



***Models 959 and 959D  
Mass Spectrometer  
Helium Leak  
Detectors***

*OPERATIONS MANUAL*

Manual No. 699909750  
Revision R  
March 2003

# Models 959 and 959D Helium Mass Spectrometer Leak Detectors



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# Preface

## Warranty

Products manufactured by Seller are warranted against defects in materials and workmanship for twelve (12) months from date of shipment thereof to Customer, and Seller's liability under valid warranty claims is limited, at the option of Seller, to repair, to replace, or refund of an equitable portion of the purchase price of the Product. Items expendable in normal use are not covered by this warranty. All warranty replacement or repair of parts shall be limited to equipment malfunctions which, in the sole opinion of Seller, are due or traceable to defects in original materials or workmanship. All obligations of Seller under this warranty shall cease in the event of abuse, accident, alteration, misuse, or neglect of the equipment. In-warranty repaired or replaced parts are warranted only for the remaining unexpired portion of the original warranty period applicable to the repaired or replaced parts. After expiration of the applicable warranty period, Customer shall be charged at the then current prices for parts, labor, and transportation.

Reasonable care must be used to avoid hazards. Seller expressly disclaims responsibility for loss or damage caused by use of its Products other than in accordance with proper operating procedures.

Except as stated herein, Seller makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except as stated herein, Seller shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise. Statements made by any person, including representatives of Seller, which are inconsistent or in conflict with the terms of this warranty shall not be binding upon Seller unless reduced to writing and approved by an officer of Seller.

## Warranty Replacement and Adjustment

All claims under warranty must be made promptly after occurrence of circumstances giving rise thereto, and must be received within the applicable warranty period by Seller or its authorized representative. Such claims should include the Product serial number, the date of shipment, and a full description of the circumstances giving rise to the claim. Before any Products are returned for repair and/or adjustment, written authorization from Seller or its authorized representative for the return and instructions as to how and where these Products should be returned must be obtained. Any Product returned to Seller for examination shall be prepaid via the means of transportation indicated as acceptable by Seller. Seller reserves the right to reject any warranty claim not promptly reported and any warranty claim on any item that has been altered or has been returned by non-acceptable means of transportation. When any Product is returned for examination and inspection, or for any other reason, Customer shall be responsible for all damage resulting from improper packing or handling, and for loss in transit, notwithstanding any defect or non-conformity in the Product. In all cases, Seller has the sole responsibility for determining the cause and nature of failure, and Seller's determination with regard thereto shall be final.

If it is found that Seller's Product has been returned without cause and is still serviceable, Customer will be notified and the Product returned at its expense; in addition, a charge for testing and examination may be made on Products so returned.

## Hazard and Safety Information

This manual uses the following standard safety protocols:

**WARNING**



*The warning messages are for attracting the attention of the operator to a particular procedure or practice which, if not followed correctly, could lead to serious injury.*

**CAUTION**



*The caution messages are displayed before procedures, which if not followed, could cause damage to the equipment.*

**NOTE**



*The notes contain important information.*

Operators and service personnel must be aware of all hazards associated with this equipment. They must know how to recognize hazardous and potentially hazardous conditions, and know how to avoid them. The consequences of unskilled, improper, or careless operation of the equipment can be serious. This product must only be operated and maintained by trained personnel. Every operator or service person must read and thoroughly understand operation/maintenance manuals and any additional information provided by Varian Vacuum Technologies. All warnings and cautions should be read carefully and strictly observed. Consult local, state, and national agencies regarding specific requirements and regulations. Address any safety, operation, and/or maintenance questions to your nearest Varian Vacuum Technologies office.

### Solvents

#### CAUTION



*The mechanical components of leak detectors are typically cleaned with alcohol, methanol, or other solvents. When heated, sprayed, or exposed to high-temperature equipment, these solvents become flammable and explosive, causing serious injury or death. Do not use these solvents near a high-temperature source. Ventilate the working area with a blower and work in a large, well-ventilated room.*

*Alcohol, methanol, or other solvents are irritants, narcotics, depressants and/or carcinogens. Their inhalation and/or ingestion may produce serious side effects. Prolonged or continued contact with the skin results in absorption through the skin and moderate toxicity. Always ensure that cleaning operations are carried out in large, well-ventilated rooms, and wear eyeshields, gloves, and protective clothing.*

#### CAUTION



*Do not clean any aluminum parts with Alconox<sup>®</sup>. Alconox is not compatible with aluminum and will cause damage.*

#### NOTE



*During reassembly, always use Loctite<sup>®</sup> PST<sup>®</sup> (teflon-impregnated pipe thread compound) on pipe threads.*

### Equipment, General

#### WARNING



*The leak detector is not designed for use with hazardous gases. Verify that the system to be tested has been purged of all hazardous gases prior to using the leak detector. When testing a system that contained hazardous gases, the exhaust of the leak detector should be connected to a scrubbed or toxic containment exhaust. Exposure to hazardous gases could result in serious injury or death.*

#### WARNING



*Equipment tightness is guaranteed for normal operating conditions when the equipment leaves the factory. It is the user's responsibility to maintain the level of tightness particularly when pumping dangerous products.*

#### CAUTION



*The performance and operating safety of this equipment can be guaranteed only if it is operated according to normal conditions of use.*

#### CAUTION



*Always allow at least 4 inches of clearance adjacent to the ventilation holes at the front, back, and bottom of the equipment enclosure.*

### Power and Static

#### WARNING



*Disconnect power from the leak detector before performing any maintenance procedure that requires physically disconnecting any part of the system.*

#### CAUTION



*Many components of the leak detector are static-sensitive devices. Varian Vacuum Technologies recommends that you wear a grounding device when performing any maintenance on the leak detector and especially when performing maintenance of static-sensitive parts.*

### WARNING



*Use only the power cord that was provided with your leak detector. The use of extension cords is not recommended and could result in damage to the equipment and loss of warranty.*

*To avoid electric shock, connect the product power cord to a grounded power receptacle. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.*

*Before powering up the leak detector for the first time, verify that the leak detector is configured to operate from the local mains supply voltage.*

*Opening the enclosure may expose hazardous voltages. Always disconnect the power cord and any interface cables before opening the enclosure. Do not touch the power inlet's contacts for at least 10 seconds after disconnecting the power cord.*

### CAUTION



*This equipment generates, uses, and can radiate RF energy, and if not installed and used in accordance with the instructional manual, may cause harmful interference to radio communications.*

*When this equipment is operated in a commercial environment, operation is subject to the following conditions:*

- ☐ *This equipment may not cause harmful interference, and*
- ☐ *This equipment must accept any interference received, including interference (RF and ESD) that may cause undesired operation.*

*This equipment may need to be reset after RF and/or ESD events by cycling the Power Switch/Circuit Breaker on the back panel of the leak detector.*

*Operation of this equipment in a residential area is likely to cause harmful radio communications interference, in which case the user will be required to correct the interference at his own expense.*

### Vacuum Equipment and Cleanliness

Cleanliness is vital when servicing the leak detector or any vacuum equipment. There are some techniques that are more important in leak detector servicing than in general vacuum work:

#### CAUTION



*Do not use silicone oil or silicone grease.*

*Use powder-free butyl or polycarbonate gloves to prevent skin oils from getting on vacuum surfaces.*

*Do not clean any aluminum parts with Alconox<sup>®</sup>. Alconox is not compatible with aluminum and will cause damage.*

#### NOTE



*Normally, it is unnecessary to use vacuum grease. However, if it must be used, avoid silicone types, and use it sparingly. Apiezon<sup>®</sup> L grease (Varian Vacuum Technologies Part No. 695400004) is recommended.*

### O-ring Care

When removing, checking, or replacing O-rings, keep in mind the following:

#### NOTE



*Varian Vacuum Technologies recommends replacing all O-rings during routine maintenance or during any maintenance procedure requiring that O-rings be removed.*

#### CAUTION



*Remove O-rings carefully with your fingers. Do not use metal tools for this task. Follow these guidelines to prevent scratching of any sealing surfaces:*

- ☐ *Wipe all O-rings clean with a lint-free cloth before installation to ensure that no foreign matter is present to impair the seal.*
- ☐ *Do not use grease or use other substances on O-rings that will come in contact with the spectrometer tube.*
- ☐ *Do not use alcohol, methanol, or other solvents on O-rings. To do so causes deterioration and reduces the O-ring's ability to hold a vacuum.*
- ☐ *In allowable situations, apply a small amount of Apiezon L grease and wipe the O-rings "shiny" dry.*



### NOTE



*VacuSolv, included in the Component and Spectrometer Tube Cleaning Kit (Part No. 670029096), is recommended for cleaning the spectrometer tube components.*

*VacuSolv can also be used for fine cleaning of other parts in the leak detector's vacuum system, such as valves and fittings. No rinsing steps or high-temperature drying is required following cleaning with VacuSolv. Although appropriate precautions are advised, VacuSolv is compatible with most materials and does not contain toxic chemicals or CFCs (chlorofluorocarbons).*

### Spectrometer Tube

#### CAUTION



*The spectrometer tube operates at a very high vacuum produced by the high vacuum pump. Service of the spectrometer tube requires that this vacuum be vented to the atmosphere.*

#### CAUTION



*Do not use grease or other substance on O-rings that will come in contact with the spectrometer tube.*

#### CAUTION



*If the spectrometer tube magnet comes in contact with a magnetic surface, the magnet may lose its field strength, causing the spectrometer tube to lose sensitivity.*

#### WARNING



*Store the ion source in a cool, dry area in a tightly sealed container. Wash hands thoroughly after handling the ion source, especially before smoking or eating.*

### Pumps

**WARNING**



*To avoid injury, use proper lifting techniques when moving pumps. Your system may have pumps that require two people to move them safely.*

**WARNING**



*The vacuum pumps are also compressors; incorrect operation may be dangerous. Study the "Installation and Operation Manual" enclosed with your pump before starting pumps.*

**WARNING**



*To avoid injury, turn off the nitrogen source in the 959D when the nitrogen purge is not in use.*

### Varian Services

The following are just a few of the many services that Varian offers its customers. Please see our catalog, or contact us to learn of other services that are available. Contact Varian Vacuum Technologies Customer Service at 1-800-8VARIAN for details.

- ☐ Rebuilt spectrometer tubes are available on an exchange basis.
- ☐ NIST-traceable calibrated leak testing and verification services.
- ☐ Courses in leak detection, including in-depth operational and maintenance instruction for the leak detector.

### Contacting Varian Vacuum Technologies

In the United States, you can contact Varian Vacuum Technologies Customer Service and Technical Support at 1-800-8VARIAN.

Internet users:

- ☐ Send email to Customer Service and Technical Support at [vpl.customer.support@varianinc.com](mailto:vpl.customer.support@varianinc.com)
- ☐ Visit our web site at [www.varianinc.com/vacuum](http://www.varianinc.com/vacuum)
- ☐ Order on line at [www.evarian.com](http://www.evarian.com)

See the back cover of this manual for a listing of our sales and service offices.

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## Section 1. Introduction

### 1.1 959 and 959D Mass Spectrometer Helium Leak Detectors

The Varian Models 959 and 959D are portable, self-contained mass spectrometer helium leak detectors using respectively dry and wet (oil-based) vacuum roughing pumps.

The dry pump in the 959D makes the system particularly useful in clean room environments where a wet, oil-based pump cannot be tolerated. The pumps have identical operating characteristics, although the 959D is somewhat heavier. The wet pump meets most mechanical vacuum pumping needs, except in clean room applications.

#### CAUTION



*The 959D with a **TriScroll 310** mechanical pump (or similar TriScroll pump) is considerably heavier than the 959 oil-based pump. Refer to Table 1-3 on page 1-13 for the weights of both.*

The pump basic components are:

- ☐ Test port that connects the leak detector to the unit under test or to an associated vacuum system
- ☐ High vacuum turbo pump
- ☐ Spectrometer tube
- ☐ Valve block
- ☐ 959D: **TriScroll™ 310** dry mechanical roughing pump  
959: DS-302 oil-based mechanical vacuum pump
- ☐ Leak detector electronics
- ☐ Front control panels, and rear I/O and power panel

The systems provide clean and automatic leak detection utilizing the Contra-Flow™ vacuum system design that allows testing at high test point pressures. The 959D provides a *dry*, oil-free vacuum pumping system. The TriScroll dry roughing pump evacuates the test port to the appropriate transfer pressure and provides ultra-clean system roughing and backing functions. The DS-302 high vacuum mechanical pump in the 959 provides the same functions in situations where the oil-free aspects of the 959D are not required.

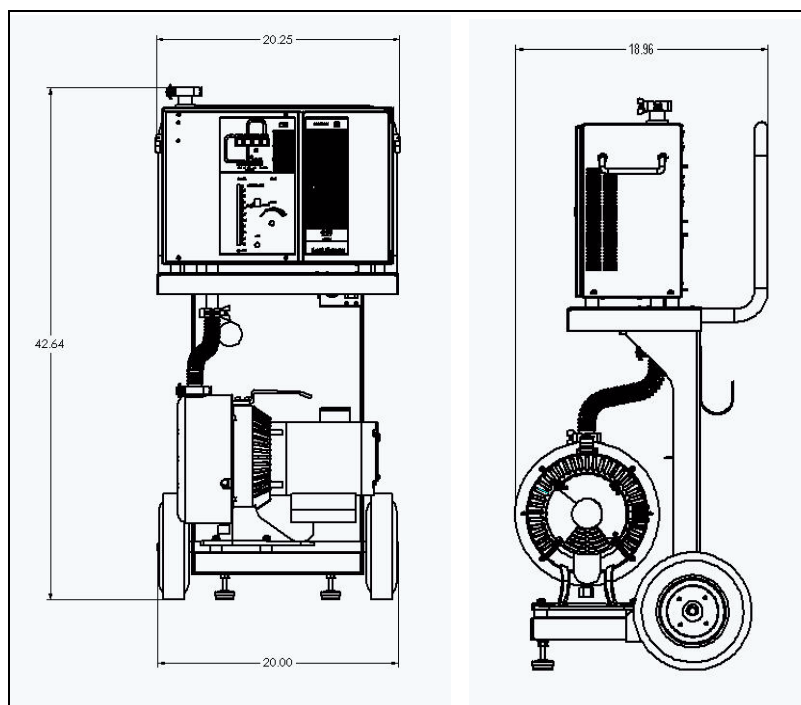
## 959 and 959D Leak Detectors

A Varian Turbo or MacroTorr™ pump is used to achieve very high vacuum in the spectrometer tube. The roughing pump is located on the cart below the leak detector. An optional power probe accessory allows the leak detector to operate as a quick-response, high-sensitivity sniffing leak detector.

Operation is performed using primary controls located on the front of the leak detector and secondary controls located behind a locking access door, also at the front of the leak detector. The front view is shown in Figure 1-1 on page 1-2 and Figure 1-2 on page 1-3. The leak detector electronics operate the spectrometer assembly, control the high vacuum pump, control the valve block, and provide leak rate and system status information to the operator through bar graph and LED indicators on the front panel, through audio, or through an optional meter or chart recorder.

The 959D has nitrogen purge available. This feature eliminates a high helium background which could interfere with testing. The use of this feature depends upon the test method and conditions. For example, using the helium spray test method in a poorly ventilated area would likely require the use of the nitrogen purge. The leak detector can detect leaks as large as  $1 \times 10^{-4}$  atm cc/sec to as small as  $2 \times 10^{-10}$  atm cc/sec (about 1 cc in 30 years). The ultimate helium sensitivity is a factor of the configuration of the pumps.

The 959 pumps are shown in Figure 1-1 through Figure 1-3.



