Operating Manual
PlasmaQuant MS product family
Inductively Coupled Plasma Mass Spectrometer (ICP-MS)
### General information

For a proper and safe use of this product follow the instructions. Keep the operating manual for future reference.

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### Implementation of the Technical Documentation

Analytik Jena AG

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1 Basic information

1.1 User manual notes

The user manual describes the following spectrometers of the PlasmaQuant series:
- PlasmaQuant MS
- PlasmaQuant MS Q
- PlasmaQuant MS Elite S
- PlasmaQuant MS Elite

In the text below these devices are collectively called PlasmaQuant MS. Differences in the devices concerning the analytical performance are detailed in the section 8.

The user manual informs about the design and function of the PlasmaQuant MS and provides the necessary know-how for the safe handling of the device and its components. The user manual includes additional notes on the maintenance and service of the equipment and potential causes and remedies of any faults.

Conventions

Instructions for actions which occur in chronological order are numbered and combined in action units.

Safety notes are indicated by pictographs and signal words. The type and source of the danger are stated together with notes on preventing the danger.

The elements of AStect MS software are indicated as follows:
- Program terms are identified with SMALL CAPS (e.g., Menu FILE).
- Buttons are shown by square brackets (e.g., [OK] button)
- Menu items are separated by arrows (e.g., FILE  OPEN).

Symbols and signal words

The user manual uses the following symbols and signal words to indicate hazards or instructions. The safety instructions are always placed before an action.

WARNING
Indicates a potentially hazardous situation which might cause fatal or very serious injuries (deformities).

CAUTION
Indicates a potentially hazardous situation which might cause light or minor injuries.

NOTICE
Provides indications of potential material and environmental damage.
1.2 Intended use

Inductively Coupled Plasma Mass Spectrometry (ICP-MS) is a powerful technique for elemental and isotopic analysis that combines the efficiency and ease of use of the inductively coupled plasma (ICP) with the sensitivity and selectivity of mass spectrometry (MS).

The ICP mass spectrometer (ICP-MS) is typically used in an analytical laboratory for the analysis of liquid – mainly aqueous – samples to determine the concentrations of up to 75 elements from major to ultra-trace levels. Coupling of hyphenated technologies like Laser Ablation for solid samples or liquid chromatography are possible as well.

The PlasmaQuant MS may only be used for the measurements described in this user manual. The license is limited to applications outside of in vitro diagnostics. The operator is exclusively liable for damages as a result of improper use.

Special provisions have to be taken for the analysis of hydrofluoric acid and organics:

- For hydrofluoric acid, we recommend the HF kit.
- For organics we recommend the organics or volatile organics kit.

In addition, for organic solvents fire and health protection must be observed.
2 Safety instructions

2.1 General notes

For your own safety and to ensure error-free and safe operation of the PlasmaQuant MS, please read this chapter carefully before using the instrument.

Observe all safety notes listed in this user manual and all messages and notes displayed by the ASpect MS software.

The safety instructions given in the following chapters were taken from a risk assessment. When handling the device there are certain residual risks which cannot be further minimized by design measures. Some of these risks are subject to external factors.

Besides the safety instructions in this user manual and the local safety regulations that apply to the operation of the device, the general applicable regulations regarding accident prevention, occupational health and safety and environmental protection have to be observed and complied with.

References to potential dangers do not replace the work protection regulations which must be observed.

2.2 Safety markings on the PlasmaQuant MS

Warnings and notice symbols have been attached to the PlasmaQuant MS which must always be observed.

Damaged or missing warning and notice symbols can cause incorrect actions leading to personal injury or hardware damage! The symbol labels must not be removed! Damaged symbol labels must be replaced immediately!
The following safety markings are attached to the PlasmaQuant MS:

On the rear side:

<table>
<thead>
<tr>
<th>WARNING! Use only hydrogen and/or helium.</th>
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<tbody>
<tr>
<td>Do NOT connect air, oxygen, or any oxidizing gas or gas mix.</td>
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</table>

<table>
<thead>
<tr>
<th>WARNING! Shock Hazard</th>
</tr>
</thead>
<tbody>
<tr>
<td>High voltages inside</td>
</tr>
<tr>
<td>No user-serviceable parts under covers.</td>
</tr>
<tr>
<td>Contact your Analytik Jena Representative for instrument repair and service.</td>
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</table>

<table>
<thead>
<tr>
<th>Warning of flammable substances</th>
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<tr>
<td>(at hydrogen connection)</td>
</tr>
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</table>

On the side wall:

| To prevent damage to the skin and eyes by UV radiation, NEVER look directly at the plasma. |

---

### 2.3 Requirements for operating personnel

The PlasmaQuant MS must only be operated by qualified personnel instructed in the use of the device. The instruction must also include conveying the content of this user manual and the user manuals of other system components (for example, the fore-line roughing pump).

In addition to the safety at work instructions in this user manual, the generally applicable safety and accident prevention regulations of the respective country of operation must be observed and adhered to. The operator must ascertain the latest version of these regulations.

The user manual must be accessible to the operating and service personnel at all times!

### 2.4 Safety instructions, transport and commissioning

Observe the following notes:

- The PlasmaQuant MS is always installed by the service engineers of Analytik Jena or an authorized and trained representative. Independent assembly and installation is not permitted. Incorrect installation can create serious hazards.

- The device weighs 186 kg. Use a lift truck to transport the device.

- Four people are required to move the device in the laboratory by holding the device on four firmly screwed-in carrying handles.
The device may only be placed on surfaces, such as desks, which were designed to bear the specific load of the device.

The device must not be placed on an uneven or inclined surface to avoid tipping over.

The instrument should never be moved or hit while the vacuum system is running.

2.5 Safety instructions - operation

2.5.1 General

Observe the following notes:

- The operator of the PlasmaQuant MS must make sure before each commissioning that the condition of the device, including its safety equipment, is sound.

- Modifications, conversions and extensions to the device are only permitted after consultation with Analytik Jena. Any unauthorized modifications can jeopardize the device's operational safety and may lead to limitations regarding the warranty and access to customer service.

- The device may only be operated if all protective equipment (e.g., interlocks and covers) are in place, properly installed and fully operational. The sound condition of the protection and safety equipment must be checked regularly. Any defects must be corrected as soon as they occur. Protective and safety equipment must never be removed, modified or decommissioned during operation.

- During operation, free access to gas and water connections, the standby switch on the front, the circuit breaker on the rear side of the device, and to the plasma off button on the right side of the device, must always be ensured.

- The ventilation equipment on the device must be in good working condition. Covered vents or ventilation slits etc. may cause the device to break down or may cause damage to it.

- To insure the instrument’s safe and long-term use, never operate the plasma unless both interface cones are installed. To prevent damage to the turbo pumps, do not vent the vacuum system or open the gate valve unless both cones are installed.

- For organic solvents, explosion protection must be observed. If the spray chamber drain is not pumped properly, the excess flammable solvents in the spray chamber may ignite and become explosive. If the torch clogs, the increased pressure in the sample introduction system may cause the spray chamber cap to blow off exposing the solvent to ignition.

- Caution when handing quartz glass and glass parts. Risk of broken glass and therefore risk of injury!

- Prevent any liquids, e.g. condensate, from entering the inside of the instrument. The liquids might get into contact with electronic components and cause a short circuit. Ensure uninterrupted air conditioning at high humidity, even during operating pauses.

- There is a risk of your hand being crushed in the peristaltic pump. Do not wear long loose hair or loose-fitting clothes as they can get caught in the peristaltic pump.
Safety instructions

- Danger of frostbite. The spray chamber and the inner parts of the thermostated holder assembly may be very cold (≥ -15 °C). Do not touch these parts in normal operation and directly after operation.

2.5.2 Safety instructions relating to ambient conditions

Explosion protection
- The PlasmaQuant MS must not be operated in explosion-hazard areas. Smoking or open flames in the operating room of the PlasmaQuant MS are prohibited! Keep all combustible materials away from the device.

2.5.3 Safety instructions - electrical equipment

Work on electrical components of the PlasmaQuant MS may only be performed by a qualified electrical technician according to applicable electro-technical regulations. Lethal voltages may occur in the device! Contact with live components may cause death, serious injury or painful electrical shock.

Observe the following notes:
- The mains plug must be connected to a proper CEE power socket to ensure that the device meets protection class I (ground connector). It may only be connected to power sources whose nominal voltage is the same as that specified on the type plate of the equipment. The protective effect must not be invalidated by the use of an extension line which does not have a protective conductor (→ section "Power supply" p. 32). Never use power cords with faulty or frayed insulation.
- The following applies to the installation of the device in North America: When using the power cable with a NRTL compliant connector, the type of connection changes to "detachable cordset".
- The PlasmaQuant MS and its system components must always be switched off before being connected to the mains.
- Any work on the electronics (within the device enclosure) may only be carried out by the customer service of Analytik Jena or by a qualified technician authorized by Analytik Jena.
- Before opening the device and for any work on the electronics of the device, use the circuit breaker on the rear panel to switch the device off. Disconnect the power plug from the power socket.

2.5.4 Hazards caused by plasma operation

Plasma is extremely hot (> 6,000 K) and emits electromagnetic and UV radiation. The induction coil is operated with 300 V RMS (and even higher at ignition) and 27 MHz. High-frequency radiation and UV radiation can cause serious injuries to skin and eyes. Contact with the torch (plasma torch) shortly after operation will cause skin burns. An electrical discharge may also occur and cause fatal injuries, electrical shock and skin injuries.

Shielding around the plasma compartment is designed to reduce UV, visible, and RF radiation to safe levels while still permitting easy access to the torch when maintenance is required.
The PlasmaQuant MS has an interlock system which is designed to extinguish the plasma if either the plasma compartment lid or the interface door is opened. The device will also extinguish the plasma when the flow rate of the cooling water or of the argon gas and the extraction output drop below the required minimum.

Nevertheless, this device can potentially affect pacemaker function. If you have a pacemaker or similar implanted device, consult your physician before using this device.

Observe the following notes:

- Do not attempt to bypass the interlock system.

To ensure safe torch operation, you must not ignite the plasma unless the following conditions are met:

- The inner plasma compartment lid and interface door are closed and latched.
- The torch is in working position.
- Sufficient water flow is provided.
- Argon flow is adequate.
- The exhaust unit is switched on. The extraction output is within the range specified in section "Exhaust unit" (p. 34).

The above mentioned components are backed up by several interlocks. Unless the reliable functioning of these components is guaranteed, the plasma will not be ignited or it will be extinguished automatically if a component reports a malfunction.

- The viewing window and the UV shield incorporated into the instrument RF enclosure enables you to view the plasma and operate the instrument without being exposed to unsafe levels of UV radiation. Never violate the interlocks.
- Before opening the plasma compartment lid or interface door, always extinguish the plasma from the software.
- There are two ports for sample introduction on the front and on the right-side of the instrument. Do not look through these openings directly into the plasma.
- Allow the torch, cones, coils, interface, and torch compartment to cool before carrying out any work in this area, or wear heat-resistant gloves.

2.5.5 Behavior in case of ring plasmas

In the following situations, press the orange plasma off button (on the right side of the instrument) immediately to prevent the torch from melting:

- The plasma produces loud noises (crackles).
- The shape of the plasma changes considerably and a bright ring is visible on the inside of the coil.
- Torch parts begin to glow.

In the pre-ignition phase, a light pink discharge is normal.
2.5.6 Safety instructions relating to the formation of ozone and toxic vapors

The interaction between the UV radiation from the plasma and the surrounding air results in the formation of a high concentration of toxic gases such as ozone and nitrogen oxides.

Observe the following notes:
- The PlasmaQuant MS may only be operated with an active exhaust unit.
- The exhaust unit must be switched on before igniting the plasma.

2.5.7 Safety instructions relating to compressed gas containers and systems

The principal gas used by the PlasmaQuant MS is argon. The only gases to be used in the integrated Collision Reaction Cell (iCRC) are hydrogen and helium. The PlasmaQuant MS is also fitted with N₂ or O₂ connections for the Nitrox option. Do not connect any other gases than those specified to the correct inlet fittings.

Observe the following notes:
- Gases are taken from compressed gas cylinders or local liquid gas systems. The required purity of the gases must be ensured.
- Work on compressed gas cylinders and systems must only be carried out by individuals with specialist knowledge and experience in compressed gas systems.
- For compressed gas operation, the safety instructions and guidelines which are valid at the operating location must be strictly complied with.
- Cylinders must be used and stored only in a vertical position and secured to an immovable structure or a properly constructed cylinder stand. Move cylinders only by securing them to a properly constructed cart.
- High pressure hoses and pressure reducers may only be used for the assigned gases.
- All pipes, hoses and screw connections must be checked weekly for leaks and externally visible damage. Possible pressure losses from closed systems and lines under pressure must be determined. Leaks and damages must be repaired immediately.
- Any leak (except that of air or oxygen) can result in an oxygen-deficient atmosphere which can cause asphyxiation. The area in which cylinders are stored and the area surrounding the instrument must be adequately ventilated to prevent such gas accumulations.
- The gas supply must be closed prior to servicing and repairs.
- After successful repair and servicing of components of the compressed gas containers or system, the device must be checked for sound operation prior to recommissioning.

Hydrogen Safety

PlasmaQuant MS instruments may be used with hydrogen gas in the iCRC system. Appropriate safety precautions must be taken, as Hydrogen is combustible over a wide range of concentrations. A hydrogen fire may be invisible under bright ambient light. The temperature increases with gas expansion, and if it is allowed to expand rapidly from high pressure, hydrogen gas can self-ignite.
Observe the following notes:

- Instead of using pressurized gas cylinders as a source of hydrogen, consider using a hydrogen gas generator. These devices only produce the required amount of hydrogen. There is no storage of hydrogen gas when the system is not being used.
- In the case of an accident hydrogen gas may escape into the laboratory atmosphere. Always ensure the exhaust unit is active when hydrogen gas is used.
- In the event of a power failure, hydrogen gas may continue to flow from the supply even if the PlasmaQuant MS is completely off. Always manually shut off the hydrogen gas supply valve when there is no power to the PlasmaQuant MS. In general, shut off the hydrogen gas supply when you are not using the iCRC.

Oxygen Safety

Oxygen gas is a powerful oxidizer which will rapidly accelerate combustion of many materials. Oxygen cylinders should be handled with care because serious explosions can result from contact between oil and high pressure oxygen.

Observe the following notes:

- Oil or grease should never be used on connections to oxygen cylinder or gas line carrying oxygen.
- Oxygen is incompatible with all flammable materials and should be stored separately.

2.5.8 Handling of samples, auxiliary and operating materials

Observe the following notes:

- The operator is responsible for the selection of substances used in the process as well as for their safe handling. This is particularly important for radioactive, infectious, poisonous, corrosive, combustible, explosive and otherwise dangerous substances.
- When handling dangerous substances, local safety codes and guidelines must be observed.
- Warnings on labels must always be observed. Only use clearly marked containers as well as protective goggles and rubber gloves. Use suitable body protection (coat, safety glasses and rubber gloves) when handling samples. Ensure sufficient ventilation.
- Cleaning with hydrofluoric acid must be carried out in a fume hood. When handling hydrofluoric acid, rubber aprons, gloves and face masks must be worn.
- Biological samples must be handled according to local guidelines regarding the handling of infectious material.
- When measuring materials containing cyanide, make sure prussic acid cannot be generated in the waste container, i.e., the waste solution must not be acidic.
- Ensure that all residue liquid from the nebulizer and the autosampler is directed into a waste container.
- The operator is responsible for ensuring that waste materials such as residue liquid from the waste container are disposed of in an environmentally responsible manner and according to local regulations.
Examples of dangerous organic solvents:

<table>
<thead>
<tr>
<th>Solvent</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methyl isobutyl ketone (MIBK)</td>
<td>Flammable, highly volatile, noxious-smelling</td>
</tr>
<tr>
<td>Toluene</td>
<td>Flammable, hazardous to health</td>
</tr>
<tr>
<td>Kerosene</td>
<td>Flammable, hazardous to the aquatic environment, hazardous to health</td>
</tr>
<tr>
<td>Methanol, ethanol, propanol</td>
<td>Flammable, partly acutely toxic</td>
</tr>
<tr>
<td>Tetrahydrofuran (THF)</td>
<td>Flammable, hazardous to health, extremely volatile, dissolves polyethylene and polystyrene</td>
</tr>
</tbody>
</table>

This list is incomplete insofar, that other solvents could be considered for use with the ICP-MS. In cases of uncertainty about an unknown liquid, this may only be used when the manufacturer has confirmed that there is no danger to safety.

### 2.5.9 Safety instructions relating to cleaning and decontamination measures

Observe the following notes:

- The operator is responsible for carrying out suitable decontamination should the device be contaminated externally or internally with dangerous substances.
- Spots, drops or larger spillages should be removed and cleaned up using water and an absorbent material such as cotton wool, laboratory wipes or cellulose. The affected areas must then be wiped with a disinfectant (e.g. Incidin Plus solution).
- Before using a cleaning or decontamination procedure other than that prescribed, check that the intended procedure will not damage the device.

### 2.6 Behavior during emergencies

Observe the following notes:

- During an emergency, if there is no immediate danger of injury, you must extinguish the plasma immediately by using the plasma off button. This is the orange button on the right side of the instrument.
- If possible, switch off the device at the circuit breaker at the rear of the instrument after allowing a cooling down period of 30 s. Then disconnect the mains plugs of the device and the system components from their power sockets.
- Close the gas supply as soon as possible after switching off the devices.
2.7 Safety instructions - maintenance and repair

Observe the following notes:

- The PlasmaQuant MS is always serviced by the service engineers of Analytik Jena or an authorized and trained representative. Otherwise the warranty is void. The operator may only carry out the tasks listed in the chapter "Maintenance and care".

- The exterior of the PlasmaQuant MS may only be cleaned with a damp cloth. Use only water and, if required, commercial surfactant. Do not use organic solvents or abrasive cleaners.

- Carefully close the interface door and the plasma compartment lid after maintenance. There is a risk of your hand being crushed.

- If water or other liquids are found to leak out of the instrument, contact the service engineers.

- Risk of damage to health due to improper decontamination! Perform a professional and documented decontamination of the device before returning it to Analytik Jena. The decontamination protocol is provided by the service when the return is registered. Analytik Jena must refuse acceptance of contaminated devices. The sender may be liable for any damage caused by inadequate decontamination of the device.

- Use only original spare parts, wear parts and consumables. They have been tested and ensure safe operation. Glass parts are wear parts and are not subject to the warranty.
3 Function and setup of the PlasmaQuant MS

3.1 Physical principle of ICP-MS

Inductively coupled plasma mass spectrometry (ICP-MS) is a powerful technique for elemental and isotopic analysis that combines the efficiency and ease of use of the inductively coupled plasma (ICP) with the sensitivity and selectivity of mass spectrometry (MS).

The inductively coupled plasma (ICP) used in analytical spectrometry is an atmospheric-pressure plasma, generated in argon gas flowing through a specially designed torch. Energy transfers into the plasma by inductive coupling of the plasma electrons and ions within the magnetic field of a radio-frequency coil.

Inductively coupled plasma offers an advantage over chemical flames with its much higher temperature. Samples introduced into the ICP heat to more than 6 000 K. This high temperature is focused on a very small area of approx. 5 cm². The sample is introduced to the plasma in the form of aerosol (small droplets in a gas). The droplets typically decompose, vaporize, atomize and ionize very quickly and effectively.

