**, touch **Clear**, touch **1 . 2 8**, touch **Apply**. This sets the MFC multiplier, which compensates for using a gas other than the gas the MFC was calibrated for.
6. Touch **Done**.

Next create the custom recipe.

1. Select **TEM Standard H2/O2 1 Min**.
2. Touch **Options**. The options screen should be displayed.
3. Touch **Copy**. This makes a copy of the recipe that can be modified.
4. Touch **Title**, touch **Clear**, touch **A r / O 2**, touch **Apply**. This sets the title to Ar/O2.
5. Touch **H2 Gas Flow**, touch **Clear**, touch **Apply**. This sets the H2 gas flow to 0 sccm.
6. Touch **O2 Gas Flow**, touch **Clear**, touch **Apply**. This sets the O2 gas flow to 0 sccm.
7. Touch **Ar/O2 Gas Flow**, touch **Clear**, touch **4 5**, touch **Apply**. This sets the ArO2 gas flow to 45 sccm. This should result in a pressure of about 450 mTorr during cleaning.
8. Touch **Cleaning Time**, set the desired time, touch **Apply**.
9. Touch **Save**.
10. Touch **Done**.

To make a recipe not visible from the main screen:

1. Select the recipe.
2. Touch **Options**.
3. Touch **Visible**.
4. Touch **No**.
5. Touch **Apply**.
6. Touch **Done**.

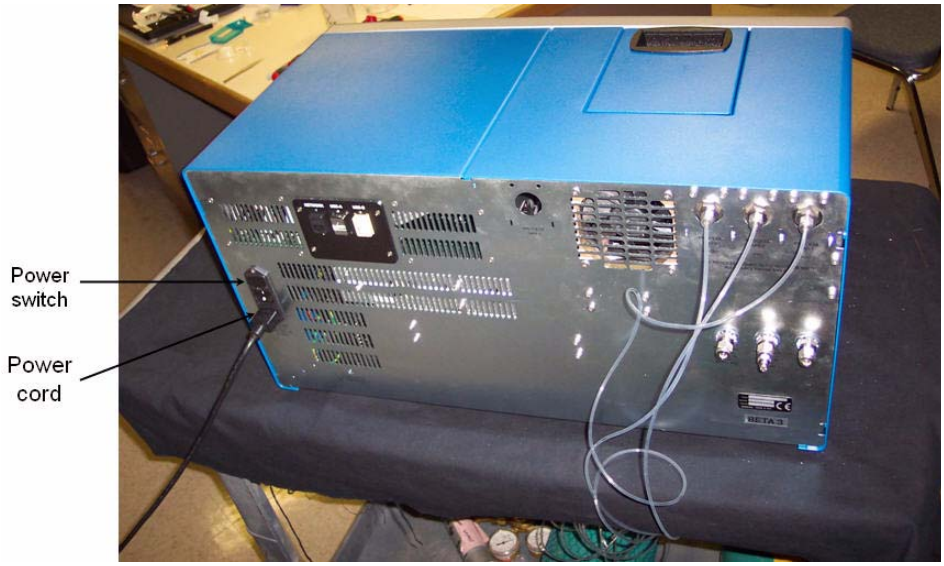
Maintenance

The turbo-molecular drag pump and diaphragm pumps require periodic maintenance. Please see the individual operator manuals of these instruments (included in the shipping crate) for instructions.

As the diaphragm pump ages, the rates at which it will pump H and O change by different amounts. This will change the H/O partial pressure ratio during cleaning, which can affect the plasma cleaning rate. Because of this, it is important to maintain the diaphragm pump properly.

Removing the Cabinet Covers

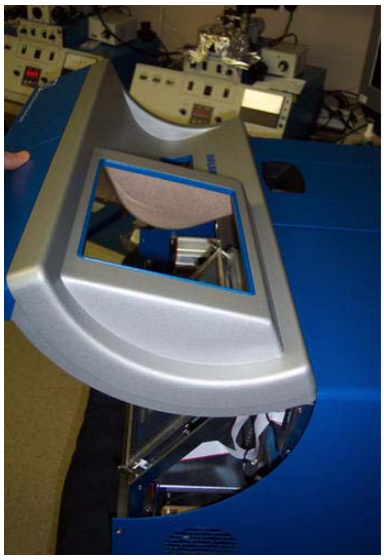
1. Shut off the power to the system and unplug the power cord. The power switch is located on the rear of the cabinet near the right side.