**Figure 1-1 959 Dry Pump - Front and Side**

## 959 and 959D Leak Detectors

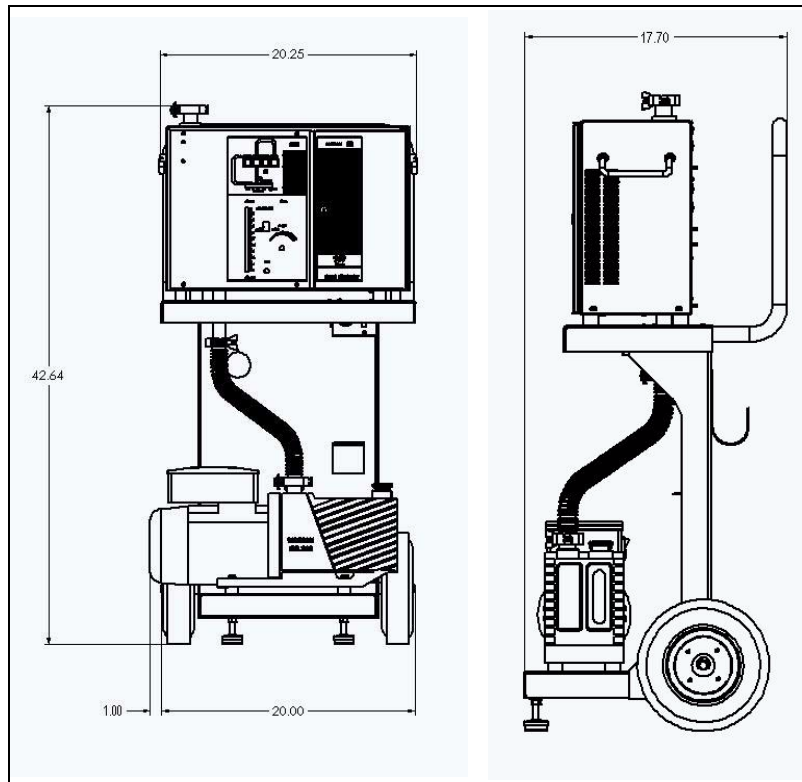


Figure 1-2 959 Wet Pump - Front and Side

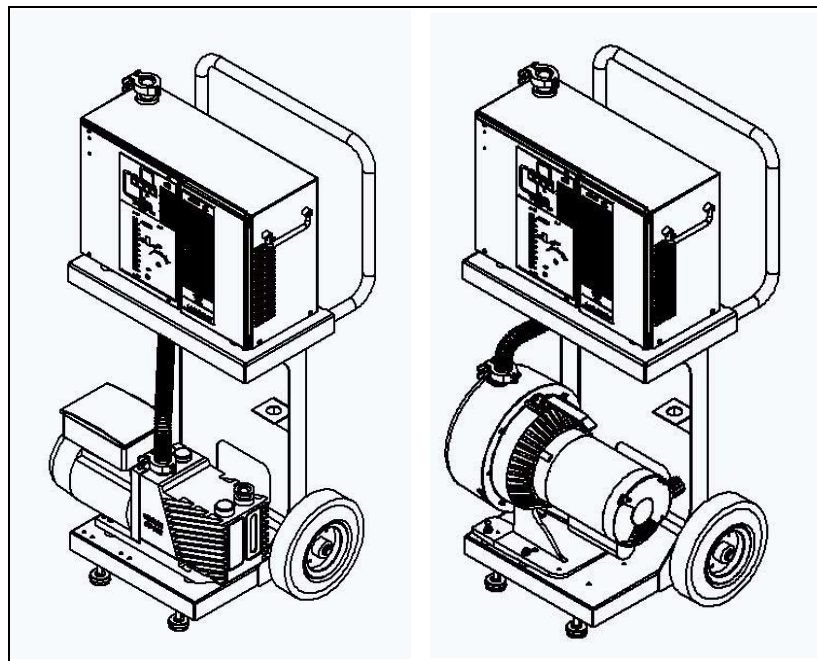


Figure 1-3 ISO View Wet and Dry Pump

### 1.2 Unpacking

The leak detectors are shipped in a single disposable shipping carton, completely assembled and ready for operation.

The following components are shipped with the system:

- ❑ This Operations Manual.
- ❑ The leak detector mounted on the top shelf of a cart with its power cable (120 VAC or 220 VAC as ordered) connected to a main power strip located on the bottom shelf of the cart.
- ❑ **TriScroll 310** or DS-302 pump bolted to the bottom shelf of the cart, connected by an NW-25 manifold to the 959. The roughing pump power cable is connected to the main power strip on the bottom shelf of the cart.
- ❑ Operation manuals for the high vacuum Turbo or MacroTorr pump and for the appropriate roughing pump.
- ❑ Any optional equipment purchased, such as nitrogen purge on the 959D.

#### 1.2.1 Unpacking Instructions

To unpack the 959D:

1. Inspect the container for evidence of damage in shipment.  
Do not discard evidence of rough handling.
2. Report, without delay, any damage to both the carrier and to Varian Vacuum Technologies Customer Service at 1-800-8VARIAN.
3. Carefully remove the outer shipping container.
4. Inspect the leak detector and related items immediately for any indication of shipping damage.
5. Carefully cut the strapping holding the leak detector on the skid.
6. Remove any loose boxes or packages and put them aside. Keep the original packing for reuse in the event that it is necessary to return the leak detector to Varian.
7. Remove the front brace by undoing the two lag bolts.
8. Remove the plastic bag covering the leak detector.  
The leak detector can now be removed from the skid.

### 1.2.2 Removing the System from the Skid

There are two methods for removing the system from the skid.

**WARNING**

*Removal of the 959D from the skid requires two people.*



#### Method 1

To perform this procedure:

1. Carefully roll the system toward the front of the skid.
2. Lift the front end of the system and *gently* lower it onto the floor.
3. Lift the rear of the system and roll it on the front casters until it is clear of the skid.
4. *Gently* lower the rear end onto the floor.

#### Method 2

To perform this procedure:

1. Using the brace removed in step 7 of Section 1.2.1 “Unpacking Instructions” as a lever, carefully raise the front edge of the skid between 1 and 2 inches.
2. Hold the leak detector against the back brace, unscrew and remove the front two Skid-Mates by turning them counterclockwise.
3. Make sure the helper is still holding the system against the back of the skid, and then gently lower the front of the skid to the floor.
4. Carefully and slowly roll the system off the skid and onto the floor.

### 1.3 Preparation for Operation

#### NOTE



*Before operating the leak detector, read and understand the warranty and safety information in the preface of this manual.*

Be sure all packing materials have been removed and that appropriate power connections are available before setting up the leak detector.

If you have purchased optional equipment for the 959D, set it up in accordance with the operations manuals that were supplied with the equipment.

### 1.4 Installation

The system is delivered completely assembled as ordered. Locate the system close to its power source and leave sufficient room for the operator to safely maneuver to perform testing. Additional ventilation requirements for your specific application, as discussed in Section 1.4.3 “Clean Room Use of the 959D”, must also be provided at this point.

#### CAUTION



*Allow at least a 4 inches of clearance to ensure that air flows freely around the leak detector. Do not block the exhaust fans at the rear of the leak detector.*

#### 1.4.1 Electrical Connections

The 959 and 959D cart-mounted systems operate from a single AC power source and can be configured for:

- ☐ 115 VAC, 50/60 Hz, 20 Amps or
- ☐ 220 VAC, 50/60 Hz, 10 Amps

The cart has a power strip equipped with a single 3-prong cable that attaches to an appropriate power line. The DS-302 wet roughing pump has an on/off switch that should be left ON at all times. The TriScroll dry roughing pump does not have a power on-off switch; it turns on when the leak detector is powered up from the AC input power strip located on the cart.

#### WARNING



*Use only the power cord provided with your leak detector. The use of extension cords is not recommended and could result in damage to the equipment and loss of warranty.*



As shown in Figure 1-4, two circuit breakers are located on the rear panel:

- ❑ 3 Amp breaker for the leak detector main **POWER**
- ❑ 1.5 Amp breaker for the **ELECTRONICS**



**Figure 1-4 Rear Panel Circuit Breakers**

Before making power connections, verify the following:

- ❑ The **MAIN POWER** switch (secondary controls behind the access door) on the leak detector is **OFF** (down).
- ❑ The power switch on the AC input power strip located at the bottom of the cart is **OFF**.
- ❑ An appropriately grounded receptacle is available.

Plug the AC power cable into the receptacle.

### 1.4.2 Gas Requirements

#### 1.4.2.1 Helium

For testing products or leak checking, use welding grade helium in a standard cylinder with a pressure regulating valve.

### 1.4.2.2 Nitrogen (optional on the 959D)

Use 99.9% pure N<sub>2</sub> for the purge operation as described in Section 2.6 “Nitrogen Purge Option (959D only)” on page 2-17.

### 1.4.3 Clean Room Use of the 959D

The 959D is highly recommended for leak detection in a clean room such as those used in semiconductor manufacturing. The employment of a dry roughing pump (**TriScroll 310**) in the 959D avoids possible contamination of the ambient atmosphere by vapors from the oil-based DS-302 pump.

Particulate matter that may be ejected by the roughing pump can be kept from the environment by connecting an exhaust hose at the NW-25 connection on the pump exhaust and running the hose outside. This procedure also reduces the background helium leak signal while lowering the possibility of particulate distribution in sensitive installations.

## 1.5 Vacuum System Description

A front view of the leak detector is shown in Figure 1-5. The test port connects to the equipment to be tested. A front panel user interface displays the test port pressure and leak rate of the test object. The spectrometer tube, high vacuum pump, and electronics assembly are enclosed in the cabinet. Abbreviated operating instructions are located behind the locking access door.



Figure 1-5 959 Front View

### 1.5.1 Measurement System

The system utilizes a Contra-Flow™ vacuum system that allows testing at high test point pressures. The leak detector vacuum system connects to the unit to be tested at the test port, maintains the required vacuum in the spectrometer tube, and removes helium after a test. An optional probe provides fast response, high sensitivity sniffing mode operations. The system includes the following components:

**Spectrometer tube** The spectrometer tube measures the helium concentration in the object under test. The information is sent to the leak rate indicator to provide a visual representation of the helium concentration. The spectrometer consists of a dual thoriated iridium filament ion source, a preamplifier, and a magnet assembly.

**High vacuum pump** Both the 959 and 959D achieve high vacuum for the spectrometer tube by use of Varian's V70 Turbo or V70D MacroTorr pumps.

- ☐ Use the V70 Turbo turbomolecular pump for best helium sensitivity.
- ☐ Use the V70D MacroTorr for operation of the leak detector with high test port pressures up to 200 mTorr.

The helium sensitivity ranges resulting from the use of these pumps are given in Table 1-1. See page 2-4 for information on the HI and LO sensitivity switches.

**Table 1-1 Helium Sensitivity Ranges and MDL**

Sensitivity Selected	Helium Sensitivity in atm cc/sec			
	HI		LO	
Pump	MDL*	Range	MDL*	Range
V70 Turbo	$2 \times 10^{-10}$	$10^{-9}$ to $10^{-6}$	$2 \times 10^{-9}$	$10^{-8}$ to $10^{-5}$
V70D MacroTorr	$2 \times 10^{-9}$	$10^{-8}$ to $10^{-5}$	$2 \times 10^{-8}$	$10^{-7}$ to $10^{-4}$
V70D MacroTorr with optional power probe [sniffing mode]	N/A	$10^{-8}$ to $10^{-5}$	N/A	$10^{-7}$ to $10^{-4}$
*MDL - minimum detectable leak				

**TriScroll 310** or  
DS-302 Roughing  
Pump

The roughing pump provides:

- ☐ The intermediate vacuum required to operate the high vacuum pump (as low as 10 mTorr). The roughing pump discharges into the atmosphere.
- ☐ The pumping capacity required to evacuate the test object to prepare it for testing.

Optional Components Optional components for use with the leak detector include:

- ❑ A Power Probe sniffer (Part No. K9565301) for fast response, high sensitivity sniffing mode operations.
- ❑ The speaker with internal impedance between  $4\ \Omega$  and  $8\ \Omega$ , and a 5-watt minimum power capability can be up to 50 feet (15.24 m) from the leak detector. This jack can also drive a set of headphones. The internal stereo loudspeaker is disabled whenever there is a connection to this rear panel jack.
- ❑ A Leak Rate-Meter or a Chart Recorder for connection to the recorder output, at the rear of the leak detector to monitor the results of leak tests.  
The remote device should have a impedance  $> 500\ \text{k}\Omega$  in a voltage range from 0 to  $\sim 5\ \text{VDC}$ . A mating plug is not supplied. Use a Switchcraft 260 monaural phone jack or equivalent for connections.
- ❑ *959D only*: A nitrogen purge system to clear background helium from the pump. The regulator, pressure relief valve and flowmeter are factory-set and do not require adjustment.

## 1.6 Internal Valving

The vacuum system is shown in Figure 1-6.

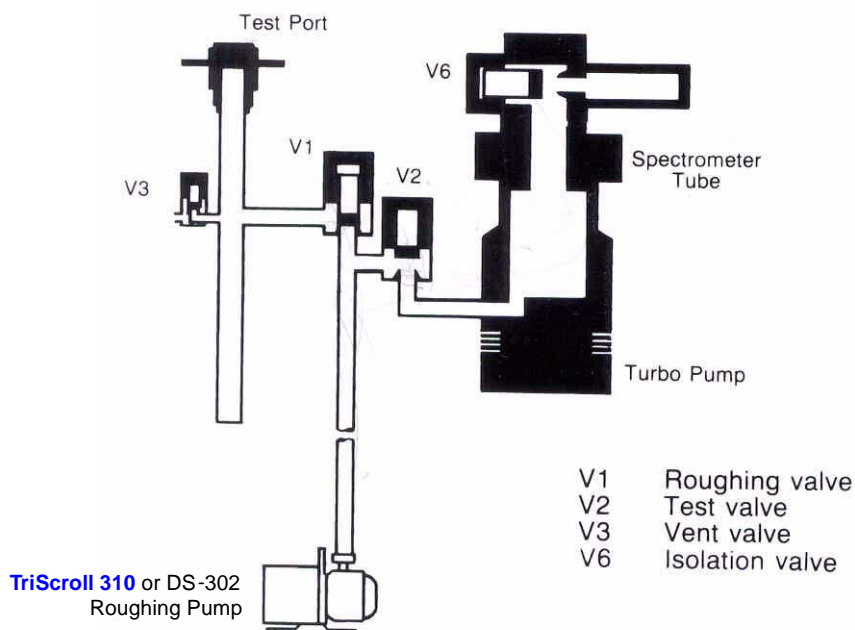


Figure 1-6 Vacuum System

### 1.6.1 Direct Operation of the Valves

The leak detector valve system allows for evacuation, testing, and venting of the object to be tested. The main electronics are responsible for automatically sequencing the testing operation as described in the next section. The front panel operating buttons display the current leak detector mode. All valve coils operate at line voltage.

There are four valves:

- ☐ Roughing valve (V1)
- ☐ Test valve (V2)
- ☐ Vent valve (V3)
- ☐ Isolation valve (V6)

The V6 isolation valve is normally closed when power is OFF, and opens automatically upon the application of electrical power.

### 1.6.2 Automatic Valve Operation for Large Volume Leak Checks

The leak detector valve control system allows large volumes to be pumped without damaging the leak detector. If the leak detector is not advanced to Test or the test port pressure is above 250 mTorr, the system automatically switches between Start mode and Hold mode every three minutes. When in Hold mode, V1 is closed, V2 is opened, and the TriScroll roughing pump clears the foreline of any back pressure that may have built up in the time the leak detector was pumping on the external volume.