The inductively coupled plasma has been used commercially as an atomization and excitation source for optical emission spectrometry for over 30 years. Many of the most intense lines in ICP optical emission spectra are produced by singly-charged ions; therefore the ICP makes an efficient ion source for mass spectrometry. In ICP nearly all the metals are over 90 % ionized. Even elements with relatively high ionization potentials (such as P, As, Hg and I) are over 20 % ionized.

The ICP ion source operates at atmospheric pressure (ca. 1 bar), while the mass spectrometer operates at a very low pressure (ca. 7 x 10⁻⁵ mbar). Efficient transfer of ions from the ICP to the mass spectrometer is therefore a major challenge, complicated by the fact that the plasma is at very high temperatures and by the high power radio frequency currents present in the plasma.

In the PlasmaQuant MS an ionized sample is extracted from the plasma through two interface cones into the mass spectrometer. The pressure is reduced gradually in three stages by differential pumping. The PlasmaQuant MS uses the ReflexION, a 3D focusing, 90-degree ion mirror, to focus ions into the mass analyzer. The ion optics allows elimination of neutrals, photons, droplets and solids that would otherwise produce high background signals and would contaminate the mass analyzer.

The quadrupole mass spectrometer separates ions of a specific mass to charge ratio. In the PlasmaQuant MS patented self-cleaning curved fringe rods are mounted in front of the mass analyzer. These pre-filters cause the ions to follow a curved trajectory shielding the quadrupole from excited neutrals. The all-digital (AD) Detector, a Discrete Dynode Electron Multiplier with eleven orders of dynamic range, records ions after they exit the mass spectrometer.
3.2 Setup of the PlasmaQuant MS

Essentially the PlasmaQuant MS consists of the following components:

- Sample introduction system with peristaltic pump, nebulizer, spray chamber and torch
- Plasma compartment with plasma generation and interference management
- Mass spectrometer compartment with ion optics, mass analyzer and detector

Devices with the Adaptive Mass Range (AMR) upgrade option have a limited isotope separation for ions of an atomic mass of more than 230 amu (atomic mass units) as stipulated by the applicable export regulations. The resolution of the atomic mass > 230 amu is > 2 amu.

Fig. 2 PlasmaQuant MS – Front view with major components
### 3.2.1 Sample introduction system

The sample introduction system is freely accessible in the sampling compartment.

The PlasmaQuant MS uses a four-channel variable-speed peristaltic pump to deliver solution to the nebulizer and to drain waste from the spray chamber. One of these channels can be used to pump an Internal Standard, so that it is added online to every sample and standard.

A nebulizer is used to convert a liquid sample into a fine aerosol, which is introduced into the spray chamber, where larger drops are eliminated. A Micromist concentric glass nebulizer is supplied as standard with the PlasmaQuant MS. The nebulizer is suitable for the routine analysis of most aqueous and organic samples. It produces a free aspiration rate of 400 µL/min for a nebulizer gas flow of 1 L/min at a 2 bar pressure.

The PlasmaQuant MS uses a Peltier-cooled spray chamber. The spray chamber is a Scott type double pass glass design and is encased in a thermostated and insulated holder assembly. Keeping the spray chamber cool increases temperature stability and reduces water and solvent vapor. Reduced vapor limits the formation of oxides and other interferences. The spray chamber and holder assembly are supported on a mounting arm attached to the outer side wall of the PlasmaQuant MS that can be swung outwards for installation and maintenance.

The PlasmaQuant MS uses a glass transfer tube to channel the aerosol from the spray chamber into the injector of the torch.

The transfer tube for optional aerosol dilution has a gas port through which the sheath gas is introduced. High-matrix samples, e.g. sea water, can then be diluted in the sample introduction system. By adapting the nebulizer and sheath gas flows from the software, the dilution can be variated to reduce matrix effects inline. Sample preparation time is reduced to a minimum.

![Sample introduction system in the PlasmaQuant MS](image)

**Fig. 3 Sample introduction system in the PlasmaQuant MS**

1. Spray chamber
2. Thermostated holder assembly
3. Peristaltic pump
4. Nebulizer
5. Transfer tube (to the torch)
6. Glassware clamp
Plasma Torch

The torch sits inside the plasma compartment of the spectrometer and can be seen (when in operation) through the plasma viewing window. The torch compartment is heavily shielded to prevent emission of stray RF energy and UV light.

The following types of torch are available for use with the PlasmaQuant MS:

- A standard one-piece torch with 2.4 mm injector, suitable for most applications
- An optional semi-demountable torch with platinum or sapphire injector, recommended for ultra-trace detection limits or for use with hydrofluoric acid and fusion samples
- A torch with 1.5 mm or optional 0.8 mm injector for use with organic samples

Analytik Jena offers sample introduction kits optimized for special applications:

- Inert sample introduction system for semiconductor type applications requiring very low contamination for ultra-trace detection limits (torch with platinum injector, PFA (perfluoralkylalkane) nebulizer, PFA spray chamber, PFA transfer tube)
- Inert sample introduction system for geochemical type samples containing hydrofluoric acid (torch with sapphire injector, PFA nebulizer, PFA spray chamber, PFA transfer tube)
- Sample introduction system for organic samples recommended for alcohols, kerosene, etc. (torch with 1.5 mm injector, solvent-resistant pump tubing)
- Sample introduction system for volatile organic samples: recommended for gasoline, naphtha, etc. (torch with 1.5 mm injector, viton pump tubing)
- Internal Standards Kit: kit for automatic addition of internal standard solution (tubing, Y-connector, Internal standard solution)

### 3.2.2 Plasma compartment

**Plasma generation**

The ion source is located in the plasma compartment to protect the user from the high-frequency radiation and UV radiation from the plasma. The spatial separation between sample introduction and plasma also prevents heat dissipating from the plasma to the spray chamber.

The solid-state RF generator (300 V RMS, 27 MHz) incorporates a water-cooled induction coil with three windings. It is virtually center grounded which makes the plasma extremely robust and eliminates the potential for coil arcing. The fundamentally balanced plasma is stable within a wide range from 0.3 to 1.6 kW, resulting in low formation of oxides and doubly charged ions.

Furthermore, the plasma's low oscillating potential keeps the energy spread of ions of the same mass low. No torch shield is needed to prevent secondary discharge as the plasma is electrically neutral. The Eco Plasma only requires 7.5-10.5 L/min plasma gas flow and has comparatively low running costs.

With the optional Nitrox gas accessory nitrogen and oxygen can be added to the auxiliary gas. Nitrogen is used for increasing ionization (of As, Se) within the plasma. Oxygen oxidizes carbon that is abundantly present in organic solvents and that would quickly deposit on the interface cones.

![Torch and induction coil](image)

**Fig. 7** Torch and induction coil

**Interface**

The interface is the boundary between the hot plasma (at atmospheric pressure) and the vacuum system. The ions produced in the plasma are sampled via a pair of coaxial cones (the sampler and skimmer cone) with an orifice diameter of 1.1 and 0.5 mm.
This first stage of the vacuum rapidly expands the plasma at supersonic speeds producing a beam of particles that are guided later-on to the mass spectrometer system.

This first part of the vacuum system can easily be brought to atmospheric pressure for maintenance while the mass spectrometer system remains under vacuum.

Fig. 8 PlasmaQuant MS with unlatched interface door

1 Handle of the interface door
2 Plasma viewing window
3 Ion source with torch and induction coil
4 Sampler cone (which is the beginning of the interface)

The sampler and skimmer cones are used to extract the ions from the plasma at atmospheric pressure, and transfer the ion beam into a high-vacuum system. The design of both cones has been optimized to provide low polyatomic ion formation, high sensitivity, and excellent long-term stability. The larger sampler cone “samples” the ions directly from the plasma. The skimmer cone then collects a portion of the supersonic jet formed behind the sampler cone. Cones are constructed of nickel and are suitable for most applications; platinum-tipped cones are available for samples containing high levels of corrosive acids (HF, H₂SO₄, H₃PO₄).
The vacuum is maintained by differential pumping, whereby the pressure is reduced in three stages. The first and most critical stage produces a beam of particles in a high vacuum system from an atmospheric pressure source by means of the sampler and skimmer cone. The interface cones are separated by a well-defined distance, with the space between them kept at a pressure of about 5 mbar by a fore-line roughing pump.

A small fraction (around 0.1 %) of the plasma passing through the sampler cone enters the orifice at the tip of the skimmer cone and passes into the second stage of the vacuum system. This arrangement allows most of the plasma that comes through the sampler cone to be removed, while providing a representative sample of the plasma for analysis. On its way after the skimmer cone the plasma loses free electrons and becomes a mixture of positively charged ions, neutral atoms and molecules.

The first and second stage of the vacuum system are separated by a gate valve that allows the first stage to be brought to atmospheric pressure for maintenance while the rest of the system remains under vacuum. The second stage of the vacuum system is kept at a pressure of around $10^{-4}$ mbar by a turbomolecular pump.
At this pressure, ions can be guided by ion optics. Neutral gas atoms, molecules and photons, on the other hand, diffuse into the vacuum chamber and are pumped away. The final stage of the vacuum system, containing the mass analyzer and the detector, is maintained at a pressure of around $7 \times 10^{-5}$ mbar by a second turbomolecular pump.

The iCRC (Integrated Collision Reaction Cell) is patented technology, superior to known Collision Cells. The iCRC removes interfering ions before they reach the mass analyzer by introducing gases (hydrogen or helium) into the plasma as it passes through the skimmer cone. Hydrogen eliminates interfering ions by reacting with them. There is no secondary chemistry found. The by-products of the reaction are neutrals and H$^+$-Ions, which is harmless.

Furthermore the iCRC gases cause all the ions to slow down, as the ions collide with the gas particles in their path. Interfering polyatomic ions are larger than the analyte ions. Hence, the polyatomic ions collide with helium atoms, more often, and reduce their speed stronger. They can be excluded from the mass analyzer by Kinetic Energy Discrimination realized in the ion optics. With the iCRC the signal-to-background ratio is improved ensuring lower detection limits.

**BOOST control:** By applying positive voltages to the skimmer cone, ions are focused at the exit of the interface, thus improving sensitivity.

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Interferences</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{40}$Ca</td>
<td>$^{40}$Ar</td>
</tr>
<tr>
<td>$^{51}$V</td>
<td>$^{35}$Cl$^{16}$O</td>
</tr>
<tr>
<td>$^{52}$Cr</td>
<td>$^{40}$Ar$^{12}$C, $^{35}$Cl$^{16}$O$^1$H, $^{36}$Ar$^{16}$O</td>
</tr>
<tr>
<td>$^{53}$Cr</td>
<td>$^{40}$Ar$^{13}$C, $^{37}$Cl$^{16}$O</td>
</tr>
<tr>
<td>$^{56}$Fe</td>
<td>$^{40}$Ar$^{16}$O, $^{40}$Ca$^{16}$O</td>
</tr>
<tr>
<td>$^{75}$As</td>
<td>$^{40}$Ar$^{35}$Cl</td>
</tr>
<tr>
<td>$^{78}$Se</td>
<td>$^{40}$Ar$^{38}$Ar</td>
</tr>
<tr>
<td>$^{80}$Se</td>
<td>$^{40}$Ar$^{40}$Ar</td>
</tr>
</tbody>
</table>

The iCRC removes interfering ions before they reach the mass analyzer by introducing gases (hydrogen or helium) into the plasma as it passes through the skimmer cone. Hydrogen eliminates interfering ions by reacting with them. There is no secondary chemistry found. The by-products of the reaction are neutrals and H$^+$-Ions, which is harmless.

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**BOOST control:** By applying positive voltages to the skimmer cone, ions are focused at the exit of the interface, thus improving sensitivity.
### Ion Optics

The electric fields produced by ion optics can alter the path of ions in much the same way as optical components like lenses, prisms or a parabolic reflectors can alter the path of photons in a beam of light.

The patented ion optics system captures ions emerging from the back of the skimmer cone and focuses them into the mass analyzer, set 90° off the axis. The central component of the ion optics is the ReflexION. This ion mirror is a flat ring consisting of four electrodes that uses a parabolic electrostatic field to reflect and focus the ion beam into the aperture of the mass analyzer. The ion mirror concept allows for controlling the ion beam along x, y and z-axis (3D), disregarding the energy spread of the ions. As a result, a sharply focused, round shaped ion beam (1 mm) enters the mass analyzer guaranteeing the highest possible sensitivity. Furthermore, the open structure lets photons, neutrals, droplets and particles pass straight through. As shown in Fig. 12 ions are reflected by the electrostatic field while neutrals, photons, droplets and solids continue straight through and are pumped away.

![Fig. 12 ReflexION](image)

1. Ion source
2. Interface cones
3. Ion beam
4. ReflexION ion mirror
5. Entrance lens of the mass analyzer
6. Beam of neutral gas and photons

### 3.2.3 Mass analyzer

The high-definition mass analyzer system consists of the quadrupole mass filter and patented curved pre-filters (see Fig. 13 p. 29). Pre-filters are placed in the first part of the mass analyzer. They are composed of a set of four curved rods that are supplied with RF power and act as a ion guide. These pre-filters cause the ions to follow a curved trajectory. This effectively shields the mass filter from high-energy neutrals, which are unaffected by the RF fields and continue on their original linear trajectories. Thus, by setting the mass analyzer off the axis, continuous background is kept low and the mass analyzer is shielded from contamination. This self-cleaning system guarantees stable and maintenance free operation. Ions are separated according to their mass-to-charge ratio (m/z) by the quadrupole mass filter. This consists of a set of four conductive rods, mounted in insulating supports so that the rods are parallel and the axes of the four rods lie on the corners of a square.
Fig. 13 Curved pre-filters and mass analyzer

Opposite pairs of rods are connected electrically. Radio frequency and DC potentials are applied to each pair of rods so that they have equal potential of opposite sign. The ions to be analyzed enter at one end of the quadrupole and those having the selected mass-to-charge ratio emerge at the other. Ions with other mass-to-charge ratios have unstable paths that cause them to be ejected from the quadrupole.

During measurement the absolute magnitude of the potential is increased, so that ions of increasing m/z will pass through the quadrupole in rapid succession. This is how the mass spectrum is scanned.

Detector

The detector in a quadrupole ICP-MS operates on the same principles as a photomultiplier tube. An individual ion enters the detector and collides with the first dynode, knocking out a free electron. This electron is accelerated to the next dynode where it knocks out several electrons. The amplification process continues until a great number of electrons are produced at the end of the detector. This large cascade of electrons is essentially an electrical “pulse” which can be measured by the detector digital electronics.

Fig. 14 All-digital extended dynamic range detector

The PlasmaQuant MS features a unique all-digital detection system, the AD Detector. It provides up to eleven orders of linear calibration range without requiring an analog operating mode. If the option of auto attenuation is selected, the software automatically chooses a suitable attenuation mode for the detector. When the detector signal is low, the software automatically turns the attenuation off. This gives the highest possible sensitivities for the analyte isotopes at a low concentration level, and therefore achieving the lowest detection limits. The detector has longer lifetimes from up to 5 years compared to dual-mode detectors. Furthermore, the detector doesn’t require frequent cross-calibration as dual-mode detectors do.
3.2.4 PlasmaQuant MS – at a look

Fig. 15 Setup of PlasmaQuant MS

<table>
<thead>
<tr>
<th>Number</th>
<th>Component</th>
<th>Advantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Nebulizer and spray chamber</td>
<td>low oxide ratio</td>
</tr>
<tr>
<td>2</td>
<td>Virtually center grounded coil</td>
<td>low plasma potential, robust plasma, no plasma shield needed, Eco Plasma with very low argon consumption</td>
</tr>
<tr>
<td>3</td>
<td>Fore-line roughing pump</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Sampler cone</td>
<td>efficient plasma extraction, simple maintenance, no clogging</td>
</tr>
<tr>
<td>5</td>
<td>Skimmer cone with iCRC</td>
<td>iCRC efficient reduction of polyatomic interferences, simple operation</td>
</tr>
<tr>
<td>6</td>
<td>Turbomolecular pump</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>ReflexION Ion Mirror</td>
<td>superfribs sensitivity, Kinetic Energy Discrimination of polyatomic ions</td>
</tr>
<tr>
<td>8</td>
<td>Curved pre-filters</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>HD Quadrupole mass analyzer</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Turbomolecular pump</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>AD Detector - All-digital detection system</td>
<td>high sensitivity (11 orders of dynamic range), long life-time</td>
</tr>
</tbody>
</table>

Summary 2 Major components and their advantages
4 Installation and commissioning

CAUTION

The device may only be assembled, installed and repaired by the service engineers from Analytik Jena or by technical personnel authorized by Analytik Jena.

Any unauthorized interference voids warranty entitlements. When starting up your device, please observe the instructions provided in the section "Safety instructions" p. 11. Always observe all warnings and instructions which are displayed on the device itself or which are displayed by ASpect MS software.

4.1 Installation conditions

4.1.1 Environmental conditions

The PlasmaQuant MS may only be operated in closed rooms. The location must have the characteristics of an analytical laboratory. The location must meet the following conditions:

- It must be free of dust, drafts, vibrations and caustic fumes.
- For optimum analytical performance, it is recommended that a positive air pressure is maintained in the laboratory at all times.
- Condensate might enter the inside of the instrument causing a short circuit. Ensure uninterrupted air conditioning at high humidity, even during operating pauses.
- Do not place the PlasmaQuant MS near sources of electromagnetic interference.
- Avoid direct sunlight and heater radiation on the PlasmaQuant MS. Air conditioning is recommended at the location. The cool air emanating from the air conditioning unit should not be directed at the device.
- A separate room is recommended for sample preparation and storing liquid chemicals.

The following requirements are placed on the climatic conditions in the operating room of the PlasmaQuant MS:

<table>
<thead>
<tr>
<th>Summary 3</th>
<th>Environmental conditions for operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature range</td>
<td>+15 to 25 °C, optimum +20 to 24 °C (as constant as possible during measuring, maximum temperature drift $\Delta T_{\text{max}} = 2$ K/h, air condition recommended)</td>
</tr>
<tr>
<td>Max. humidity</td>
<td>20 to 80 % at 20 °C (non-condensing)</td>
</tr>
<tr>
<td>Max. altitude</td>
<td>2000 m</td>
</tr>
</tbody>
</table>
4.1.2 Power supply

**WARNING**

Shock hazard!

During electrical installation, observe the VDE (German Association for Electrical Engineers) electrotechnical guidelines and local regulation requirements!

The mains supply must be correctly earthed. Do not use an adapter in the mains cabling.

The PlasmaQuant MS is available as a single-phase electrical configuration. If single-phase electricity supply is not available, most three-phase supply systems can be adapted to supply the correct line-to-neutral voltage in the specified range.

To enable the PlasmaQuant MS to be used in areas with power supply voltages of 100 V/115 V/120 V/127 V, connection to 2 phases is possible via optional accessories. Contact Analytik Jena if required. This installation may only be carried out by service engineers from Analytik Jena or by specialist personnel authorized and trained by Analytik Jena.

Electrical power is connected from your supply outlet to the PlasmaQuant MS by a single three meter 1 ph power cable (length 3 m, Ø min. 4 mm² Cu). With the electrical power cable connected to your power outlet and the power turned on at the power outlet, power can still be isolated at the instrument itself.

The PlasmaQuant MS incorporates a circuit breaker (located at the rear of the instrument) and a standby switch (located on the front panel of the instrument) to control power flow between the power outlet and the power distribution module of the instrument. Both of these isolation devices must be in their ON position before the instrument can function.

To avoid sudden voltage fluctuations, do not connect the PlasmaQuant MS to the same electrical circuits as other power-intensive devices.