2. Remove any plugs or holder-adapters from the front-entry ports.

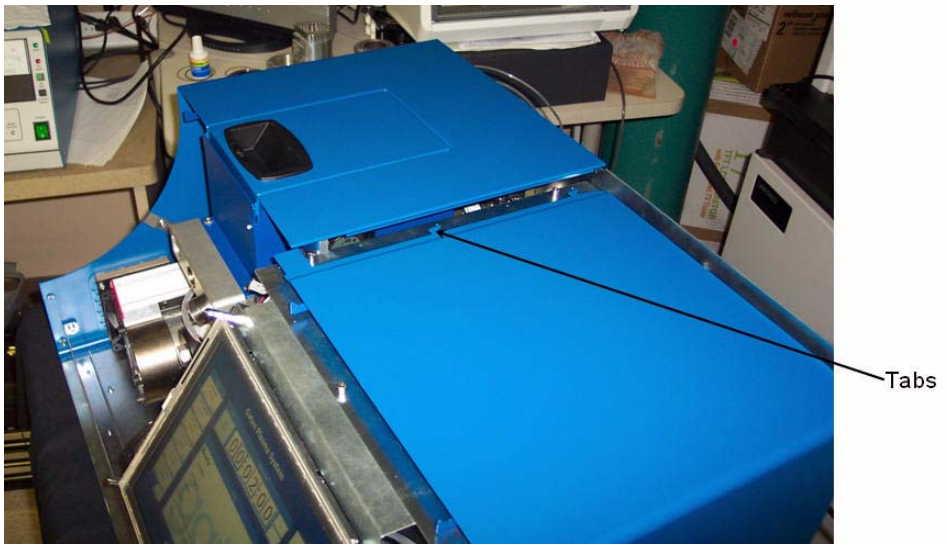
3. Loosen the captive screws located on each side of the cabinet near the front. The two screws on each side closest to the front release the bezel, the other releases the covers.

4. Tilt the bottom of the bezel upward, making sure that the cut-out does not scrape against the edge of the right side-entry port.

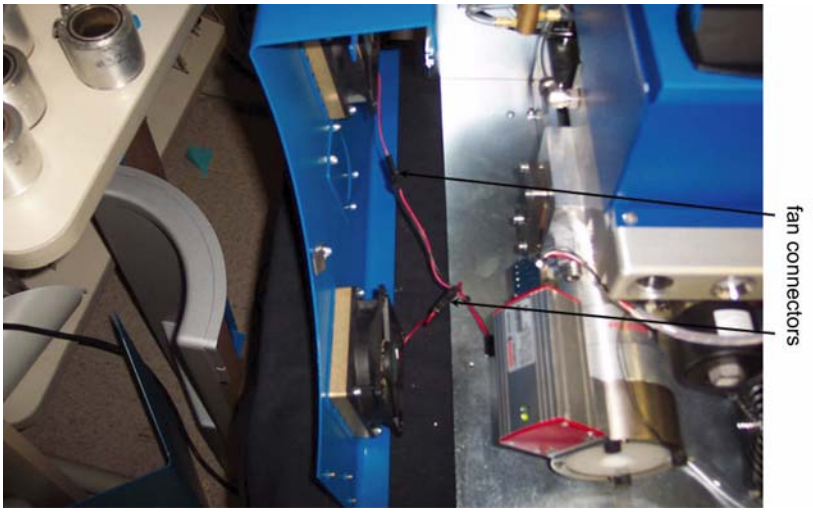


5. Pull the bezel up and forward to release it from the cabinet. There are three slots in the top of the bezel that fit to three connecting pieces in the cabinet.
6. Loosen the captive screws located on each side of the cabinet near the back.
7. Loosen the captive screw on the top-front center of the cabinet.

8. The remaining cabinet cover consists of two pieces. First remove the cover on the right by pulling it slightly forward then out (to the right). This disengages two locking tabs at the far left of the cover-piece. If the bottom catches on the frame, push it slightly down and out to clear.



9. Unplug the two fans mounted on the left cover prior to removing it completely. The top of the left cover-piece protrudes down about 1 inch (25 mm) into the top loading port region while the bottom curves under the frame. Because of this, it is necessary to bend the bottom outward until it clears the frame before lifting upward on the cover. Also make sure the captive screws are clear before raising the cover.