The leak detector remains in Hold mode for 30 seconds. After this time, the Test valve V2 automatically closes and the Roughing valve V1 opens to continue pumping on the external volume. This switching continues indefinitely if the leak detector is left in Start mode or until the leak detector is switched into Test mode. If the test port pressure rises to between 125 mTorr and 300 mTorr, overpressure protection automatically sets the leak detector into Hold mode. The normal operating states of the valves are shown in Table 1-2.

**Table 1-2 Valve Operating States**

Valve Operating Mode	Roughing (V1)	Test (V2)	Vent (V3)
VENT	Closed	Open	Open
START	Open	Closed	Closed
HOLD	Closed	Open	Closed
TEST	Open	Open	Closed

### 1.6.3 Main Electronics Assembly and Circuit Boards

The main electronics assembly and circuit boards provide control for the leak detector. The main electronics assembly provides the following controls:

- ❑ Adjustment of spectrometer tube voltages for leak rate tuning
- ❑ Volume control and threshold adjustment
- ❑ Calibration
- ❑ Filament selection, activation, and emission adjustment
- ❑ Residual helium signal background check used during prolonged leak checking

The internal enclosure houses four circuit boards:

Display board	The display board controls the bar graph displays and associated drivers.
Main electronics board	The main electronics board operates and controls the spectrometer tube.
Logic board	The logic board controls the front panel operation buttons.
Turbo pump controller board	The turbo pump controller board powers the V70 Turbo pump and the V70D MacroTorr pump. It is a microprocessor-controlled, solid-state frequency converter with self-protection features. The pump controller incorporates all the facilities required for automatic operation of the V70 and V70D Turbo pumps.

## 1.7 Specifications

Operating specifications for the 959 and 959D leak detectors are given in Table 1-3.



*For detailed specifications for the V70 or V70D high vacuum pumps, and the DS-302 and TriScroll roughing pumps refer to their manuals.*

**Table 1-3 Operating Specifications**

Parameter	Value
Response Time	Less than 2 seconds for helium, in accordance with AVS Standard 2.1
Amplifier Drift	Less than 2% of most sensitive scale in accordance with AVS Standard 2.1
Noise Level	Less than 2% of full scale, peak-to-peak, in accordance with AVS Standard 2.1
Leak Indicator	50-segment bar graph with exponent display. Two sets of direct reading sensitivity ranges comprise four decades in each range: $10^{-9}$ to $10^{-6}$ atm cc/sec (HI sensitivity, low speed) $10^{-8}$ to $10^{-5}$ atm cc/sec (LO sensitivity, high speed)
High Vacuum Pump	70 l/m, maintenance-free turbomolecular pump or MacroTorr pump
Roughing Pumps	959D: <b>TriScroll 310</b> Pump with 10 mTorr base pressure
	959: DS-302 Oil-based Pump
Test Port	1-1/8 inch (28.5 mm) ID quick coupling, NW-25 adapter included
Operating Temperature	5 °C to 35 °C (41 °F to 95 °F)
Power Requirements	<input type="checkbox"/> 115 VAC, 50/60 Hz, 20 Amps <input type="checkbox"/> 220 VAC, 50/60 Hz, 10 Amps
Vacuum Gauges	Thermocouple gauges with ranges from ATM to $10^{-3}$ Torr monitor pressures in the spectrometer tube and in the test port manifold.

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## Section 2. Operation

This section contains instructions for operating the leak detector in its *test* cycle. The test cycle utilizes a connection between the test object and the leak detector so that helium passing through a leak in the object can be detected. It is good practice to tune and calibrate the leak detector at the beginning of each day's testing. Instructions are provided for tuning the spectrometer tube and for calibrating the leak detector prior to operation.

### 2.1 Operator Interface

The front panel has primary and secondary controls and indicators that are shown in Figure 2-1 [The 959 panel is the same except for the nameplate.]. Primary controls and indicators are for performing a test; secondary controls, located behind an access panel, are used to tune and calibrate the leak detector.

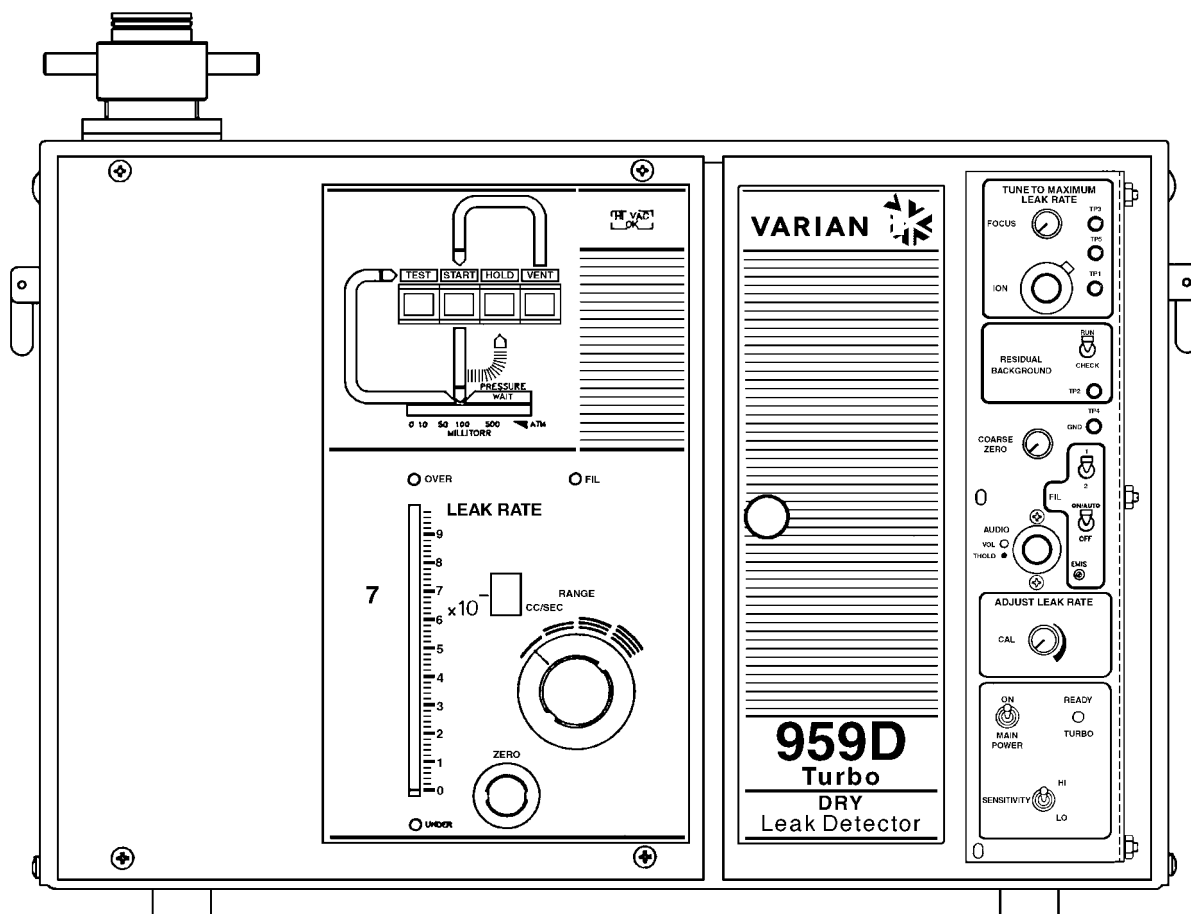
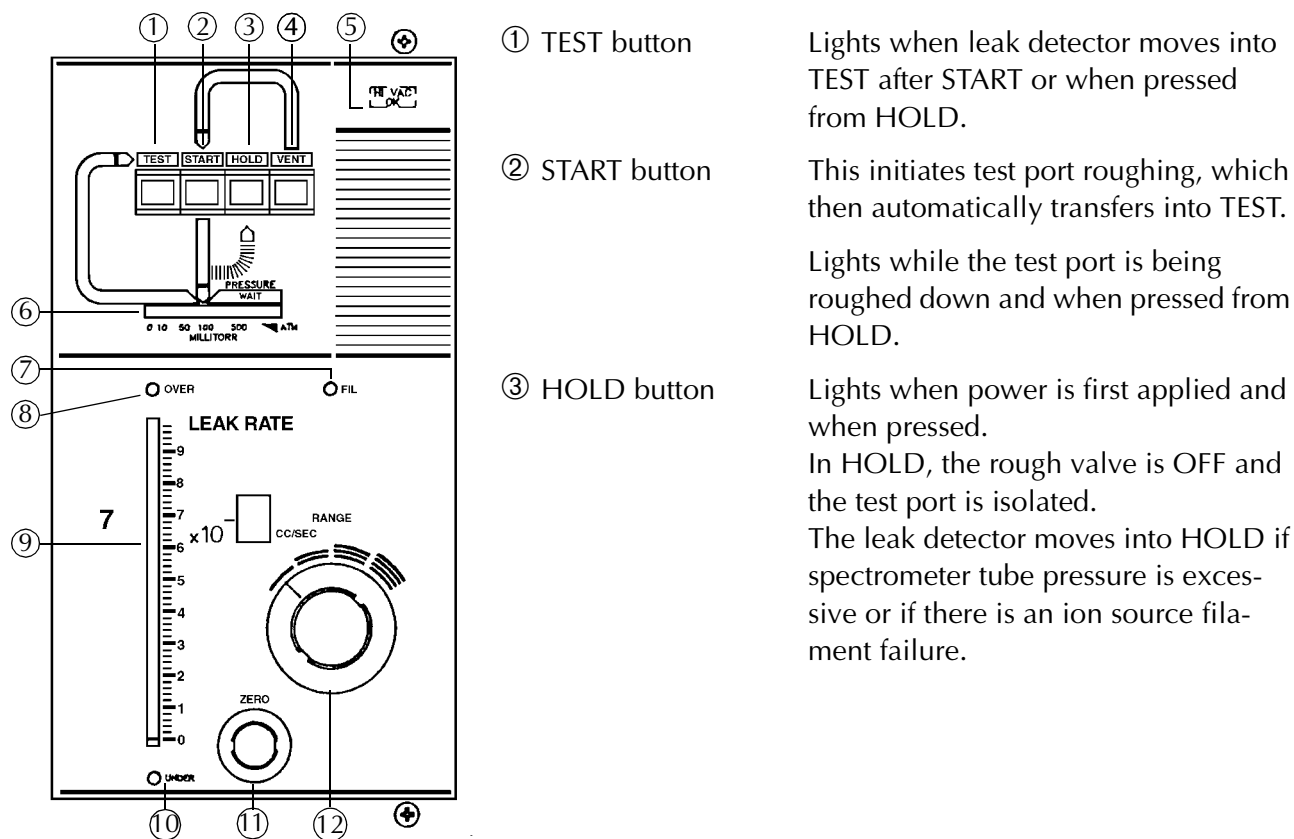


Figure 2-1 Primary (left) and Secondary (right) Controls

## 2.1.1 Primary Controls and Indicators

The primary controls are shown in the front panel drawing of Figure 2-2.



**Figure 2-2 Primary Controls and Indicators**

- |                      |   |
|----------------------|---|
| ④ VENT button        | Lights when pressed to vent the test port to the atmosphere.  |
| ⑤ HI VAC OK          | Green LED lights when operational vacuum is reached in the spectrometer tube. Remains lit until vacuum condition is lost.                 |
| ⑥ PRESSURE indicator | Horizontal bar graph that displays test port pressure in milliTor.  |
| ⑦ FIL Indicator      | Green LED indicating that the spectrometer tube filament is turned on and emission is present.  |
| ⑧ OVER range         | LED at top of pressure bar graph indicates an over-scale condition. See Section 2.4.2 "Out-of-Range Situations" on page 2-10 for details. |

- ⑨ LEAK RATE display    Bar graph shows leak rate of the object under test in atm cc/sec.  
The mantissa (x10) is on the vertical bar graph; the exponent is shown in the LCD window.
- ⑩ UNDER range        LED located at the bottom of the pressure bar graph indicates an under-scale condition. See Section 2.4.2 “Out-of-Range Situations” on page 2-10 for details.
- ⑪ ZERO Adjustment    For fine control of the zero leak rate setting. The control is used in conjunction with the COARSE ZERO adjustment on the secondary control panel.
- ⑫ RANGE Switch        Clockwise: Low sensitivity, large leaks.  
Counterclockwise: High sensitivity, small leaks. Table 1-1 on page 1-9 shows the range values.

### 2.1.2 Secondary Controls and Indicators

The secondary controls are on the front of the leak detector behind a keyed access panel. The partially open panel is shown in Figure 2-3.



**Figure 2-3    Opening the Access Panel**

The secondary control panel is shown in detail in Figure 2-4 on page 2-4.

The leak detector is tuned and calibrated at the factory prior to shipment. During normal use, the leak detector should be recalibrated using the secondary controls. These controls are grouped according to calibration and tuning functions. Refer to Section 2.5 “Calibration and Tuning” on page 2-11 for information on how and when to calibrate.

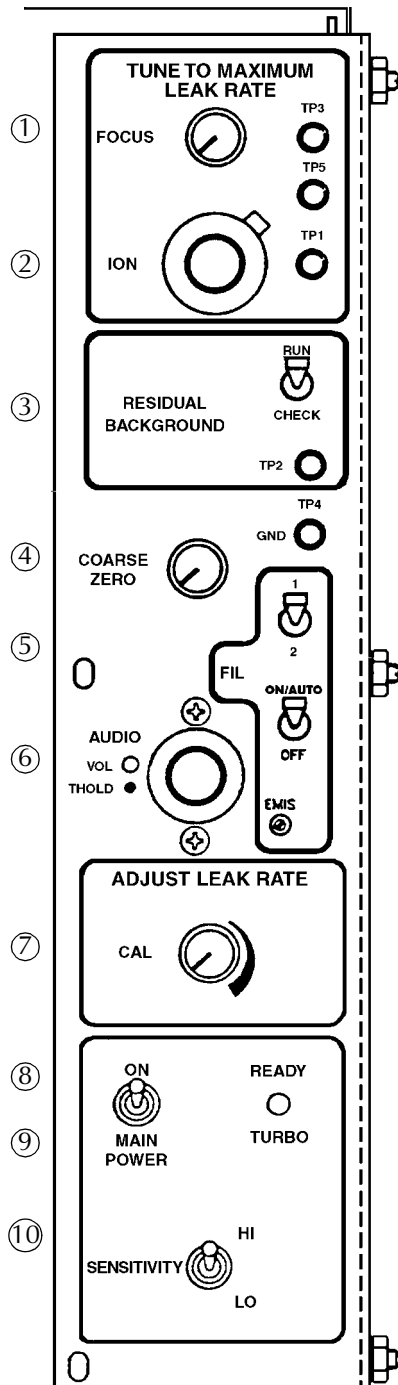
## MAXIMUM LEAK RATE Grouping

### ① FOCUS

Used for tuning the spectrometer tube by adjusting the focus plate-to-chamber voltage.

### ② ION

A 10-position dial for adjusting the ion source chamber voltage. Used for tuning the spectrometer tube.



### ③ RESIDUAL BACKGROUND

Kept in the RUN position except when checking the background leak rate.

### ④ COARSE ZERO

For large zero leak rate adjustments.

### ⑤ FIL Grouping

Controls the filament in the ion source.

#### 1 or 2 toggle switch

Selects between ion source filaments 1 and 2.

#### ON/AUTO or OFF toggle switch

ON/AUTO provides filament activation when HI VAC OK is achieved. OFF disables filament emission.

#### EMIS

Adjusts the ion source emission voltage when tuning the spectrometer tube.

### ⑥ AUDIO

VOL outer ring: Controls the volume of internal speaker, external speaker, or headphones.  
THOLD inner ring: Volume threshold for an alarm.

### ⑦ CAL

Adjusts amplifier gain to make the leak rate reading agree with a calibrated leak.