### Summary 4 Power supply

<table>
<thead>
<tr>
<th>Summary 4</th>
<th>Power supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
<td>200–240 V AC ± 5 %</td>
</tr>
<tr>
<td>Frequency</td>
<td>50/60 Hz</td>
</tr>
<tr>
<td>Typical average power consumption</td>
<td>2700 VA</td>
</tr>
<tr>
<td>Max. power consumption</td>
<td>3700 VA</td>
</tr>
<tr>
<td>Line current</td>
<td>18 A max.</td>
</tr>
<tr>
<td>Fuse provided (mains side)</td>
<td>25 A, Curve C</td>
</tr>
</tbody>
</table>
### 4.1.3 Gas supply

**WARNING**

Danger of explosions! Hydrogen is highly combustible. Oxygen is a powerful oxidizer.

Further, any leak in the gas supplies (except for oxygen) can result in an oxygen-deficient atmosphere which can cause asphyxiation!

The operator must ensure that the connector type used on the outlet side of the gas pressure controller is adequate for the national requirements that apply.

The operator must carry out the necessary safety leakage tests weekly on all gas supplies up as far as the device. For this, possible pressure losses from closed systems and lines under pressure are to be determined. Any leak is to be localized and corrected immediately.

If the gas is supplied by pressure cylinders, these must be secured to the wall in an upright position with cylinder mounts outside the laboratory space.

The following gases are used in conjunction with the PlasmaQuant MS:

- Argon as plasma gas, auxiliary gas, sheath gas (optional) and nebulizer gas
- Helium and Hydrogen as gases for the integrated Collision Reaction Cell (iCRC)
- Nitrogen and Oxygen as additive gases to the auxiliary gas (Nitrox only)

Do not connect any other gases than those specified to the correct inlet fittings. Use only instrument-grade gases with your spectrometer. Do not exceed the maximum inlet pressures.

Argon gas from the gas supply regulator flows to the ICP-MS gas box module through a 3 m PTFE hose supplied with the instrument. If other hose lengths are preferred, please contact the service department at Analytik Jena.

#### Summary 5 Gas supply

<table>
<thead>
<tr>
<th>Type of Gas</th>
<th>Argon</th>
<th>Helium</th>
<th>Hydrogen</th>
<th>Nitrogen</th>
<th>Oxygen</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Purity</strong></td>
<td>≥ 4.6 (99.996 %)</td>
<td>≥ 4.6 (99.996 %)</td>
<td>≥ 4.6 (99.996 %)</td>
<td>≥ 4.6 (99.996 %)</td>
<td>≥ 4.6 (99.996 %)</td>
</tr>
<tr>
<td>5 ppm O₂</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 ppm N₂</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 ppm H₂O</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 ppm H₂</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Input Pressure</strong></td>
<td>550-700 kPa (80-100 psi)</td>
<td>150 kPa (21.5 psi) regulated</td>
<td>100 kPa (14.5 psi) regulated</td>
<td>125 kPa (18.1 psi) regulated</td>
<td>125 kPa (18.1 psi) regulated</td>
</tr>
<tr>
<td><strong>Max. Input Pressure</strong></td>
<td>700 kPa (100 psi)</td>
<td>250 kPa (36.3 psi)</td>
<td>170 kPa (24.7 psi) regulated</td>
<td>150 kPa (21.5 psi)</td>
<td>150 kPa (21.5 psi)</td>
</tr>
<tr>
<td><strong>Flow Range</strong></td>
<td>0-28 L/min</td>
<td>0-0.2 L/min</td>
<td>0-0.2 L/min</td>
<td>0-0.2 L/min</td>
<td>0-0.2 L/min</td>
</tr>
<tr>
<td><strong>Typical flow range</strong></td>
<td>9-12.5 L/min</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.1.4 Exhaust unit

CAUTION

Danger from hazardous gases such as ozone and nitrous gases! Switch on the exhaust unit prior to igniting the plasma.

The exhaust unit is meant to remove hazardous gases generated during plasma operation, such as ozone or nitrous gases.

Correct exhaustion requires the connection of flexible ducting from your exhaust system to the exhaust port on top of the PlasmaQuant MS. The instrument exhaust outlet has a diameter of 100 mm (4 in). Use an exhaust unit made of heat and corrosion-resistant material.

Summary 6 Exhaust unit requirements

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>Heat and corrosion resistant (recommended V2A steel)</td>
</tr>
<tr>
<td>Extraction output</td>
<td>3.0 m³/min (110 ft³/min) – 4.5 m³/min (160 ft³/min) recommended value: 3.5 m³/min (125 ft³/min)</td>
</tr>
<tr>
<td>Adapter using flexible</td>
<td>Internal pipe diameter Ø 100 mm (4 in)</td>
</tr>
<tr>
<td>aluminum or plastic pipe</td>
<td>Length: up to 5000 mm (15 ft)</td>
</tr>
<tr>
<td></td>
<td>Corrosion- and heat-resistant (up to 60 °C)</td>
</tr>
</tbody>
</table>

The exhaust port moves when the interface door is opened during regular maintenance; therefore, it is not possible to use a rigid duct connection.

4.1.5 Water cooler

NOTICE

The PlasmaQuant MS may be damaged if the maximum cooling water pressure of 500 kPa (72.5 psi) is exceeded.

A water cooling system is needed to circulate water to the induction coils, plasma interface assembly, RF generator, and both turbo pumps. The recirculating chillers supplied by Analytik Jena are adapted to the required cooling performance of the PlasmaQuant MS. If the recirculating chiller is not obtained from Analytik Jena, the following minimum requirements must be met:

Summary 7 Cooling circuit requirements

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling capacity</td>
<td>Minimum of 1.8 kW</td>
</tr>
<tr>
<td>Water temperature (water supplied</td>
<td>20 °C ± 1 °C (68 °F ± 1.8 °F)</td>
</tr>
<tr>
<td>to the instrument)</td>
<td></td>
</tr>
<tr>
<td>Water Pressure</td>
<td>440 ± 40 kPa (64 ± 6 psi)</td>
</tr>
<tr>
<td></td>
<td>Pressure at the instrument water inlet</td>
</tr>
</tbody>
</table>
Parameters | Properties
--- | ---
Max. Water Pressure | 500 kPa (72.5 psi)
Pressure at the instrument water inlet | 75-150 µS/cm, target range 100-120 µS/cm (particle size < 0.1 mm)
Water purity | Conducitivity: permitted range
75-150 µS/cm, target range 100-120 µS/cm (particle size < 0.1 mm)
pH: 7-9
Total Chlorine: < 20 mg/L (20 ppm),
total Nitrate: < 10 mg/L (10 ppm),
total Sulfate: < 100 mg/L (100 ppm)

Please observe the information provided in the recirculating chiller's operating instructions.

The system must be filled with cooling water that has been mixed with a cooling water additive which must be obtained from Analytik Jena. The preparation of the cooling water is described in section "Changing the cooling water" on page 114. The coolant additive prevents potential damage to the PlasmaQuant MS resulting from corrosion and biological contamination. Damage to the device due to operation without coolant additive is excluded from the warranty!

The PlasmaQuant MS water cooling system incorporates a flow switch to monitor water flow and an inlet water valve. If a sufficient water flow rate is not maintained, the plasma will be shut down, inhibiting ignition until sufficient water flow is restored.

4.1.6 Fore-line roughing pump

A fore-line roughing pump is included with the PlasmaQuant MS vacuum system.

<table>
<thead>
<tr>
<th>Device model</th>
<th>Pump model</th>
<th>Pump type</th>
</tr>
</thead>
<tbody>
<tr>
<td>PlasmaQuant MS</td>
<td>SV40BI</td>
<td>Rotary vane pump</td>
</tr>
<tr>
<td>PlasmaQuant MS Q</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PlasmaQuant MS Elite S</td>
<td>XD546i</td>
<td>Oil-free pump with taper screw technology</td>
</tr>
<tr>
<td>PlasmaQuant MS Elite</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The PlasmaQuant MS (Q) is equipped with an adsorption trap (with aluminum oxide). This trap protects the ICP-MS against oil vapors from the fore-line pump SV40BI. Aluminum oxide must be replaced once a year by the customer service department.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protection class</td>
<td>I</td>
</tr>
<tr>
<td>Voltage</td>
<td>200-240 V</td>
</tr>
<tr>
<td>Frequency</td>
<td>50/60 Hz</td>
</tr>
<tr>
<td>Line Current</td>
<td>10 A max.</td>
</tr>
<tr>
<td>Weight</td>
<td>43 kg</td>
</tr>
<tr>
<td>Oil capacity</td>
<td>1.0 L</td>
</tr>
</tbody>
</table>
The fore-line roughing pump is used as both the primary pump for the first vacuum stage and as a fore-line pump for the two turbomolecular pumps on the second- and third-stage vacuum chambers. The PlasmaQuant MS supplies the fore-line roughing pump with 200-240 V.

The vacuum pump is a floor-mounted pump, typically placed under or behind the bench where the PlasmaQuant MS is located. The pump can also be located remotely (up to 12 m away from the ICP-MS) for noise reduction, and this is also recommended for Clean Room operation.

Some mass spectrometer benches may be fitted with a noise- and vibration-isolating compartment to install the vacuum pump. If this is used, take adequate action to prevent the pump from overheating.

The outlet of the pump has to be connected to an exhaust unit. If the pump is linked to the exhaust unit for the PlasmaQuant MS, the suction device must be operated even if the PlasmaQuant MS is in the energy-saving standby mode. Alternatively, a separate suction device can be used.

For models SV40BI, the pump must be equipped with an additional oil mist filter if the pump is linked to the exhaust unit for the ICP-MS.

Only use protection class I fore-line roughing pumps which have a power cord with protective earth (PE).

Please refer to section "Maintenance and care" p. 96 for information on maintenance and care of the fore-line pump.

### 4.1.7 Device layout and space requirements

The PlasmaQuant MS is a compact device conceived for table-top operation. The space required is a function of all components needed for the measurement.

The autosampler is installed next to the base instrument. Between these two instruments 30 cm of clearance is required to allow space for opening the interface door. Additional space may be needed for a PC and possibly a printer. The PC and printer may also be placed on a separate table.

The workbench must meet the following requirements:

- The dimensions of the workbench for the PlasmaQuant MS and the autosampler must be at least 1800 mm x 800 mm. The height of the bench should be chosen according to ergonomic aspects.
- The workbench must be capable of bearing a load of at least 220 kg.
- The workbench surface must be wipeable, corrosion resistant and must not absorb moisture.

- It must be freely accessible from all sides. A distance of at least 200 mm to the next wall must be kept. Alternatively, a heavy lift roll-top table can be used.

Due to the dissipated heat and possible noise it is recommended to place the water cooler outside the laboratory. An extension of the cooling water tubing is permitted if the minimum pressure and the flow volume are maintained. The surfaces of the housing sides of the water cooler require a minimum distance of 15 cm from adjacent objects, for unimpeded cooling air circulation.

The fore-line roughing pump is a floor-mounted pump, typically placed under or behind the bench where the PlasmaQuant MS is located.

The pump can also be located remotely (up to 12 m away from the ICP-MS) for noise reduction, and this is also recommended for Clean Room operation.

A bottle for receiving residue sample liquids and autosampler wash liquid is placed underneath the bench.

<table>
<thead>
<tr>
<th>Component</th>
<th>Width [mm]</th>
<th>Height [mm]</th>
<th>Depth [mm]</th>
<th>Mass [kg]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>On the workbench</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PlasmaQuant MS</td>
<td>660</td>
<td>1131</td>
<td>589</td>
<td>186</td>
</tr>
<tr>
<td>Autosampler (ASPQ 3300)</td>
<td>285</td>
<td>510</td>
<td>490</td>
<td>15</td>
</tr>
<tr>
<td>Autosampler (Cetac ASX-560)</td>
<td>580</td>
<td>620</td>
<td>550</td>
<td>12</td>
</tr>
<tr>
<td><strong>Outside the laboratory / or next to the workbench</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water-air cooler</td>
<td>460</td>
<td>703</td>
<td>735</td>
<td>92</td>
</tr>
<tr>
<td>Water-water cooler</td>
<td>360</td>
<td>590</td>
<td>470</td>
<td>33 (empty)</td>
</tr>
<tr>
<td>Fore-line roughing pump</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model SV40BI</td>
<td>330</td>
<td>380</td>
<td>500</td>
<td>43</td>
</tr>
<tr>
<td>Model XDS46i</td>
<td>340</td>
<td>400</td>
<td>480</td>
<td>48</td>
</tr>
<tr>
<td><strong>Under the work table</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste bottle</td>
<td>200</td>
<td>400</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Fig. 16  Dimensions of the PlasmaQuant MS

1131 mm  44.5 in
660 mm    26.0 in
589 mm    23.5 in
4.2 Supply and control connections

The supply lines for the instrument are connected during the installation of the PlasmaQuant MS by service engineers from Analytik Jena.

On the rear side of the instrument there are the connections for PC and accessories as well as the connections for gases and the cooling water inlet and outlet. The PlasmaQuant MS incorporates a circuit breaker that is located at the rear of the instrument (10 in Fig. 17).

![Connections and interfaces on the rear side of the device](image)

Fig. 17 Connections and interfaces on the rear side of the device

1 Interface for external trigger (for Laser Ablation) 7 Connections for water cooling
2 USB interface for PC 8 Nitrox (N₂/O₂) - additive gases to the auxiliary gas
3 Interface for optional control of the water cooler via ICP-MS 9 Fore-line pump circuit breaker
4 Hydrogen, Helium – iCRC gases 10 Instrument circuit breaker
5 Fitting for the vacuum pump 11 Mains connection
6 Argon - plasma gas, auxiliary gas, sheath and nebulizer gas 12 Power connection to the vacuum pump

In the PlasmaQuant MS, argon is used as a gas for the torch and the nebulizer. Nitrogen and oxygen can be optionally connected as additive gases to the auxiliary gas (Nitrox option). Helium and hydrogen are used as iCRC gases.

The required gas, water cooling, and control communications for the sample introduction system are found just behind the spray chamber mounting arm. They are all labelled and have unique connectors. The orange plasma off button is also located on the right side of the instrument.
Installation and commissioning

Fig. 18 Overview of connections on the right side of the instrument

1. Plasma OFF
2. Argon – sheath gas (optional, connection to the transfer tube)
3. Argon – nebulizer gas
4. Interface to the spray chamber
5. Connection for cooling (H₂O out)
6. Connection for cooling (H₂O in)
7. Nebulizer gas
8. Cooling water connections to the spray chamber

The green standby switch is located on the front panel of the instrument. It controls power flow between the power outlet and the power distribution module of the instrument.

The standby switch and the circuit breaker on the rear side of the device must both be in their ON position before the instrument can function.

On the front panel there is also an opening for possible coupling to accessories.

Fig. 19 Switches and connections on the front side of the instrument

1. Opening for possible coupling to accessories
2. Standby switch

The electrical connection data can be found on the type plate on the terminal strip.
# Summary 11  
## Information on the type plate

<table>
<thead>
<tr>
<th>Manufacturer (with address)</th>
<th>Analytik Jena AG, Konrad Zuse Str. 1, D-07745 Jena</th>
</tr>
</thead>
</table>
| Device type and model       | PlasmaQuant MS  
                                 | PlasmaQuant MS Q  
                                 | PlasmaQuant MS Elite S  
                                 | PlasmaQuant MS Elite |
| Voltage / frequency         | 200-240 V AC  
                                 | 50/60 Hz |
| Maximum power consumption   | 3700 VA |
| CE marking                  | |
| Waste disposal symbol acc. to WEEE directive (2012/19/EU) | Meaning: Do not dispose of as domestic waste! |
| Protection class of the housing | IP 20 |
| Safety symbols              | Attention, observe accompanying documents! |
| Legal notice                | Attention, observe patents! |
| Device number               | |

### PlasmaQuant MS

<table>
<thead>
<tr>
<th>Standard</th>
<th>10-5000-040-62-AXXXX</th>
</tr>
</thead>
<tbody>
<tr>
<td>with Aerosol Dilution (AD)</td>
<td>10-5000-050-62-AXXXX</td>
</tr>
<tr>
<td>with Nitrox (NI)</td>
<td>10-5000-060-62-AXXXX</td>
</tr>
<tr>
<td>with AD and NI</td>
<td>10-5000-070-62-AXXXX</td>
</tr>
</tbody>
</table>

### PlasmaQuant MS Q

<table>
<thead>
<tr>
<th>Standard</th>
<th>10-5000-041-62-AXXXX</th>
</tr>
</thead>
<tbody>
<tr>
<td>with AD</td>
<td>10-5000-051-62-AXXXX</td>
</tr>
<tr>
<td>with NI</td>
<td>10-5000-061-62-AXXXX</td>
</tr>
<tr>
<td>with AD and NI</td>
<td>10-5000-071-62-AXXXX</td>
</tr>
</tbody>
</table>

### PlasmaQuant MS Elite S

<table>
<thead>
<tr>
<th>Standard</th>
<th>10-5000-043-62-AXXXX</th>
</tr>
</thead>
<tbody>
<tr>
<td>with AD</td>
<td>10-5000-053-62-AXXXX</td>
</tr>
<tr>
<td>with NI</td>
<td>10-5000-063-62-AXXXX</td>
</tr>
<tr>
<td>with AD and NI</td>
<td>10-5000-073-62-AXXXX</td>
</tr>
</tbody>
</table>

### PlasmaQuant MS Elite

<table>
<thead>
<tr>
<th>Standard</th>
<th>10-5000-042-62-AXXXX</th>
</tr>
</thead>
<tbody>
<tr>
<td>with AD</td>
<td>10-5000-052-62-AXXXX</td>
</tr>
<tr>
<td>with NI</td>
<td>10-5000-062-62-AXXXX</td>
</tr>
<tr>
<td>with AD and NI</td>
<td>10-5000-072-62-AXXXX</td>
</tr>
</tbody>
</table>
4.3 Installing the PlasmaQuant MS

NOTICE
After transport, wait for 12 hours until the PlasmaQuant MS has reached room temperature. Only start up the device after this period has elapsed. The sensitive electronics may otherwise be damaged by condensed water.

The PlasmaQuant MS is delivered directly to its final destination by a transportation company. The delivery by this company requires the presence of a person responsible for instrument installation.

It is imperative that all persons designated to operate the device are present during the briefing by the service technician.

Check that all requirements are met at the installation location (see the section "Installation conditions" p. 31).

The PlasmaQuant MS is installed and connected by service engineers from Analytik Jena or by technical personnel authorized by Analytik Jena.

Sample introduction components, including the torch, the nebulizer with spray chamber and the autosampler have to be installed by the customer during maintenance operations. Descriptions of these installation procedures are provided in the sections below.

WARNING
Plasma emits UV radiation and high-frequency electromagnetic radiation which can cause serious eye and skin injuries as well as other health problems.

Therefore, the plasma compartment door must be closed before igniting and operating the plasma. Safety interlocks must not be bypassed by the user!

Before opening the plasma compartment lid for installation or maintenance work, always extinguish the plasma from the software.

CAUTION
The torch compartment and interface, including the cones, are still very hot after the plasma has been extinguished. Contact with these hot surfaces can cause burns.

Therefore, wait 5 minutes after extinguishing the plasma before touching the torch and the cones or wear heat-resistant gloves.
4.3.1 Installation of the torch

**CAUTION**
Danger of injury from breaking glass! Always take care when installing or removing the parts.

1. Fit one quick-connect fitting to each length of tubing.
2. Fit the quick-connect snap fitting to the other end of one length of tubing. Slide the fittings onto the torch. The line with the quick-connect fitting on the other end goes on the side arm nearest the spherical joint. This will be the auxiliary gas line (2). Tubing (1) will be the plasma gas line.

