

TSQ Quantum GC

User Guide

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Regulatory Compliance

Thermo Fisher Scientific performs complete testing and evaluation of its products to ensure full compliance with applicable domestic and international regulations. When the system is delivered to you, it meets all pertinent electromagnetic compatibility (EMC) and safety standards as described below.

EMC Directive 89/336/EEC as amended by 92/31/EEC and 93/68/EEC

EMC compliance has been evaluated by **TUV Rheinland of North America Inc.**

EN 55011	1998, 1999, 2002	EN 61000-4-3	2002
EN 61000-3-2	1995, A1; 1998, A2; 1998, A14; 2000	EN 61000-4-4	1995, A1; 2000, A2; 2001
EN 61000-3-3	1998, 2001	EN 61000-4-5	1995, A1; 2001
EN 61326-1	1998, 2001, 2003	EN 61000-4-6	1996, A1; 2003
EN 61000-4-2	2001	EN 61000-4-11	1994, A1; 2001
		CISPR 11	1998

FCC Class A, CFR 47 Part 15

Low Voltage Safety Compliance

Compliance with safety issues is declared under Thermo Fisher Scientific sole responsibility.

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Changes that you make to your system may void compliance with one or more of these EMC and safety standards. Changes to your system include replacing a part or adding components, options, or peripherals not specifically authorized and qualified by Thermo Fisher Scientific. To ensure continued compliance with EMC and safety standards, replacement parts and additional components, options, and peripherals must be ordered from Thermo Fisher Scientific or one of its authorized representatives.

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CAUTION Read and understand the various precautionary notes, signs, and symbols contained inside this manual pertaining to the safe use and operation of this product before using the device.



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Your instrument is designed to work in a controlled electromagnetic environment. Do not use radio frequency transmitters, such as mobile phones, in close proximity to the instrument.

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Thermo Electron has contracted with one or more recycling/disposal companies in each EU Member State, and this product should be disposed of or recycled through them. Further information on Thermo Electron's compliance with these Directives, the recyclers in your country, and information on Thermo Electron products which may assist the detection of substances subject to the RoHS Directive are available at www.thermo.com/WEEERoHS.

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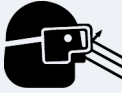

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Conformité DEEE

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CAUTION Symbol	CAUTION	VORSICHT	ATTENTION	PRECAUCION	AVVERTENZA
	Electric Shock: High Voltages capable of causing personal injury are used in the instrument. The instrument must be shut down and disconnected from line power before service is performed. Do not operate the instrument with the top cover off. Do not remove protective covers from PCBs.	Elektroschock: In diesem Gerät werden Hochspannungen verwendet, die Verletzungen verursachen können. Vor Wartungsarbeiten muß das Gerät abgeschaltet und vom Netz getrennt werden. Betreiben Sie Wartungsarbeiten nicht mit abgenommenem Deckel. Nehmen Sie die Schutzabdeckung von Leiterplatten nicht ab.	Choc électrique: L'instrument utilise des tensions capables d'infliger des blessures corporelles. L'instrument doit être arrêté et débranché de la source de courant avant tout intervention. Ne pas utiliser l'instrument sans son couvercle. Ne pas enlever les étuis protecteurs des cartes de circuits imprimés.	Descarga eléctrica: Este instrumento utiliza altas tensiones, capaces de producir lesiones personales. Antes de dar servicio de mantenimiento al instrumento, éste deberá apagarse y desconectarse de la línea de alimentación eléctrica. No opere el instrumento sin sus cubiertas exteriores quitadas. No remueva las cubiertas protectoras de las tarjetas de circuito impreso.	Shock da folgorazione. L'apparecchio è alimentato da corrente ad alta tensione che può provocare lesioni fisiche. Prima di effettuare qualsiasi intervento di manutenzione occorre spegnere ed isolare l'apparecchio dalla linea elettrica. Non attivare lo strumento senza lo schermo superiore. Non togliere i coperchi a protezione dalle schede di circuito stampato (PCB).
	Chemical: Hazardous chemicals might be present in the instrument. Wear gloves when handling toxic, carcinogenic, mutagenic, or corrosive/irritant chemicals. Use approved containers and procedures for disposing of waste oil.	Chemikalien: Dieses Gerät kann gefährliche Chemikalien enthalten. Tragen Sie Schutzhandschuhe beim Umgang mit toxischen, karzinogenen, mutagenen oder ätzenden/reizenden Chemikalien. Entsorgen Sie verbrauchtes Öl entsprechend den Vorschriften in den vorgeschriebenen Behältern.	Chimique: Des produits chimiques dangereux peuvent se trouver dans l'instrument. Portez des gants pour manipuler tous produits chimiques toxiques, cancérigènes, mutagènes, ou corrosifs/irritants. Utilisez des récipients et des procédures homologuées pour se débarrasser des déchets d'huile.	Química: El instrumento puede contener productos químicos peligrosos. Utilice guantes al manejar productos químicos tóxicos, carcinogénos, mutagénos o corrosivos/irritantes. Utilice recipientes y procedimientos aprobados para deshacerse del aceite usado.	Prodotti chimici. Possibile presenza di sostanze chimiche pericolose nell'apparecchio. Indossare dei guanti per maneggiare prodotti chimici tossici, cancerogeni, mutageni, o corrosivi/irritanti. Utilizzare contenitori aprovo e seguire la procedura indicata per lo smaltimento dei residui di olio.
	Heat: Allow heated components to cool before servicing them.	Hitze: Warten Sie erhitzte Komponenten erst nachdem diese sich abgekühlt haben.	Haute Temperature: Permettre aux composants chauffés de refroidir avant tout intervention.	Altas temperaturas: Permita que los componentes se enfríen, ante de efectuar servicio de mantenimiento.	Calore. Attendere che i componenti riscaldati si raffreddino prima di effettuare l'intervento di manutenzione.
	Fire: Use care when operating the system in the presence of flammable gases.	Feuer: Beachten Sie die einschlägigen Vorsichtsmaßnahmen, wenn Sie das System in Gegenwart von entzündbaren Gasen betreiben.	Incendie: Agir avec précaution lors de l'utilisation du système en présence de gaz inflammables.	Fuego: Tenga cuidado al operar el sistema en presencia de gases inflamables.	Incendio. Adottare le dovute precauzioni quando si usa il sistema in presenza di gas infiammabili.
	Eye Hazard: Eye damage could occur from splattered chemicals or flying particles. Wear safety glasses when handling chemicals or servicing the instrument.	Verletzungsgefahr der Augen: Verspritzte Chemikalien oder kleine Partikel können Augenverletzungen verursachen. Tragen Sie beim Umgang mit Chemikalien oder bei der Wartung des Gerätes eine Schutzbrille.	Danger pour les yeux: Des projections chimiques, liquides, ou solides peuvent être dangereuses pour les yeux. Porter des lunettes de protection lors de toute manipulation de produit chimique ou pour toute intervention sur l'instrument.	Peligro par los ojos: Las salicaduras de productos químicos o partículas que saltan bruscamente pueden causar lesiones en los ojos. Utilice anteojos protectores al manipular productos químicos o al darle servicio de mantenimiento al instrumento.	Pericolo per la vista. Gli schizzi di prodotti chimici o delle particelle presenti nell'aria potrebbero causare danni alla vista. Indossare occhiali protettivi quando si maneggiano prodotti chimici o si effettuano interventi di manutenzione sull'apparecchio.
	General Hazard: A hazard is present that is not included in the above categories. Also, this symbol is used on the instrument to refer the user to instructions in this manual. When the safety of a procedure is in doubt, before you proceed, contact your local Technical Support Organization for Thermo Electron San Jose Products.	Allgemeine Gefahr: Es besteht eine weitere Gefahr, die nicht in den vorstehenden Kategorien beschrieben ist. Dieses Symbol wird im Handbuch außerdem dazu verwendet, um den Benutzer auf Anweisungen hinzuweisen. Wenn Sie sich über die Sicherheit eines Verfahrens im unklaren sind, setzen Sie sich, bevor Sie fortfahren, mit Ihrer lokalen technischen Unterstützungsorganisation für Thermo Electron San Jose Produkte in Verbindung.	Danger général: Indique la présence d'un risque n'appartenant pas aux catégories citées plus haut. Ce symbole figure également sur l'instrument pour renvoyer l'utilisateur aux instructions du présent manuel. Si la sûreté d'un procédé est incertaine, avant de continuer, contacter le plus proche Service Clientèle pour les produits de Thermo Electron San Jose.	Peligro general: Significa que existe un peligro no incluido en las categorías anteriores. Este símbolo también se utiliza en el instrumento para referir al usuario a las instrucciones contenidas en este manual. Cuando la certidumbre acerca de un procedimiento sea dudosa, antes de proseguir, pongase en contacto con la Oficina de Asistencia Técnica local para los productos de Thermo Electron San Jose.	Pericolo generico. Pericolo non compreso tra le precedenti categorie. Questo simbolo è utilizzato inoltre sull'apparecchio per segnalare all'utente di consultare le istruzioni descritte nel presente manuale. Quando è in dubbio la misura di sicurezza per una procedura, prima di continuare, si prega di mettersi in contatto con il Servizio di Assistenza Tecnica locale per i prodotti di Thermo Electron San Jose.

CAUTION Symbol

CAUTION

危険警告

危險警告



Electric Shock: High Voltages capable of causing personal injury are used in the instrument. The instrument must be shut down and disconnected from line power before service is performed. Do not operate the instrument with the top cover off. Do not remove protective covers from PCBs.

電撃：この計測器は高電圧を使用し、人体に危害を与える可能性があります。保守・修理は、必ず操作を停止し、電源を切ってから実施して下さい。上部カバーを外したままで計測器を使用しないで下さい。プリント配線板の保護カバーは外さないで下さい。

電撃：儀器設備使用會造成人身傷害的高伏電壓。在維修之前，必須先關儀器設備並切除電源。務必要在頂蓋蓋上的情況下操作儀器。請勿拆除PCB保護蓋。



Chemical: Hazardous chemicals might be present in the instrument. Wear gloves when handling toxic, carcinogenic, mutagenic, or corrosive/irritant chemicals. Use approved containers and procedures for disposing of waste oil.

化学物質：危険な化学物質が計測器中に存在している可能性があります。毒性、発がん性、突然変異性、腐食・刺激性などのある薬品を取り扱う際は、手袋を着用して下さい。廃油の処分には、規定の容器と手順を使用して下さい。

化学品：儀器設備中可能存在有危險性的化學物品。接觸毒性致癌、誘變或腐蝕／刺激性化學品時，請配帶手套。處置廢油時，請使用經過許可的容器和程序。



Heat: Allow heated components to cool before servicing them.

熱：熱くなった部品は冷えるのを待ってから保守・修理を行って下さい。

高溫：請先等高溫零件冷卻之後再進行維修。



Fire: Use care when operating the system in the presence of flammable gases.

火災：可燃性のガスが存在する場所でシステムを操作する場合は、充分な注意を払って下さい。

火災：在有易燃氣體的場地操作該系統時，請務必小心謹慎。



Eye Hazard: Eye damage could occur from splattered chemicals or flying particles. Wear safety glasses when handling chemicals or servicing the instrument.

眼に対する危険：化学物質や微粒子が飛散して眼を傷つける危険性があります。化学物質の取り扱い、あるいは計測器の保守・修理に際しては防護眼鏡を着用して下さい。

眼睛傷害危險：飛濺的化學品或顆粒可能造成眼睛傷害。處理化學品或維儀器設備時請佩戴安全眼鏡。



General Hazard: A hazard is present that is not included in the above categories. Also, this symbol is used on the instrument to refer the user to instructions in this manual.

一般的な危険：この標識は上記以外のタイプの危険が存在することを示します。また、計測器にこの標識がついている場合は、本マニュアル中の指示を参照して下さい。

一般性危險：説明未包括在上述類別中的其他危險。此外，儀器設備上使用這個標誌，以指示用戶本使用手冊中的說明。

When the safety of a procedure is in doubt, before you proceed, contact your local Technical Support Organization for Thermo Electron San Jose Products.

安全を確保する手順がよくわからない時は、作業を一時中止し、お近くのサーモエレクトロンサンローゼプロダクトのテクニカルサポートセンターにご連絡ください。

如對安全程序有疑問，請在操作之前與當地的菲尼根技術服務中心聯繫。

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Preface

The Thermo Scientific TSQ Quantum GC™ system is a member of the TSQ™ Quantum family of mass spectrometers.

This TSQ Quantum GC User Guide contains a description of the modes of operation and principle hardware components of your TSQ Quantum GC system. In addition, this manual provides step-by-step instructions for cleaning and maintaining your mass spectrometer.

Related Documentation

In addition to this manual, Thermo Fisher provides the following for the TSQ Quantum GC:

- Preinstallation Requirements Guide
- Help available from within the software

Safety and Special Notices

Make sure you follow the precautionary statements presented in this guide. The safety and other special notices appear in boxes.

Safety and special notices include the following:



CAUTION Highlights hazards to humans, property, or the environment. Each CAUTION notice is accompanied by an appropriate CAUTION symbol.

IMPORTANT Highlights information necessary to prevent damage to software, loss of data, or invalid test results; or might contain information that is critical for optimal performance of the system.

Note Highlights information of general interest.

Tip Highlights helpful information that can make a task easier.

Safety Precautions

Observe the following safety precautions when you operate or perform service on the mass spectrometer.



CAUTION Do Not Perform Any Servicing Other Than That Contained in the TSQ Quantum GC User Guide. To avoid personal injury or damage to the instrument, do not perform any servicing other than that contained in the TSQ Quantum GC User Guide or related manuals unless you are qualified to do so.



CAUTION Shut Down the Mass Spectrometer and Disconnect It From Line Power Before You Service It. High voltages capable of causing personal injury are used in the instrument. Some maintenance procedures require that the mass spectrometer be shut down and disconnected from line power before service is performed. Do not operate the mass spectrometer with the top or side covers off. Do not remove protective covers from PCBs.



CAUTION Respect Heated Zones. Treat heated zones with respect. The ion source and transfer line might be very hot and might cause severe burns if they are touched. Allow heated components to cool before you service them.



CAUTION Provide an Adequate Fume Exhaust System. It is your responsibility to provide an adequate fume exhaust system. Samples and solvents that are introduced into the TSQ Quantum GC will eventually be exhausted from the forepump. Therefore, the forepump should be connected to a fume exhaust system. Consult local regulations for the proper method of exhausting the fumes from your system.



CAUTION Use Care When Changing Vacuum Pump Oil. Treat drained vacuum pump oil and pump oil reservoirs with care. Hazardous compounds introduced into the system might have become dissolved in the pump oil. Always use approved containers and procedures for disposing of waste oil. Whenever a pump has been operating on a system used for the analysis of toxic, carcinogenic, mutagenic, or corrosive/irritant chemicals, the pump must be decontaminated by the user and certified to be free of contamination before repairs or adjustments are made by a Thermo Fisher San Jose Customer Support Engineer or before it is sent back to the factory for service.

Solvent and Gas Purity Requirements

Use the highest purity solvents available. The TSQ Quantum GC mass spectrometer is extremely sensitive to solvent impurities. Some solvent impurities are transparent to UV/Visible detectors, but are easily detected by the TSQ Quantum GC mass spectrometer. Liquid chromatography grade is the minimum acceptable purity. Higher grade solvents are preferred. Distilled water is recommended. Deionized water contains chemicals and is not recommended.

The following is a list of international sources that can supply high quality solvents:

Solvent Source	Telephone Number
Mallinckrodt/Baker, Inc.	Tel: (800) 582-2537 Fax: (908) 859-9370
Burdick & Jackson, Inc.	Tel: (800) 368-0050 Fax: (616) 725-6216
E. M. Science, Inc.	Tel: (800) 222-0342 Fax: (800) 336-4422

The TSQ Quantum GC mass spectrometer uses argon as a collision gas. The argon must be high purity (99.995%). The required gas pressure is 135 ± 70 kPa (20 ± 10 psig). Thermo Fisher has found that particulate filters are often contaminated and are therefore not recommended.

Service Philosophy

Servicing the TSQ Quantum GC system consists of performing procedures required to maintain system performance standards, prevent system failure, restore the system to an operating condition, or all of the above. Routine and preventive maintenance procedures are documented in this manual.

The user is responsible for routine and preventive maintenance during and after the warranty period. Regular maintenance increases the life of the system, maximizes the up-time of your system, and allows you to achieve optimum system performance.

Only a Thermo Fisher Scientific Customer Support Engineer can perform services not described in this manual.

Level of Repair

Thermo Fisher Scientific's service philosophy for the TSQ Quantum GC system calls for troubleshooting to the lowest part, assembly, printed circuit board (PCB), or module listed in the "Replaceable Parts" chapter of this manual.

For mechanical failures: A mechanical assembly typically is to be repaired to the level of the smallest item listed in the “Replaceable Parts” chapter of this manual.

For electronic failures: PCBs are not repaired to the component level except in certain cases of fuses, relays, and so on. When these exceptions occur, component information can be found in the “Replaceable Parts” chapter.

Contacting Us

There are several ways to contact Thermo Fisher Scientific.

❖ To contact Technical Support

Phone	800-685-9535
Fax	561-688-8736
E-mail	TechSupport.C+MS@thermofisher.com
Knowledge base	www.thermokb.com

Find software updates and utilities to download at www.mssupport.thermo.com.

❖ To contact Customer Service for ordering information

Phone	800-532-4752
Fax	561-688-8731
Web site	www.thermo.com/finnigan

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- Send an e-mail message to the Technical Publications Editor at techpubs.finnigan-lcms@thermofisher.com.

Introduction

The TSQ Quantum GC™ is a member of the TSQ™ Quantum family of Thermo Scientific mass spectrometers. The TSQ Quantum GC is an advanced analytical instrument that includes a mass spectrometer and the Xcalibur™ data system. See [Figure 1](#).

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- [Ionization Modes](#)
- [Ion Polarity Modes](#)
- [Scan Modes](#)
- [Scan Types](#)
- [Data Types](#)
- [Mass/Charge Range](#)

In a typical analysis, a gas chromatograph (GC) introduces a sample. The GC separates the sample into its various components. The components elute from the GC and pass into the mass spectrometer where they are analyzed.

Figure 1. TSQ Quantum GC mass spectrometer, TriPlus autosampler, and TRACE GC Ultra gas chromatograph



The TSQ Quantum GC mass spectrometer includes an electron ionization/chemical ionization (EI/CI) ion source, ion optics, a triple-stage mass analyzer, and an ion detection system, all of which are enclosed in a vacuum manifold. Ionization of the sample takes place in the ion source. The specific process used to ionize the sample is known as the ionization mode. The ion optics transmit the ions produced in the ion source into the mass analyzer, where they are separated according to their mass-to-charge ratio. The polarity of the potentials applied to the lenses in the ion source and ion optics determines whether positively charged ions or negatively charged ions are transmitted to the mass analyzer. You can configure the TSQ Quantum GC mass spectrometer to analyze positively or negatively charged ions (called the *positive* or *negative ion polarity mode*).

The TSQ Quantum GC instrument's triple-stage mass analyzer performs either one or two stages of mass analysis:

- The TSQ Quantum GC system is operated as a conventional mass spectrometer with one stage of mass analysis. The ion source ionizes the sample and the ion products are subjected to mass analysis in the first rod assembly. The second and third rod assemblies transmit the resulting mass-selected ions to the ion detection system.¹

- The TSQ Quantum GC system is operated as a tandem mass spectrometer with two stages of mass analysis. The ion source ionizes the sample and the ion products are mass analyzed by the first rod assembly. In this case, however, mass-selected ions exiting the first rod assembly collide with an inert gas in the second rod assembly and fragment to produce a set of ions known as product ions. (A chamber called the collision cell surrounds the second rod assembly. The collision cell can be pressurized with an inert gas.) The product ions undergo further mass analysis in the third rod assembly to detect selected ions. Two stages of mass analysis yield far greater chemical specificity than a single stage can achieve, because of the system's ability to select and determine two discrete but directly related sets of masses.

In a first stage of mass analysis the TSQ Quantum GC systems can be used to elucidate the structures of pure organic compounds and the structures of the components within mixtures. Furthermore, in a second stage of mass analysis, the mass spectrometer can fragment and separate each ionic fragment of a molecule formed in the ion source to build up an entire structure for the molecule, piece by piece. Thus, TSQ Quantum GC systems make investigating all pathways for the formation and fragmentation of each ion in the mass spectrum possible.

The two stages of mass analysis, with resultant reduction of chemical noise in the final mass spectrum, allow for very selective and sensitive analysis.

Each sequence of single or triple-stage mass analysis of the ions is called a scan. The TSQ Quantum GC mass spectrometer uses several different scan modes and different scan types to filter, fragment, or transmit ions in the mass analyzer. Along with the ionization and ion polarity modes, the ability to vary the scan mode and scan type affords the user great flexibility in the instrumentation for solving complex analytical problems.

Ionization Modes

The specific process used to ionize the analyte is referred to as the ionization mode. You can operate the TSQ Quantum GC mass spectrometer in either of two ionization modes:

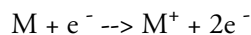
- Electron ionization mode
- Chemical ionization mode

Electron Ionization Mode

In electron ionization (EI) mode, electrons are emitted by a heated, wire filament that has electric current running through it, by thermionic emission. The filament and its reflector are typically maintained at a -70 V potential relative to the ion source block. This potential

¹ The instrument can also be used as a single-stage mass spectrometer by transmitting the ions through the first and second rod assemblies followed by mass analysis in the third rod assembly.

accelerates the electrons through the ionization space, called the *ion volume*. These energetic electrons interact with neutral, gas-phase analyte molecules present in the ion volume and cause the analyte to lose an electron and produce a radical cation:



Frequently, numerous cleavage reactions give rise to fragment ions, which provide structural information about the analyte.

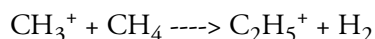
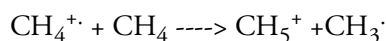
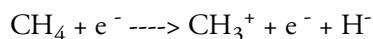
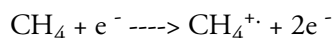
EI positive-ion mode is the only commonly used EI mode.

Chemical Ionization Mode

In chemical ionization (CI) mode, ionization of the sample molecules is a multi-step process:

1. Reagent gas is introduced into the CI ion volume at a flow (for methane) of about 2 mL/min, along with sample vapors typically present at partial pressures of less than one-thousandth that of the reagent gas.
2. The energetic (typically 100 eV) electrons emitted by the heated filament interact to ionize the reagent gas and form a plasma. This reaction also produces thermal electrons.
3. Reagent gas ions react with reagent gas molecules to form a variety of secondary ions that are stable with respect to further reaction with reagent gas.

For example, for methane:



4. Positive sample ions are formed by one of the following:
 - The transfer of a proton from a secondary reagent gas ion to a sample molecule
 - The abstraction of an electron by a reagent gas ion
 - An ion association reaction in which an adduct ion is formed between a reagent gas ion and a sample molecule

In methane positive ion mode CI, the relevant peaks observed are MH^+ , $[M+CH_5]^+$, and $[M+C_2H_5]^+$; but mainly MH^+ .

In isobutane positive ion mode CI, the main peak observed is MH^+ .

In ammonia positive ion mode CI, the main peaks observed are MH^+ and $[M+NH_4]^+$.

Negative sample ions are most commonly formed by one of the following:

- Sample molecules capture the secondary thermal electrons present in the ion source

- Electron transfer from ionized reagent gas (e.g. NH_2^-)
- Proton abstraction

Molecular ions observed in negative ion chemical ionization mass spectra are usually M^- or $[\text{M-H}]^-$.

Ion Polarity Modes

You can operate the TSQ Quantum GC mass spectrometer in either of two ion polarity modes: positive or negative. Both positively charged and negatively charged ions form in the ion source of the mass spectrometer. The TSQ Quantum GC mass spectrometer can control whether positive ions or negative ions are transmitted to the mass analyzer for mass analysis by changing the polarity of the potentials applied to the ion source and ion optics. The ion optics deliver the ions produced in the ion source, in a collimated beam, to the mass analyzer.

The information obtained from a positive-ion mass spectrum is different from and complementary to the information from a negative-ion spectrum. Thus, the ability to obtain both positive-ion and negative-ion mass spectra aids you in the qualitative analysis of your sample. You can choose the ion polarity mode and ionization mode to obtain maximum sensitivity for the particular analyte of interest.

Scan Modes

You can operate the TSQ Quantum GC mass spectrometer in a variety of scan modes. The most commonly used scan modes can be divided into two categories: single mass spectrometry (MS) scan modes and MS/MS scan modes. The scan modes in each category are as follows:

- MS scan modes: Q1MS and Q3MS scan modes
- MS/MS scan modes: product scan mode, parent scan mode, Neutral Loss scan mode
- Data-dependent scan mode

The scan modes that can be employed depend on the number and type of rod assemblies and the voltages applied to the rod assemblies.

The TSQ Quantum GC system mass analyzer has three rod assemblies.² The first and third rod assemblies, Q1 and Q3, are quadrupoles, and the second rod assembly, Q2, is a square-profile quadrupole.

Rod assemblies can operate in either of two capacities:

- As ion transmission devices

² A rod assembly is a regular array of metal rods. Refer to “Mass Analyzer” on page 28 for a discussion of the rod assemblies used on the TSQ Quantum GC instrument.

- As mass analyzers

If only RF voltage is applied, a rod assembly serves as an ion transmission device that passes all ions within a large range of mass-to-charge ratios (that is, virtually all ions present).

When you apply both RF and dc voltages to a rod assembly, the separation of ions of different mass-to-charge ratios occurs. This separation allows the rod assembly to serve as a mass analyzer.

On the TSQ Quantum GC mass spectrometer, the quadrupole rod assemblies can operate with RF and dc voltages or with only RF voltage. That is, Q1 and Q3 can act either as mass analyzers or ion transmission devices. The Q2 rod assembly operates exclusively with RF voltage. Thus, Q2 is always an ion transmission device. For a summary of how the rod assemblies function in several of the major scan modes, see [Table 1](#).

Table 1. Summary of scan modes

Scan Mode	Q1 quadrupole	Q2 Collision Cell	Q3 quadrupole
Q1MS	Scan ^a	Pass all ions ^b	Pass all ions
Q3MS	Pass all ions	Pass all ions	Scan
Product	Set ^d	Fragment ions ^c , then pass all fragments	Scan
Parent	Scan	Fragment ions, then pass all fragments	Set
Neutral Loss	Scan	Fragment ions, then pass all fragments	Scan

^aScan = full scan or transmission of selected ions

^bPass all ions or fragments = pass ions or fragments within a wide range of mass-to-charge ratios

^cFragment ions = collisions with argon gas cause ions to fragment

^dSet = set to pass ions of a single mass-to-charge ratio or a set of mass-to-charge ratios

Q1MS and Q3MS Scan Modes

In the Q1MS and Q3MS scan modes, only one stage of mass analysis is performed. The mass spectrum obtained is equivalent to the mass spectrum obtained from an instrument with a single mass analyzer. In the one stage of analysis, ions formed in the ion source enter the analyzer assembly. One of the mass analyzers (Q1 or Q3) is scanned to obtain a complete mass spectrum. The other rod assemblies (Q2 and Q3, or Q1 and Q2, respectively) act as ion transmission devices. In the Q1MS scan mode, Q1 is used as the mass analyzer; in the Q3MS scan mode, Q3 is used as the mass analyzer.

Product Scan Mode

Product scan mode performs two stages of analysis. In the first stage, ions formed in the ion source enter Q1, which is set to transmit ions of one mass-to-charge ratio. Ions selected by this first stage of mass analysis are called parent ions. (As a result, Q1 is referred to as the

parent mass analyzer, and the mass-to-charge ratio of ions transmitted by the parent mass analyzer is referred to as the parent set mass.) Parent ions selected by Q1 then enter Q2, which is surrounded by the collision cell.

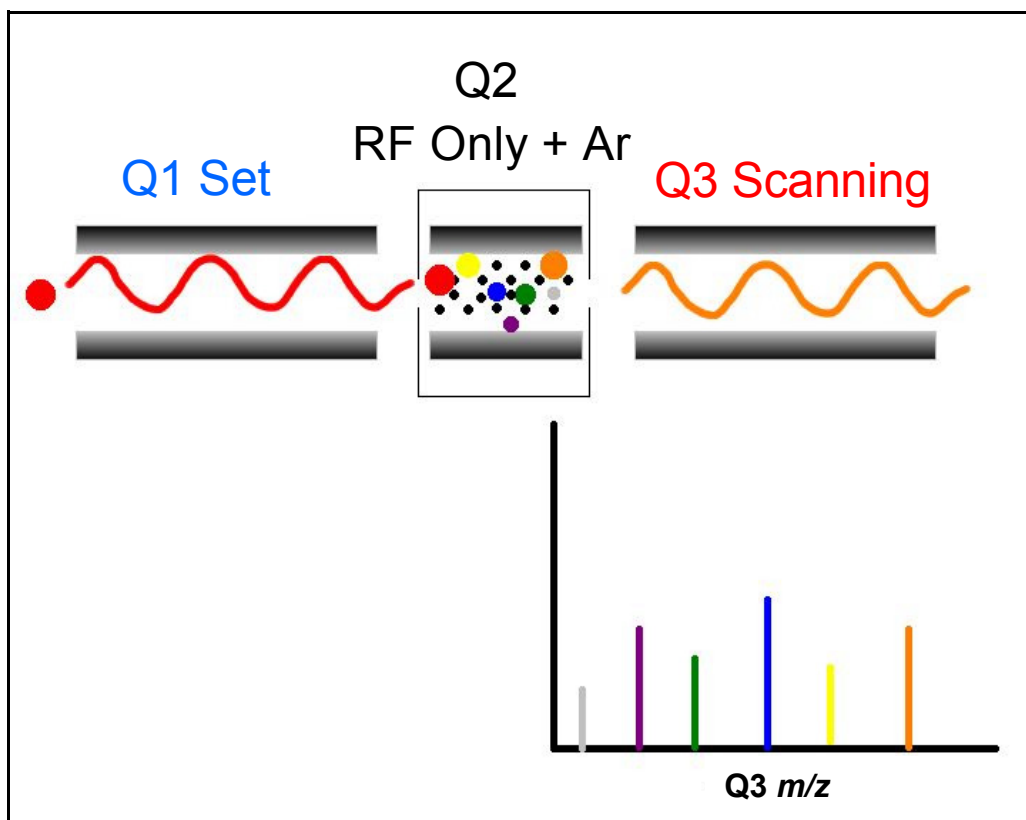
Note When referring to the first, second, and third rod assemblies as pieces of hardware, it is convenient to call them Q1, Q2, and Q3, respectively. However, when discussing their function in MS/MS scan modes, it often adds clarity to refer to them as the parent mass analyzer, collision cell (ion transmission device surrounded by the collision cell), and product mass analyzer, respectively.

In the second stage of analysis, ions in the collision cell can fragment further to produce product ions. Two processes produce product ions: by unimolecular decomposition of metastable ions or by interaction with argon collision gas present in the collision cell. This latter step is known as collision-induced dissociation (CID). Ions formed in the collision cell enter Q3 (the product mass analyzer) for the second stage of mass analysis. Q3 is scanned to obtain a mass spectrum that shows the product ions produced from the fragmentation of the selected parent ion.

A mass spectrum obtained in the Product scan mode (product mass spectrum) is the mass spectrum of a selected parent ion.

The Product scan mode is illustrated in [Figure 2](#).

Figure 2. Illustration of Product scan mode



Parent Scan Mode

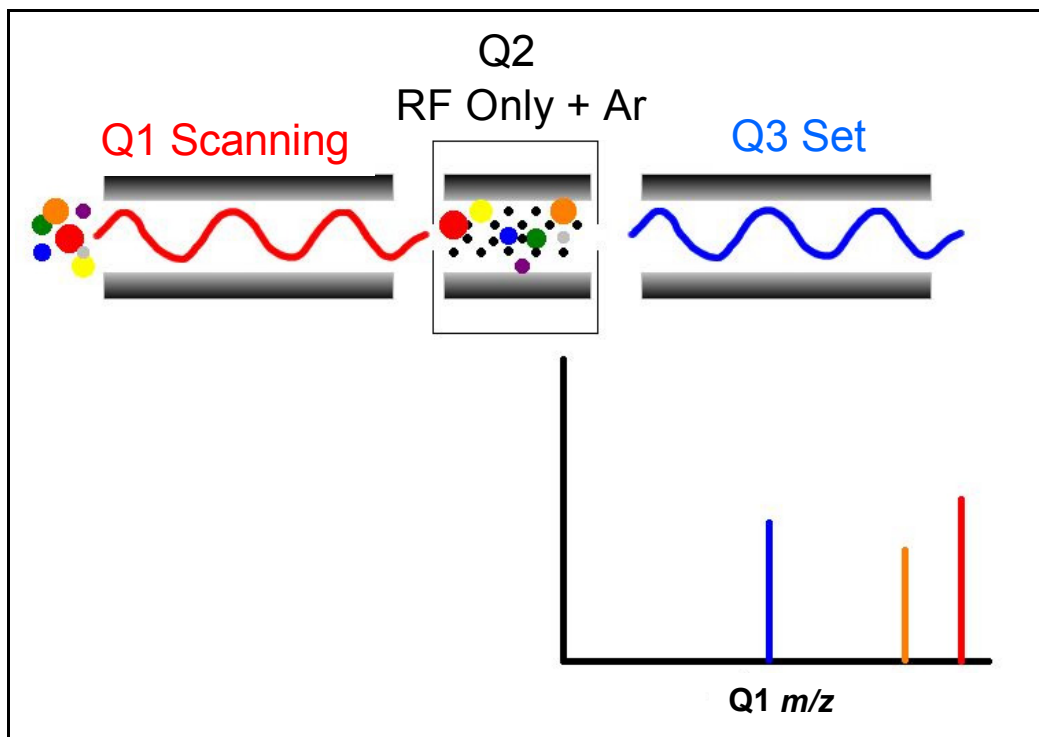
The Parent scan mode also uses two stages of analysis. In the first stage, ions formed in the ion source are introduced into the parent mass analyzer, which is scanned to transmit parent ions sequentially into the collision cell.

In the second stage of analysis, in the collision cell, parent ions can fragment to produce product ions by unimolecular decomposition of metastable ions or by collision-induced dissociation. Ions formed in the collision cell enter the product mass analyzer, which transmits a selected product ion. (The product set mass is the mass-to-charge ratio of ions transmitted by the product mass analyzer.)

The resultant spectrum shows all the parent ions that fragment to produce the selected product ion. Note that for a mass spectrum obtained in the Parent scan mode (parent mass spectrum), data for the mass-to-charge ratio axis are obtained from Q1 (the parent ions), whereas data for the ion intensity axis are obtained from Q3 (from monitoring the product ion).

The Parent scan mode is illustrated in [Figure 3](#).

Figure 3. Illustration of the Parent scan mode



Experiments that employ the parent scan mode (parent experiments) can be used in structure and fragmentation studies as well as in survey analyses of mixtures. In general, parent experiments detect all compounds that decompose to a common fragment. The experiments are useful for the rapid detection of a series of structural homologs (for example, substituted aromatics, phthalates, steroids, or fatty acids) that have a common fragment ion (for example, m/z 149 for the phthalates).

Neutral Loss Scan Modes

In the Neutral Loss scan mode, the two mass analyzers (Q1 and Q3) are linked together so that they are scanned at the same rate over mass ranges of the same width. The respective mass ranges, however, are offset by a selected mass, such that the product mass analyzer scans a selected number of mass units lower than the parent mass analyzer.

Thus, in the Neutral Loss scan mode, there are two stages of mass analysis. In the first stage, the parent mass analyzer separates ions formed in the ion source by mass-to-charge ratio. Then the ions are introduced sequentially into the collision cell.

In the second stage of analysis, ions admitted to the collision cell can fragment further by metastable ion decomposition or by CID to produce product ions. The product mass analyzer then separates these product ions by mass-to-charge ratio. Neutral Loss scan mode is illustrated in [Figure 4](#). Examples of compounds with a common neutral loss fragment appear in [Figure 5](#).

To detect an ion, between the time the ion leaves Q1 and enters Q3, it must lose a neutral moiety whose mass (the neutral loss mass) is equal to the difference in the mass ranges being scanned by the two mass analyzers. Thus, a neutral loss mass spectrum is a spectrum that shows all the parent ions that lose a neutral species of a selected mass.

Note that a neutral gain (or association) experiment can also be performed in which the mass range scanned by Q3 is offset by a selected mass above the mass range scanned by Q1.

For a neutral loss (or neutral gain) mass spectrum, as for a parent mass spectrum, data for the mass-to-charge ratio axis are obtained from Q1 (the parent ion), whereas data for the ion intensity axis are obtained from Q3 (the product ion being monitored).

Experiments that use the Neutral Loss scan mode (neutral loss experiments) are useful when a large number of compounds are being surveyed for common functionality. Neutral moieties are frequently lost from substituent functional groups (for example, CO_2 from carboxylic acids, CO from aldehydes, HX from halides, and H_2O from alcohols).

Figure 4. Illustration of the Neutral Loss scan mode

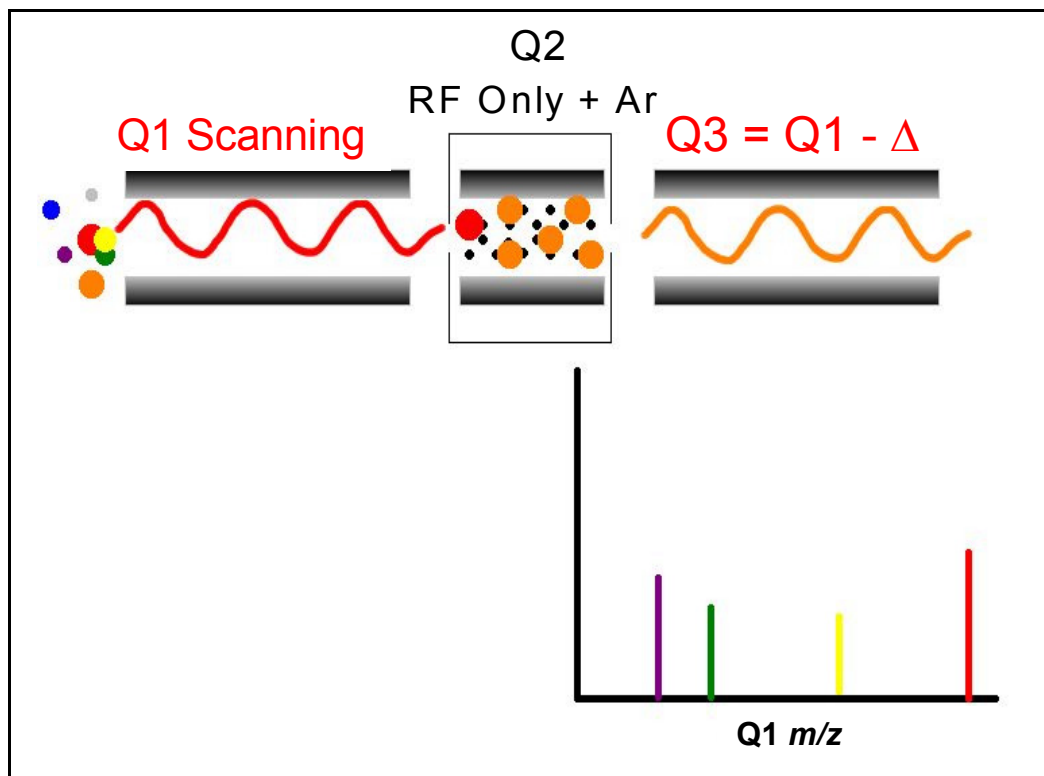
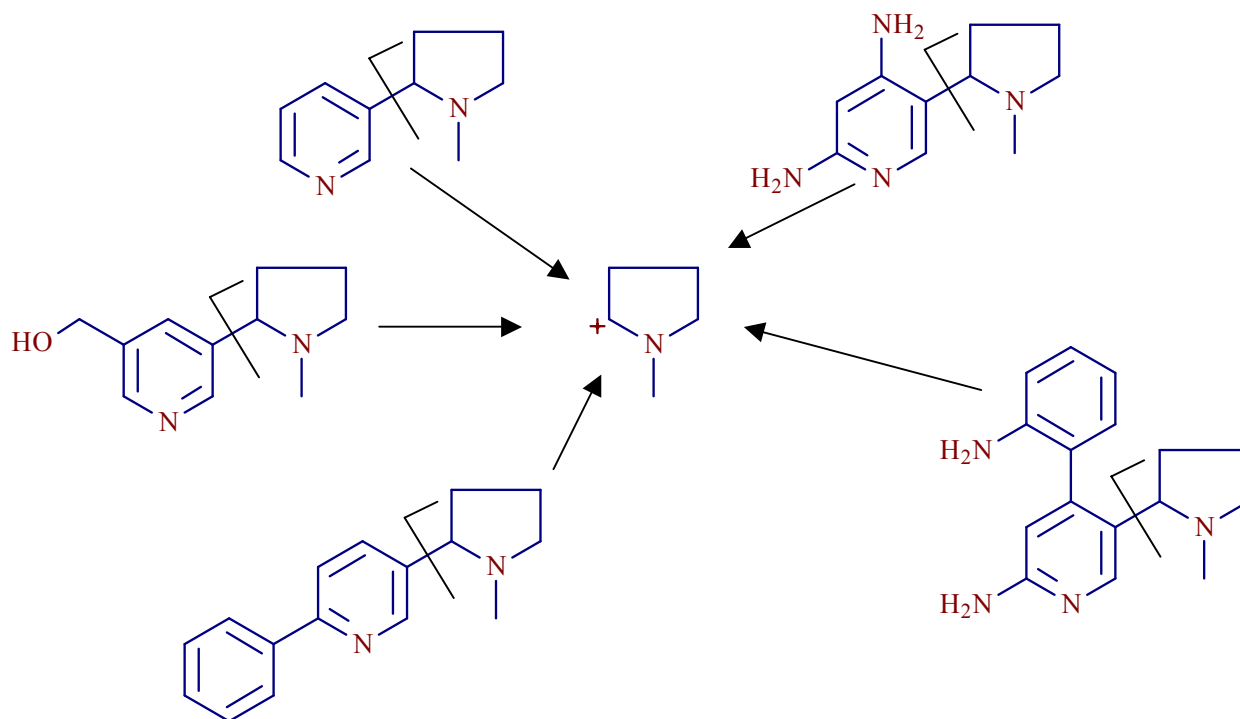


Figure 5. Examples of compounds with a common neutral-loss fragment



Data Dependent Scan Mode

The TSQ Quantum GC mass spectrometer uses the information in a data-dependent scan mode experiment to make automatic decisions about the next step of the experiment without input from a user. In data-dependent scan mode you specify criteria to select one or more ions of interest on which to perform subsequent scans, such as MS/MS. You can approach the setup of data-dependent experiments in either of two ways:

- If you have some idea of what the parent ion is, or if you expect a certain kind of parent, you can set up a list of possible parent ions. Then, when one of the parent ions you specified is detected, you can acquire product spectra and analyze the information. Conversely, you can also set up a list of ions that you do *not* want selected for fragmentation.
- If you have little information about your compound, you can set up the parameters of a data-dependent experiment so that if the intensity of the ion signal is above a specified threshold, the TSQ Quantum GC system generates product spectra. Later, you can decide if the information is useful.