### ⑧ MAIN POWER

Main power control for the leak detector.

### ⑨ READY/TURBO

LED that indicates the Turbo or MacroTorr pump is at full operational speed.

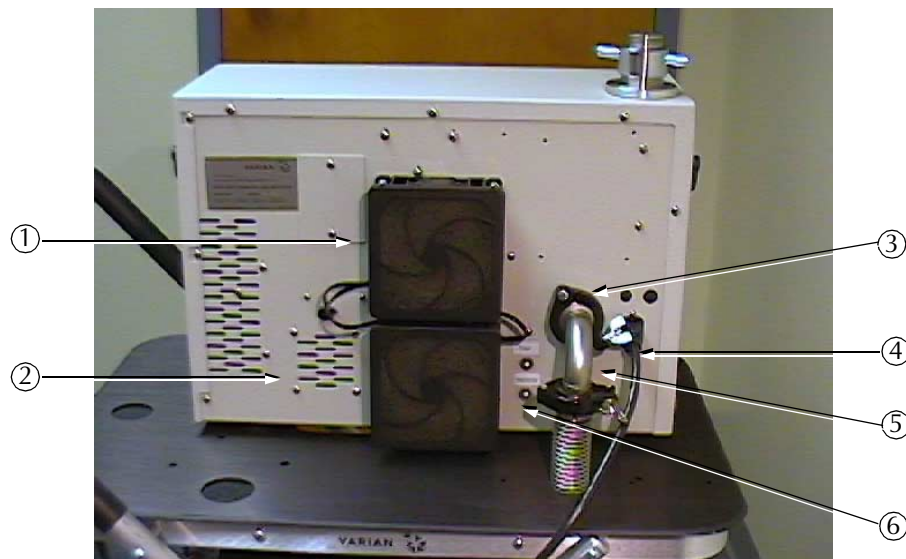
### ⑩ SENSITIVITY

Switches leak rate sensitivity between HI and LO. Used in conjunction with the RANGE switch.

**Figure 2-4 Secondary Controls and Indicators**

### 2.1.3 Rear Panel Components

Rear panel components are shown in Figure 2-5.



**Figure 2-5 Rear Panel Components**

- |                                |   |
|--------------------------------|---|
| ① Exhaust fans                 | Two exhaust fans cool the high vacuum pump and internal electronics.  |
| ② Speaker                      | Loud speaker provides an audible indication of leak rate.   |
| ③ Roughing/Foreline Connection | An NW-25 connection to the <b>TriScroll 310</b> or DS-302 roughing pump.  |
| ④ Power cable                  | 120 or 220 VAC line power cable. Voltage is factory-set.  |
| ⑤ Phono Jack (under manifold)  | Connection for loudspeaker or headphones, and a rate meter or chart recorder.   |
| ⑥ Circuit Breakers             | <p>The POWER circuit breaker provides AC to the leak detector.</p> <p>The ELECTRONICS circuit breaker provides independent protection to the power distribution within the leak detector.</p> <p>Both breakers are push-to-reset.</p> <p>The MAIN POWER switch inside the front panel access door subsequently turns the leak detector on or off. (see Figure 1-4 on page 1-7).</p> <p>The roughing pumps get their power directly from the power strip at the base of the cart. The DS-302 wet pump has an on/off switch that should always remain ON.</p> |

### 2.1.4 Connecting to the Test Port

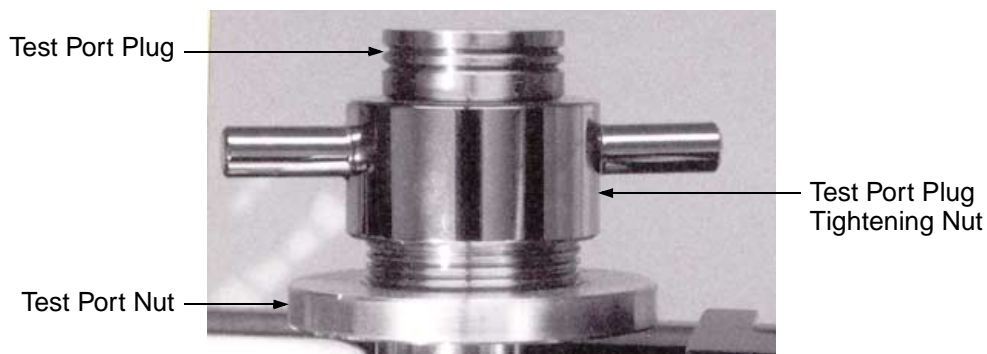
The unit under test or the associated vacuum system to be monitored is connected to the test port at the top of the leak detector (Figure 2-6). Information regarding the various leak detection methods is given in Appendix A "Introduction to Leak Detection".



*You should have a variety of adapter tubulation sizes on hand to fit the test port. The Test Port Adapter Kit (Varian Part No. 86428801) has twelve adapters ranging from 1/16" to 1" in diameter.*



*To avoid contamination of the vacuum system, the test port plug should be in place when the leak detector is not being used for testing.*



**Figure 2-6 Vacuum Test Port**

To connect to the test port:

1. Loosen the tightening nut to remove the test port plug.
2. Place the object to be tested onto the test port and tighten the nut.

Reasonable hand-tightness is sufficient to compress the O-ring and establish a vacuum-tight seal in the test port.



*Be careful not to drop the test port plug when you remove it. It is deceptively heavy for its size.*

## 2.2 Startup Procedure

The controls referred to in the following procedure are shown in Figure 2-2 on page 2-2 and Figure 2-4 on page 2-4.

To perform this procedure:

1. Be sure that the plug is in the test port and that the nut is tight.
2. Check the vacuum connections at the top of the **TriScroll 310** or DS-302 roughing pump and at the rear of the system for tightness.



*On the 959, be sure the power switch on the DS-302 roughing pump is ON; this switch is left on at all times.*

3. Turn the cart power strip ON. The roughing pump starts.
4. Open the access panel door and move the MAIN POWER switch to ON.

Check that the ON/AUTO switch is ON. The turbo pump starts.

5. Set the FIL toggle to ON/AUTO.

- ☐ The HOLD button will be lit.
- ☐ The HI VAC OK and TURBO READY indicator LEDs lights.
- ☐ Wait until the FIL indicator lights.

You may have to repeat step 5 until the FIL light stays on. If the filament does not light after repeated attempts, the ion source may have to be replaced.

Qualitative analysis for leak presence or absence can begin immediately.

Allow 1/2 hour warm-up time to perform calibration and quantitative measurements.  
To calibrate the leak detector, see Section 2.5 “Calibration and Tuning” on page 2-11.

## 2.3 Changing the Audible Threshold

The frequency of the signal is proportional to the leak rate. The controls referred to in the procedure are shown in Figure 2-2 on page 2-2 and Figure 2-4 on page 2-4. The volume control **VOL** for the speaker is located with the secondary controls behind the locking access door. The audible threshold **THOLD** is set to zero at the factory.

To change the audible threshold:

1. Rotate the **THOLD** knob clockwise until the desired point is reached.
2. Note the position of the RANGE and ZERO controls.
3. Select a sensitive range using the **RANGE** control.
4. Use the **ZERO** control to move the bar graph segment up scale.

The alarm should be audible and rise relative to the increase on the bar graph.

5. If the alarm is not audible, be sure that the threshold is set correctly and that the VOL is turned up.
6. Return the ZERO and RANGE controls to their original positions once verification is complete.

## 2.4 Running a Leak Test

### 2.4.1 Basic Test Procedure

Allow 1/2 hour for the pumps to warm up completely and for the system to stabilize. Verify that the leak detector has been recently tuned and calibrated as instructed in Section 2.2 "Startup Procedure". The principal test controls are shown in Figure 2-7.

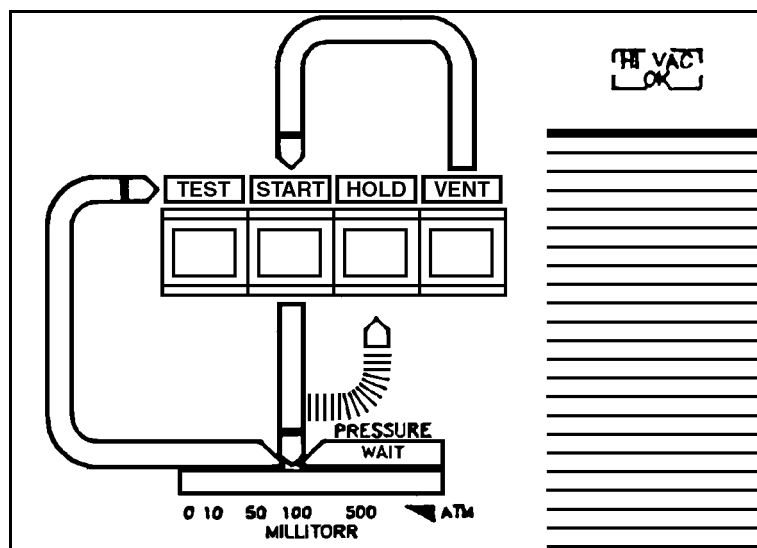


Figure 2-7 Principal Test Controls



To perform this procedure:

1. Press **VENT** to vent the test port to atmosphere.
2. Loosen the tightening nut, remove the test port plug, connect a test object to the test port, and retighten the tightening nut.
3. Press **START**.

When the test port pressure goes below 250 mTorr (shown as the green band on the **PRESSURE** display), the **TEST** button illuminates indicating a measurement is in progress.

If the test port pressure does not get down to 250 mTorr in three minutes, the system assumes that there is a gross leak in the test object or the system is pumping down a very large volume. The system goes into HOLD to allow more time for pumpdown. When the pressure drops below 250 mTorr, the TEST reactivates.

The HOLD button illuminates for 30 seconds alternating with the START button every three minutes if the test port pressure fails to drop below 250 mTorr.

### NOTE



*If the HI VAC OK or the FIL LED turn off, contact Varian Vacuum Technologies Customer Service at 1-800-8VARIAN.*

4. Observe the bar graph display to determine if the object passes or fails the leak test.
5. When the test is done:
  - ☐ Press **VENT**.
  - ☐ Loosen the test port tightening nut.
  - ☐ Remove the test object.

### 2.4.2 Out-of-Range Situations

The testing range of the leak detector is set by the RANGE switch. The leak rate within the set range is displayed as a 0 to 10 vertical illumination on the primary front control panel of Figure 2-2. Either the **OVER** or **UNDER** LED lights up if the measured leak rate is out-of-range for the particular setting of the RANGE switch.

<b>OVER</b> range	If the OVER LED is steadily ON and the vertical bar graph is at maximum, rotate the RANGE switch clockwise until the vertical display falls within its operating range. If the Range switch arrives at its highest setting of 4 bars and the display is still stuck at its highest point, you can assume that a gross leak exists associated with the object under test.
<b>UNDER</b> range	If the UNDER LED is steadily ON and the vertical bar graph is at minimum, rotate the RANGE switch counter-clockwise until the vertical display falls within its operating range. If the Range switch arrives at its lowest setting of 1 bar and the display is still stuck at its lowest point, you can assume that the system background is actually <i>below</i> any previously set zero value. Refer to section 2.6.1 to re-zero the leak detector.

### 2.4.3 Testing above 200 mTorr

The leak detector detects very small leaks at very low pressures, but, the system can also detect leaks at relatively high pressures (gross leaks) by placing the optional throttle valve, Part No. 626603345, between the test object and the test port. The throttle valve maintains a tolerable foreline pressure of less than 250 mTorr.

To measure a leak at a test port pressure above 200 mTorr, first attach the throttle valve and then proceed with the measurement.

To perform this procedure:

1. Press **VENT** to vent the test port to atmosphere.
2. Loosen the tightening nut and remove the test object.
3. Place the throttle valve in the test port and tighten the nut to compress the O-ring and establish a vacuum-tight seal.
4. Connect the object on the throttle valve at the test port.
5. Press **START** and follow the procedure described in the previous section.
6. Adjust the throttle valve for a pressure less than 250 mTorr or allow the leak detector to transfer into **TEST**.

### 2.5 Calibration and Tuning

It is good practice to calibrate the system daily. Calibration checks requiring gross adjustments indicate that the spectrometer tube requires tuning or replacement. This situation is indicated when one or more of the following controls come close to their maximum setting:

- ☐ **FOCUS**
- ☐ **ION**
- ☐ **EMIS** (filament emission)
- ☐ **CAL**

You must *retune* the system when:

- ☐ The ion source has been replaced
- ☐ Calibration adjustments go out-of-range
- ☐ The background cannot be zeroed

Use one of the following procedures to calibrate or tune the leak detector:

- ☐ Section 2.5.1 “Calibrating with a Calibrated Leak” on page 2-12
- ☐ Section 2.5.2 “Use of a Capillary Type Calibrated Leak for Tuning to He” on page 2-13
- ☐ Section 2.5.3 “Tuning the Spectrometer Tube Using a Calibrated Leak for Tuning to He” on page 2-14
- ☐ Section 2.5.4 “Tuning the Spectrometer Tube Using a Tuning Leak” on page 2-15

### 2.5.1 Calibrating with a Calibrated Leak

Verify that startup has taken place, that the pumps are up to speed, and that the leak detector is ready to test (Section 2.2 “Startup Procedure” on page 2-7). Both primary and secondary controls are used in this procedure. Refer to Figure 2-2 on page 2-2 and Figure 2-4 on page 2-4.

#### CAUTION



*If the leak detector has been off for over 3 hours, wait the full 1/2 hour warm-up period before recalibrating or tuning.*

The optional calibrated leak level is printed on a label on the side of the leak. The first step is to attach the calibrated leak to the test port.

To perform this procedure:

1. Press **VENT**.
2. Place **RESIDUAL BACKGROUND** in **RUN**.
3. Loosen the test port tightening nut and remove the test port plug.
4. Install the calibrated leak with its valve open into the test port and re-tighten the tightening nut.
5. Press **START** and wait until **TEST** lights up.
6. Check the leak rate indication on the vertical bar graph.  
It may be different from the calibrated leak value.
7. Set **RANGE** to the value that corresponds to the exponent on the calibrated leak.
8. Close the valve on the calibrated leak.

The leak rate shown on the bar graph should drop to zero (one bar lit).

- ☐ If the leak rate drops to zero, go on to step 9.
- ☐ If the leak rate *does not* drop to zero, the leak detector is not detecting helium.

Go to Section 2.5.3 “Tuning the Spectrometer Tube Using a Calibrated Leak for Tuning to He”.

9. Rotate **RANGE** to the far left, its most sensitive position.

10. Slowly **ZERO** the leak detector using the control on the primary panel.

If a larger adjustment is necessary, first adjust **COARSE ZERO** on the secondary panel and then **ZERO** on the primary panel.

11. Set **RANGE** to the value that corresponds to the exponent on the calibrated leak.

12. Open the calibrated leak valve and wait about 10 seconds for the leak rate bar graph to settle.

13. Use **CAL** to set the bar graph to the value that corresponds to the mantissa on the calibrated leak.

- ☐ If calibration is successful, you can set the bar graph indicator equal to the calibrated leak value.
- ☐ If calibration is not successful, the leak detector requires tuning.

Refer to the procedure in Section 2.5.3 “Tuning the Spectrometer Tube Using a Calibrated Leak for Tuning to He” on page 2-14.

### CAUTION



*To prevent a build-up of helium and minimize deterioration of the calibrated leak, always store the calibrated leak with its valve open.*

14. Press **VENT**, remove the calibrated leak, and proceed with testing.

### 2.5.2 Use of a Capillary Type Calibrated Leak for Tuning to He

To calibrate using a capillary type of calibrated leak:

Follow the procedure for checking calibration using a calibrated leak, Section 2.5.1 “Calibrating with a Calibrated Leak” on page 2-12, except:

- ☐ Apply helium (from a source) as a substitute for opening the valve on the calibrated leak
- ☐ Remove helium as a substitute for closing the valve on the calibrated leak.