   Torch tubing: 4.75 mm ID / 1.52 mm wall length 300 mm

3. Carefully insert the ignition lead into the open end of the other length of tubing (1) until only the connector is exposed.

4. Open the plasma compartment lid on the front side of the instrument.

5. Open the clamp inside the torch compartment. Place the torch in the clamp sliding it forward between the induction coils.

6. To position the torch correctly, slide the torch forward until the glass nubs on its bottom side are touching the outside of the clamp.
7. Close and lock the clamp arm: push the locking knob down and turn it 90-degrees until it clicks in place.

8. Connect the torch to the glass transfer tube with the glassware clamp.

9. Connect the plasma gas line (1) and the auxiliary gas line (2) to the fittings in the plasma compartment. The gas lines should not intersect when installed correctly.

   **Plasma gas line:**
   - Carefully push the ignition wire connector onto the pin inside the plasma gas supply fitting. Make sure the connector is oriented straight up on the pin, so it does not bind on the tubing.
   - Gently push the plasma gas tubing down over the outside of the barbed fitting, taking care not to bind or jam the ignition wire.

   **Auxiliary gas line:**
   - Connect the auxiliary gas line to the quick-connect snap fitting.
4.3.2 Installation of the nebulizer

1. Fit the gas and sample tubing to the nebulizer.
   - Insert the capillary tubing connector directly onto the sample inlet of the nebulizer as far as it will go to minimize the dead space in the nebulizer (1).
   - To fit the gas inlet tubing, cut a 14” (350 mm) length of Nalgene 1/8” x 1/4” (3.18 x 6.35 mm) tubing and fit one end over the barbed fitting of the adapter, securing it with the clamp provided. Press the other end of the adapter into place on the side arm of the nebulizer (2).
   - Attach the insert coupling into the other end of the tubing (3).

2. Attach the gas tubing from the nebulizer to the gas box outlet labeled “Nebulizer”.

3. Connect the free end of the nebulizer capillary tubing to the sample pump tubing from the peristaltic pump.

4. Install the nebulizer in the spray chamber.
4.3.3 Installation of the spray chamber

1. Attach a ~10 cm piece of drain tubing to the waste outlet at the bottom of the spray chamber.

2. Open the holder assembly. Place the spray chamber into position in the lower half of the holder assembly.

3. Place the top half of the holder assembly in position over the spray chamber and secure it using the two knurled knobs.

If the glass transfer tube is already in place:

4. Swing the mounting arm inward towards the transfer tube.

5. Fit the spherical joint of the transfer tube into the joint of the spray chamber and secure it using the glassware clamp.

If the transfer tube is not in place, refer to the installation instructions on the next page.
### 4.3.4 Installation of the transfer tube

There are two different transfer tubes:

- Standard transfer tube
- Transfer tube for Aerosol Dilution (optional)

The transfer tube for Aerosol Dilution has an extra connection for sheath gas. The following instruction shows the installation of the transfer tube for Aerosol Dilution.

**WARNING**

Risk of eye and skin injuries due to UV and electromagnetic radiation!

If you are using a non-standard sample introduction configuration, there may be a danger of direct exposure to UV or electromagnetic radiation from the opening in the side wall of the torch compartment.

A UV and EMR protective cover is supplied with your PlasmaQuant MS instrument for use with non-standard configurations.

1. For Aerosol Dilution: fit the tubing and gas connector to the transfer tube (if not already fitted).
2. Swing the mounting arm of the spray chamber outward to allow access to the opening in the side wall of the torch compartment.
3. Open the torch compartment lid to allow access to the lever arm of the transfer tube protection mechanism.
4. Hold the lever arm down.
5. Feed the spherical joint of the transfer tube into the torch compartment through the opening in the torch compartment wall.

6. Connect the torch to the transfer tube with the glassware clamp.
   Do not use conventional spherical joint clamps. These may cause signal stability problems.

7. If the spray chamber is already in place, fit the spherical joint of the glass transfer tube into the joint of the spray chamber and secure it using the glassware clamp.
8. For Aerosol Dilution: attach the gas tubing from the transfer tube to the gas box outlet labeled “Sheath Gas”.

![Image of gas tubing attachment](image-url)
4.3.5 Installation of the peristaltic pump tubing

CAUTION
Risk of injury!
Always switch off the peristaltic pump before installing or removing the pump tubing. Take care to keep loose clothing, jewelry, etc. clear of the pump while it is running.

1. Select pump tubing for the sample, drain, and Internal Standard (if required).

2. Assemble the sample pump tubing as follows:
   - Connect the sample and drain tubing supplied with the instrument. The pump tubing is color-coded according to its size (internal diameter). The sample tubing used is typically ‘black-black’ (0.76 mm ID). The drain tubing is normally ‘blue-blue’ (1.65 mm ID). Attach one end of the capillary tubing to the sample pump tubing. Insert the other end directly into the sample or to the autosampler probe.
   - Insert the nebulizer capillary tubing into the free end of the sample pump tubing as shown in the figure below.

![Fig. 21 Sample tubing](image)

3. Assemble the drain tubing as follows:
   - Fit the smaller end of a 1.6 to 3.2 mm (1/16" to 1/8") barb to one end of the drain pump tubing.
   - Cut a piece of Nalgene tubing long enough to extend between the peristaltic pump and the drain vessel and fit one end over the larger end of the barb.
   - Connect the drain tubing extending from the spray chamber to the other end of the drain pump tubing. Always ensure that the drain pump tubing pumps liquid away at a faster rate than the sample/internal standard pump tubing can supply it. The drain pump tubing should be at least two sizes “larger” than the supply pump tubing to ensure sufficient drainage.

4. Stretch the tubing around the pump rollers. Use the plastic stoppers on the tubing to hold the tubing in the grooves below the pump rotor.

5. Close the pressure bars.
6. Place the capillary that extends from the sample pump tubing into the sample or rinse solution.

7. Place the Nalgene tubing that extends from the drain pump tubing into the drain vessel.

8. Turn on the peristaltic pump by pressing [F11].

   Ensure the nebulizer gas is turned off before adjusting the pressure bar. When in operation, the concentric glass nebulizer creates a low-pressure region at the nebulizer tip. This results in liquid flowing to the nebulizer even if the pump is not in use, and makes it impossible to see if the pump tension is correctly set.

9. Adjust the pressure on the pump tubing as follows:
   - Loosen the appropriate pressure bar screw so that no liquid is pumping.
   - Slowly tighten the screw until liquid just starts to move along the tubing.
   - Tighten the screw another half turn.

   When not in use, release the pressure bars and unhook the pump tubing from the grooves at one end. This will extend the life of the pump tubing.

10. Adjust the pressure on the drain pump tubing.

    A drain vessel is not supplied with the PlasmaQuant MS system. You should use a chemically inert, wide-necked container with minimum of two liters (four pints) capacity to catch the waste liquids. Place the container in full view of the operator to prevent it being accidentally knocked over, and to ensure that it will not be allowed to overflow.

    The addition of an Internal Standard is important in ICP-MS to account for physical and matrix interferences. Internal Standards with multiple elements can be measured over large mass ranges to account for mass bias effects. The inline addition of an Internal Standard minimizes sample preparation and is therefore often preferred.
Always change the sample and Internal Standard tubing at the same time to avoid uneven wear of the tubing.

1. Fit another pump tubing to the peristaltic pump in the next available channel. This will be the Internal Standard channel. The pump tubing should be the same type as the sample tubing. Ensure that the pressure bar is adjusted as per the sample tubing.

2. Connect the outlet of the Internal Standard channel to a commercially available plastic Y-piece (or T-piece). Connect a piece of capillary tubing to the inlet end of the Internal Standard tubing. The capillary can then be placed in a suitable vessel (e.g., a 500 mL container) containing the Internal Standard solution.

3. Connect the outlet of the sample pump tubing and the nebulizer capillary tubing to the other arms of the Y-piece/T-piece. In this way, the Internal Standard will be mixed with the sample at the Y-piece/T-piece and the combined flow will pass to the nebulizer.

Fig. 23  Pump tubing with Internal Standard tubing

Fig. 24  Peristaltic pump - tubing connections with Internal Standard
5  Operation

This chapter gives an outline of how to get your PlasmaQuant MS up and running for analysis and how to shut it down. The following topics cover basic ICP-MS operations:

- Starting the ASpect MS Software
- Turning on the power to the PlasmaQuant MS
- Starting the vacuum System
- Igniting the plasma
- Warming up the PlasmaQuant MS
- Shutting down the PlasmaQuant MS

These operations have to be carried out whenever starting the instrument. At the end of a working day the PlasmaQuant MS should be left in standby mode, with the vacuum system on and the plasma off. A complete shutdown is only recommended if the instrument is not going to be used for an extended period of time (>2 weeks) or needs to be shut down due to interruptions in the laboratory facilities such as a power outage.

5.1  Starting ASpect MS software

To start the ICP-MS Software, double-click the ASPECT MS icon on the desktop. If no icon is present, click the Windows START button ➤ ALL PROGRAMS ➤ ASPECT MS ➤ ASPECT MS. For a more detailed overview of ASpect MS software, refer to the software help.

Before applying power to the PlasmaQuant MS, ensure that:

- The plasma compartment lid and interface door are closed to ensure interlocks are activated.
- ASpect MS Software has been correctly installed and the computer is turned on.

5.2  Turning on power to the PlasmaQuant MS

When the power is turned on, the PlasmaQuant MS will perform an automated initialization sequence, the Power-On-Self-Test (POST).

1. Switch on the power at the electrical outlet.
2. Switch the circuit breaker at the rear of the instrument to its ON position.
3. If the instrument standby switch (the green light at the front of the instrument) is not illuminated, press the button in to turn on the instrument.
4. View the instrument’s status in the INSTRUMENT SUMMARY window. Click the [INSTRUMENT] button in the quick start menu or select INSTRUMENT ➤ INSTRUMENT SETUP on the main toolbar. The INSTRUMENT SUMMARY window will then appear as shown.
5. Verify the system is in a ready state and there are no outstanding error conditions in the SUMMARY window on the lower left.
5.3 Starting the vacuum system

If the system does not reach the required vacuum pressure within 10 minutes, an error will be displayed and the vacuum system will be shut down.

1. Click the [VACUUM] button on the Main Toolbar of the ASpect MS Software, or choose VACUUM ON from the ACTIONS menu, or press [SHIFT+F6]. A sequence will automatically initiate the appropriate vacuum components to bring the instrument to the required system pressure.

2. Watch the Status Bar (at the bottom of the Main window) to see the progress. Countdown times (in seconds) for the various stages are displayed.

3. After restarting the vacuum system it is recommended to carry out an Automated Instrument Setup (see section "Instrument Automated Setup" on page 59).
5.4 Igniting the plasma

**WARNING**

Risk of eye and skin injuries due to UV and electromagnetic radiation!

To ensure safe torch operation, you must not ignite the plasma unless the following conditions are met:

- The plasma compartment lid and the interface door are closed and latched.
- The water cooler is ready for operation.
- Argon supply is ensured.
- The exhaust sensor registers sufficient air flow rate.

If this is not the case safety interlocks will prevent plasma ignition.

Furthermore, the torch and all other components of the sample introduction system are in working position, are free of deposits and damage.

1. Turn on the water cooler.
2. Tighten the peristaltic pump tubing pressure bars.
3. Open the gas supply valves including iCRC gases.
4. Click the [PLASMA] button on the main toolbar, or choose PLASMA ON from the ACTIONS menu, or press [SHIFT+F4].

If plasma will not light see section "Troubleshooting" p. 127. It is important to ensure that the torch axis is perfectly aligned on the axis of the sampler cone orifice for optimal signal efficiency. It is a common practice (but not required) to align the torch during daily warm-up time scan since it only takes about five minutes to complete (see section "Torch alignment" p. 59).

5.5 Tuning solution preparations

The following chapters refer to a standard tuning solution whenever using optimization routines. Freshly prepare a 1 µg/L (1 ppb) solution using the provided ICP-MS tuning solution, which contains Ba, Be, Ce, Co, In, Pb and Mg (10 mg/L) in 1 % HNO₃.

Alternatively, user-defined tuning solutions can be used when tuning the instrument manually. In general, the concentration of a tuning solution should not exceed 1 µg/L of each analyte of interest.
5.6 Warming up the PlasmaQuant MS

With the plasma lit:

1. Open the PLASMA ALIGN tab of the INSTRUMENT window.
2. Select TIME for the scan type in the lower-left corner of the window.
3. By clicking [BROWSE] in the bottom of the window select one worksheet of the default worksheets for the setup.
4. Press [START].

5. To aspirate solution directly from a bottle rather than an autosampler, select MANUAL SAMPLE INTRODUCTION from the window that appears, or direct the autosampler to the rack/tube which contains the tuning solution.

6. The PlasmaQuant MS will begin to scan. Aspirate the 1 µg/L (1 ppb) tuning solution during instrument warm-up to provide a quick visual indication of instrument performance.

The instrument will reach thermal stability within 15 minutes of operation after a warm-up time scan is started.

✓ The PlasmaQuant MS is now ready for hardware optimization (if required), or to commence analysis (if a method is ready).

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Fig. 26 Time scan displaying the signal during warm-up
5.7 Shutting down the PlasmaQuant MS

Normally the PlasmaQuant MS should be left in standby mode, with the vacuum system on and the plasma off, unless it is not going to be used for an extended period of time (>2 weeks) or needs to be shut down due to interruptions in the laboratory facilities such as a power outage.

5.7.1 Putting the PlasmaQuant MS into standby mode

NOTICE

In emergency shutdown situations, press the plasma off button (the orange button on the side panel of the instrument). Do not use the plasma off button for routine plasma shutdown.

NOTICE

If the exhaust unit is the same for the fore-line roughing pump as for the PlasmaQuant MS, the exhaust unit must be operated even in standby mode to avoid pollution caused by oil vapors of the pump.

1. Flush the nebulizer and spray chamber thoroughly by aspirating ultrapure water.
2. Click the [PLASMA] button on the Main Toolbar, or choose PLASMA OFF from the ACTIONS menu, or press [F4] to turn off the plasma.
3. Release the pressure bars and unhook the pump tubing from the grooves at one end.

5.7.2 Complete shutdown of the PlasmaQuant MS (Power Off)

1. Flush the nebulizer and spray chamber thoroughly by aspirating ultrapure water.
2. Click the [VACUUM] button on the Main Toolbar, or choose VACUUM OFF from the ACTIONS menu, or press [F6] to shut down the plasma and the vacuum system.
   
   The vacuum chambers are brought to atmospheric pressure by initiating the venting sequence, which shuts down the vacuum system components and vents the vacuum chambers with argon gas.
   
   This process will take approximately 10 minutes.
3. Turn off the gas supply to the instrument, including iCRC gases.
4. Turn off the cooling water supply to the instrument.
5. Release the pressure bars and unhook the pump tubing from the grooves at one end.
   
   ✓ It is now safe to turn off the power to the PlasmaQuant MS and to shut down the exhaust unit.
Optimizing hardware

There is a difference between Hardware Optimization and Method Optimization. The information contained in the following section refers to parameters required to make the PlasmaQuant MS run at peak efficiency. These parameters are independent of any specific analytical method and are referred to as Hardware Optimization.

Section 7 refers to individual worksheets created to run a particular analysis/sample matrix, which may differ from the general optimization created for Hardware Optimization.

The following optimization routines are available:

- Torch alignment
- Mass calibration
- Peak resolution and trim
- Detector voltage
- Detector attenuation

All of these hardware optimization routines are carried out from the various tabs of the INSTRUMENT window. They all use the same default worksheet (except for Detector Attenuation) and require the PlasmaQuant MS tuning solution. All of these functions must be calibrated in order for the instrument to operate properly.

The optimization routines are to be repeated on a regular basis, especially after maintenance has been done (see section "Maintenance intervals" p. 97). It is important that the instrument be running (scanning) for at least 15 minutes so it is fully warmed up before doing any of these optimizations.

In order to ensure proper function and effective analysis, you must:

- Calibrate the hardware (section 6)
- Optimize worksheet settings (section 7)

Because hardware calibration requires worksheets and worksheet optimization requires calibrated hardware, it can be confusing to know where to begin. The key thing to remember is that during set up, as long as there is enough signal for the automated operations to function, the instrument does not need to be at optimal performance.

The instrument software contains several default worksheets for instrument set-up. In addition, specific conditions used for the instrument during final testing are included in the shipping documents. The service engineer of Analytik Jena will have started with these settings to test and install your instrument, and may possibly have modified them further for best performance. Use these default worksheets to calibrate the hardware.

After you have the hardware calibrations done, you can then optimize your worksheet settings for the best analytical performance.
6.1 Instrument Automated Setup

The ASpect MS can automatically perform plasma alignment, resolution and trim and mass calibration routines.

All routines use the same default System Setup-worksheet: System Setup.msws. They require the 1 µg/L (1 ppb) tuning solution.

Some customers use the instrument automated setup as a daily start-up of the PlasmaQuant MS because you can add to the routine that the plasma is automatically ignited and the system is warmed up.

1. Click the arrow next to the INSTRUMENT icon on the Main Toolbar and select INSTRUMENT AUTO-SETUP to open the INSTRUMENT AUTOMATED SETUP window. Alternatively select WINDOW ➤ INSTRUMENT AUTO-SETUP.

2. Select the setup tasks you would like to perform by selecting the appropriate check boxes in the TASK SCHEDULE / NAME column.

3. If desired, you can modify the task frequency and autosampler settings by highlighting a task and clicking the [EDIT] button.

4. Select the OPEN REPORT AT COMPLETION check box to preview and print a report at the end of the setup.

5. Click the [START] button to start the initialization process. The area at the top of the window will display the current task, and the estimated time left.

If you need to stop the set-up process, click the [CANCEL] button.

If all selected tasks passed, the instrument is ready to analyze your samples and you can close the INSTRUMENT AUTOMATED SETUP window.

6.2 Torch alignment

It is important to ensure that the torch axis is perfectly aligned on the axis of the sampler cone orifice for optimal signal efficiency. This should be done every time a torch is installed or disturbed (e.g., moved aside to change/clean the cones).

It is a common practice to do this following routine once a week. It only takes about five minutes to complete.

When done automatically, the best XY position found is stored by the instrument until the next adjustment. The peak is found by summing all of the enabled isotopes together and then selecting the location of the maximum of this signal. This means that sometimes the selected peak may not be coincident with the maxima of the largest signal scan present.
1. Click the arrow next to the Instrument icon on the Main Toolbar and select INSTRUMENT SETUP to open the INSTRUMENT window. Alternatively select WINDOW ▶ INSTRUMENT SETUP.

2. On the INSTRUMENT window, click the PLASMA ALIGN tab.

3. When the instrument is ready, aspirate the 1 µg/L (1 ppb) tuning solution in time scan mode as described (see section “Warming up the PlasmaQuant MS” p. 56) and wait until the signal has stabilized.

4. Click [STOP].

5. Select the AUTOMATIC ALIGNMENT checkbox directly above the SCAN TYPE menu.

6. Click [START]. The instrument scans horizontally across the interface, then vertically, then horizontally again. When finished, the instrument finds and stores the optimum XY position for maximum signal.

6.3 Peak resolution and trim

The Resolution and Trim optimization routine correctly positions the lightest and the heaviest isotopes in the calibration solution. Furthermore, the routine ensures that the peaks have the smallest possible overlap at maximum signal intensity. The optimal signal width is determined at 5 % peak height. Both, the peaks for high masses and for low masses must be within ±0.05 amu of the target peak width.