Because a data-dependent scan needs to use a target ion from a previous scan, the first scan event cannot be a data-dependent scan.

Scan Types

TSQ Quantum GC systems can be operated with a variety of scan types. The most common scan types are as follows:

- [Full Scan](#)
- [Selected Ion Monitoring \(SIM\)](#)
- [Selected Reaction Monitoring \(SRM\)](#)
- [AutoSIM](#)

Full Scan

The full-scan scan type provides a full mass spectrum of each analyte. With full scan, the scanning mass analyzer is scanned from the first mass to the last mass, without interruption, in a given scan time.

Full-scan experiments are used to determine or confirm the identity of unknown compounds or the identity of each component in a mixture of unknown compounds. (Generally, a full mass spectrum is needed to determine the identity of an unknown compound.)

The full-scan scan type gives you more information about an analyte than does SIM, but a full scan does not yield the sensitivity that the other two scan types can achieve. With full scan, you spend less time monitoring the signal for each ion than you do in SIM or SRM. Full scan provides greater information but lower sensitivity than the other two scan types.

To use the SIM or SRM, you need to know what ions or reactions you are looking for before you can perform an experiment with these scan types. Thus, you might use a full scan for SIM to determine the identity of an analyte and to obtain its mass spectrum and a full scan for SRM to determine the mass spectrum and product mass spectra for parent ions of interest. Then, you might use SIM or SRM to do routine quantitative analysis of the compound.

Selected Ion Monitoring

Selected ion monitoring (SIM) monitors a particular ion or set of ions. SIM experiments are useful in detecting small quantities of a target compound in a complex mixture when you know the mass spectrum of the target compound. Thus, SIM is useful in trace analysis and in the rapid screening of a large number of samples for a target compound.

Because SIM monitors only a few ions, it can provide lower detection limits and greater speed than the full-scan modes. SIM achieves lower detection limits because more time is spent monitoring significant ions that are known to occur in the mass spectrum of the target analyte. SIM can achieve greater speed because it monitors only a few ions of interest; SIM does not monitor regions of the spectrum that are empty or have no ions of interest.

SIM can improve the detection limit and decrease analysis time, but it can also reduce specificity. Because SIM monitors only specific ions, any compound that fragments to produce those ions will appear to be the target compound. The result could be a false positive.

Selected Reaction Monitoring

Selected reaction monitoring (SRM) monitors a particular reaction or set of reactions, such as the fragmentation of an ion or the loss of a neutral moiety.

SRM monitors a limited number of parent/product-ion pairs. In product-type experiments, a parent ion is selected as usual, but generally only one product ion is monitored. SRM experiments are normally conducted with the product scan mode.

As does SIM, SRM provides for the very rapid analysis of trace components in complex mixtures. However, because SRM selects two sets of ions, it obtains specificity that is much greater than what SIM can obtain. Any interfering compound would not only have to form an ion source product (parent ion) of the same mass-to-charge ratio as the selected parent ion from the target compound, but that parent ion would also have to fragment to form a product ion of the same mass-to-charge ratio as the selected product ion from the target compound.

AutoSIM

In the scan type known as AutoSIM, the mass spectrometer automatically selects the most intense masses (m/z values) in a survey scan, builds a SIM scan list for them, and then acquires and records ion current at only these selected masses. AutoSIM scans can be performed on any full scan in any scan mode, but not on data-dependent scans.

There might be times when the scan ranges of two (or more) selected masses overlap. If this happens, both masses are placed in one SIM window. In Tune Master, the SIM table in the Define Scan view displays the center mass for this new scan window, not each selected mass.

Data Types

You can acquire and display mass spectral data (intensity versus mass-to-charge ratio) with the TSQ Quantum GC mass spectrometer in one of two data types:

- Profile data type
- Centroid data type

Profile Data Type

In the profile data type, you can see the shape of the peaks in the mass spectrum. Each atomic mass unit is divided into many sampling intervals. The intensity of the ion current is determined at each of the sampling intervals. The profile data type displays the intensity at each sampling interval with the intensities connected by a continuous line. In general, use the profile scan data type when you tune and calibrate the mass spectrometer so that you can easily see and measure mass resolution.

Centroid Data Type

The centroid data type displays the mass spectrum as a bar graph and sums the intensities of each set of multiple sampling intervals. This sum is displayed versus the integral center of mass of the sampling intervals. In general, use the centroid scan data type for data acquisition for faster scan speed. Data processing is also much faster for centroid data.

Mass/Charge Range

The TSQ Quantum GC mass spectrometer can operate in a mass/charge range of 10 to 3000 Da.

Functional Description

This chapter describes the principal components of the TSQ Quantum GC system and their respective functions.

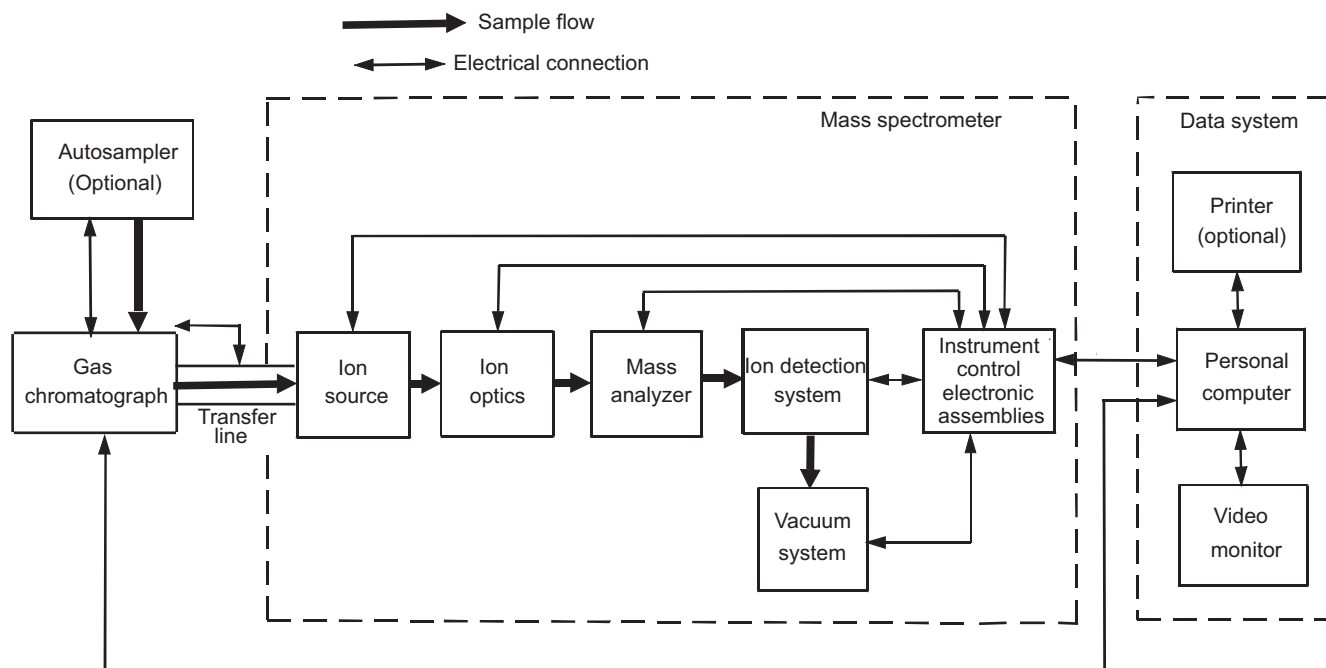
Contents

- [Autosampler](#) (optional)
- [Gas Chromatograph](#)
- [Direct Sample Probes](#) (optional)
- [Transfer Line](#)
- [Mass Spectrometer](#)
- [Data System](#)

A functional block diagram of the TSQ Quantum GC system is shown in [Figure 6](#). A sample transfer line connects the GC to the mass spectrometer. The autosampler and GC are installed on the left side of the mass spectrometer.

In analysis by GC/MS, a sample is injected into a GC column. The sample is then separated into its various components. The components elute from the GC column and pass through the transfer line into the mass spectrometer where they are analyzed. You can also use a direct sample probe to introduce sample into the mass spectrometer.

Electron ionization (EI) or chemical ionization (CI) ionize sample molecules upon entering the mass spectrometer. The ion optics focus and accelerate the resulting sample ions into the mass analyzer where they are analyzed according to their mass-to-charge ratios. An ion detection system that produces a signal proportional to the number of ions detected then detects the sample ions. The system electronics receive and amplify the ion current signal from the ion detection system. That signal is then passed on to the data system for further processing, storage, and display. The data system provides the primary TSQ Quantum GC mass spectrometer user interface.

Figure 6. Functional block diagram of the TSQ Quantum GC system

Autosampler

The (optional) Thermo Scientific TriPlus autosampler is used to inject samples automatically into the GC inlet. With an autosampler, you can automate your GC/MS/MS analyses. The TriPlus autosampler is shown in [Figure 1](#) on [page 2](#).

Autosampler Start/Stop signals with the TSQ Quantum GC mass spectrometer are provided by contact closure.

You configure TriPlus autosampler from the data system computer. Select the TriPlus instrument button in the Instrument Configuration window, which is available by choosing **Start > All Programs > Xcalibur > Instrument Configuration**. Refer to Xcalibur Help for a description of TriPlus configuration options.

You also use the data system to set up the TriPlus autosampler to inject samples. Choose **Start > All Programs > Xcalibur > Xcalibur** and click **Instrument Setup** to open the Instrument Setup window. Then, click the **TriPlus** icon to open the TriPlus Autosampler page. Refer to the Help for instructions on running the TriPlus autosampler.

Refer to the documentation provided with the autosampler for maintenance procedures.

Gas Chromatograph

The Thermo Scientific TRACE GC Ultra gas chromatograph (GC) separates a sample mixture into its chemical components by gas chromatography. In gas chromatography, the sample mixture is partitioned between a solid stationary phase and a mobile gas. The stationary phase is adhered to the inside of a small-diameter glass tube: the capillary column. The molecular structure of each component of the mixture determines in which order each component elutes from the GC and enters the mass spectrometer. The TRACE GC Ultra gas chromatograph is shown in [Figure 1](#) on [page 2](#).

Gas chromatography is widely used in analytical chemistry, though the high temperatures used in GC make it unsuitable for high molecular weight biopolymers, frequently encountered in biochemistry. It is well suited for use in the petrochemical, environmental monitoring, and industrial chemical fields. It is also used extensively in chemistry research.

You configure TRACE GC Ultra gas chromatograph from the data system computer. Select the TRACE GC Ultra instrument button in the Instrument Configuration window, which is available by choosing **Start > All Programs > Xcalibur > Instrument Configuration**. Refer to Xcalibur Help for a description of TRACE GC Ultra configuration options.

The TSQ Quantum GC mass spectrometer data system computer can directly control the TRACE GC Ultra. Choose **Start > Programs > Xcalibur > Xcalibur** and click **Instrument Setup** to open the Instrument Setup window. Click the **TRACE GC Ultra** icon to open the TRACE GC Ultra page. Refer to the Help for instructions for operating the TRACE GC Ultra.

Front-panel (keypad) operation of the GC and maintenance procedures for the GC are described in the documentation provided with the GC. To replace the GC capillary column, see [“Removing and Installing a GC Capillary Column”](#) on [page 104](#).

Direct Sample Probes

With the (optional) direct sample probes you can introduce compounds directly into the ion source without GC column separation. See [Figure 7](#). The direct sample probes are ideal for qualitative or semi-quantitative analysis of materials that don't require a GC column separation, or are difficult, if not impossible, to elute chromatographically, such as solids. The direct sample probes introduce samples directly into the ion source via a vacuum interlock. A single controller box ([Figure 7](#)) with interchangeable probe tools makes it easy to select the best method of sample introduction.

The direct sample probe system includes two probe tools:

- Direct exposure probe
- Direct insertion probe

2 Functional Description

Transfer Line

The direct exposure probe (DEP) has a heated filament that rapidly vaporizes liquids or solutions. The DEP is ideal for rapid molecular weight confirmation of liquids or solids dissolved in a suitable solvent. The DEP can vaporize compounds with a high boiling point.

The direct insertion probe (DIP) has a temperature-controlled, heated capillary tube that slowly vaporizes solid samples. You can use the DIP for rapid analysis of solids or trace components in solid matrices, such as forensic samples or tissue.

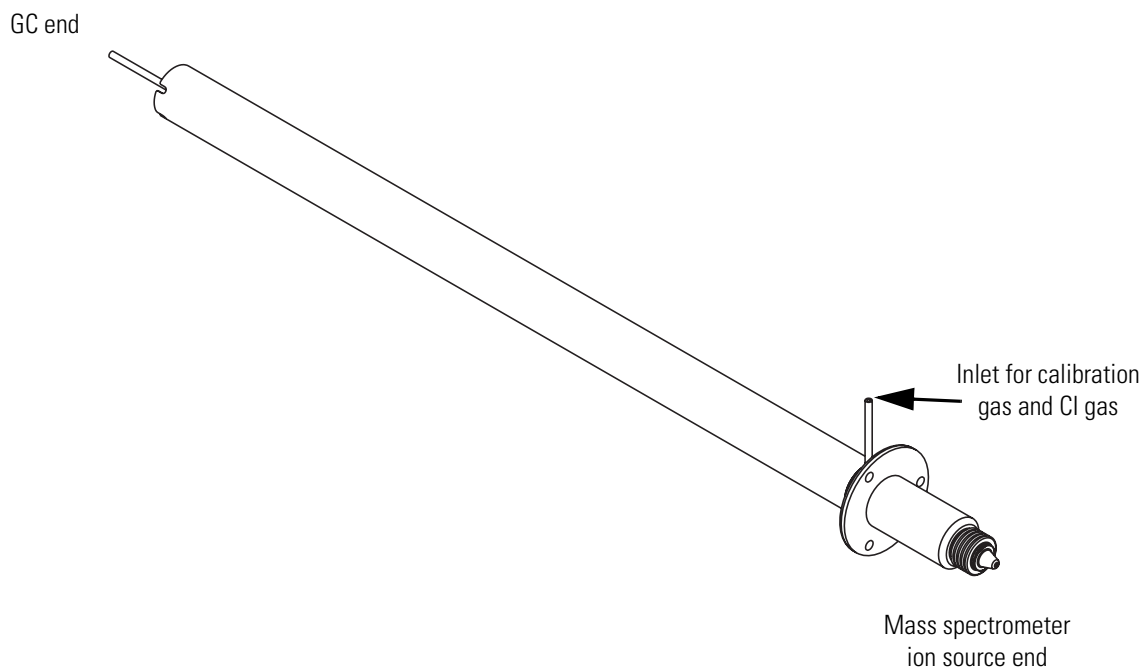
Figure 7. Direct sample probe and controller



Transfer Line

The transfer line is the interface between the GC and mass spectrometer. The transfer line heats the capillary column as it passes from the GC into the ion source in the mass spectrometer. This prevents the sample from condensing. The transfer line includes an inlet for calibration gas and CI gas.

Figure 8. Transfer line



Mass Spectrometer

The TSQ Quantum GC mass spectrometer provides sample ionization and mass analysis of samples introduced from a gas chromatograph or direct insertion probe. The mass spectrometer uses a triple-quadrupole mass analyzer with an ion source external to the mass analyzer. Several important features of the TSQ Quantum GC mass spectrometer are as follows:

- High sensitivity and resolution
- m/z 10 to 3000 mass range
- EI and CI ionization modes
- Positive and negative ion polarity modes
- MS and MS/MS scan modes
- Full-scan, SIM, SRM, AutoSIM, and data-dependent scan types

The mass spectrometer includes the following components:

- [Controls and Indicators](#)
- [Ion Source](#)
- [Ion Optics](#)

- [Mass Analyzer](#)
- [Ion Detection System](#)
- [Vacuum System and Inlet Gasses Hardware](#)
- [Electronic Assemblies](#)
- [Data System](#)

Controls and Indicators

Five light-emitting diodes (LEDs) are located at the upper right side of the front panel of the mass spectrometer. See [Figure 9](#).

The Power LED illuminates green whenever power is supplied to the vacuum system and electronic assemblies of the mass spectrometer.

The Vacuum LED illuminates yellow when the turbomolecular pump is nearly at speed (80% of its operating speed of 750 MHz) and it is safe to turn on the ion gauge. The Vacuum LED is off if the turbomolecular pump is not at speed. The Vacuum LED illuminates green whenever the pressure in the analyzer chamber, as measured by the ion gauge, is at or below the value required to enable high voltages to the mass analyzer. See [Table 2](#).

Figure 9. Front panel LEDs of the mass spectrometer

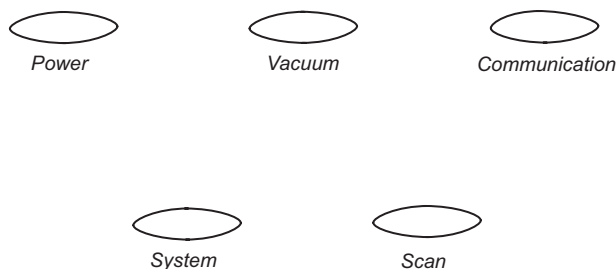


Table 2. Maximum allowed pressure to turn on high voltages

Carrier gas	Ar collision gas	Maximum pressure (Torr)
He	Off	6×10^{-6}
He	On	5×10^{-5}
H ₂	Off	5×10^{-5}
H ₂	On	1×10^{-4}

The Communication LED illuminates yellow when the mass spectrometer and the data system are trying to establish a communication link. The Communication LED illuminates green when the Ethernet communication link between the mass spectrometer and the data system has been made.

The System LED illuminates yellow whenever the mass spectrometer is in Standby—that is, high voltage is not supplied to the ion source, mass analyzer, or ion detection system, but the mass spectrometer power is on. The System LED illuminates green whenever the high voltage is enabled and the system is in the On state. High voltage is enabled if the analyzer chamber is below the values listed in [Table 2](#).

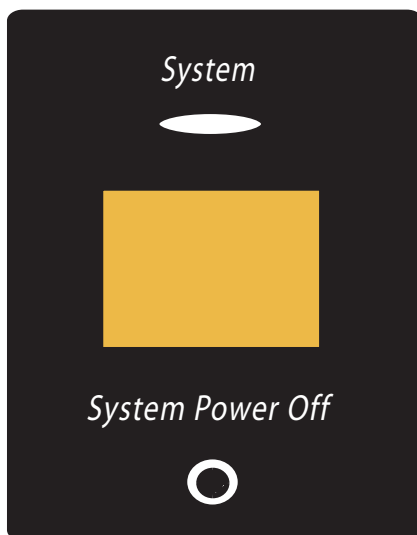
The Scan LED flashes blue whenever the mass spectrometer is on and is scanning ions.

The System Power Off button, located on the front of the electronics module, turns off power to the mass spectrometer, gas chromatograph, and autosampler. See [Figure 10](#). You must use the main power circuit breaker, located on the back of the electronics module, to restore power to the mass spectrometer, gas chromatograph, and autosampler.



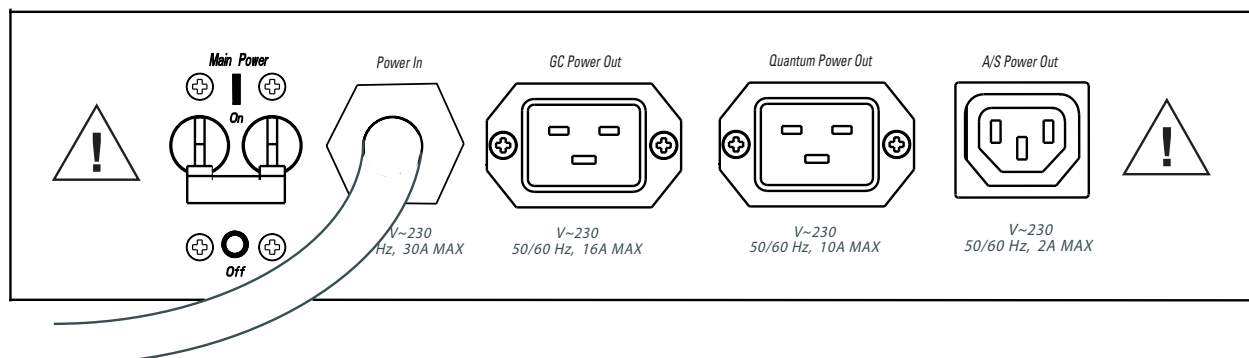
CAUTION In an emergency, to shut off all power to the mass spectrometer, gas chromatograph, and autosampler, press the System Power Off button located at the front of the instrument.

Figure 10. Front panel System Power Off button



The main power circuit breaker switch (labeled Main Power) is located on the power panel at the back of the electronics module. See [Figure 11](#). In the Off (O) position, the circuit breaker removes all power to the mass spectrometer, gas chromatograph, and autosampler. In the On (I) position, power is supplied to the mass spectrometer, gas chromatograph, and autosampler. In the standard operational mode, the circuit breaker is kept in the On (I) position.

Figure 11. Rear power panel of the electronics module



The mass spectrometer main power circuit breaker switch (labeled Main Power) is located on the mass spectrometer power panel in the lower corner of the right-side panel of the mass spectrometer. See [Figure 12](#). In the Off position, the circuit breaker removes all power to the mass spectrometer, including the vacuum pumps. In the On position, power is supplied to the mass spectrometer. In the standard operational mode, the circuit breaker is kept in the On position.

The electronics service switch (labeled Electronics) is located next to the main power circuit breaker on the mass spectrometer power panel ([Figure 12](#)). In the Service Mode position the switch removes power to all components of the mass spectrometer other than the vacuum system. The Operating Mode position supplies power to all non-vacuum system components of the mass spectrometer.

The vacuum service switch (labeled Vacuum) is located next to the electronics service switch on the mass spectrometer power panel ([Figure 12](#)). In the Service Mode position the switch removes power to all components of the vacuum system, including the forepump, turbomolecular pump, and turbomolecular pump controller. The switch in the Operating Mode position supplies power to all vacuum system components of the mass spectrometer.

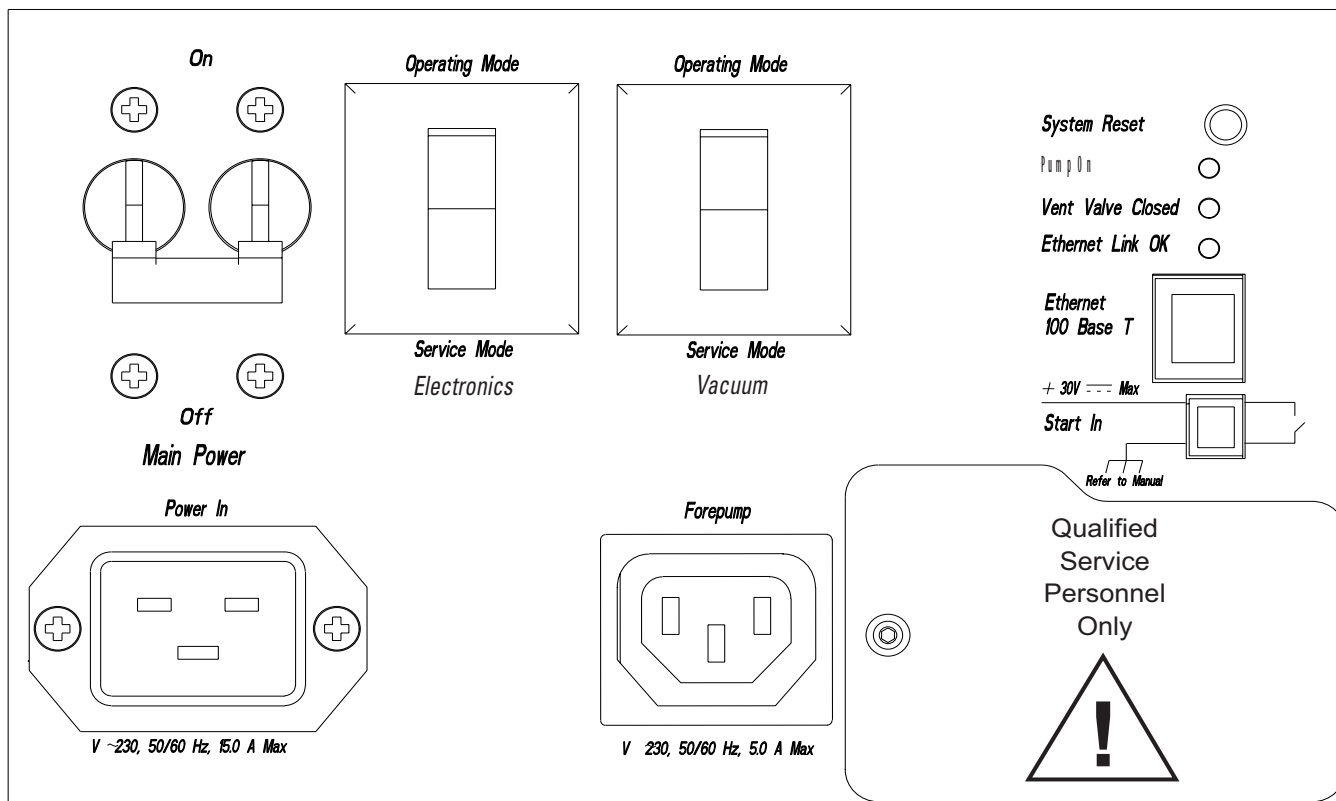
The System Reset button is also located on the mass spectrometer power panel. Pressing the System Reset button takes the 5 V logic to ground and causes the embedded computer on the System Control PCB to reboot. The TSQ Quantum GC mass spectrometer software is then reloaded from the data system. See [“Resetting the Mass Spectrometer”](#) on [page 54](#) for information on how to reset the mass spectrometer.

Three LEDs are located on the power panel: The Pump On LED is green when the rough pump current sensor detects current to the forepump. The LED is off when the rough-pump current sensor does not detect current to the forepump. If the current sensor detects a loss of current when the TSQ Quantum Access is on, the vacuum system vents.

The Vent Valve Closed LED is green whenever the vent valve current sensor detects current through the vent valve and the vent valve is closed. The LED is off when the vent valve is open.

The Ethernet Link OK LED is green when the System Control PCB is communicating with the data system PC. The LED is off when there is no communication between the System Control PCB and the data system PC.

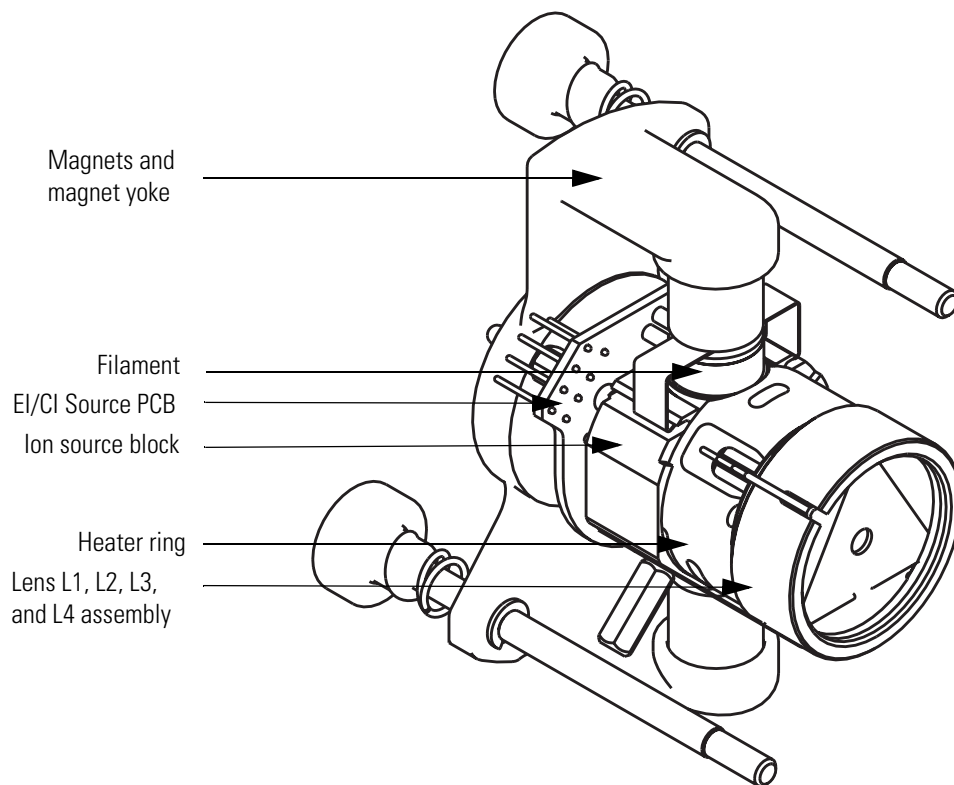
Figure 12. Right-side power panel of the mass spectrometer



Ion Source

The ion source forms gas phase sample ions from sample molecules that elute from the GC or are introduced by the direct sample probe. You can operate the ion source in either the electron ionization (EI) or chemical ionization (CI) mode.

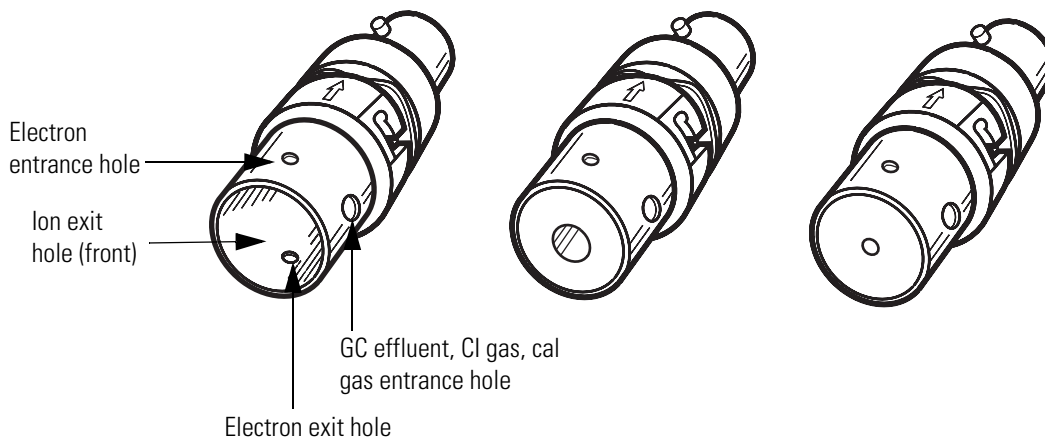
Figure 13. Ion source



The ion volume, located in the center of the ion source, is the site where electrons interact with sample or reagent gas molecules to form ions. Three exchangeable ion volumes and ion volume holders are available for use in the ion source. See [Figure 14](#). The choice of ion volume depends on the ionization mode. The EI ion volume is open on the analyzer end, with a relatively large electron entrance hole. The closed EI ion volume has a smaller ion exit hole than the EI ion volume. This results in a higher pressure of analyte, and greater sensitivity, but less dynamic range. The CI ion volume is closed on the analyzer end, except for a small ion exit hole and a relatively small electron entrance hole. In the CI mode it is important to maintain a relatively high reagent gas pressure.

The ion source block holds the ion volume in its center. Samples are introduced from the GC capillary column through an aperture on the side of the ion source block and then into the ion volume. Gases for calibration or chemical ionization enter the ion volume through a gas inlet tube.

Figure 14. EI (left), closed EI (center), and CI (right) on volumes and holders



Cartridge heaters heat the ion source block to minimize the rate at which deposits form on the ion source block and ion volume. The ion source block is also heated to assist in the rapid temperature equilibration of the ion source block and ion volume after the filament is turned on. In EI mode, the ion source is typically maintained at 150 °C to 220 °C. However, lower or higher temperatures are sometimes used for certain applications. In the CI mode, the ion source is typically maintained at 180 °C to 200 °C. The ion source heater is feedback controlled.

The filament assembly, positioned in a recess at the top of the ion source block, contains the filament, reflector, and electron lens. The filament is a rhenium wire that is electrically heated to produce electrons by thermionic emission. The reflector repels electrons emitted by the filament away from the filament toward the ion volume. The filament and its reflector are maintained at a negative potential relative to the ion volume. The electron lens prevents positive ions from traveling up the electron beam. In turn, this prevents positive ions from leaving the ion volume through the electron entrance hole. The difference in potential between the filament and the ion volume determines the electron energy.

Two permanent magnets are held in a magnet yoke in the proper position above and below the ion source block. The permanent magnets collimate the electron beam and cause the beam to spiral through the ion volume. This ensures optimum ionization of the sample.

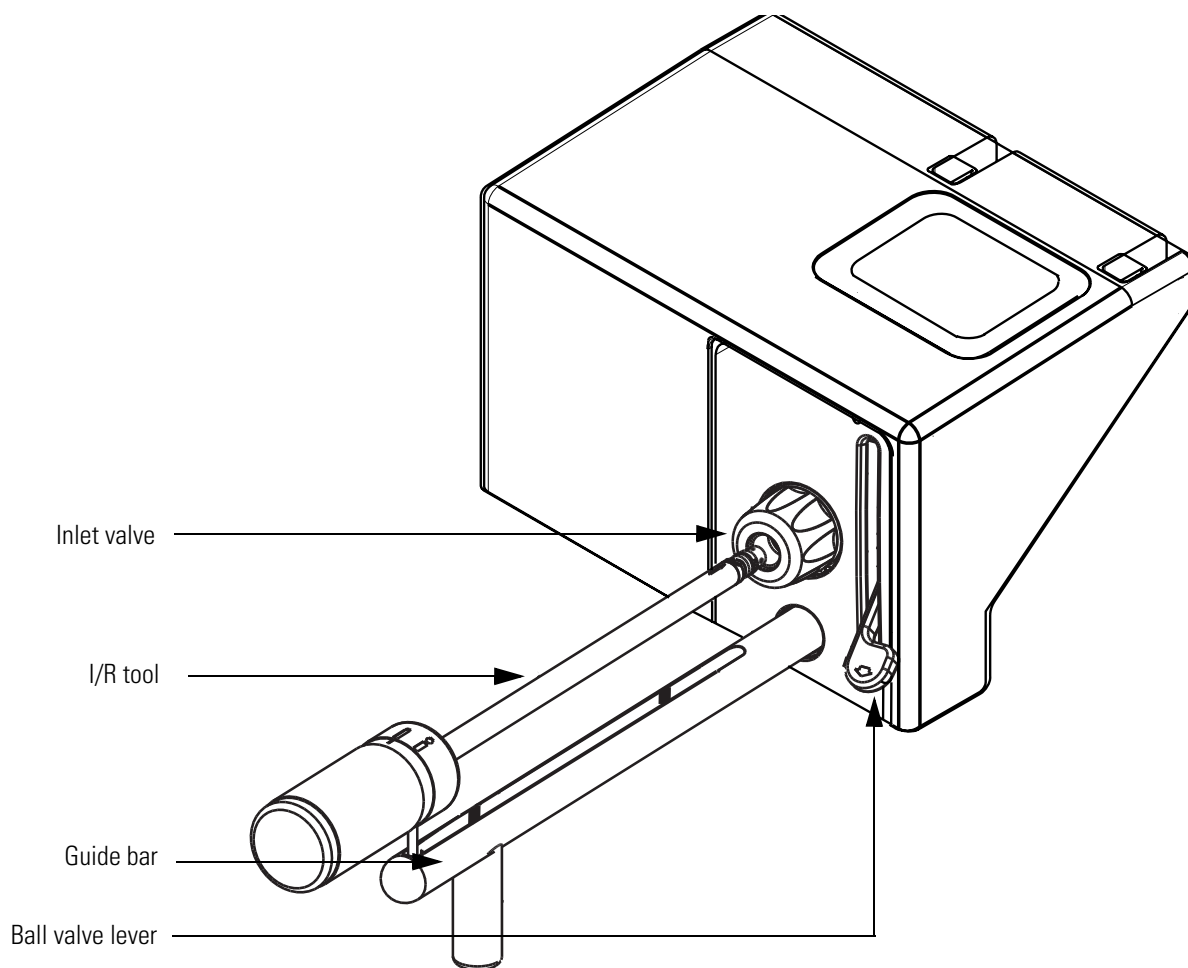
Four ion source lenses, designated L1, L2, L3, and L4, extract the ions formed in the ion source and transmit them to the ion optics. The lens L2 voltage is mass dependent. Lenses L1 and L3 voltages are constant and equal in magnitude. The lens L4 voltage depends on the lowest mass. In positive ion mode, the lenses are adjusted to a negative potential, and in negative ion mode, the lenses are adjusted to a positive potential. The arrangement of the lenses and their spacers enables quick and efficient pump-out of the ion source.

Inlet Valve

The inlet valve, which is attached to the front of the vacuum manifold, is a vacuum-sealed valve that allows you to change ion volumes or insert the direct exposure probe without venting the mass spectrometer to atmosphere. You use the insertion/removal (I/R) tool to insert or remove ion volumes. See [Figure 15](#). The forepump evacuates the inlet valve.

The ball valve is a ball with a hole in it, and it is located between the vacuum manifold and the inlet valve block. The ball valve is open when the hole in the ball is aligned with the opening between the vacuum manifold and the inlet valve. The ball valve lever opens and closes the ball valve. When the ball valve is closed, it prevents the vacuum manifold from venting to atmosphere.

Figure 15. Inlet valve, I/R tool, guide bar, and ball valve lever

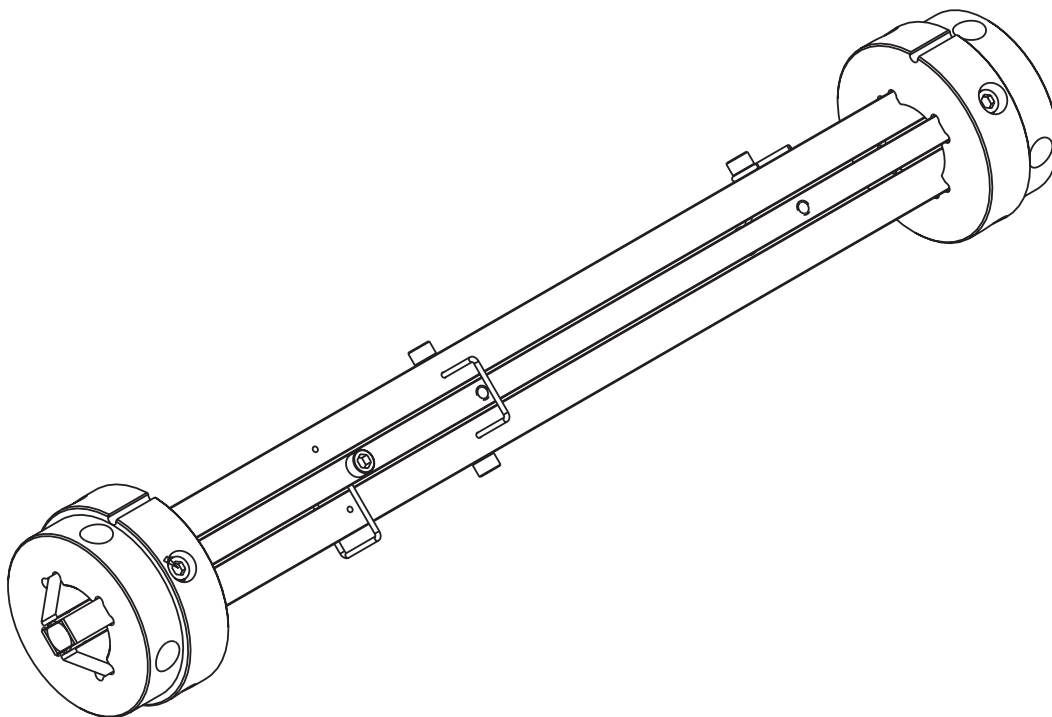


Ion Optics

The ion optics focus the ions produced in the ion source and transmit them to the mass analyzer. The ion optics includes the Q0 quadrupole and lenses L11 and L12.

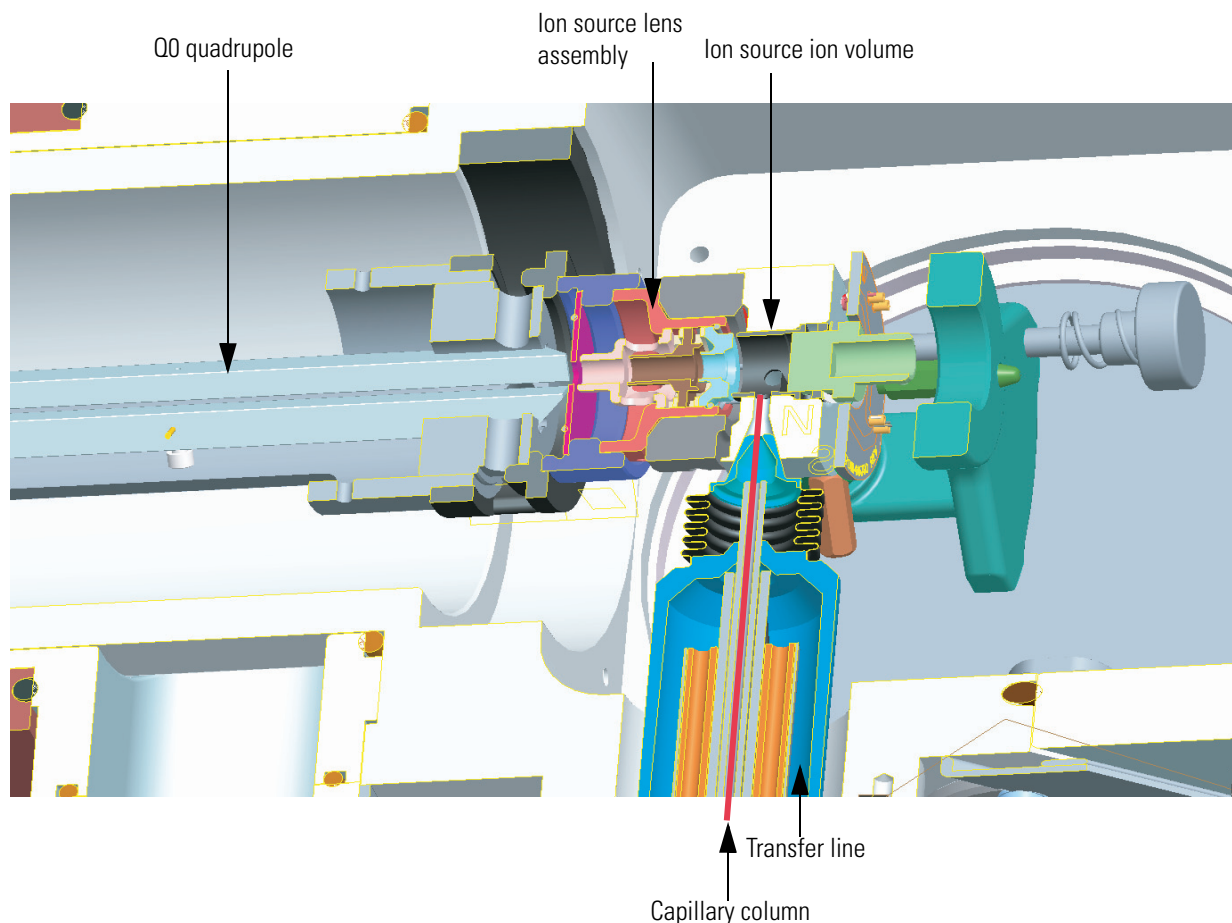
The Q0 quadrupole is a square array of square-profile rods that acts as an ion transmission device. See [Figure 16](#). An RF voltage applied to the rods gives rise to an electric field that guides the ions along the axis of the quadrupole. The Q0 offset voltage increases the translational kinetic energy of ions emerging from the ion source.