### 2.5.3 Tuning the Spectrometer Tube Using a Calibrated Leak for Tuning to He

When tuning is done carefully, the day-to-day changes are very small and subsequent calibration may require only slight adjustment of the CAL control. The leak detector should be warmed up before you attempt to tune the spectrometer tube. The controls mentioned in the following procedure are shown in Figure 2-2 on page 2-2 and Figure 2-4 on page 2-4.

**NOTE**

*Increasing the audible tone can aid in leak detector tuning.*

To tune the spectrometer tube using a calibrated leak:

1. Perform steps 1 through 7 of the calibration procedure on page 2-12.
2. Turn **RANGE** to the value of the exponent indicated on the calibrated leak.  
If the bar graph display is <1 or >9, move **RANGE** until the bar graph displays between 1 and 9.
3. Slowly adjust **FOCUS** for a maximum on the leak rate display.  
It is now necessary to be sure that the spectrometer tube is tuning to a helium peak and not another element such as carbon or hydrogen.
  - a. Close the valve on the calibrated leak.
  - b. The leak rate should drop to zero (one bar lit).  
If the leak rate does not drop to zero, repeat the **FOCUS** adjustment and verification.
4. Slowly adjust **ION** on the secondary panel for a maximum on the leak rate display.  
The ION control is a 10-turn potentiometer and normally needs to be adjusted only slightly for a maximum peak on the display. When tuned to helium, the outer dial on the ION control at the 12 o'clock position should indicate between 2 and 8.

**NOTE**

*To achieve optimum Ion-Focus and Emission adjustment, adjust in one direction until the leak rate bar graph reaches its maximum value and then begins decreasing. Readjust back to the max value. This is now the peak of the signal. The audible signal can also be used in finding the peak signal.*

5. Close the valve on the calibrated leak.  
The leak rate should drop to zero with just one bar lit on the display.
6. Adjust the filament emission pot (Figure 2-4 on page 2-4, item 5) for the maximum helium leak rate signal.

A change in one adjustment may affect the others. Therefore, it may be necessary to repeat step 2 through step 5 until no significant change occurs in the leak rate reading. The leak detector is now tuned to helium.



**NOTE**

*If tuning cannot be achieved, system service may be necessary. Contact Varian Vacuum Technologies Customer Service at 1-800-8VARIAN for further instructions.*

7. Calibrate the leak detector.

See Section 2.5.1 “Calibrating with a Calibrated Leak” on page 2-12.

8. Press **VENT** and remove the calibrated leak.

**CAUTION**



*To prevent a build-up of helium and to minimize deterioration of the calibrated leak, always store the calibrated leak with its valve open.*

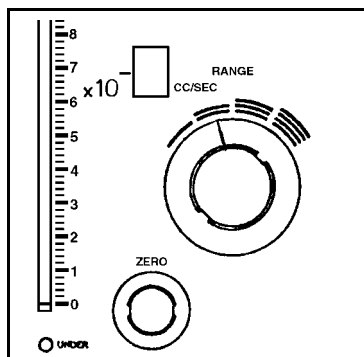
### 2.5.4 Tuning the Spectrometer Tube Using a Tuning Leak

The tuning leak is an adjustable needle valve in an adapter to fit the test port. When the needle valve is opened such that test port pressure is 100 mTorr, helium naturally present in the atmosphere (5 parts per million) enters the leak detector giving a leak rate reading of approximately  $10^{-6}$  atm cc/sec. Since this reading is about 10 times as large as with the reservoir type of calibrated leak, tuning the spectrometer tube is easier. The controls referred to in the procedure are shown in Figure 2-2 on page 2-2 and Figure 2-4 on page 2-4.

To perform this procedure:

1. Verify that start up has taken place, that the pumps are up to speed, and that the leak detector is ready to test (see Section 2.2 “Startup Procedure” on page 2-7).
2. Press **VENT**.
3. Set **RESIDUAL BACKGROUND** to **RUN**.
4. Loosen the test port tightening nut and unplug the test port.
5. Place the tuning leak onto the test port and hand-tighten it to compress the O-ring and establish a vacuum-tight seal.
6. Close the valve in the tuning leak.
7. Press **START**.

8. Once the leak rate displayed on the bar graph has settled, set **RANGE** in the *two-arcs* ( $10^{-6}$ ) position.



**Figure 2-8 Range at Two Arcs**

9. Slowly adjust **ZERO** on the primary panel.  
If zeroing cannot be achieved, adjust **COARSE ZERO** on the secondary panel, and then **ZERO**.
10. *Very slowly* open the tuning leak valve until the test port pressure rises to 100 mTorr, and note a corresponding rise in the leak rate indication.
11. If the bar graph does not display between 1 and 9, move **RANGE** until it does.  
See Section 2.5.4 "Tuning the Spectrometer Tube Using a Tuning Leak" on page 2-15.
12. Slowly adjust **FOCUS** and then **ION** for a maximum on the leak rate display.  
The ION control is a 10-turn potentiometer and normally needs to be adjusted only slightly for a maximum peak on the display. When tuned to helium, the outer dial on the ION control at the 12 o'clock position should indicate between 2 and 8.  
A change in one adjustment may affect the others. Therefore, it may be necessary to repeat step 9 through step 12 until no significant change occurs in the leak rate reading.  
The leak detector is now tuned to helium. When performed correctly, day-to-day changes are very small, and daily adjustment may not be required.
13. Close the tuning leak valve and verify that the leak rate drops to zero.  
If the leak rate does not drop to zero, repeat this procedure to retune the spectrometer tube beginning with step 9.
14. Press **VENT** and remove the tuning leak.  
Proceed with testing.



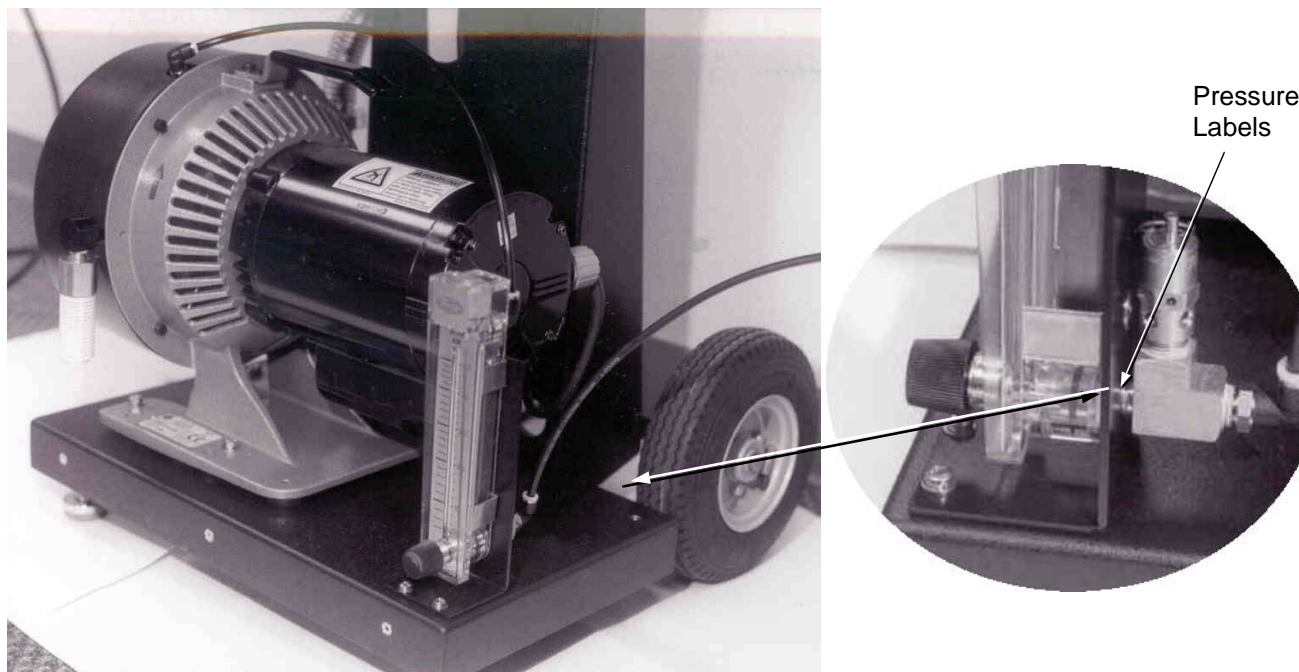
### 2.6 Nitrogen Purge Option (959D only)

A continuous purge of the 959D TriScroll roughing pump and the associated vacuum system in the leak detector with laboratory grade nitrogen assures that residual helium levels do not raise the system background to unacceptable levels. The N<sub>2</sub> purge option consists of an inlet port with a pressure-relief valve and a flowmeter mounted on the bottom of the cart adjacent to the roughing pump, as is seen in Figure 2-9. The nitrogen is introduced to the system via a port on the roughing pump, from where it flows through the pump toward the leak detector and replaces and then blocks the entry of ambient helium.

To set up the nitrogen purge:

1. Remove the plug on the nitrogen port and connect the N<sub>2</sub> as shown in Figure 2-9.
2. Adjust the flow meter to 5 liters/minute by rotating the knob at its base.

For more information about the role of the nitrogen purge feature, contact Varian Vacuum Technologies Customer Service at 1-800-8VARIAN. If the leak detector is not going to be used for a few hours, the N<sub>2</sub> flow should be closed off.



**Figure 2-9 N<sub>2</sub> Purge System on the 959D**

## 2.7 Residual Background Check

### 2.7.1 Measuring the Background

When testing is complete and helium is no longer entering the leak detector through a leak, the vacuum system rapidly removes most of the remaining helium. The residual amount, called background, is steady and can be cancelled by zeroing the leak rate display.

Measure the background to:

- ☐ Check for a dirty system that needs cleaning or overhaul
- ☐ Determine whether the system is detecting helium
- ☐ Determine whether the reading is a result of electrical noise associated with the preamplifier.

To measure the residual background, refer to Figure 2-2 on page 2-2 and Figure 2-4 on page 2-4.

To perform this procedure:

1. Verify that the system is warmed up, tuned and calibrated.
2. Place the test port plug in the test port and tighten the nut.
3. Set **RESIDUAL BACKGROUND** to **CHECK**.

When this switch is in the CHECK position, the leak detector is almost completely insensitive to all gases, including helium.

4. Move **RANGE** fully counterclockwise to its most sensitive position.
5. Press **START** and wait until minimum test port pressure is reached.
6. Adjust the **ZERO** and **COARSE ZERO** until the leak rate bar graph indicates zero, with only one bar lit.
7. Move the **RESIDUAL BACKGROUND** switch to **RUN**.

The value indicated on the bar graph is the background. Record this value.

#### CAUTION



*If the background reading is unstable or cannot be zeroed, or the UNDER light is on after the leak detector was zeroed in the check position, leak-check the system. Contact Varian Vacuum Technologies Customer Service at 1-800-8VARIAN for assistance.*

### 2.7.2 Zero the Background

To zero the background:

1. Perform a residual check as described in Section 2.7 “Residual Background Check” on page 2-18.
2. Leaving the **RESIDUAL BACKGROUND** switch in the **RUN** position, zero the leak detector using the **COARSE ZERO** and **ZERO** switches to set the leak rate bar graph display to zero (one bar lit).

## 2.8 Shutdown and Restart Procedures

- ❑ If the leak detector is going to be idle a few hours, put it into standby, as explained in Section 2.8.1 “Standby”.
- ❑ If the leak detector is not going to be used for an extended period, such as eight hours or more, perform the shutdown procedure to prolong bearing life.
- ❑ If the leak detector is to be moved to a remote location, perform a complete shutdown procedure.

### 2.8.1 Standby

To shut down the leak detector for a period of up to 8 hours:

1. Plug the test port.
2. Press the **VENT** button.
3. Leave the switch in the **ON/AUTO** position.

### 2.8.2 Shutdown

To perform this procedure:

1. Plug the test port.
2. Press the **VENT** button.
3. Turn off the **MAIN POWER** switch on the front panel.
4. Switch off the AC power strip located on the cart.

### 2.8.3 Starting After Short-Term Shutdown (Standby)

No special steps are required for preparing the leak detector for operation when the green FIL. indicator is illuminated and the system pressure is in the green band in the vertical display. If necessary, tune and calibrate the leak detector (Section 2.5 “Calibration and Tuning” on page 2-11) before running a test.

### 2.8.4 Temporary Power Loss

The occurrence of a temporary power loss followed by power restoration can be recognized by the following symptoms:

- ☐ The green FIL indicator is not lit
- ☐ The mechanical pump is running
- ☐ The HI VAC OK pressure indication is lit

To perform this procedure:

1. Set the **FIL.** switch to the **ON/AUTO** position and release it.  
This may have to be repeated several times. The green FIL. indicator should remain lit.
2. If the filament does not light, move the filament selector switch to the other filament and try to light it again.
3. If the filament still does not light, perform a complete shutdown, wait a few minutes, and then start the leak detector following the start-up procedure.
4. If the filament still does not light, replace the ion source.  
See Section 3.4.1 "Removing the Ion Source" on page 3-6 for the replacement procedure.
5. Allow 1/2 hour for the pumps to warm up and the leak rate to stabilize; then tune and calibrate the leak detector (see Section 2.5 "Calibration and Tuning" on page 2-11).  
You can proceed with testing.

## Section 3. Maintenance and Parts Replacements

The 959 and 959D leak detectors require periodic maintenance to assure continued reliable operation and accurate measurements. After prolonged use, the leak detector accumulates contaminants from even the cleanest of products tested. These contaminants eventually impair operation.

Cleaning of the spectrometer tube assembly, consisting of the ion source and the preamplifier can be done by user maintenance personnel. If the ion source exhibits severe contamination or if a filament is burned out, replacement of the ion source may be required. Advice on cleaning and replacing components of the spectrometer tube can be obtained by contacting Customer Service at Varian Vacuum Technologies.

### 3.1 Safety and Maintenance

#### 3.1.1 AC Power

**WARNING**



*Disconnect power from the power strip on the cart before performing any maintenance procedure that requires physically disconnecting any part of the system.*

#### 3.1.2 Static Charge

**CAUTION**



*Wear a grounding device when performing any maintenance on the leak detector and especially when performing maintenance of static-sensitive parts.*

#### 3.1.3 Ion Source

**WARNING**



*When handling the ion source, wear powder-free butyl or polycarbonate gloves.*

*If you handle the ion source with bare hands, wash them thoroughly, especially before smoking or eating.*

### 3.1.4 O-rings

Whenever installing an O-ring, follow these guidelines to prevent scratching of any sealing surfaces:

- ❑ Wipe all O-rings clean with a lint-free cloth before installation to assure that no foreign matter is present to impair the seal.
- ❑ Do not use grease or use other substances on O-rings that comes in contact with the spectrometer tube.
- ❑ Do not use alcohol, methanol, or other solvents on O-rings. These chemicals cause deterioration and reduce the O-ring's ability to hold a vacuum.
- ❑ In allowable situations, apply a small amount of Apiezon L grease and wipe the O-rings "shiny" dry.

### 3.1.5 Cleaning Kit

Use the Varian Component and Spectrometer Tube Cleaning Kit, Part No. 670029096, to clean the spectrometer tube components, as well as for the fine cleaning of other parts in the leak detector's vacuum system such as valves and fittings. Rinsing or high-temperature drying are not required following cleaning with the VacuSolv used in this kit. Although appropriate precautions are advised, VacuSolv is compatible with most materials and does not contain toxic chemicals or CFCs.