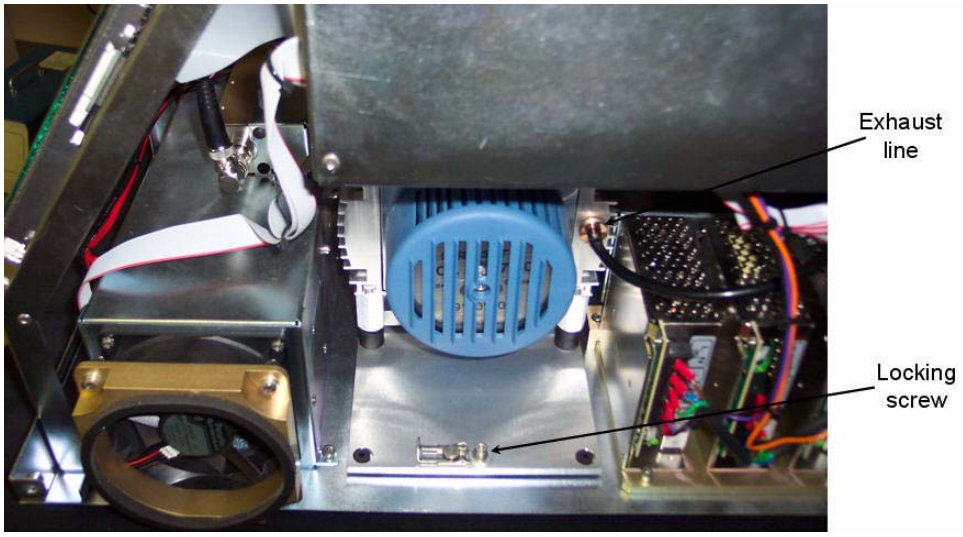


10. The covers can be replaced by following the reverse of these directions.

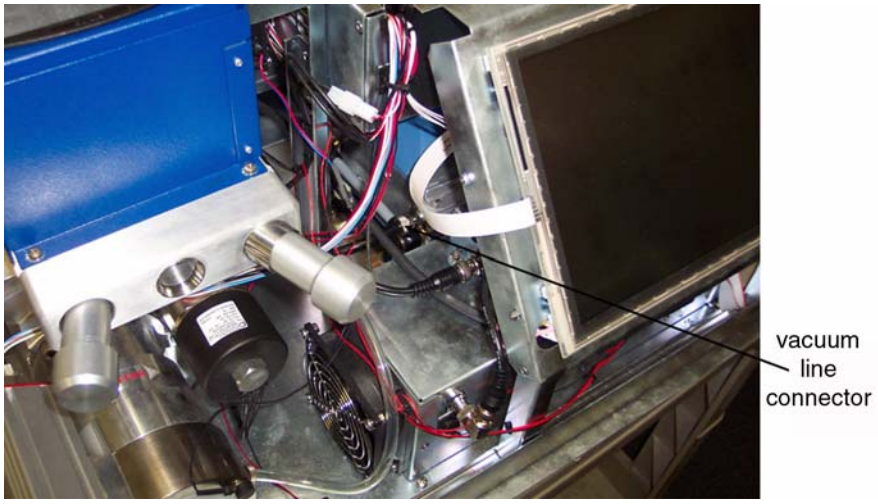
Removing the Diaphragm Pump

1. Shut off the power to the system and unplug the power cord. The power switch is located on the rear of the cabinet near the right side
2. Remove the front bezel and the right cover. (see instructions above)
3. Remove the locking screw that holds the pump base-plate to the frame. Remove the exhaust line from the pump by pulling on it. The pump and the

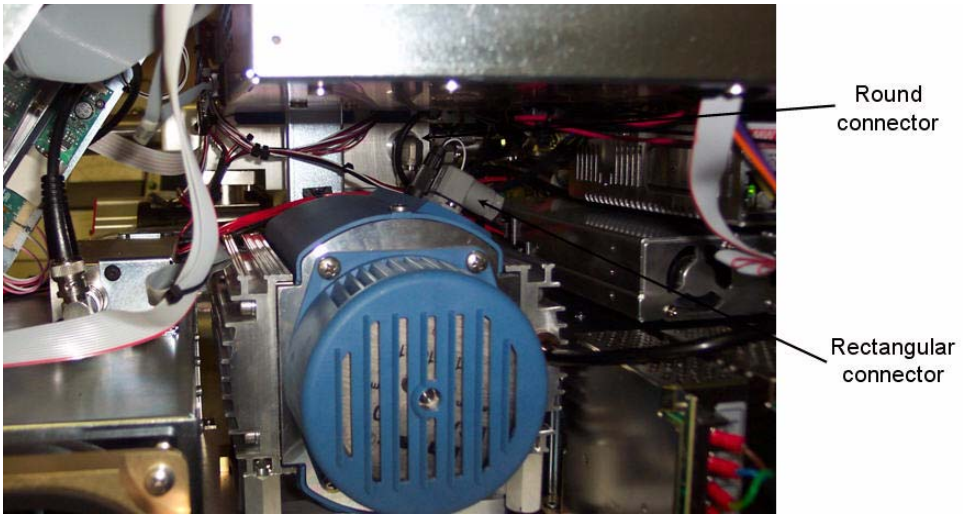
base-plate will slide out of the cabinet together once all connections are removed.