The optimization routine allows selecting the elements for low and high masses. By default, the selected low mass is 9Be and the selected high mass is 208Pb for devices with and without AMR option. For devices without AMR option it is possible to use 232Th as an alternative high mass. Note: The default settings are restored when restarting the software.
After changing the resolution and trim settings, you must redo the mass calibration to set the position and resolution of the remaining spectrum.

Resolution and trim should be checked routinely once a month and whenever mass calibration does not give satisfactory results for peak widths. Resolution and trim should also be checked any time after the PlasmaQuant MS power has been off. Generally, if the mass calibration routine passes and finds satisfactory results for all of the requested peaks, the resolution and trim are okay and do not need adjustment.

If the optimization routine fails refer to section "Troubleshooting" p. 127.

1. Aspirate the 1 µg/L (1 ppb) tuning solution.
2. On the INSTRUMENT window, click the RESOLUTION AND TRIM tab.
3. Ensure that the RESOLUTION (AMU) box is set to 0.80.
4. Select the elements $^{9}$Be and $^{208}$Pb (default settings) from the LOW ISOTOPE and HIGH ISOTOPE list.
5. Click [START].
6. Select the sample introduction mode (manual, autosampler) in the dialog box and click [READ].

✓ The system automatically selects the optimum peak widths and positions.
6.4 Mass calibration

To calibrate, the software finds and identifies the peaks across its operating mass range. Mass calibration is done using the tuning solution supplied with the instrument; it contains a series of isotopes across the mass range (3-260 AMU). The software finds these expected peaks, and can then extrapolate all other peak positions in the mass range from these known values.

The isotope with the highest mass in the calibration solution is $^{208}$Pb. Devices with AMR option only allow calibrating the masses up to $m/z = 230$, since the resolution for $m/z > 230$ amu is greater than 2 amu. For devices without AMR option it is possible to order a calibration solution which contains $^{232}$Th as the isotope with the greatest mass. The user can set the isotopes to be considered in the system setup worksheet System Setup.msws.

A mass calibration should be done every time the vacuum system is re-started or about once every week. Some regulatory agencies (i.e., U.S. EPA) may require a mass calibration to be performed daily. Be sure to know what your requirements are before starting analysis. If mass calibration fails refer to section "Troubleshooting" p. 127.

1. Aspirate the 1 $\mu$g/L (1 ppb) tuning solution.
2. On the INSTRUMENT window, click the MASS CAL tab.
3. When you do a mass calibration after a resolution and trim: Click the [DEFAULTS] button to base the mass calibration on the values of the previous resolution and trim.
4. Click [START].
5. Select the sample introduction mode (manual, autosampler) in the dialog box and click [READ].

✓ The instrument automatically calibrates the quadrupole electronics by identifying selected peaks in default positions and then stores these values.

Fig. 29 Mass calibration
6.5 Detector voltage

Over time, and with continued use, the detector “ages” and requires increased voltage to produce the same signal level from a given concentration of sample. Check the detector voltage weekly and keep the voltage set to the optimum.

The software scans the detector voltage across the specified range, and recommends the ideal set point. When the detector voltage nears its maximum setting of 4 kV, the detector needs to be replaced.

If you do a detector scan and the new recommended voltage is within ~200 V of the previous setting, there is no need to change it. You can also repeat the detector scan more than once to ensure the set point is reproducible. Make note of the current detector voltage set point before doing a scan, so you can return to that if the software chooses a slightly different value.

Fig. 30 Detector voltage calibration

If the From/To voltages are too close together or too far apart, an error message will be generated. There must be enough scan range to create an S-shaped curve without over-ranging, and the From/To voltage ranges may need to be adjusted. Typically, as the detector ages, the voltage range needs to be changed to obtain an accurate scan.

1. Aspirate the 1 µg/L (1 ppb) tuning solution.
2. On the INSTRUMENT window, click the DETECTOR SETUP tab.
3. Ensure that NONE is selected in the ATTENUATION MODE drop-down menu for the manual mode.
4. Set the DWELL TIME for 50,000 µs.
5. Make a note of the present DETECTOR VOLTAGE. You need to compare this value to the recommended voltage in a later step.

6. Click [START].

The PlasmaQuant MS scans the detector voltage across the scan range shown in the FROM and TO boxes in the lower-left (e.g. from 1500 to 3500 Volts).

When the scan is finished, the software calculates a curve-fitting algorithm on the signal obtained, and determines the recommended operating voltage.

7. Click [OK] to display the recommended voltage in the DETECTOR VOLTAGE box at the bottom of the display.

8. If you want to change the detector voltage to the recommended setting, click APPLY. Generally, if the recommended voltage is >200 V different than the previous setting, you should update the detector voltage to the new recommended setting and re-do the attenuation if applicable (see Chapter 9 for more information on detector attenuation procedures).

### 6.6 Detector attenuation

The detector operates across a wide dynamic range (11 orders of magnitude) by attenuating high-level signals so they are always within its operating range. The attenuation system must be calibrated by measuring low and high concentrated standards of every element (isotope) that is to be analyzed.

The attenuation factors should be checked routinely once or twice a year. Every time the detector operating voltage is changed, the attenuation factors must be confirmed as well. Attenuation factors are stored independently of any worksheet. After the attenuation values have been created for a specific detector voltage, they can then be applied to any sample matrix or condition set.

A detailed procedure for calibrating the detector for extended range mode (attenuation) is found in section 9.

![Fig. 31 Setting up detector attenuation](image-url)
7 Method development

Before running any samples, an analytical protocol, which will be referred to in this documentation as a "Method", must be developed. This method defines the software and hardware parameters used during data acquisition for the elements/isotopes of interest in the samples to be measured. A brief summary of method development is presented here. For more complete details, refer to the software help.

Method development involves the following topics:

- Create new worksheet
- Select elements and isotopes
- Calculate isotope ratios
- Optimize the method settings
- Set up calibration standards
- Enter scan settings
- Configure sampling settings
- Configure QC tests
- Enter notes and save method parameters

After method development a sequence must be developed. It contains information on your sample parameters (labels, weights/volumes, etc.). Access the sequence page by selecting the SEQUENCE tab from the main page of the worksheet. To run an analysis click the [RUN] button on the toolbar of the main page. For further information on developing a sequence and running an analysis see the software help.

7.1 Create new worksheet

The ASpect MS software uses a single file structure for all data files. Each electronic file (referred to hereafter as a "worksheet") contains all method settings, sequence and sample names, data, and calibrations, all stored together. The files are indicated with the *.msws file extension in the Microsoft Windows file system.

1. Click on NEW in the FILE menu or click on [WORKSHEET] ▶ [NEW] in the Quick Start menu or click on the corresponding icon in the icon bar.
2. Enter a file name for the new worksheet.
3. Click **[SAVE]** to create the new worksheet. The main page of the worksheet is opened.

![Main page of the worksheet](image)

*Fig. 32 Main page of the worksheet*

Consider using a consistent naming/numbering system for worksheet data files, such as the date the worksheet was created, as well as a short description of what that particular worksheet was for. This practice makes it much easier to find, sort, and retrieve old data months later. Use sub-folders to group worksheets together for particular projects or customers.
7.2 Select elements and isotopes

Elements and isotopes can be selected for analysis in the method.

1. From the main page of the worksheet, click [EDIT METHOD].
2. Select the ELEMENT tab.
3. Select each element to be included in the method as analyte, Internal Standard, or semi-quant analyte using the browser window:
   - Click the element in the PERIODIC TABLE.
   - Select ANALYTE, SEMIQUANT, or INTERNAL STANDARD in the ADD ELEMENT window.
   - Click [OK]. The ELEMENT tab information updates to show selected elements.
   - To select specific isotopes, select the element in the ELEMENTS table, and select those isotopes that should be included in the ISOTOPES AND EQUATIONS table.

4. To quick-add elements and isotopes using the PERIODIC TABLE:
   - Right-click the element in the PERIODIC TABLE.
   - From the QUICK ADD AS menu, select the ANALYTE, SEMIQUANT ANALYTE, or INTERNAL STANDARD menu, and select the desired isotope to add.
5. Add an Internal Standard correction for those analytes that require it. Interpolate correction is recommended if more than one Internal Standard is selected.

- Select the INTERNAL STANDARD column for the appropriate analyte.
- Select the Internal Standard correction from the drop-down list.

6. Add or modify an isotope correction equation if applicable.

- Select the element to adjust from the ELEMENTS list.
7.3 Calculate isotope ratios

Slightly different acquisition parameters are required in order to make the best isotope ratio measurements. Typically fast scanning with a longer total acquisition time delivers the best results. Configure the species for isotope ratio measures, if required. This is usually not done in routine analysis, but is available for certain specialized applications.

1. From the main page of the worksheet, click [EDIT METHOD].
2. Select the ISOTOPE RATIOS tab.
3. In each SPECIES column, define the two species for inclusion as a ratio by entering the appropriate element symbols and their m/z values.

If the m/z value is not entered, a default isotope for the selected element is used.
All elemental symbols, masses, signs, and many molecular combinations, such as CeO+ and Ba++, can be entered. For example, to measure the ratio of cerium oxide formation, enter 'CeO+' in the first species column (the software automatically interprets this as $^{140}\text{Ce}^{16}\text{O}^+$) and Ce+ in the second species column. Refer to the software help for more details.

### 7.4 Optimize method settings

Method optimization is used to fine-tune the plasma and ion optics settings, including the gas flows, sampling pump rate, sampling depth, and RF power settings for the plasma, as well as the voltages applied to the ion optics. iCRC gas settings for the interference management can be modified.

All of these settings influence important performance attributes such as sensitivity, interferences, noise, and background levels.

For further information on method optimization, including best practices, refer to section 8.

### 7.5 Set up calibration standards

Calibration standards are used to generate quantitative (or semi-quantitative) measurements of unknown samples by comparing the signal from standards against samples. On the STANDARDS tab of the Method Editor, the calibration mode can be defined and the calibration parameters adjusted.

1. From the main page of the worksheet, click [EDIT METHOD].
2. Select the STANDARDS tab.

![Image of calibration standards setup](Fig. 38 Setting up calibration standards)
3. Select the Analysis Type:
   - Quantitative: Typically used for routine quantitative elemental analysis
   - Semi-Quantitative
   - Standard Additions

4. Type the number of standards included in the analysis in the Number of Standards field.

5. To change the names of the standards:
   - Click the [Edit Standard Labels] button. A pop-up window appears, and the individual names of each calibration standard can be edited here.
   - Specify a new name for each standard. It can be useful to give the standards a descriptive name, indicating which elements are in it, or when it was made.
   - Click [OK] to save changes.

6. For each standard in the Standard Concentrations table:
   - Select a unit of concentration from the drop-down list.
   - Type a concentration value for the standard. It is possible to measure elements with different concentration units and values in the same worksheet.

7. Configure calibration parameters. The availability of calibration parameters is dependent on the analysis type:
   - For a semi-quantitative analysis, no calibration parameters are available.
   - For a standard additions analysis, only Weighted Fit and Correlation Coefficient Limit are available for each isotope.
   - For a quantitative analysis, Thru Blank, Weighted Fit, Max % Error, Reslope Standards, Max % Reslope Change, and Correlation Coefficient Limit are available. For a detailed description of these options, see the software help.

During method development, to ensure that a calibration curve is generated under most conditions, it is recommended to set the Max % error value quite high (e.g., 50 %) or simply exclude the Max % error check (leave this check-box blank), then study the calibration curve to determine the optimal calibration parameter settings.

Some common causes of calibration failure include poor preparation of the standards, incorrect entry of concentration values, blank contamination, and poor standard/s precision.

7.6 Enter scan settings

The scan settings page is used to configure the quadrupole scan mode and parameters. These include dwell time, scans per replicate, replicate per sample, and detector attenuation factors, most of which can be left to their default settings for typical applications. Refer to section 9 for detailed information on detector attenuation factors.

1. From the main page of the worksheet, click [Edit Method].
2. Select the Scan Settings tab.
3. Select the **SCAN MODE**. For details on each **SCAN MODE**, see the software help.

4. Select the scan **SPACING**, or the distance between measurement points on a single mass peak.

   Typical methods use **PEAK HOPPING** scan mode, with the **POINTS PER PEAK = 1** in the **ACQUISITION** settings. In this case, the **SPACING** selection is irrelevant. See the software help for more details about when to select different scan modes.

5. Select the **ACQUISITION MODE**. If **TIME RESOLVED** is selected, type a **SAMPLING TIME**.

6. Type values for each **ACQUISITION** parameter: **POINTS PER PEAK**, **SCANS/REPLICATE**, and **REPLICATES/SAMPLE**. Acquisition time is calculated based on the parameters entered.

7. Set the detector **ATTENUATION CORRECTION**. To apply the detector attenuation factors from a template, click [BROWSE] and select an existing template file.

### 7.7 Configure sampling settings

Sample introduction parameters such as spray chamber temperature, can be set, as well as the uptake delay or rinse time of the autosampler.

Typically, the uptake and rinse delay times of 60 s are sufficient for most applications.
1. From the main page of the worksheet, click [EDIT METHOD].

2. Click the SAMPLING tab.

For details on the options available on this screen, see the software help.

For aqueous samples, to reduce the amount of solvent entering into the plasma, set the spray chamber temperature to 3-4 °C. For organic liquid samples, a lower spray chamber temperature can often be used depending on the properties of the organic solvent.

### 7.8 Configure QC Tests

The QC tests page is used to configure quality control protocols (QCPs) and limits. The QCPs are for quantitative methods only. QC ‘actions’ (what happens when a particular QC test fails) are defined in the SEQUENCE tab of the Method file.

1. From the main page of the worksheet, click [EDIT METHOD].

2. Select the QC TESTS tab.

For details on the options available on this screen, see the software help.
Enter notes and save method parameters

The NOTES page is a text editor. It can be used to enter any additional information about the method.

To include information entered in the NOTES page in the printed report, select the checkbox for METHOD NOTES in the REPORT SETTINGS & EXPORT window: FILE ➔ REPORT AND EXPORT SETTINGS ➔ REPORT FORMAT ➔ METHOD NOTES.

Click the [SAVE] button on the toolbar of the EDIT METHOD window to save the current method file with the new selections.
Method optimization is used to fine-tune the plasma and ion optics settings, including the gas flows, sampling pump rate, sampling depth, and RF power settings for the plasma, as well as the voltages applied to the ion optics. iCRC gas settings for the interference management can also be modified.

All of these settings influence important performance attributes such as sensitivity, interferences, noise, and background levels.

Method optimization is part of a regular “tune up” routine, which is required periodically during normal operation, especially after maintenance has been performed or consumables have been replaced.

The topics covered for method optimization are:

- Instrument initialization and solution preparations
- Manual optimization
- Automatic optimization
- Method optimization troubleshooting

The PlasmaQuant MS is designed for ease of use, with system operations fully controlled by the ASpect MS software. The system can be tuned to suit each individual application simply by adjusting the method parameters through the software, manually or automatically. The auto tuning routines included in the software provide fully-automated optimization of all ion optics parameters (except Pole Bias).

The following analytical performances have been specified for the four models of PlasmaQuant MS product family:

<table>
<thead>
<tr>
<th>Element</th>
<th>Sensitivity</th>
<th>PlasmaQuant MS</th>
<th>PlasmaQuant MS Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>Be, Mg, Co, Ba, Ce, In, Pb</td>
<td>1 µg/L</td>
<td>1 µg/L</td>
<td></td>
</tr>
<tr>
<td>Sensitivity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>⁹Be</td>
<td>&gt;2,0 \times 10⁴ c/s</td>
<td>&gt;2,5 \times 10⁴ c/s</td>
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<tr>
<td>¹¹⁵In</td>
<td>&gt;0,5 \times 10⁸ c/s</td>
<td>&gt;0,8 \times 10⁸ c/s</td>
<td></td>
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<tr>
<td>²⁰⁸Pb</td>
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<td>&gt;3,15 \times 10⁵ c/s</td>
<td></td>
</tr>
<tr>
<td>²³²Th (without AMR option)</td>
<td>&gt;0,3 \times 10⁶ c/s</td>
<td>&gt;0,5 \times 10⁶ c/s</td>
<td></td>
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<tr>
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Method optimization

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<td>1 µg/L</td>
</tr>
<tr>
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<td>1 µg/L</td>
</tr>
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<td>9Be</td>
<td>&gt;3,5 · 10^4 c/s</td>
<td>&gt;5,0 · 10^4 c/s</td>
</tr>
<tr>
<td>115In</td>
<td>&gt;1,1 · 10^6 c/s</td>
<td>&gt;1,5 · 10^6 c/s</td>
</tr>
<tr>
<td>208Pb</td>
<td>&gt;4,5 · 10^5 c/s</td>
<td>&gt;5,8 · 10^5 c/s</td>
</tr>
<tr>
<td>232Th (without AMR option)</td>
<td>&gt;0,7 · 10^6 c/s</td>
<td>&gt;1,0 · 10^6 c/s</td>
</tr>
</tbody>
</table>

Doubly-charged ratio 138Ba++/138Ba+ <3 % <3 %

Oxide ratio 160Ce16O/160Ce <2 % <2 %

Background m/z = 5 <0,7 c/s <1 c/s

8.1 Instrument initialization and solution preparations

Before starting the method optimization, check the following:

1. Verify that the PlasmaQuant MS is warmed up and set up properly. See section “Optimizing hardware” p. 58 for details.
   - Verify the torch alignment.
   - Verify the mass calibration settings.
   - Verify the mass resolution settings.
   - Verify detector settings.

2. Prepare the tuning solution:
   - The standard tuning solution is required when using the auto optimization routine. Alternatively, a user-defined tuning solution can be used when tuning the instrument manually.
   - In general, the concentration of a tuning solution should not exceed 1 µg/L (1 ppb) of each analyte of interest and should be freshly prepared in a clean environment.

3. Proceed to section 8.3 for automatic optimization or section 8.2 for manual optimization.

8.2 Manual optimization

8.2.1 Copy and paste optimization settings

If possible, it is recommended to use "known well" settings. If there is an existing worksheet that has settings that result in good sensitivity and stability, those settings can be copied to begin the optimization process. If there are no worksheets to use, the system setup worksheet or factory test records supplied with the instrument can be used as initial settings.

Manually entering instrument settings into a worksheet can be a time-consuming process. To copy from an existing worksheet:
1. Open the existing worksheet and select the Optimization tab.
2. Use the mouse to highlight the optimization settings.
3. Right-click the highlighted area and click COPY. The highlighted optimization settings are stored on the computer’s clipboard.
4. Close the method editor.

![Fig. 42 Copying optimization settings](image)

5. Create a new worksheet, or open an existing worksheet that you would like to modify. Select the Optimization tab.
6. Use the mouse to drag a rectangle over the optimization settings. They will be highlighted, as before.
7. Right-click the highlighted area and click PASTE.
8.2.2 Scan settings for method optimization

The Scan Setup window is opened by clicking the [TIME SCAN SETUP] button on the OPTIMIZATION tab. The default settings are shown below for this window (using several elements in the tuning solution to monitor sensitivity and interferences); however the isotopes and dwell time can be adjusted for specific applications.

![Default settings in the scan setup window](image)

In the Scan Setup window, add the isotopes (or ratios) of interest to be used in the time scan, and/or delete any unwanted isotope species. Reset the time scan display (color) and/or change the DWELL TIME, if required. Then close the Scan Setup by clicking [OK].

You can also adjust the WINDOW SIZE and STORAGE RANGE settings to define how long an interval of time will be displayed in the TIME SCAN window, and how far back in time the instrument will store the time scan when it is running. This can be very useful when adjusting settings manually, by scrolling backwards to see how the current signal compares to earlier adjustments.