Figure 16. Q0 quadrupole



[Figure 17](#) gives a cross-sectional view of the transfer line, ion source, and Q0 quadrupole.

Figure 17. Cross-sectional view of the transfer line, ion source, and Q0 quadrupole



The L11 and L12 lenses are metal disks with a circular hole in the center through which the ion beam can pass. Together they act as a two-element cone lens. An electrical potential can be applied to the lens to accelerate (or decelerate) ions as they approach the lens and to focus the ion beam as it passes through the lens. The value ranges between 0 and ± 300 V. Lenses L11 and L12 also act as a vacuum baffle between the Q0 quadrupole chamber and the mass analyzer chamber.

Mass Analyzer

The mass analyzer separates ions according to their mass-to-charge ratio and then passes them to the ion detection system. The mass analyzer on the TSQ Quantum GC consists of three quadrupole rod assemblies (Q1, Q2, and Q3) and three lens sets.

The mass analyzer is discussed in detail in the following subtopics:

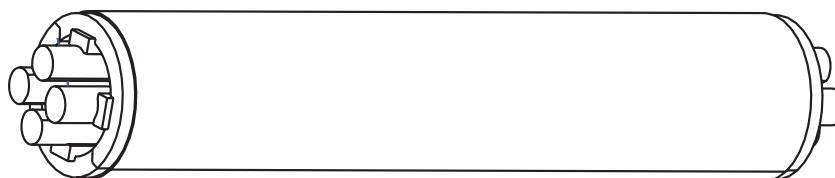
- [Quadrupole Rod Assemblies](#)
- [RF and DC Fields Applied to the Quadrupoles](#)
- [Mass Analysis](#)
- [Collision Cell and CID Efficiency](#)
- [Quadrupole Offset Voltage](#)
- [Mass Analyzer Lenses](#)

Quadrupole Rod Assemblies

The three rod assemblies used in the TSQ Quantum GC mass spectrometer are numbered from the ion source end of the manifold and are designated Q1, Q2, and Q3. Q1 and Q3 are quadrupoles that enable high-resolution scans without signal loss.

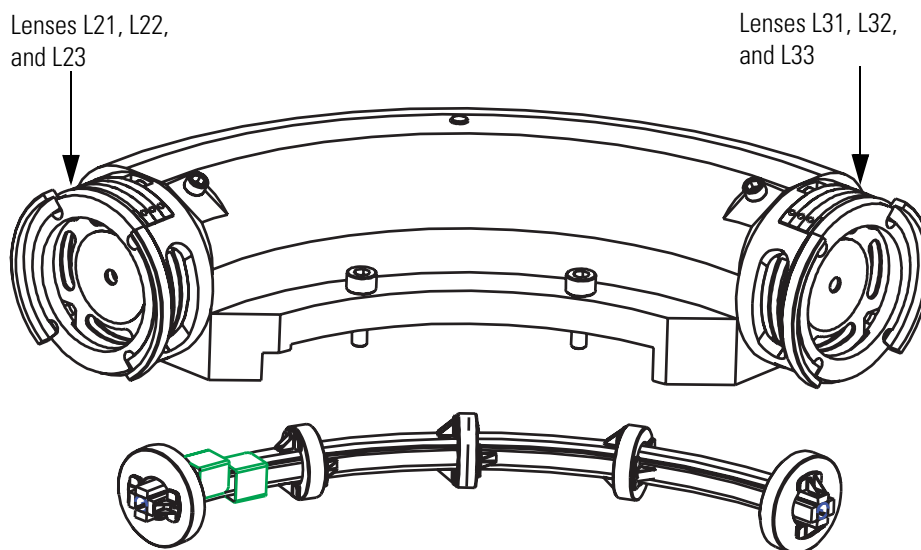
Q1 and Q3 are square arrays of precision-machined and precision-aligned, hyperbolic-profile round rods. Q1 or Q3 are shown in [Figure 18](#). Quartz spacers act as electrical insulators between adjacent rods.

Figure 18. Q1 or Q3 quadrupole



Q2 is a square-profile quadrupole rod assembly. Q2 always acts as an ion transmission device. The Q2 quadrupole rods are bent through a 90-degree arc. In addition to reducing the footprint of the instrument, this prevents the transmission of unwanted neutral species to the detector and dramatically lowers the noise level in the data. Q2 has become synonymous with the term *collision cell*. Technically, the collision cell is the chamber that encloses Q2 where collision-induced dissociation can take place if the argon collision gas is present. See [Figure 19](#).

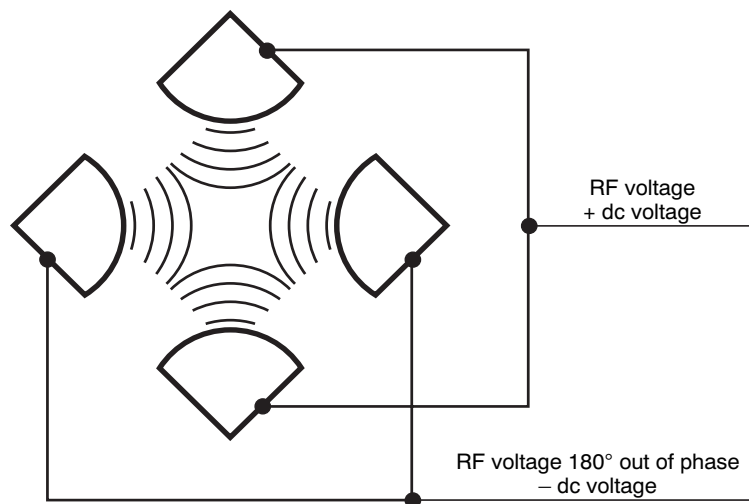
Figure 19. Collision cell, Q2 quadrupole, and lenses



RF and DC Fields Applied to the Quadrupoles

In a quadrupole rod assembly, because rods opposite each other in the array connect electrically, the four rods can be considered as two pairs of two rods each. Ac and dc voltages are applied to the rods and these voltages are ramped during the scan. Voltages of the same amplitude and sign are applied to the rods of each pair. However, the voltages applied to the different rod pairs are equal in amplitude but opposite in sign. See [Figure 20](#).

Figure 20. Polarity of the RF and dc voltages applied to the rods of the Q1 and Q3 mass analyzers



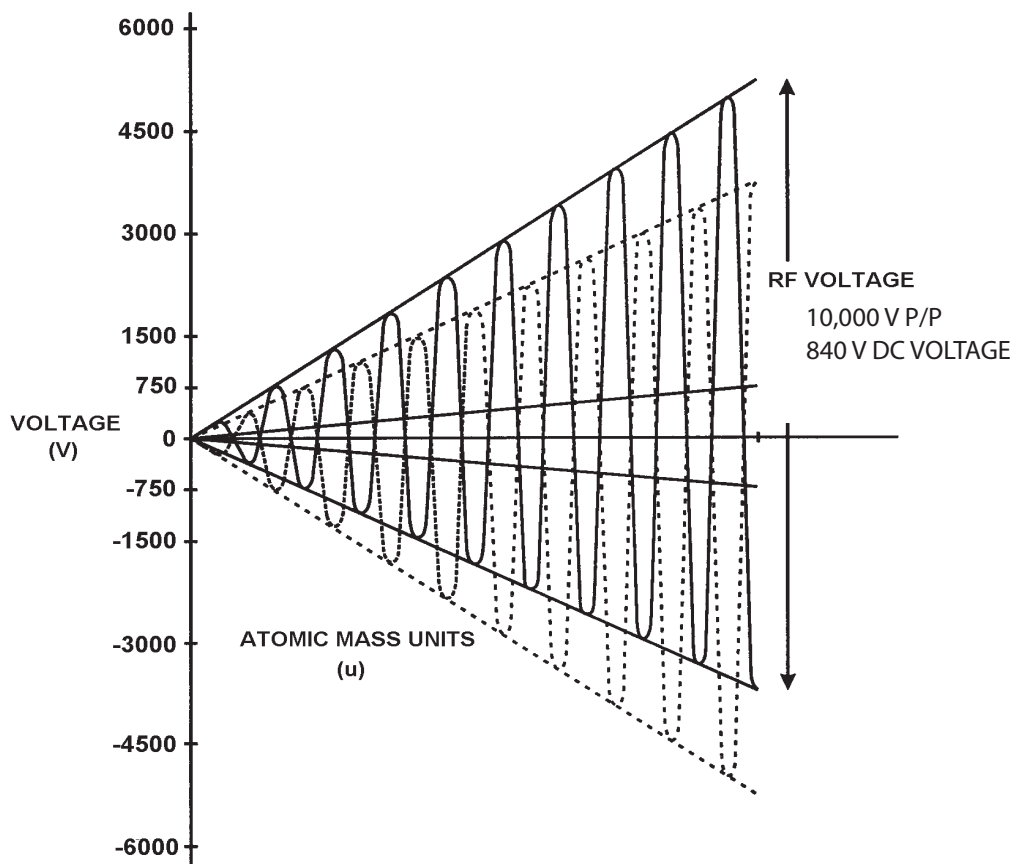
The ac voltage applied to the quadrupole rods is of constant frequency (1.123 MHz). The RF voltage applied to the rods varies from 0 to 10000 V P/P, and the dc voltage varies from 0 to ± 840 V. Voltages of the same amplitude and sign are applied to each rod pair. However, the voltages applied to the other rod pair are equal in amplitude but opposite in sign.

Because the frequency of this ac voltage is in the radio frequency range, it is referred to as RF voltage. In Figure 21, the solid line represents the combined RF and dc voltage applied to one rod pair, and the dashed line represents the combined RF and dc voltage applied to the other rod pair. The ratio of RF voltage to dc voltage determines the ability of the mass spectrometer to separate ions of different mass-to-charge ratios.

The first and third quadrupole rod assemblies (Q1 and Q3 quadrupoles) can act as mass analyzers or as ion transmission devices. When both RF and dc voltages are applied, Q1 and Q3 function as mass analyzers. When only RF voltage is applied, they act as ion transmission devices. In the ion transmission mode, the quadrupole rod assemblies allow ions in a wide window of mass-to-charge ratios to pass.

The square quadrupole rod assembly (Q2) operates in the ion transmission mode only. Surrounding Q2 is a collision cell where collision-induced dissociation (CID) can take place if the argon collision gas is present in the cell.

Figure 21. Magnitude of the RF and dc voltages applied to the rods of the Q1 and Q3 mass analyzers



Mass Analysis

The mass analyzers (Q1 and Q3) are square arrays of precision-machined and precision-aligned round-profile rods. The rods are charged with a variable ratio of RF voltage and dc voltage (Figure 21). These potentials give rise to an electrostatic field that gives stable oscillations to ions with a specific mass-to-charge ratio and unstable oscillations to all others.

At any given instant, one particular set of RF and dc voltage values is being applied to the mass analyzer rods. Under these conditions, only ions of one mass-to-charge ratio (for example, m/z 180) are maintained within bounded oscillations as their velocity carries them through the mass analyzer. During this same time, all other ions undergo unbounded oscillations. These ions strike one of the rod surfaces, become neutralized, and are pumped away, or they are ejected from the rod assembly.

Then, at a later time, both RF and dc voltages change, and ions of the next mass-to-charge ratio (for example, m/z 181) are allowed to pass, while all other ions (including m/z 180) become unstable and undergo unbounded oscillations. This process continues, with ions of one mass-to-charge ratio after another being transmitted, as the RF and dc voltages change in value. At the end of the scan, the RF and dc voltages are discharged to zero, and the process is repeated.

The potentials on the quadrupole rods can be changed rapidly and precisely. The RF and dc voltages in the TSQ Quantum GC mass spectrometer can be scanned over the full mass range of the system, m/z 10 to 3000, in 0.85 s.

The more closely the electrostatic field generated by a set of quadrupole rods approximates a hyperbolic geometry, the better their operating characteristics are. As a result, the precision quadrupole rods of the TSQ Quantum GC mass spectrometer provide excellent sensitivity, peak shape, resolution, and high mass transmission.

Collision Cell and CID Efficiency

In the MS/MS scan modes, the TSQ Quantum GC applies a large voltage of opposite polarity to the rod pairs between scans, which empties the collision cell. This process ensures that no ions remain in the collision cell from scan to scan.

The collision cell quadrupole rod assembly (Q2), which always acts as an ion transmission device, is a quadrupole array of square-profile rods. A variable RF voltage charges the rods, which creates an electrostatic field that gives stable oscillations to ions in a wide window of mass-to-charge ratios.

The collision cell surrounds Q2 and is usually pressurized from about 1×10^{-3} to 4×10^{-3} Torr with argon collision gas. The collision cell is where collision-induced dissociation takes place.

CID is a process in which an ion collides with a neutral atom or molecule and then, because of the collision, dissociates into smaller fragments. The mechanism of dissociation involves converting some of the translational kinetic energy (TKE) of the ion into internal energy. This collision places the ion in an excited state. If the internal energy is sufficient, the ion fragments.

Three expressions convey the efficiency of the CID process:

- Collection efficiency
- Fragmentation efficiency
- Overall CID efficiency

Collection efficiency: The ion flux ratio measured at the exit of the collision cell and at its entrance. With no collision gas present, the TSQ Quantum GC obtains virtually 100 percent collection efficiency. Collection efficiency is a mass-dependent parameter. For example, with mid-range collision gas pressure, the collection efficiency might vary from about 50 percent for comparatively less massive ions (which are more prone to scatter) up to 75 percent for comparatively more massive ions (which are less prone to scatter).

Fragmentation efficiency: The fraction of the ion flux at the exit of the collision cell that results from fragmented ions. Fragmentation efficiency depends directly on the stability of the ion and indirectly on the mass of the ion. The more stable the ion, the less likely a given collision will fragment the ion. The more massive the ion, the greater its ability to distribute the vibrational energy imparted by a collision. As a result, ion fragmentation might decrease.

With a mid-range collision gas pressure, fragmentation efficiency might vary from 15 percent to 65 percent for various compounds. As the collision gas pressure increases, the fragmentation efficiency for all compounds approaches 100 percent due to multiple collisions. The collection efficiency decreases, however, due to scattering.

Overall CID efficiency: The product of the collection efficiency and the fragmentation efficiency. The overall CID efficiency exhibits a maximum with intermediate pressure. As the pressure is increased beyond the optimum value, more and more collisions take place, the probability of scattering increases, and fewer and fewer ions pass through the collision cell. This results in the collection efficiency decreasing. The fragmentation efficiency also decreases as the pressure is decreased from its optimum value, because fewer and fewer collisions take place.

Quadrupole Offset Voltage

The quadrupole offset voltage is a dc potential applied to the quadrupole rods in addition to the ramping dc voltage. The offset voltage applied to the two rod pairs of the assemblies is equal in amplitude and equal in sign. The quadrupole offset voltage accelerates or decelerates ions and, therefore, sets the TKE of the ions as they enter the quadrupole rod assembly.

In general, for a given experiment, the TSQ Quantum GC has fixed offset voltages for Q1 and Q2. However, in MS/MS experiments, the quadrupole offset voltage applied to Q3 usually varies as a scan proceeds. The TSQ Quantum GC automatically computes the Q3 quadrupole offset voltage necessary and then varies the voltage, as appropriate, as each scan proceeds.

The offset voltage applied to Q2 (which contains the collision cell) is responsible for the collision energy. The collision energy is the difference in potential between the ion source (where parent ions are formed) and Q2 (where they collide with collision gas). As the offset voltage on Q2 increases, the TKE of the parent ions also increases. As a result, increases in the Q2 offset voltage increase the energy of ion/Ar collisions. The collision energy is generally set to one value for an entire scan and can be set from 0 to ± 200 V.

Before obtaining any mass spectra, the TSQ Quantum GC tunes Q1 in the Q1MS scan mode (Q2 and Q3 RF voltage only), and tunes Q3 in the Q3MS scan mode (Q1 and Q2 RF voltage only). During tuning, the TSQ Quantum GC determines the optimum quadrupole offset voltage for Q1 and for Q3.

Mass Analyzer Lenses

The TSQ Quantum GC system mass analyzer has three lens sets. See [Figure 19 on page 30](#). Those between Q1 and Q2 are designated L21, L22, L23; those between Q2 and Q3 are designated L31, L32, L33; and the lens between Q3 and the ion detection system is designated as L4 (or exit lens). All of the lenses have circular holes in their centers through which the ion beam passes.

The lens assemblies also retain the three rod assemblies to ensure accurate and automatic axial alignment of the rod assemblies.

The L2x lens set (between Q1 and Q2) and the L3x lens set (between Q2 and Q3) serve these functions:

- To minimize the amount of collision gas that enters the mass analyzers (Q1 and Q3) from the collision cell (Q2). (For high-mass transmission, it is important to maintain a low pressure in the mass analyzers.)
- To retain the collision gas. Lenses L23 and L3 form two of the walls of the collision cell, so they tend to hold the collision gas in the collision cell. The collision gas escapes, however, through the same lens holes through which the ion beam passes.
- To prevent gas from entering the mass analyzers. Lenses L22 and L21 on one side of Q2 and lenses L32 and L33 on the other side of Q2 act as baffles to help prevent the gas that escapes from the collision cell from entering the mass analyzers.
- To shield Q1 from the RF voltage applied to Q2 and vice versa (L2x lens set) and to shield Q3 from the RF voltage applied to Q2 and vice versa (L3x lens set).

- To focus the ion beam. The three lenses between Q1 and Q2 (and those between Q2 and Q3) together form a three-element aperture lens. The first and third lenses are generally set to similar or identical values and the central lens is set to a value different (either higher or lower) from the other two.

The voltage applied to each of the lenses can vary from about -300 to +300 V. Typically, however, the voltage applied to the first and third elements of the L2x lens set is somewhat greater than the quadrupole offset voltage applied to Q1. Because the Q1 quadrupole offset voltage is generally set to about ± 5 V (depending on the charge of the ions of interest), the voltage applied to lenses L21 and L23 is typically about -10 V for positive ions and +10 V for negative ions. The voltage applied to the central lens of the L2x lens set is typically about ± 225 V.

In the Q3MS scan mode, the voltage applied to the lenses of the L3x lens set is about the same as that applied to the corresponding lens in the L2x lens set. Note, however, that in the MS/MS scan modes, the voltage applied to the L3x lens set automatically varies with the quadrupole offset voltage applied to Q3. As the Q3 quadrupole offset voltage ramps, the voltages applied to the lenses ramp correspondingly.

Lens L4 is located between Q3 and the ion detection system. L4 is held at ground potential. Its purpose is to shield Q3 from the high voltage applied to the ion detection system and to shield the ion detection system from the high RF voltages applied to Q3.

Ion Detection System

The TSQ Quantum GC mass spectrometer is equipped with a high-sensitivity, off-axis ion detection system. This system produces a high signal-to-noise ratio and allows for voltage polarity switching between positive ion and negative ion modes of operation. The ion detection system includes a 15 kV conversion dynode and a channel electron multiplier. The ion detection system is located at the rear of the vacuum manifold behind the mass analyzer.

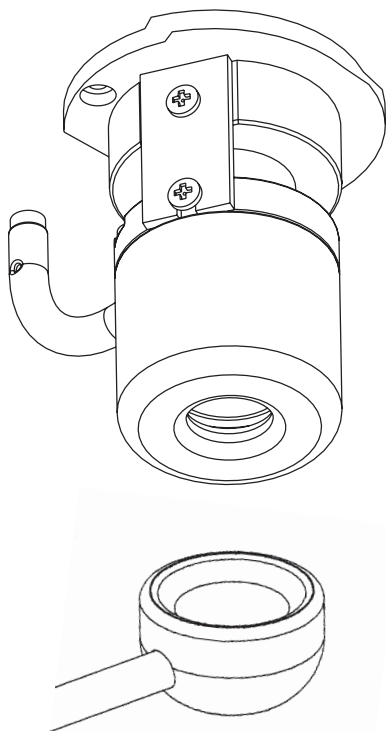
The conversion dynode is a concave metal surface located at a right angle to the ion beam. The TSQ Quantum GC applies to the conversion dynode a potential of +15 kV for negative ion detection or -15 kV for positive ion detection. When an ion strikes the surface of the conversion dynode, one or more secondary particles are produced. These secondary particles can include positive ions, negative ions, electrons, and neutrals. When positive ions strike a negatively charged conversion dynode, the secondary particles of interest are negative ions and electrons. When negative ions strike a positively charged conversion dynode, the secondary particles of interest are positive ions. The curved surface of the conversion dynode focuses these secondary particles and a voltage gradient accelerates the particles into the electron multiplier.

The electron multiplier includes a cathode and an anode. The cathode of the electron multiplier is a lead-oxide, funnel-like resistor. The high voltage ring applies a potential of up to -2.5 kV to the cathode. The exit end of the cathode (at the anode) is near ground potential.

The anode of the electron multiplier is a small cup located at the exit end of the cathode. The anode collects the electrons produced by the cathode. The anode screws into the anode feedthrough in the base plate.

Secondary particles from the conversion dynode strike the inner walls of the electron multiplier cathode with sufficient energy to eject electrons. The ejected electrons are accelerated farther into the cathode, drawn by the increasingly positive potential gradient. The funnel shape of the cathode causes the ejected electrons not to travel far before they again strike the inner surface of the cathode, which causes the emission of more electrons. A cascade of electrons is then created that finally results in a measurable current at the end of the cathode where the anode collects the electrons. The current collected by the anode is proportional to the number of secondary particles striking the cathode.

Figure 22. Ion detection system, showing the electron multiplier (top) and conversion dynode (bottom)



Typically, the electron multiplier is set to a gain of about 3×10^5 (that is, for each ion or electron that enters, 3×10^5 electrons exit) in MS mode and 2×10^6 in MS/MS mode. The electrometer circuit converts the current that leaves the electron multiplier via the anode to a voltage and the data system records the voltage.

The ion detection system of the TSQ Quantum GC mass spectrometer increases signal and decreases noise. The high voltage applied to the conversion dynode results in a high conversion efficiency and increased signal. That is, for each ion striking the conversion dynode, many secondary particles are produced. The increase in conversion efficiency is more pronounced for more massive ions than it is for less massive ions.

Because of the off-axis orientation of the ion detection system relative to the mass analyzer, neutral molecules from the mass analyzer tend not to strike the conversion dynode or electron multiplier. As a result, noise from neutral molecules is reduced.

Vacuum System and Inlet Gasses Hardware

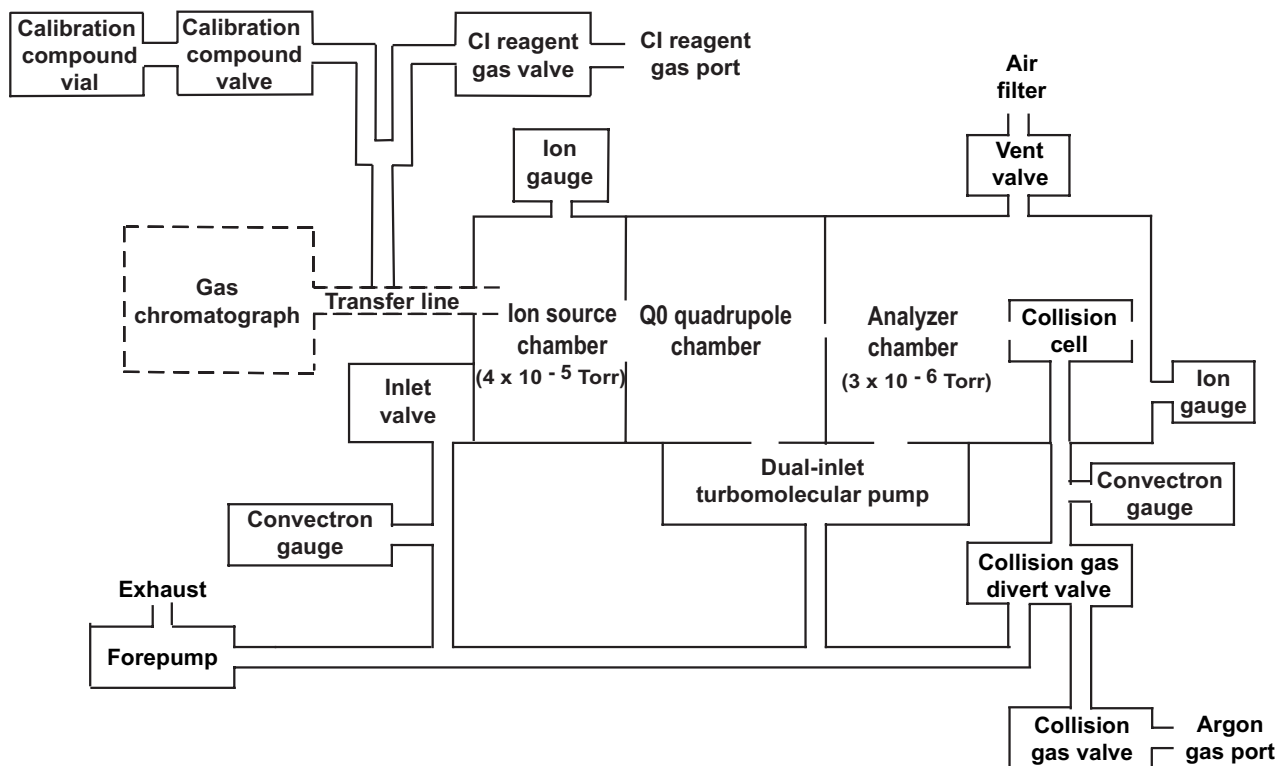
The vacuum system evacuates the region around the ion source, ion optics, mass analyzer, and ion detection system. The principal components of the vacuum system include the following:

- Vacuum Manifold
- Turbomolecular Pump
- Forepump
- Convectron[®] Gauges
- Ion Gauges

The inlet gasses hardware controls the flow of collision gas, CI reagent gas, calibration compound, and air (during venting) into the mass spectrometer. The inlet gasses hardware includes the following components:

- Vent Valve
- Collision Gas Flow Control Valves
- Calibration Compound and CI Reagent Gas Flow Control

Figure 23 shows a functional block diagram of the vacuum system and inlet gasses hardware.

Figure 23. Functional block diagram of the vacuum system and inlet gasses hardware

Vacuum Manifold

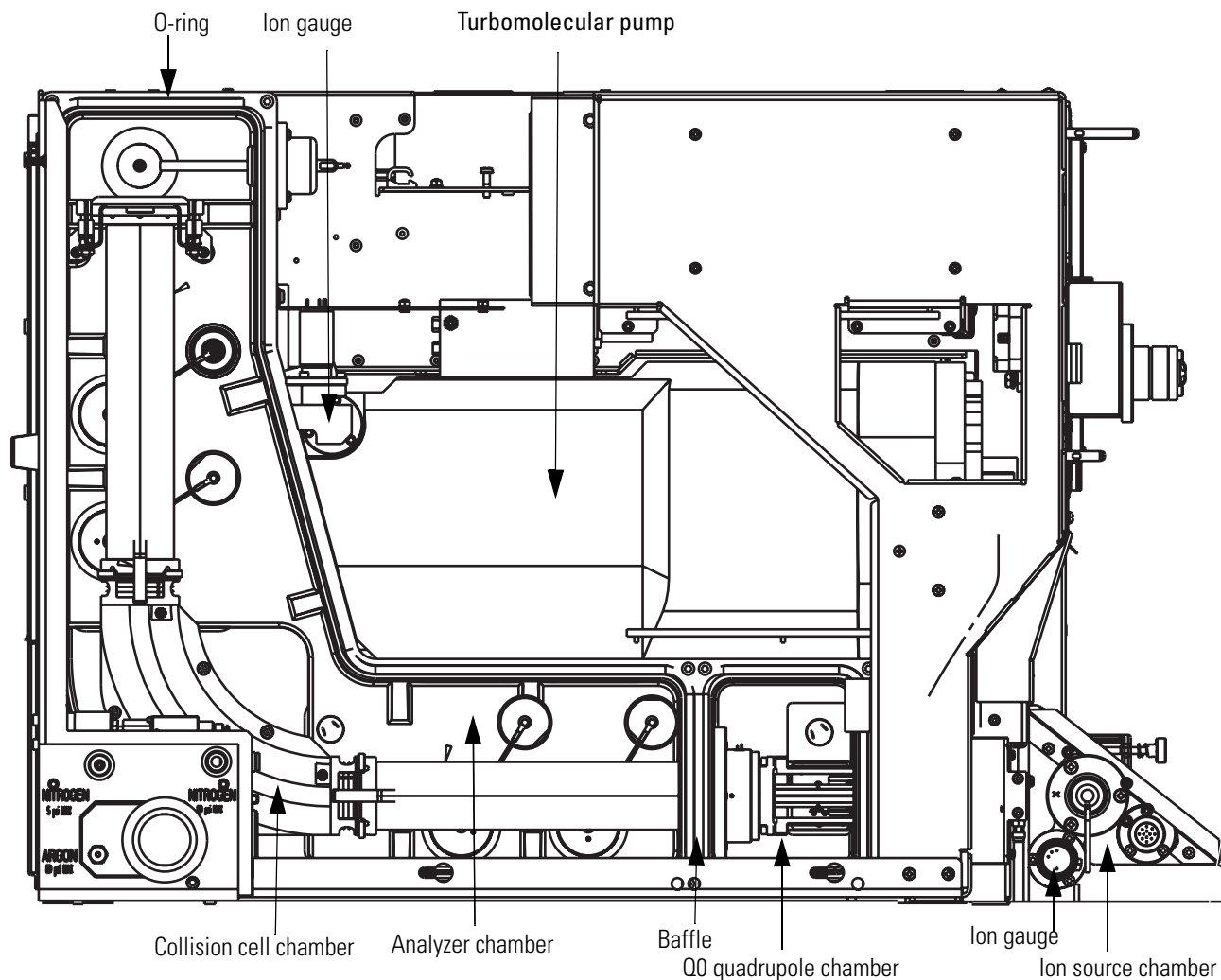
The vacuum manifold encloses the ion source, ion optics, mass analyzer, and ion detection system assemblies. The vacuum manifold is a thick-walled, aluminum chamber with two removable side cover plates, with openings on the front, sides, and top, and various electrical feedthroughs and gas inlets.

The main vacuum manifold is divided into two chambers by a baffle. See [Figure 24](#). The high vacuum port of the turbomolecular pump evacuates the region inside the first chamber, called the analyzer region, to less than 10^{-5} Torr. The turbomolecular pump then discharges into the forepump through the foreline.

The region inside the second chamber, called the Q0 quadrupole region, is evacuated to 1 mTorr by the interstage port of the turbomolecular vacuum pump.

A second vacuum manifold houses the ion source, which is open to the Q0 quadrupole chamber. The interstage port of the turbomolecular pump evacuates the ion source region.

Figure 24. Vacuum manifold (interior)



When CID is turned on, the collision cell chamber, inside the analyzer chamber, has a user controlled argon pressure of between 1 and 4 mTorr. The forepump evacuates the argon in the collision cell when CID is turned off.

The vacuum manifold has the following feedthroughs and inlets:

- A feedthrough for the high voltage for the conversion dynode
- A feedthrough for the high voltage for the electron multiplier
- A feedthrough for the ion current signal from the anode of the electron multiplier
- Two feedthroughs for the Q1 quadrupole RF voltage
- Two feedthroughs for the Q3 quadrupole RF voltage
- A feedthrough for the Q2 quadrupole RF voltage

- A feedthrough for lens L21, L22, L23, L31, L32, and L33 voltages
- A feedthrough for the Q0 quadrupole RF voltage
- A vacuum connection for measuring the pressure in the analyzer region with the ion gauge
- An argon gas inlet into the collision cell
- A vent gas inlet

Two removable side cover plates on the left side of the vacuum manifold allow access to the Q0 ion optics, mass analyzer, and ion detection system. Two electrically conductive O-rings provide a vacuum-tight seal between the side cover plates and the vacuum manifold.

Turbomolecular Pump

A Leybold TW220/150/15S double-inlet turbomolecular pump provides the vacuum for the ion source, Q0 quadrupole region, and analyzer region of the vacuum manifold. The turbomolecular pump mounts onto the top of the vacuum manifold ([Figure 24](#)).

The turbomolecular pump has two pumping inlets:

- A high-vacuum inlet at the top of the rotor stack, which evacuates the analyzer chamber
- An interstage inlet about halfway down the rotor stack, which evacuates the ion source and Q0 quadrupole chambers

The turbomolecular pump is controlled by a Leybold TDS controller and powered by a +24 V dc (250 W) power supply. The mass spectrometer circuit breaker switch and the vacuum service switch, but not the electronics service switch, turn power for the turbomolecular pump off and on. A fan draws air in from the front of the instrument cools the pump.

Power to the turbomolecular pump shuts off if the foreline pressure, as measured by the Convectron gauge, is too high, or if the turbomolecular temperature is too high.

Forepump

An Edwards E2M30 forepump (or roughing pump) establishes the vacuum necessary for the proper operation of the turbomolecular pump. The forepump also evacuates the inlet valve and the collision cell. The pump has a maximum displacement of 650 L/min and maintains a minimum pressure of approximately 1 Pa (0.01 Torr).

The forepump is connected to the turbomolecular pump by a section of reinforced PVC tubing. The power cord of the forepump is plugged into the outlet labeled *Forepump* on the power panel (see [Figure 12](#) on [page 23](#)). This outlet supplies power to the pump and is controlled by the main power circuit breaker switch and vacuum service switch, not by the electronics service switch.



CAUTION Always plug the forepump power cord into the outlets labeled *Forepump* on the right side power panel of the mass spectrometer. Never plug it directly into a wall outlet.

Convectron® Gauges

A Convectron gauge measures the pressure in the inlet valve and the foreline, which connects the turbomolecular pump and the forepump. A second Convectron gauge measures the pressure of argon collision gas in the collision cell.

The Convectron gauge uses a Wheatstone bridge with a temperature dependent resistor to measure pressure down to a fraction of a milliTorr. The voltage present at the top of the bridge depends on how fast the resistor can radiate heat, which is related to the pressure. The pressure measured by the Convectron gauge is monitored by vacuum protection circuitry on the Source PCB, which in turn is monitored by the embedded computer on the System Control PCB. The vacuum protection circuitry detects whether the foreline pressure is too high for the proper operation of the turbomolecular pump.

Ion Gauges

A Granville-Phillips® 342™ mini ion gauge measures the pressures in the analyzer region of the vacuum manifold and the Q0/ion source region. The ion gauge produces energetic electrons that cause the ionization of molecules in the ion gauge. Positive ions formed in the ion gauge are attracted to a collector. The collector current is related to the pressure in the vacuum manifold. The ion gauge is also involved in vacuum protection.

Vent Valve

The vent valve, located in the area of Q2, allows the vacuum manifold to be vented to air that has been filtered through a sintered nylon filter. The vent valve is a solenoid-operated valve, which is controlled by the Vent Delay PCB. When the solenoid is energized, the vent valve closes. If the power fails or the main power circuit breaker is placed in the Off (O) position, a 4-farad capacitor located in the Power Entry Module keeps the solenoid in the closed position for several minutes. If power is not restored in this time, then the solenoid opens and the system is vented with filtered air. The vent valve closes after power is restored to the mass spectrometer.

Collision Gas Flow Control Valves

The collision gas flow control valves control the flow of argon collision gas into and out of the Q2 collision cell. A solenoid valve acts to shut off argon gas flow to the cell. The collision gas pressure is regulated by a proportional valve that is controlled by the data system. You can set the collision gas pressure (0 to 4 milliTorr) in the Define Scan view of the Tune Master window.

Ions enter the Q2 collision cell, collide with the argon collision gas, and then, because of the collision, dissociate into smaller fragments. See “Collision Cell and CID Efficiency” on page 32.

Argon enters the mass spectrometer through a 1/8-in. port on the left side of the mass spectrometer.

A second proportional valve allows the forepump to evacuate the Q2 collision cell of argon and waste gasses when CID is turned off. The TSQ Quantum GC mass spectrometer automatically opens and closes the collision gas evacuation valve, depending on whether Q2 is acting as an ion transmission device or a collision cell.

Calibration Compound and CI Reagent Gas Flow Control

The calibration compound gas flow control valve controls the flow of calibration compound gas into the ion source, via the transfer line. The calibration gas flow can be either high or low. Normally low flow is used, but high flow might be necessary for negative ion CI calibration.

The CI gas flow control valve controls the flow of chemical ionization reagent gas into the ion source, via the transfer line. The maximum CI gas flow rate is about 4 mL/min, depending on the gas.

Electronic Assemblies

The electronic assemblies that control the operation of the mass spectrometer are distributed among various PCBs and other modules located in the tower, in the embedded computer, and on or around the vacuum manifold of the mass spectrometer.

The Power Entry Module provides mass spectrometer power control, a contact closure interface, vent valve control, an Ethernet 100 base-T connection from the System Control PCB to the data system PC, a mechanical pump failure protection circuit (linked to vent valve control), a system reset button, status LEDs, and service ports. The right-side power panel, shown in Figure 12 on page 23, is part of the Power Entry Module.

The Power Entry Module accepts line power, filters it, and provides it to various components of the mass spectrometer. The Power Module includes the following components:

- Main power circuit breaker switch
- Surge suppressor
- Line filter
- Electronics service switch
- Vacuum service switch

The “brains” of the TSQ Quantum GC mass spectrometer is the System Control PCB. The System Control PCB and embedded computer include the following:

- PowerPC processor
- Serial Peripheral Interconnect (SPI) bus
- I/O coprocessor
- Super Harvard Architecture Computer (Sharc) bus
- Scan generator DSP
- Acquisition processor DSP
- Interbus bridge
- 100 base-T Ethernet port

The RF voltage generation electronic assemblies produce the Q0, Q1, Q2, and Q3 RF voltages that enable ion transmission and mass analysis. All RF voltages are controlled by the Analyzer Control PCB and the System Control PCB.

The Q1 and Q3 RF voltage amplifier circuits are identical, and the circuits for Q0 and Q2 are similar.

The RF voltage generation electronic assemblies include the following components:

- RF oscillator
- RF Voltage Amplifier PCB
- Low Pass Filter PCB
- RF voltage coil
- RF voltage detector
- Mass DAC
- Integrating amplifier

The ion detection system electronic assemblies provide high voltage to the electron multiplier and conversion dynode of the ion detection system. They also receive the electron multiplier output current signal, convert it to a voltage (by the electrometer circuit), and pass it to the embedded computer.

The ion detection system electronic assemblies include the following:

- Electron multiplier power supply
- Conversion dynode power supply
- Electrometer PCB
- Acquisition DSP

The Analyzer Control PCB contains circuitry for controlling and monitoring the operation of the ion source, ion optics, mass analyzer, and ion detection system. These circuits are in turn monitored by the PowerPC processor of the System Control PCB via the SPI bus.

The Analyzer Control PCB controls and monitors the RF voltages for Q0, Q1, Q2, and Q3 quadrupoles. It also has lens voltage drivers that convert ± 330 V dc power from the DC Rod Driver PCB to dc voltages that are applied to the lenses

Data System

The data system controls and monitors the TSQ Quantum GC mass spectrometer. The data system also processes data that the TSQ Quantum GC mass spectrometer acquires. The data system is composed of the following:

- [Computer Hardware](#)
- [Data System / Mass Spectrometer / GC Interface](#)
- [Data System / Local Area Network Interface](#)

Computer Hardware

The data system computer has the following major features:

- Intel® Pentium® IV processor
- High capacity hard disk drive
- Recordable/rewriteable CD drive
- Primary Ethernet port (data system to mass spectrometer)
- Secondary Ethernet port (data system to local area network)
- High performance video graphics card
- CDRW drive
- DVD drive
- 1280×1024 resolution color monitor
- Keyboard and mouse

For more information about the computer, refer to the appropriate manuals.

Data System / Mass Spectrometer / GC Interface

The data system computer contains a 100 base-T Ethernet adapter (called the primary Ethernet adapter) that is dedicated to data system/mass spectrometer/GC communications. This primary Ethernet adapter communicates with the mass spectrometer and GC modules via a 10/100 base-T Ethernet switch. The Ethernet adapter on the mass spectrometer resides on the System Control PCB. A twisted pair, Ethernet cable connects the primary Ethernet adapter of the data system to the Ethernet switch, which is connected to the Ethernet connector on the power panel of the mass spectrometer and to the GC.

Data System / Local Area Network Interface

The data system computer contains a secondary Ethernet adapter. This secondary Ethernet adapter is not involved in data system/mass spectrometer or GC communications. You can use this secondary Ethernet adapter to access your local area network.

System Shutdown, Startup, and Reset

Many maintenance procedures for the TSQ Quantum GC system require that the mass spectrometer be shut down completely. In addition, you can place the TSQ Quantum GC mass spectrometer in standby mode if the system is not to be used for 12 hours or more.