4. Disconnect the vacuum line from the left side of the pump by unscrewing the knurled knob (not the hex nut).



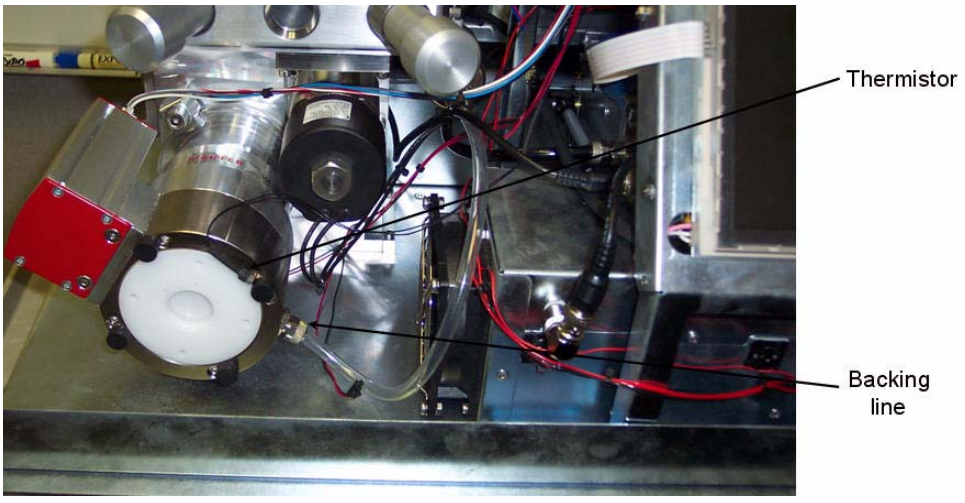
5. Slide the pump out of the cabinet until the two connectors on the top can be accessed. Unplug the two connectors (one is held captive by a screw).



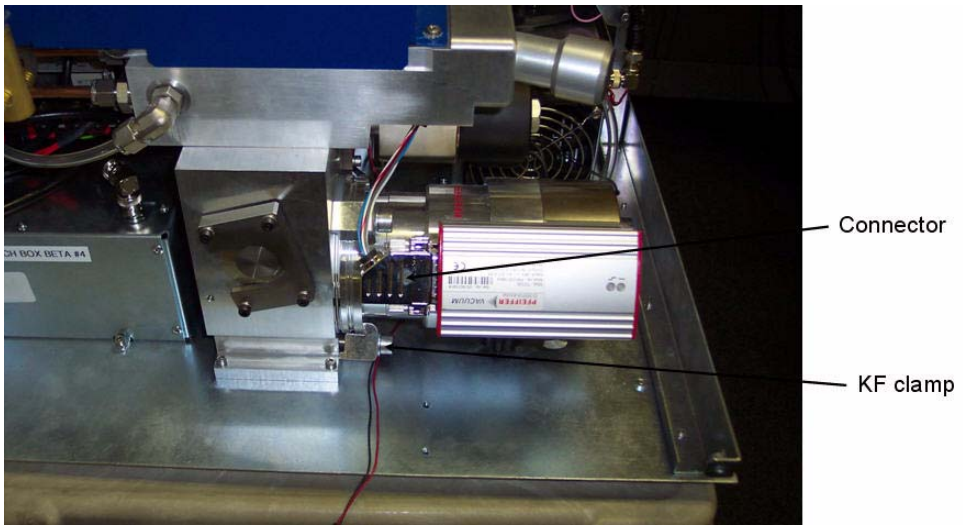
6. Slide the pump completely out of the cabinet.
7. The pump can be installed by following the reverse of these directions.

Removing the Molecular Drag Pump

1. Shut off the power to the system and unplug the power cord. The power switch is located on the rear of the cabinet near the right side.
2. Remove the front bezel and both covers. (see instructions above)
3. Disconnect the backing line from the pump by loosening the knurled knob and pulling (not the hex nut).



4. Unscrew the rubber foot and remove the thermistor.
5. Unscrew the bolts on the three KF clamps that hold the pump to the manifold. Hold the pump as this is done to ensure that it does not fall.



6. Remove the connector from the controller.
7. Cover the openings in the pump and the manifold with clean aluminum foil while the pump is disconnected to prevent contamination.
8. The pump can be installed by following the reverse of these directions.

