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ANALYZAVAC™
Residual Gas Analyzer

USER MANUAL

ANV-08142024 - V 1.2.1.0

WARRANTY

Ideal Vacuum warrants to the original purchaser this product to be free from defects in workmanship and materials for a period of one year from the original delivery date **with the specific exception of the RGA probe, ionizer, and probe which does not carry any warranty after removal from the original packaging**. The liability of Ideal Vacuum, under this warranty, is limited to servicing, adjusting, repairing or replacing any unit or component part which, at Ideal Vacuum's sole discretion, is determined to have failed during normal, intended use. This warranty does not cover improper installation, process related damage, product use in any way other than defined in this manual, or any misuse, abuse, negligence, accident, or customer modification to the product.

Prior to returning any product, we require that you contact us by phone or email to to rule out the possibility of a simple solution that could save time and money. If the issue cannot be resolved in that manner, we will issue an RMA number and provide product return instructions.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING THE IMPLIED WARRANTY OF MERCHANTABILITY AND THE IMPLIED WARRANTY OF FITNESS FOR USE OR FITNESS FOR A PARTICULAR PURPOSE. IDEAL VACUUM SHALL NOT BE LIABLE UNDER ANY CIRCUMSTANCES FOR INDIRECT, SPECIAL, CONSEQUENTIAL OR INCIDENTAL DAMAGES ARISING OUT OF THE USE OF THE PRODUCT. THE TOTAL LIABILITY OF IDEAL VACUUM SHALL NOT EXCEED THE PURCHASE PRICE OF THE PRODUCT UNDER ANY CIRCUMSTANCES.

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If you have any questions concerning the installation or operation of this equipment, or if you need warranty or repair service, please contact us. Customer Service and Technical Support is available weekdays, from 8am-5pm, Mountain Time.

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	techsupport@idealvac.com
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SAFETY

IMPORTANT SAFETY INFORMATION

Thank you for purchasing this equipment from Ideal Vacuum Products. We want you to operate it safely.

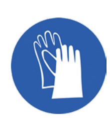
- **Read this manual and all associated equipment manuals before installing or operating this equipment. Failure to follow the warnings and instructions may result in serious injury or equipment damage.**
- **Follow all codes that regulate the installation and operation of this equipment.**
- **This equipment may only be installed, operated, and serviced by trained, qualified personnel, wearing appropriate protective equipment.**
- **Keep this manual in a safe location for future reference.**

WARNING SYMBOLS AND DEFINITIONS

DANGER	**Indicates an imminently hazardous situation that, if not avoided, will result in death or severe injury.**
WARNING	**Indicates an imminently hazardous situation that, if not avoided, could result in death or severe injury.**
CAUTION	**Indicates a potentially hazardous situation that, if not avoided, could result in moderate or minor injury. It may also be used to alert against unsafe practices.**
NOTICE	**Indicates a potentially hazardous situation that, if not avoided, could result in equipment or property damage.**
NOTE	**Indicates helpful tips and recommendations, as well as information for efficient, trouble-free operation.**

Internationally recognized safety symbols may be used with safety warnings to specify the type of hazard or a safety protocol to follow. For example:

Indicates an electric shock hazard



Indicates gloves are required

1. GENERAL INFORMATION

1.1 INTRODUCTION

The Ideal Vacuum AnalyzaVac is a family of compact quadrupole mass spectrometers known as residual gas analyzers (RGAs). Their primary function is to assist in determining the identity and concentration of gases that remain in a vacuum chamber (residual gases) after it has been pumped down.

The simplest way to separate, detect, and identify the remaining gases in a vacuum chamber is by their mass-to-charge ratio (m/z^+). The AnalyzaVac RGA ionizes a small percentage of these gases, then directs the ions through an oscillating electomagnetic field which selects and separates them by m/z^+. A very sensitive detector measures the current generated by each the ions at each m/z^+ type. The current for each m/z^+ is finally translated into a partial pressure and a mass spectrum is produced of all the scanned masses.

Typical RGA useage includes leak detection, outgassing analysis, contamination and impurity identification, feed gas quality control in coating and etching applications, and process troubleshooting. For example, the presence of N_2 in a vacuum system could be an indication of a vacuum leak, while pronounced presence of hydrocarbons could indicate contamination.

An AnalyzaVac RGA is a highly sensitive instrument designed to operate only in a high vacuum environment. Unlike other RGA's, the AnalyzaVac has a built-in convection enhanced Pirani and Bayard-Alpert hot ion gauge that measure total system pressure. These gauges protect the RGA from operating at unsuitably high pressures while reducing system complexity and preventing costly maintenance.

The AnalyzaVac family of RGAs includes six bare RGA models for direct connection to a CF 2.75" port on a chamber, and twelve manual high pressure kits for safely operating the RGA at pressures above high vacuum (up to 1000 Torr). Some models include an electron multiplier which increases sensitivity by up to 1000 times. Bare AnalyzaVac RGAs make excellent replacements for existing RGA installations. AnalyzaVac kits are best for experiments and processes that operate in the rough and medium vacuum regime.

Every AnalyzaVac RGA model , whether bare or kit, includes a probe with ionizer, quadrupole mass filter, and a Faraday cup detector. All AnalyzaVAC probes come with a Faraday cup detector which provides repeatable, quantitative, highly linear detection down to 1.5×10^{-12} Torr**, an electronics control unit (ECU), a 24 VDC, 2.5 A external power supply with power cable, an RS-232 serial cable with serial-to-USB adapter, a flange bolt kit, a USB drive with the AnalyzaVac and AutoZ$^+$ manuals, and Ideal Vacuum's AutoZ$^+$ non-expiring, basic version software for Windows® 10 and 11 operating systems. A premium version of AutoZ$^+$ software is available on a yearly subscription basis and adds data logging, a substance library with editor for adding user specific chemicals.

Manual high pressure kits add either an Agilent TPS-mini™ or a Pfeiffer HiCube 80 ECO turbo pumping station, a manual variable leak valve with CF 1.33" inlet flange for connecting to the chamber with a bellows tube or hard line, and a welded probe tee manifold.

All AnalyzaVac models require minor assembly and come with copper sealing gaskets.

***Measured with nitrogen gas, 5 second dwell time, 1 amu full peak width, 10% height, 70 eV electron energy, 6 eV ion energy, and 2 mA electron emission, and calculating three standard deviations from baseline noise.*

1.2 PROBE FRAGILITY AND EXPECTED LONGEVITY

The AnalyzaVAC probe is a delicate instrument. Inappropriate use, mishandling of the probe, or operating at elevated pressures for extended amounts of time can contaminate and damage it. Consequently, for bare RGA units, the probe does not carry a warranty after removal from its original packaging. For RGA kits which are a part of an ExploraVac build and are delivered assembled and tested, the probe is only warranted against physical damage in shipping.

The optimal total operational pressure of the RGA is 2 x 10^{-7} Torr for most gases. Operation at higher pressures for extended periods will result in premature aging of the probe, loss of gain, spectral drift, and filament and ionizer burnout. The RGA can be used at the following pressure regions for approximately the corresponding durations:

- 10^{-4} Torr, several hours
- 10^{-5} Torr, several days
- 10^{-6} Torr, several months
- 10^{-7} Torr, several years
- 10^{-8} Torr, indefinitely

Organic vapors should be kept at half the pressure of atmospheric gases to prevent soot contamination of the fillament and ionizer. Silicone vapors should be kept at pressures less than one-tenth of atmospheric gases to prevent glass buildup on the filament and ionizer. Corrosive or metallic vapors are also more damaging to the RGA than normal gases. By properly managing pressure, the RGA can be used to measure these gases without incurring costly repairs.

The AnalyzaVac high pressure RGA kits are designed to maintain pressures at 10^{-7} Torr and below, even when the chamber is at atmoshere.

Neither the RGA bare instrument nor the high pressure kits are designed for operation above 1000 Torr.

1.3 SPECIFICATIONS

<table>
<tr><th>RGA Parameter</th><th colspan="3">Measure/Type</th></tr>
<tr><td>Mass filter type</td><td colspan="3">Quadrupole</td></tr>
<tr><td>Detector type</td><td colspan="3">Faraday cup standard, electron multiplier optional</td></tr>
<tr><td>Resolution</td><td colspan="3">Greater than 0.5 amu @ 10% peak height (per AVS std. 2.3). Adjustable to constant peak width throughout the mass range.</td></tr>
<tr><td>Sensitivity (A/Torr)</td><td colspan="3">6×10^{-4} into Faraday cup. Measured with N_2 @ 28 amu with 1 AMU full peak width, 10% height, 70 eV electron energy, 6 eV ion energy and 2 mA electron emission current.</td></tr>
<tr><td rowspan="5">Minimum detectable partial pressure</td><td>Detector</td><td>Dwell</td><td>Minimum detectable</td></tr>
<tr><td rowspan="2">Faraday Cup</td><td>200 ms</td><td>2.4×10^{-12} Torr*</td></tr>
<tr><td>5 sec.</td><td>5×10^{-13} Torr*</td></tr>
<tr><td rowspan="2">Electron multiplier</td><td>200 ms</td><td>1×10^{-14} Torr*</td></tr>
<tr><td>5 sec.</td><td>2×10^{-15} Torr*</td></tr>
<tr><td>Total pressure measurement</td><td colspan="3">Pirani gauge, 10^{-3} Torr to Atmosphere.
Bayard-Alpert gauge 2×10^{-10} to 5×10^{-3} Torr.</td></tr>
<tr><td>Scanning pressure</td><td colspan="3">RGA $<10^{-4}$ Torr, electron multiplier $<10^{-7}$ Torr</td></tr>
<tr><td rowspan="3">Recommended continuous scanning pressure</td><td colspan="2">Bare RGA</td><td>Manual high pressure kit</td></tr>
<tr><td colspan="2">$<1 \times 10^{-6}$ Torr**</td><td><1000 Torr</td></tr>
<tr><td colspan="3">Optimal pressure ≈ 2×10^{-7} Torr</td></tr>
<tr><td>Maximum operating temperature</td><td colspan="3">50 °C Electronics, 100 °C Probe</td></tr>
<tr><td>Bakeout temperature</td><td colspan="3">300°C (Probe Only, ECU Removed)</td></tr>
<tr><th>Ionizer</th><th colspan="3"></th></tr>
<tr><td>Type</td><td colspan="3">Open ion source, electron impact ionization</td></tr>
<tr><td>Filament</td><td colspan="3">Dual thoria coated iridium. Field replaceable.</td></tr>
<tr><td>Electron energy</td><td colspan="3">11 to 150 eV, programmable</td></tr>
<tr><td>Ion energy</td><td colspan="3">1 to 12 V, programmable</td></tr>
<tr><td>Electron emission current</td><td colspan="3">0.1 to 4 mA, programmable</td></tr>
<tr><th>Probe</th><th colspan="3"></th></tr>
<tr><td>Materials</td><td colspan="3">304 Stainless steel, Kovar, tungsten, alumina, iridium, copper, nickel, thoria, platinum. Field replaceable.</td></tr>
<tr><td>Minimum tube I.D.</td><td colspan="3">1.375”</td></tr>
<tr><td>Mounting/Connecting flange</td><td colspan="2">Bare RGA, CF 2.75"</td><td>High pressure Kit, CF 1.33"s</td></tr>
<tr><td>Warm-up time</td><td colspan="3">Mass stability ± 0.1 AMU after 30 minutes</td></tr>
<tr><th>Other</th><th colspan="3"></th></tr>
<tr><td>Communication</td><td colspan="3">Serial RS-232, 25' DB-9 cable and USB-to-DB-9 adapter included.</td></tr>
<tr><td>Power</td><td colspan="3">24 VDC @ 2.5A, 120/240 VAC power supply included</td></tr>
<tr><td>Weight</td><td colspan="3">Bare RGA ≈ 9 lb. High pressure RGA kit ≈ 33 lb.</td></tr>
</table>

* Measured by calculating one standard deviation of the baseline noise divided by the sensitivity for nitrogen.
** Scanning with the bare RGA above 10^{-6} Torr leads to dramatically reduced ionizer, filament, and quadrupole longevity.

Table 1 - Specifications

1.4 WHAT'S INCLUDED

All RGAs include all the parts of the bare RGA (Figure 1). Manual high pressure kits include all the bare RGA parts plus an Agilent TPS-mini or Pfeiffer turbo pumping station, a manual variable leak valve, a welded probe tee manifold, and all the bolts and metal gaskets needed for assembly.