Contents

- [Shutting Down the System in an Emergency](#)
- [Placing the System in Standby Mode](#)
- [Shutting Down the System Completely](#)
- [Starting Up the System after a Complete Shutdown](#)
- [Resetting the Mass Spectrometer](#)
- [Resetting the Data System](#)
- [Turning Off Selected Mass Spectrometer Components](#)

Shutting Down the System in an Emergency

You can turn off all power to the mass spectrometer, gas chromatograph, and autosampler by pressing the System Power Off button, located on the front of the electronics module, or the main power circuit breaker, located on the rear of the electronics module. You can turn on the system power only with the main power circuit breaker on the rear of the electronics module and not the System Power Off switch.

❖ To turn off the mass spectrometer in an emergency



CAUTION Press the System Power Off button located on the front of the electronics module. See [Figure 25](#). The System Power Off button turns off all power to the mass spectrometer (including the vacuum pumps), gas chromatograph, and autosampler. Although removing power abruptly does no harm to any component within the system, under normal conditions do not shut down the system with the System Power Off button. For the recommended procedure, see “Shutting Down the System Completely” on [page 49](#).

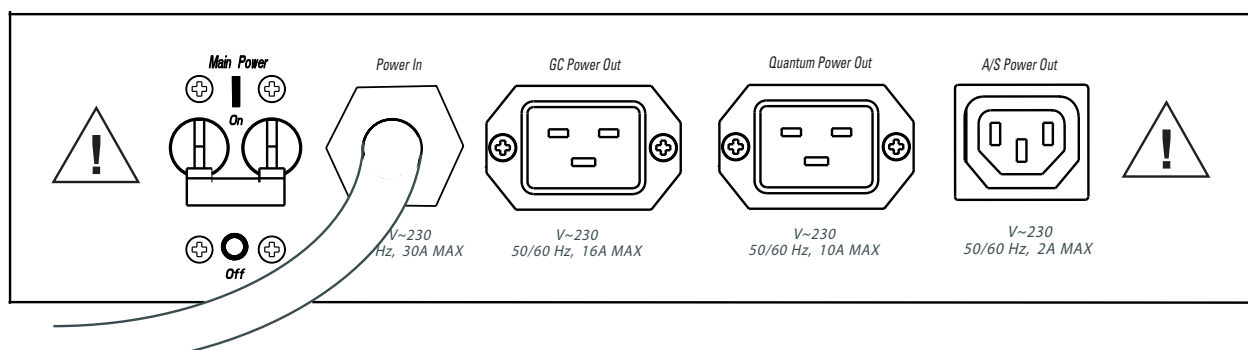
3 System Shutdown, Startup, and Reset

Placing the System in Standby Mode

Figure 25. System Power Off button on the front of the electronics module



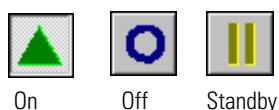
Figure 26. Power panel on the rear of the electronics module



Placing the System in Standby Mode

If you are not going to use the TSQ Quantum GC system for a short period of time, such as overnight or over weekends, it does not need to be shut down completely. When you are not going to operate the system for 12 hours or more, you can leave the system in standby mode.

❖ To place the TSQ Quantum GC system in standby mode



1. Wait until data acquisition, if any, is complete.
2. From the Quantum Tune Master window, choose **Control > Standby** (or click the **On/Standby** button) to put the mass spectrometer in standby.

When you choose Control > Standby, the TSQ Quantum GC system turns off the electron multiplier, the conversion dynode, the ion source filament and lenses (but not the heater), and the mass analyzer and ion optics RF voltages. See [Table 4 on page 57](#) for

the On/Off status of mass spectrometer components when the mass spectrometer is in standby mode. The System LED on the front panel of the mass spectrometer illuminates yellow when the system is in standby.

3. Leave the mass spectrometer power on.
4. Leave the GC power on with column flow.
5. Leave the autosampler power on.
6. Leave the data system power on.

Shutting Down the System Completely

Shut down the TSQ Quantum GC system completely only if it is to be unused for an extended period or if it must be shut down for a maintenance or service procedure. For a short period of time, such as overnight or over weekends, you can place the system in standby mode. See [“Placing the System in Standby Mode.”](#)

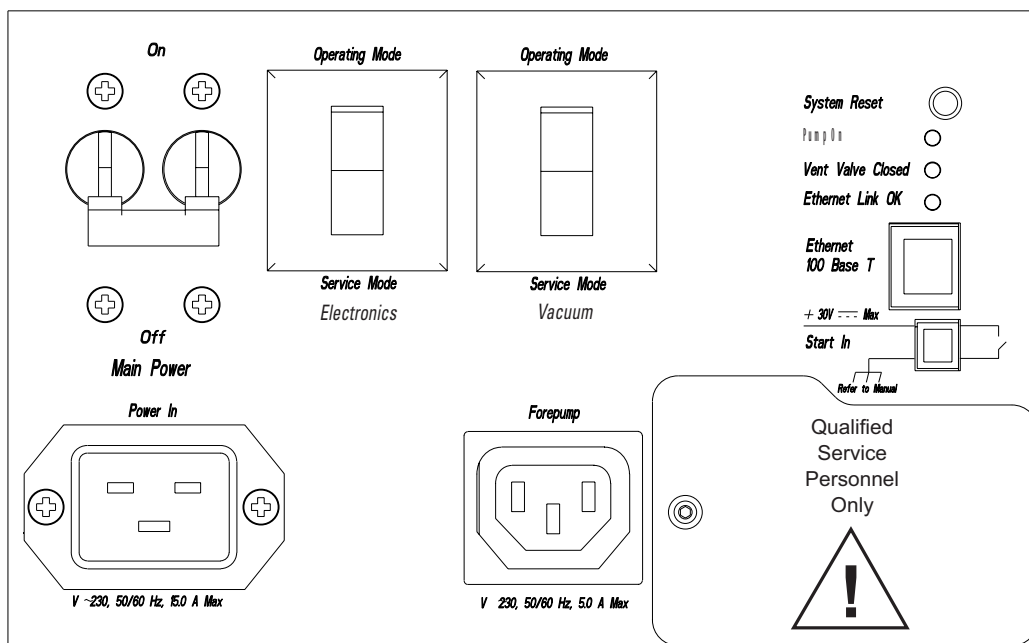
❖ To shut down the TSQ Quantum GC system completely

1. Cool the GC, transfer line, and ion source:
 - GC oven **30 °C**
 - Injector **off**
 - Transfer line **off**
 - Ion source **30 °C**
- Note** If you do not plan to change the column or perform maintenance on the gas chromatograph, you do not have to lower the injector temperature.
2. From the Quantum Tune Master window, choose **Control > Standby** (or click the **On/Standby** button) to put the mass spectrometer in standby.
 3. Place the electronics service switch, located on the right-side power panel, in the Service Mode.

3 System Shutdown, Startup, and Reset

Shutting Down the System Completely

Figure 27. Right-side power panel of the mass spectrometer



4. Place the vacuum service switch, located on the right-side power panel, in the Service Mode position.
5. Place the mass spectrometer main power circuit breaker switch, located on the right-side power panel, in the Off position. When you place the main power circuit breaker switch in the Off position, the following occurs:
 - All power to the mass spectrometer is turned off. (All LEDs on the front panel of the mass spectrometer are off.)
 - A capacitor on the Vent Delay PCB provides power to the vent valve for two to four minutes (to allow the turbomolecular pump to spin down). After the capacitor discharges, power to the vent valve solenoid shuts off. When power to the vent valve solenoid shuts off, the vent valve opens and the vacuum manifold vents to filtered air. You can hear a hissing sound as the air passes through the air filter.
 - After about two minutes, the pressure of the vacuum manifold reaches atmospheric pressure.
6. Unplug the power cord for the mass spectrometer.



CAUTION Allow heated components to cool before servicing them.

Note If you plan to perform routine or preventive system maintenance on the mass spectrometer only, you can leave the argon, data system, GC, and autosampler on. In this case, the shutdown procedure is complete. However, if you do not plan to operate your system for an extended period of time, Thermo Fisher Scientific recommends that you turn off the GC, data system, and autosampler as described in steps 7 through 12 below.

7. Turn off the GC. Follow the procedure described in the manual that came with the GC.
8. Turn off the autosampler by using the main power on/off switch.
9. Press the System Power Off button (Figure 25) to remove all power from the TSQ Quantum GC system.
10. If the TSQ Quantum GC is not to be used for an extended period, turn off the argon collision gas supply at the tank.
11. Turn off the data system:
 - a. Choose **Start > Shut Down** from the Windows® task bar. The Shut Down Windows dialog box appears.
 - b. To start the Windows shutdown procedure, select **Shut down** and click **OK**.
12. Turn off the (optional) printer by using the on/off switch.

Starting Up the System after a Complete Shutdown

Start the TSQ Quantum GC system after it has been shut down completely by doing the following:

- [Restoring Power to the TSQ Quantum GC system](#)
- [Starting Up the GC](#)
- [Starting Up the Data System](#)
- [Starting Up the Mass Spectrometer](#)
- [Starting Up the Autosampler](#) (autosampler is optional)
- [Setting Up Conditions for Operation](#)

Restoring Power to the TSQ Quantum GC system

❖ **To restore power to the TSQ Quantum GC system**

Place the main power circuit breaker, located on the rear of the electronics module (Figure 26), in the On position.

Starting Up the GC

❖ To start the GC

Follow the startup procedure described in the manual that came with the GC. Verify that the gas chromatograph is on and there is carrier gas flowing through the column into the mass spectrometer.

Starting Up the Data System

❖ To start the data system

1. Turn on the monitor, computer, and printer.
2. Observe the Windows startup procedure on the monitor and press **CONTROL+ALT+DELETE** when you are prompted to do so. To complete the startup procedure, click **OK** or enter your password (if you have one) in the Logon Information dialog box.

Starting Up the Mass Spectrometer

❖ To start the mass spectrometer



CAUTION If you turn on the mass spectrometer without column flow, air can damage the GC column. This large air leak into the TSQ Quantum GC also causes the ion source to require cleaning.

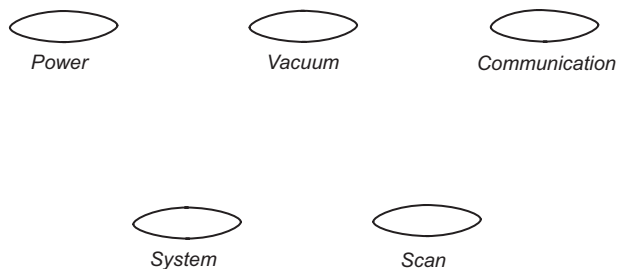
1. Turn on the flow of argon at the tank if it is off.
Note The data system must be running before you start the mass spectrometer. The mass spectrometer will not operate until it receives software from the data system.
2. Make sure that the mass spectrometer main power circuit breaker switch, located on the right side power panel (Figure 27), is in the Off (O) position and the electronics service switch and the vacuum service switch are both in the Service Mode position.
3. Plug in the power cord for the mass spectrometer.
4. Place the mass spectrometer main power circuit breaker switch in the On (I) position. When you place the main power circuit breaker switch in the On (I) position, power is supplied to those mass spectrometer components that are not affected by the vacuum service switch and the electronics service switch.
5. Place the vacuum service switch in the Operational position.

6. Place the electronics service switch in the Operational position. When you place the electronics service switch in the Operational position, the following occurs:
- The Power LED on the mass spectrometer front panel illuminates green to indicate that power is provided to the mass spectrometer electronics. (The electron multiplier, conversion dynode, ion source, and mass analyzer and ion optics RF voltages remain off.)
 - The embedded computer reboots. After several seconds the Communication LED on the front panel illuminates yellow to indicate that the data system and the mass spectrometer have started to establish a communication link.
 - After several more seconds, the Communication LED illuminates green to indicate that the data system and the mass spectrometer have established a communication link. Software for the operation of the mass spectrometer is then transferred from the data system to the mass spectrometer.
 - After three minutes, the System LED illuminates yellow to indicate that the software transfer from the data system to the mass spectrometer is complete and that the instrument is in standby.
 - The Vacuum LED on the front panel of the mass spectrometer remains off until the turbomolecular pump reaches 80 percent of its operational speed of 750 Hz. At this time the ion gauge is turned on and the Vacuum LED illuminates yellow. The Vacuum LED illuminates green, and the high voltage can be turned on, only if the pressure in the mass analyzer region of the vacuum manifold is less than the appropriate value listed in [Table 3](#).

Table 3. Maximum allowed pressure to turn on high voltage

Carrier gas	Ar collision gas	Maximum pressure (Torr)
He	Off	6×10^{-6}
He	On	5×10^{-5}
H ₂	Off	5×10^{-5}
H ₂	On	1×10^{-4}

Figure 28. Front panel LEDs of the mass spectrometer



If you have an autosampler, go to “Starting Up the Autosampler” on page 54. If you do not have an autosampler, go to “Setting Up Conditions for Operation” on page 54.

Starting Up the Autosampler

❖ To start the autosampler

Place the main power switch on the autosampler in the On position. If necessary, configure the autosampler. For procedures for placing sample vials, preparing solvent and waste bottles, installing syringes, and so on, refer to the manual that came with the autosampler.

Setting Up Conditions for Operation

❖ To set up your TSQ Quantum GC mass spectrometer for operation

1. Before you begin data acquisition with your TSQ Quantum GC system, allow the system to pump down for at least one hour. Operation of the system with excessive air and water in the vacuum manifold can cause reduced sensitivity, tuning problems, and reduced lifetime of the electron multiplier.
2. Ensure that the argon pressure is within the operational limits [argon: 135 ± 70 kPa (20 ± 10 psig)].

Note Air in the argon line must be purged or given sufficient time to be purged for normal TSQ Quantum GC mass spectrometer performance.

3. Look at the Instrument Information Center or Status view in the Quantum Tune Master window. Check that the pressure measured by the ion gauge is below about 3×10^{-6} Torr (2×10^{-5} Torr with H₂ carrier gas) with the collision gas turned off.

Note You do not need to calibrate and tune the TSQ Quantum GC mass spectrometer each time you restart the TSQ Quantum GC system. To tune and calibrate the TSQ Quantum GC, see Chapter 4, “Tuning and Calibrating.”

Resetting the Mass Spectrometer

If communication between the mass spectrometer and data system computer is lost, it might be necessary to reset the mass spectrometer using the Reset button on the right-side power panel. Pressing the System Reset button creates an interrupt in the embedded computer. This causes the embedded computer to restart in a known (default) state. See Figure 27 on page 50 for the location of the System Reset button.

The procedure given here assumes that the mass spectrometer and data system computer are both powered on and operational. If the mass spectrometer, data system computer, or both are off, go to “Starting Up the System after a Complete Shutdown” on page 51.

❖ **To reset the mass spectrometer**

Press the System Reset button located on the right-side power panel. Make sure the Communication LED is extinguished before releasing the System Reset button. When you press the Reset button, the following occurs:

- An interrupt on the embedded computer causes the CPU to reboot. All LEDs on the front panel of the mass spectrometer are off except the Power LED.
- After several seconds, the Communication LED illuminates yellow to indicate that the data system and the mass spectrometer are starting to establish a communication link.
- After several more seconds, the Communication LED illuminates green to indicate that the data system and the mass spectrometer have established a communication link. Software for the operation of the mass spectrometer is then transferred from the data system to the mass spectrometer.
- After three minutes the software transfer is complete. The System LED illuminates either green to indicate that the instrument is functional and the high voltages are on, or yellow to indicate that the instrument is functional, and it is in standby.

Resetting the Data System

There are two ways to reset the data system:

- [Resetting the Data System by Using the Windows Shutdown and Restart Procedure](#)
- [Resetting the Data System by Turning the Personal Computer Off Then On](#)

Resetting the Data System by Using the Windows Shutdown and Restart Procedure

If possible, use the Windows shutdown and restart procedure to shut down and restart the data system so that Windows can properly close programs and save changes to files.

❖ **To reset the data system by using the Windows shutdown and restart procedure**

1. Choose **Start > Shut Down** from the Windows task bar. The Shut Down Windows dialog box appears.
2. Select **Restart** and click **OK** to start the Windows shutdown and restart procedure.
3. Observe the Windows shutdown and restart procedure on the monitor. Press CTRL+ALT+DELETE when you are prompted to do so. To complete the shutdown and

restart procedure, click **OK** or enter your password (if you have one) in the Logon Information dialog box.

Note The communications link between the data system and the mass spectrometer should automatically reestablish after you reset the data system. When this occurs the Communication LED on the front panel of the mass spectrometer illuminates yellow and then green. If the system is unable to reestablish the communications link, press the System Reset button on the power panel of the mass spectrometer.

Resetting the Data System by Turning the Personal Computer Off Then On

If you are unable to reset the data system by using the Windows shutdown and restart procedure, proceed as follows:

1. Press the Power button on the personal computer to turn the personal computer off.
2. After several seconds, press the Power button on the personal computer to turn the personal computer on.
3. Observe the Windows XP startup procedure on the monitor and press CTRL+ALT+DELETE when you are prompted to do so. To complete the shutdown and restart procedure, click **OK** or enter your password in the Logon Information dialog box.
4. When the shutdown and restart procedure has completed, choose **Start > All Programs > Xcalibur > Quantum Tune** to display the Quantum Tune Master window.

Note The communications link between the data system and the mass spectrometer should automatically reestablish after you reset the data system. When this occurs the Communication LED on the front panel of the mass spectrometer illuminates yellow and then green. If the system is unable to reestablish the communications link, press the System Reset button on the right-side power panel of the Power Entry Module of the mass spectrometer.

Turning Off Selected Mass Spectrometer Components



There are different ways that you can turn off some or all of the mass spectrometer components:

- Turn off individual mass spectrometer components from the Quantum Tune Master window. Turning off individual mass spectrometer components might be necessary when you are troubleshooting or when you are running certain diagnostic procedures.

- Place the mass spectrometer in standby mode. Standby is the normal condition to leave the mass spectrometer in when it is not in use. Choose **Control > Standby** (or toggle the On/Standby button) from the Quantum Tune Master window to place the mass spectrometer in standby.
- Place the mass spectrometer in the Off condition. The Off condition is similar to Standby, except all high voltage components of the mass spectrometer are turned off. Choose **Control > Off** from the Quantum Tune Master window to place the mass spectrometer in the Off condition.
- Place the electronics service switch in the Service Mode position. The electronics service switch turns off all components in the mass spectrometer other than the +24 V power supply, forepump, turbomolecular pump, Vent Delay PCB, and fans.
- Place the vacuum service switch in the Service Mode position. The vacuum service switch turns off all vacuum system components, including the +24 V power supply, forepump, turbomolecular pump, Vent Delay PCB, and fans.
- Place the right-side power panel circuit breaker switch in the Off position. Placing the right-side power panel circuit breaker switch in the Off position removes all power to the mass spectrometer, including the vacuum system.
- Press the System Power Off button. Pressing the System Power Off button removes all power to the mass spectrometer, gas chromatograph, and autosampler.

Table 4 summarizes the on/off status of mass spectrometer components, voltages, and gas flows.



Table 4. On/Off status of mass spectrometer components and voltages (Sheet 1 of 2)

Mass spectrometer component	Standby 	Off 	Electronics service switch in Service Mode position	Vacuum service switch in Service Mode position	MS Main power circuit breaker switch in Off position
Electron multiplier	Off	Off	Off	Off	Off
Conversion dynode	Off	Off	Off	Off	Off
Mass analyzer RF voltage	Off	Off	Off	Off	Off
Mass analyzer dc offset voltage	Off	Off	Off	Off	Off
Q0 ion optics RF voltage	Off	Off	Off	Off	Off
Q0 ion optics dc offset voltage	Off	Off	Off	Off	Off
Ion source filament	Off	Off	Off	Off	Off
Ion source heater	On	On	Off	Off	Off
Ion source lenses	Off	Off	Off	Off	Off
Argon collision gas	Off	Off	Off	Off	Off

3 System Shutdown, Startup, and Reset

Turning Off Selected Mass Spectrometer Components

Table 4. On/Off status of mass spectrometer components and voltages (Sheet 2 of 2)

Mass spectrometer component	Standby 	Off 	Electronics service switch in Service Mode position	Vacuum service switch in Service Mode position	MS Main power circuit breaker switch in Off position
Vent valve	Closed	Closed	Closed	Open (after 2 to 4 min)	Open (after 2 to 4 min)
Turbomolecular pump	On	On	On	Off	Off
Forepump	On	On	On	Off	Off
Vent Delay PCB	On	On	On	On	Off
Embedded computer	On	On	Off	On	Off
Turbomolecular pump controller	On	On	On	Off	Off
Power supply, electron multiplier and conversion dynode	Off	Off	Off	On	Off
Power supply, 8 kV	Off	Off	Off	On	Off
PS1 power supply, +24 V	On	On	On	Off	Off
PS2 power supply, +5, ±15, ±24 V dc	On	On	Off	Off	Off
PS3 power supply, +36, -28 V dc	On	On	Off	Off	Off
Fan, turbomolecular pump	On	On	On	Off	Off
Fan, above manifold	On	On	On	Off	Off
Fan, center wall	On	On	On	Off	Off
Convectron gauge, foreline	On	On	On	On	Off
Convectron gauge, collision cell	On	On	Off	On	Off
Ion gauge	On	On	Off	Off	Off

Tuning and Calibrating

Tune parameters are instrument parameters that affect the intensity of the ion signal. Calibration parameters are instrument parameters that affect the mass accuracy and resolution of the mass spectrum. Tune and calibrate the Quantum GC automatically with Quantum Tune Master. Quantum Tune Master uses FC-43 as the tuning and calibration compound. FC-43 resides in a vial inside the mass spectrometer.

Contents

- [Displaying the FC-43 Mass Spectrum](#)
- [Running Auto Tune and Calibration](#)
- [Saving the Tune and Calibration Report](#)
- [Password Protection](#)

Record the ion signal intensity of FC-43 (see [Figure 29](#)) just after you tune and calibrate the mass spectrometer. Periodically check the FC-43 ion signal. Re-tune and calibrate the mass spectrometer if the FC-43 ion signal falls below 50% of the tuned value. Also, re-tune and calibrate after switching between EI and CI modes or between positive and negative polarity modes.

Note You may need to calibrate more often if you operate in H-SRM mode (as opposed to SRM mode only).

[Table 5](#) lists typical peaks that are observed in the FC-43 mass spectrum in EI, positive polarity mode.

Table 5. Typically observed FC-43 peaks in EI, positive polarity mode

m/z 69
m/z 100
m/z 114
m/z 119
m/z 131
m/z 169
m/z 219
m/z 264
m/z 314
m/z 352
m/z 402
m/z 414
m/z 464
m/z 502
m/z 614

Displaying the FC-43 Mass Spectrum

The first step in tuning and calibrating the Quantum GC mass spectrometer is to display the FC-43 mass spectrum.

❖ To display the FC-43 mass spectrum

1. Choose **Start > All Programs > Xcalibur > Quantum Tune** to open the Tune Master window.
2. Choose **Workspace > System Tune and Calibration** to display the System Tune and Calibration workspace (Figure 29).
3. Choose a polarity mode. In this example the mass spectrometer is in positive polarity mode. If necessary, toggle the polarity button.



Positive Negative

Note For EI negative polarity mode, you might have to set the calibration gas flow to high.

4. Select Scan Type: **Full Scan** and Scan Mode: **Q1MS**.
5. Enter a First Mass and a Last Mass to define the displayed range. In this example we use m/z **50** and **600**.



Cal Gas Off

..On



.Filament Off



On

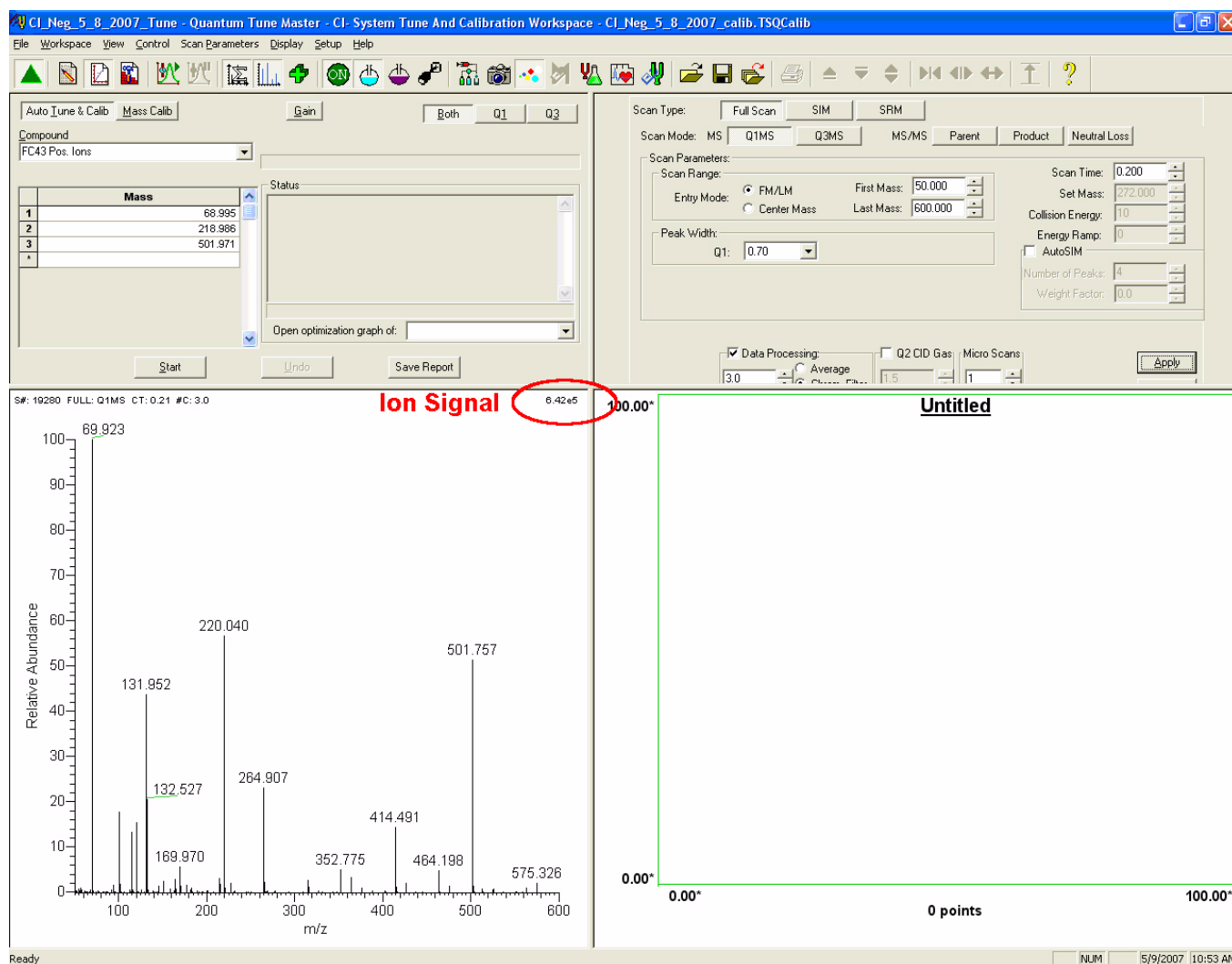
6. Click the **Calibration Gas** button in the Tune Master toolbar to turn on the flow of calibration gas into the ion source.

7. Click the **Filament** button in the Tune Master toolbar to turn on the filament.

8. Choose **Control > On** to start the mass spectrometer scanning.

If your mass spectrum looks very different from the one in [Figure 29](#), see “[Diagnostics and Troubleshooting](#)” on [page 111](#).

Figure 29. System Tune and Calibration Workspace, showing the FC-43 mass spectrum in EI, positive polarity mode before tuning and calibrating



Running Auto Tune and Calibration

Run the tune and calibration procedure after you obtain a good FC-43 ion signal.

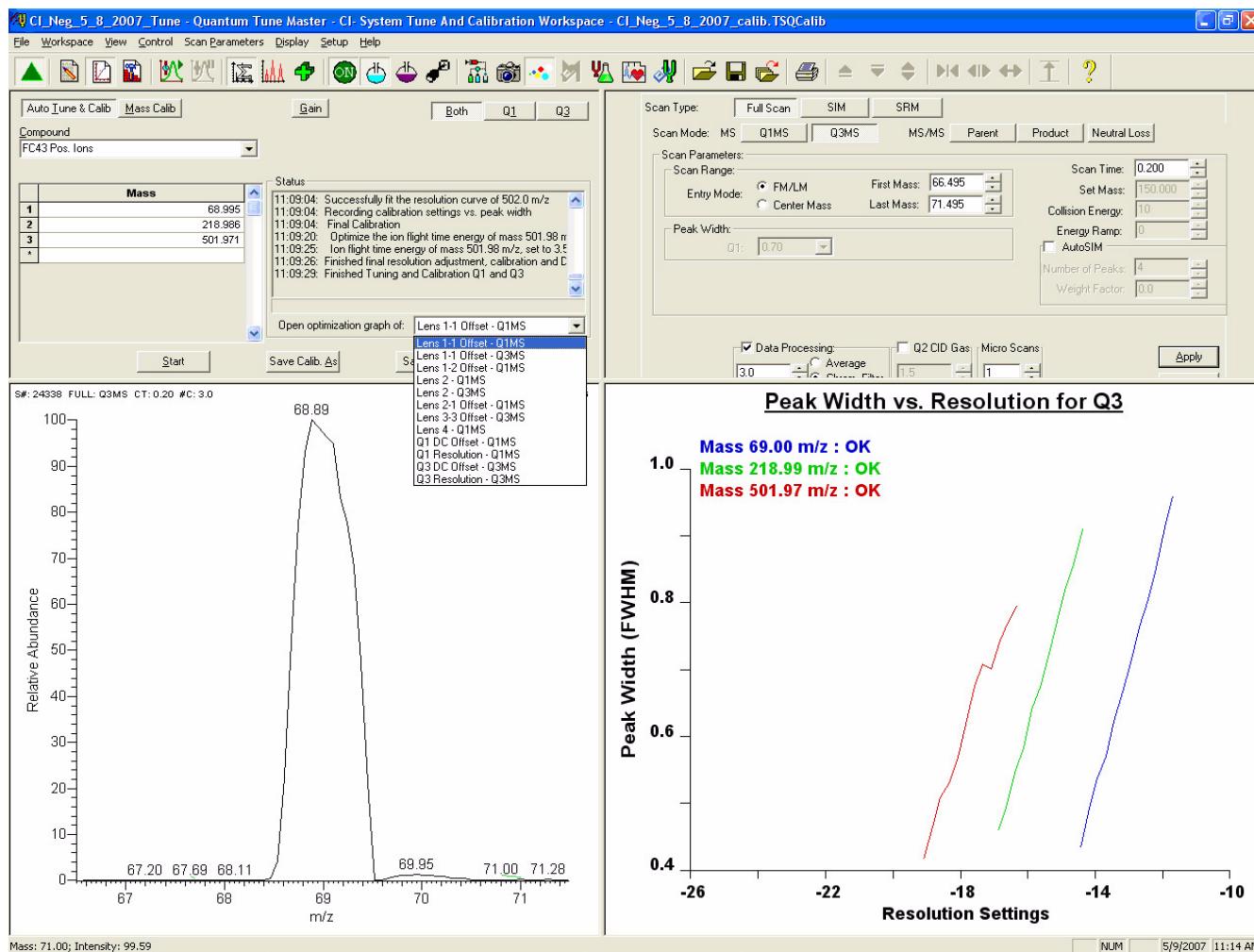
❖ **To tune and calibrate your mass spectrometer automatically in the EI, positive ion mode**

1. Display the FC-43 positive ion mass spectrum as described in the previous section.
2. In the Compound list, select **FC43 pos. ions**. This automatically selects the positively charged FC-43 ions to be used for automatic tuning and calibrating.
3. Select **Auto Tune - Calibration** to specify a full tune and calibration.
4. Select **Both** to tune and calibrate both the first and third quadrupoles.
5. Click **Start** to start the automatic tuning and calibration procedure.

The Status box displays real-time messages about the system tune and calibration so that you can monitor the progress of each sub-procedure. After a sub-procedure is complete, the result is reported (for example, whether it passed or failed). At the end of the entire procedure, it displays a summary.

- If errors occur during the automatic tuning and calibration procedure, go to [step 6](#).
 - If the automatic tuning and calibration procedure finishes without errors, go to [step 7](#).
6. If errors occur during the automatic tuning and calibration procedure, restore the previous mass spectrometer device settings and perform the tuning and calibration procedure again by completing the following steps:
 - a. To restore the prior tuning and calibration settings, click **Undo**.
 - b. To reload the prior tuning and calibration settings to the mass spectrometer, click **Accept**.
 - c. Troubleshoot and correct the problem that caused the tuning and calibration procedure to fail. See “[Tuning Issues](#)” on [page 125](#).
 - d. Go to [step 5](#) and restart the tuning and calibration procedure.

Figure 30. System Tune and Calibration Workspace during an automatic tune and calibration



7. Click **Accept** to accept the results of the tuning and calibration procedure.

After you accept the results of the tuning and calibration procedure, a message box asks whether you want to copy the positive ion tuning and calibration settings to the negative ion mode.

- If you have already tuned and calibrated the instrument successfully in the negative ion mode, click **No**. (Do not copy the positive ion mode parameters to the negative ion mode.)
- If you have not tuned and calibrated the instrument in the negative ion mode, click **Yes**.

Note If you intend to perform high-sensitivity, negative-ion mass spectrum analysis, Thermo Fisher Scientific recommends that you also perform a full tune and calibration of the instrument in the negative ion mode.

4 Tuning and Calibrating

Saving the Tune and Calibration Report

8. Save the calibration file as follows:
 - a. Click **Save Calib. As** to open the Save Calibration File dialog box.
 - b. In the File Name box, enter a name for your calibration file.
 - c. Click **Save** to save the calibration file. The Save As dialog box appears.
9. Save the tune method file as follows:
 - a. In the File Name box, enter a name for your tune method file.
 - b. Click **Save** to save the tune method file.

The mass spectrometer is now tuned and calibrated in the positive ion mode.

Saving the Tune and Calibration Report

You can save the information that appears in the Status box and in the parameter optimization plots as a PDF file. Examples of status information and parameter optimization plots from the tune and calibration report follow.

Figure 31. Tune and calibration report, status page

```
Quantum Tune Master - Tune and Calibration

Results from System Tune and Calibration using FC43 Pos. Ions:

Q1 and Q3 Tuning & Calibrating

10:55:29: Tuning and Calibrating Q1
10:55:39: Tuning Q1MS at mass 69.00 m/z
10:55:41: Opening resolution
10:55:42: Adjusting resolution
10:56:02: The adjusted resolution is -13.33 at the width 0.78
10:56:02: Coarse resolution done - Quick calibration
10:56:07: The adjusted calibration of mass 69.0 is -0.88
10:56:08: Averaging Stopping Curve...
10:56:12: Q1 Quadrupole Offset set to -0.85 for all reswidths
10:56:14: Optimizing Lens 2 for ion 69.00 m/z
10:56:20: Previous Setting = -7.00, New Setting = -0.80
10:56:20: Maximum Intensity = 1.04e+06
10:56:20: 322 % Improvement
10:56:20: Optimizing Lens 4 for ion 69.00 m/z
10:56:26: Previous Setting = -10.00, New Setting = -46.55
10:56:26: Maximum Intensity = 1.61e+06
10:56:26: 60 % Improvement
10:56:26: Optimizing Lens 1-1 for ion 69.00 m/z
10:56:32: Previous Setting = -5.00, New Setting = -0.86
10:56:32: Maximum Intensity = 1.93e+06
10:56:32: 15 % Improvement
10:56:32: Optimizing Lens 1-2 for ion 69.00 m/z
10:56:38: Previous Setting = -21.90, New Setting = -5.00
10:56:38: Maximum Intensity = 2.43e+06
10:56:38: 41 % Improvement
10:56:38: Optimizing Lens 2-1 for ion 69.00 m/z
10:56:45: Previous Setting = -8.45, New Setting = 3.92
10:56:45: Maximum Intensity = 2.56e+06
10:56:45: 17 % Improvement
10:56:45: Tuning Q1MS at mass 501.97 m/s
10:56:47: Opening resolution
10:56:48: Adjusting resolution
10:57:04: The adjusted resolution is -14.38 at the width 0.78
10:57:04: Coarse resolution done - Quick calibration
10:57:10: The adjusted calibration of mass 502.0 is -0.16
10:57:11: Averaging Stopping Curve...
10:57:16: Q1 Quadrupole Offset set to -2.00 for all reswidths
10:57:18: Optimizing Lens 2 for ion 501.97 m/z
10:57:24: Previous Setting = -7.00, New Setting = -2.70
10:57:24: Maximum Intensity = 2.97e+05
10:57:24: 223 % Improvement
10:57:24: Optimizing Lens 1-2 for ion 501.97 m/z
10:57:30: Previous Setting = -50.14, New Setting = -51.11
10:57:30: Maximum Intensity = 4.35e+05
10:57:30: 6 % Improvement
10:57:30: Optimizing Lens 2-1 for ion 501.97 m/z

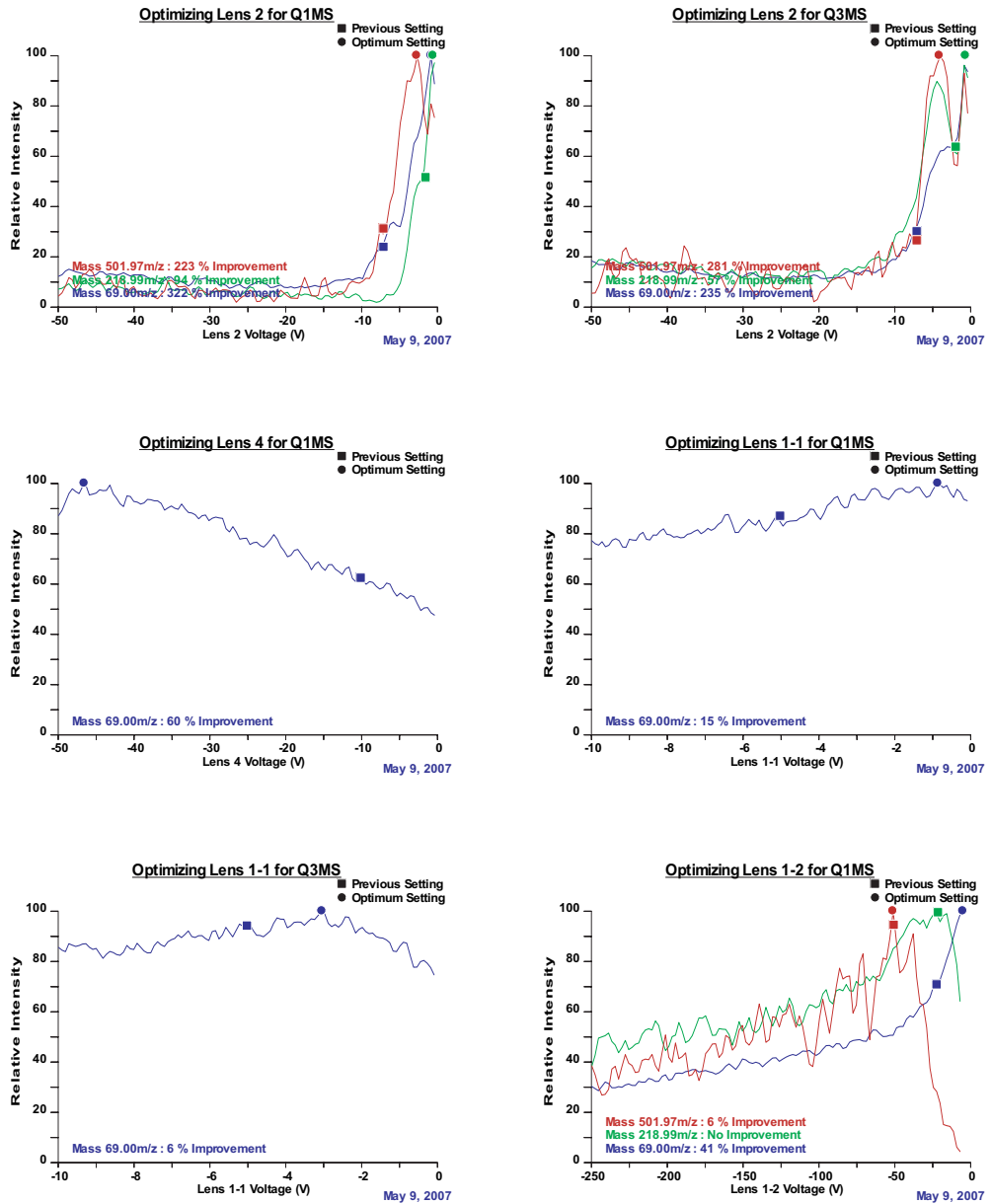
Signature: _____
```

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Figure 32. Tune and calibration report, parameter optimization plots

Quantum Tune Master – Tune and Calibration



❖ **To save the tune and calibration report**

1. In the System Tune and Calibration Workspace, click **Save Report**. The Save As dialog box appears.
2. Enter the name and the path of the report, and click **Save**.

Password Protection

You can password protect the secure workspaces in Tune Master. The workspaces you can protect are System Tune and Calibration, Full Instrument Control, and Diagnostics.

Three levels of protection are possible:

- No protection—All operators can access all workspaces.
- Automatic protection—Tune Master uses the default password, lctsq, to protect the secure workspaces.
- Custom password protection—The Key Operator (or Laboratory Administrator or Manager) can select a password to protect the secure workspaces.

If your TSQ Quantum GC system has been password protected, you need to obtain the password before you can access the secure workspaces (including the System Tune and Calibration workspace). If the instrument password is lost, you need to reinstall the TSQ Quantum GC software to reset the default password (lctsq).

Changing Ionization Modes

You can operate the TSQ Quantum GC in either EI or CI ionization mode. Changing ionization modes requires changing ion volumes. It is not necessary to shut down the mass spectrometer to change ion volumes.

The following sections describe how to change the ionization mode.