Removing the View Port

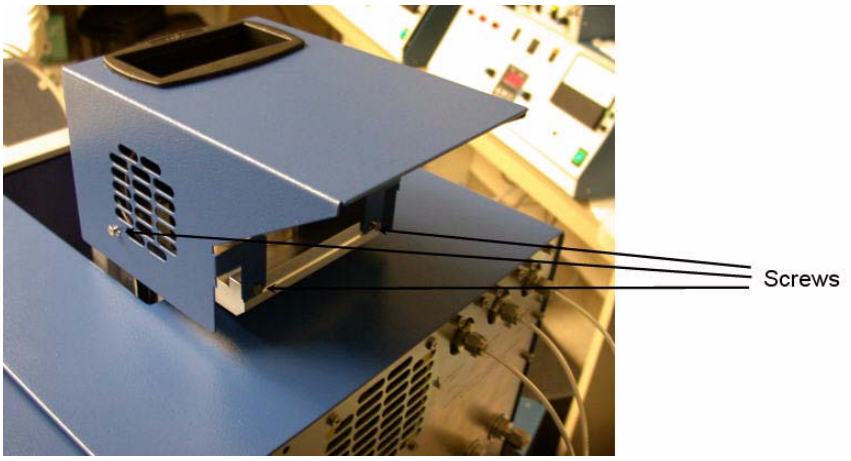
The view port can be removed so that it or the o-ring can be cleaned or replaced.

1. Squeeze the two holes in the viewport clamp with snap ring pliers and gently pull the clamp out.

Calibrating the Pirani Gauge

The gauge is calibrated prior to shipment. Contamination or a long time in operation can result in a zero drift. If the gauge is severely out of calibration, it can be calibrated in the field. This should only be done when necessary. It will not result in the most accurate calibration because the Solarus is not designed to evacuate the specimen chamber below 7.5 x 10^{-5} Torr (1 x 10^{-4} mbar). This slight miscalibration will not affect plasma cleaning efficiency, and the system will function properly.

1. Lift the lid to the specimen chamber.
2. Remove the four screws that hold the cover to the specimen chamber lid and remove the cover.



3. Lower the lid back to a closed position, but leave the chamber at atmospheric pressure.
4. Operate the gauge for 10 minutes at atmospheric pressure.
5. Press the button on the gauge momentarily (i.e., less than 5 sec). The button is located below a hole behind the specimen chamber (see picture below). This activates the atmospheric calibration and adjusts the gauge to 750 Torr (1000 mbar). A tool of less than 1.1 mm (such as a small hex key) diameter is needed to operate the button.

figure 24 Access to Pirani gauge calibration button

NOTE: The button is in the Pirani gauge, which is located just below this hole. You will have to feel for the button with a tool.

6. Touch **Vacuum** on the Solarus touch screen. Wait for the system to pump the chamber down to its operating pressure.
7. Touch **Display**. The display will change so that the pressure will be shown. Wait for the pressure reading to stabilize at a minimum value. 10 minutes should be fine.

8. Press the button on the gauge momentarily. This will activate the high vacuum calibration and adjust the gauge to 7.5 x 10^{-5} Torr (1 x 10^{-4} mbar).
9. The calibration is complete. Return the cover to the specimen chamber lid using the four screws.

Maintenance Report

The maintenance report provides a time/date log of all processes run by the system, as well as completion and failure statistics.