Figure 1 - Bare RGA components

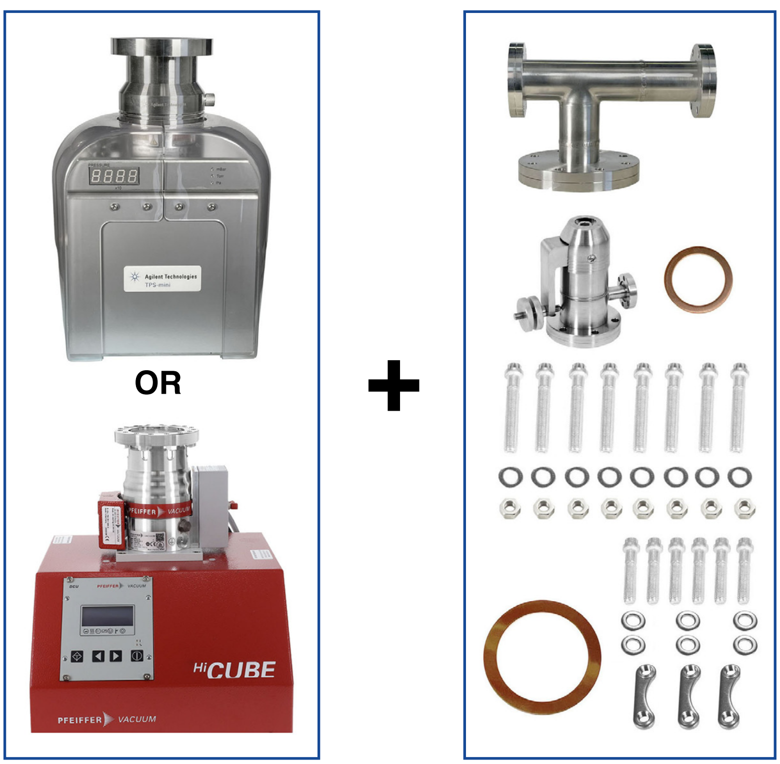


Figure 2 - High pressure kit additional components

1.5 CONFIGURATIONS

Bare RGA Models	Part Number	Description
AV100	P1013457	1 - 100 AMU
AV200	P1013462	1 - 200 AMU
AV300	P1013459	1 - 300 AMU
AV100-EM	P1013456	1 - 100 AMU with electron multiplier
AV200-EM	P1013458	1 - 200 AMU with electron multiplier
AV300-EM	P1013460	1 - 300 AMU with electron multiplier

Table 2 - Bare RGA configurations

Agilent TPS-Mini Manual High Pressure Kits	Part Number	Description
AV100-MK-A	P1013467	1 - 100 AMU, includes RGA plus turbo pump, manual leak valve, and probe manifold.
AV200-MK-A	P1013469	1 - 200 AMU, includes RGA plus turbo pump, manual leak valve, and probe manifold.
AV300-MK-A	P1013471	1 - 300 AMU, includes RGA plus turbo pump, manual leak valve, and probe manifold.
AV100-EM-MK-A	P1013468	1 - 100 AMU, includes RGA w/electron multiplier, plus turbo pump, manual leak valve, and probe manifold.
AV200-EM-MK-A	P1013470	1 - 200 AMU, includes RGA w/electron multiplier, plus turbo pump, manual leak valve, and probe manifold.
AV300-EM-MK-A	P1013472	1 - 300 AMU, includes RGA w/electron multiplier, plus turbo pump, manual leak valve, and probe manifold.
Pfeiffer HiCube 80 ECO Manual High Pressure Kits	**Part Number**	**Description**
AV100-MK-P	P1013666	1 - 100 AMU, includes RGA plus turbo pump, manual leak valve, and probe manifold.
AV200-MK-P	P1013668	1 - 200 AMU, includes RGA plus turbo pump, manual leak valve, and probe manifold.
AV300-MK-P	P1013670	1 - 300 AMU, includes RGA plus turbo pump, manual leak valve, and probe manifold.
AV100-EM-MK-P	P1013667	1 - 100 AMU, includes RGA w/electron multiplier, plus turbo pump, manual leak valve, and probe manifold.
AV200-EM-MK-P	P1013669	1 - 200 AMU, includes RGA w/electron multiplier, plus turbo pump, manual leak valve, and probe manifold.
AV300-EM-MK-P	P1013671	1 - 300 AMU, includes RGA w/electron multiplier, plus turbo pump, manual leak valve, and probe manifold.