Contents

- [Removing the Ion Volume](#)
- [Installing the Ion Volume](#)

Removing the Ion Volume



Tools Needed

- Gloves, clean, lint- and powder-free
- Insert/removal (I/R) tool and guide bar



Frequency

When you change ionization modes or as needed to clean the ion volume

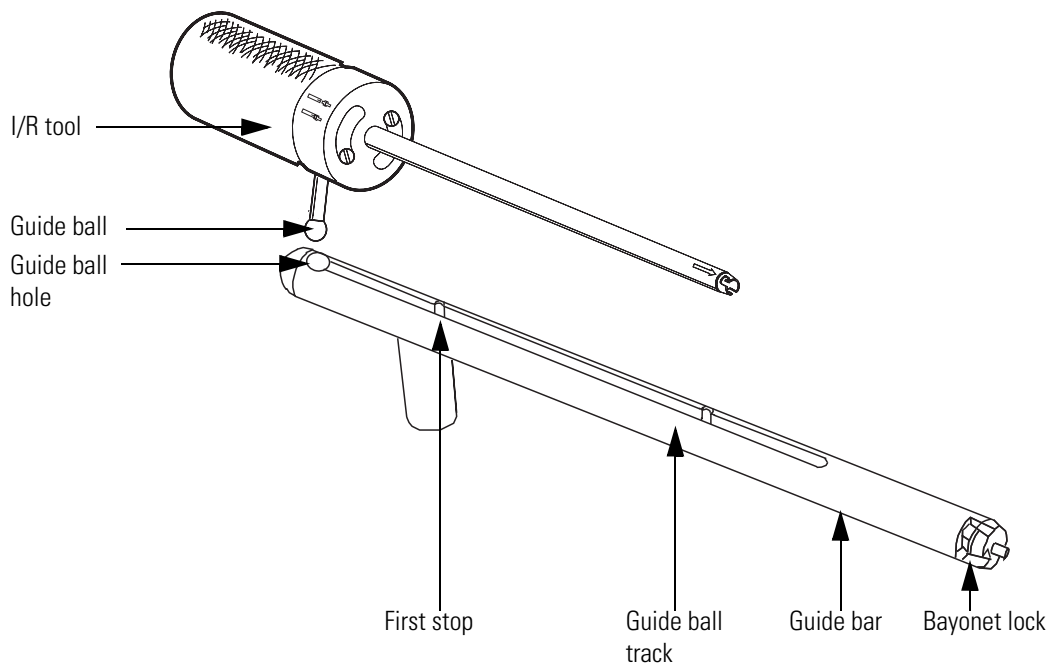
❖ To remove the ion volume

1. Install the guide bar.
 - a. With the guide ball track facing left, insert the guide bar into the entry housing. See [Figure 33](#).
 - b. Push the guide bar in as far as it will go; then rotate it 90° clockwise to lock the guide bar in the entry housing.

5 Changing Ionization Modes

Removing the Ion Volume

Figure 33. Insertion/removal (I/R) tool and guide bar




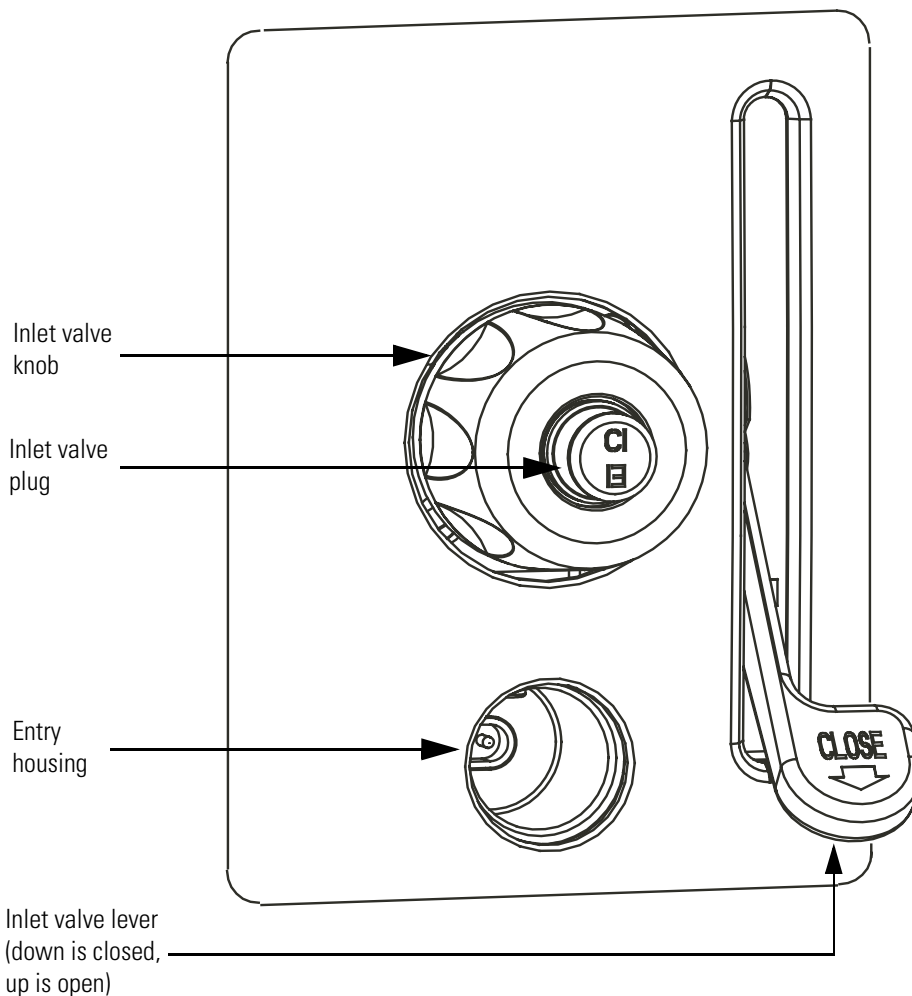
2. Prepare the inlet valve and I/R tool for insertion.
 - a. Make sure the inlet valve is closed. [Figure 34](#) shows the inlet valve lever is down for closed.
 - b. Loosen the inlet valve knob counter-clockwise and remove the inlet valve plug. The inlet valve plug prevents air from entering the vacuum manifold in case the inlet valve is inadvertently opened.
 - c. Turn the I/R tool to the unlock position , which indicates the I/R tool is in position to accept the ion volume.

Figure 34. Inlet valve components




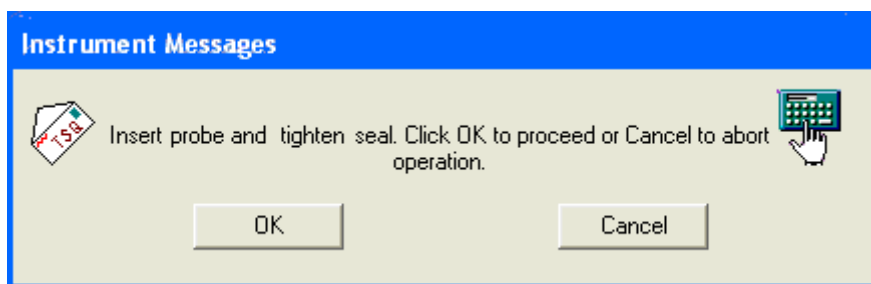
3. Choose **Start > All Programs > Xcalibur > Quantum Tune** to open the Tune Master window.
4. Click the **Probe**  button in the Tune Master toolbar. The Insert Probe message appears (Figure 35).

Figure 35. Insert Probe message

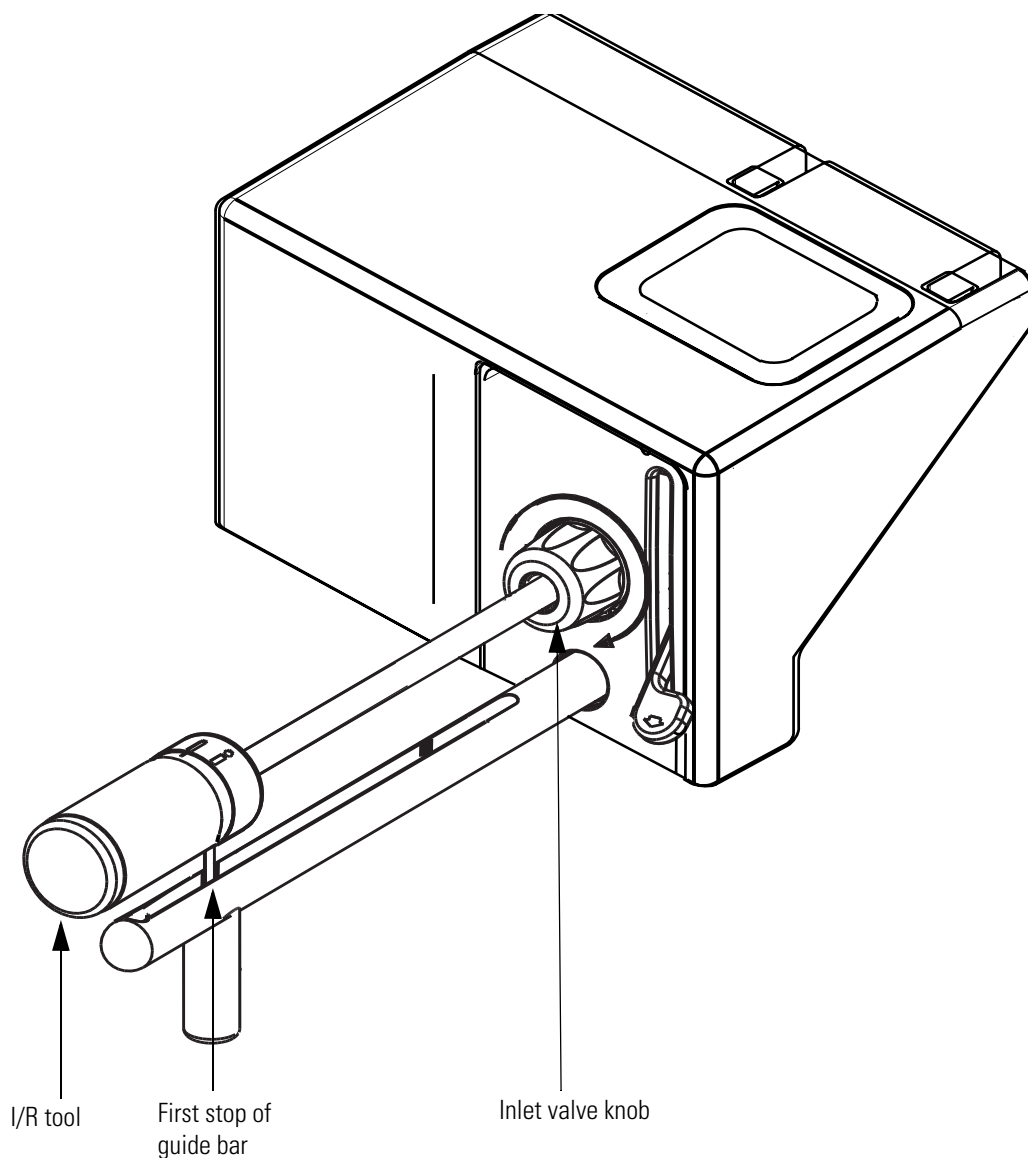


5 Changing Ionization Modes

Removing the Ion Volume

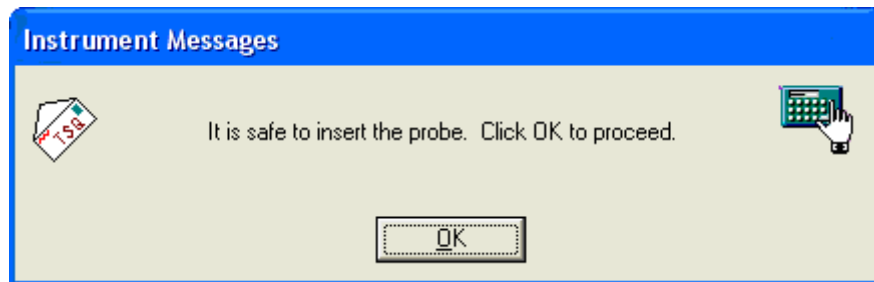
5. Inset the I/R tool into the inlet valve.
 - a. Insert the guide ball into the guide ball hole.
 - b. Slide the I/R tool forward into the inlet valve until the guide ball is at the guide bar's first stop (see [Figure 36](#)).
 - c. Tighten the inlet valve knob clockwise to ensure a leak-tight seal.

Figure 36. I/R tool at the first stop on guide bar and the inlet valve knob tightened



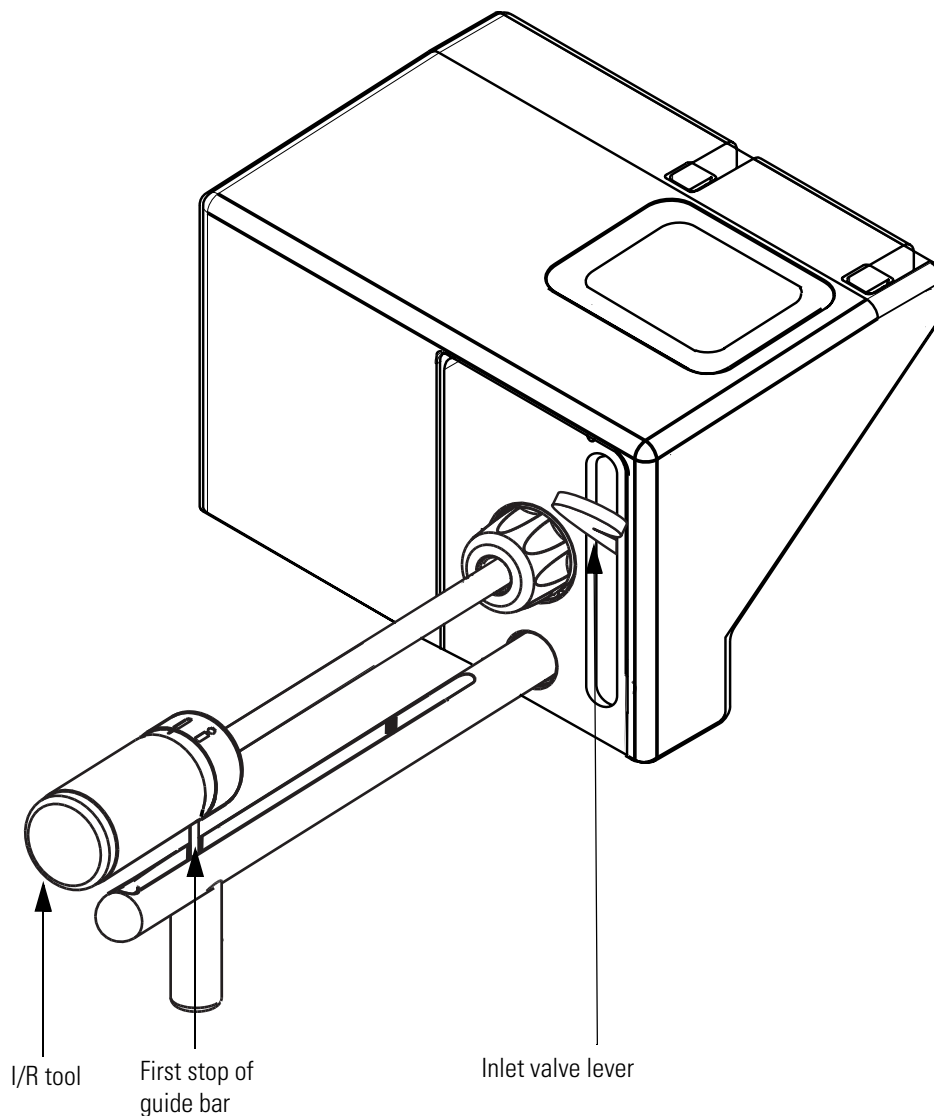
6. Click **OK**. The forepump evacuates the inlet valve. Wait until the safe to insert probe message appears, and then click **OK**.

Figure 37. Safe to insert the probe message



7. Once evacuation is complete, pull the inlet valve lever up to open the inlet valve.

Figure 38. I/R tool at first stop and inlet valve lever up



5 Changing Ionization Modes

Removing the Ion Volume

8. Remove the ion volume.
 - a. Slide the I/R tool into the vacuum manifold until the tip of the I/R tool is fully inserted into the ion volume holder. The head of the arrow on the I/R tool (Figure 40), when viewed through the window of the ion source manifold, should not be visible.

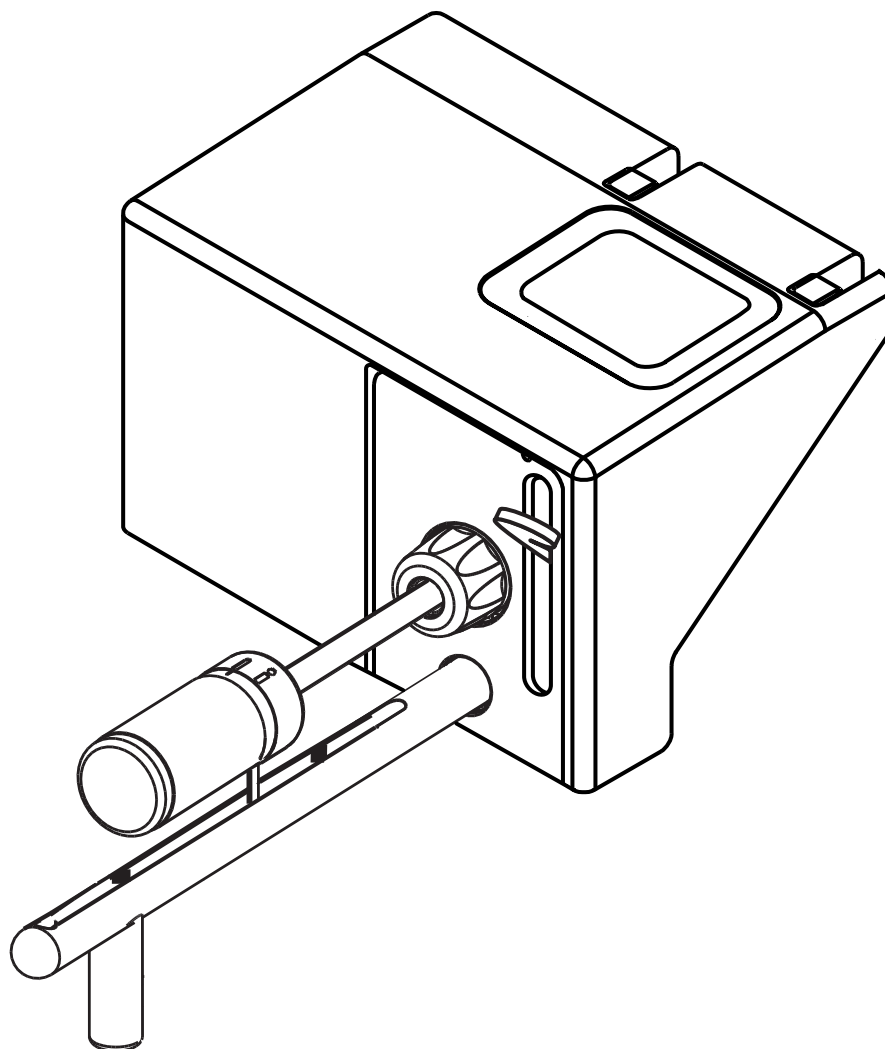



Figure 39. I/R tool inserted into the inlet valve

- b. Turn the I/R tool handle counterclockwise to put the I/R tool into lock position . Listen for a click, which indicates that the handle is fully engaged in the lock position and is holding the ion volume.
- c. Withdraw the I/R tool (with the ion volume attached) until the guide ball reaches the first stop (see Figure 38).
- d. Pull the lever down to close the inlet valve.



CAUTION Do not withdraw the I/R tool beyond the point where the guide ball reaches the first stop in the guide bar. Close the inlet valve first. Otherwise, the system vents to the atmosphere.

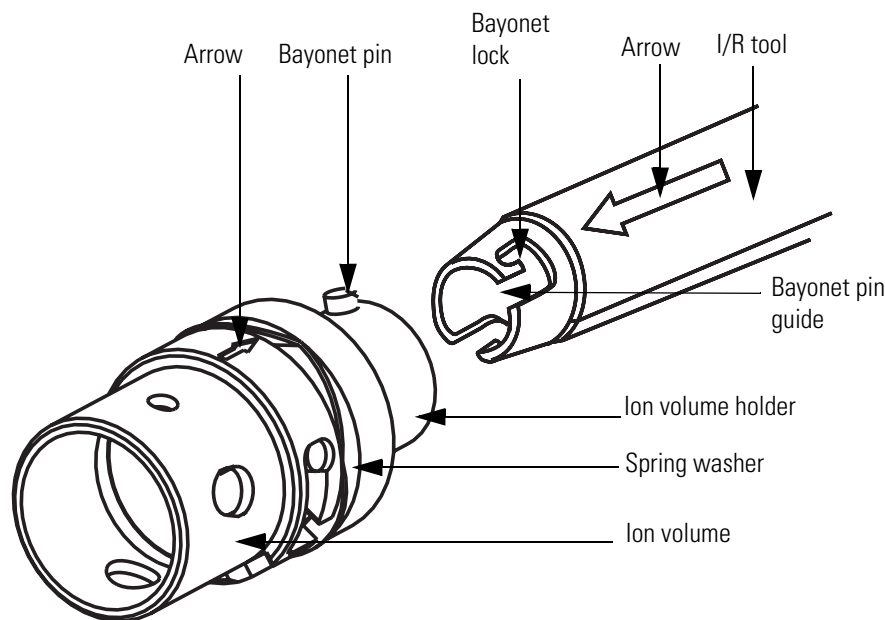
- e. Loosen the inlet valve knob by turning it counterclockwise to release the seal.
- f. Continue withdrawing the I/R tool completely from the inlet valve by sliding the I/R tool through the guide ball track in the guide bar.



CAUTION Because the ion volume might be too hot to touch, let it cool to room temperature before handling it.

9. Remove the ion volume from the I/R tool. See [Figure 40](#).
 - a. Wearing clean gloves, press the ion volume forward into the tip of the I/R tool and rotate it to disconnect the bayonet pins from the pin guides.
 - b. Pull the ion volume out of the I/R tool.

Figure 40. Ion volume, ion volume holder, and I/R tool



10. To clean the ion volume, use the instructions in [“Cleaning Stainless Steel Parts”](#) on [page 95](#). If you are cleaning a CI ion volume, be sure to clean out the small electron entrance hole. Aluminum oxide can get trapped in this hole, which can adversely affect sensitivity. Use a dental pick or old syringe needle to clean the hole.

Installing the Ion Volume

You install an ion volume after cleaning or to change ionization modes.



❖ To install the ion volume

Note Wear clean, lint- and powder- free gloves when you handle a clean ion volume.

1. Place the clean ion volume on the I/R tool with the arrows aligned. See [Figure 40](#).



CAUTION Make sure the arrows on the I/R tool and ion volume are aligned to avoid damage to the ion source.

2. Turn the I/R tool handle to the lock position .
3. Install the guide bar.
 - a. With the guide ball track facing left, insert the guide bar into the entry housing (see [Figure 33](#)).
 - b. Push the guide bar in as far as it will go, and then rotate it 90° clockwise to lock the guide bar in the entry housing.
4. Prepare the inlet valve for insertion.
 - a. Make sure the inlet valve is closed. [Figure 34](#) shows the inlet valve lever is down for closed.
 - b. Remove the inlet valve plug. The inlet valve plug prevents air from entering the vacuum manifold in case the inlet valve is inadvertently opened.
5. Choose **Start > All Programs > Xcalibur > Quantum Tune** to open the Tune Plus window.
6. Click the **Probe**  button in the Tune Master toolbar. The Insert Probe message appears. See [Figure 35](#).
7. Inset the I/R tool into the inlet valve.
 - a. Insert the guide ball into the guide ball hole.
 - b. Slide the I/R tool forward into the inlet valve until the guide ball is at the guide bar's first stop. See [Figure 36](#).
 - c. Tighten the inlet valve knob clockwise to ensure a leak-tight seal.
8. Click **OK**. The forepump evacuates the inlet valve. Wait for the safe to insert probe message to appear ([Figure 37](#)); then click **OK**.
9. Once evacuation is complete, pull the inlet valve lever up to open the inlet valve.


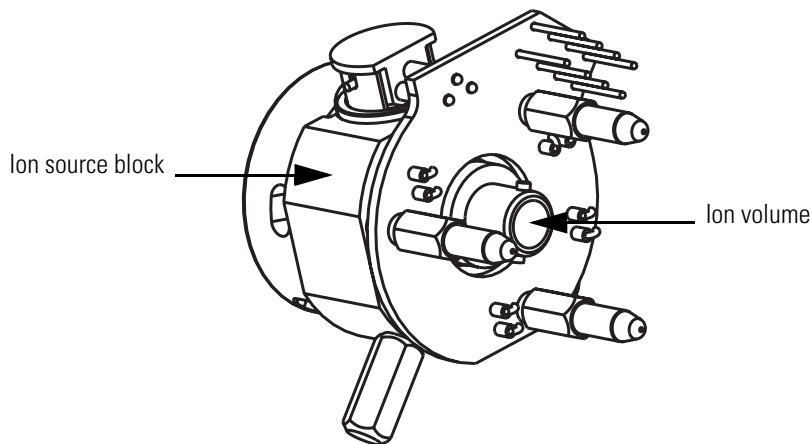
10. Install the ion volume.
 - a. Slide the I/R tool and ion volume assembly into the vacuum manifold until the ion volume assembly is fully inserted and seated into the ion source block. Listen for a click, which indicates that the ion volume has connected with the ion source block.
 - b. Turn the I/R tool handle to the unlock position  to release the ion volume from the I/R tool.

Figure 41. Ion volume seated in the ion source block



11. Verify that the ion volume is fully seated in the ion source block:
 - Withdraw the I/R tool away from the ion volume about 2.5 cm (1 in.), and turn the I/R tool handle to the lock position.
 - Slide the I/R tool back into the vacuum manifold until the end of the I/R tool just touches the ion volume.
 - Test that the I/R tool does not go into the inlet valve completely, which indicates that the ion volume is seated properly.
12. Remove the I/R tool.
 - a. Withdraw the I/R tool until the guide ball reaches the first stop (see [Figure 38](#)).
 - b. Close the inlet valve by pulling the inlet valve lever down (see [Figure 36](#)).



CAUTION Do not withdraw the I/R tool beyond the point where the guide ball reaches the first stop in the guide bar. Close the inlet valve first. Otherwise, the system vents to the atmosphere.

- c. Loosen the inlet valve knob by turning it counter-clockwise.
 - d. Continue withdrawing the I/R tool completely from the inlet valve by sliding the I/R tool through the guide ball track in the guide bar.
13. Remove the guide bar by rotating it 90° counter-clockwise and sliding it out of the entry housing.

5 Changing Ionization Modes

Installing the Ion Volume

14. Replace the inlet valve plug. Orient the plug to indicate whether an EI or CI ion volume is installed.
15. Tighten the inlet valve knob clockwise to create a leak-tight seal.
16. (Optional) To prevent the inlet valve from being opened accidentally, pull free and remove the inlet valve lever.

Maintenance

This chapter describes routine maintenance procedures that you must perform to ensure optimum performance of the instrument. Optimum performance of the TSQ Quantum GC mass spectrometer depends on the maintenance of all parts of the instrument. **You are responsible for maintaining your system properly by performing the system maintenance procedures on a regular basis.**

Note When you perform maintenance procedures, be methodical; always wear clean, lint-free gloves when handling the components of the ion source; always place the components on a clean, lint-free surface; and never overtighten a screw or use excessive force.

Table 6 lists routine and infrequent mass spectrometer maintenance procedures. For instructions on maintaining the GC or autosampler, refer to the manual that comes with the GC or autosampler.

Table 6. Maintenance procedures (Sheet 1 of 2)

Mass Spectrometer Component	Procedure	Frequency	Procedure Location
Ion source	Cleaning the ion volume	As needed*	Page 82
Ion source	Cleaning the lenses	As needed*	Page 83
Ion source	Cleaning entire ion source	As needed*	Page 90
Ion source	Replacing the filament or other components	If the filament fails	Page 90
Inlet valve	Replacing the ball valve seal	If there is an air leak in the inlet valve	Page 102
Calibration compound	Adding calibration compound	If Tune error message indicates low intensity of calibration gas ions	Page 99
Gas chromatograph	Replacing the capillary column	If chromatographic separation is bad	Page 104
Q0 ion optics	Cleaning Q0 quadrupole and lenses L11 and L12**	As needed*	

Table 6. Maintenance procedures (Sheet 2 of 2)

Mass Spectrometer Component	Procedure	Frequency	Procedure Location
Mass analyzer	Cleaning Q1, Q2, and Q3 quadrupoles and lenses**	As needed*	
Forepump	Purging pump oil	If pump oil is cloudy	Manufacturer's documentation
Forepump	Adding oil	If pump oil level is low	Manufacturer's documentation
Forepump	Changing oil	Every 4 months or if pump oil is cloudy and discolored	Manufacturer's documentation
Ion detection system	Replacing electron multiplier assembly**	If noise in spectrum is excessive or proper electron multiplier gain cannot be achieved	
Electronic modules	Replacing electronic module**	If electronic module fails	
PCBs	Replacing PCB**	If PCB fails	

*The frequency of cleaning the components of the mass spectrometer depends on the types and amounts of samples and solvents that are introduced into the instrument. Cleaning of the Q0, Q1, Q2, and Q3 quadrupoles is rarely (if ever) required.

**A Thermo Fisher Scientific Field Service Engineer should perform this maintenance procedure.

Contents

- [Cleaning Ion Source Components](#)
- [Replacing the Ion Source Filament](#)
- [Maintaining the Forepump](#)
- [Adding Calibration Compound](#)
- [Replacing the Ball Valve Seal](#)
- [Removing and Installing a GC Capillary Column](#)

Cleaning Ion Source Components

An important part of maintaining your TSQ Quantum GC is making sure that the ion source components are clean. Follow the cleaning procedures in this section to clean stainless steel and non-stainless steel parts.

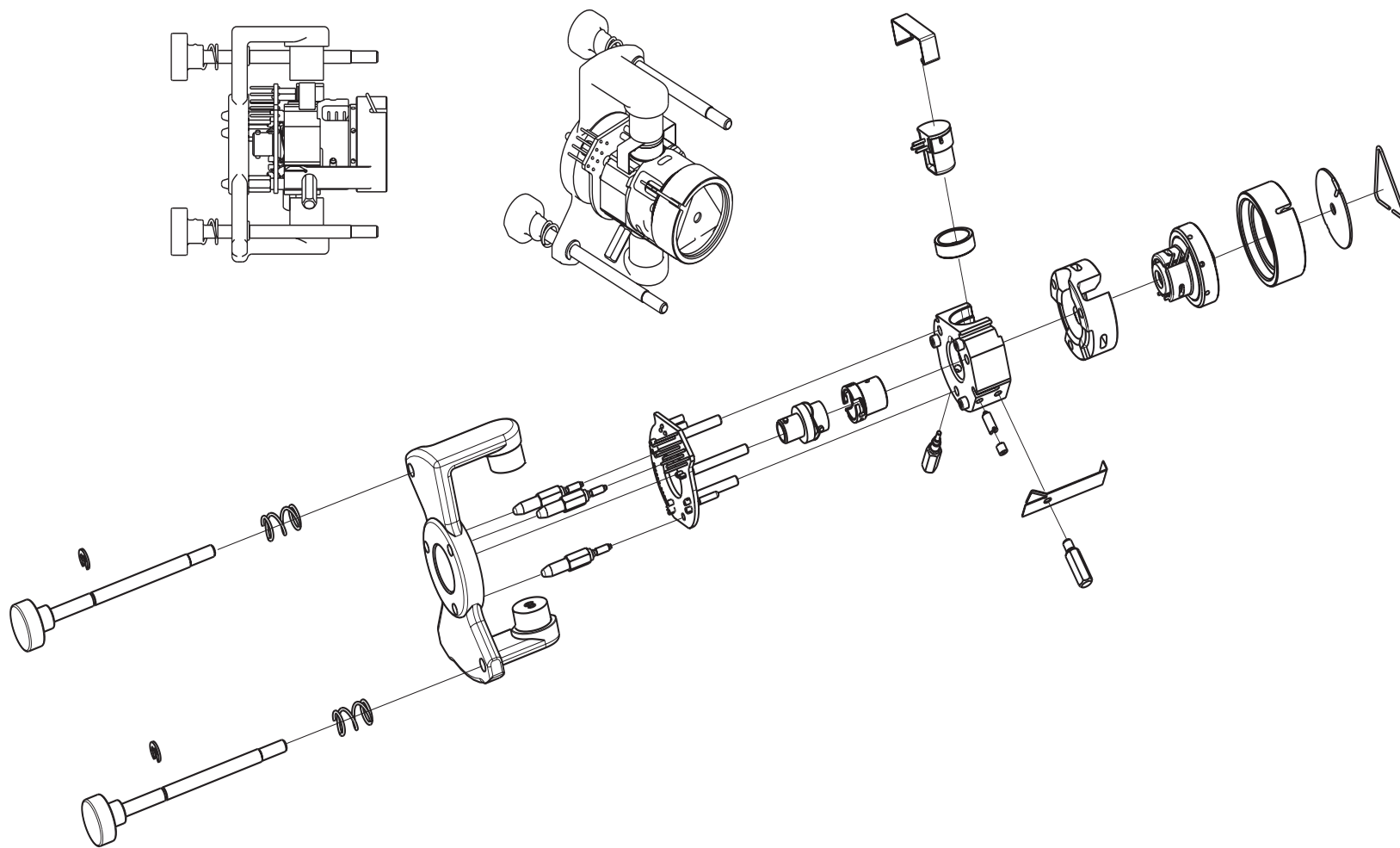
When your TSQ Quantum GC is clean and in good working order, perform benchmark tests and record the results. When the tested performance of your system decreases significantly from your benchmark test results, clean the ion volume. If this does not restore performance, clean the lenses.

How often you clean the ion source depends on the types and amounts of samples and solvents you introduce into the system. In general, the closer a component is to the sample introduction point, the more rapidly the component becomes dirty. For example, you clean the ion volume more often than other parts. If you just want to change or clean the ion volumes, you do not need to shut down the system.

Most parts can be removed and disassembled by hand. Make sure you have all the tools needed before starting each procedure.

[Figure 42](#) shows an exploded view of the ion source assembly.

Figure 42. Ion source assembly, exploded and assembled views



Cleaning Ion Volumes

You do not need to vent the TSQ Quantum GC to atmosphere to clean the ion volume.

❖ To clean the ion volume

1. Remove the ion volume. See [“Removing the Ion Volume”](#) on page 69.



CAUTION Burn Hazard. The ion volume might be hot. Allow the ion volume to cool to room temperature before touching it.

2. Clean the ion volume. See [“Cleaning Stainless Steel Parts”](#) on page 95. If you are cleaning a CI ion volume, be sure to clean out the small electron entrance hole. Aluminum oxide can get trapped in this hole, which can adversely affect sensitivity. Use a dental pick or old syringe needle to clean the hole.
3. Reinstall the ion volume. See [“Installing the Ion Volume”](#) on page 76.

Cleaning Ion Source Lenses

If cleaning the ion volume does not restore system performance, clean the ion source lenses.

Note Lens L4 requires cleaning less often than lens L1, L2, and L3.

❖ To clean the ion source lenses

1. Shut down and vent the system. See [“Shutting Down the System Completely”](#) on page 49.



CAUTION Shock Hazard. Unplug the TSQ Quantum GC before proceeding.



CAUTION Burn Hazard. The ion source might be hot. Allow the ion source to cool to room temperature before touching it.

2. Remove the ion source. See [“Removing the Ion Source”](#) on page 84.
3. Remove the ion source lens assembly from the ion source and disassemble it. See [“Removing the Ion Source Lens Assembly”](#) on page 86.
4. Clean the lenses and the spacers. See [“Cleaning Stainless Steel Parts”](#) on page 95 and [“Cleaning Non-Stainless Steel or Hybrid Part”](#) on page 97, respectively.

5. Reassemble the ion source lens assembly and install it onto the ion source. See [“Reassembling the Ion Source Lens Assembly”](#) on page 89.
6. Reinstall the ion source into the mass spectrometer. See [“Reinstalling the Ion Source”](#) on page 89.
7. Restart the system. See [“Starting Up the System after a Complete Shutdown”](#) on page 51.

Removing the Ion Source

Remove the ion source to clean the lenses or replace the filament.



Tools Needed

- Gloves, cleanroom grade (P/N 23827-0008 and 23827-0009)
- Lint-free cloth



Frequency

As needed to perform ion source maintenance

❖ To remove the ion source



CAUTION Do not remove the ion source without first pulling back the capillary column, or else the capillary column might break.

1. Shut down and vent the TSQ Quantum GC. See [“Shutting Down the System Completely”](#) on page 49.



CAUTION Shock Hazard. Unplug the TSQ Quantum GC before proceeding.

2. Pull back the capillary column.
 - a. Lower the oven, injector, and transfer line temperatures to 30 °C and allow them to cool before continuing.

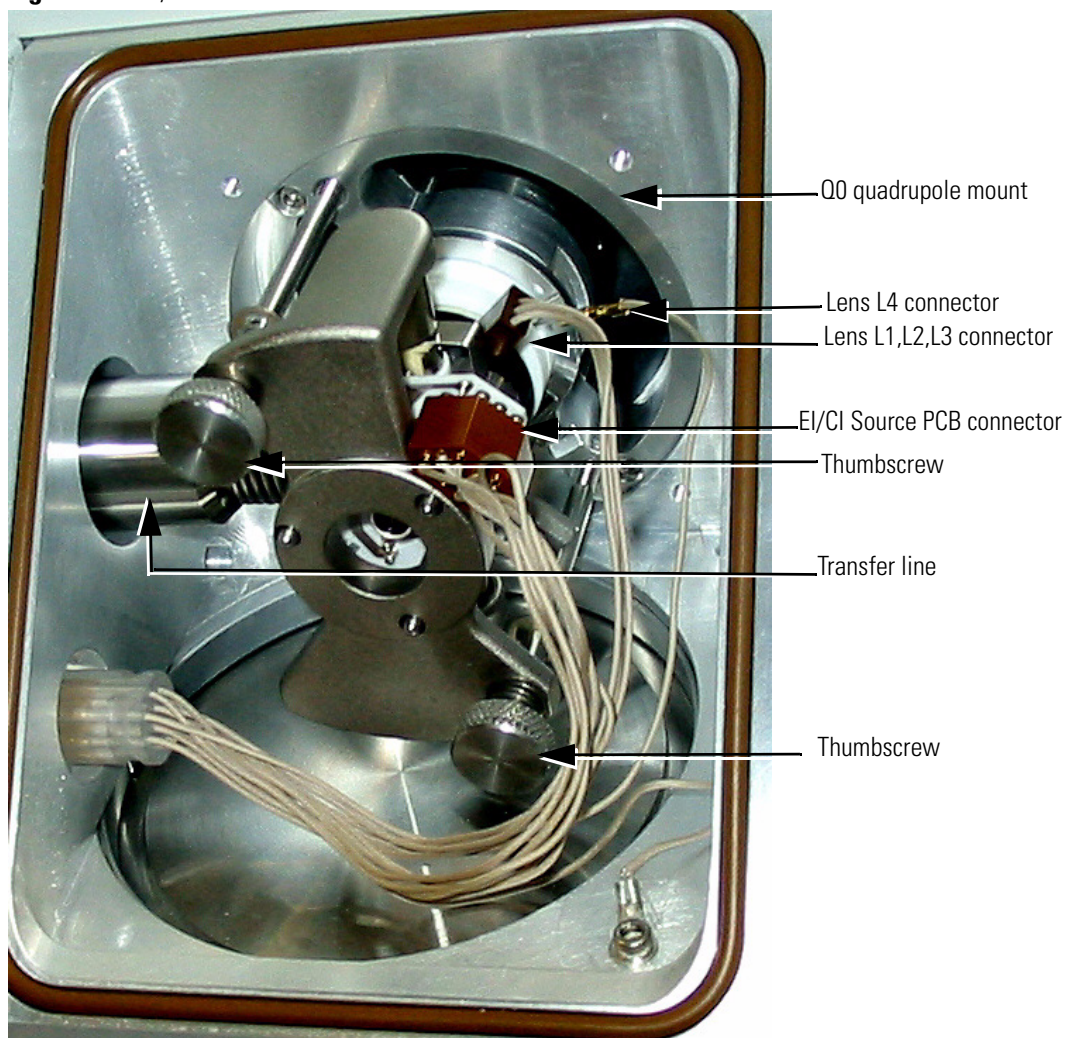


CAUTION Burn Hazard. The GC oven, injector, and transfer line are hot. Allow them to cool to room temperature before touching them.

- b. Once the oven, injector, and transfer line are cool, turn off the gas chromatograph.
- c. Loosen the transfer line nut. See [Figure 54](#) on page 105.
- d. Pull back the column. (You can first mark the column's position with white out or something similar.)

3. Prepare a clean work area by covering the area with lint-free cloth.
4. Undo the two latches that secure the lid of the ion source vacuum manifold, and open the lid.
5. Disconnect the connectors from the lead pins at the EI/CI Source PCB, lens L1, L2, L3 assembly, and lens L4 assembly. See [Figure 43](#).

Figure 43. EI/CI ion source



CAUTION Burn Hazard. The ion source might be hot. Allow the ion source to cool to room temperature before touching it.

Note Wear clean, lint- and powder- free gloves when you handle the ion source.

6. While holding the ion source assembly, loosen the two thumbscrews that secure the ion source assembly to the Q0 quadrupole.

7. Pull the ion source assembly away from the Q0 quadrupole and 2 mm to the right to clear the transfer line bellows.
8. Slide the ion source off the magnet yoke.
9. Place the ion source and magnet yoke on a clean, lint-free cloth.
10. Close the lid of the ion source vacuum manifold.