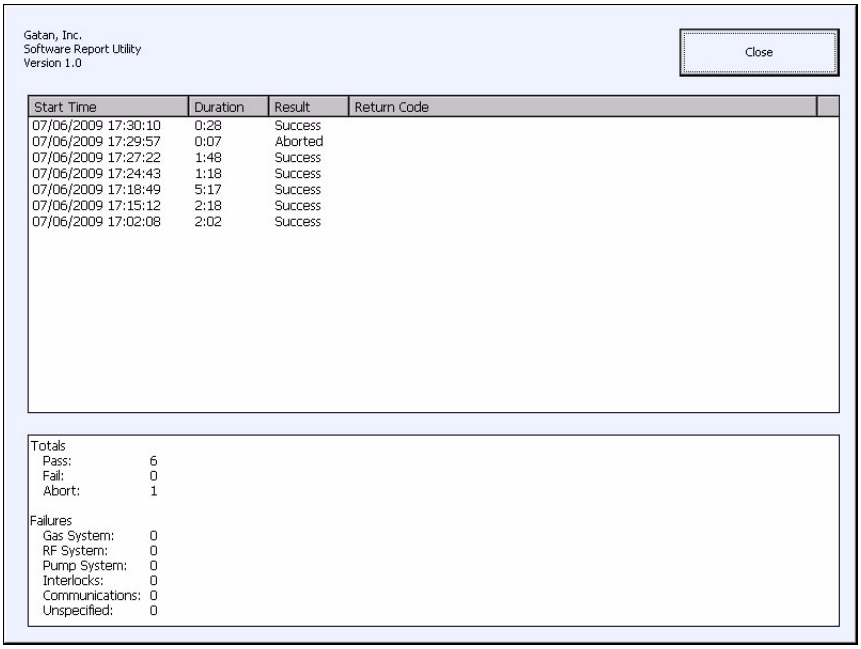


figure 25 Example maintenance report

Viewing the Maintenance Report

1. Touch Options.
2. Touch Service.
3. Touch Maintenance Report.

Clearing the Maintenance Report History

1. Touch Options.
2. Touch Service.
3. Touch Reset History.
4. Touch Yes to confirm.

Troubleshooting

If the system does not pump down, it may be caused by the top cover not seating properly. In such a situation, please follow these steps:

1. Press down on the top door of the chamber.
2. If this does not solve the problem, there may be a dirty o-ring. Inspect the o-rings on the top cover as well as on the holder adapters and plugs.
3. Clean any lint or particles from the surface of the o-rings. If there are any cuts or nicks in the o-rings, replace them.

Follow the steps below if the following error message appears:

Error Message: Mass flow controller could not match the specified gas flow.

1. Be sure gases are connected and the pressure is correct (25 psi).
2. Be sure the system has been powered on for at least 45 minutes. This is required for the mass flow controllers to function properly.
3. Verify that the H_2 in-line filter is not clogged.
4. If no gas is connected, i.e., you are using air as the process gas, be sure you are not using the standard H/O recipe. The H mass flow controller cannot meet the flow rate with atmospheric pressure. See the examples in the creating custom recipes section for instructions on using air as the process gas.
5. Check for a leaking gas inlet line. The easiest way to test this is to purge the gas lines, as described in the installation section.

Spares and Consumables

PART NUMBER	DESCRIPTION
950.B	Gatan Advanced Plasma System—Basic
950.08350	Phillips P1 Adapter (all non-Compustage TEMs)
950.08380	JEOL J5 adapter (1210, 2010, 3010)
950.08410	Hitachi H3 Adapter (S900, S5000)
950.10024	Specimen Table, ½”
950.10026	Specimen Table, ¾”
950.10028	Specimen Table, 1”
950.10030	Blanking Plug
950.19060	JEOL J2 Adapter (100, 200, 1200, 2000, 1010, 6000)
950.19061	Hitachi H1 Adapter (500, 600, 700, 800, 7000, 7100, 8000, 8001, HF2000
950.19069	Phillips P5 Adapter (all Compustage TEMs)
950.19081	Topcon Adapter
950.50400	Assy, RF Generator
950.30000	Assy, RF Detector
950.50300	Assy, RF MatchBox
950.03000	PCA, RF Control Board
950.20100	PCA, I/O Expansion Board
950.31000	PCB,VGX, Single board Computer
06458	Viton o-ring, #117
18605	Conductive 0-ring, .139” x 3.734”
14116	In-line Particulate Filter, 0.5 micron

Battery Considerations

Information in this section is provided in accordance with the European Union Battery Directive, 2006/66/EC.

A "button" type battery is contained within the Graphics ClientM card (Gatan part # 100699) used in the 950 Solarus Advanced Plasma System. The battery is located as shown in Figure 26 below.

Battery Characteristics

The Lithium button cell battery (Rayovac BR1225 or equivalent operates from -30°C to +80°C under normal operating conditions. The typical shelf life of the battery is 8 years at room temperature.