8.2.3 Perform manual method optimization

Manual optimization is performed by acquiring data in real time, adjusting instrument parameters in the ASpect MS software, and observing the effect those changes have on the sensitivity and stability of the signals.

It is recommended to begin with the parameters identified as having the most effect on performance, such as sheath and nebulizer gas flow and voltages applied on the ion optics lenses.

1. Start the time scan by clicking [START] on the OPTIMIZATION page.
2. Present a tuning solution containing the analytes to be tuned.
3. Click [READ].
4. Wait for the solution to reach the nebulizer and for the spray chamber to stabilize.
5. Slightly adjust the argon gas flow rates, mainly sheath/nebulizer gas, RF power, and sampling pump rate to obtain a low oxide ratio (<2 %) and optimum sensitivity for each isotope of interest.
6. Slightly adjust the voltages applied to ion optics to achieve the required sensitivity for each isotope of interest.

When close to optimum, any further changes to the ion optic settings will typically begin to bias the sensitivity towards the low-mass or high-mass element.

As this is done, monitor the oxide ratio and doubly-charged ratio to make sure they all meet performance requirements (see Method optimization p. 75).

If the oxide ratio is too high, slightly adjust the sheath/nebulizer gas flow or the peristaltic pump speed to reduce it.

Changes applied to the ion optics will have very little influence on the oxide ratio. The main influencing factors on the proportion of oxides are the sheath gas flow/auxiliary gas flow, the plasma conditions (RF power) and the pump speed.

7. Click the [SAVE] button or select SAVE from the FILE menu to save the parameters.

8.3 Automatic optimization

Included in the ASpect MS software are several auto-tuning routines, which allow the optimization of the ion optics, based on the factory's specifications. Using the auto-tune functions will greatly simplify the operation of the PlasmaQuant MS and always ensure it is operating at peak performance.

During an auto optimization, the results for each criterion and overall response can be monitored visually. At the end of optimization, the best settings can be transferred automatically to the Method of a current worksheet. Alternatively, the auto optimization can be stopped at any time if the settings found are satisfactory, and these settings are saved as the "best-so-far" settings.

Before starting the method optimization of the ion optics, prepare a 1 µg/L (1 ppb) tuning solution, (containing Ba, Be, Ce, Co, In, Pb and Mg). The tuning solution is required when using the Auto-Optimization feature in standard or high performance mode. The ion optics auto-optimization routine in iCRC mode requires a solution of 5 µg/L (5 ppb) As, 20 µg/L (20 ppb) Sc and 20 µg/L (20 ppb) Y in 1 % HNO₃ (no HCl).

8.3.1 Copy and paste optimization settings

If possible, it is recommended to use "known well" settings. If there is an existing worksheet that has settings that result in good sensitivity and stability, those settings can be copied to begin the optimization process. If there are no worksheets to use, the system setup worksheet or factory test records supplied with the instrument can be used as initial settings.

For information on copy and paste, see section "Copy and paste optimization settings" p. 76.
8.3.2 Run automatic optimization

1. Select an optimization routine from **WINDOWS > OPTIMISE ION OPITCS**.

2. Verify that the selected optimization routine is appropriate. There are routines for normal and high sensitivity and for the iCRC mode. The auto optimization window appears after selecting an optimization routine.

3. Select **START** from the **OPTIMIZE** menu or press [SHIFT+F8].
4. Present a tuning solution.
5. Allow the solution nebulization to stabilize, click [READ].
6. Select one of the three tabs during the optimization to view optimization details.
   - **VISUAL**: Shows overall response to the calibration.
   - **GRAPHS**: Shows the response of each individual criterion.
   - **BEST**: Shows the best settings and responses so far.

   The automatic optimization ends when the best settings are found or the maximum time is reached (20 minutes for ion optics, 15 minutes for plasma optimization). Optimization can also be stopped early; the best settings found to that point will be used.

7. Close the **OPTIMIZATION** window. A prompt appears, asking to replace current parameter settings with the best settings. Click [YES] to accept the settings; click [NO] to ignore the optimization settings.
8. Click [SAVE] or select **SAVE** from the **FILE** menu to save the method.
8.4 Optimize the iCRC gas flows

When running in iCRC-He or iCRC-H₂ mode the gas flow rates need to be optimized to ensure best analytical results. The amount of the iCRC gas required to remove the interferences may vary, depending on the type of samples and interfering ions. The use of more iCRC gas could also result in a loss of analyte sensitivity due to excessive loss of ion energy in collisions with the iCRC gas. Hence, care needs to be taken when adjusting the gas flow rate. Do not use more iCRC gas than necessary; otherwise the analyte sensitivity will be reduced.

In general, hydrogen gas is used to remove plasma based interferences, such as $^{40}\text{Ar}^{16}\text{O}^+$, $^{40}\text{Ar}^{35}\text{Cl}^+$, and $^{40}\text{Ar}^{40}\text{Ar}^+$. Helium gas is used to remove sample/matrix based interferences, such as $^{35}\text{Cl}^{16}\text{O}^+$ and $^{35}\text{Cl}^{16}\text{O}^{+}\text{H}^+$.

When should you optimize the iCRC gas flows?
- When analyzing any new and complex sample matrix
- After any routine maintenance
- 100 mg/L Analytik Jena Internal Standard Solution (containing Li, Sc, Y, In, Tb, Bi, prepared in 5 % HNO₃)
- Solution A (prepared from Analytik Jena Internal Standard Solution with 10 µg/L Li, Sc, Y, In, Tb, Bi), used for iCRC gas flow optimization
- Solution B (prepared from Analytik Jena Internal Standard Solution with 10 µg/L Li, Sc, Y, In, Tb, Bi + analytes of interest, e.g. 1 µg/L V, Cr, Fe, As, Se), used for iCRC gas flow verification

Solution A and B are prepared from the Internal Standard Solution in a mixed acid matrix of HNO₃ and HCl (1 % of each).

Check that the iCRC gases (H₂ and/or He) are connected properly, and ensure the gas supply is switched on.
- Select ACTIONS > iCRC GAS SUPPLY PURGE to verify the iCRC gas system is ready.
- Ensure the instrument has been warmed up for 15 minutes before starting the optimization procedure. During the warm-up period, a time scan should be run to ensure that the quadrupole is scanning.

**Optimization**

1. Open a system setup worksheet, or create a new worksheet. Click on [EDIT METHOD] and select the analytes/isotopes of interest from the ELEMENT page.

2. Go to the OPTIMIZATION page by clicking on the OPTIMIZATION tab in EDIT METHOD window and tune the instrument by adjusting the ion optics and plasma settings. Alternatively, you can copy all (or partially) the method parameters from an existing worksheet to a newly created worksheet.

3. Open the SCAN SETUP window by clicking [TIME SCAN SETUP] on the OPTIMIZATION page. Set up reference and interference isotopes to be used for the iCRC-gas flow rate optimization (see table below). E.g. for $^{75}\text{As}$ set $^{89}\text{Y}$ as a reference ion and $^{40}\text{Ar}^{35}\text{Cl}^+$ as interfering ion.

Also set up the ratio between reference and interference ion, i.e. $^{89}\text{Y}/^{40}\text{Ar}^{35}\text{Cl}^+$, to be monitored as a signal to background level during the optimization.

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Interference</th>
<th>Reference</th>
<th>Recommended iCRC gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{51}\text{V}^+$</td>
<td>$^{35}\text{Cl}^{16}\text{O}^+$</td>
<td>$^{45}\text{Sc}^+$</td>
<td>He</td>
</tr>
<tr>
<td>$^{52}\text{Cr}^+$</td>
<td>$^{40}\text{Ar}^{12}\text{C}^+$, $^{35}\text{Cl}^{16}\text{O}^+\text{H}^+$</td>
<td>$^{45}\text{Sc}^+$</td>
<td>He or H₂</td>
</tr>
<tr>
<td>$^{56}\text{Fe}^+$</td>
<td>$^{40}\text{Ar}^{16}\text{O}^+$</td>
<td>$^{45}\text{Sc}^+$</td>
<td>H₂</td>
</tr>
<tr>
<td>$^{75}\text{As}^+$</td>
<td>$^{40}\text{Ar}^{35}\text{Cl}^+$</td>
<td>$^{89}\text{Y}^+$</td>
<td>He or H₂</td>
</tr>
<tr>
<td>$^{78}\text{Se}^+$</td>
<td>$^{40}\text{Ar}^{38}\text{Ar}^+$</td>
<td>$^{89}\text{Y}^+$</td>
<td>H₂</td>
</tr>
<tr>
<td>$^{80}\text{Se}^+$</td>
<td>$^{40}\text{Ar}^{40}\text{Ar}^+$</td>
<td>$^{89}\text{Y}^+$</td>
<td>H₂</td>
</tr>
</tbody>
</table>

Click [OK] to close the Scan Setup window.

4. Start the time scan in the optimization page by clicking [START] and at the prompt, present the iCRC tuning Solution A.

Monitor the sensitivity changes in the time scan graph (in the Optimization window), allowing time for the solution to reach the nebulizer and stabilize.

5. Turn on the skimmer gas by selecting an appropriate gas source (selections from OFF, H₂ or He) in the iCRC parameters area.

6. Adjust the iCRC skimmer gas flow rate manually using the up and down arrows to achieve the optimal sensitivity ratio between the reference and interference.

Always monitor the background (or interference) level, and make sure there is no significant increase in the background signals. The background signal measured in Solution A should be less than 100 c/s.
Once an optimal flow rate is determined and set, you can further enhance sensitivity by re-tuning the instrument's ion optics parameters to achieve the highest possible sensitivity for each reference isotope in iCRC mode. For more information on auto-optimization of the ion optics in iCRC mode see section “Automatic optimization” on page 79. Note that the auto-optimization routine requires a solution of 5 µg/L (5 ppb) As, 20 µg/L (20 ppb) Sc and 20 µg/L (20 ppb) Y in 1% HNO₃ (no HCl).

7. Change the iCRC tuning solution from Solution A to Solution B, without stopping the time scan, and allow time for the signal/nebulization to stabilize.

Then monitor the net signal changes between the two tuning solutions for the analytes of interest, such as ⁵¹V⁺, ⁵²Cr⁺, ⁵６Fe⁺, ⁷⁵As⁺, ⁷⁸Se⁺ and ⁸⁰Se⁺, etc. This can be easily done by moving the mouse cursor over the graph and reading off the X, Y data displayed at the top. If the sensitivity for a selected analyte is too low, or the background level is too high, then repeat the ion optics optimization.

8. Once the optimal iCRC conditions have been found, save the parameters by clicking the [SAVE] icon or selecting SAVE from the FILE menu in the EDIT METHOD window, then exit EDIT METHOD, and start/run the sample analysis worksheet.

8.5 Method optimization troubleshooting

If sensitivity is much lower than expected and no significant changes are observed when changing the sheath/nebulizer gas flow and/or the ion mirror lens settings, then check the following:

- Inspect the sample introduction system and ensure that the tuning solution is pumped into the spray chamber correctly and the solution waste from the spray chamber is drained out properly.
- Make sure that a correct tuning solution is used.
- Check that the detector voltage is set up correctly (accessed from the INSTRUMENT/DETECTOR SETUP page).

If you cannot achieve a low oxide ratio or meet the required sensitivity for some isotopes, complete the following:

- Perform a torch alignment.
- Prepare a fresh tuning solution.
- Check the spray chamber temperature setting (accessed from the SAMPLING page). When changing the temperature setting, wait for at least 10 min to allow temperature stabilization.
- Check the mass calibration and mass resolution (if mass calibration failed).
- Try to perform an auto optimization.
- Try cleaning the sampler and skimmer cones (or replacing with new ones).

If performance specifications are not met after running an ion optics auto optimization, check the following:

- Ensure that a correct tuning solution is used: 1 µg/L (1 ppb).
- Start the time scan from the OPTIMIZATION page of the Method Editor. Slightly change the voltage for the Entrance Lens (±5V) and Fringe Bias (±0.5V).
If there are not significant improvements in the sensitivities, then check the next point; otherwise run the ion optics auto optimization again.

- Run a plasma auto optimization by selecting a plasma optimization routine during auto optimization. Then re-run the ion optics optimization.

- Double check the instrument setup by running the plasma alignment, mass calibration, and mass trim (if mass calibration failed), and then re-run the ion optics auto optimization.
9 Detector calibration

The PlasmaQuant MS features a unique all-digital extended dynamic range detector. If the option of auto attenuation is selected, the ASpect MS software automatically chooses a suitable attenuation mode for the detector. The auto attenuation offers a wide calibration range with the lowest possible detection limit. When the detector signal is low, the software automatically turns the attenuation off. This gives the highest possible sensitivities for the analytes at a low concentration level, achieving the lowest possible detection limit.

Setup of attenuation factors covers these topics:
- Attenuation Modes
- Instrument Initialization and Solution Preparations
- Detector Calibration Worksheet
- Scan Settings for Attenuation Calibration
- Detector Calibration
- Attenuation Factors on the existing Worksheet
- Attenuation Factors Calibration Troubleshooting

9.1 Attenuation modes

Attenuation of the detector in the PlasmaQuant MS makes use of a control section and a gain control as illustrated above. The gain control sets the voltage on the dynode that is known as the control section of the detector. By modifying the response of the control section dynode, the number of electrons generated by it when it is struck by incoming electrons can be modified. There are three different voltage settings that can be applied to the control section:
- No attenuation
- Medium attenuation
- High attenuation
There are four attenuation mode settings available for any isotope in a method:

- No attenuation
- Medium
- High
- Auto

Each attenuation mode can be selected on a per mass basis and works best over different concentration ranges for any given isotope. However, with iCRC the use of attenuation modes is limited (see Summary 14).

<table>
<thead>
<tr>
<th>Summary 14</th>
<th>Detector attenuation with and without iCRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto attenuation</td>
<td>Manual attenuation</td>
</tr>
<tr>
<td>without iCRC</td>
<td>✓</td>
</tr>
<tr>
<td>with iCRC</td>
<td>-</td>
</tr>
</tbody>
</table>

Possible attenuation modes:

- No attenuation
- Medium attenuation

When manually choosing medium attenuation mode, the signal in the detector is suppressed, so very low concentrations may not be detected at all. However, a greater concentration of ions can be measured because the signal which may have over-ranged in NONE mode is suppressed by attenuation so that the counts reaching the end of the detector are lower and can now be measured. Similar logic applies for high attenuation mode.

Fig. 48  Linear dynamic range of different attenuation modes
Before any replicate measurements are made for a solution, one very short pre-read scan (100 µs) is performed using maximum attenuation; the detector is least sensitive in this mode. This pre-reading gives an indication of what the counts per second obtained will be for that solution; if a reading is obtained that indicates that the detector will over-range – produce counts above 4x10^6 c/s – then that particular mass will not be scanned for that replicate. The software will then flag that replicate in the associated solution as over-range. This prevents detector damage, and avoids making any measurements in the non-linear region of detector operation.

Prior to using the auto attenuation, you must calibrate/set up the detector attenuation factors for all isotopes or analytes of interest. The DETECTOR ATTENUATION page is designed for the calibration of attenuation factors, and this page can be accessed from the INSTRUMENT window by selecting the DETECTOR ATTENUATION tab.

Check the detector calibration each time the operating voltage of the detector is changed after a detector scan.

Within the DETECTOR ATTENUATION page, you can:

- Calibrate and/or set up the detector attenuation factors
- Display the detector calibration results, including attenuation factors and RSD of the factors
- Show the attenuation factors graphically
- Save the new attenuation factors to your worksheet
- View the attenuation factors from existing worksheets

It is not necessary to perform a detector calibration if the auto attenuation function is not used/selected in your method/worksheet (if you are only ever measuring very low concentrations).

9.2 Instrument initialization and solution preparations

To calibrate the detector attenuation system, you need two attenuation calibration solutions, A and B. Typically these would be multi-element calibration standards, such as those you were going to use for your analysis. The absolute concentration of these solutions is not as important as the ability to generate appropriate signals for the detector. Typically, 1 µg/L (1 ppb) and 50 µg/L (50 ppb) calibration standards work very well, but if you find you get too many over-range error messages when doing the attenuation, then you may need a more dilute Solution B. Ideally, these solutions would contain all the elements you wish to analyze as well as any Internal Standards you may want to use. In reality, it is not always possible to get every desired element into the same solution due to chemical compatibility or stability issues. In cases like this, more than one attenuation calibration can be combined into your final analytical worksheet, or the attenuation factor table can be edited manually.

Before performing a detector calibration, it is very important to check the following:

- Ensure that the PlasmaQuant MS instrument is warmed up and set up properly. Check the torch alignment, mass resolution, mass calibration, and detector settings. Refer to the Aspect MS software help for details on how to set up the instrument either manually or automatically.
- Prepare two detector calibration solutions, i.e., Solution A and Solution B, which must contain all the analytes of interest. Solution A is used to calibrate the medium attenuation factor, and Solution B is used to calibrate the high attenuation factor. To avoid possible detector over-range, it is recommended that the concentration for Solution A be around 1 µg/L and the concentration for Solution B be 50 µg/L. The solution concentration levels for specific analyte/s may vary depending on the sensitivities and the background interferences. A lower concentration may be required for a given isotope/analyte with higher sensitivity or higher background, and vice versa, a higher concentration may be needed for an isotope with lower sensitivity.

9.3 Detector calibration worksheet

To perform a detector calibration, you must use/create a worksheet that is specially designed for the detector calibration task. There is a specific detector calibration worksheet, named DETECTOR CALIBRATION TEST.MSWS, supplied with the software (in the Supplied Worksheet folder). This worksheet, however, only calibrates the attenuation factors for the isotopes/elements presented in the standard tuning solution. You can either modify this worksheet to your needs or create a new detector calibration worksheet.

The following describes some key steps on how to create a detector calibration worksheet. Refer to the software help for details about creating/developing a new ASpect MS worksheet.

Most users measure other elemental isotopes that are not in the supplied worksheet. To do this, you must create a worksheet to use in the detector calibration routine; it should contain all the same isotopes as those intended to be used in a worksheet analysis of unknown samples. One way to simplify the process of creating a suitable worksheet is to create a worksheet that is intended to be used for analysis. After that worksheet has been created successfully and is in a semi-final "ready to run" form (that is, the worksheet is ready to run, except that the attenuation factors are missing), then make a copy of this worksheet (Save As).

The reason for making a copy and using the copy for the detector calibration routine is because worksheet settings need to be slightly different for this routine than those in the worksheet that is used for analysis. A worksheet intended to be used for detector calibration must be checked (and modified if required) so that only one isotope should be chosen per element entry in the ELEMENT page of the METHOD EDITOR.

For example, by default, three isotopes are selected for lead; only one should be selected per each line entry for calibration of the attenuation mode. Refer to the screen capture below, which shows a correct entry for multiple isotopes of lead. This is because factors need to be determined on a per mass basis.
Detector calibration

9.3.1 Scan settings for attenuation calibration

1. Open the SCAN SETTINGS tab.

   This tab is used to set up the scan mode and scan parameters such as dwell time, scans per replicate, replicates per sample, and detector attenuation factors.

2. Configure the scan settings for attenuation calibration:
   - Set PEAK HOPPING mode.
- Set ATTENUATION to HIGH for all isotopes.
- Set the DWELL TIME to at least 50,000 µs.

![Fig. 50 Configuring scan settings for attenuation calibration](image)

3. Open the SAMPLING tab.
4. Set appropriate sample introduction parameters, such as sample uptake delay, spray chamber temperature, and autosampler settings.
5. Save the worksheet by clicking the [SAVE] button.
6. Exit the EDIT METHOD window.