Table 3 - Manual high pressure kit RGA configurations

1.6 DIMENSIONAL DRAWINGS

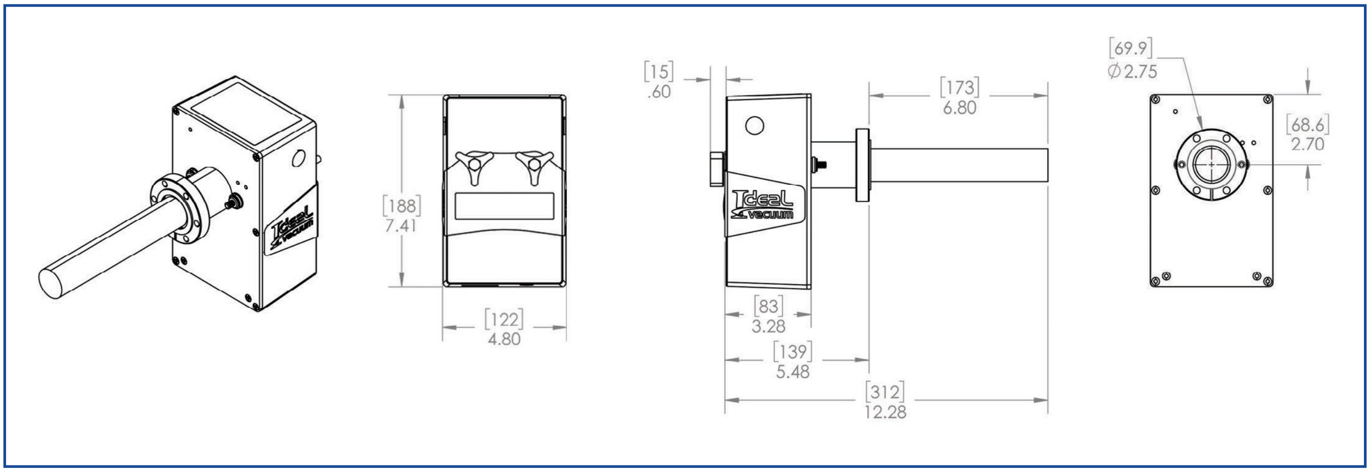


Figure 3 - Bare RGA dimensions

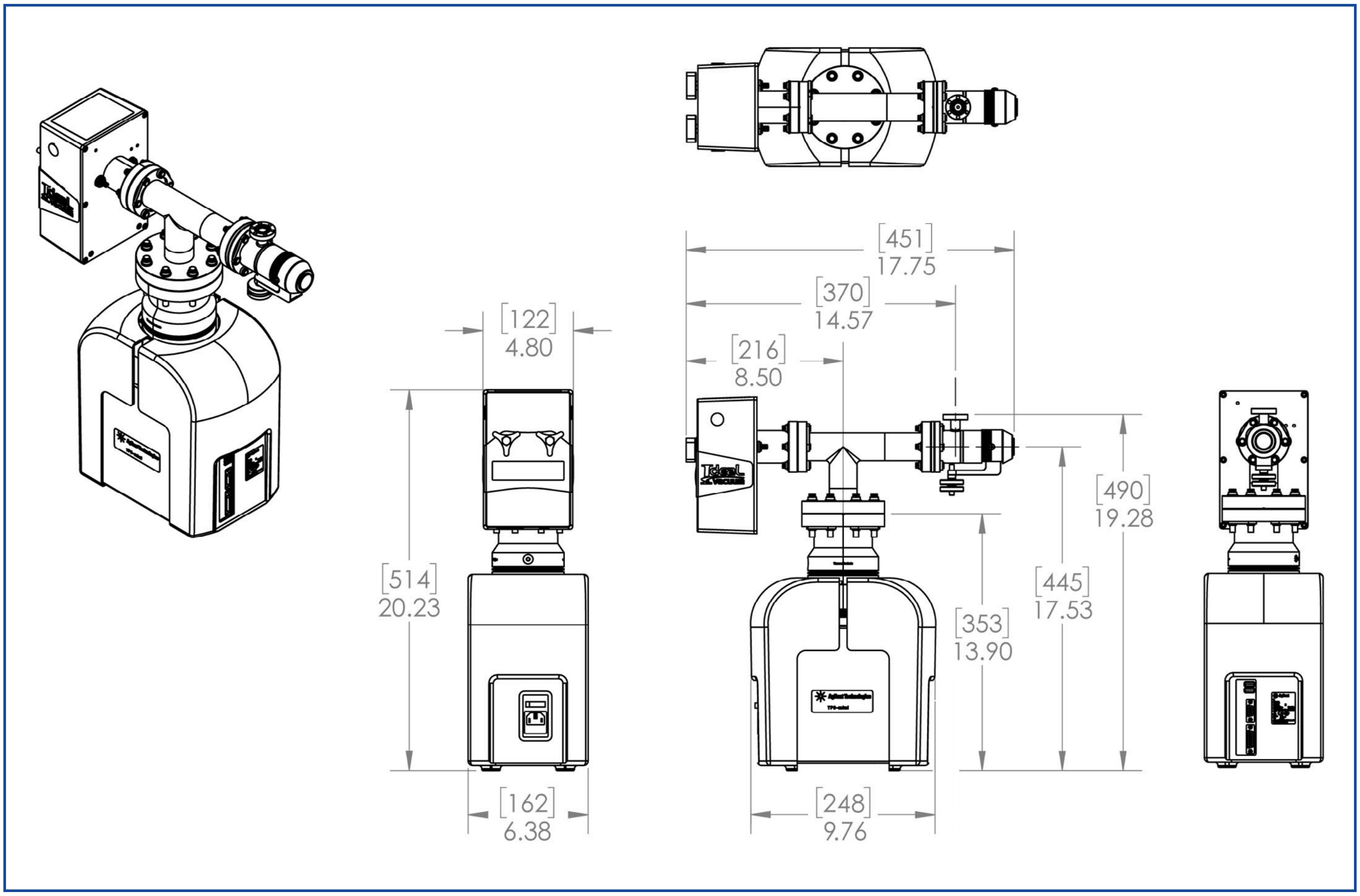


Figure 4 - RGA manual high pressure kit with Agilent TPS-mini dimensions

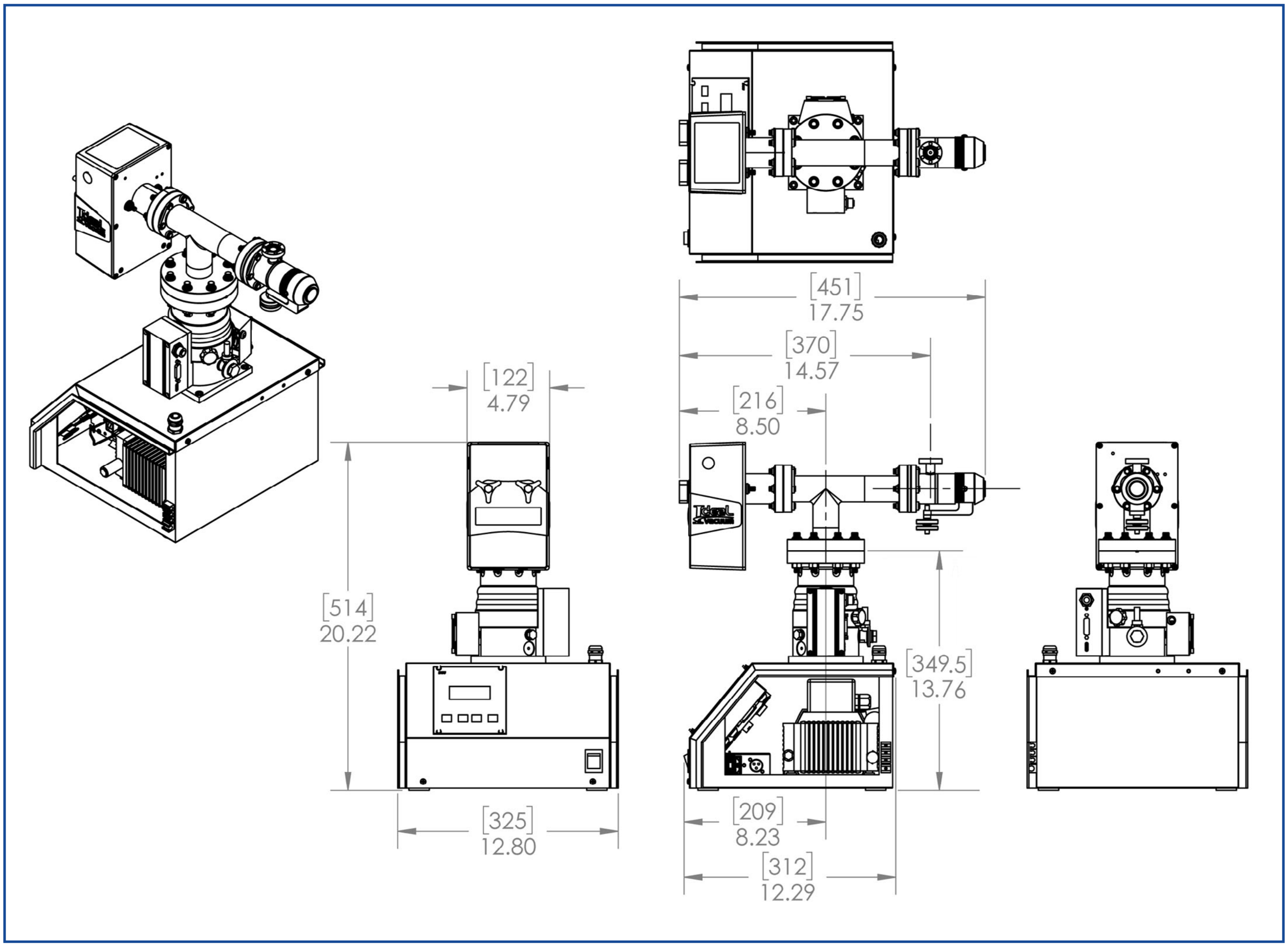


Figure 5 - RGA manual high pressure kit with Pfeiffer HiCube 80 ECO dimensions

1.7 COMPONENT IDENTIFICATION

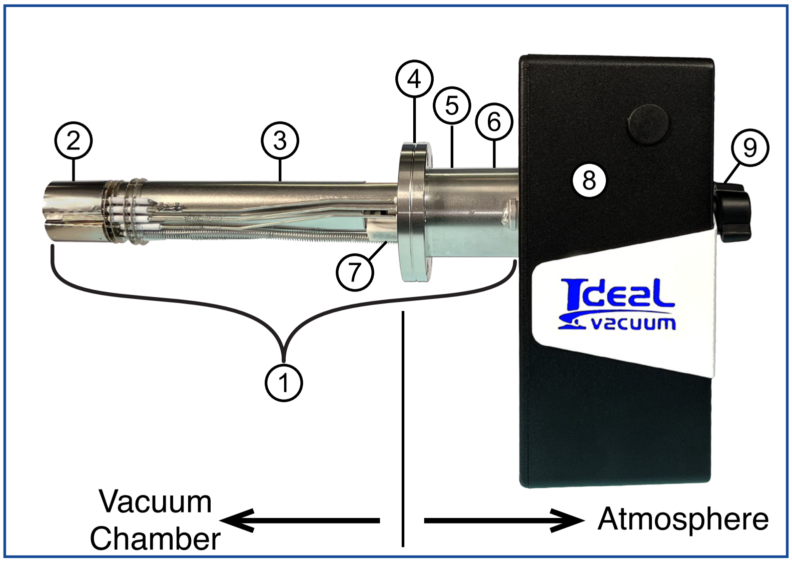


Figure 6 - Bare RGA components

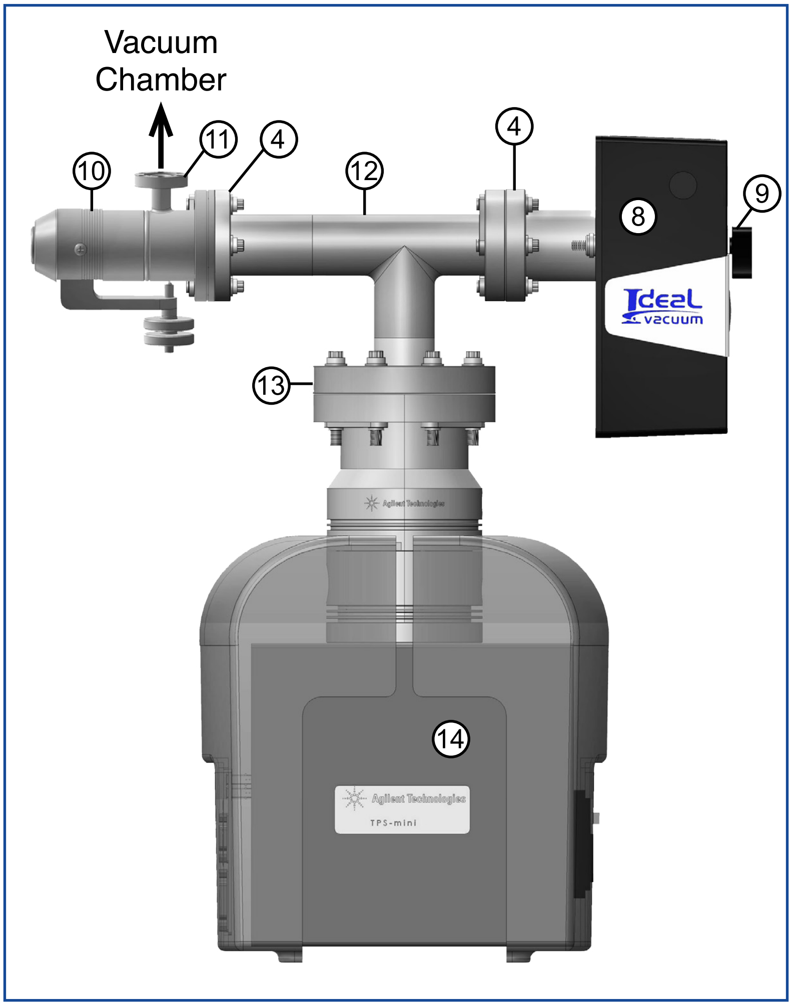


Figure 7 - Manual high pressure RGA kit components

Item	Description
1	Sensor probe
2	Ionizer
3	Quadrupole mass filter
4	CF 2.5" flange
5	Pirani gauge
6	Faraday cup detector
7	Electron multiplier
8	Electronics control unit (ECU)
9	ECU mounting bolts with knobs
10	Agilent variable leak valve CF 2.5" x CF 1.33" (P105211)
11	CF 1.33" flange
12	Probe tee manifold
13	CF 4.5" flange
14	Turbomolecular pumping system with CF 4.5" flange. Choice of either Agilent TPS-Mini with TwisTorr 74FS turbo (P103100 shown), or Pfeiffer HiCube 80 ECO (P103218 not shown).

Table 4 - Bare RGA and RGA high pressure kit parts

1.8 REPLACEMENT PARTS & ACCESSORIES

All replacement probes and probe parts are delivered with a new copper gasket.

Part Number	Description
P1013487	Probe, 1 to 100 AMU, without Electron Multiplier
P1013488	Probe, 1 to 100 AMU, with Electron Multiplier
P1013489	Probe, 1 to 200 AMU, without Electron Multiplier
P1013490	Probe, 1 to 200 AMU, with Electron Multiplier
P1013491	Probe, 1 to 300 AMU, without Electron Multiplier
P1013492	Probe, 1 to 300 AMU, with Electron Multiplier
P1013493	Ionizer, for all AnalyzaVac RGAs
P1013494	Dual thoriated iridium filaments, for all AnalyzaVac RGAs
P1013495	Electron multiplier, for all AnalyzaVacs with electron multiplier
P1013496	Power supply, for all AnalyzaVac RGAs

Table 5 - Replacement parts

Part Number	Description
P1013508	CF 2.75" full nipple, 7" long, through hole flanges
P102227	CF 1.33" flexible bellows tube, 24" long, through hole flanges
P102228	CF 1.33" flexible bellows tube, 48" long, through hole flanges
P102230	CF 2.75" flexible bellows tube, 24" long, through hole flanges
P102231	CF 2.75" flexible bellows tube, 48" long, through hole flanges
P104397	Silver-plated bolt kit for CF 1.33" through hole flanges
P104378	Silver-plated bolt kit for CF 2.75" through hole flanges
P104377	Silver-plated bolt kit for CF 4.50" through hole flanges
P102277	Copper gasket for CF 1.33" flanges
P102278	Copper gasket for CF 2.75" flanges
P102280	Copper gasket for CF 4.50" flanges
P105418	Conflat Gasket Retaining Clip Set
P1011810	Manual 90° right angle bellows valve, CF 1.33" flanges
P1011847	Manual in-line bellows valve, CF 2.75" flanges
P1013504	25 ft. DB-9 serial extension cable, shielded, male-to-female

Table 6 - Accessories

For adapters from CF to other CF sizes, or to a different flange type (i.e., KF, ISO), please visit idealvac.com. Use metal seals for all RGA plumbing connections. Special metal seals are available for KF and ISO flanges adapters.

Because there are substantial diffences in the ECU, it is not possible to simply add an electron multiplier to an RGA without one.

2. PRINCIPLES OF OPERATION

2.1 OVERVIEW

The AnalyzaVac RGA operates by high-energy electron impact ionization of a small fraction of the gas molecules in an evacuated chamber. The resulting positively charged ions, or cations, are directed through a quadrupole mass filter where they are separated by mass-to-charge ratio (m/z) using a combination of varying radio frequencies and DC voltages applied to the quadrupole's four parallel conducting rods.

The positively charged ions travel down the center of the quadrupole and are either amplified by an electron multiplier or detected directly by a faraday cup detector at the end of the probe. The faraday cup measures the electron current generated by the ions of each selected mass-to-charge ratio. The electron current generated of each mass is then converted mathematically to a partial pressure and a spectrum is produced over the range of atomic masses scanned.

Each gas produces a unique spectral fingerprint which is a combination of the natural isotopic abundance of its elements and molecular fragmentation (cracking) caused by the RGA's high-energy electron ionization. The amplitude of the current, or height of the partial pressure peaks, for each ion helps to determine the type and relative abundance of a particular gas species.

In order for the RGA to produce quality partial pressure scans, the chamber pressure must be low enough (around 10^{-6} Torr) so that the mean free path of the ions make it unlikely they will collide with other gas molecules before they are filtered through the quadrupole and detected by the Faraday cup. Furthermore, if the RGA is exposed to higher pressures of chemically active gases for prolonged periods of time, deteriorization of the ionizer, filament and quadrupole mass filter will occur. Even water vapor will eventually oxidize the filaments causing inaccurate readings and ultimately filament failure.

2.1 IONIZER

The ionizer, located at the tip of the probe, is where electrons ionize gas molecules. Figure 8 is an actual photograph where its main components are identified. Figure 9 is a simplified drawing illustrating the same components.