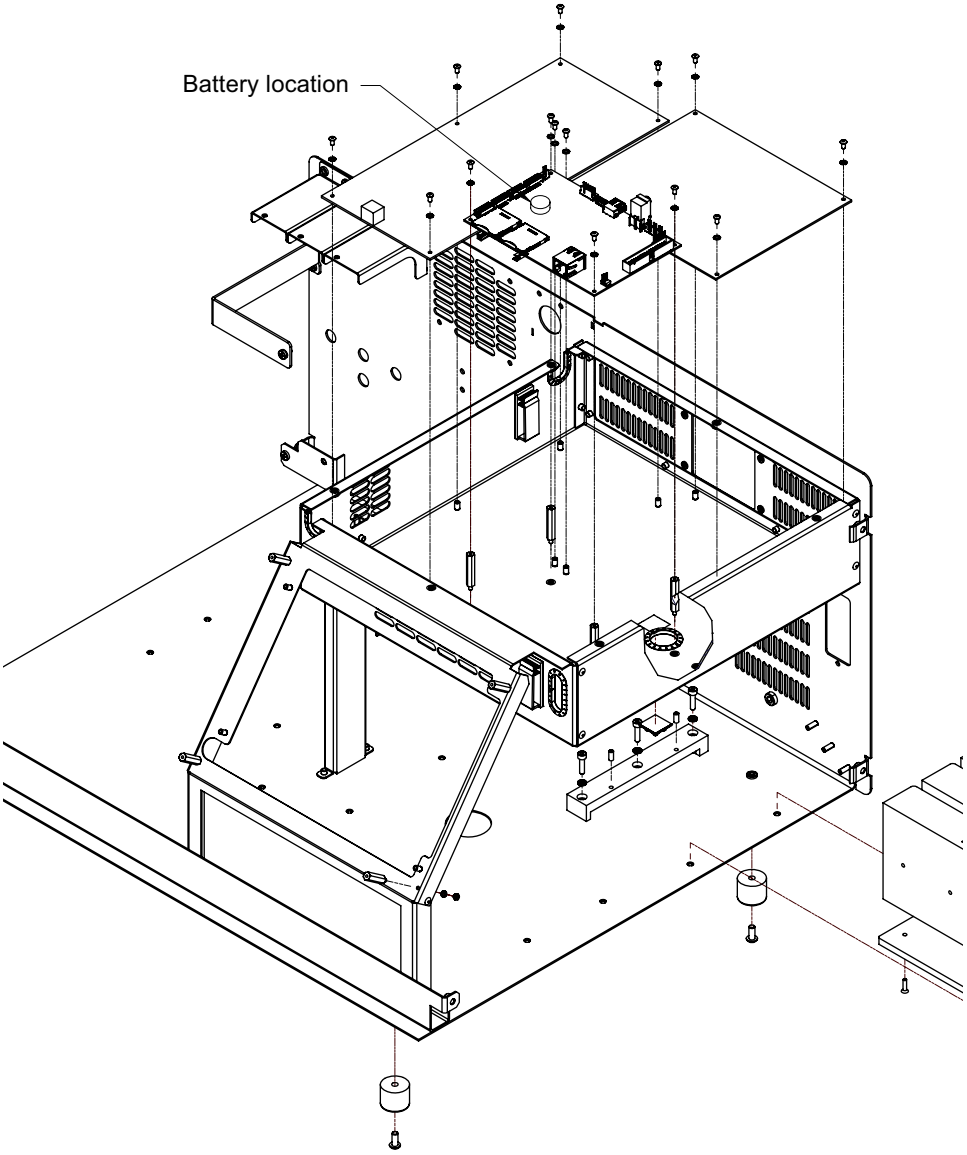


figure 26 Battery Location

Battery Replacement

Each customer must evaluate their operating conditions to determine if a battery maintenance program is required as part of a regular maintenance cycle for their product. In the event the battery must be replaced, contact Gatan Customer Service Department at www.gatan.com and follow the link to Customer Service.

NOTE: If you decide to replace the battery in the field, you are responsible for any damage that may occur during battery replacement.

Battery Specifications

Voltage: 3 V

Capacity: 48 mAh

Electrochemical Construction: Lithium Carbon Monofluoride (BR) coin cell

Battery Socket Locations: See Figure 26, “Battery Location,” on page 49.

CAUTION: The 950 Solarus Advanced Plasma System contains a Lithium Battery. There is a danger of explosion if the battery is incorrectly replaced or handled. Do not disassemble or recharge the battery. Do not dispose of the battery in fire. When the battery is replaced, the same type or an equivalent type recommended by the manufacturer must be used. Used batteries must be disposed of according to the battery manufacturer's instructions.

Information on the battery specifications, including handling and disposal are provided by Rayovac via their webpage at:

http://ca.rayovac.com/technical/msds.htm

Gatan Product Warranty

Gatan warrants that products manufactured by Gatan shall be free of defects in materials and workmanship for the warranty period, which commences at date of shipment. Gatan tests the performance of a unit as part of its final test procedure, prior to shipment from its factory. Gatan warrants that the unit meets Gatan's published specifications at time of shipment from its factory. All product warranties provide, for a period of one year after shipment to customer, parts (excluding all normal consumable, wear, and maintenance items) and labor. For Specimen Preparation Equipment and Specimen Holders, Gatan will correct any defects in the instrument either by repair in our facility or replacing the defective part, with the shipping party responsible for shipping costs. For products which attach to the column (Cameras, DigiScan, GIF, and PEELS), travel of up to 100 miles from a Gatan authorized repair center (Pleasanton, CA; Warrendale, PA; Munich, GmbH; and Corby, UK) is included. Travel expenses for service beyond 100 miles will be charged for.