### 9.4 Detector calibration

1. Select the DETECTOR ATTENUATION tab from the INSTRUMENT window.
2. Select the detector calibration worksheet by clicking [BROWSE].
3. Set up the required number of calibrations. Five calibrations are recommended.
4. Click the [START] button to begin a detector calibration.
5. Present required solution A and/or solution B at the prompt.
6. When the calibration is complete, a table is displayed.

7. Review the DETECTOR ATTENUATION CORRECTION FACTORS VIEWER table and verify both attenuation factors (Medium and High) are calibrated for all isotopes of interest. Also verify that a good RSD (<3 %) is obtained for the calibrated attenuation factors.
8. Click [SHOW GRAPH OF THE TABLE] to view a graphical representation of attenuation factors.

![Graphical representation of attenuation factors](image1)

Fig. 53 Graphical representation of attenuation factors

9. Click [SET AS DEFAULT] to set the newly-calibrated factors as the default factors. Click [SAVE] to save the new factors to the current worksheet and as a template for later use.

![Saving attenuation correction factors](image2)

Fig. 54 Saving attenuation correction factors
9.5 Attenuation factors on the existing worksheet

1. After adding isotopes and analytes of interest, open the SCAN SETTINGS tab from the Method Editor and in the ATTENUATION CORRECTION field click [BROWSE].

2. Select the desired attenuation correction factors from the list of FACTOR TEMPLATE on the left-side of the browser window that appears.

3. Click [OK] to apply the factors to the current method.
9.6 Attenuation factors calibration troubleshooting

If no significant sensitivity is observed for selected isotope/s when running the detector calibration, then check the following:

- Inspect the sample introduction system and verify that the detector calibration solution is pumped into the spray chamber and the solution waste from the spray chamber is drained out properly.
- Make sure that a correct detector calibration solution is prepared and used. The solution must contain the isotope/s selected for the attenuation factor calibration.
- Verify that a correct worksheet is selected and re-tune the method parameters (if necessary) to achieve an adequate sensitivity for the selected isotope/s, typically over 10,000 c/s per isotope.

If no detector attenuation factor is calculated for some of the selected isotopes:

- Un-calibrated attenuation factor is often due to a detector over-range. Open the detector calibration worksheet, start the time scan from the method optimization page (WORKSHEET ➤ EDIT METHOD ➤ OPTIMIZATION ➤ START), and ensure that the sensitivity for the isotope of interest is not over-ranged; if required, re-tune the instrument or, if necessary, dilute the appropriate calibration solution. One way to work around this is to temporarily override the maximum count limit the detector will accept without over ranging.
- If the attenuation factors are not set up correctly, there is a possibility that your attenuation results will not be linear for higher concentrations (meaning the results from the instrument will not be correct). At very high count rates, the detector will start to saturate and exhibit curvature as its response falls off the slope – although it should read “over-range” before this occurs. The software assumes the data is always linear when in fact it may not be in this case. You should independently verify the linearity of your working concentration/ standards range when working with higher concentrations.

If the %RSD for some of the factors are poor, typically over 5 %:

- Ensure that the instrument achieved an adequate sensitivity for the selected isotope/s, typically over 10,000 c/s per isotope.
- Make sure the dwell time and scans per replicate are set up properly. It is recommended to use 50,000 µs dwell time per isotope and use 50 scans per replicate. Also, set the number of detector calibrations to be five from the INSTRUMENT ➤ DETECTOR ATTENUATION window.
10 Maintenance and care

This chapter contains all the instructions for care and maintenance which users can and must perform themselves. All maintenance work and repairs beyond this scope must only be performed by service engineers from Analytik Jena or persons authorized by Analytik Jena. To maintain optimum operational performance, the PlasmaQuant MS should be serviced on an annual basis by service engineers from Analytik Jena. Only use replacement parts from Analytik Jena. Laboratory parts required for routine operation can be ordered from Analytik Jena.

Analytik Jena recommends that records of the system operating conditions be maintained. Careful comparison of records can provide valuable clues to identifying and solving problems.

---

**WARNING**

Plasma emits UV radiation and high-frequency electromagnetic radiation which can cause serious eye and skin injuries as well as other health problems.

Therefore, the plasma compartment door must be closed before igniting and operating the plasma. Safety interlocks must not be bypassed!

Before opening the plasma compartment lid or the interface door for maintenance work, always extinguish the plasma from the software.

---

**CAUTION**

The torch compartment and interface, including the cones, are still very hot after the plasma has been extinguished. Contact with these hot surfaces can cause burns.

Therefore, wait 5 minutes after extinguishing the plasma before touching the torch or wear heat-resistant gloves.

---

**CAUTION**

Observe the safety instructions! Any unauthorized interference limits warranty entitlements.

Compliance with these safety instructions is a requirement for error free installation and the proper functioning of your PlasmaQuant MS measuring environment. Always observe all warnings and instructions which are displayed on the device itself or which are displayed by the control program of the PlasmaQuant MS.
## 10.1 Maintenance intervals

The following maintenance tasks must be performed:

<table>
<thead>
<tr>
<th>Maintenance item</th>
<th>Action</th>
<th>Reason, frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Base device</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic device</td>
<td>Clean surface with soft cloth, water or a mild detergent.</td>
<td>Daily</td>
</tr>
<tr>
<td></td>
<td>Clean the air vents with a soft cloth, water or a mild detergent.</td>
<td>Monthly</td>
</tr>
<tr>
<td></td>
<td>PlasmaQuant MS (Q) only: Replace aluminum oxide of the adsorption trap.</td>
<td>Once a year by customer service</td>
</tr>
<tr>
<td><strong>Sample introduction system</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample introduction system</td>
<td>Aspirate ultrapure water.</td>
<td>At the end of each analysis</td>
</tr>
<tr>
<td>Drain vessel</td>
<td>Check the waste level.</td>
<td>Daily</td>
</tr>
<tr>
<td></td>
<td>Empty the drain vessel.</td>
<td>If necessary</td>
</tr>
<tr>
<td><strong>Torch</strong></td>
<td>Remove and clean.</td>
<td>Weekly</td>
</tr>
<tr>
<td></td>
<td>Check for cracks or deformation caused by overheating.</td>
<td>Weekly</td>
</tr>
<tr>
<td></td>
<td>Replace the torch.</td>
<td>If necessary</td>
</tr>
<tr>
<td></td>
<td>Align the plasma.</td>
<td>Weekly</td>
</tr>
<tr>
<td></td>
<td>Check the plasma and auxiliary gas tubing for wear.</td>
<td>Weekly</td>
</tr>
<tr>
<td><strong>Spray chamber</strong></td>
<td>Remove and clean.</td>
<td>Monthly</td>
</tr>
<tr>
<td><strong>Nebulizer</strong></td>
<td>Remove and clean.</td>
<td>Monthly</td>
</tr>
<tr>
<td><strong>Transfer tube</strong></td>
<td>Remove and clean.</td>
<td>Monthly</td>
</tr>
<tr>
<td><strong>Peristaltic pump</strong></td>
<td>Clean with a soft cloth, water or a mild detergent.</td>
<td>If necessary</td>
</tr>
<tr>
<td><strong>Peristaltic pump tubing</strong></td>
<td>Inspect pump tubing.</td>
<td>Daily</td>
</tr>
<tr>
<td></td>
<td>Replace pump tubing.</td>
<td>If it has lost elasticity. As a general guide sample tubing should be replaced after 20 hours of continuous use.</td>
</tr>
<tr>
<td><strong>Interface</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Induction coil</td>
<td>Inspect the state. Check for deformation.</td>
<td>Monthly</td>
</tr>
<tr>
<td><strong>Sampler cone</strong></td>
<td>Remove and clean.</td>
<td>Daily (for high matrix samples) or weekly</td>
</tr>
<tr>
<td><strong>Skimmer cone</strong></td>
<td>Remove and clean.</td>
<td>Daily (for high matrix samples) or weekly</td>
</tr>
<tr>
<td><strong>Mass spectrometer system</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass spectrometer system</td>
<td>Perform a mass calibration.</td>
<td>Weekly</td>
</tr>
<tr>
<td><strong>Detector</strong></td>
<td>Check the detector voltage.</td>
<td>Weekly</td>
</tr>
<tr>
<td><strong>Autosampler</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Surfaces</strong></td>
<td>Clean.</td>
<td>Daily</td>
</tr>
<tr>
<td><strong>Collection tray</strong></td>
<td>Remove residue liquid from tray.</td>
<td>If there are residues in the tray</td>
</tr>
<tr>
<td>Maintenance item</td>
<td>Action</td>
<td>Reason, frequency</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>---------------------------------</td>
<td>--------------------------------------------------------</td>
</tr>
<tr>
<td>Sample tubing/cannula</td>
<td>Check that they are free of blockages.</td>
<td>Daily, Blockages can falsify measurement results</td>
</tr>
<tr>
<td>Pump tubing</td>
<td>Check for flexibility and tightness.</td>
<td>Daily, replace if necessary</td>
</tr>
<tr>
<td>Wash cup</td>
<td>Clean.</td>
<td>Weekly</td>
</tr>
<tr>
<td>Water cooler</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coolant tank</td>
<td>Check water level and water condition at the tank. Replenish or replace water.</td>
<td>Weekly If necessary</td>
</tr>
<tr>
<td>In-line water filter</td>
<td>Remove and clean.</td>
<td>Every six months</td>
</tr>
<tr>
<td>Fore-line roughing pump</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model XDS46i</td>
<td>Replace seals.</td>
<td>Annually by service</td>
</tr>
<tr>
<td>Seals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model SV40BI</td>
<td>Check the oil level.</td>
<td>Weekly If necessary</td>
</tr>
<tr>
<td>Oil</td>
<td>Top the oil up.</td>
<td>On a regular basis, either every 12 months or if oil has become dark / gummy.</td>
</tr>
<tr>
<td></td>
<td>Change the oil.</td>
<td></td>
</tr>
<tr>
<td>Exhaust system</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexible exhaust ducting</td>
<td>Check for tears.</td>
<td>Weekly If necessary</td>
</tr>
<tr>
<td></td>
<td>Repair tears.</td>
<td></td>
</tr>
</tbody>
</table>

### 10.2 Cleaning the exterior surfaces

**NOTICE**

Do not use organic solvents or abrasive cleaners to clean the surfaces of the PlasmaQuant MS.

Clean the exterior surfaces of the basic device daily with a damp (not dripping!) cloth. To remove stubborn contamination a mild detergent may be used.

Spots, drops or larger spillages should be removed and cleaned using an absorbent material such as cotton wool, laboratory wipes or cellulose.
10.3 Sample introduction system maintenance

WARNING
Risk of eye and skin injuries due to UV and electromagnetic radiation!

Plasma emits UV radiation and high-frequency electromagnetic radiation which can cause serious eye and skin injuries as well as other health problems. Before removing the glass components of the sample introduction system for maintenance work, always extinguish the plasma from the software.

CAUTION
Risk of injury from breaking glass!

The standard sample introduction system components are made from high purity quartz glass and susceptible to breakage if handled roughly. Always use care when installing, removing, or cleaning these items!

NOTICE
Risk of contamination!

Do not use compressed air to dry the glass components. Compressed air often contains oil vapor and the oil will contaminate the glass components.

It is safe to leave the power to the ICP-MS on when maintaining the glass components of the sample introduction system.

The glass components of the sample introduction system (torch, transfer tube, spray chamber, nebulizer) may require periodic cleaning if extended rinsing does not eliminate contamination. The glass components can be cleaned in almost any solvent or acid bath mixture (except for HF acid) without damaging them. Typically soaking the components overnight in strong acid or detergent followed by extended rinsing in deionized water is suitable. Remove all fittings and connectors from the glassware before soaking them.

All glassware parts except the nebulizer can also be cleaned in an ultrasonic bath as well.
10.3.1 Cleaning the nebulizer

The nebulizer must be cleaned if particles or high concentrations of salt in the samples have clogged it up. An indicator that this has occurred is an increase in the nebulizer gas pressure.

**NOTICE**
Do not hold the nebulizer by the lateral gas inlet and pull on it. There is a risk of breakage!

Do not touch the tip of the nebulizer in order to avoid contamination.

### Removing the nebulizer

Turn off the plasma by clicking on the [PLASMA] button on the main toolbar or pressing [F4] before removing the nebulizer.

1. Release the nebulizer gas connection by uncoupling the line fitting at the gasbox wall.
2. Gently twist the nebulizer to remove it from the spray chamber end cap, being careful not to touch the tip of the nebulizer. The concentric glass nebulizer is fragile and easily broken. Handle it with extreme care.
3. Disconnect the gas inlet tubing.
4. Pull out the tubing connector with the sample capillary from the sample inlet of the nebulizer.

### Cleaning the nebulizer

Wash the nebulizer using the nebulizer cleaning tool. This tool can be ordered from Analytik Jena.

1. Unscrew the nebulizer holder from the syringe and fill the syringe with methanol. Pull the plunger out to the first red O-ring.
2. Screw the nebulizer holder on the syringe.
3. Push the nebulizer with the tip first into the holder until the lateral carrier gas connection comes to rest in the holder groove.

4. Hold the nebulizer cleaning tool over a receptacle and push the plunger into the syringe. The methanol should flow out of both connection pieces.
   To remove stuck particles from the nebulizer cannula, you can increase the pressure by closing the carrier gas connector with a finger. Use the same method to increase the pressure by closing the sample inlet to remove particles from the carrier gas connector.

5. Gently shake the nebulizer cleaning tool to remove the methanol from the nebulizer.

6. Remove the nebulizer from the holder. Shake any remaining methanol from the nebulizer cleaning tool.

7. Place the nebulizer once again in the holder and move the plunger three times quickly in and out to remove the methanol also from the nebulizer.

8. Remove the nebulizer from the holder and rinse it with ultrapure water.

Replacing the tubing

Sample tubing for the concentric nebulizer is supplied as a single unit consisting of a tubing connector with sample capillary.

1. Push the tubing connector into the sample inlet of the nebulizer as far as it will go to minimize the dead space in the nebulizer.
   **Warning!** Excessive force may break the nebulizer and you could cut yourself.
   Always use care when handling the nebulizer.

2. To fit the gas inlet tubing, cut a 14" (350 mm) length of Nalgene 1/8" x 1/4" (3.18 x 6.35 mm) tubing and fit one end over the barbed fitting of the adapter, securing it with the clamp provided. Press the other end of the adapter into place on the side arm of the nebulizer.

3. Attach the insert coupling into the other end of the tubing.

For reinstalling the nebulizer see section "Installation of the nebulizer" on page 45.
10.3.2 Cleaning the spray chamber

The function of the spray chamber is to act as a filter for the sample droplets. Fine droplets go through the spray chamber up to the torch and the larger droplets hit the side of the spray chamber and coalesce to form larger droplets, which then move down the drain tubing to the waste liquid vessel. To provide effective filtering, the surface of the spray chamber must always be clean and free of contaminants.

The plastic end cap on the spray chamber (which holds the nebulizer) contains two O-rings (one that fits around the spray chamber and the other that grips the nebulizer). These should be inspected and replaced periodically.

1. Turn off the plasma by clicking on the [PLASMA] button on the main toolbar or pressing [F4] before removing the nebulizer.

2. Remove the nebulizer from the end cap of the spray chamber (see section “Cleaning the nebulizer” p. 100). Store the nebulizer in a safe place to avoid breakage.

3. Remove the glassware clamp that secures the spherical joint of the spray chamber and the transfer tube.

4. Rotate the mounting arm outward to disengage the spray chamber and transfer tube.

5. Unscrew the two thumbscrews on the upper cover of the spray chamber and lift the upper cover to remove it.
6. Lift the spray chamber from the lower cover.
7. Remove the drain tubing from the spray chamber.
8. Remove the plastic cap from the spray chamber by rotating it.
9. Inspect the two O-rings and replace them if necessary.

**Cleaning the spray chamber**

1. Place the spray chamber in an ultrasonic bath containing a neutral surfactant, for 5 to 15 minutes. Alternatively, soak the spray chamber overnight in in strong acid or detergent.
2. When the spray chamber is clean, remove it from the bath and rinse it thoroughly with ultrapure water.
3. Let the spray chamber dry before reinstalling it in the holder assembly (see section "Installation of the spray chamber" p. 46).
10.3.3 Cleaning the transfer tube

The following instruction shows the steps for cleaning the transfer tube for aerosol dilution. The maintenance of the standard transfer tube is largely identical.

1. Turn off the plasma by clicking on the [PLASMA] button on the main toolbar or pressing [F4].
   Wait for approx. 5 min before touching the glass components in the plasma compartment.

2. Remove the glassware clamp that secures the spherical joint of the spray chamber and the transfer tube.

3. Rotate the mounting arm outward to disengage the spray chamber and transfer tube.

4. Open the plasma compartment lid.

5. While carefully holding the transfer tube, remove the glassware clamp that secures the spherical joint of the transfer tube and the torch.
6. Remove the transfer tube via the opening in the side wall of the torch compartment.

7. With the transfer tube for Aerosol Dilution: Remove the tubing from the transfer tube.

**Cleaning the transfer tube**

1. Place the transfer tube in an ultrasonic bath containing a neutral surfactant for 5 to 15 minutes. Alternatively, soak the transfer tube overnight in strong acid or detergent.

2. When the transfer tube is clean, remove it from the bath and rinse it thoroughly with ultrapure water.

3. Let the transfer tube dry before reinstalling it in the sample introduction system (see section "Installation of the transfer tube" p. 47).
10.3.4 Cleaning the torch

CAUTION

Plasma is extremely hot. Risk of burns! Wait for approx. 5 min after extinguishing the plasma before you dismantle the torch!

During normal operation, deposits may form on the torch that may interfere with the operation of the instrument. Periodically inspect the torch for deposits or stains and clean as required. Weekly cleaning of the torch is recommended to avoid analytical problems.

1. Turn off the plasma by clicking on the [PLASMA] button on the main toolbar or pressing [F4].
2. Open the plasma compartment lid.
3. Remove the clamp that secures the spherical joint of the torch and the transfer tube.
4. Rotate the mounting arm of the spray chamber slightly outward to disengage the transfer tube and the torch.
5. Disconnect the plasma and auxiliary gas tubing from the torch.
   It is not necessary to disconnect the plasma and auxiliary gas tubing from the gas outlets in the plasma compartment.
   Check the plasma and auxiliary gas tubing for wear. Replace the tubing, if necessary.
6. Turn the torch clamp locking knob 90° to release the clamp holding the torch in position and swing the clamp arm clear of the torch.
7. Remove the torch from the torch compartment.
Inspecting the torch

Check the torch for cracks or deformation caused by overheating. You should replace the torch if any part of it is cracked, partly melted, or severely eroded.

Specifically, inspect the torch for:

- Deposits in the injector tube (the innermost tube of the torch, which carries the sample), which could affect sample introduction to the plasma or interfere with analyses.
- Deposits between the intermediate and outer tubes of the torch, which may block gas flow to the plasma, extinguishing the plasma altogether. Partial blockage in this area can cause localized torch overheating.
- Deposits on the end of the outer tube of the torch, which may cause localized torch overheating and lead to deformation of the torch.

Cleaning the torch

WARNING

Nitric acid (HNO₃), hydrochloric acid (HCl), aqua regia and hydrofluoric acid (HF) are all very corrosive and can cause severe burns when they come in contact with the skin.

Always wear appropriate protective clothing when handling these acids. For handling hydrofluoric acid (HF) a face shield is needed.