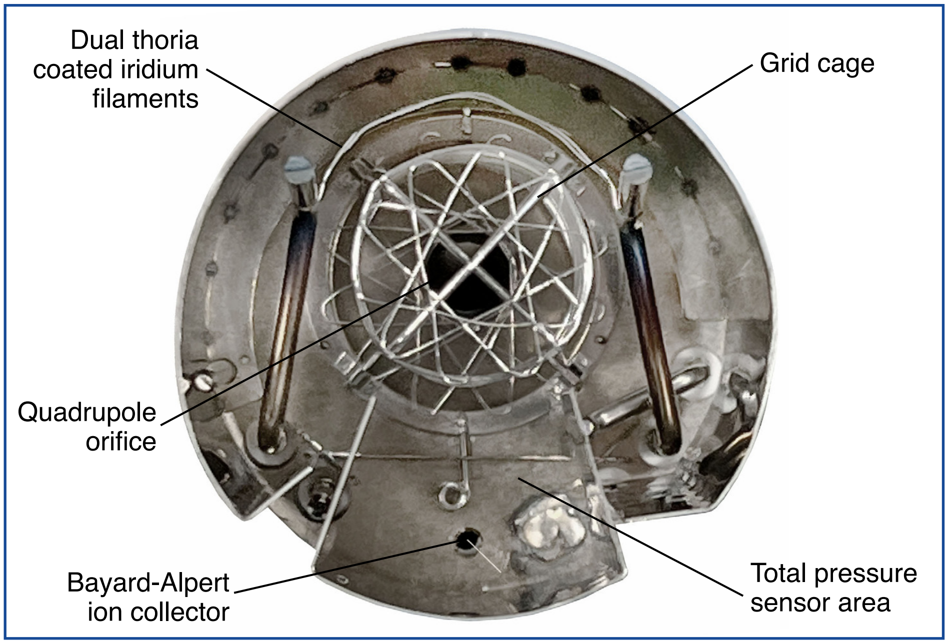


Figure 8 - Probe ionizer photograph, top view

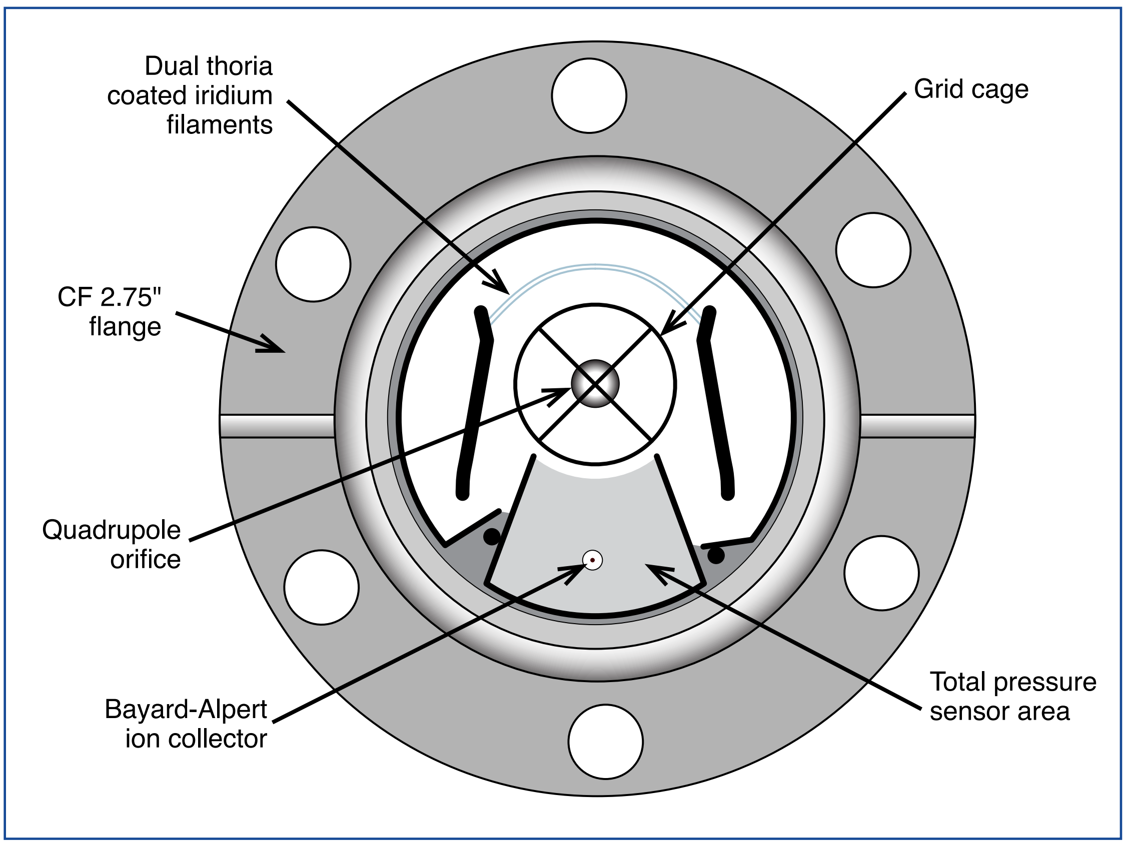


Figure 9 - Probe ionizer, simplified drawing, top view

2.1.1 MEASUREMENT OF TOTAL AND CORRECTED PRESSURE

The AnalyzaVac RGA has a built-in enhanced Pirani and a Bayard-Alpert ion gauge for total chamber pressure measurements and to determine when it is safe for the ionizer filament to be energized.

The AutoZ$^+$ software is factory set to an upper pressure limit of 1 x 10^{-4} Torr (user adjustable) before the ionizer can be turned on.

The enhanced Pirani gauge, located at the flange end of the probe, measures from atmospheric pressure to about 10^{-4} Torr (Figure 6, item 5, p. 13). It is on whenever power is applied to the ECU.

The Bayard-Alpert gauge, located in the ionizer's total pressure sensor area, produces accurate measurements between 5 x 10^{-3} Torr to 2 x 10^{-10} Torr (the X-ray limit).

Both gauges are factory calibrated for pure nitrogen gas, which is within 5% the same as air. Other gases, such as pure argon, can cause inaccurate pressure readings. When the RGA is scanning, the AutoZ$^+$ software automatically applies gas correction factors for the other gases (that it can identify) to produce more accurate "corrected" chamber pressure measurements.

Figure 10, below, illustrates how the Bayard-Alpert gauge works.

When the pressure is sufficiently low, the dual thoria coated iridium filaments are energized with a negative voltage (−) and emit electrons (e^-). The generated electrons are attracted to the positively biased grid cage made of thin wires (+). Since the electrons are fast moving and of small size, a large majority pass through the grid into the total pressure sensor area (shown in light gray). Gas molecules in this area are ionized by electron impact (R^+). The Bayard-Alpert ion collector (gauge) in the center of the total pressure area is a small, negatively biased wire (−). The positively charged ions are attracted to and captured by the wire producing a current. This ion current is directly proportional to the total pressure of all the residual gases in the chamber.

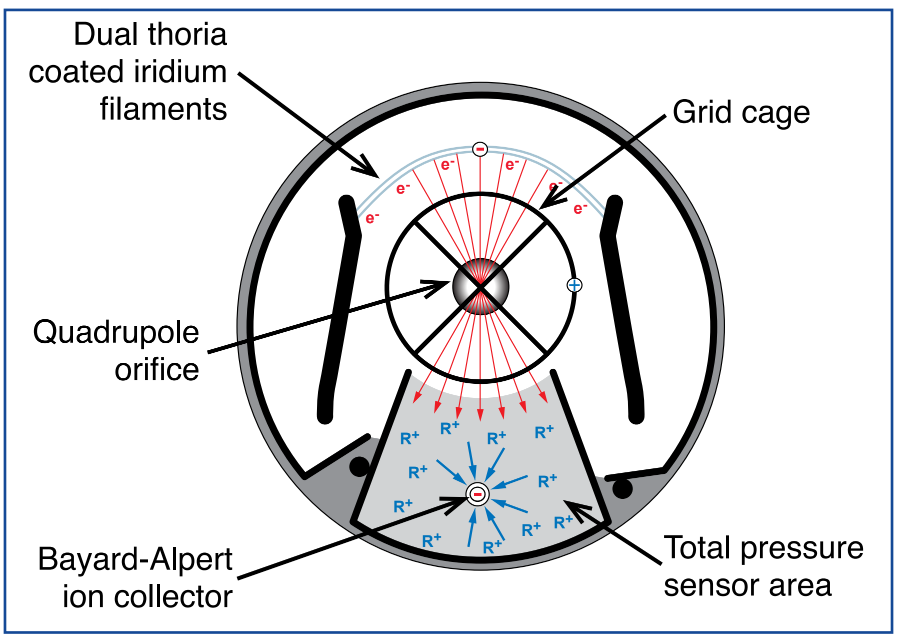


Figure 10 - Total pressure measurement with the Bayard-Alpert gauge

2.1.2 IONS ARE DIRECTED INTO THE QUADRUPOLE

While most of the electrons generated by the ionization filament pass through the grid cage to ionize the gas molecules in the total pressure sensor area, a small percentage of them ionize the gas molecules inside the grid cage.

The electrons collide with the gas molecules in the cage with sufficient energy to strip one or more electrons from them creating a variety of ions (**R^+**).

In addition to multiple ionization, this electron impact ionization can also produce molecular fragmentation of the parent molecules resulting in ions with smaller masses.

The rate and type of ions produced depends on the gas pressure, temperature, species of the individual molecules, and the electron energy.

The positively charged ions within the grid cage tend to remain inside the cage and congregate towards its central axis, being repelled inward due to the cage's positive bias.

Repelled by the positive cage voltage and attracted towards the negatively biased Faraday cup detector on the opposite end of the probe, these caged ions are propelled through the orifice in the center of the grid cage and into the quadrupole mass filter.

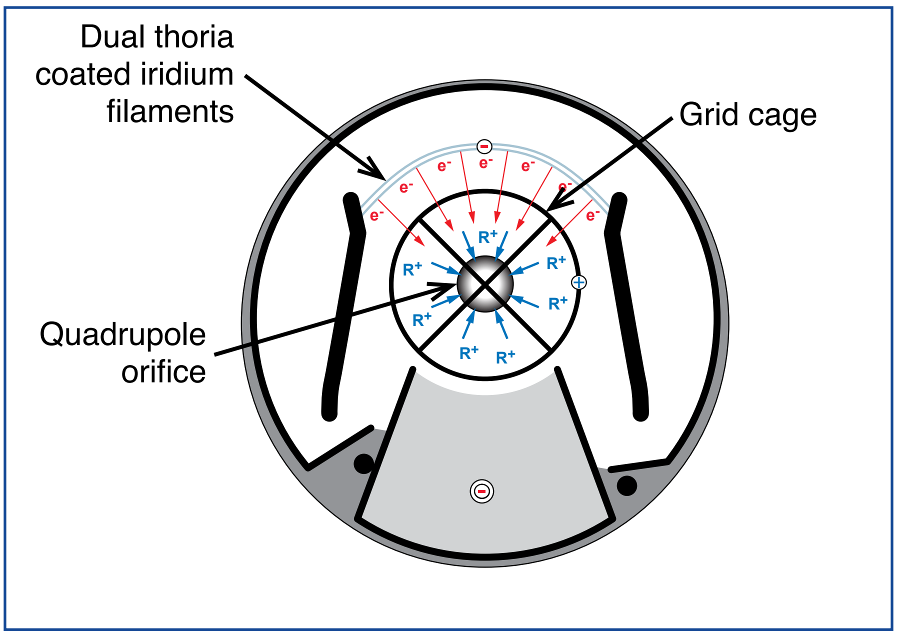


Figure 11 - Ions are directed into the quadrupole

2.2 QUADRUPOLE MASS FILTER

The quadrupole mass filter is constructed of four precision machined 304 stainless steel electrodes (rods) which are precisely separated and aligned parallel to each other with very tight tolerances. The electrodes are paired and connected together electrically.

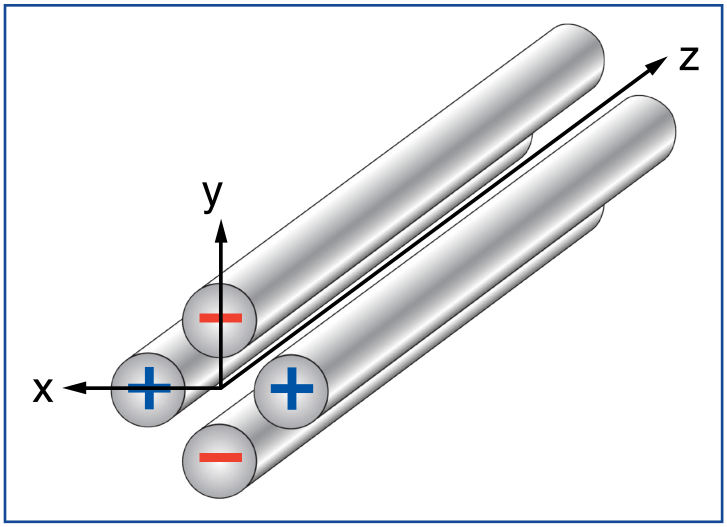


Figure 12 - Paired quadrupole electrodes

Each pair of electrodes receives a combination of DC and radio frequency AC voltages. In Figure 12, above, the pair of electrodes in the x-z plane are positively biased. Most of the time these electrodes are electrically positive. In the y-z plane, they are negatively biased at the same intensity. The quadrupole electrical connections can be seen in Sec. 4.5, Step 12, p. 36.

As ions enter the quadrupole filter they begin oscillating in the x- and y- directions, resulting in a spiral ion path as they travel through the quadrupole.

When the oscillating electrical field created by the voltages on the two pairs of electrodes is just right, ions of a particular mass-to-charge ratio move through the quadrupole in a stable trajectory and are collected at the Faraday cup detector at the other end. All other ions of differing mass-to-charge ratios have an unstable trajectory and are rejected out of the quadrupole.

By varying the DC and RF voltages, each mass-to-charge ratio in the quadrupole range can be selected to pass through the quadrupole gauntlet and be detected by the Faraday cup. By scanning across many masses and collecting many points, a scan of a entire mass spectrum is obtained.

The AutoZ+ software allows the user to adjust the scan parameters such as the range of masses to be scanned, the resolution, and the scan speed. These parameters are sent to the ECU where the complex DC and RF voltages needed for scanning are calculated and automatically applied.

The amplitude of the spectral peaks shows the relative quantities of individual ions. Determination of the specific gases which produce those peaks is up to the user to interpret. The basic version of AutoZ+ assists the user to determine the concentration (partial pressures) of the twelve most common gases found in vacuum chambers. Premium AutoZ+ includes more than 80 additional gases and allows the user to add gas spectra specific to their processes.