Instruments, parts, and accessories not manufactured by Gatan will be warranted by Gatan for the specific items and periods in accordance with and provided by the warranty received by Gatan from the Original Equipment Manufacturer. All such accessory warranties extended by Gatan are limited in accordance with all the terms, conditions, and other provisions stated in this Original Equipment Manufacturer warranty. Gatan makes no warranty whatsoever concerning products or accessories not of its manufacture, except as noted above.

Customer Responsibilities

The customer bears the following responsibilities with regard to maintaining the warranty. The customer shall:

1. Perform the routine maintenance and cleaning procedures at the required intervals as specified in Gatan's operating manuals. Failure to perform specified maintenance will automatically void warranty.
2. Use Gatan replacement parts. Failure to use the specified replacement parts will automatically void warranty.
3. Use Gatan or Gatan-approved consumables.
4. Provide Gatan authorized service representatives access to the products during normal Gatan working hours during the coverage periods to perform service.
5. Provide adequate and safe working space around the products for servicing by Gatan authorized service representatives.
6. Provide access to, and use of, all information and facilities determined necessary by Gatan to service and/or maintain the products. (Insofar as these items may contain proprietary or classified information, the customer shall assume full responsibility for safe-guarding and protecting them from wrongful use.)

Repairs and Replacements

Gatan will, at its option, either repair or replace defective instruments or components with conforming goods. Repair or replacement of products or parts under warranty does not extend the original warranty period. With the exception of consumable and maintenance items, the replacement parts or products used on instruments out of warranty are themselves warranted to be free of defects in materials and workmanship for 90 days.

Any products, part, or assembly returned to Gatan for examination or repair shall have Gatan's prior approval, with the customer requesting a Returned Material Authorization (RMA) approval. This RMA and the associated RMA number may be obtained through Gatan Service or directly from Gatan's Warrendale facility at 724-776-5260. If the item is not under warranty, to obtain an RMA, the customer must provide a Purchase Order (PO) for the repair. If the item is under warranty and the customer is requesting an expedited exchange, as may be the case for a printed circuit board, a PO will be required. A credit against this PO will be issued by Gatan upon receipt of the item as returned in accordance with the RMA instructions. The returned item should be shipped prepaid by the customer with the RMA number clearly marked on the exterior of the shipping container and on the enclosed shipping documents. If the returned item is under warranty, return transportation will be prepaid by Gatan. If the returned item is not under warranty, return transportation will be charged to the customer.

Warranty Limitations

The warranty does not cover:

1. Parts and accessories which are expendable or consumable in the normal operation of the instrument.
2. Any loss, damage, and/or instrument malfunction resulting from shipping or storage, accident (fire, flood, or similar catastrophes normally covered by insurance), abuse, alteration, misuse, neglect, or breakage or abuse of parts by User.
3. Operation other than in accordance with correct operational procedures and environmental and electrical specifications.
4. Performance to specifications or safety of use (including X-ray emissions) if the unit is physically installed on, used in conjunction with, or used as part of a third party's equipment and is not installed by a Gatan service engineer.
5. Performance to specifications or safety of use (including X-ray emissions) as a result of the use of Gatan's equipment with that of a third party due to the third party's product design.
6. Modification of, or tampering with, the system.
7. Improper or inadequate care, maintenance, adjustment, or calibration by User.
8. User-induced contamination or leaks.
9. Any loss, damage, and/or instruments malfunction resulting from use of User-supplied software, hardware, interfaces, or consumables other than those specified by Gatan.

Warranty Exclusions

In the course of normal use and maintenance, certain parts have finite lifetimes. For this reason, the consumables, wear, and maintenance parts as specified in Gatan's operating manuals carry a 90-day warranty unless otherwise specified.

Post Warranty Period Support and Product Obsolescence

After the expiration of the warranty period described above, Gatan will provide service support for Gatan manufactured products at Gatan's service labor rates and parts pricing in effect at the time of the repair. Gatan will continue to provide billable service support for the products for a period of three years after discontinuance or design obsolescence by Gatan. After this three year period, service support will be offered at the sole discretion of Gatan.

Liability Limitations

This warranty is in lieu of and excludes all other expressed or implied warranties, including (but not limited to) warranties of merchantability of fitness for a particular purpose. Under no circumstances will Gatan Inc. or Gatan International be liable for any direct, indirect, special, incidental or consequential damages (including lost profit) or loss of any kind, whether based on warranty, contract, tort, or any other legal theory. The limits of Gatan liability in any dispute shall be the price received from the purchaser for the specific equipment at issue. The laws of the state of Pennsylvania apply to all aspects of this warranty.

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