### 3.1.6 Maintenance Schedules

Refer to Table 3-1 and Table 3-2 for maintenance schedules.

**Table 3-1 Scheduled Maintenance**

Description	Daily	12 Months	Refer to
Calibration check	X		Section 2.5 “Calibration and Tuning” on page 2-11
Spectrometer tube overhaul		12 months or less depending on application.	Section 3.4 “Cleaning or Replacing the Spectrometer Tube” on page 3-5
<b>TriScroll 310</b> & DS-302 roughing pumps	Watch for degrading performance of the leak detector.		Refer to the respective user manual supplied with the system

**Table 3-2 As-Required Maintenance**

Function	Most Common Symptom	Refer to
Cleaning the test port		Section 3.2 “Cleaning the Test Port” on page 3-4
Spectrometer tube cleaning	Loss of sensitivity, increase in background.	Section 3.2 “Cleaning the Test Port” on page 3-4 and Section 3.4 “Cleaning or Replacing the Spectrometer Tube” on page 3-5
Ion source replacement	Filament failure.	Section 3.4.1 “Removing the Ion Source” on page 3-6 (as soon as convenient after second filament is in use)

## 3.2 Cleaning the Test Port

Clean the test port periodically depending upon your application.

To perform this procedure:

1. Turn the test port tightening nut counterclockwise to loosen it (Figure 3-1).
2. Remove the tightening nut and the test port plug.
3. Remove the test port compression ring and O-ring from the top of the test port.



**Figure 3-1 Removing the Test Port Compression Ring and O-ring**

4. Examine the O-ring, and clean or replace it as necessary.



*Varian recommends replacing all O-rings during routine maintenance or during any maintenance procedure requiring that O-rings be removed.*

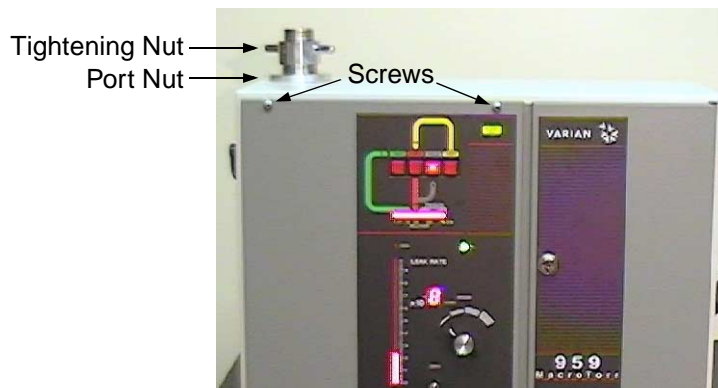
5. Before reusing O-rings or installing new O-rings, wipe them down with a lint-free cloth to ensure that there is no foreign matter present to impair the vacuum seal.
6. Apply a small amount of Apiezon L grease and wipe the O-rings “shiny” dry.
7. Examine all parts of the test port, including inside the test port.  
Use a VacuSolv wipe to remove any dirt or foreign matter. Allow parts to air dry.
8. Place the O-ring into the groove of the compression ring.
9. Place the compression ring and O-ring onto the top of the test port.
10. Place the test port tightening nut onto the test port and turn it clockwise until it is just tight enough to stay in place.
11. Place the test port plug into the test port tightening nut. Be sure it is completely seated.
12. Tighten the test port tightening nut completely.



### 3.3 Removing the Cover

To perform this procedure:

1. Loosen and remove the test port tightening nut and the port nut (Figure 3-2). Place them on a clean and safe surface.



**Figure 3-2 Front and Side Views**

2. Loosen and remove the two screws located at the top of the left front panel.  
There is no need to remove the bottom screws on the front panel.
3. Loosen and remove two screws located at the bottom of each side.
4. Lift the cover up and off the leak detector.

### 3.4 Cleaning or Replacing the Spectrometer Tube

The ion source and the preamplifier require periodic inspection and cleaning. After a certain amount of use, they may also require replacement. The following set of procedures covers both replacement with new components, and cleaning of the existing items.

**NOTE**



*Varian recommends replacing all O-rings during routine maintenance or during any maintenance procedure requiring that O-rings be removed.*

Tools and supplies required:

- ☐ Phillips screwdriver
- ☐ Thin slotted screwdriver
- ☐ Ion source, Part No. 82850302
- ☐ Protective gloves
- ☐ Allen wrench, 5/32-inch
- ☐ Locking screwdriver
- ☐ Spectrometer Tube Cleaning Kit, Part No. 670029096

### 3.4.1 Removing the Ion Source

Replace the ion source when cleaning the spectrometer tube or as soon as possible after a filament burns out. Tuning is required after replacement.

#### WARNING



*When handling the ion source, wear powder-free butyl or polycarbonate gloves. If you handle the ion source with bare hands, wash them thoroughly especially before smoking or eating.*

To perform this procedure:

1. Shut down the leak detector.
  - ❑ Press the **VENT** button.
  - ❑ Turn off the **MAIN POWER** switch on the front panel.
  - ❑ Turn off the power switch on the AC power strip located at the bottom of the cart.

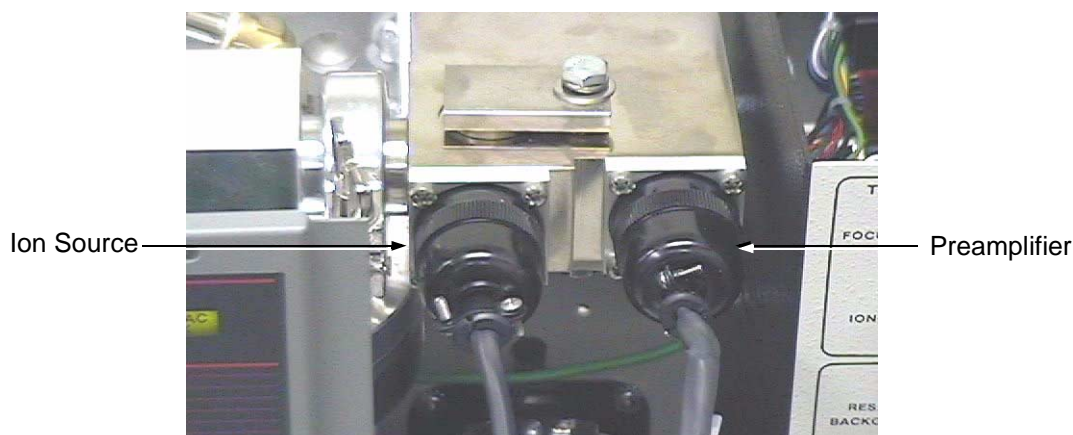
#### WARNING



*Disconnect the power strip from its source before performing any maintenance procedure that requires physically disconnecting any part of the system.*

2. Remove the top cover as described in Section 3.3 “Removing the Cover” on page 3-5.
3. Locate and remove the connectors from the preamplifier and the ion source (Figure 3-3) by grasping each plug and gently pulling straight off the contact pins.

If the connector cables are not labeled **ION SOURCE** and **PRE-AMP**, label them now.

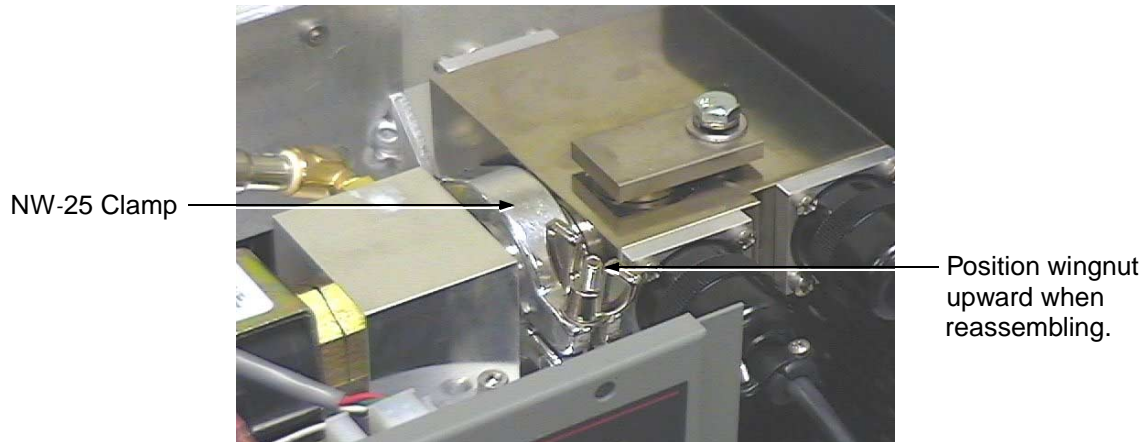


**Figure 3-3 Ion Source and Preamplifier Connectors**

## 959 and 959D Leak Detectors

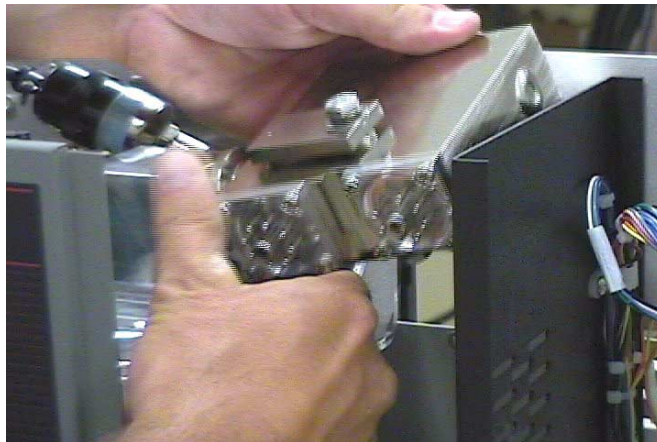
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4. Loosen the wing nut and remove the NW-25 clamp that holds the spectrometer tube onto the turbo pump (Figure 3-4).



**Figure 3-4 Wing Nut and Clamp**

5. Lift the entire spectrometer tube assembly off the turbo pump and out of the leak detector, as shown in Figure 3-5.



**Figure 3-5 Extracting the Spectrometer Tube**

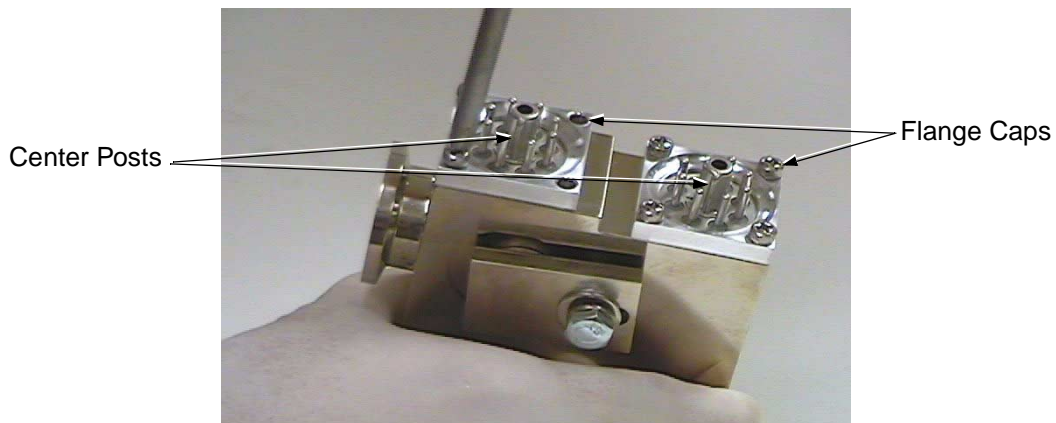
You may have to rock the spectrometer tube gently to break the vacuum.

6. Remove the O-ring and centering ring (Figure 3-6) and place them on a clean *non-magnetic* surface.



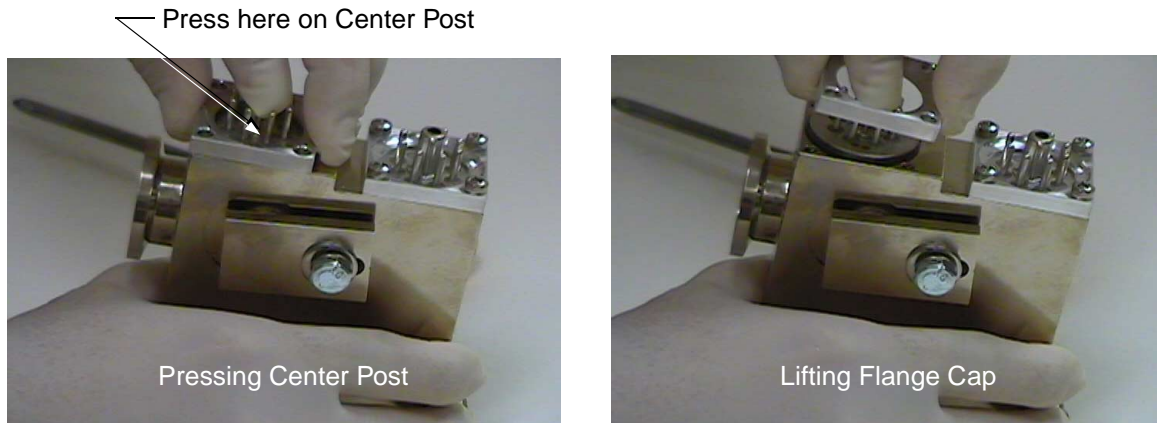
**Figure 3-6 Spectrometer Tube O-ring and Centering Ring**

7. Remove the 4 screws that hold the ion source flange cap (Figure 3-7).



**Figure 3-7 Removing Flange Cap Screws**

8. Remove the ion source flange cap by pressing down on the ion source center post and lifting the flange cap up and off the ion source as shown in the images of Figure 3-8.



**Figure 3-8 Disengaging Flange Cap**

9. If the flange cap and ion source come up together, hold one hand under the ion source to catch it, then push down on the center post.
10. Remove the ion source from the spectrometer tube body as shown in Figure 3-9.



**Figure 3-9 Removing the Ion Source**

### 3.4.2 Examining the Ion Source

To perform this procedure:

1. Examine the ion source (Figure 3-10) and cavity (Figure 3-11) for deposits and discoloration.

If either is discolored or dirty, clean with VacuSolv, and, if necessary replace the part.

#### NOTE

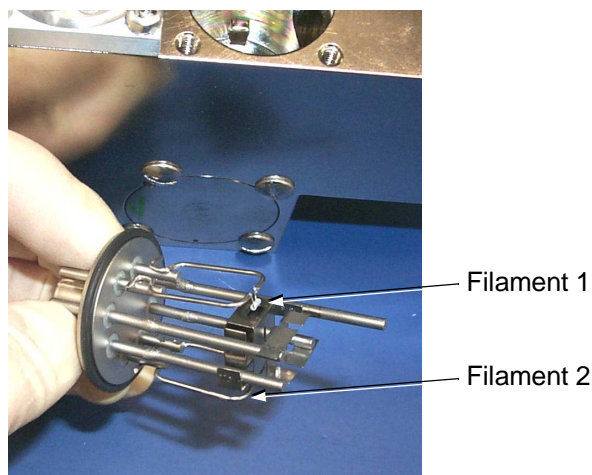


*VacuSolv is included in the Varian Vacuum Technologies' Component and Spectrometer Tube Cleaning Kit, Part No. 670029096. This compound is recommended for cleaning the spectrometer tube components.*

#### CAUTION



*Do not clean filaments. They are extremely fragile.*



**Figure 3-10 Ion Source**

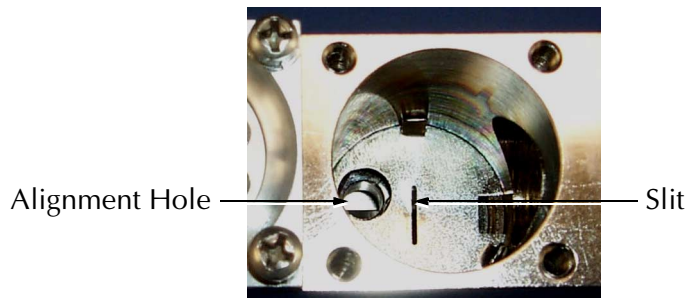
#### NOTE



*Dark carbon-like deposits around the ion source filament and/or a rainbow-like discoloration on the inside walls of the ion source cavity indicate that the spectrometer tube has been operated at too high a pressure. This can occur from a system pressure leak or transferring into test at too high a pressure.*



2. Look into the ion source cavity (Figure 3-11) and find the ground slit plate.



**Figure 3-11 Ion Source Cavity**

3. Carefully note the position of the ground slit plate inside the ion source cavity, as it must be replaced in exactly the same relative position.
  - ❑ If the ground slit plate or ion source cavity walls are lightly discolored, remove the plate and clean using the next procedure, or replace it (see Section 3.4.4 “Installing the Ion Source” on page 3-14).
  - ❑ If the ground slit plate is highly discolored, contact Varian Vacuum Technologies Customer Service at 1-800-8VARIAN.