2.3 FARADAY CUP DETECTOR

The Faraday cup detector is located at the end of the quadrupole in the probe's base and is normally negatively biased (Figure 6, item 6, p. 13). Ions of a specific mass-to-charge ratio that make it through the quadrupole strike the Faraday cup. This creates an ion current proportional to the abundance of that ion. A measurement of the current generated by each ion is sent to the ECU where it is converted into a partial gas pressure, reported to the software, and graphed.

2.4 ELECTRON MULTIPLIER (OPTIONAL)

The electron multiplier converts the positive charge of an ion into a much greater electron current. A typical gain of 10^3 is used for most applications (adjustable in software). This amplification in signal strength allows for faster scans with the same signal-to-noise ratio and much increased sensitivity. This is particularly useful when there are very low concentrations of gases whose ions cannot be separated from the noise floor of the machine.

The electron multiplier is mounted between the end of the quadrupole and the Faraday cup on RGAs equipped with the -EM option. It is a curved, tapered tunnel, coated on the interior with resistive leaded glass. Along its exterior, a large negative voltage is applied at its mouth that attracts positive ions and produces a bias voltage that becomes less negative towards its tail end due to the resistance of the glass. The Faraday cup's voltage is switched to positive when the multiplier is in operation.

When enabled (in software), positive ions are drawn into the multiplier's mouth by the large negative voltage. An ion strike on the glass coating at the multiplier's mouth causes multiple secondary electrons to be emitted. Each secondary electron is accelerated towards the opposite side of the tunnel. Each successive electron strike yields several more secondary electrons. Within a millisecond, a cascade of electrons is generated and repelled out of the multiplier where they impact on the positively biased Faraday cup. The result is an electron current of far greater magnitude (absolute value) than produced by the original ions directly striking the Faraday cup.

The electron multiplier is best used at or below 10^{-7} Torr. At higher pressures and voltages, its useful lifetime is decreased dramatically. Even under optimal conditions, its gain decreases over time and should be checked regularly. As it ages and its gain decreases, a higher voltage must be used for the same amplification. Eventually the ECU cannot supply the multiplier with enough power to maintain the desired signal strength and the multiplier must be replaced (Sec. 1.8, p. 14). The actual electron multiplier can be seen in Sec. 4.9, Step 26, p. 45.

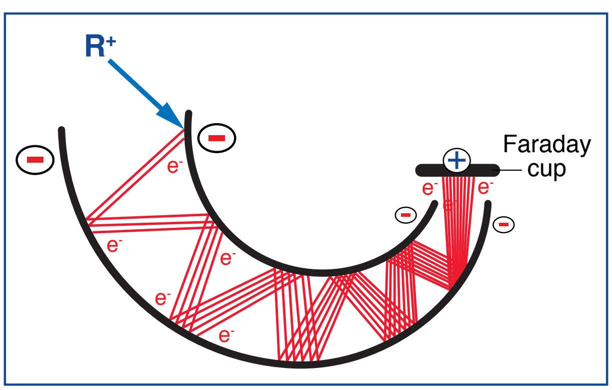


Figure 13 - Electron multiplier operation

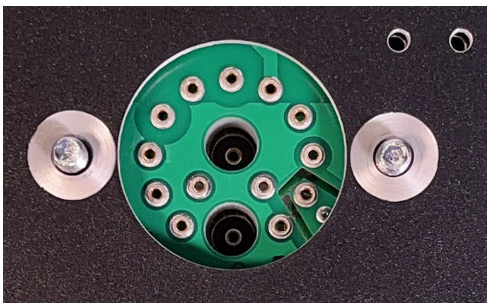
3. INSTALLATION

3.1 ASSEMBLE THE BARE RGA

- **The bare RGA comes as a kit which must be assembled.**
- **WEAR GLOVES! DO NOT TOUCH THE PROBE WITH BARE HANDS!**
- **Handle the RGA probe gently by the flange. It is fragile.**
- **Use metal sealing gaskets for all RGA fittings and connections.**

Unpack all the RGA parts except for the probe. It is shipped in a custom shock absorbing vacuum formed plastic container. Leave the probe it in its packaging until it will be installed.

On the back of the ECU is recessed circular green circuit board connector. The back of the probe (flange end) has the mating plug.



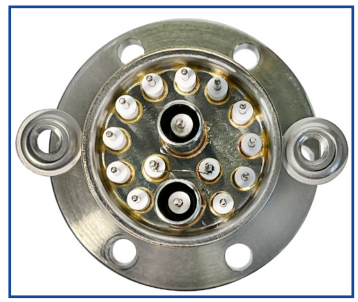


Figure 14 - ECU connector and probe plug

Align the two larger coax pins, and very carefully plug the probe into the ECU. Make sure to plug it in straight so the pins don't get bent. It may need a bit of wiggling.

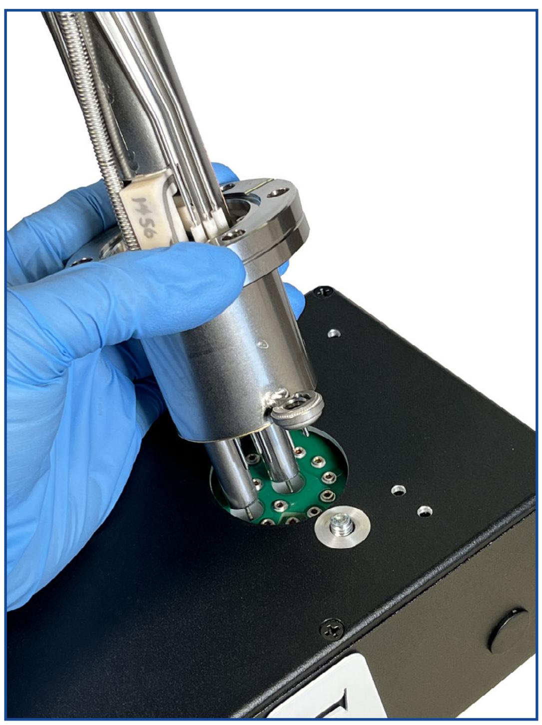


Figure 15 - Plug probe into ECU

Make sure the probe is fully seated in the ECU.

Figure 16 - Probe inserted fully into ECU

Finally, screw in the probe retaining knobs from the front of the ECU.

Figure 17 - Screw in probe retaining knobs

3.2 CONNECT THE BARE RGA TO A CHAMBER

The probe is best mounted so the probe is horizontal. For maximum RGA performance, all plumbing connections between the RGA and chamber should use metal seals (copper, silver, or gold plated). For proper techniques to ensure leak-tight CF vacuum connections refer to Sec. 3.4, p. 27.

The bare RGA may be mounted directly to a CF 2.75" port on the chamber with the bare probe extending into the chamber (about 7"). This is an acceptable mounting solution when the chamber is used only for ultra-high vacuum processes or experiments which do not use or create contaminants that could become deposited on the probe. In most cases, this method is not recommended and could lead to premature probe damage or failure.

The probe requires a vacuum flange with a minimum 1.375" inside diameter. In all cases, make sure that the probe does not touch any part of the chamber, flanges, or vacuum lines when mounted. The probe has a pair of anti-shorting rings behind the ionizer. These help to keep the probe wires from touching anything else.

CAUTION

DO NOT MODIFY THE PROBE IN ANY WAY!
If any part of the probe other than the anti-shorting rings touches any part of the chamber, flanges, or vacuum lines when powered, it can cause an electric shock, and/or the probe can short out and require expensive replacement.

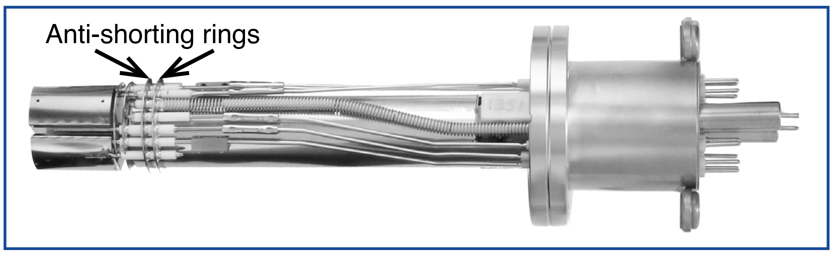


Figure 18 - Anti-shorting ring location on probe

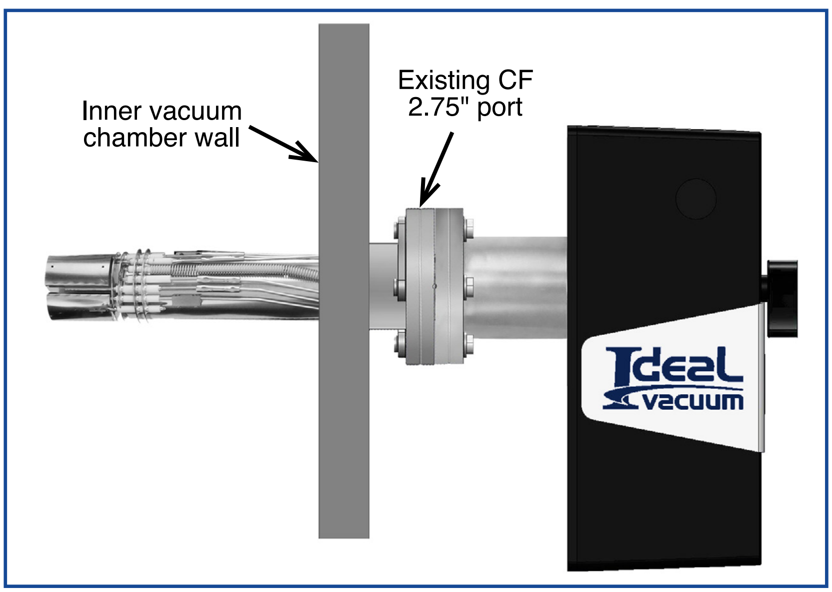


Figure 19 - RGA connected directly into chamber port

For nearly all situations, it is best to mount the RGA so that the probe does not extend into the chamber. Attach a 7" long CF 2.75" nipple over the probe (part number P1013508).This protects the probe from inadvertent damage if it is bumped when objects are placed or removed from the chamber. Moreover, a nipple which fully encases the probe ensures it cannot get short circuited by direct contact, and minimizes contamination of the probe caused by direct deposition.

To further separate the probe from undesirable process exposure, it is recommended to add an inline manual bellows isolation valve between it and the chamber when first installing the RGA (part number P1011847). With a bellows valve installed and closed, pump down the clean chamber to high vacuum without anything inside. Open the valve. This will momentarily raise the vacuum pressure. When the pressure stabilizes, close the valve. The RGA should now be kept under high vacuum at all times, including during chamber venting and pump down, when test objects are exchanged, and especially during dirty processes that create large amounts of contaminants. Once the chamber is at high vacuum, the manual valve may be opened and the RGA safely operated.

Note that the valve's preferred orientation is with the sealing port towards the RGA.

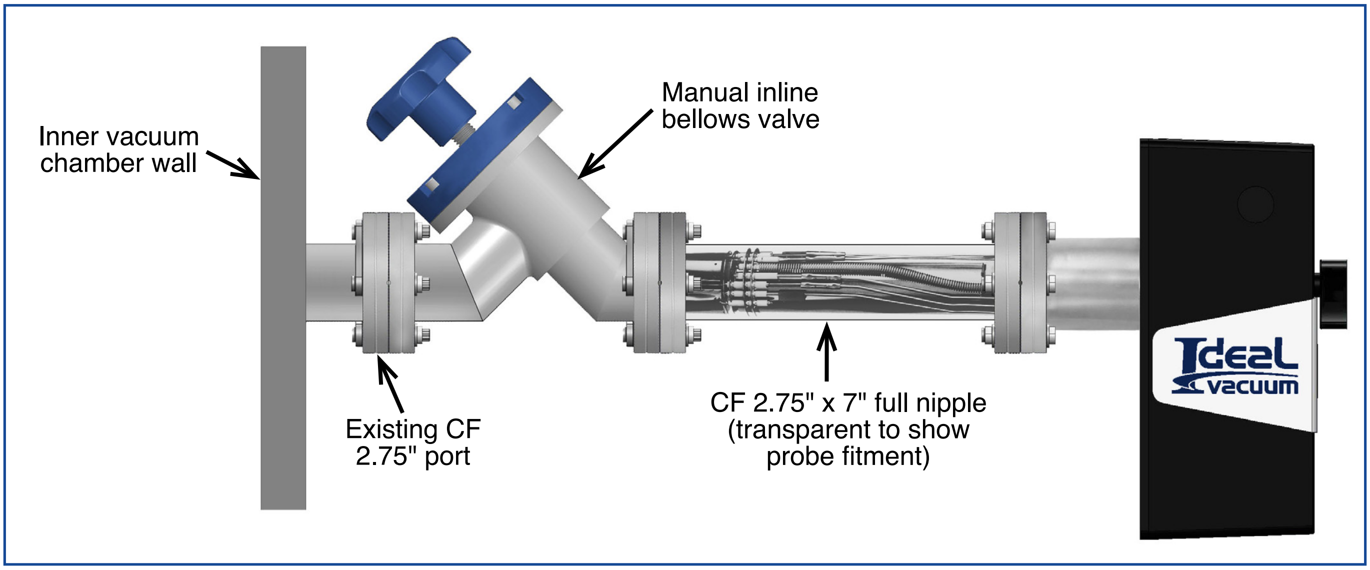


Figure 20 - Recommended bare RGA kit configuration with nipple and bellows valve

3.3 CONNECT THE MANUAL HIGH PRESSURE KIT TO A CHAMBER

An AnalyzaVac manual high pressure kit allows the RGA to operate safely from high vacuum to pressures up to 1000 Torr. Manual kits include their own mini pumping station. It is comprised of a small roughing diaphragm pump connected to a turbo pump with a CF 4.5" inlet. A tee manifold with CF 4.5" flange connects to the turbo inlet. Smaller CF 2.75" flanges on either end of the manifold connect to the RGA on one end, and to a variable leak valve on the other. The leak valve has a CF 1.33" input flange for connection to the vacuum chamber (Figure 21, below).