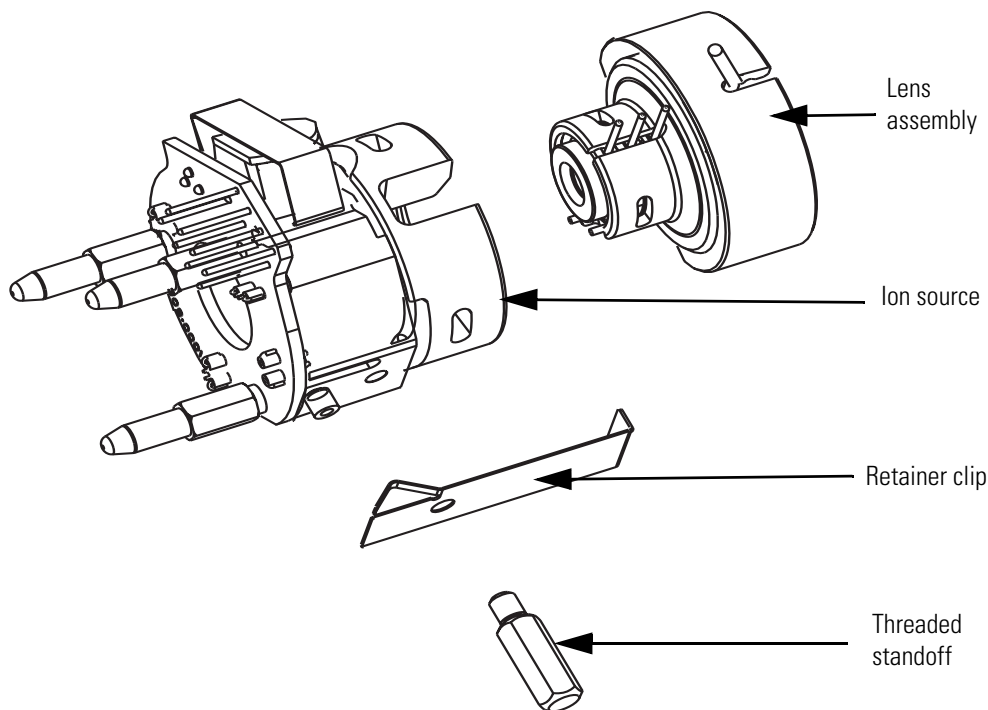
Removing the Ion Source Lens Assembly

The ion source lens assembly includes lens L1, L2, L3, and L4. You must remove and disassemble the ion source lens assembly to clean the lenses. A retainer clip fastens the lens assembly to the ion source block.

To remove the ion source lens assembly

1. Wearing clean, lint- and powder- free gloves, unscrew the threaded hexagonal standoff and remove the retainer clip that secures the lens assembly to the ion source block. See [Figure 44](#).
2. Pull the lens assembly out of the ion source.
3. Place the ion source and lens assembly on a clean surface.

Figure 44. Lens assembly removed from the ion source

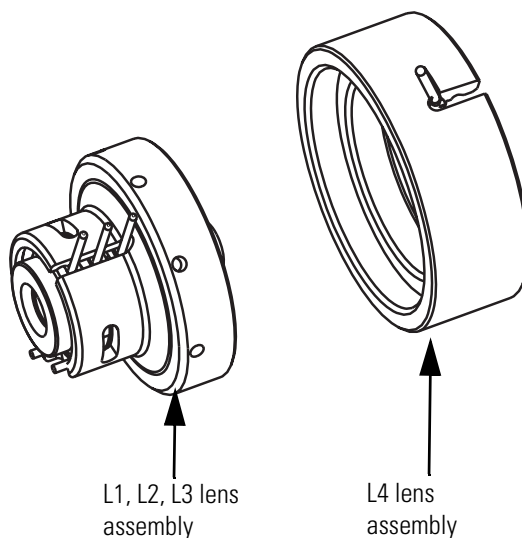


Disassembling the Ion Source Lens Assembly

❖ To disassemble the lens assembly

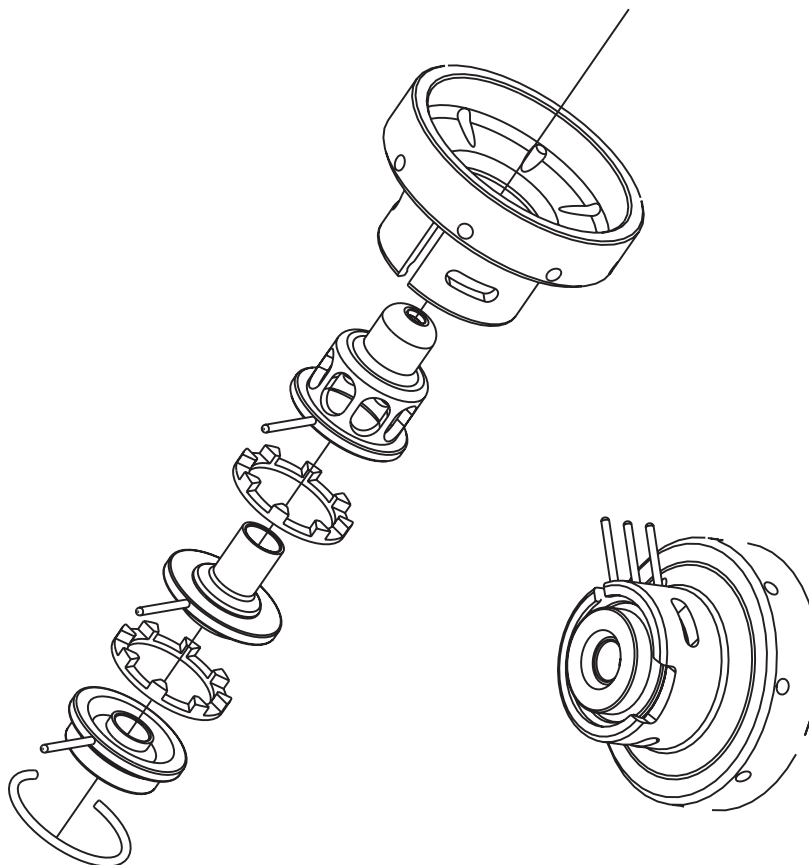
1. Pull the L1, L2, L3 lens assembly from the L4 lens assembly.

Figure 45. Ion source lens assembly separated into L1, L2, L3 lens assembly (left) and L4 lens assembly (right)



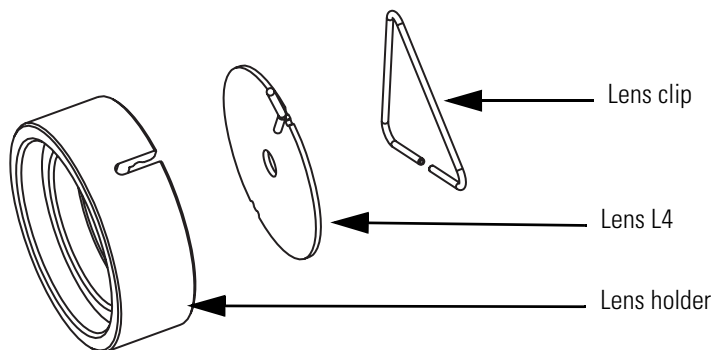
2. Disassemble the L1, L2, L3 lens assembly.
 - a. Remove the lens clip by pinching the ends with your fingers or a pair of tweezers.
 - b. Remove the lenses and spacers from the lens holder.
 - c. Place the components on a clean surface.

Figure 46. L1, L2, L3 lens assembly, exploded and assembled views



3. Disassemble the L4 lens assembly.
 - a. Remove the lens clip by pinching the ends with your fingers or a pair of tweezers.
 - b. Remove the lens L4 from the lens holder.
 - c. Place the components on a clean surface.

Figure 47. L4 lens assembly, exploded view



Note To clean the ion source lenses, follow the procedure in “[Cleaning Stainless Steel Parts](#)” on [page 95](#).

Reassembling the Ion Source Lens Assembly

Ensure that the lenses are clean and dry before you reassemble the lens assembly.

❖ To reassemble the ion source lens assembly

1. Wearing clean, lint- and powder- free gloves, reassemble the L4 lens assembly.
 - a. Insert lens L4 into the lens holder. See [Figure 47](#).
 - b. Install the lens clip by pinching the ends with your fingers or a pair of tweezers. Seat the lens clip in the lens holder.
2. Reassemble the L1, L2, L3 lens assembly. See [Figure 46](#).
 - a. Reinstall the lenses and spacers in the lens holder in the order and orientation shown in [Figure 46](#).
 - b. Reinstall the lens clip by pinching the ends with your fingers or a pair of tweezers and seating it in the lens holder.
 - c. Insert the lens alignment tool (in the TSQ Quantum GC Accessory Kit) into the lens assembly and align the lenses
3. Insert the L4 lens assembly into the L1, L2, L3 lens assembly. Align the lead pins. See [Figure 45](#).

Reinstalling the Ion Source Lens Assembly

❖ To reinstall the ion source lens assembly onto the ion source

1. Wearing clean, lint- and powder- free gloves, insert the lens assembly into the ion source. See [Figure 45](#).
2. Use the retainer clip and threaded standoff to secure the lens assembly to the ion source. See [Figure 44](#).

IMPORTANT For accurate temperature readings of the heater block, fully screw the threaded standoff into the ion source to ensure contact between the temperature sensor with the heater block.

Reinstalling the Ion Source

❖ To reinstall the ion source into the vacuum manifold

1. Wearing clean, lint- and powder- free gloves, place the ion source onto the magnet yoke.
2. Position the ion source in the vacuum manifold and ensure the following:
 - The transfer line is seated in the sample inlet aperture in the ion source.

6 Maintenance

Replacing the Ion Source Filament

- The two thumbscrews are aligned with the screw holes in the Q0 quadrupole mount. See [Figure 43](#).
- 3. Secure the ion source to the Q0 quadrupole mount by alternately tightening each thumbscrew one-half turn at a time. Make sure there is no play in the ion source.
- 4. Reconnect the connectors to the lead pins on the EI/CI Source PCB, lens L1, L2, L3 assembly (the orientation is not important), and lens L4 assembly. See [Figure 43](#).
- 5. Reinsert the capillary column into the ion source.
 - a. Using the I/R tool, remove the ion volume. See [“Removing the Ion Volume”](#) on [page 69](#).
 - b. Push the column in until you can see it through the inlet valve.
 - c. Pull the column back just far enough that you cannot see it.
 - d. Tighten the transfer line nut and transfer line union.
 - e. Using the I/R tool, install the ion volume. See [“Installing the Ion Volume”](#) on [page 76](#).
- 6. Close and secure the cover to the ion source vacuum manifold.

Replacing the Ion Source Filament

The number of ions produced in the ion source is approximately proportional to the filament emission current. If ion production is lacking, you might have to replace the filament. If the measured emission current is substantially less than the value that the emission current is set to, or if the measured emission current decreases over time, then the filament has failed or is failing and requires replacement.

See [Figure 42](#) on [page 82](#) and [Figure 48](#) on [page 91](#) for the location of the ion source components.



Tools Needed

- Filament (P/N 120320-0030)
- Gloves, cleanroom grade (P/N 23827-0008 and 23827-0009)
- Lint-free cloth



Frequency

If filament fails

❖ **To replace the ion source filament**

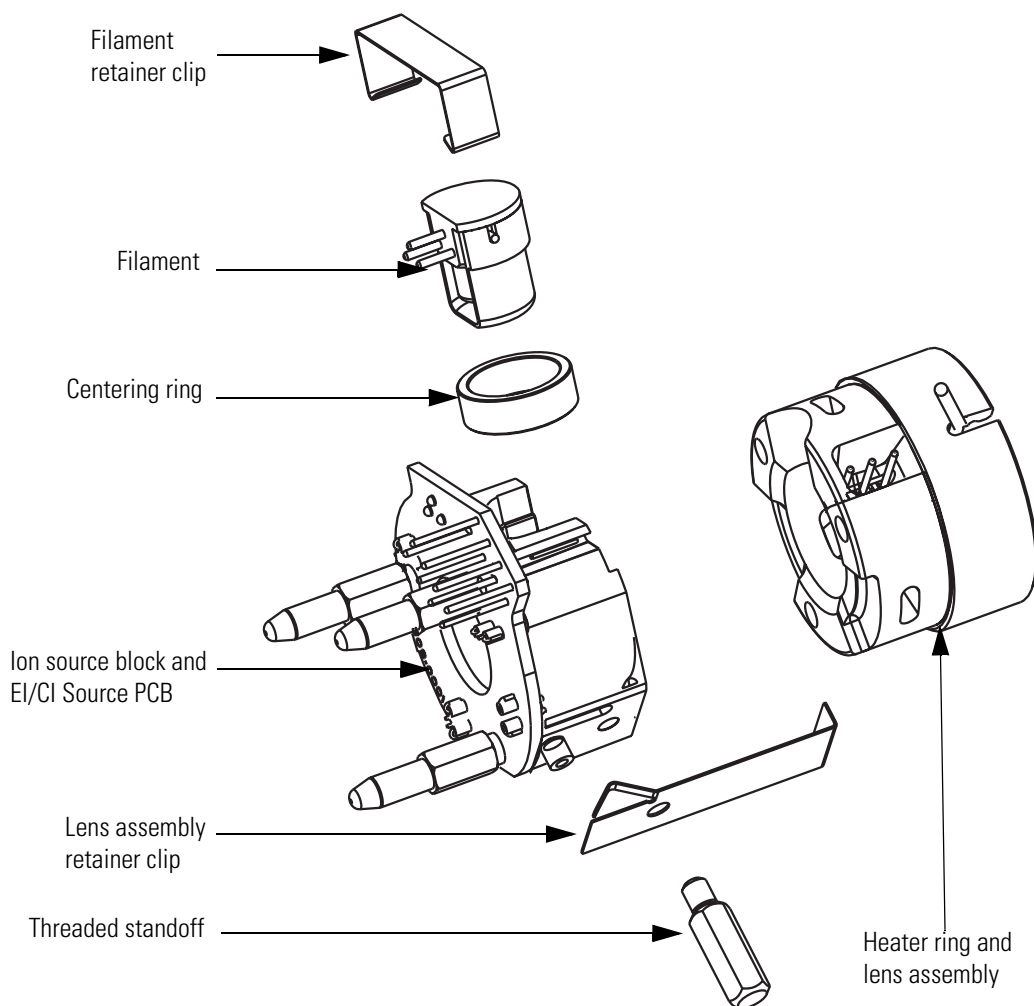
1. Prepare a clean work area by covering the area with lint-free cloth.
2. Shut down and vent the TSQ Quantum GC. See “[Shutting Down the System Completely](#)” on [page 49](#).



CAUTION Shock Hazard. Unplug the TSQ Quantum GC before proceeding.

3. Wearing clean, lint- and powder- free gloves, remove the ion source from the magnet yoke.

Figure 48. Disassembling the ion source to replace the filament



4. Unscrew the threaded standoff and remove the retainer clip that secures the heater ring and lens assembly to the ion source block. See [Figure 48](#).
5. Pull the heater ring and lens assembly out of the ion source block.

6 Maintenance

Disassembling and Reassembling the Ion Source Completely

6. Remove the retainer clip that secures the filament and centering ring to the ion source block.
7. Remove the filament and centering ring from the ion source block.

Note Now is a good time to clean the ion source block. Use the procedure described in “[Cleaning Stainless Steel Parts](#)” on [page 95](#) to clean the ion source block.

8. Inspect and install a new filament (P/N 120320-0030, in the TSQ Quantum GC Accessory Kit).
 - a. Verify that the filament wire is centered in the electron lens hole.
 - b. Insert the filament into the centering ring.
 - c. Seat the filament on the EI/CI Source PCB.
 - d. Secure the filament with the retainer clip.
9. Press the heater ring and lens assembly onto the ion source block.
10. Use the retainer clip and threaded standoff to secure the lens assembly to the ion source. See [Figure 48](#).

IMPORTANT For accurate temperature readings of the heater block, fully screw the threaded standoff into the ion source to ensure contact between the temperature sensor with the heater block.

11. Reinstall the ion source onto the magnet yoke.
12. Reinstall the ion source into the vacuum manifold. See “[Reinstalling the Ion Source](#)” on [page 89](#).
13. Restart the system. See “[Starting Up the System after a Complete Shutdown](#)” on [page 51](#).

Disassembling and Reassembling the Ion Source Completely

Disassemble the ion source completely to clean the ion source block or replace the EI/CI Source PCB.

See [Figure 49](#) for the location of the ion source components.



Tools Needed

- Gloves, cleanroom grade (P/N 23827-0008 and 23827-0009)
- Lint-free cloth



Frequency

As needed

❖ **To disassemble the ion source completely**

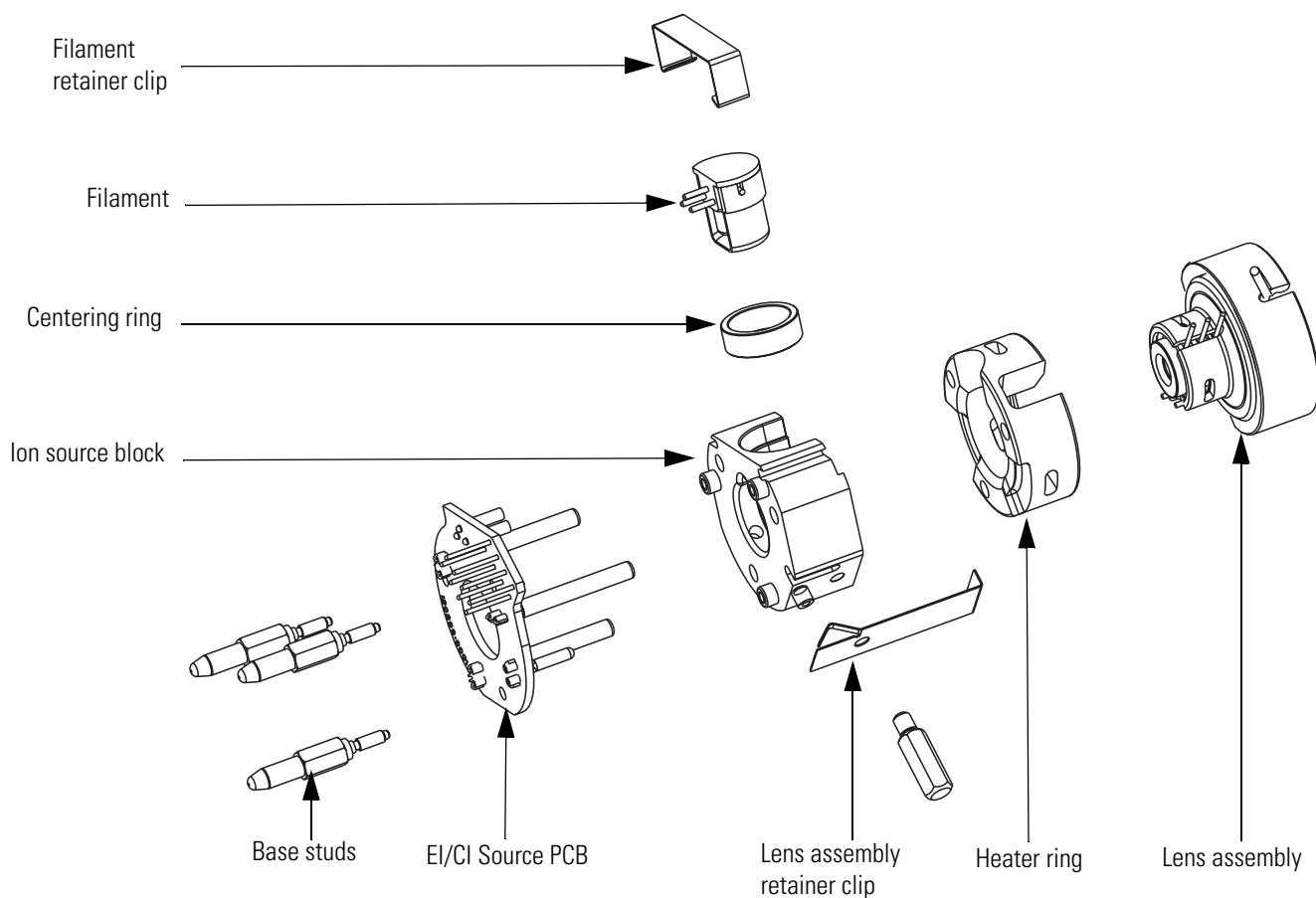
1. Prepare a clean work area by covering the area with lint-free cloth.
2. Shut down and vent the TSQ Quantum GC. See “[Shutting Down the System Completely](#)” on [page 49](#).



CAUTION Shock Hazard. Unplug the TSQ Quantum GC before proceeding.

3. Wearing clean, lint- and powder- free gloves, remove the ion source. See “[Removing the Ion Source](#)” on [page 84](#).
4. Remove the ion source from the magnet yoke.

Figure 49. Disassembling the ion source



5. Remove the ion source lens assembly from the ion source. See “[Removing the Ion Source Lens Assembly](#)” on [page 86](#).
6. Pull the heater ring off the ion source block.
7. Unscrew and remove the three base studs.

6 Maintenance

Disassembling and Reassembling the Ion Source Completely



CAUTION Shock Hazard. Do not pull the EI/CI Source PCB out of the ion source block. This might damage the EI/CI Source PCB.

8. Remove the EI/CI Source PCB.
 - a. Place the ion source on a clean surface with the cartridge heaters down and the EI/CI Source PCB up.
 - b. Press down on the ion source block to separate it from the EI/CI Source PCB.
9. Remove the retainer clip that secures the filament and centering ring to the ion source block.
10. Remove the filament and centering ring from the ion source block.
11. Clean the ion source block and lenses. See [“Cleaning Stainless Steel Parts”](#) on page 95. Clean non-stainless steel parts as described in [“Cleaning Non-Stainless Steel or Hybrid Part”](#) on page 97.

❖ To reassemble the ion source

1. Reinstall the EI/CI Source PCB and filament.
 - a. Align and insert the cartridge heaters and temperature sensor on the EI/CI Source PCB with the corresponding holes in the ion source block.

IMPORTANT Ensure that the temperature sensor is seated snugly.
 - b. Reinstall the three base studs.
 - c. Align the filament leads with the EI/CI Source PCB connectors and gently press the leads into the connectors. Normally, there is a small gap (about 0.016 in.) between the filament and the connectors. The gap allows the ceramic centering ring to properly position and align the electron lens hole with the ion volume.
2. Press the heater ring and lens assembly onto the ion source block.
3. Use the retainer clip and threaded standoff to secure the lens assembly to the ion source. See [Figure 49](#).

IMPORTANT For accurate temperature readings of the heater block, fully screw the threaded standoff into the ion source to ensure contact between the temperature sensor with the heater block.

4. Reinstall the ion source into the vacuum manifold. See [“Reinstalling the Ion Source”](#) on page 89.
5. Restart the system. See [“Starting Up the System after a Complete Shutdown”](#) on page 51.

Cleaning Stainless Steel Parts



Tools Needed

- Acetone, reagent grade (or other suitable polar solvent)
- Aluminum oxide abrasive, number 600 (P/N 32000-60340)
- Applicators, cotton-tipped (P/N 00301-01-00015)
- Beaker, 450 mL
- Clean, dry gas
- De-ionized water
- Detergent (Alconox, Micro, or equivalent)
- Dremel rotary tool or equivalent (recommended)
- Foil, aluminum
- Forceps (P/N 76360-0400)
- Gloves, cleanroom grade (P/N 23827-0008 and 23827-0009)
- Glycerol, reagent grade
- Lint-free cloth
- Protective eyewear
- Tap water
- Toothbrush, soft
- Ultrasonic cleaner



Frequency

As needed to clean these stainless steel parts:

- Ion volumes
- Ion source block
- Ion source lenses



CAUTION Material and Eye Hazard. Wear impermeable laboratory gloves and eye protection when performing cleaning procedures.

❖ To clean stainless-steel parts

1. Remove contamination from all the surfaces you are cleaning.
 - a. Use a slurry of number 600 aluminum oxide in glycerol and a cleaning brush or cotton-tipped applicator. Contamination appears as dark or discolored areas, but often is not visible. The heaviest contamination is usually found around the apertures, such as the electron entrance hole on an ion volume.
 - b. Clean each part thoroughly, even if no contamination is visible.
 - c. To clean the inside corners, use the wooden end of an applicator cut at an angle.
 - d. Use a Dremel® tool with the polishing swab at its lowest speed to increase cleaning efficiency, as well as decrease the time required to clean the items. To prevent

6 Maintenance

Disassembling and Reassembling the Ion Source Completely

personal injury, be sure to keep the Dremel tool away from possible hazards, such as standing water or flammable solvents.

2. Rinse the parts with clean water. Use a clean applicator or toothbrush to remove the aluminum oxide slurry. Do not let the slurry dry on the metal; dried aluminum oxide is difficult to remove.
3. Sonicate the parts in a warm detergent solution.
 - a. Using forceps, place the parts in a beaker containing warm detergent solution.
 - b. Place the beaker and contents in an ultrasonic bath for five minutes.
 - c. Rinse the parts with tap water to remove the detergent.
4. Sonicate the parts in deionized water.
 - a. Using forceps, place the parts in a beaker containing deionized water.
 - b. Place the beaker and contents in an ultrasonic bath for five minutes.
 - c. If the water is cloudy after sonicating, pour off the water, add fresh water, and place the beaker and its contents in an ultrasonic bath again for five minutes. Repeat until the water is clear.
5. Sonicate the parts in acetone.
 - a. Using forceps, place the parts in a beaker containing acetone.
 - b. Using forceps, transfer the parts to a beaker containing fresh acetone.
 - c. Place the beaker and contents in an ultrasonic bath again for five minutes.
6. Blow-dry the parts immediately. Use clean, dry gas to blow the acetone off the parts.
7. Using forceps, place the parts in a beaker, cover the beaker with aluminum foil, and put the beaker in the oven.
8. Dry the parts in an oven set at 100 °C for 30 minutes.
9. Allow the parts to cool before putting them back together.

Cleaning Non-Stainless Steel or Hybrid Part



Tools Needed

- Acetone, reagent grade (or other suitable polar solvent)
- Aluminum oxide abrasive, number 600 (P/N 32000-60340)
- Applicators, cotton-tipped (P/N 00301-01-00015)
- Beaker, 450 mL
- Clean, dry gas
- De-ionized water
- Detergent (Alconox, Micro, or equivalent)
- Dremel rotary tool or equivalent (recommended)
- Forceps (P/N 76360-0400)
- Gloves, cleanroom grade (P/N 23827-0008 and 23827-0009)
- Glycerol, reagent grade
- Lint-free cloth
- Protective eyewear
- Tap water
- Toothbrush, soft



Frequency

As needed to clean non-stainless steel parts (such as aluminum, ceramic, or gold-plated), or to clean hybrid parts that are partially made of stainless steel:

- Lens holder and spacers
- Filament spacer
- Heater ring



CAUTION Material and Eye Hazard. Wear impermeable laboratory gloves and eye protection when performing cleaning procedures.

❖ To clean non-stainless steel or hybrid parts

1. Remove contamination from stainless steel surfaces. It is only necessary to clean a surface that comes in contact with the ion beam.
 - a. Use a slurry of number 600 aluminum oxide in glycerol and a cleaning brush or cotton-tipped applicator. Contamination appears as dark or discolored areas, but often is not visible.
 - b. Clean each part thoroughly, even if no contamination is visible.
 - c. To clean the inside corners, use the wooden end of an applicator cut at an angle.

6 Maintenance

Maintaining the Forepump

- d. Use a Dremel tool with the polishing swab at its lowest speed to increase cleaning efficiency, as well as decrease the time required to clean the items. To prevent personal injury, be sure to keep the tool away from possible hazards, such as standing water or flammable solvents.
2. Rinse the parts with clean water. Use a clean applicator or toothbrush to remove the aluminum oxide slurry. Do not let the slurry dry on the metal; dried aluminum oxide is difficult to remove.
3. Scrub all of the parts with a warm detergent solution.
 - a. Scrub the parts with a toothbrush or clean applicator. Do not soak or sonicate the parts in detergent.
 - b. Using forceps, rinse the parts thoroughly with tap water to remove the detergent.



CAUTION Do not leave aluminum parts, such as the heater ring, in the detergent. Basic solutions, like detergent, discolor aluminum.

4. Rinse the parts in deionized water. Using forceps, dip the parts in a beaker of deionized water. Change the water if it becomes cloudy. Do not soak or sonicate the parts.
5. Rinse the parts with acetone. Using forceps, dip the parts in a beaker of acetone. Change the acetone if it becomes cloudy. Do not soak or sonicate the parts.
6. Blow-dry the parts immediately. Use clean, dry gas to blow the acetone off the parts.

Maintaining the Forepump

The forepump is located under the TSQ Quantum GC work table. Inspecting, adding, purging, and changing the oil are all that is required to maintain the forepump.

Forepump oil is a translucent, light amber color, which you must check often. During normal operation, oil must always be visible in the oil level sight glass between the MIN and MAX marks. If the oil level is below the MIN mark, add oil. If the oil is cloudy or discolored, purge the oil to decontaminate dissolved solvents. If the pump oil is still discolored, change it. You should change the pump oil every 3,000 hours (about four months) of operation. Refer to the manufacturer's documentation for procedures for purging, adding, and changing the forepump oil.



CAUTION If you use ammonia as a chemical ionization reagent gas, change the oil every month. Ammonia is highly basic and quickly damages seals in the forepump. Purging the oil with the Gas Ballast Control helps remove dissolved ammonia from the oil.

Adding Calibration Compound



Tools Needed

- Calibration compound (P/N 50010-02500)
- Syringe (P/N 36502019)
- 9/16-in., open-ended wrench



Frequency

Yearly or as needed

The calibration compound is a liquid whose mass spectrum of ions is used to tune and calibrate the TSQ Quantum GC. The TSQ Quantum GC uses FC-43 as its calibration compound. Although you cannot *visually* determine when a calibration compound needs to be added to the TSQ Quantum GC, Xcalibur Automatic Tune produces an error message indicating that “the intensity of calibration gas ions is too low.” This message indicates that calibration compound must be added. However, there are many factors other than a decrease in the calibration compound that can cause a shortage of calibration gas ions. As a rule, add calibration compound to the TSQ Quantum GC once a year.

❖ To add calibration compound

1. Shut down and vent the TSQ Quantum GC. See “[Shutting Down the System Completely](#)” on [page 49](#).
2. Lower the GC oven and transfer line temperatures to 30 °C and allow them to cool before continuing.



CAUTION The transfer line is hot. Allow it to cool to room temperature before moving the GC.

3. Move the GC far enough from the mass spectrometer to access the calibration compound vial compartment. See the location of the calibration compound vial compartment in [Figure 50](#).
4. Remove the cover to the calibration compound vial compartment.
5. Remove the calibration compound vial from the calibration gas flow module. See [Figure 51](#).
 - a. Use a 9/16-in. wrench to remove the nut from the calibration compound vial.
 - b. Slide the vial away from the calibration valve fitting with the ferrule and nut attached.

- c. Remove the ferrule and nut.



CAUTION Having more than 0.1 mL of the calibration compound can damage the calibration gas flow module. Be sure that there is less than 0.1 mL of the calibration compound in the vial.

6. Add the calibration compound.
 - a. Draw up no more than 0.1 mL of calibration compound into a clean syringe.
 - b. Insert the syringe in the calibration compound vial until it comes in contact with the white frit at the bottom of the vial.
 - c. Inject no more than 0.1 mL of calibration compound into the white frit. The frit absorbs the calibration compound, so if the calibration compound is pooled (calibrant covers the top of the frit), then you have too much in the vial. Immediately pour out the excess calibrant according to local environmental regulations.
7. Remove the syringe from the calibration compound vial.

Figure 50. Location of the calibration compound vial compartment

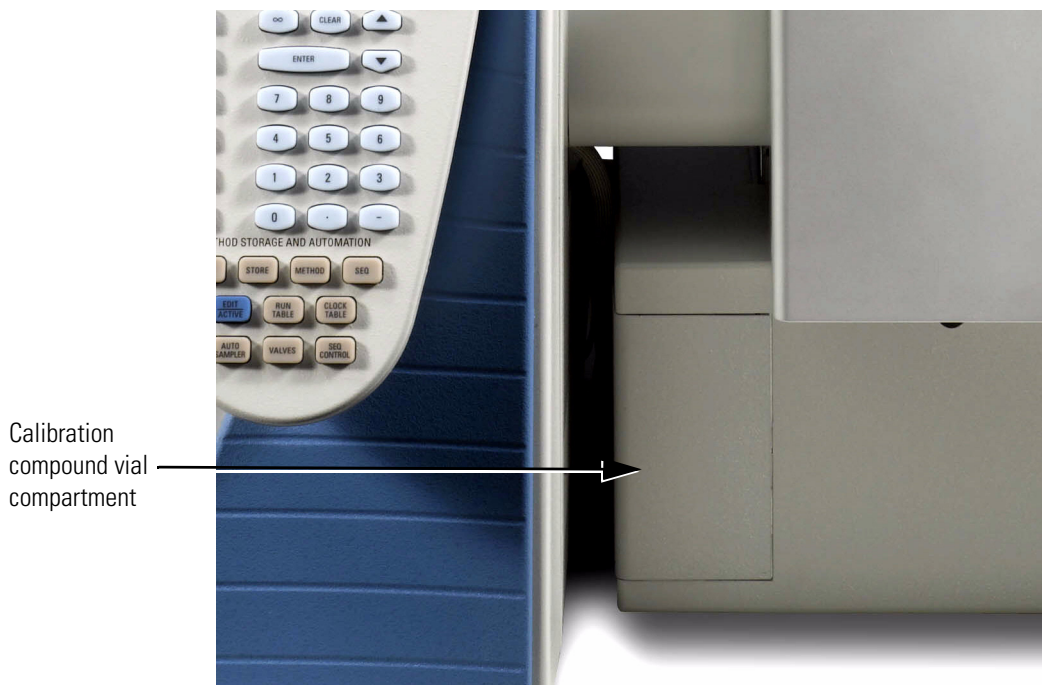
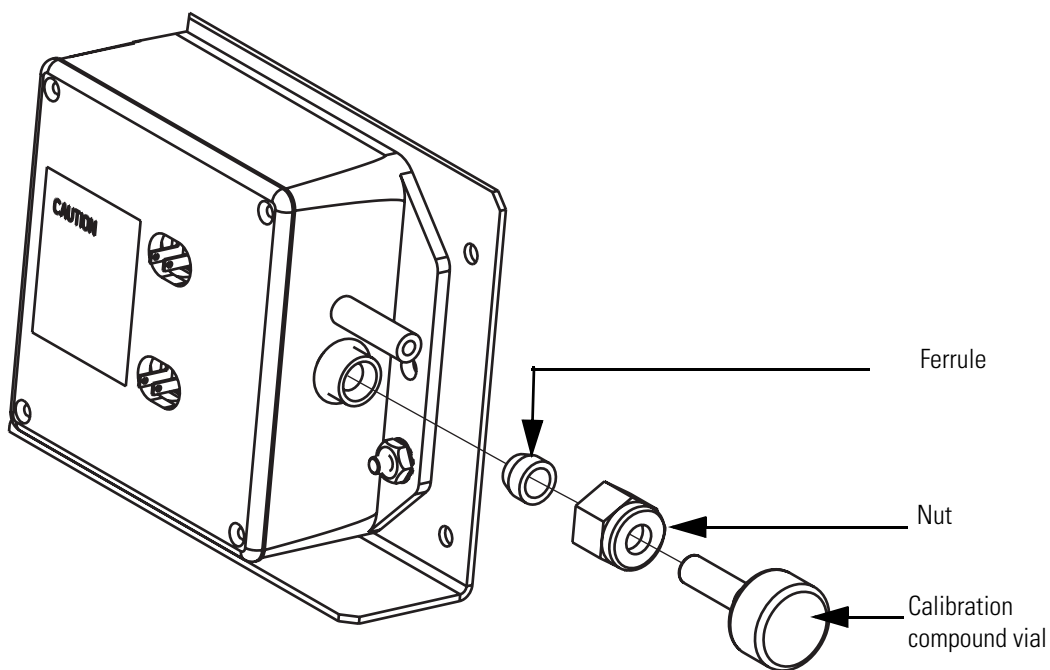


Figure 51. Calibration compound vial



8. Inspect the 1/4-in. ferrule for damage. Replace it if necessary (P/N 95001-20310).
9. Reinstall the calibration compound vial (P/N 96000-40013) into the module.
 - a. Hold the vial vertically and place the nut on the neck of the vial.
 - b. Place the 1/4-in. ferrule over the neck of the vial and into the nut.
 - c. Connect the vial to the calibration valve fitting with the nut and ferrule.
10. Reinstall the cover to the calibration compound vial compartment.
11. Position the GC next to the mass spectrometer.
12. Restart your system. See [“Starting Up the System after a Complete Shutdown”](#) on [page 51](#).

Replacing the Ball Valve Seal



Tools Needed

- Ball valve seal kit (P/N 119265-0003)



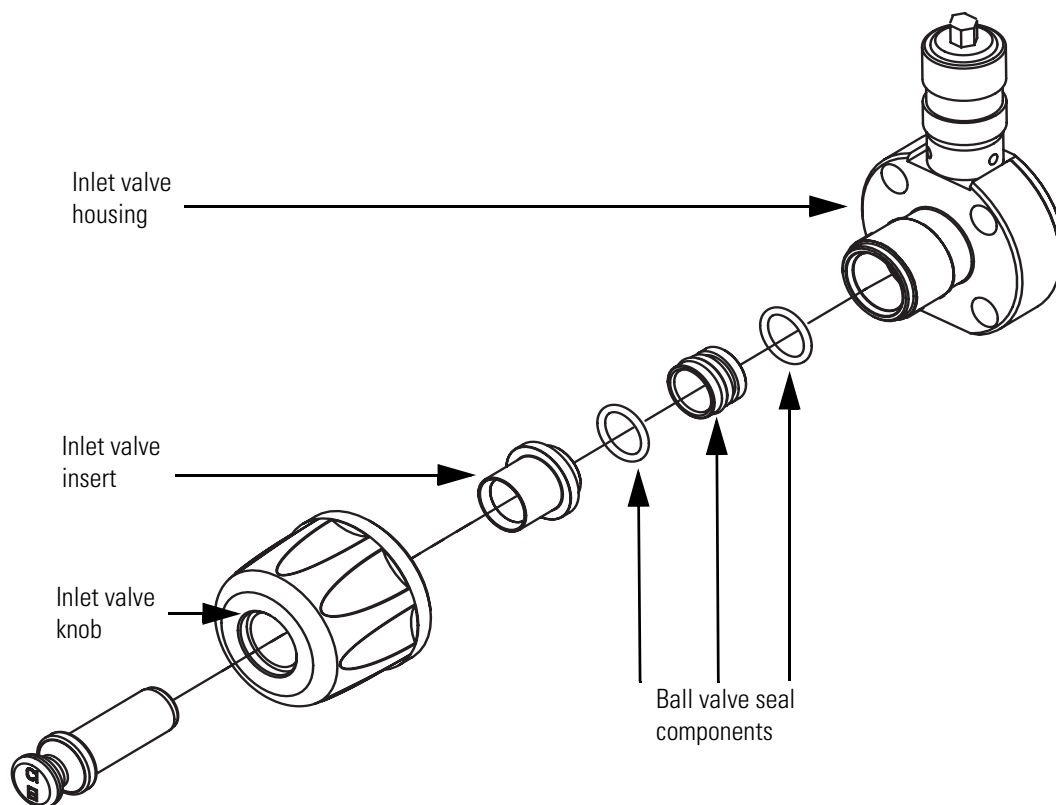
Frequency

If the ball valve seal leaks air after you insert the direct insertion probe or I/R tool into the inlet valve and tighten the inlet valve knob

The ball valve seal in the inlet valve can become worn over time. Replace the ball valve seal if it leaks air after you insert the direct insertion probe or I/R tool and tighten the inlet valve knob. The ball valve seal kit (P/N 119265-0003) is included in the TSQ Quantum GC Accessory Kit.

The ball valve seal consists of a Teflon[®] spool and two O-rings. See [Figure 52](#).

Figure 52. Components of the ball valve seal and inlet valve

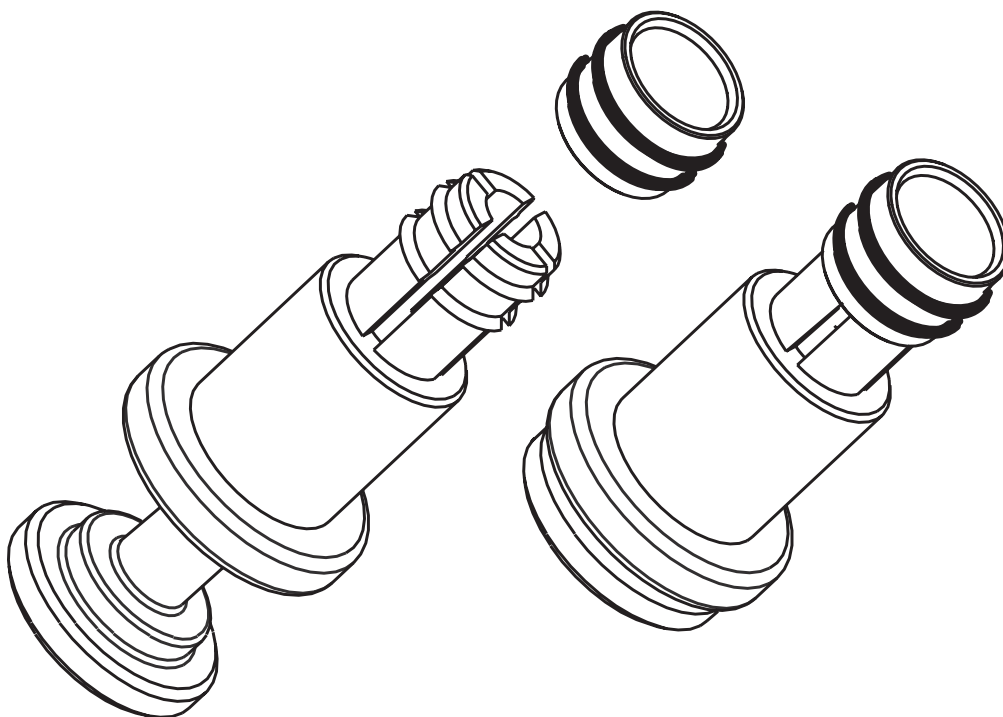


Use the ball valve seal extraction tool (part of the ball valve seal kit, P/N 119265-0003) to remove the ball valve seal. See [Figure 53](#).

❖ **To remove the ball valve seal**

1. Loosen the inlet valve knob counter-clockwise until you can remove it.
2. Remove the inlet valve knob, plug, and insert.
3. Insert the not-engaged ball valve seal extraction tool into the inlet valve housing.
4. Engage the ball valve seal by pushing the plunger of the ball valve seal extraction tool forward.
5. Remove the seal and tool.
6. Pull the plunger back to disengage the seal.

Figure 53. Ball valve seal extraction tool and ball valve seal, not engaged (left) and engaged (right)



❖ **To install the ball valve seal**

1. Obtain the ball valve seal kit (P/N 119265-0003) from the Accessory Kit.
2. Assemble the ball valve seal by installing the two O-rings onto the Teflon spool.
3. Insert the ball valve seal into the ball valve manifold with your finger.
4. Install the inlet valve knob and insert.
5. Install the inlet valve plug and tighten the inlet valve knob clockwise.