### 3.4.3 Cleaning the Ground Slit Plate

#### WARNING



*When handling the ion source, wear powder-free butyl or polycarbonate gloves. If you handle the ion source with bare hands, wash them thoroughly, especially before smoking or eating.*

To perform this procedure:

1. Remove the ground slit plate (Figure 3-12) by placing a thin, slotted screwdriver snug into the slot and carefully twisting and prying with the screwdriver.
2. Place the ground slit plate on a clean surface.



Ground Slit Plate

**Figure 3-12 Ground Slit Plate**

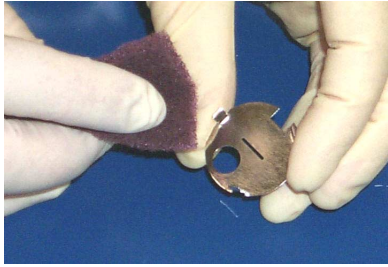
#### NOTE



*This procedure requires the use of a locking screwdriver of the type designed to grab onto the slot of a screw.*



3. Use a Scotch-Brite™ pad to polish away any discolored areas of the ground slit plate (Figure 3-13).



**Figure 3-13** Cleaning the Ground Slit Plate

**CAUTION**



*The ground slit plate is very thin. Take care not to bend or scratch it during cleaning.*

4. Use a VacuSolv wipe to clean the ground slit plate, the flange cap and to wipe the cavity and the outside of the spectrometer tube.

Let all the parts air dry. Take great care not to scratch any parts when wiping or when setting onto a surface to dry.

5. Inspect all O-rings, then wipe with a lint-free cloth to be sure they are free of debris.

**CAUTION**



*Remove O-rings carefully with your fingers. Do not use metal tools for this task.*

Follow these guidelines to prevent scratching of any sealing surfaces:

- ☐ Wipe all O-rings clean with a lint-free cloth before installation to assure that no foreign matter is present to impair the seal.
  - ☐ Do not use grease or use other substances on O-rings that come in contact with the spectrometer tube.
  - ☐ Do not use alcohol, methanol, or other solvents on O-rings.  
To do so causes deterioration and reduces the O-ring's ability to hold a vacuum.
  - ☐ In allowable situations, apply a small amount of Apiezon L grease and wipe the O-rings "shiny" dry.
6. Inspect the preamplifier as part of a spectrometer tube cleaning procedure.  
This procedure is contained in Section 3.4.5 "Cleaning the Preamplifier Cavity" on page 3-17.
  7. If you do not remove the preamplifier, allow all parts associated with the ion source to air dry thoroughly.

### 3.4.4 Installing the Ion Source

If you did not remove the ground slit plate, begin at step 4.

To perform this procedure:

1. Place the ground slit plate onto the locking screwdriver as you did to remove it (Figure 3-12) with the prongs facing up.

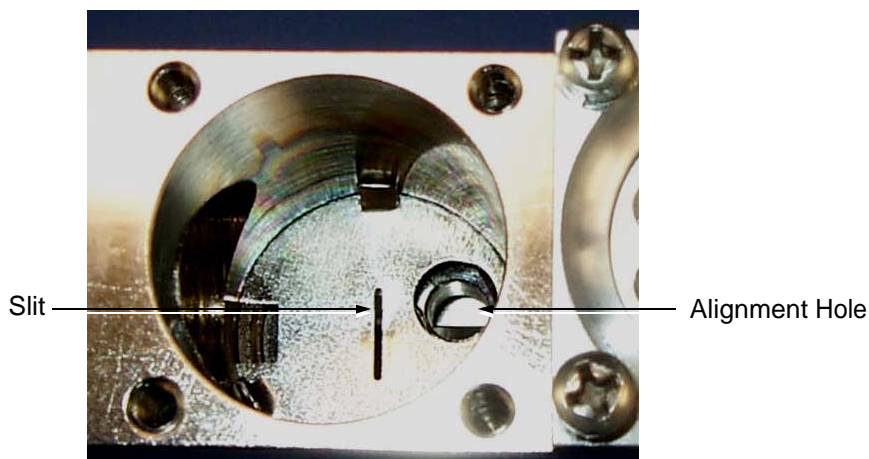
#### CAUTION



*Be sure to seat the ground slit plate firmly and in its proper orientation.*

2. Carefully place the ground slit plate into the cavity, being sure to align the slit so that it is perpendicular to the back and front of the spectrometer tube (Figure 3-14).

The hole in the ground slit plate will line up with the alignment hole on the bottom of the ion source cavity.



**Figure 3-14 Ground Slit Plate Properly Inserted**

#### CAUTION



*If it is necessary to bend the ground slit plate prongs out, be sure to bend them only slightly so that the prongs do not scratch the ion source cavity while the plate is being inserted. If the plate is damaged, replace it with Part No. 3088001.*

3. Check that the ground slit plate is firmly seated in the ion source cavity.

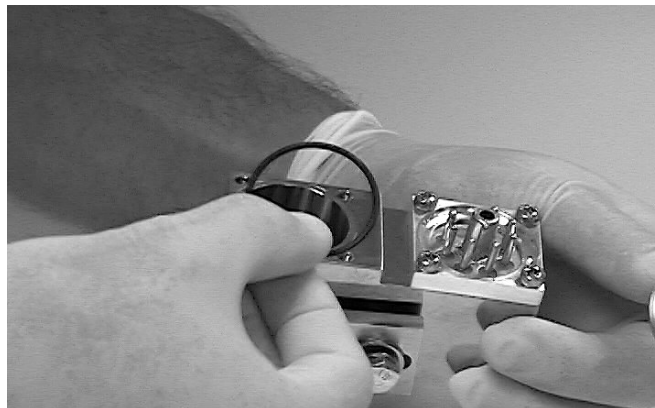
If it is not, remove it and, using a screwdriver, bend the prongs out *slightly* and place the ground slit plate into the cavity again.

**WARNING**



*When handling the ion source, wear powder-free butyl or polycarbonate gloves. If you handle the ion source with bare hands, wash them thoroughly, especially before smoking or eating.*

4. Place the O-ring on the ion source as shown in Figure 3-15.



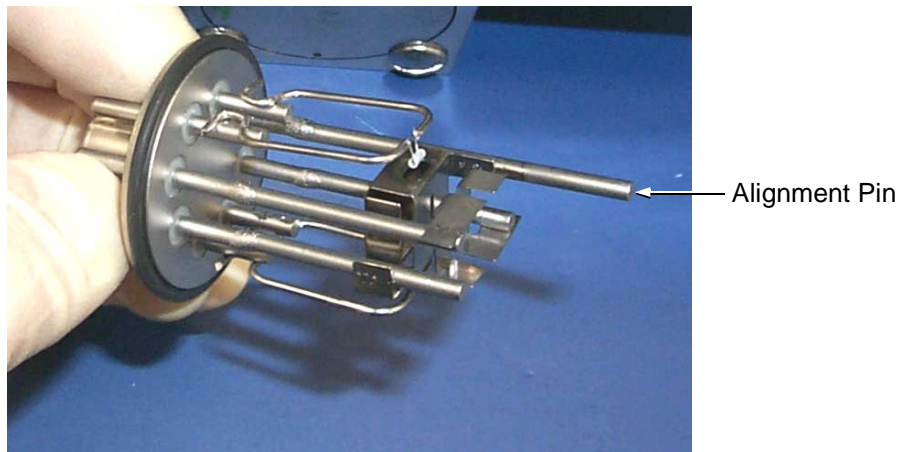
**Figure 3-15 Replacing the Ion Source O-ring**

**NOTE**



*When replacing the preamplifier and ion source, line up the key of the center post perpendicular to the spectrometer tube body. This alignment happens by default for some pieces. Replace the flange cap with the groove aligned with the two legs on either side of the key.*

5. Holding the ion source by the connector pins, and the O-ring if necessary, insert the ion source into the cavity so that its alignment pin falls in the center of the hole in the cavity (Figure 3-16).



**Figure 3-16 Ion Source Alignment Pin**

**CAUTION**



*A short circuit could take place at power up if the alignment pin touches the sides of the alignment hole.*

6. Hold onto the O-ring so that it seats properly when inserting the ion source.
7. Replace the ion source flange cap so that the grooves in the depression of the flange cap line up with the legs on either side of the center post key.
8. Insert and tighten the four screws.

### 3.4.5 Cleaning the Preamplifier Cavity

#### CAUTION



*Wear a ground strap while handling the preamplifier. The preamplifier is a static-sensitive device.*

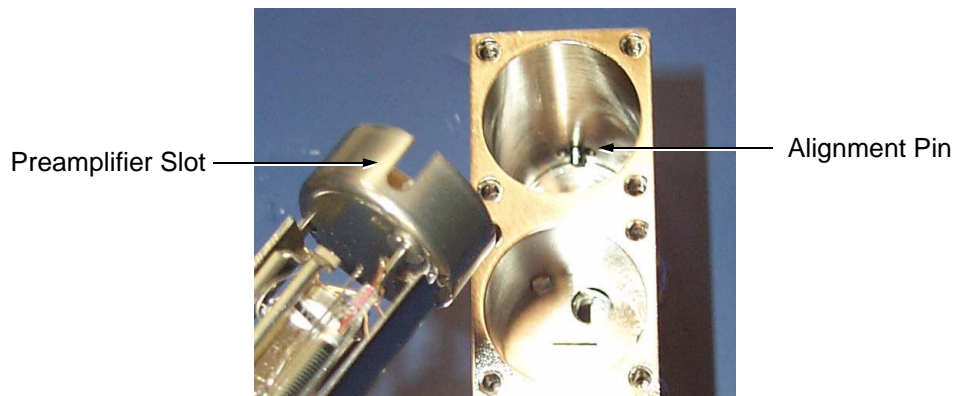
To perform this procedure:

1. Remove the four screws that hold the preamplifier flange cap.
2. Remove the preamplifier flange cap by pressing down on the preamplifier center post and lifting the flange cap up and off of the preamplifier.
3. If the flange cap and preamplifier come up together, hold one hand under the preamplifier to catch it, and push down on the center post to remove the flange cap from the preamplifier.
4. Carefully remove the preamplifier from the spectrometer tube body and place it on a clean, non-magnetic surface.
5. Remove and discard the O-ring from the preamplifier.
6. Clean the preamplifier cavity if discoloration is present.

### 3.4.6 Replacing the Preamplifier

To perform this procedure:

1. Wipe the new O-ring and mating surfaces.
2. Place the preamplifier in its cavity with the new O-ring in place.
3. Orient the preamplifier so that the vertical slot in the preamplifier engages the pin in the spectrometer tube body.



**Figure 3-17 Replacing the Preamplifier**

4. Tighten the flange cap evenly and firmly using the four screws.

### 3.4.7 Installing the Spectrometer Tube

To perform this procedure:

1. Wipe the centering ring using a VacuSolv wipe (Figure 3-18).



**Figure 3-18 Spectrometer Tube O-ring and Centering Ring**

2. Wipe the O-ring with a clean, lint-free cloth and place it onto the centering ring.
3. Wipe the turbo flange and the spectrometer tube flange using a VacuSolv wipe and let them air dry.
4. Place the centering ring and O-ring against the turbo pump flange.
5. Place the spectrometer tube against the centering ring, then attach and fully tighten the NW-25 clamp, making sure the wingnut is facing upward.
6. Attach the connector plugs for the preamplifier and the ion source.
7. Replace the mylar sheeting.
8. Replace the cover as described in Section 3.3 "Removing the Cover" on page 3-5.
9. Turn the leak detector on and wait 1/2 hour for the pumps to warm up and for the leak detector to stabilize.
10. Tune and calibrate the leak detector following the procedures in Section 2.5 "Calibration and Tuning" on page 2-11.

### 3.5 Replacement Parts

Table 3-3 lists replacement parts.

**Table 3-3 Replacement Parts**

Assembly	Part Number
Ion Source	82850302
Preamplifier [for each type of high vacuum pump]	With MacroTorr: L9030301 With Turbo: K3333301
Spectrometer Tube Assembly Exchange Program	GGL9713301
Spectrometer Tube Cleaning Kit	670029096
Ground Slit Plate	K3088001
V70 Turbo Pump Exchange Program	Call Varian
V70D Turbo Pump Exchange Program	Call Varian
DS-302 Oil-based Mechanical Pump Exchange Program	Call Varian
DS-302 Maintenance Parts Kit	949-9370
DS-302 Gasket Kit	949-9370
<b>TriScroll 310</b> Dry Mechanical Pump Exchange Program	<b>Call Varian</b>
<b>TriScroll 310</b> Maintenance Parts Kit	<b>PTSS0300MK</b>
<b>TriScroll 310</b> Replacement Tip Seal Kit	<b>PTSS0300TS</b>

### 3.6 Accessories

Refer to Table 3-4 for 959 and 959D accessories.

**Table 3-4 Accessories**

Part	Part Number
Calibrated Leak-Helium reservoir Refillable Leak $10^{-7}$ atm cc/sec range	F8473301
Refillable calibrated leak for evacuation sniffing use, $10^{-5}/10^{-6}$ range	F8473320
Power Probe Sniff Accessory	K9565301
Throttle valve for manual gross leak testing	626603345
Test Port Adapter Kit	86428801

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## Appendix A. Introduction to Leak Detection

### A.1 Why Leak Testing is Necessary

Even with today's complex technology it is, for all practical purposes, impossible to manufacture a sealed enclosure or system that can be guaranteed leak proof without first being tested.

Using the modern mass spectrometer leak testing techniques implemented by the Varian Vacuum Technologies 959D Helium Leak Detector, leak rates in the  $10^{-10}$  atm cc/sec range can be reliably detected. The discussion that follows is a summary of information pertinent to the subject of leak detection.

### A.2 Classes of Leak Detection

There are four general classes of leak detection:

<b>Hermetic Enclosures</b> (or parts thereof)	These are tested to prevent entrance of contaminants or loss of fluid that would affect performance of the enclosed unit. Examples include electronic devices, integrated circuits, sealed relays, motors, ring pull tab can ends, and multipin feedthroughs.
<b>Hermetic Systems</b>	These are tested to prevent loss of fluid or gas within. Examples include: hydraulic systems and refrigeration systems.
<b>Evacuated Enclosures</b> (or parts thereof)	These are tested to prevent excessively rapid deterioration of a vacuum over time. Examples include TV picture tubes, bellows sensing elements, and full-panel opening can ends.
<b>Vacuum Systems</b>	These are tested to minimize in-leakage and to allow attainment of better vacuum or higher gas removal ability at any given vacuum (absolute pressure).