While the pumping station is on, the valve is adjusted so that the RGA is under high vacuum even while the chamber is at a higher pressure. The leak valve allows miniscule amounts of chamber gases to reach the RGA through a bellows tube. This allows the RGA to safely measure residual gases for processes performed under rough vacuum or even at ambient atmosphere. Because the RGA is isolated from the chamber through the leak valve, most processes should not contaminate the probe. It is possible, however, for very dirty processes to clog the small leak valve orifice.

To keep the probe always under vacuum, and to keep from having to regularly adjust the leak valve, it is recommended to add a right angle CF 1.33" manual bellows isolation valve between it and the chamber (part number P1011810).

With the leak valve (and the optional isolation valve) installed and closed, pump down the clean chamber to the normal operating pressure of the experiment or process. Open the bellows valve. Then, slowly crack the leak valve (open is counterclockwise). This may momentarily raise the chamber vacuum pressure. When the chamber pressure stabilizes, adjust the leak valve so that the total gauge pressure reading is about 2 x 10^{-7} Torr, the RGAs optimal operating pressure.

If no isolation valve is installed, it will be necessary to close, then open and readjust the leak valve each time the chamber is cycled. When a bellows valve is installed, closing it will keep the RGA at optimal pressure even when the chamber is cycled during object exchanges. This is especially useful for dirty processes that create large amounts of process contaminants during pump down. Once the chamber is back to its normal operating pressure, the manual valve is reopened and the RGA can be safely operated. No adjustment of the leak valve is required. Please download and read the Agilent leak valve user manual or find it on the USB drive included with the RGA.

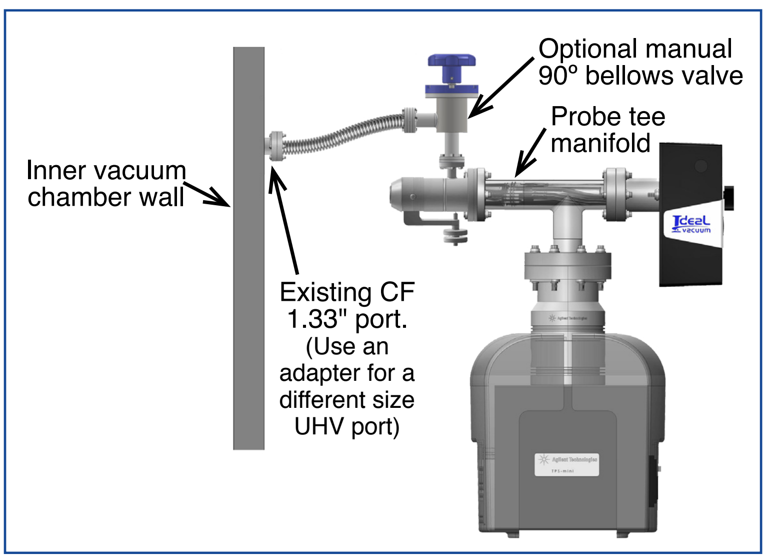


Figure 21 - Recommended high pressure kit configuration

3.3.1 HIGH PRESSURE KIT LATENCY

When using a high pressure kit with the RGA, the variable leak valve introduces latency, or a time gap, between the introduction of a gas into the sample chamber to when the gas is first observed at the RGA, and when the partial gas pressure in the RGA becomes stable. These conditions are observed using the AutoZ+ intensity graph (AutoZ+ User Manual, Sec. 3.3.4, p. 25).

The latency duration is a function of the leak valve orifice size, the gas species, and the relative magnitude of the gas pressure introduced into the sample chamber compared to the sample chamber pressure.

The figure below shows latency duration from tests where a small quantity of helium was injected into a nitrogen filled chamber. When the sample chamber was at medium-to-high vacuum, the orifice was wide open and the latency was short - just a few seconds. As the sample chamber pressure was increased towards atmospheric pressure, the valve had to be increasngly more closed to maintain optimal RGA pressure and the latency was much longer - as long as 10 minutes for first detection and 50 minutes to fully stabilize.

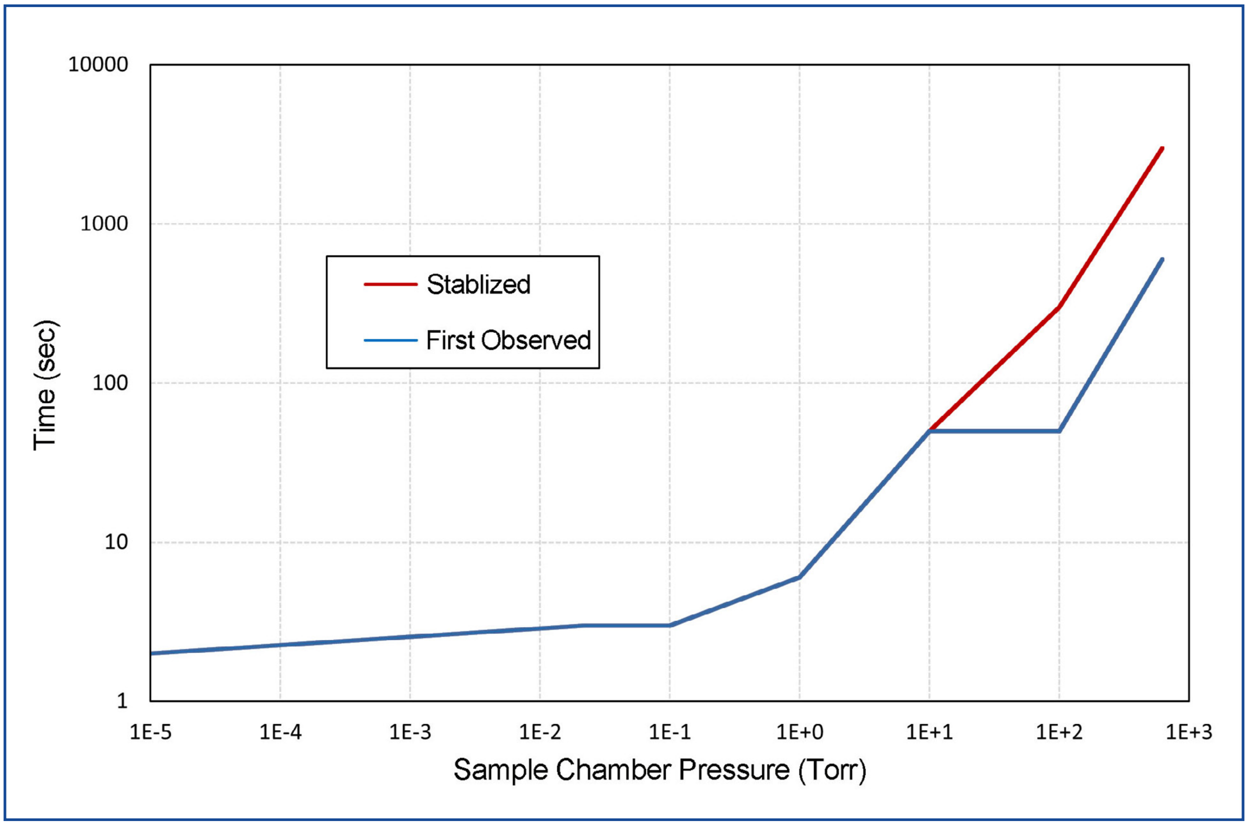


Figure 22 - High pressure kit latency duration over sample chamber pressure

3.4 MAKING LEAK-TIGHT CF CONNECTIONS

It is vital that all fitting connections be properly assembled for leak-tight seals. Using the proper technique and tightening to the proper torque is more critical on CF connections than on other flange types since metal seals are less forgiving than O-ring seals.

For all CF flange connections, it is crucial to tighten bolts gradually and equally around the flange so that they are brought together parallel to each other. Bolts are all started and made hand tight initially. Then, using a torque wrench, bolts are each tightened by 1/8 to 1/4 turn until each bolt receives the correct torque. This can take as many as 8 or 10 “passes” around the tightening pattern. Tightening below or beyond the correct torque specification can cause an imperfect seal and create a vacuum leak.

A “star” or “cross” pattern of tightening is used (Figure 23). This is similar to tightening the lug nuts on a car. This simply means tightening opposing bolts while working around the flange. The higher the vacuum, the more important it is to use the proper tightening technique. When fittings are improperly tightened, seals get damaged and the likelihood of achieving a leak-proof seal is significantly reduced. Note that there will be a small gap between CF flange faces when torqued to the correct tightness.

Figure 23 - Six hole tightening pattern (CF)

CF Size (Flange OD)	Bolt Kit PN	Nominal Tube OD (in.)	# Bolt Holes	Bolt Size (inch)	Torque (lb-in)
1.33”	P104397	0.75	6	8-32	28
2.75”	P104378	1.5	6	1/4-28	110
4.5”	P102280	2.5	8	5/16-24	190

Table 7 - CF flange basic technical information

More information about fittings and assembly techniques is available in this white paper:
idealvac.com/files/manuals/Common_Vacuum_Fittings-Selection_and_Assembly_Guide.pdf

The example below illustrates how to join two smooth bored CF flanged fittings. It is imperative to use a torque wrench to tighten the bolts in a star pattern and to correctly torque each bolt.

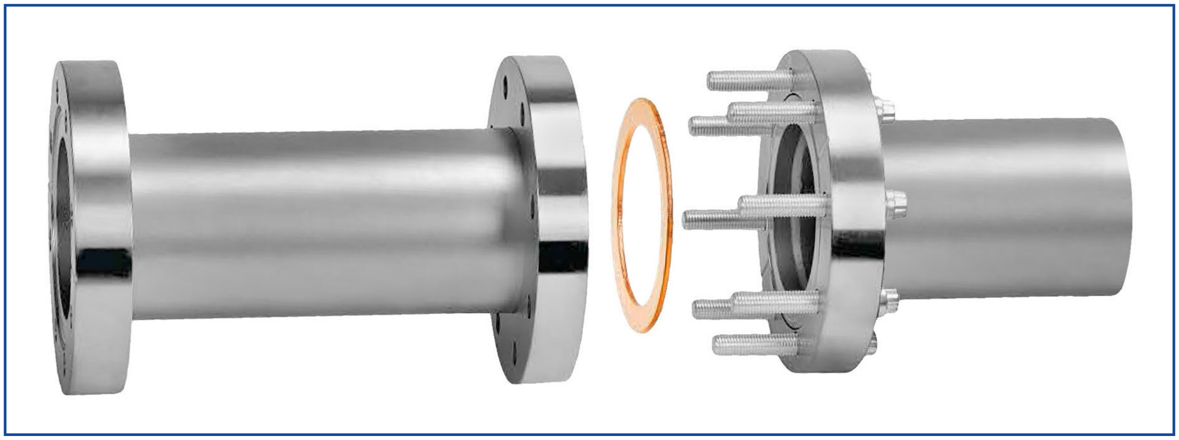


Figure 24 - Bring CF flanges together with copper gasket in between

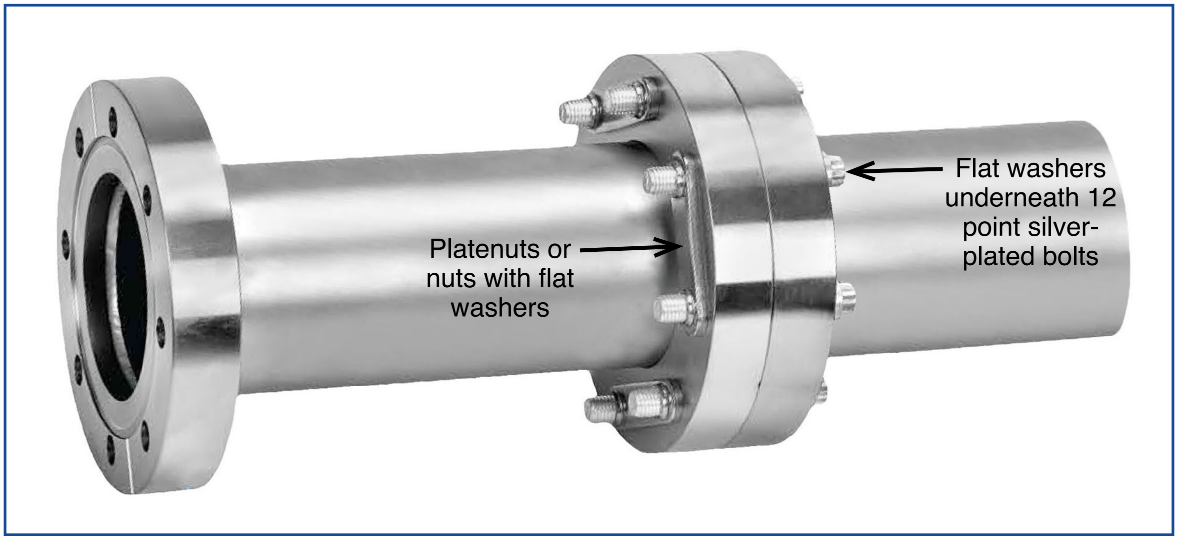


Figure 25 - Fasten CF flanges with silver-plated,12 point bolts, washers, and nuts