Removing and Installing a GC Capillary Column

Removing a GC Column

**Tools Needed**

- Gloves, cleanroom grade (P/N 23827-0008 and 23827-0009)
- Wrench, open-ended, 5/16-in.
- Wrench, open-ended, 7/16-in.
- Wrench, open-ended, 6 mm

**Frequency**

As needed for maintenance or column replacement

❖ To remove a GC capillary column

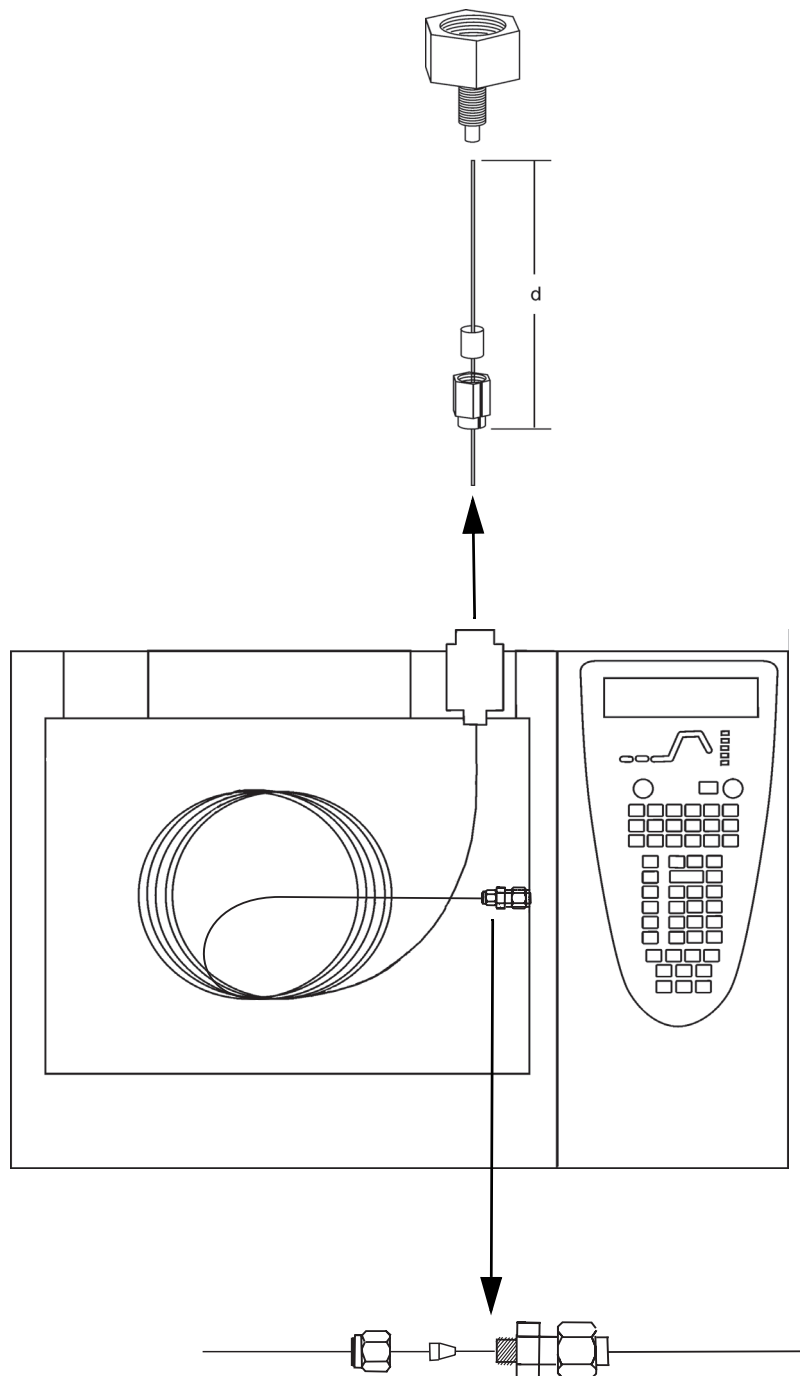
1. Shut down the TSQ Quantum GC and gas chromatograph.
 - a. Shut down and vent the TSQ Quantum GC. See [“Shutting Down the System Completely”](#) on [page 49](#).
 - b. Lower the oven, injector, and transfer line temperatures to 30 °C and allow them to cool before continuing.



CAUTION The oven, injector, and transfer line are hot. Allow them to cool to room temperature before touching them.

- c. Once the oven, injector, and transfer line are cool, turn off the gas chromatograph.
2. Remove the column from the transfer line. See [Figure 54](#).
 - a. Unscrew the transfer line nut.
 - b. Remove the column from the transfer line.

Figure 54. GC injector and transfer line unions



3. Remove the column from the injector. See [Figure 54](#).
 - a. Unscrew the injector nut.
 - b. Remove the column from the injector.

Installing a GC Column



Tools Needed

- Capillary column
- Gloves, cleanroom grade (P/N 23827-0008 and 23827-0009)
- Injector ferrule, for 0.25 mm column (P/N 290 134 88)
- Leak detector, hand-held electronic (GL Sciences, Inc., model LD-228, or equivalent)
- Lint-free tissue
- Magnifying glass
- Methanol or other suitable solvent
- Scoring wafer (or sapphire scribe) to cut capillary column
- Transfer line ferrule, 0.4 mm ID (P/N A0101-18100)
- Wrench, open-ended, 5/16-in.
- Wrench, two, open-ended, 7/16-in.
- Wrench, open-ended, 6 mm



Frequency

As needed

Refer to the manuals supplied with your GC for additional setup information.

❖ To install a GC capillary column



CAUTION Burn Hazard. The injector, oven, and transfer line might be hot. Allow them to cool to room temperature before touching them.

1. Connect the column to the injector as shown in [Figure 54](#).

Note Wear clean, lint- and powder-free gloves when you handle the column and injector ferrule.

- a. Unwind about half a turn of the column.
- b. Wipe about 100 mm (4 in.) of the column with a tissue soaked in methanol.
- c. Insert the column through the injector nut and ferrule (open end up).
- d. Wipe the column again with a tissue soaked in methanol.

Note To help you measure the proper distance between the nut and the end of the column, slide a septum on the column before the injector nut.

- e. Score and then break the column about 2.5 cm (1 in.) from the end with a scoring wafer. With the magnifying glass, check for an even, flat cut. Repeat if necessary.

- f. Insert the column into the injector so that the end of the column is the proper distance from the back of the injector nut. Proper distances are as follows: splitless = 64 mm, split = 40 mm, PTV = 30 mm.
 - g. Tighten the injector nut by hand, and then turn it an additional quarter turn with the wrench.
 - h. Score and break the column outlet about 2.5 cm (1 in.) from the end with a scoring wafer.
 - i. Turn on the gas chromatograph.
2. Set up the gas chromatograph.
 - a. Set the oven and injector temperatures to 30 °C.
 - b. Set the injector flow to 1.0 mL/min.
 - c. Turn off vacuum compensation (under the Right or Left Carrier menu).
 - d. Dip the column outlet in a small vial of methanol. Bubbles indicate there is flow through the column.
 - e. Allow the column to purge for at least 10 minutes.
 3. Perform a column characterization.
 - a. Raise the oven and injector temperatures to 50 °C and allow them to stabilize.
 - b. Run a column evaluation according to the procedures in the GC documentation.
 - c. Expect a K factor of about 0.7 to 0.9 for a 15 m, 0.25 mm ID column (1.3 to 2.0 for a 30 m, 0.25 mm ID column). If the column does not report a K factor within this range or within 0.1 units of the previously stored value, check for a leak or broken column using the leak detector. The K factor is a measured resistance for the column. A K factor that is too low might indicate a leak in the system, while a K factor that is too high might indicate a blockage.
 - d. Raise the oven temperature to 150 °C and allow it to stabilize.
 4. Perform a column leak check.
 - a. Run an automated leak check according to the procedures in the GC documentation.
 - b. If the report indicates a leak, look for leaks and use the leak detector to fix leaks at all the fittings in the GC.
 - c. Repeat column evaluation and leak check procedures until no leaks can be found.



CAUTION Do not raise the oven temperature until you are sure the system is leak-free. At temperatures above 100 °C, oxygen exposure will destroy the column.

5. Condition the column. New columns must be conditioned before inserting them into the TSQ Quantum GC.

6 Maintenance

Removing and Installing a GC Capillary Column



CAUTION If the column is inserted into the transfer line, the material released from the column during the conditioning (column bleed) will contaminate the ion source. You must then clean the ion source.

- a. Raise the injector temperature to the desired temperature (normally 250 °C).
- b. Run the slow temperature program that is recommended by the manufacturer. For example, hold the column at 40 °C for 15 minutes; then ramp it to 10 °C per minute up to 10 °C above the maximum temperature at which you will operate the column (normally 300 + 10 °C = 310 °C). Hold the column at this temperature for two hours.



CAUTION Never exceed the manufacturer's maximum operating temperature.

6. Connect the column to the transfer line.
 - a. Shut down and vent the TSQ Quantum GC. See [“Shutting Down the System Completely”](#) on [page 49](#).
 - b. Lower the oven temperature to 30 °C and allow it to cool before continuing.



CAUTION Burn Hazard. The oven and transfer line might be hot. Allow them to cool to room temperature before touching them. Do not touch the injector when it is hot.

- c. Wearing clean, lint- and powder-free gloves, unwind about one turn of the column (shown in [Figure 54](#)) from the column outlet end.
- d. Wipe about 450 mm (18 in.) of the column with a tissue soaked in methanol.

Note Sliding a septum on the column before the transfer line nut helps you measure the proper distance between the nut and the end of the column. The column should extend approximately 1 to 2 mm past the end of the transfer line.
- e. Insert the column through the transfer line nut and ferrule. Wipe the column again with a tissue soaked in methanol.
- f. Score and break the end of the column with a scoring wafer. With the magnifying glass, check for an even, flat cut. Repeat if necessary.
- g. Insert the column into the transfer line.
 - i. Open the lid of the ion source vacuum chamber so that you can get a better view of the column.
 - ii. Using the I/R tool, remove the ion volume. See [“Removing the Ion Volume”](#) on [page 69](#).
 - iii. Insert the column into the transfer line and tighten the transfer line nut by hand.

- iv. Push the column in until you can see it through the inlet valve.
 - v. Pull the column back just far enough that you cannot see it.
 - vi. Tighten the transfer line nut and transfer line union.
 - vii. Using the I/R tool, replace the ion volume. See [“Installing the Ion Volume”](#) on [page 76](#).
7. Condition the transfer line ferrule. Graphite/vespel ferrules like the transfer line ferrule require conditioning to ensure a leak-tight seal.
- a. Raise the oven temperature to the maximum temperature at which you will operate the column (normally 300 °C).
 - b. Wait 10 minutes.
 - c. Lower the oven temperature to 30 °C and allow it to cool before continuing.



CAUTION The oven might be hot. Allow it to cool to room temperature before opening it. Do not touch the injector, which will still be hot.

- d. Re-tighten the transfer line nut and the transfer line union.
8. Set up the gas chromatograph.
- a. Make sure the column does not have any sharp bends and that it does not touch any metal objects or walls inside the oven.
 - b. Raise the oven temperature to the initial temperature that you will use (normally 40 °C).
 - c. Turn on the vacuum compensation (under the Right or Left Carrier menu).

Diagnostics and Troubleshooting

The TSQ Quantum GC system diagnostics can test many components of the TSQ Quantum GC mass spectrometer. If there is a problem with the instrument electronics, the diagnostics can often locate the problem. Replacing a faulty PCB or assembly can usually correct the problem. After the PCB or assembly is replaced, the diagnostic tests are rerun to verify the instrument is functioning properly.

Contents

- [Running the TSQ Quantum GC System Diagnostics](#)
- [Troubleshooting](#)
- [Replacing a Fuse](#)
- [Replacing PCBs and Power Supplies](#)

Note Three levels of protection are possible:

- No protection—All operators can access all workspaces.
- Automatic protection—Tune Master uses the default password, lctsq, to protect the secure workspaces.
- Custom password protection—The Key Operator (or Laboratory Administrator or Manager) can select a password to protect the secure workspaces.

If your TSQ Quantum GC system has been password protected, you must obtain the password before you can access the secure workspaces (including the System Tune and Calibration workspace). If the instrument password is lost, you must reinstall the TSQ Quantum GC software to reset the default password (lctsq).

Running the TSQ Quantum GC System Diagnostics

The TSQ Quantum GC system diagnostics are used to test the major electronic circuits within the instrument and indicate whether the circuits pass or fail the tests. If there is a problem with the instrument electronics, the TSQ Quantum GC system diagnostics can often locate the problem.

The TSQ Quantum GC system diagnostics do not diagnose problems that are not electrical in nature. For example, they do not diagnose poor sensitivity due to misaligned or dirty components or to improper tuning. Therefore, it is important that the person running the diagnostics be familiar with system operation and basic hardware theory as well as the details of the diagnostics.

Typically, only a Thermo Fisher Scientific Field Service Engineer runs diagnostic tests because certain tests can overwrite system parameters. However, before calling a Thermo Fisher Scientific Field Service Engineer to run diagnostics, consider the following:

- Did the system fail when you were running samples?
- Did problems occur after you performed maintenance on the instrument, data system, or peripherals?
- Did you change the configuration of the system, cables, or peripherals just before the problem occurred?

If the answer is yes to the first item above, there is the possibility of a hardware failure, and running the diagnostics is appropriate.

If the answer is yes to either of the last two questions above, the problem is probably mechanical, not electrical. Reverify that alignment, configurations, and cable connections are correct before you call the Thermo Fisher Scientific Field Service Engineer. Keep careful notes documenting the nature of the problem and the corrective steps you have taken. If you are not successful in correcting the problem, you can e-mail this information to Field Service engineer. Field Service can then do a preliminary evaluation of the problem before the Field Service engineer arrives at your site.

Troubleshooting

The following topics discuss possible TSQ Quantum GC problems and solutions.

Communication Issues

Communication issues likely involve links between the data system and the mass spectrometer, gas chromatograph, or autosampler. This section does not address communication issues with other devices.

Communication issues can occur during the following:

- Data transfer between the mass spectrometer and the data system
- Mass spectrometer, gas chromatograph, and autosampler current status readbacks
- Instrument control, method downloading, and uploading
- Start, stop, pause, and initialize functions
- Error messages

How does the MS communication work?

The flow of digital information in the TSQ Quantum GC system is bi-directional; the data system downloads analytical methods to the instrument and activates functions to start, stop, shut down, start up, and initialize. The TSQ Quantum GC reports its readiness state, current tasks, various voltages, heated zones, and pressure readings. It also delivers a steady stream of mass spectral data during acquisition.

Why does the MS have communication issues?

Some communication issues are due to mechanical faults—for instance, a cable might be unplugged, or a device might be turned off. In other cases, the instrument method could be incorrect for TSQ Quantum GC operations. Less common communication issues are due to defective electronic hardware components.

How do I detect communication issues?

You might detect communication issues from an error message delivered by the data system, or you might notice the failure of the data system to perform some expected task.

Issue: Data system is unable to initiate communication with TSQ Quantum GC.

Possible Causes/Solutions

- The software is not configured correctly. Select and configure the TSQ Quantum GC from the Instrument Configuration window.
- The Ethernet cable is unplugged. Verify that the Ethernet cable is connected to the Ethernet port on the TSQ Quantum GC. See [Figure 12](#) on page [page 23](#).

- The Ethernet card in the PC is not configured or is faulty. Check the configuration or replace the Ethernet card if necessary.
- The system is in Service Mode. Return the electronics service switch to operating position.
- The incorrect Ethernet cable is used for the MS. Use the supplied 10 Base-T Category 5 crossover cable (P/N 76396-0052, in TSQ Quantum GC Accessory Kit).

Note You can extend the length of the Ethernet cable by plugging a standard Category 5 cable in series with the supplied crossover cable.

Issue: Computer intermittently loses communication with TSQ Quantum GC.

Possible Cause/Solution

- The Ethernet cable is loose or damaged. Inspect the cable and replace it if necessary.

Issue: Unable to download methods to the TSQ Quantum GC.

Possible Cause/Solution

- The software is not properly configured. Verify the correct settings in Instrument Configuration.

Issue: Acquisition does not begin as expected.

Possible Causes/Solutions

- The TSQ Quantum GC start mode is not properly configured. Verify that the instrument is configured properly. Refer to Xcalibur Help for more information.
- The TSQ Quantum GC Instrument Setup file has incorrect settings. Check the start time in the TSQ Quantum GC Instrument Setup file.
- The forepressure is too high due to solvent peak. Reduce injection volume or extend filament/multiplier delay time until after solvent peak.
- The remote start cable to the GC is disconnected. Connect the remote start cable.
- The GC did not start. Verify GC instrument method and configuration. Verify the connection between the autosampler and GC.
- The autosampler did not start. Verify autosampler instrument method and configuration. Verify that the sample is present.
- The heated zone stipend is not attained. See [“Heated Zone Issues”](#) on [page 118](#).

Issue: Acquisition terminates unexpectedly.

Possible Causes/Solutions

- The end run time in the TSQ Quantum GC instrument method is incorrect. Check the instrument method for the GC and the MS.
- The data system is out of disk space. Check disk space; back up and remove files.

Issue: Unable to initialize the gas chromatograph.

Possible Causes/Solutions

- The GC is not turned on. Turn on the GC.
- The GC is not configured properly in Xcalibur. Check Instrument Configuration.
- The cable between COM1 and GC is disconnected. Verify connection.
- COM1 is not configured properly. Verify COM port configuration.

Issue: Unable to download methods to the gas chromatograph.

Possible Causes/Solutions

- There is a discrepancy between the instrument method and configuration. Verify consistency between method and instrument configuration.
- COM1 is not configured properly. Verify COM port configuration.

Issue: Unable to initialize the autosampler.

Possible Causes/Solutions

- The autosampler is not turned on. Turn on autosampler.
- The autosampler is not configured properly in Xcalibur. Check Instrument Configuration.
- The cable between the GC and autosampler is disconnected. Verify connection.
- The autosampler instrument configuration is not set to the correct port. Verify connection and configuration.

Issue: Unable to download methods to the Autosampler.

Possible Cause/Solution

- There is a discrepancy between instrument method and configuration. Verify consistency between instrument method and instrument configuration.

Contamination Issues

Chemical noise is always present in any mass spectrometer. As a result, the high sensitivity of the mass spectrometer can cause new users to confuse background with a contamination problem. Additionally, the spectra shown in Xcalibur Tune and Real-Time Display are auto-normalized, which can make the background appear high-level.

Some chemical noise does occur, such as septum bleed after a series of injections, vial sample bleed (which occurs if more than one injection is made from a sample vial), and siloxane peaks that appear in the chromatogram at regular intervals from focusing at the head of the column or in the injector.

Other possible contamination sources include hydrocarbon contamination of the carrier gas, pump oil, or instrument cleaning solvents.

Always wear clean, lint- and powder- free gloves when handling ion source and mass analyzer components, and ensure that the carrier gas filter, carrier gas lines, and gas regulators are free of contamination and leaks.

Issue: Excessive chemical background due to a column bleed (m/z 429, 355, 281).

Possible Causes/Solutions

- The capillary column has not been properly conditioned. Condition the capillary column.
- The capillary column is damaged as a result of exposure to oxygen. Find the source of the oxygen in the carrier gas or air leak. Recondition or replace the capillary column.

Issue: Excessive injection port septum bleed (Typical m/z 207, 429, 355, 281).

Possible Causes/Solutions

- The septum is worn out or damaged. Replace the septum.
- Small pieces of septum are in the injection port liner. Replace the injection port liner; condition the capillary column.

Issue: Phthalate background (m/z 149, 167, 279).

Possible Causes/Solutions

- Phthalate contamination has occurred due to sample handling or solvent contamination.
- Packaging materials could be the source of phthalates.
- Isolate source of phthalates such as vial lids or plastic solvent containers and remedy.

Issue: Excessive hydrocarbon contamination (Typical ions are m/z 43, 57, 71, 85, 99).

Possible Causes/Solutions

- Carrier gas tubing is contaminated.
- Isolate source of hydrocarbon contamination and remedy.
- Replace carrier gas tubing.
- Change carrier gas filters.

Issue: Chemical background due to rhenium oxide (m/z 185/187, 201/203, 217/219, 233/235, 250/252).

Possible Causes/Solutions

- These series of rhenium oxide ions come from oxidation of the rhenium filament wire due to the introduction of air into the ion source while the filament is on.
- Check for air leaks and remedy. See “[High Vacuum Issues](#)” on [page 119](#) for more information.

Issue: Spectra are observed due to the following solvents:

Solvent Spectra

Acetone (*m/z* 43, 58, 59)

Hexane (*m/z* 41, 43, 56, 57, 58, 85, 86)

Methanol (*m/z* 31)

Methylene chloride (*m/z* 84, 83)

Toluene (*m/z* 91, 92)

Trichloroethane (*m/z* 151, 153)

Xylene (*m/z* 105, 106)

Possible Causes/Solutions

- There is residual solvent from a cleaning procedure or laboratory background contamination. When you finish performing a cleaning procedure, allow cleaned components to dry thoroughly. Warm parts in the GC oven to drive off residual solvent.
- The observed compounds have been introduced through sample injection. The ultimate source is either a sample solvent or the autosampler rinsing solvent. Optimize GC method to separate solvent peak from the area of interest in the chromatogram.

Filament and Lens Control Issues

The lifetime of a filament depends on its exposure to oxygen and solvent vapors. The filament assembly protects the filament and increases its lifetime for many months.

Xcalibur diagnostics test the filament for continuity and current regulation. Testing the filament for continuity before each acquisition ensures that an open filament condition will stop an autosampler sequence and generate an error message.

Diagnostics test the lenses of the TSQ Quantum GC. A flat line, which represents voltage readback versus the predicted voltage ramp, indicates a lens or other control fault. Contamination causes lens performance to deteriorate over time; the amount of time depends on what type of sample and ionization mode you use.

Be careful to handle the lenses with care, and do not use harsh cleaning techniques. Damaged lenses cause short circuits, which in turn can cause damage to the lens drivers.

Issue: Diagnostics indicate that the filament is open.

Possible Cause/Solution

- The filament is open. Vent the system and remove the filament. Normal resistance is 1.0 Ω . Replace if open.

Issue: Unstable emission current.

Possible Cause/Solution

- The filament is near the end of its life span. Replace the filament.

Issue: Short filament lifetime.

Possible Causes/Solutions

- There is an air leak contributing to short filament lifetime. Check for leaks; repair if any are found. See “[High Vacuum Issues](#)” on [page 119](#) for more information.
- The filament is on during the solvent peak. Increase acquisition delay time until the solvent peak has passed.
- High emission current is being used. Use lower emission current to extend lifetime.

Issue: Diagnostics indicate a flat lens response.

Possible Causes/Solutions

- The power supply to the lens has a fault. Contact Thermo Fisher Scientific Technical Support.
- There is a fault with the lens drivers. Contact Thermo Fisher Scientific Technical Support.

Heated Zone Issues

The ion source and transfer line are heated zones related to the TSQ Quantum GC. The ion source heater is controlled by the TSQ Quantum GC and the transfer line heater is controlled by the Aux1 heated zone of the TRACE GC.

A heated zone problem is often the result of downloading an instrument method to the TSQ Quantum GC that has a different setpoint than the current setting, causing a delay while the heated zone heats or cools.

Component failures are less common but can occur. These are usually related to open circuits in heater cartridges or faulty temperature sensors.

This manual does not discuss heated zones in the gas chromatograph.

Issue: Excessive chromatographic peak tailing.

Possible Causes/Solutions

- The ion source, transfer line, or both are not hot enough. Increase the transfer line temperature. It should be at least as hot as the highest GC oven temperature. Then, try increasing the ion source temperature.
- The sample analyte is adsorbing in the GC injector. Clean and deactivate the injection liner. You can also try liners made of different materials.
- The GC oven is not ramped to a high enough temperature. Extend upper oven temperature.
- The GC column must be replaced or does not have the appropriate stationary phase for your application. Change the GC column. See “[Removing and Installing a GC Capillary Column](#)” on [page 104](#).

- The GC column does not extend far enough past the end of the transfer line tip. If the end of the column is inside the tip, an excessive amount of GC effluent will contact the inside wall of the tip. Follow the procedure described in “[Installing a GC Column](#)” on [page 106](#).

Issue: Source heater will not heat.

Possible Causes/Solutions

- One or more heater cartridges on the EI/CI Source PCB is defective. Replace the EI/CI Source PCB.
- The ion source temperature sensor (RTD) is defective. Replace the EI/CI Source PCB.

Issue: Source heater overheats.

Possible Cause/Solution

- The ion source temperature sensor (RTD) is defective. Replace the EI/CI Source PCB if necessary.

Issue: Transfer line will not heat.

Possible Causes/Solutions

- Aux1 zone of the GC is not configured for MS Transfer Line. Configure Aux1 zone of the GC and set transfer line temperature in the GC Method Editor.
- Transfer line heater elements are defective. Replace the transfer line.
- The transfer line temperature sensor (RTD) is defective. Replace the transfer line.

Issue: Transfer line overheats.

Possible Cause/Solution

- The transfer line temperature sensor is defective. Replace the transfer line.

High Vacuum Issues

High vacuum problems can manifest themselves in two ways:

- An intermittent vacuum condition (the vacuum pressure in the vacuum manifold fluctuates intermittently) can cause chromatographic signals to drop out, or, if the pressures exceed the maximum allowed pressures set in Xcalibur (See [Table 3](#) on [page 53](#)), then the TSQ Quantum GC turns off.
- If the vacuum is consistent enough that it does not exceed the maximum allowed pressure and avoids the Xcalibur automatic shutdown, non-reproducible false chromatographic peaks can be generated in the chromatogram.

Typical forepressure readbacks are 30 to 40 mTorr (in EI mode), and typical manifold pressure (ion gauge readback) is 2×10^{-5} Torr with argon collision gas on, and 2×10^{-6} Torr with Ar collision gas off.

The most reliable way to find vacuum leaks is to spray a gas around the vacuum manifold and look for the characteristic ions in full-scan EI. Argon produces m/z 40. Alternatively, you can use compressed electronic dusting spray containing an HFC. For example, Falcon[®] Dust-Off[®] and MicroCare[®] Micro-Blast[™] contain tetrafluoroethane, which produces ions at m/z 69 and 83.

Issue: Forepump will not turn on.

Possible Causes/Solutions

- The forepump is off. Check the forepump switch.
- The vacuum service switch is in the Off position. Place the vacuum service switch in the operating position.
- The forepump power cable from the TSQ Quantum GC is not connected. Connect the power cable.
- The forepump is faulty. Replace the forepump.

Issue: Forepump powers on, but will not pump down.

Possible Causes/Solutions

- The oil level in the forepump is insufficient. Check oil level; add oil if necessary.
- The foreline is leaking. Check the clamps and connectors. Replace the foreline hose if a hole is found.
- The vacuum manifold cover is leaking.
- The forepump is faulty. Replace the forepump.

Issue: Turbo pump shuts off during operation.

Possible Cause/Solution

- The foreline pressure is too high. Check for leaks in the foreline.

Issue: Unexpected full ventilation occurs.

Possible Causes/Solutions

- A gross leak is present. Check for leaks.
- The system was vented through the inlet valve. Close and plug the inlet valve.
- The GC column broke at the transfer line. Replace the GC column. See [“Removing and Installing a GC Capillary Column”](#) on page 104.
- The foreline was cut. Replace the foreline hose.

Issue: Vacuum is faulty.

Possible Solutions

- A gross leak is present. Check for leaks.
- The pressure in the analyzer region of the vacuum manifold, as measured by the ion gauge, must be below the pressures listed in [Table 3](#) on [page 53](#).

Linearity Issues

Linearity issues occur when a plot of intensity versus concentration of a known compound is not linear. Poor instrument operating conditions can cause linearity problems. Additionally, certain compounds do not give a desired linear response due to chromatographic activity.

A well-maintained instrument provides good linear response over a wide range of concentrations for most compounds. Like any instrument, however, the TSQ Quantum GC has a saturation point.

Perform routine injector and column maintenance to minimize linearity problems. Usually, a hardware fault that affects linearity shows different issues than those that might be attributed to linearity.

Issue: Calibration plots not sufficiently linear.

Possible Causes/Solutions

- High-end standards are too concentrated for the MS. Use the split injection technique to decrease the amount of sample or lower emission current to reduce MS sensitivity.
- The ion volume and lenses are dirty. Clean ion volume and lenses as described in [“Cleaning Ion Source Components”](#) on page 81.
- The electron multiplier setting is incorrect. Run Auto Tune - Calibration as described in [“Tuning and Calibrating”](#) on page 59.
- The injection port liner or capillary column is dirty. Change the injection port liner and trim the capillary column.
- The capillary column stationary phase is too thin for high concentration samples. Use a higher capacity capillary column with a thicker stationary phase, or use a split injection technique.
- The capillary column is bad. Replace the capillary column. See [“Removing and Installing a GC Capillary Column”](#) on page 104.

Power Supply Issues

Xcalibur diagnostics detect most power supply issues. Power supply problems often involve a blown fuse, faulty electronic components, or something as simple as a disconnected cable. Fuses should be replaced by a Thermo Fisher Scientific Field Service Engineer.

Issue: TSQ Quantum GC will not power on.

Possible Causes/Solutions

- The power cord is disconnected. Verify that the power cord is plugged in.
- Voltage is not coming from the electrical outlet. Verify that the electrical outlet is operational.
- The Power Module is faulty. Contact Thermo Fisher Scientific Technical Support.

Issue: The TSQ Quantum GC powers on, but trips the circuit breaker.

Possible Causes/Solutions

- The Power Module is faulty. Contact Thermo Fisher Scientific Technical Support.
- The forepump causes the circuit breaker to trip. Check forepump; replace it if necessary.

Sensitivity Issues

If you observe a drop in instrument sensitivity, you should determine if the sensitivity drop was sudden or if it occurred gradually. A sudden loss of sensitivity can be the result of sudden component failure or an unnoticed change in the analytical method. Simple errors such as a plugged autosampler syringe or too low sample level in the sample vial can give the appearance of instrument failure.

Gradual drops in sensitivity are usually the result of ion volume or lens contamination, and are easily remedied by cleaning the ion volume or lenses.

The electron multiplier influences sensitivity and has a limited lifetime. Eventually the electron multiplier must be replaced.

Improper GC maintenance is another cause of diminished sensitivity. It is important to establish a routine maintenance program for the GC. See the *TRACE GC Maintenance Manual* for more information on establishing a maintenance program.

Issue: The chromatogram has a low total ion current signal.

Possible Causes/Solutions

- The GC temperature ramp does not continue to a high enough temperature to elute high boiling point compounds. Multiple injections cause these compounds to accumulate in a column, reducing sensitivity. Extend upper temperature or the time at upper temperature in the GC oven ramp.
- The instrument is out of tune, or the tune file is incorrect. Select correct tune file for the method or run automatic tune as described in “[Tuning and Calibrating](#)” on [page 59](#).
- The ion volume is contaminated. Clean the ion volume.
- The ion volume is incorrectly positioned. Position the ion volume properly.
- The magnets above and below the ion source are installed incorrectly. Position both magnets so the south pole is on top. Electrons will not focus into the ion volume if one magnet is upside down.
- Dust has collected in the Electron Multiplier or on the conversion dynode. Contact Thermo Fisher Scientific Technical Support.
- The emission current is set too low. Check the setting listed for the emission current. Choose **Tune > Manual** and select the **Controls** tab.
- The ground connection between the electrometer PCB and anode feedthrough is faulty. Contact Thermo Fisher Scientific Technical Support.

- There is a problem with the filament or lens control. See “[Filament and Lens Control Issues](#)” on [page 117](#) for more information.
- The EI/CI Source PCB is faulty, allowing emission current to leak to ground. Contact Thermo Fisher Scientific Technical Support.
- Reagent gas is leaking into the analyzer, suppressing EI signal. Check for presence of CI Reagent ions in spectrum. Replace CI Gas Flow Module if necessary.

Issue: Poor compound sensitivity.

Possible Causes/Solutions

- The syringe, injection port liner, and column depth in injector are incorrectly matched. See *TRACE GC Operators Manual* for the correct combination.
- Sample delivery is insufficient due to a plugged syringe needle. Clean or replace the syringe.
- The injection port liner is contaminated. Clean or replace the injection port liner.
- Graphite or septa particles contaminate the injection port. Clean the injection port.
- The injector or septum is leaking. Replace septum and perform leak check on the GC.
- The capillary column is at the end of its life span. Replace the capillary column.
- Method development problems are present. Contact Thermo Fisher Scientific Technical Support.

Issue: Sensitivity is unstable or shows decrease with repeated injections.

Possible Causes/Solutions

- The GC temperature ramp does not continue to a high enough temperature to elute high boiling point compounds. Multiple injections cause these compounds to accumulate in a column, reducing sensitivity. Extend the upper temperature or the time at upper temperature in the GC oven ramp.
- The ion volume or lenses are contaminated. Clean the ion volume and lenses as described in “[Cleaning Ion Source Components](#)” on [page 81](#).
- The ion source temperature is too low and causes the ion source to contaminate too quickly. Clean ion volume and lenses as described in “[Cleaning Ion Source Components](#)” on [page 81](#) and then raise ion source temperature.
- There is a problem with the filament emission current control. See “[Filament and Lens Control Issues](#)” on [page 117](#) for more information.
- The electron multiplier is faulty. Contact Thermo Fisher Scientific Technical Support.
- The injection port liner or capillary column is contaminated. Replace the injection port liner and trim the capillary column.

Issue: Poor sensitivity in CI mode.

Possible Causes/Solutions

- An EI ion volume is installed. Install a CI ion volume as described in [“Changing Ionization Modes”](#) on page 69.
- The small hole in the CI ion volume is plugged. Use a dental pick or old syringe needle to clear it.
- The filament is not aligned. Remove the ion volume and check if the ion burn is centered around the small electron entrance hole. Be sure the filament is properly inserted into the connector. Carefully bend the filament wire to better align it with the ion volume.
- The ion volume is not inserted properly. While running the instrument, you can push on the ion volume with the I/R Tool. Be sure to monitor the pressure to ensure that you get a good seal around the I/R Tool. Otherwise, you may damage the filament. An increase in signal calibration gas as you push on the ion volume usually indicates that the filament is not aligned properly.

Stability Issues

Stability helps provide consistent instrument precision and the reproducibility of accurate results. Good operating conditions for the mass spectrometer, gas chromatograph, and autosampler contribute to instrument stability.

Sample preparation, spiking errors, sample injection errors, and lack of routine maintenance on the instruments can cause false stability issues.

When hardware faults affect instrument stability, investigate simple solutions first, such as cleaning the ion volume and lenses, or checking for air leaks. Usually, a hardware fault that affects stability shows different issues than those which might be attributed to stability.

Issue: The signal response is unstable or drops out unexpectedly.

Possible Causes/Solutions

- There is a problem with the filament or lens control. See [“Filament and Lens Control Issues”](#) on page 117 for more information.
- There is an air leak. Check for leaks. See [“High Vacuum Issues”](#) on page 119 for more information.
- There is a high vacuum problem. See [“High Vacuum Issues”](#) on page 119 for more information.
- There is a contamination problem. See [“Contamination Issues”](#) on page 115 for more information.
- Dust has collected in the electron multiplier or on the conversion dynode. Contact Thermo Fisher Scientific Technical Support.

Tuning Issues

You can suspect a tuning problem when Xcalibur Auto Tune - Calibration fails. Auto Tune - Calibration performs several functions, and issues or error messages indicate different problems. Diagnostics can usually uncover a tuning problem.

Issue: "Cannot find Calibration Gas" error message received.

Possible Causes/Solutions

- There is a mechanical problem with the ion source or lenses. Verify that an EI ion volume is installed. Verify correct orientation and cleanliness of ion volume. Verify cleanliness and correct operation of lenses.
- Tune file settings are out of usable range. Restore default tune settings and calibration settings. Run Auto Tune - Calibration. See ["Tuning and Calibrating"](#) on page 59.
- The calibration gas vial is empty. Add 100 μ L (max) of calibration compound to calibration gas vial. See ["Adding Calibration Compound"](#) on page 99.

Issue: The electron multiplier gain calibration fails.

Possible Causes/Solutions

- The electron multiplier has not been given sufficient time to outgas since venting. Allow more time to pump out.
- The GC column flow is too high. Lower it to 1 mL/min.
- The multiplier is near the end of its lifetime. Multipliers typically last about 2 to 3 years before they are too noisy for the gain to be set accurately. Contact Thermo Fisher Scientific Technical Support.
- The multiplier power supply is faulty. Contact Thermo Fisher Scientific Technical Support.
- The filament is the source of too much background noise. See ["Filament and Lens Control Issues"](#) on page 117 for more information.
- Chemical background in the manifold is elevated. Remedy leaks or sources of water contamination in carrier gas. See ["High Vacuum Issues"](#) on page 119 for more information.
- The difference between the electron energy and the setpoint is greater than 5 V. Contact Thermo Fisher Scientific Technical Support for assistance.

Issue: Poor high mass response.

Possible Causes/Solutions

- Poor high m/z ion intensity because the ion source temperature is too high. Reduce the ion source temperature to reduce the amount of thermal decomposition and fragmentation of your analyte.
- Poor high m/z ion intensity because of bad ion source lens settings. Run Auto Tune - Calibration. See ["Tuning and Calibrating"](#) on page 59.

- Helium pressure in the ion source is too high or low. Set flow to 1.0 mL per minute for most applications.
- There is a vacuum leak. Find and repair any leaks. Be sure to check the transfer line fitting in the GC oven. See “[High Vacuum Issues](#)” on [page 119](#) for more information.
- An excess amount of low m/z ions, such as hydrocarbons or column bleed. Remedy the source of these low m/z ions.
- The ion volume or lenses are contaminated. Clean the ion volume or lenses. See “[Cleaning Ion Source Components](#)” on [page 81](#).
- m/z 131 is not base peak because the multiplier gain is too low. The multiplier gain calibration may set the multiplier voltage too low for a noisy multiplier. Electron multipliers older than 2 to 3 years are often noisy. Contact Thermo Fisher Scientific Technical Support.
- There is poor high m/z intensity and poor resolution of low m/z ions because the conversion dynode is faulty. Contact Thermo Fisher Scientific Technical Support.
- The injection RF is not calibrated. Run Auto Tune - Calibration as described in “[Tuning and Calibrating](#)” on [page 59](#).
- There is a problem with the filament or lens control. See “[Filament and Lens Control Issues](#)” on [page 117](#) for more information.
- Reagent gas is leaking into the analyzer, suppressing EI signal. Check for the presence of CI Reagent ions in spectrum. Replace the CI Reagent Gas Flow Module if necessary.

Issue: Weak signal.

Possible Causes/Solutions

- The ion volume or ion source lenses are dirty. Clean the contaminated components as described in “[Cleaning Ion Source Components](#)” on [page 81](#).
- The multiplier is set too low. Run multiplier gain calibration in Auto Tune - Calibration as described in “[Tuning and Calibrating](#)” on [page 59](#). An electron multiplier older than 2–3 years may be too noisy for the multiplier gain calibration to accurately set the voltage. The electron multiplier might need to be replaced. Contact Thermo Fisher Scientific Technical Support.
- The wrong type of ion volume is installed. EI and CI require different ion volumes. They may not be used interchangeably. Change the ion volume as described in “[Changing Ionization Modes](#)” on [page 69](#).
- The ion volume is absent or incorrectly positioned. Verify that the ion volume is positioned correctly.
- There is a filament or lens control problem. See “[Filament and Lens Control Issues](#)” on [page 117](#) for more information.
- The electron multiplier is faulty. Contact Thermo Fisher Scientific Technical Support.

Replacing a Fuse



CAUTION Fuses protect the various circuits by opening the circuits whenever overcurrent occurs. On the TSQ Quantum GC mass spectrometer, a failed fuse indicates a failed board or electronic module that must be replaced by a Thermo Fisher Scientific Field Service Engineer.

Replacing PCBs and Power Supplies



CAUTION The TSQ Quantum GC mass spectrometer electronic assemblies are close-packed to minimize the size of the system. Due to the complexity of removing and reinstalling the TSQ Quantum GC mass spectrometer electronic assemblies, only a Thermo Fisher Scientific Field Service Engineer can replace electronic assemblies.

Using the Direct Sample Probe

With the direct sample probes (direct insertion probe and direct exposure probe) you can introduce compounds directly into the ion source without GC column separation. This chapter covers, step-by-step, a direct insertion probe (DIP) experiment using perfluorotetracosane ($\text{CF}_3(\text{CF}_2)_{22}\text{CF}_3$, molecular weight 1238.18, melting point 190 °C). You can perform a similar experiment using your compound.