## A.3 Terminology

The following terminology has application throughout this manual:

### Flow

atm cc/sec      One cubic centimeter of gas per second at a pressure differential of one standard atmosphere (760 torr at 0 °C).

atm cc/sec      One cubic centimeter of gas per second at ambient atmospheric pressure and temperature (used interchangeably with *atm cc/sec* because the difference is insignificant for leak testing purposes).

### Rate-of-Rise

In vacuum systems this is defined as the rate of increase of absolute pressure per unit time, with the vacuum pump isolated from the system, and is the sum of actual inleakage and internal outgassing. Rate of rise is usually expressed in torr or microns (milliTorr) per hour. The flow rate should be expressed in torr-liters/second.

### Conversions

1 std cc/sec\*      0.76 torr-liter/sec

1 torr-liter sec\*      1.3 std cc/sec

1 std cc/sec       $9.7 \times 10^4$  micron cubic feet per hour or practically  $10^5$  micron CFH ( $\mu$ CFH)

1  $\mu$ CFH      practically  $10^{-5}$  std cc/sec

*\*for practical purposes, equal*

### Numerical

#### Notation-Exponential System

Most leak rates of commercial significance are very small fractions of atm cc/sec. Therefore negative powers of ten are used as a convenient system of numerical shorthand.

Table A-1 shows the relationship of exponents and multipliers (to the base 10) to the arithmetic form, and the equivalent result.

**Table A-1    Decimal Notation**

Multiplier x $10^n$		Arithmetic Form		Result
$1 \times 10^2$	=	$1 \times 10 \times 10$	=	100
$1 \times 10^1$	=	$1 \times 10$	=	10
$1 \times 10^0$	=	1	=	1
$1 \times 10^{-1}$	=	$1 \times 1/10$	=	.1
$1 \times 10^{-2}$	=	$1 \times 1/10 \times 1/10$	=	.01
$5 \times 10^{-3}$	=	$5 \times 1/10 \times 1/10 \times 1/10$	=	.005
$5 \times 10^{-7}$	=	$5 \times 1/10 \times 1/10 \times 1/10 \times 1/10 \times 1/10 \times 1/10 \times 1/10$	=	.0000005
$5 \times 10^{-9}$	=	$5 \times 1/10 \times 1/10 \times 1/10 \times 1/10 \times 1/10 \times 1/10 \times 1/10 \times 1/10 \times 1/10$	=	.000000005

## A.4 Leak Detection Methods

There are many methods of testing for leaks in enclosures, systems or containers. The more commonly used methods and their accuracy ranges are listed below:

<b>Water Immersion</b> (Air Bubble Observation)	This method is good to approximately $10^{-3}$ atm cc/sec, and can be more sensitive if internal pressure is increased or vacuum is created above water pressure. This method is limited because of difficulty in differentiating between leakage bubbles and surface desorption bubbles. It is used to test industrial items such as valves, hydraulic components, castings, automotive and air conditioning components.
<b>Dye Penetrant</b>	A special dye, applied to one side of a surface suspected to contain a leak, seeps through the leak and appears on the other side. This method can take an hour or more for a $10^{-4}$ atm cc/sec leak to show up. This test is inexpensive but destructive in some applications, as well as slow and messy.
<b>Ultrasonic</b>	This method is good to approximately $10^{-3}$ atm cc/sec. It tests for ultrasonic sounds coming from a gas leak and for testing high pressure lines.
<b>Halogen</b> (sensitive to halogen elements or compounds, especially refrigerant gases)	This method is good to approximately $10^{-5}$ atm cc/sec in most current applications, but extendable to $10^{-9}$ std cc/sec under some limited situations. It is critically dependent on operator judgement if leaks are below $10^{-5}$ atm cc/sec and requires constant flow of fresh air in the test area because of the tendency of trace gas to <i>hang</i> in the area. The detector used in this method is sensitive to a variety of gases from external sources such as cigarette smoke and solvent fumes.
<b>Radioisotope</b>	This method is useful only for testing hermetically sealed cavities. It has approximately the same range as the helium method but it involves an expensive installation (from four to ten times the cost of a helium installation) depending on the degree of isolation of radiation required). It also requires a radiation safety officer.
<b>Helium</b>	This method is good to $10^{-11}$ atm cc/sec. It is useful for testing hermetic seals, vacuum enclosures, and vacuum systems, and is the most versatile of industrial and laboratory leak detection testing methods.

## A.5 Helium Mass Spectrometer Leak Detection (MSLD)

Helium is an excellent trace gas because it is the lightest of the inert gases and as a consequence readily penetrates small leaks. In addition, its presence in the atmosphere is minute (5 PPM or 4 milliTorr absolute). Helium is easily detected by a simple mass spectrometer (helium has a mass of 4 so that adjacent *peaks* of 3 and 6 are easily separated by this technique). Also, helium is readily available at reasonable cost, and is completely non-toxic and non-reactive. The basic principles of the helium MSLD technique are discussed below.

### A.5.1 Principles of Mass Spectrometry

A mass spectrometer sorts gases by their molecular weights (mass number) to determine the quantity of each gas present. With the helium MSLD, the point of interest is primarily in helium and the mass spectrometer tube is relatively simple. The principle is to ionize the gases in vacuum, accelerate the various ions through a fixed voltage, and then separate the ions by passing them through a magnetic field. A slit, properly placed, allows only helium ions to pass through and be collected. The resulting current is amplified and a leak rate bar graph indicates the presence and amount of helium.

### A.5.2 Application as a Leak Detector

A mass spectrometer leak detector consists of a spectrometer tube, the electronics to operate and interpret it, and a high vacuum system to maintain proper vacuum. In addition, means are provided for connecting a test object, and a *rough vacuum* pump and a system of *roughing* and *test* valves is provided to evacuate the test object for connection to the spectrometer tube; or, if it is a sealed object containing helium, to evacuate a chamber containing the test object.

### A.5.3 The Nature of Flow in a Vacuum

It should be noted that the purpose of the vacuum system is to support operation of the analyzing spectrometer tube. Helium molecules entering through a leak individually reach the spectrometer tube in a few milliseconds. Helium molecules as well as molecules of other gases are continuously removed by the vacuum system turbo pump. If helium is continuously applied to a leak, the concentration in the spectrometer tube rises sharply at first, then reaches equilibrium when it is being pumped out at the same rate as it is entering. When helium is completely removed from the leak, the input drops to zero while the residual helium is pumped out of the system. Thus, a leak is indicated by a rise in output signal of the spectrometer tube.

### A.5.4 Facts About Leak Rates

<b>Visualizing Leaks in</b>	$10^{-5}$ atm cc/sec: approximately 1 cc/day
<b>Everyday Terms</b>	$10^{-7}$ atm cc/sec: approximately 3 cc/year

#### **Audible or Visual Detection by Observer**

- |                            |                                |
|----------------------------|--------------------------------|
| a. Bubbles rising in water | $10^{-4}$ atm cc/sec or larger |
| b. Audible Leaks           | $10^{-1}$ atm cc/sec or larger |

#### **Sizes of Leaks in Man-Made Joints**

Studies indicate that almost all leaks at joints are about  $5 \times 10^{-7}$  std cc/sec (about 1 cc/month) or larger. This is true of ceramic-to-metal, plastic-to-metal seals, welded, soldered and brazed joints. Some long-path leaks are slightly smaller. Diffusion of helium through glass can be as high as  $10^{-8}$  std cc/sec per square centimeter of surface area.

#### **Variation in Leak Sizes**

Leaks unintentionally *built-in* at joints during manufacture can vary from hour to hour and day to day. Breathing on a  $10^{-6}$  std cc/sec leak provides enough moisture to close it temporarily; perhaps for several days. Atmospheric particles can close a leak of this size. Never depend on an *accidentally made* leak to remain constant. Manufactured standard leaks for calibration purposes require special techniques.

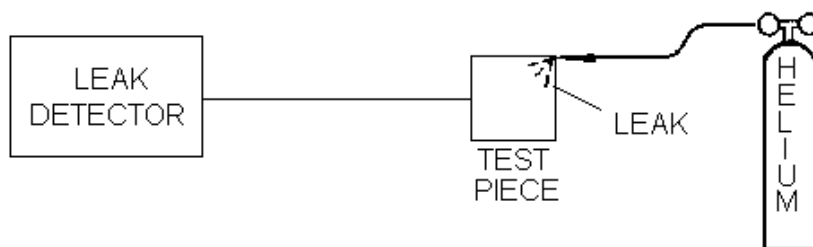
## A.6 Using Helium for Leak Detection

Most leak detection methods depend on the use of a tracer gas passing through the leak and being detected on the other side (for example, visual detection of air bubbles in water).

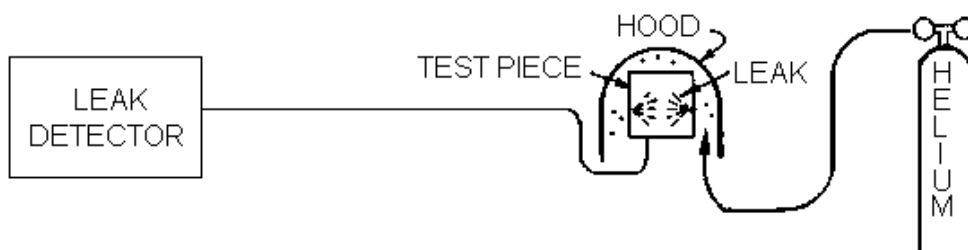
The mass spectrometer leak detector operates with helium as a tracer and is widely used because it combines high sensitivity with production testing capability. There are three basic methods in common use.

### A.6.1 Test Piece Evacuated

The object to be tested is evacuated by the leak detector roughing pump, then valved into the spectrometer vacuum system (Figure A-1 and Figure A-2). The surface of the test object is then probed with a small jet of helium to locate individual leaks, or surrounded by helium (hooded) for an overall leak check.



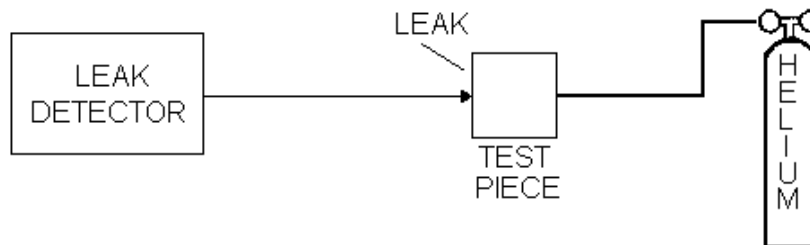
**Figure A-1 Test Piece Evacuated: Tracer Probe Used to Locate Leak**



**Figure A-2 Test Piece Evacuated and Hooded with Helium**

### A.6.2 Test Piece Pressurized

Figure A-3 is an illustration of a Detector Probe used to locate a leak in a pressurized test piece.



**Figure A-3 Test Piece Pressurized: Detector Probe Used to Locate Leak**

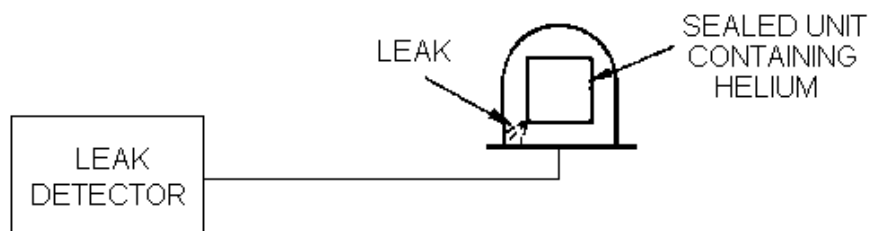
A sampling probe is connected to the leak detector. The object to be tested is filled with helium at the desired test pressure and the probe is moved over its surface. Some of the helium escaping from a leak is captured through the probe and enters the leak detector, thus locating the leak.

Sensitivity of this type of testing is limited to about  $10^{-7}$  atm cc/sec, since most of the escaping helium diffuses into the surrounding atmosphere. The sensitivity is also limited by operator technique and variation in ambient helium concentration in the vicinity of the testing.

An alternative to probing is to enclose the object and probe the enclosure for a change in helium content.

### A.6.3 Test Piece Already Sealed

Figure A-4 is an illustration of a bell jar used to determine overall leak rate of a sealed test piece.



**Figure A-4 Test Piece Sealed with Helium and/or Other Gases**

Sometimes it is necessary to leak check a completely sealed object. This can be done by placing helium inside the object before sealing (either 100% or mixed with other gas used for backfilling). The object is then placed in a vacuum chamber connected to the leak detector. Helium escaping from the object into the vacuum chamber is detected by the spectrometer tube. Sensitivity depends on the partial pressure of helium in the object.

If the presence of helium in the finished object is undesirable, units already sealed can first be placed in a container that is then pressurized with helium for a specific time at a known pressure. Helium enters the object through leaks that are later detected, as described in the previous paragraph. Gross leaks are sometimes not detected, since all the helium entering through a large leak can be lost prior to testing. Also, spurious signals can be given by helium not entering the object, but entering surface fissures and remaining long enough to be detected.

### A.7 Mass Spectrometer Leak Detector

The 959D consists of an analytical sensing tube called a *spectrometer tube*, electronics to operate the tube, and a vacuum system to maintain a very high vacuum within this tube (usually less than 0.1 milliTorr or about one ten-millionth of ordinary atmospheric pressure).

In the spectrometer tube, gas molecules are ionized (given a positive electrical charge) by bombarding them with electrons from a hot thoriated iridium filament. The ions, thus formed, are accelerated into a magnetic field where the mass 4 (helium) ions are deflected 90° (Figure A-5). Only helium ions reach the collector.

An extremely stable electrometer provides an electron current to the collector, which neutralizes the current produced by the collection of helium ions. The *feedback* current is presented on the leak rate bar graph. Since this current is directly proportional to the number of helium ions striking the collector per unit time, the panel leak rate bar graph directly reflects the concentration of helium in the vacuum system at any time. Any helium entering the system causes an increased concentration of helium within the spectrometer tube, which is reflected as an increase on the leak rate bar graph. In addition to the electrometer, the electronics also provide suitable voltages to operate the spectrometer tube and controls and instrumentation for the vacuum system.



Test pieces are generally *rough* pumped (or, if pressurized, the chamber in which they are to be tested is *rough* pumped) by a mechanical vacuum pump before they are connected to the spectrometer tube (Figure A-5). This prevents overloading the vacuum pumping system.

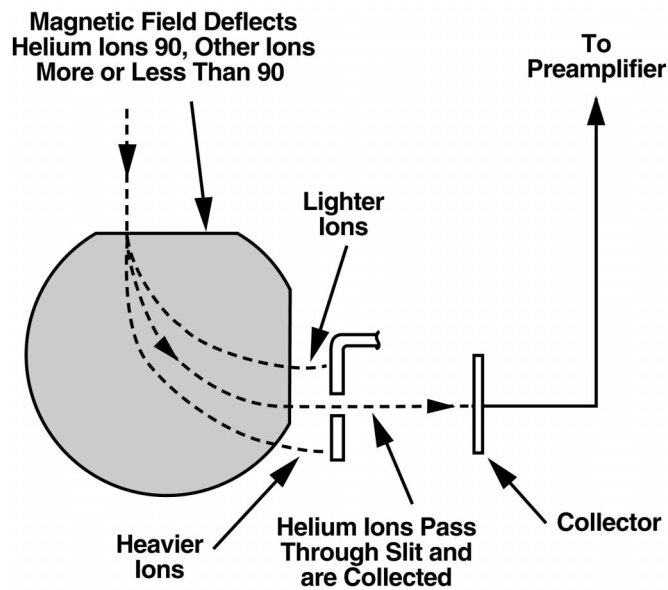


Figure A-5 Magnetic Separation Principle

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