To help keep gaskets (metal or O-ring) in place during assembly, gasket clips can be used (part number P105418). These clips fit into the CF flange's leak detection slots and hold the gasket centered on the flange's knife edges.

Figure 26 - CF gasket retaining clips

3.5 POWER AND COMMUNICATION CONNECTIONS

Once the bare RGA or RGA kit is assembled and plumbed to the chamber, the power and communication cables may be connected to the RGA and to a computer. The connections are on the bottom of the ECU box.

Get the gray 25' serial cable, the USB to serial adapter, the power supply and the power supply power cord from the box.

Connect the male 15 pin serial plug into the bottom of the ECU. Connect the USB adapter to the other end of the gray cable and plug it into the computer.

Plug the power supply's barrel plug into the power connector on the ECU. Plug the power wire into the power supply and plug it into a convenient wall outlet.

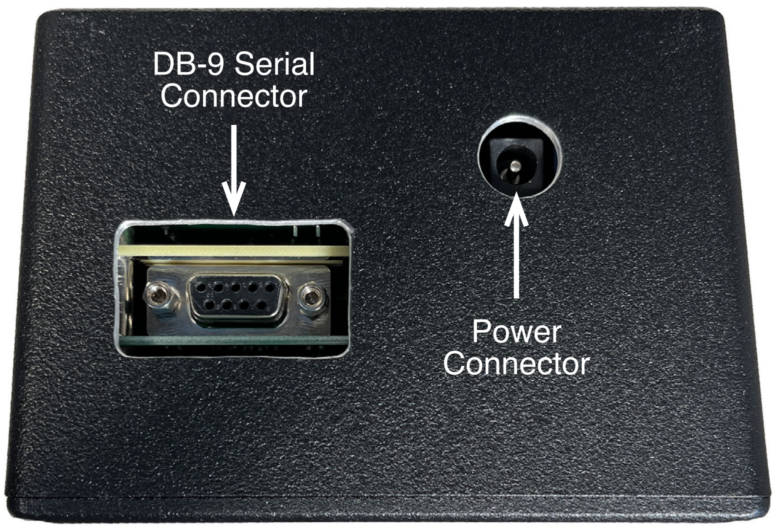


Figure 27 - Power and serial connections, bottom of ECU

On the manual high pressure kit, plug the power cord into the mini-task pumping station and the other end into a wall outlet.

Get the USB drive from the box.

Follow the installation instructions in the AutoZ± User Manual to install the software onto the computer.

After the software is installed, the RGA and pumping station may be energized.

4. SERVICING THE RGA

AutoZ+ software continually monitors the RGA to ensure that it is functioning correctly. If an issue arises, the software informs you with a notification and provides information about what is needed to correct it. Over time, parts wear or become contaminated and must be replaced. Degassing and bakeout can extend the useful life of the probe and its parts. Try degassing the ionizer first. If the results are unsatisfactory, try baking out the probe.

The complete probe, ionizer filament, complete ionizer assembly, and electron multiplier are replaceable parts (Sec. 1.8, p. 14). All replacement probe parts include a new copper gasket. A new gasket must be used anytime the RGA is unbolted from the vacuum system. Any time a part is replaced, the RGA should be recalibrated.

Whenever handling the probe, or replacing parts, **WEAR GLOVES**. Contamination from fingerprints remains for a long time making it difficult to properly calibrate or get good results from the RGA.

4.1 REPLACE THE COMPLETE PROBE

The probe replacement comes complete with a new ionizer assembly and filament. If replacing the probe, unscrew the two bolts which secure it to the ECU (Fig. 17, p. 22).

Then, carefully pull the probe out of the ECU connector. It may require a little side-to-side motion to separate it.

Follow the probe installation instructions in Chap. 3, p. 21.

4.2 REPLACE OTHER PARTS - BEFORE YOU BEGIN

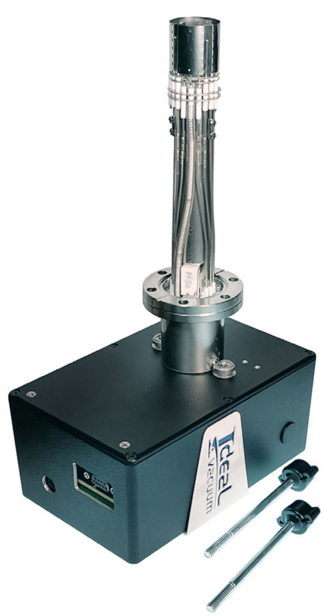
To replace individual probe parts, remove the RGA from the vacuum system.

Remove the two thumbscrews that hold the probe onto the ECU (Fig. 17, p. 22).

Place the RGA on the ECU (probe up) onto a flat surface.

Tools required:

- Gloves
- 0.050" hex wrench
- large paper clip
- steel dental pick
- Strong tweezers
- long nosed pliers



4.3 REMOVE THE FILAMENT

STEP 1

Get the 0.050" hex wrench.

Loosen the top set screw on the barrel connector that secures the first filament conductor.

STEP 2

Loosen the other top set screw on the other barrel connector.

STEP 3

Get the tweezers or long nose pliers.

From inside the ionizer, begin pulling on one filament conductor, then the other.

STEP 4

Work back and forth until the filament can be grabbed with your hands.

Remove the filament completely from the ionizer and discard it.

If replacing the filament only, skip to Sec. 4.8, Step 20, p. 42.

If replacing the ionizer assembly proceed to Step 5 (next page).

4.4 REMOVE THE IONIZER ASSEMBLY

STEP 5

If replacing the ionizer assembly, the filament must be removed first. Begin at Step 1 (p. 31)

Get the 0.050" hex wrench.

Loosen the bottom set screw on the first barrel connector.

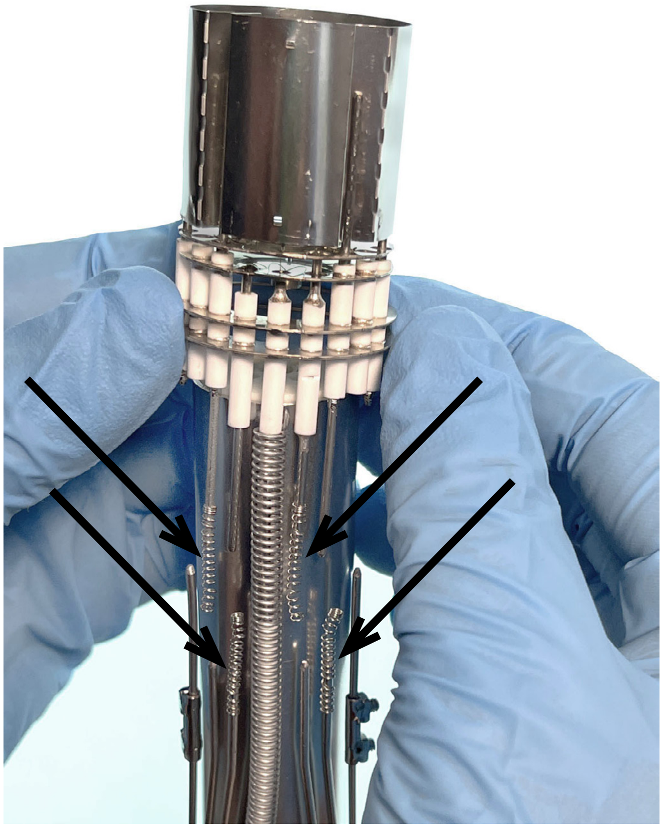
Stabilize the hard wire with both hands to keep it from bending.

Let the barrel connector slide down the wire towards the ECU.

STEP 6

Loosen the bottom set screw on the other barrel connector.

Let the barrel connector slide down the hard wire towards the ECU.



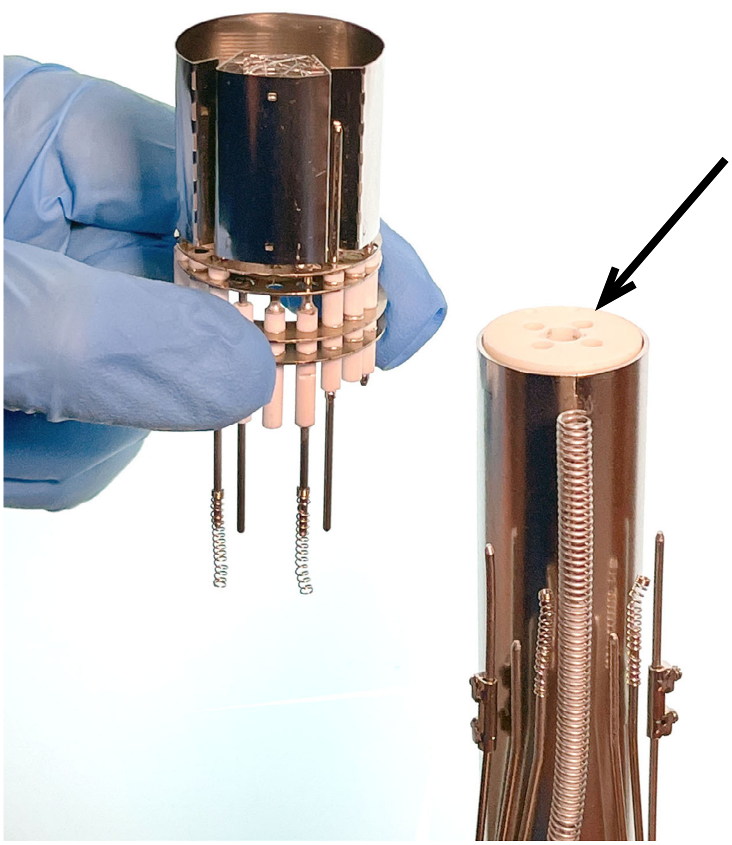
STEP 7

Grasp the ionizer assembly with both hands at the anti-shorting rings and gently pull upwards.

Wiggle and gently twist the ionizer to release the 4 springs that attach it to the hard wires.

Use tweezers if needed to help release the springs.

Note: 2 of the springs are firmly attached to the probe's hard wires.



STEP 8

Lift the ionizer assembly off the probe end. This exposes the ceramic disk at the end of the quadrupole.

If the ionizer is to be reused, put it aside.

If it is to be replaced, remove the two springs if they are still attached. They are reused on the new ionizer.

Discard the old ionizer.

If the quadrupole does not need cleaning, proceed to Sec. 4.7, Step 17, p. 40.

4.5 REMOVE AND CLEAN THE QUADRUPOLE

STEP 9

If the quadrupole needs to be cleaned, it must first be removed from the probe tube.

Get a large paper clip and straighten it.

Put a bend in it, then run it through the center hole of the ceramic disk and out the side notch of the probe.

STEP 10

Bend the paperclip into a circle.