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- [Creating an Instrument Method](#)
- [Creating a Sequence](#)
- [Preparing the Probe and Inlet Valve](#)
- [Preparing the Mass Spectrometer](#)
- [Running the Sequence](#)
- [Examining the Raw Data in Qual Browser](#)
- [Removing the Probe](#)

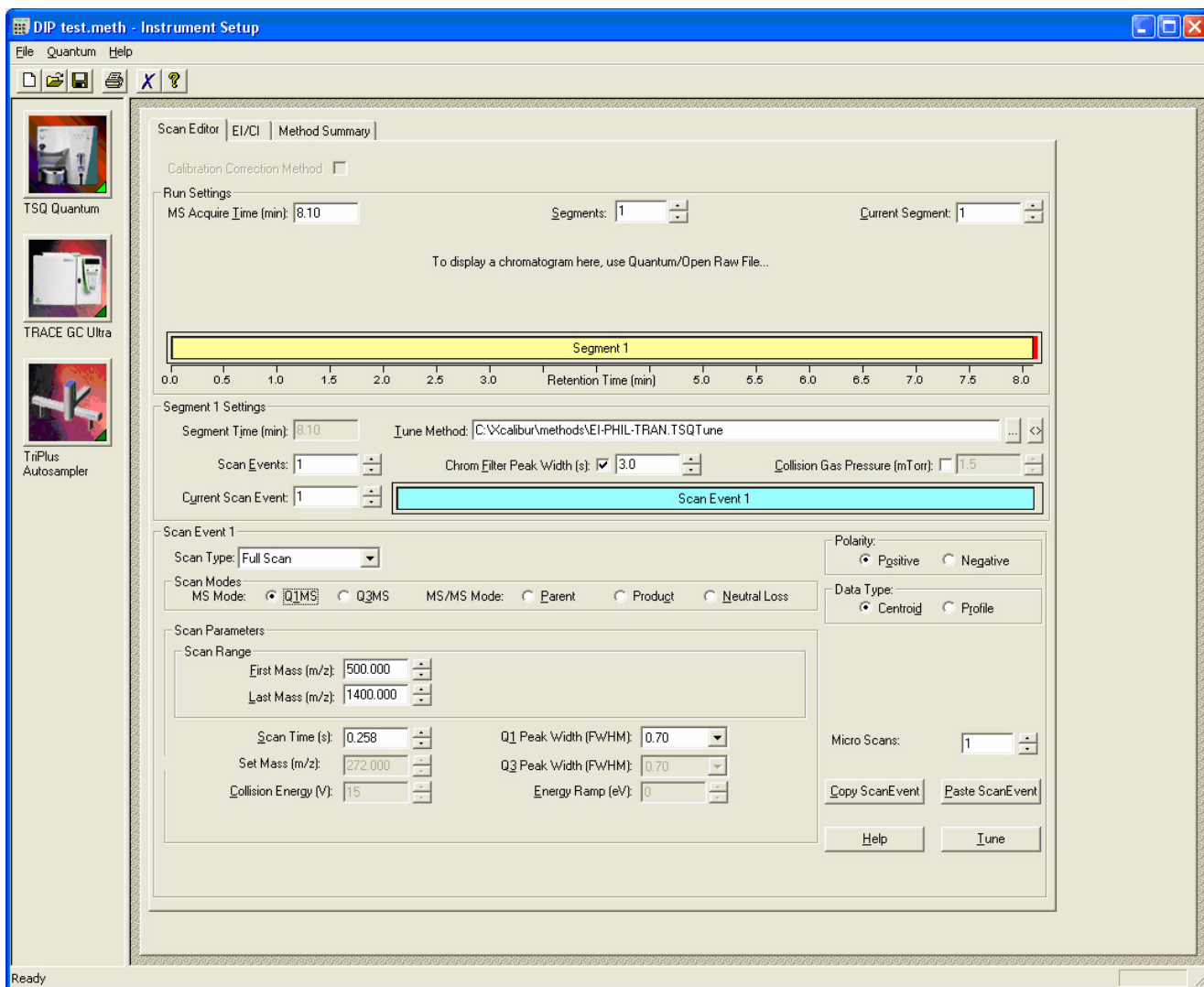
Creating an Instrument Method

An instrument method contains the settings that the TSQ Quantum GC uses during an experiment. Use the Instrument Setup view to create the instrument method.

❖ To create an instrument method

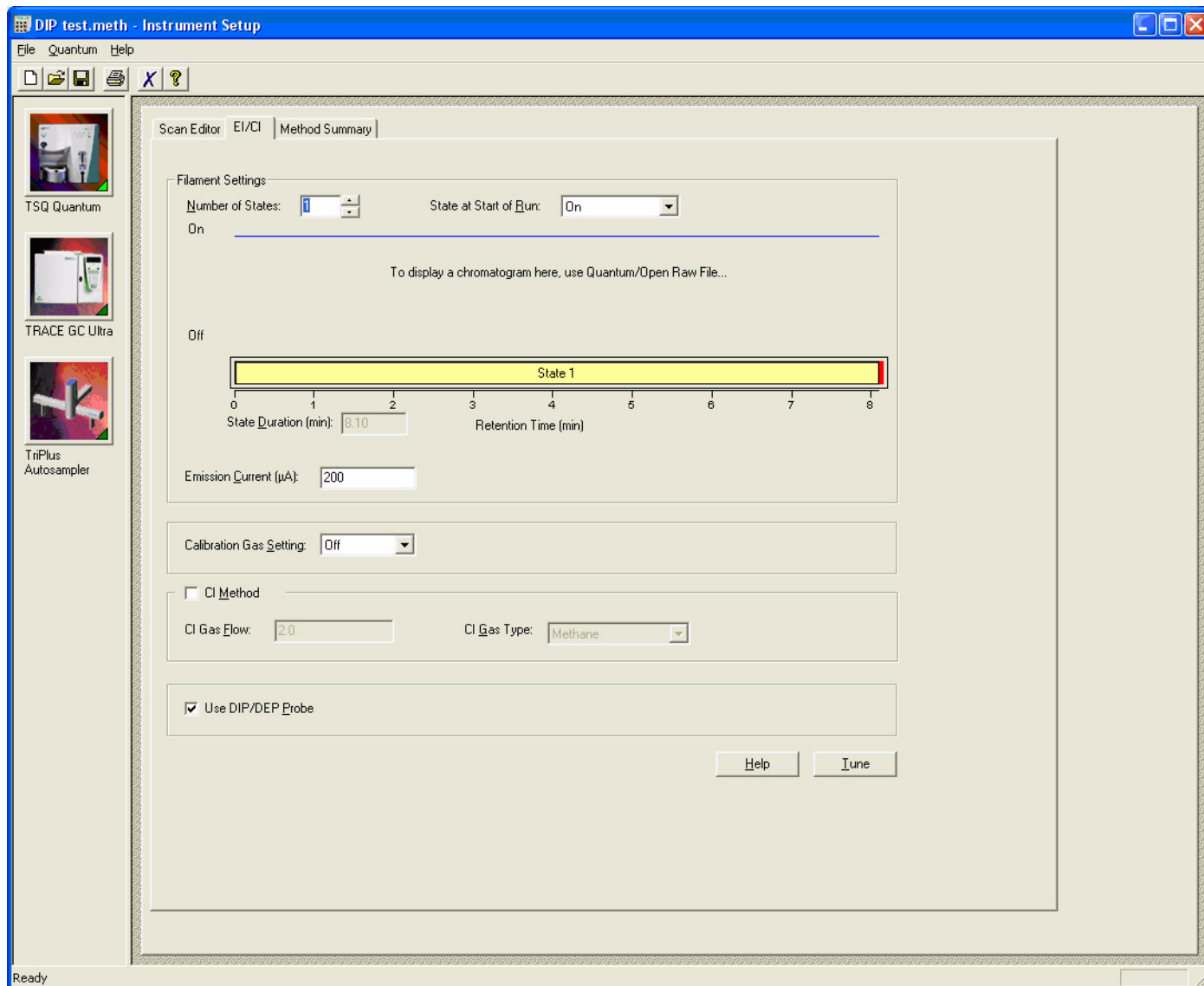
1. On the Xcalibur Home Page, click the **Instrument Setup** icon to open the Instrument Setup view. Click the **Scan Editor** tab.
2. On the Scan Editor page, create a one segment, one scan event instrument method. In this example, the segment is 8 minutes long (see [Figure 55](#)).
3. Specify the mass spectrometer settings, for this example, full-scan scan type, Q1MS scan mode, and positive polarity.

Figure 55. Scan Editor page of Instrument Setup



4. Click the **EI/CI** tab to display the EI/CI page (see [Figure 56](#)).

Figure 56. EI/CI page of Instrument Setup



5. Enter or select the following settings:

- Number of States: **1**
- State at Start of Run: **On**
- Calibration Gas Setting: **Off**
- Use DIP/DEP Probe:

This example is an EI experiment with a 200 μA emission current.

6. Save the instrument method.

- a. Choose **File > Save As** to open the Save As dialog box.

- b. Save the instrument method as a .meth file. In this example we name the instrument method **Dip test.meth**.

Creating a Sequence

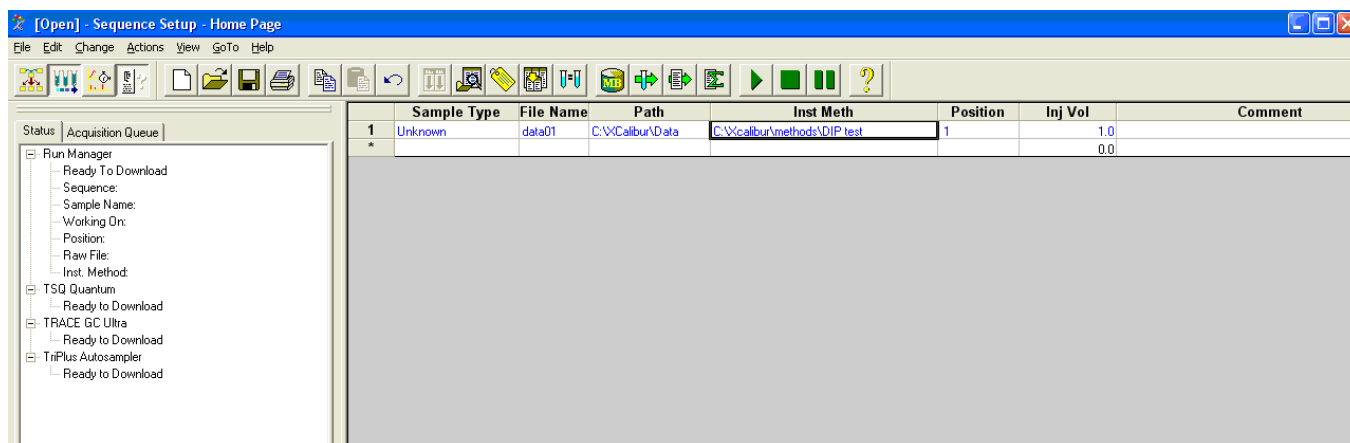
A sequence contains sample information—one sample per row. In this example the sequence has one sample.

Note If the sequence has more than one sample, Xcalibur prompts you to reload the probe after each sample.

❖ To create a sequence

1. On the Xcalibur Home Page, click the **Sequence Setup** icon to open the Sequence Setup view (see [Figure 57](#)).
2. Enter the name and path of the instrument method. In this example, it is C:\Xcalibur\methods\DIP test.
3. Enter a file name and path for the raw file that contains the acquired data. In this example, it is C:\Xcalibur\Data\data01.

Figure 57. Sequence Setup view, showing one sample in the sequence



Preparing the Probe and Inlet Valve

❖ To prepare the probe and inlet valve

1. Connect the direct sample probe controller to the mass spectrometer by contact closure with the probe start cable (P/N 70111-63627, in TSQ Quantum GC Accessory Kit).
2. Create a probe method on the controller. Refer to the probe manual. This example uses the following DIP settings:
 - Initial temperature: **50 °C**
 - Initial time: **5 s**
 - Ramp rate: **100 °C/min**
 - Final temperature: **200 °C**
 - Ramp hold time: **200 s**
3. Load sample on the probe.
4. Install the guide bar.
 - a. With the guide ball track facing left, insert the guide bar into the entry housing. See [Figure 15](#) on [page 26](#).
 - b. Push the guide bar in as far as it goes. Rotate it 90° clockwise to lock the guide bar in the entry housing.
5. Prepare the inlet valve.
 - a. Make sure the inlet valve is closed with the inlet valve lever down, as shown in [Figure 15](#) on [page 26](#).
 - b. Loosen the inlet valve knob counter-clockwise, and remove the inlet valve plug.

Preparing the Mass Spectrometer

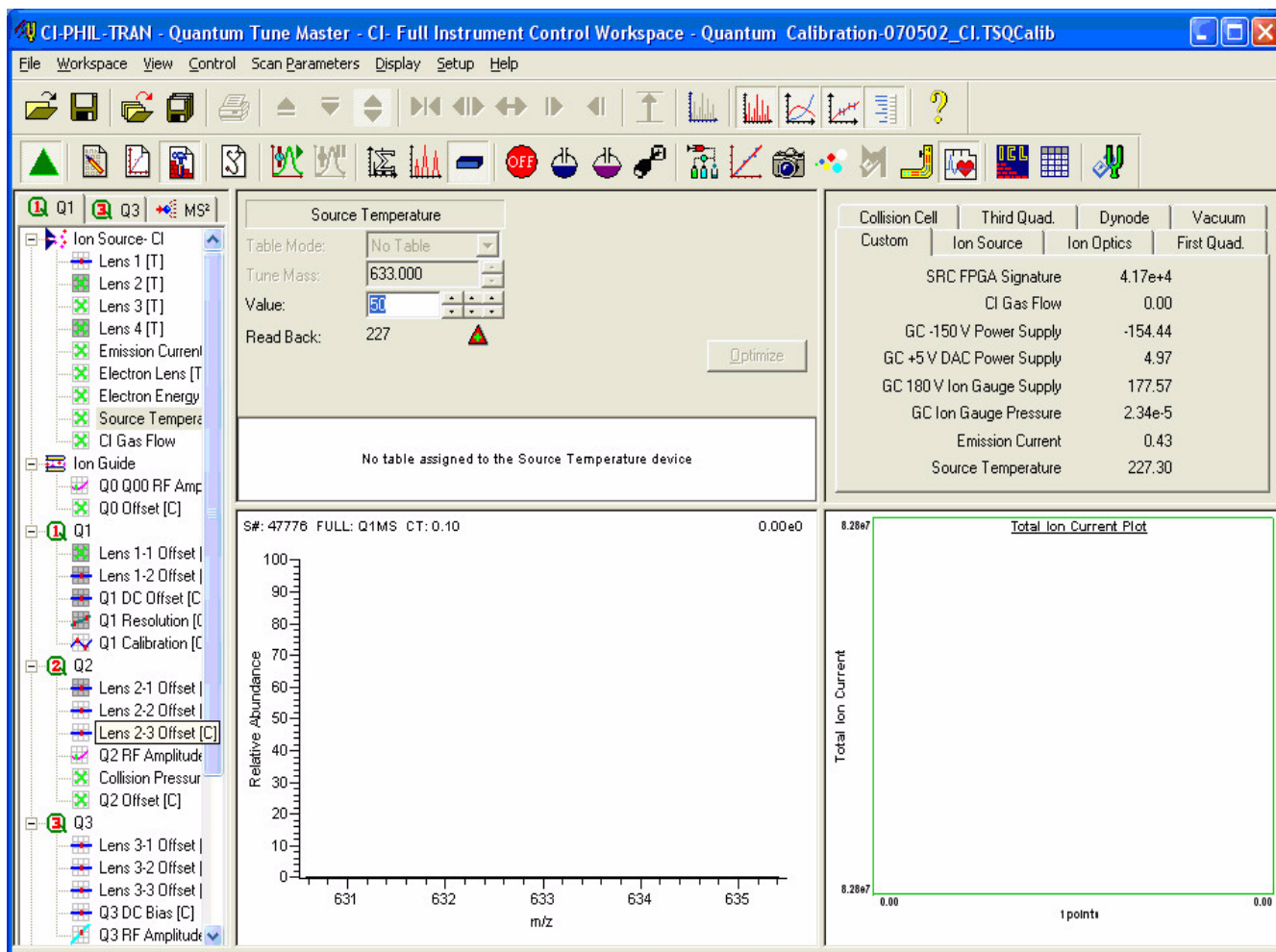
❖ To prepare the TSQ Quantum GC for the experiment

1. Choose **Start > All Programs > Xcalibur > Quantum Tune** to open the Tune Master window if it is not already open. See [Figure 58](#).

8 Using the Direct Sample Probe

Preparing the Mass Spectrometer

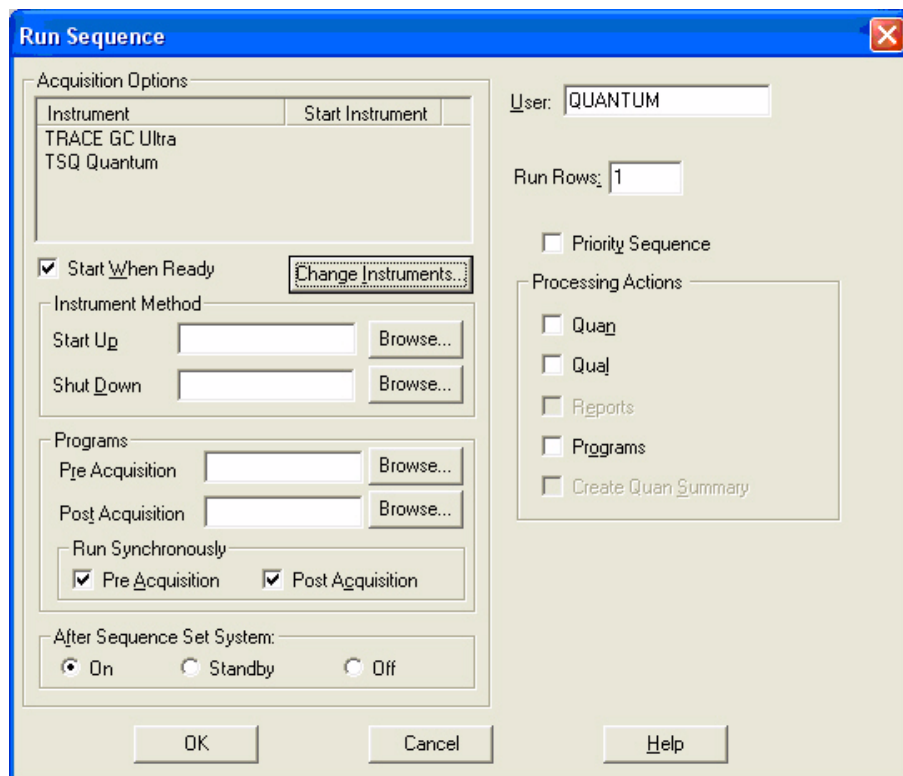
Figure 58. Quantum Tune Master view



2. Ensure that the TSQ Quantum is the only instrument in use and that there are no start instruments.

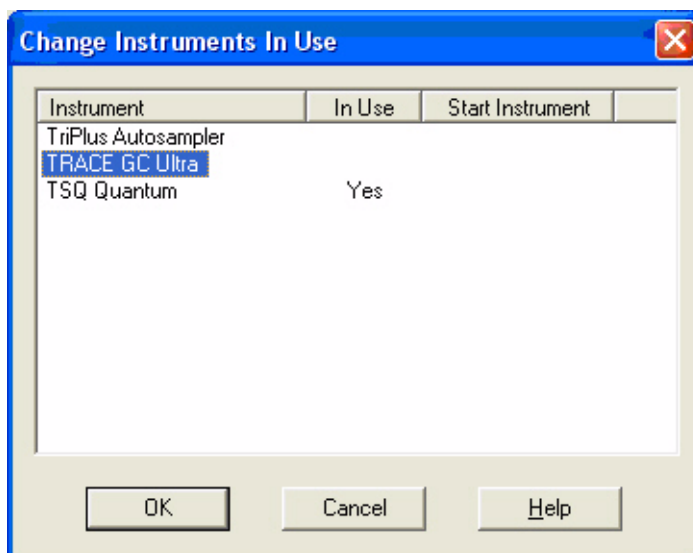
- On the Xcalibur Home Page, click the **Sequence Setup** icon to open Sequence Setup, if it is not already open.
- In Sequence Setup, choose **Actions > Run Sequence**. The Run Sequence dialog box opens (see Figure 59).

Figure 59. Run Sequence dialog box, showing instruments in use



- c. Click **Change Instruments** to open the Change Instruments In Use dialog box.

Figure 60. Change Instruments In Use dialog box, showing TSQ Quantum in use and no start instruments



- d. Click any **Yes** in the In Use column to clear all instruments other than the TSQ Quantum.

- e. Ensure that the TSQ Quantum GC has a Yes in the In Use column. Click the area if necessary.
 - f. Click any **Yes** in the Start Instrument column to clear all start instruments.
3. Click **OK** to save your settings and close the Change Instruments In Use dialog box.

Running the Sequence

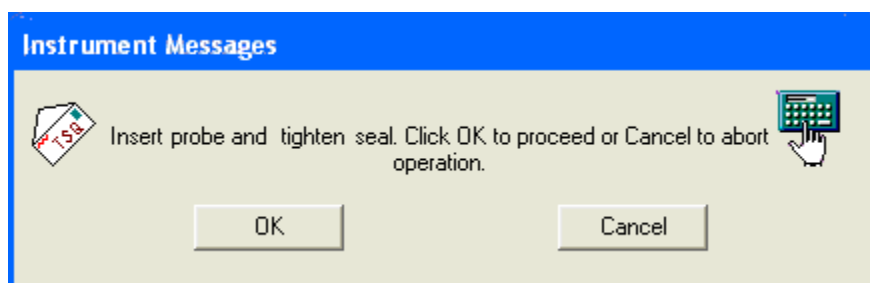
You acquire data by running the sequence. Xcalibur saves the acquired data in a raw file.

Note You must have Quantum Tune Master or QuickQuan running so that Xcalibur can display instrument methods.

❖ To run the sequence

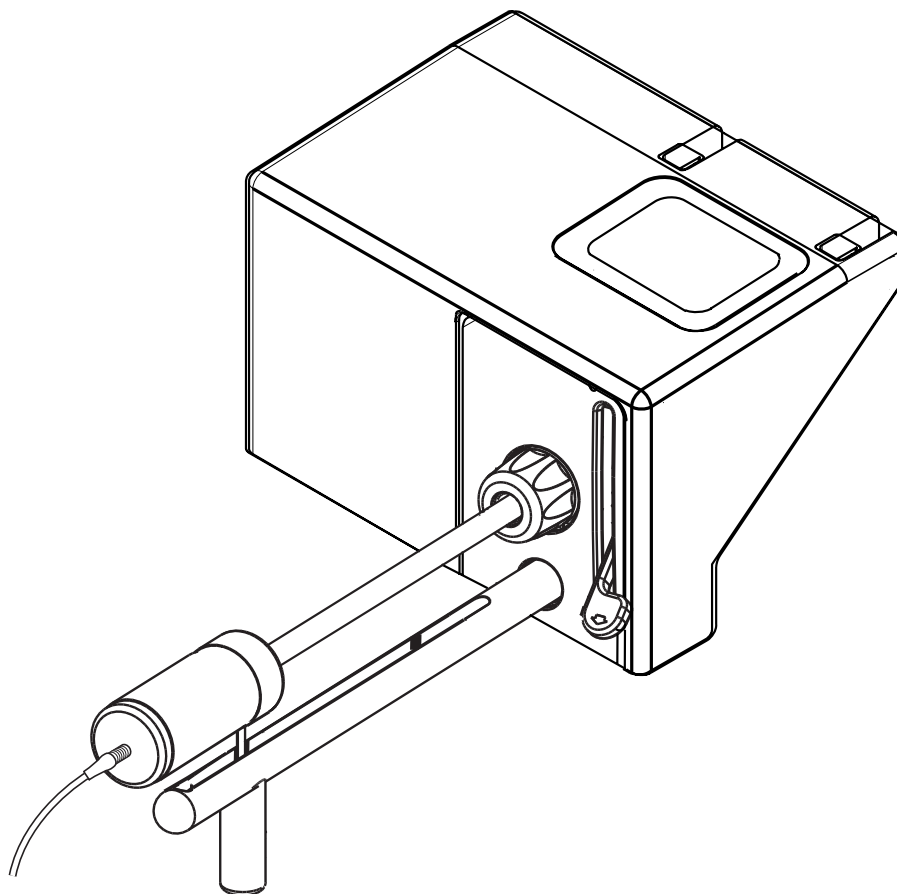
1. In the Run Sequence dialog box (see [Figure 59](#) on [page 135](#)), click **OK** to start the acquisition. Xcalibur displays the Insert Probe message.

Figure 61. Insert Probe message



2. Inset the probe into the inlet valve.
 - a. Insert the guide ball on the DIP probe into the guide ball hole on the guide bar.
 - b. Slide the probe forward into the inlet valve until the guide ball is at the guide bar's first stop. See [Figure 62](#).
 - c. Tighten the inlet valve knob clockwise to ensure a leak-tight seal.

Figure 62. Probe at the first stop on guide bar



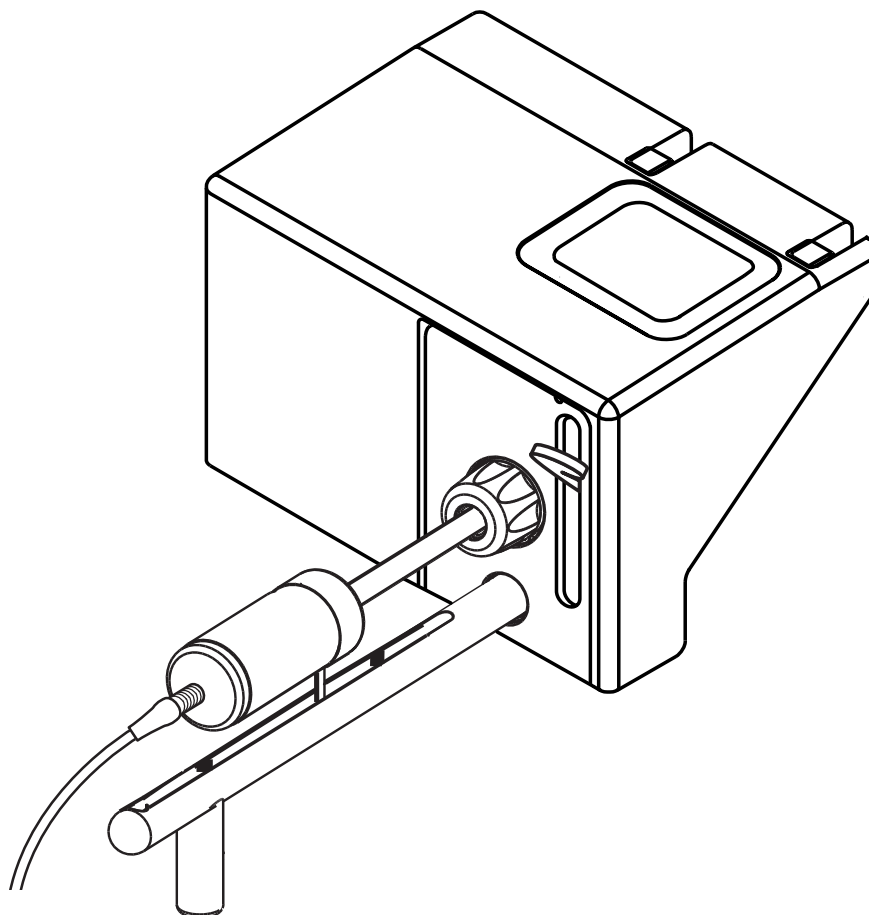
3. Click **OK**. The forepump evacuates the inlet valve.
4. When the Safe to Open Valve message appears, click **OK**.

Figure 63. Safe to Open Valve message



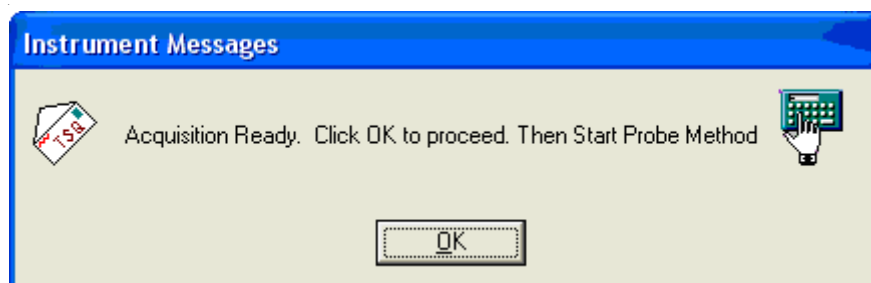
5. Pull the inlet valve lever up to open the inlet valve.
6. Slide the probe into the vacuum manifold until the tip of the probe is fully inserted into the ion volume holder. See [Figure 64](#).

Figure 64. Probe inserted into the inlet valve



7. When you receive the Acquisition Ready message, click **OK**. The Quantum GC is now waiting for contact closure.

Figure 65. Acquisition Ready message



8. In Sequence Setup, choose **View > Real Time Plot View** to display the mass spectrum and chromatogram.
9. Start the probe method from the probe controller to initiate data acquisition. See [Figure 66](#) and [Figure 67](#).

Figure 66. Perfluorotetracosane mass spectrum at 0.56 minute retention time

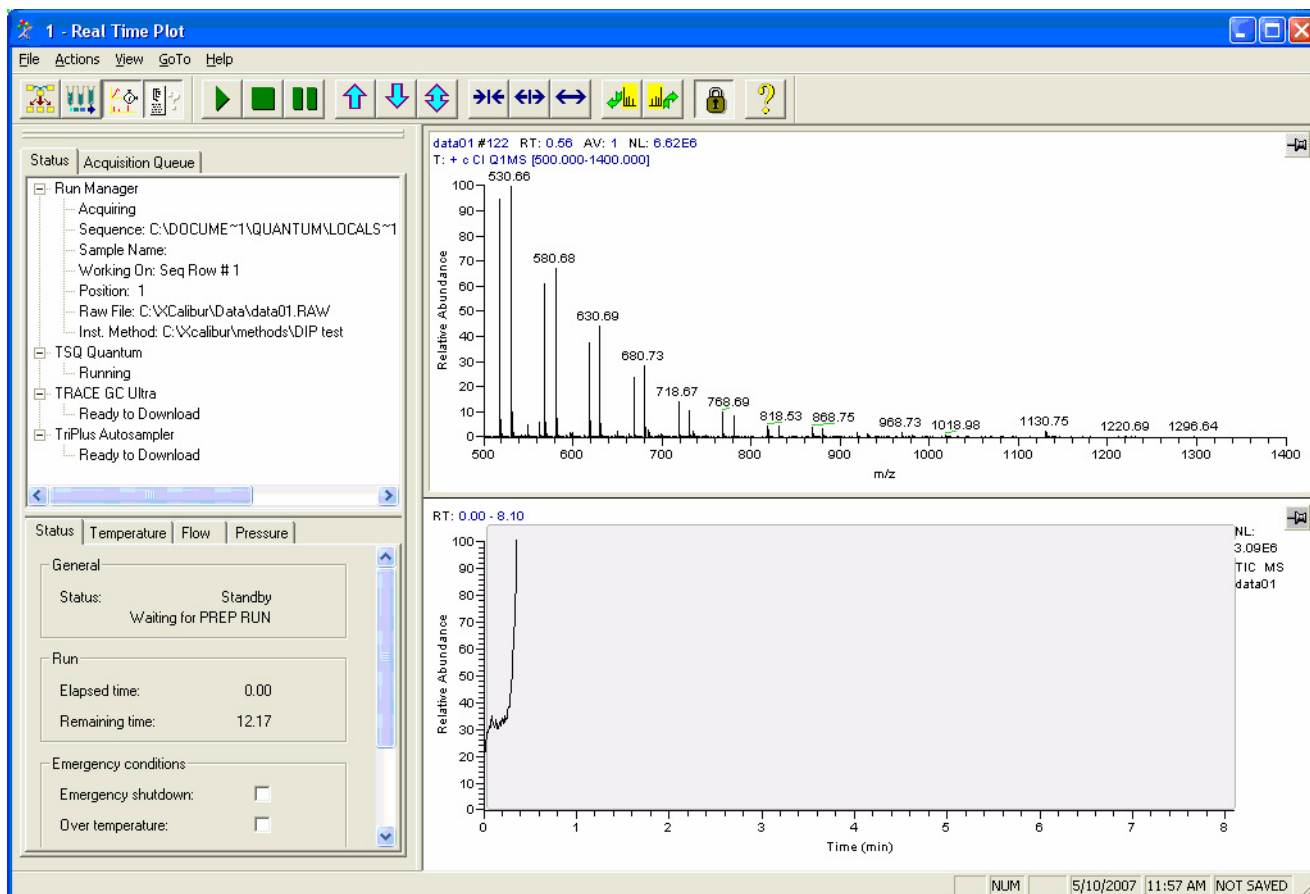
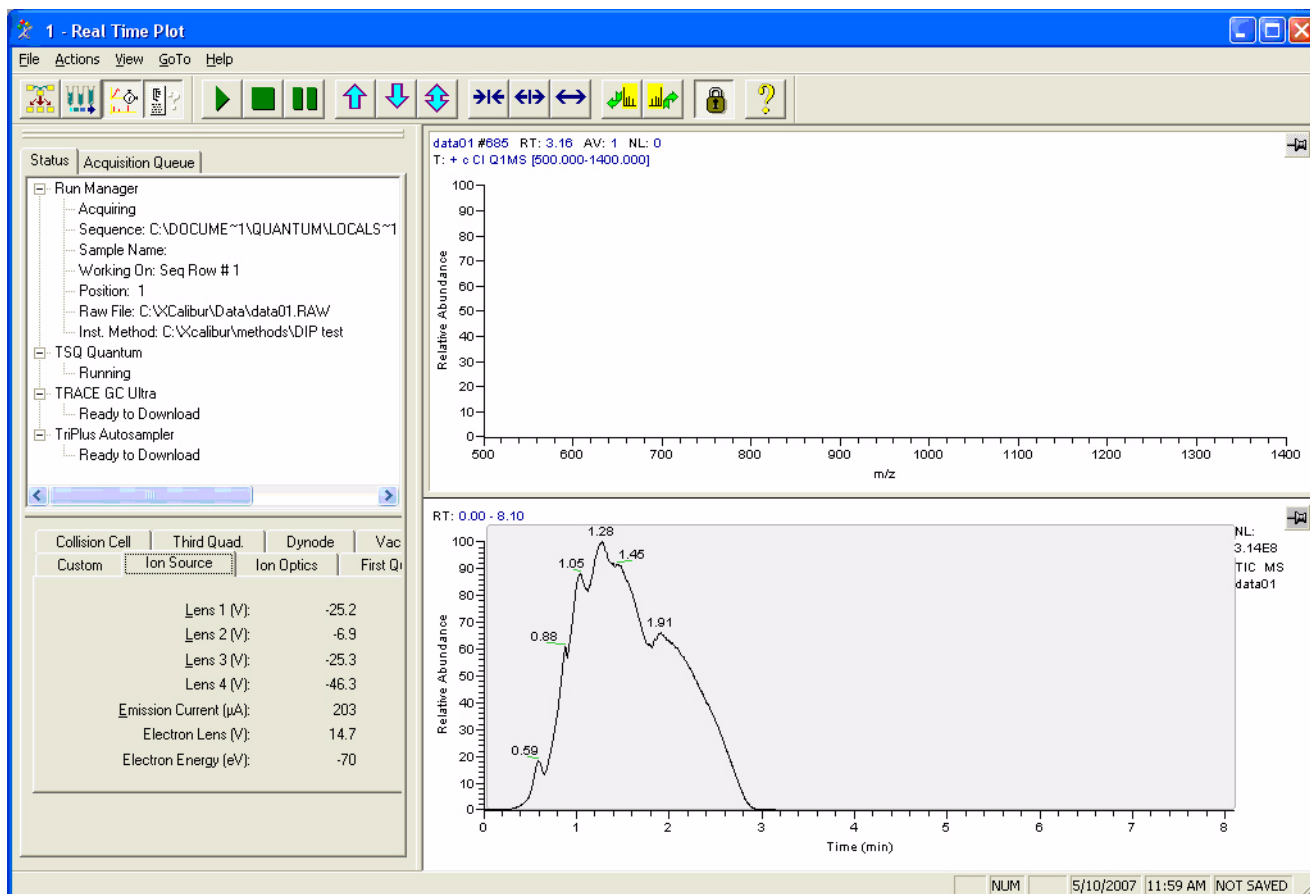


Figure 67. Perfluorotetracosane chromatogram



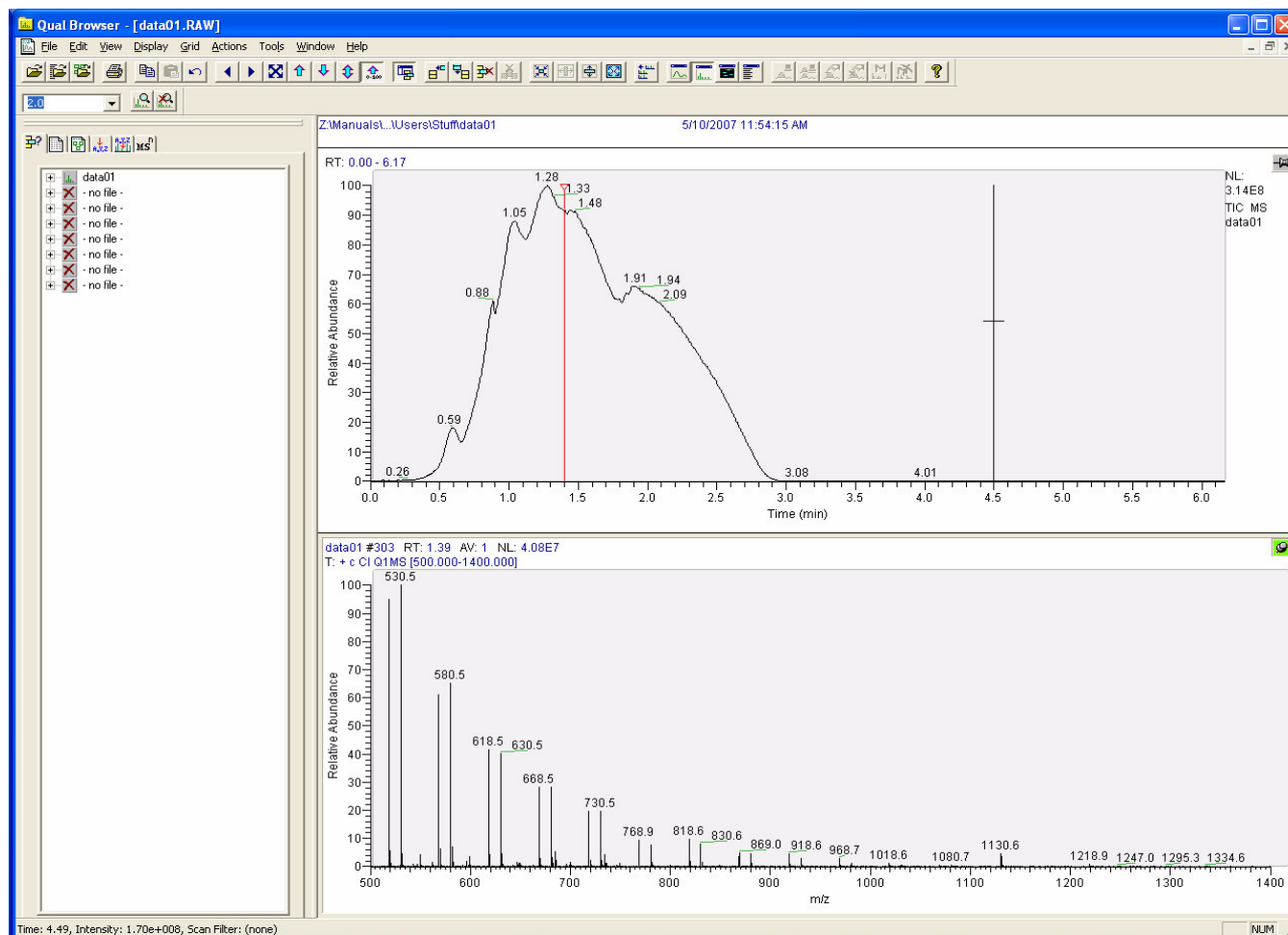
Examining the Raw Data in Qual Browser

You can use Qual Browser to display the mass spectrum at various times in the chromatogram.

❖ To examine the raw data

1. On the Xcalibur Home Page, click the **Qual Browser** icon to open the Qual Browser window.
2. Click on the chromatogram to display the mass spectrum at that retention time. See [Figure 68](#).

Figure 68. Raw file displayed in Qual Browser



Removing the Probe

❖ To remove the probe

1. Withdraw the probe until the guide ball on the probe reaches the first stop on the guide bar (Figure 62).
2. Close the inlet valve by pushing the lever down.



CAUTION Close the inlet valve first. Otherwise, the system vents to the atmosphere. Do not withdraw the probe beyond the point where the guide ball reaches the first stop in the guide bar.

3. Loosen the inlet valve knob by turning it counter-clockwise.

8 Using the Direct Sample Probe

Removing the Probe

4. Continue withdrawing the probe completely from the inlet valve by sliding it through the guide ball track in the guide bar.
5. Store the probe in its case.
6. Remove the guide bar by rotating it 90° counter-clockwise and sliding it out of the entry housing.
7. Replace the inlet valve plug and tighten the inlet valve knob clockwise to form a seal. The inlet valve plug prevents air from entering the vacuum manifold in case the inlet valve is accidentally opened. You can also remove the inlet valve lever by pulling it free.

Replaceable Parts and Consumables

This chapter contains TSQ Quantum GC part numbers for replaceable parts and consumables. To ensure proper results in servicing the Quantum GC system, order only the parts listed or their equivalent. Contact Thermo Fisher Scientific San Jose and have your TSQ Quantum GC serial number ready.

These kits with replaceable parts and consumables are available for the TSQ Quantum GC:

Contents

- [Accessory Kit](#)
- [Chemicals Kit](#)

Accessory Kit

Table 7. TSQ Quantum GC Accessory Kit (P/N 70111-62077) (Sheet 1 of 2)

Description	Function	Part Number
Fitting, ferrule, SWG, 1/8-in., brass, set		00101-08-00009
Fitting, connection, 1/4 to 1/8-in.		00101-01709
Fitting, connection, 1/4 to 1/8-in.		00101-01712
Fitting, ferrule, SWG, front, 3/8-in., brass		00101-11500
Ferrule, 0.4mm ID × 1/16		00101-18100
Restek [®] capillary-grade hydrocarbon trap	For removing hydrocarbons from the GC carrier gas	00106-99-00001
Restek high-capacity oxygen trap	For removing oxygen from the GC carrier gas	00106-99-00002
Cotton swabs	For applying cleaning paste to stainless steel parts	00301-01-00015
Tubing, 1/8-in., copper, pre-cleaned	Gas lines	00301-22701
Ball valve seal kit (replacement)	For replacing the ball valve seal in the inlet valve	119265-0003
Lens alignment tool	For aligning ion source lenses 1, 2, and 3	120271-0001

9 Replaceable Parts and Consumables

Chemicals Kit

Table 7. TSQ Quantum GC Accessory Kit (P/N 70111-62077) (Sheet 2 of 2)

Description	Function	Part Number
Filament assembly	For replacing a failed filament in the ion source	120320-0030
Nitrile gloves medium	For handling clean parts that are under vacuum	23827-0008
Nitrile gloves large	For handling clean parts that are under vacuum	23827-0009
Syringe, 10 uL, 80mm	For adding calibration compound	36502019
Tee union, 1/8-in.		00101-01-00012
Cable, start, probe	Contact closure cable between the direct sample probe and the mass spectrometer	70111-63627
Cable, start, GC	Contact closure cable between the GC and the mass spectrometer	70111-63626
Forceps, 10-in., stainless steel	For handling ion volumes and clean components	76360-0400
Cable, 10 base-T, crossover, 15-ft, shielded		76396-0052

Chemicals Kit

Table 8. TSQ Quantum GC Chemicals Kit (P/N 70111-62078)

Description	Function	Part Number
Perfluorotributylamine (FC-43)	Tuning and calibration compound	50010-02500
Aluminum Oxide	Cleaning stainless steel parts	32000-60340
Benzohexane	Performance testing	120150-TEST
Octafluoronaphthalene	Performance testing	120150-TEST

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