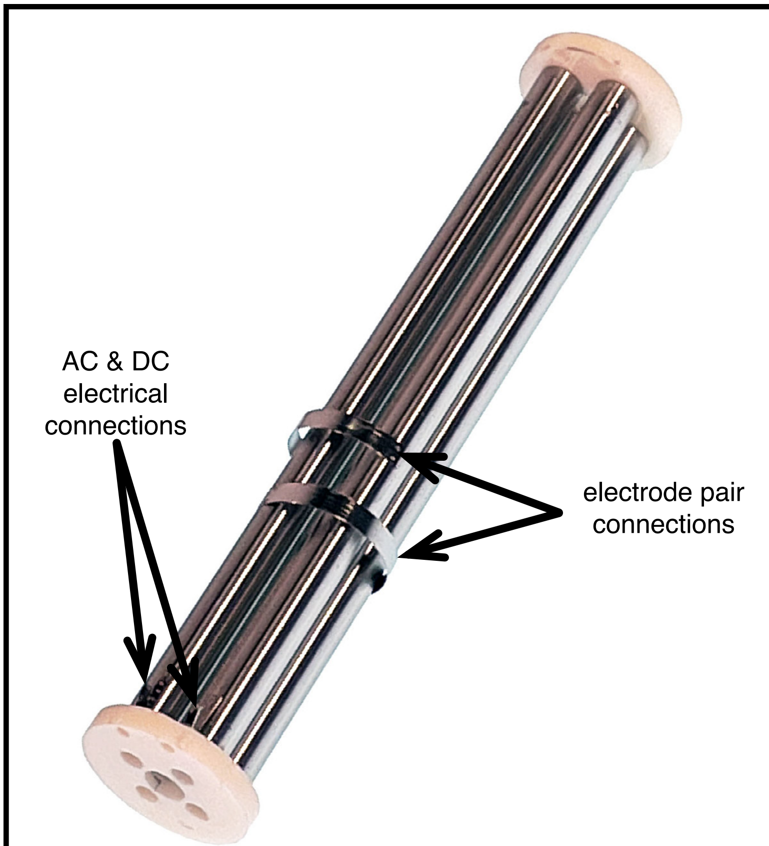
STEP 11

Hold the RGA down with one hand.

Grasp the paperclip with the other hand.

Firmly and steadily pull and twist the quadrupole out of the probe tube.

Note: The quadrupole can be fairly tight. Do not attempt to jerk or yank it out of the tube.



STEP 12

Once the quadrupole is separated from the probe, the electrical connections can be seen.

At the end of the quadrupole are the two electrical connections that supply the AC and DC voltage to it.

Towards the quadrupole center, the two circular bands connect the opposite pairs of electrodes (rods).

STEP 13

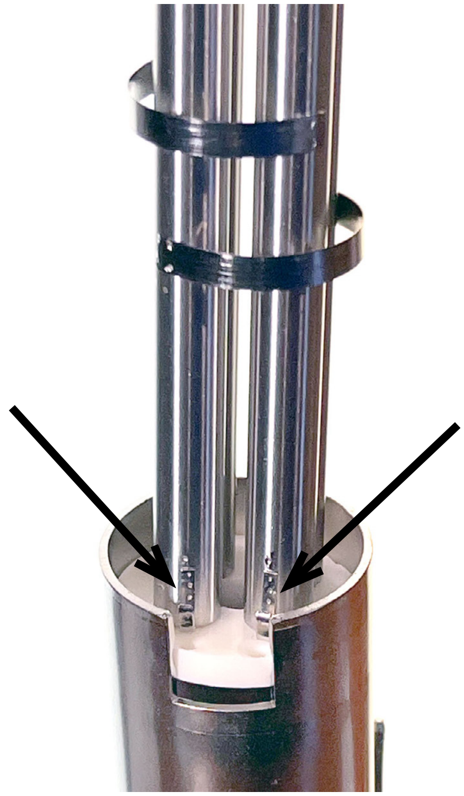
Once the quadrupole is free of the probe tube, it may be very carefully sanded with 1200 grit (or finer) waterproof aluminum oxide (alumina) sandpaper and distilled water until the rods are bright. Be careful not to bend any of the contacts.

Clean the quadrupole in Alconox® detergent with an ultrasonic cleaner at 40-45kHz.

Thoroughly rinse with distilled water in the ultrasonic bath several times.

Dry at 75ºC.

4.6 REPLACE THE QUADRUPOLE



STEP 14

Align the electrical contacts with the tube notch.

Slowly, carefully lower the quadrupole down the probe tube.

It may require a little twisting to slide it into the tube.

STEP 15

When the quadrupole is almost fully inserted down the probe tube, make sure its base is aligned with the two ceramic wire connectors near the CF flange.

STEP 16

Push the quadrupole into the tube fully.

When fully inserted, the ceramic tip may not be quite flush with the probe tube.

4.7 REPLACE THE IONIZER

STEP 17

Get the new ionizer (or the old one).

If needed, attach the two springs previously removed from the old ionizer back onto the two ionizer hard wires.

Place the ionizer on top of the probe tip.

The central large spring has a hard wire inside it.

Align the ionizer so that the large spring slips over the ceramic insulator and the inner hard wire slips into the ceramic insulator as shown.

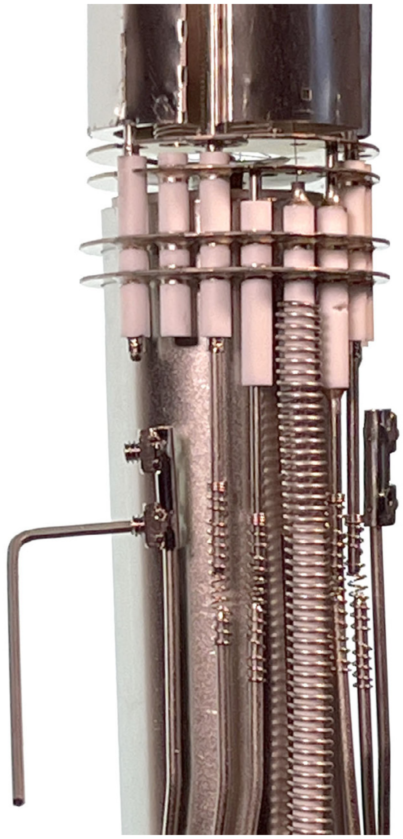
The smaller springs should line up with the other bare hard wires.

STEP 18

Hold the ionizer down on the probe tip.

One-by-one, slip the smaller springs over the hard wires.

Use the tweezers to pull the springs over the wires as needed.



STEP 19

Once all the springs are reconnected, slide both barrel connectors up to the ends of the hard wires.

Tighten the lower barrel screws with the 0.050" hex wrench.

Note: Do not overtighten the set screw. They are easily stripped.

4.8 REPLACE THE FILAMENT

STEP 20

Get the new filament out of its plastic jar. Handle it by the hard wire.

Do not touch the actual filaments.

STEP 21

Carefully slide the filament into the holes in the bottom of the ionizer.

The two filament conductors should protrude through the bottom of the ionizer.

STEP 22

As you gently push down on the filament, align the barrels with the filament conductors so that they slide into the barrels.

Tighten both top barrel screws with the 0.050" hex wrench.

Note: Do not overtighten the set screws. They are easily stripped.

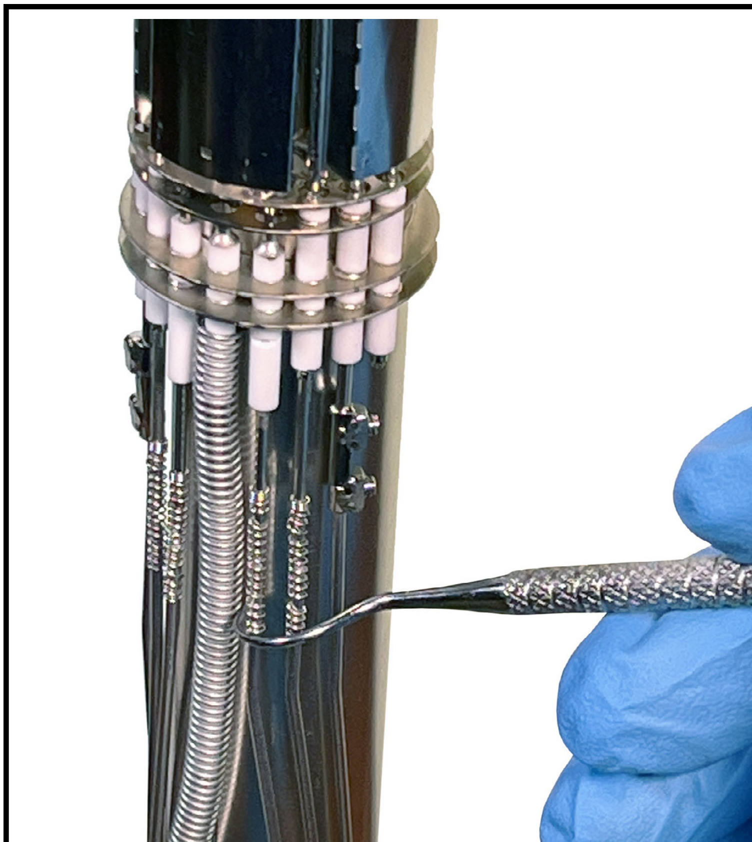
STEP 23

Use two hands to bend the top of the filament back and forth to break the hoop off.

Alternatively, use a long nose pliers.

STEP 24

Discard the filament hoop.



STEP 25

Get a dental pick.

Check that there is a gap between all the hard wires.

If one is touching another, adjust as needed.

Note: If any of the wires or springs are touching, it will cause a short circuit and damage the probe.

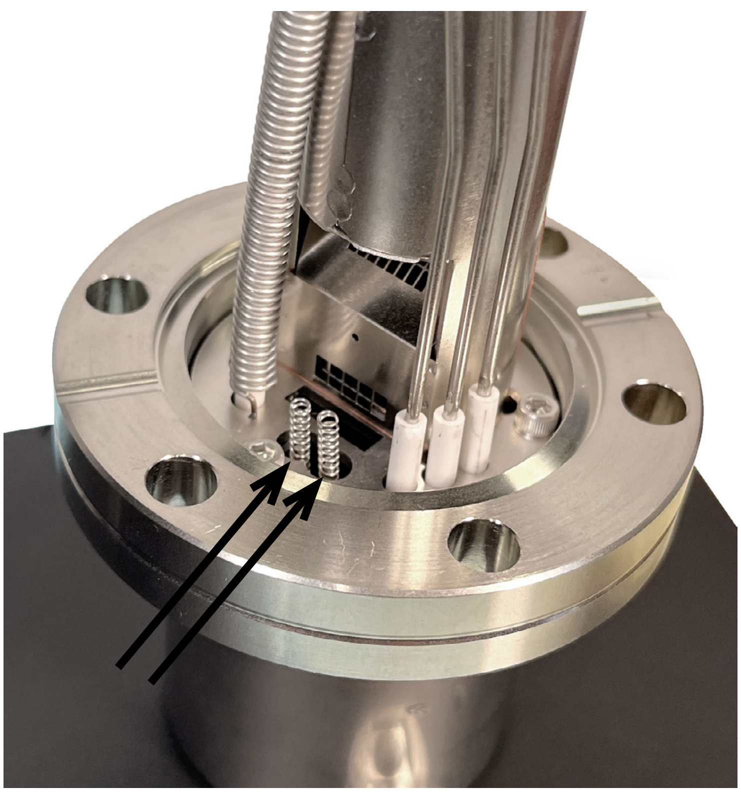
4.9 REPLACE THE ELECTRON MULTIPLIER

STEP 26

The electron multiplier (EM) is spring loaded and held in with a tooth.

Push down the top of the EM and pull it towards you.

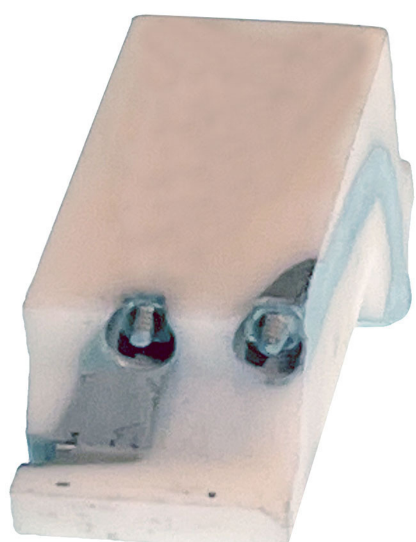
Remove it.



STEP 27

Notice the two springs just inside the flange.

Also notice the two contacts on the bottom of the EM.



STEP 28

Get the new EM.

Place the bottom into the slot and align the EM contacts onto the two springs.

STEP 29

Push the EM down and forward so that the top of the EM fits into the slot.

Let go of the EM. The tooth will catch and the EM will stay in place.

STEP 30

If the springs didn't catch on the EM contacts, use a dental pick to adjust them.

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