NOTICE

Hydrofluoric acid is highly corrosive. Repeated or continual use of hydrofluoric acid may cause the walls of the torch to weaken or break.

Always ensure that the torch is completely dry before replacing it in the instrument. Any moisture remaining in the torch will cause difficulties during plasma ignition.

The cleaning requirements for the torch will vary, depending on the type of sample matrix analyzed. It may not be necessary to complete all of the steps below when cleaning the torch.

1. Soak the torch in water to see if any of the deposits will dissolve in water.
2. For more stubborn deposits and stains, soak the torch overnight in aqua regia (concentrated nitric and hydrochloric acid 1:3 by volume).
3. For persistent stains, soak the torch in diluted hydrofluoric acid for a few seconds. Repeat if necessary.
4. Once the torch is clean, rinse it well with ultrapure water and blow it dry with argon or nitrogen.

10.3.5 Replacing peristaltic pump tubing

Check the pump tubing daily before starting work and replace any tubing if it is discolored, no longer flexible or even porous (see the section "Installation of the peristaltic pump tubing" p. 50).
10.4 Interface maintenance

10.4.1 Cleaning the sampler cone

**CAUTION**

Plasma is extremely hot. Risk of burns!
Wait for approx. 5 min after extinguishing the plasma before servicing the interface cones!

**NOTICE**

The tips of the interface cones are fabricated from nickel, so the orifices are fragile. Take extreme care when handling the cones as microscopic defects in the cone tips will have adverse effects on analytical performance.

**NOTICE**

After cleaning, any vacuum component (cones, O-rings) should not be touched with bare hands to minimize contamination of the system. Always wear clean gloves when working inside the plasma interface.

Never use any grease or lubricants on the O-rings.

Do not use compressed air to dry the cones as it often contains oil vapor and the oil will contaminate the cone surface.

The interface cones must be kept clean and free of deposits to ensure optimum performance. How often you clean the cones depends on which samples you analyze. Solutions with a high content of dissolved solids will cause deposits to form more rapidly than solutions with low dissolved solids, so the cones will require cleaning more often.

Removing the sampler cone

The sampler cone is held in place with a threaded retaining ring. A tool is provided to loosen the ring so the cone can be removed.

Fig. 58 Sampler cone in position with retaining ring and sampler cone tool

The sampler cone tool has a spring-locking mechanism so the pins will clip into place on the retaining ring when enough twisting force is applied in either direction.
1. Before opening the interface door, extinguish the plasma from the software by clicking on the [PLASMA] button on the main toolbar or pressing [F4].

2. Allow the interface to cool down for at least five minutes before servicing the sampler cone or wear heat-resistant gloves.

3. Insert the sampler cone tool into the slots provided on the retaining ring.

4. Turn the tool slightly counterclockwise. The spring-loaded clips will click into the holes provided.

5. Rotate the tool further counterclockwise until the retaining ring is free.

6. The retaining ring may sometimes stick into place due to repeated heating/cooling cycles of plasma operation.

   If this is the case, use a large screwdriver or similar tool to gain extra leverage on the cone retainer tool.
7. Press your finger against the bottom tab to help remove the cone from the interface assembly flange.

8. Remove the sampler cone (1) and retaining ring (2) from the interface assembly.

9. There is a single silicone O-ring which fits into a grooved channel behind the sampler cone.

Whenever the cone is removed for maintenance or cleaning, inspect this O-ring for cracks or tears, and replace it if required.

Cleaning the sampler cone

1. Create a paste by mixing Analytik Jena cleaning powder with a suitable quantity of water.

2. Work the paste across the front and rear surfaces of the cone with a damp cloth. Continue to scrub the surface of the cone with the paste until the entire surface is thoroughly clean.

3. Rinse all the paste from the cone.

4. Ultrasonically clean the cone for 10 min in a mixture of 10 % caustic detergent and water.

5. Rinse the cone with ultrapure water. Submerge it in ultrapure water and ultrasonically clean it again for ten minutes.

6. Allow the cone to dry thoroughly before re-installing it into the interface assembly.
From an analytical viewpoint, there is no need to clean the sampler cone clamping ring.

1. Position the sampler cone in the interface.

2. There are three tabs on the cone which have a unique orientation, meaning there is only one way the cone will fit back into position. Rotate the cones until the tabs align and press it into place.

3. Reinsert the retaining ring and tighten it fully with the sampler cone tool. Turn the tool clockwise to fasten the ring.

The retaining ring should be flush with the adjacent surface of the interface casting if it is correctly seated.

If it is not flush, it is likely the O-ring was incorrectly positioned, preventing the cone from being tightened fully into place.

10.4.2 Cleaning the skimmer cone

The skimmer cone is visible once the sampler cone has been removed. It has a smaller and sharper orifice at the tip, which is more fragile and can be easily damaged as a result.
1. Insert the skimmer cone tool into the three slots provided on the cone.
2. Turn the tool counterclockwise and remove the cone from the interface assembly.

3. There are two O-rings on the skimmer cone, a larger one on the outer side and a smaller one on the inner side. Inspect the O-rings for wear and change them if necessary.

Cleaning the skimmer cone

1. Create a paste by mixing Analytik Jena cleaning powder with a suitable quantity of water.
2. Work the paste across the front and rear surfaces of the cone with a damp cloth. Continue to scrub the surface of the cone with the paste until the entire surface is clean. There may remain residual patina on the cone.
3. Rinse all the paste from the cone.
4. Ultrasonically clean the cone for ten minutes in a mixture of 10% caustic detergent and water.
5. Rinse the cone with ultrapure water. Submerse it in ultrapure water and ultrasonically clean it again for ten minutes.
6. Allow the cone to dry thoroughly before re-installing it into the interface assembly.

Replacing the skimmer cone

1. Replace the two O-rings on the skimmer cone if necessary.
2. Reinstall the cone in the interface assembly using the skimmer cone tool. Turn the tool clockwise to fasten the cone.
10.4.3 Cleaning the extraction lenses

Extraction lens 1 and 2 are the first part of the ion optics. Placed behind the skimmer cone they direct the ion beam through the gate valve into the second stage of the vacuum system.

The first extraction lens is visible once the skimmer cone has been removed. The second lens is positioned behind extraction lens 1. The two extraction lenses can easily be removed with the provided retainer tool.

1. Insert the retainer tool into the two slots provided on the extraction lens.
2. Turn the tool clockwise or counterclockwise to remove the extraction lens from the interface assembly.
3. Insert the retainer tool into the two slots provided on the second extraction lens.
4. Turn the tool clockwise or counterclockwise to remove the extraction lens from the interface assembly.
1. Only for heavily soiled lenses: Clean the lens surface using fine grade sandpaper such as grade 800. Alternatively, create a paste by mixing Analytik Jena cleaning powder with a suitable quantity of water.

2. Rinse the lenses with water.

3. Ultrasonically clean the lenses for ten minutes in a mixture of 10 % caustic detergent and water.

4. Rinse the extraction lenses with ultrapure water. Submerse them in ultrapure water and ultrasonically clean them again for ten minutes.

5. Allow the extraction lenses to dry thoroughly before re-installing.

6. Re-install the extraction lenses in the interface assembly using the retainer tool.

10.5 Maintenance of the water cooler

10.5.1 Cleaning the cooling fins

The cooling fins behind the front panel must be checked monthly and cleaned if necessary.

1. Carefully remove the slitted metal sheet from the front. Be careful not to damage the varnish.

2. Remove fluff and dust from the cooling fins using for example a vacuum cleaner. Do not twist the cooling fins.

3. Reinstall the front panel.

10.5.2 Changing the cooling water

**CAUTION**

Take care when handling the biocide. It is corrosive, sensitization possible by skin contact.

**NOTICE**

Danger of damage to the instrument by corrosion or algae growth!

Never operate the PlasmaQuant MS without using the cooling water additive. Warranty and liability claims are excluded for damage resulting from operation without cooling water additive.

**NOTICE**

Trapped air can cause the instrument to register a "water flow failure" condition. Plasma will not ignite. Do not drain the water tank under the minimum water level to keep out air of the cooling water lines.

Change the cooling water yearly. Therefore, rinse cooling water lines repeatedly with the cooling water circulation on. You can have the customer service perform this task as part of the annual maintenance.
**PlasmaQuant MS product family**

**Maintenance and care**

---

**Required equipment**
- Cooling water additive (10 g biocide + 10 g corrosion inhibitor)
- Distilled / demineralized water (σ < 10 µS/cm)
- Beaker (V = 1 L) for mixing the cooling water additive
- Short tubing, olive, bucket to catch the drained coolant

**Starting conditions**
- The water cooler is drained as far as the marking MIN.
- The water cooler is connected to the PlasmaQuant MS.

**Conductivity of the cooling water**
- Optimum conductivity range 100-120 µS/cm
- Target conductivity range 75-150 µS/cm

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1. **Dissolve both bottles of the biocide and corrosion inhibitor in 1 L of distilled / demineralized water.**

2. **Pour about 300 mL of the prepared solution into the water tank:**
   - Open the door at the top of the water cooler.
   - Unscrew the sealing cap from the filling opening of the tank and insert a funnel.
   - Pour the solution into the tank.

3. **Fill the tank with distilled / demineralized water until the MAX level mark is reached.**

4. **Switch on the water cooler. Switch on the PlasmaQuant MS: Start the vacuum system and ignite the plasma.**

5. **Allow the system to run for 10 minutes to rinse the cooling water lines.**

6. **Shut down the PlasmaQuant MS and switch off the water cooler.**

7. **Drain the coolant:**
   - Attach the short tubing to the drain tap (marked with "Drain"). Hold the tubing in the bucket.
   - Open the tap and drain the tank as far as the marking MIN.

   For models without drain tap:
   - At the water cooler remove the inlet connection with the marking "Return". With the tubing olive connect the short tubing to the connection. The valve at the inlet connection closes automatically if no olive is connected.
   - Hold the tubing in the bucket to catch the drained coolant.
   - Drain the tank as far as the marking MIN.
   - Reconnect the tubing to the inlet connection of the water cooler.

8. **Rinse the system once more. Therefore, repeat steps 2-7.**

9. **Fill the rinsed water tank with cooling water:**
   - Pour about 300 mL of the prepared solution into the tank.
   - Fill the tank with distilled / demineralized water until the MAX level mark is reached.
   - Remove the funnel. Seal the filling opening with the screw cap. Close the door at the top of the water cooler.
10.6  Maintenance of the fore-line roughing pump SV40BI

**WARNING**

Vacuum pump oil can be extremely hot if the pump has been running for an extended period of time. Used pump oil may contain residual contaminants from the samples or sample matrix.

Always wear gloves when handling used pump oil, and take appropriate precautions when disposing of it.

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**NOTICE**

Do not mix the pump oil (LVO420) with other oils! The pump oil will immediately harden when mixed with other oils.

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The oil in the forevacuum pump SV40BI should be checked weekly. The pump oil must be changed:

- Regularly every 12 months
- When the oil has become dark brown or black
- When the oil is viscous or resinous

Analytik Jena recommends the following synthetic pump oil: Perfluorinated polyether (PFPE) Leybonol LVO420. Other pump oils are available for highly specialized applications; for more information please contact the Analytik Jena customer service department.

The connection for changing the oil of the pump is located very close to the base of the device. To facilitate maintenance, place the pump about 10 cm above the floor.

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![Forevacuum pump](image)

**Fig. 61**  Forevacuum pump

1. Suction port
2. Drain port with brass cap
3. Inspection window
4. Filler opening with cover
Required equipment:

- 1 L fresh pump oil (Leybonol LVO420)
- Blind flange for intake connector (DN 40 KF) or plastic cap
- 12 mm hexagon socket wrench
- Large screwdriver
- Separate power cord
- Receptacle (flat) for waste oil

There is a spring valve inside the drain port. The oil will not drain until the valve is pressed inwards with a large screwdriver, for example.

1. Turn the pump off and remove the power cable.
2. Remove the vacuum tubing from the suction port of the pump.
3. Remove the brass outer drain cap from the pump.
   The inner spring valve will still be closed at this point.

4. Have a suitable container ready to catch the pump fluid as it comes out.
5. Push the spring valve with a screwdriver inwards about 1 cm. The pump fluid will then start to flow from the drain.
   Removing the fluid filler cap allows the used fluid to drain from the pump faster.
   To completely remove as much old fluid as possible, tilt the pump slightly as the last fluid drains out. Remember the pump is quite heavy.

6. Open the filler cap just above the view port with the wrench.
7. Add 200 mL of fluid. Close the filler cap.
8. Close the suction port with the blind flange.
9. Connect the pump with the mains.
10. Start the pump and run it for about 30 seconds.
11. Stop the pump and disconnect the mains power connection.
12. Drain the pump fluid. Re-fit the outer drain cap.

13. Open the filler cap just above the view port.
14. Add fluid until it is halfway up the window. Do not fill the pump over the mark MAX. The internal exhaust filter would stand in the fluid and it would thus lose its properties.
15. Close the filler cap by hand.
16. Attach the vacuum tubing to the suction port.
17. Connect the pump with the power cable to the power connection on the rear side of the PlasmaQuant MS (12 in Fig. 17 p. 39).
18. Switch on the power switch of the pump. The pump is controlled from the PlasmaQuant MS. The pump will only run when the PlasmaQuant MS is put into operation.
11 Autosampler ASPQ 3300

11.1 Function and setup

The autosampler allows fully automated routine analysis. It can be equipped with three sample racks and two racks each with 6 or 11 special samples, e.g., standards and QC solutions. The following sample racks are available:

<table>
<thead>
<tr>
<th>Rack/number of samples</th>
<th>Cup volume (mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>50</td>
</tr>
<tr>
<td>11 (special samples)</td>
<td>15</td>
</tr>
<tr>
<td>21</td>
<td>50</td>
</tr>
<tr>
<td>24</td>
<td>30</td>
</tr>
<tr>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>60</td>
<td>14</td>
</tr>
<tr>
<td>90</td>
<td>7</td>
</tr>
</tbody>
</table>

The rinse station is installed on the autosampler. A hose pump delivers the rinse solution from the wash bottle into the wash cup – this action cleans the dipped cannula inside and outside. Excess rinse solution is pumped into the waste container during rinsing. The rinse solution for rinsing between samples is also taken from the wash cup. A mains connection supplies operating voltage to the autosampler.
11.2 Installation

Connections

For the use of the autosampler on the PlasmaQuant MS, only the connections described in Fig. 64 are required. All other connections and displays are for service purposes or not in use.
Installing the autosampler

The autosampler is installed next to the PlasmaQuant MS. Between these two instruments 30 cm of clearance is required to allow space for opening the interface door.

**NOTICE**
The autosampler must not be connected to the mains during installation.

1. Place the tray on the autosampler foot and on it the base plate for holding the sample racks.
   In this case, the place for the wash cup must be located at the rear on the left. The base plate is correctly mounted if it fails to move after light shaking.

2. Install the wash cup. Insert the wash cup into the rear left recess and turn it by 90° in a clockwise direction.

3. Fit the racks for standards and QC solutions (1) in the base plate and attach the required sample racks (2).
4. Connect the pump tubing to the lower inlet connector (1a) of the wash cup. Clamp the tubing between two stoppers into the pump with the connection to the wash cup facing upwards. Connect the other end of the pump tubing (1b) with a coupling to the aspiration tubing for the wash solution.

5. Connect the waste tubing (2a) to the upper outlet connector of the wash cup. Clamp the tubing between two stoppers into the pump with the connection to the wash cup facing downwards. Connect the other end of the tubing (2b) with the waste tubing and place it in the waste container on the floor.

**Notice!** Note the pump direction! The pump moves in a clockwise direction.

6. Close the pressure bars over the pump tubing.

7. Insert the cannula into the holder on the autosampler head. Move the holder along the Z-axis (down and up) and check whether the cannula fits through the guide at the lower end of the head. Fasten the cannula with the nut on the holder (arrow in figure on the left).

8. Guide the sample capillary tubing initially in a loop through the hook on the cannula holder (1).

9. Thread the tubing from the left side through the hook (2) at the lower end of the head.

10. Place the tubing at the rear in the guides at the rear of the autosampler arm.
11. Set all eight DIP switches (1) to off (right position); none of
the switches is set to "ON".

12. Connect the autosampler (2, "HOST") with the interface cable
to the computer. Use the provided USB-adapter, if necessary.

13. Connect the mains cable to the autosampler (3) and then
with the mains socket.

14. Connect the autosampler tubing to the sample tubing of the PlasmaQuant MS.

15. Set the pump speed on the autosampler with the speed controller (10 in
Fig. 63) so that the liquid level
remains constant and not too much rinse solution overflows.

11.3 Maintenance

Contamination on the sample tray and the housing can be removed with a dry cloth on
a daily basis as required. In addition, if required:

- Replace the pump tubing
- Replace the cannula and the suction tubing
- Clean the wash cup after overflow

11.3.1 Replacing the cannula and the sample tubing

The autosamplers are delivered with a cannula to which the sample tube is attached.
Cannula and sample tube are always replaced at the same time.

1. Switch off the automatic sampler at the power switch.

2. Cut the connection between the sample tube of the autosampler and the basic
unit.

3. Carefully pull the sample tube off the tube guides on the automatic sampler.

4. Unscrew the cannula from the holder on the automatic sampler. Remove the
cannula with sample tube and coupling pieces from the holder in the automatic
sampler.

5. Prepare the new cannula with sample tube:

- Attach the coupling piece (1) to the sample tube.
- Push the narrow end of the conical nipple downward into the cannula. Position
the conical nipple near the upper edge of the cannula.
- Push the banjo bolt (3) from below onto the cannula. Screw the banjo bolt into
the coupling piece (1).
6. Insert the cannula into the holder in the automatic sampler. Use the coupling piece (4) to fix the cannula from below in the holder. To do this, screw the coupling pieces (1) and (4) together.

7. Attach the sample tube to the tube guides on the automatic sampler (see section "Installation" on page 120).

Fig. 65 Cannula with sample tube of the autosampler
1 Coupling piece (attachment to the holder)
2 Conical nipple
3 Banjo bolt
4 Coupling piece (attachment to the holder)
5 Cannula with sample tube (one piece)

In older models, the cannula and the sample tube can be replaced separately.

1. Switch off the autosampler at the power switch.

2. Disconnect the connection between the sample tubing of the sampler and the ICP-MS.

3. Carefully pull the sample tubing from the tubing guides on the autosampler.

4. Unscrew the cannula from the holder on the autosampler.

5. Unscrew the banjo bolt at the cannula and the sample tubing from the connecting piece.

6. Only use a straight-cut, round and unpinched tubing end for the connection when replacing the sample tubing. First push the banjo bolts and then one sealing cone with the conical side onto the tubing and the cannula. The sealing cone and the tubing or cannula end must be flush (see the figure below).

7. Screw the banjo bolts into the connecting piece hand-tight.

Install the cannula in the autosampler holder and thread the sample tubing through the tubing guides at the autosampler (see section "Installation" p. 120).

Fig. 66 Autosampler cannula and sample tubing dismantled
1 Cannula
2, 6 Banjo bolt
3, 5 Sealing cone
4 Connecting piece
5 Sample tubing
11.3.2 Replacing the pump tubing

1. Switch off the autosampler at the power switch.
2. Place a tray or an absorbent cloth underneath the connectors of the wash cup.
3. Release the pressure bars at the pump and fold them down.
4. Pull the pump tubing from the connectors on the wash cup.
5. Pull the pump tubing from the connections to the aspiration tubing for the wash solution and the waste tubing. Remove the pump tubing from the pump.
6. Attach the new pump tubing at the lower inlet connector (1a) of the wash cup and clamp the tubing between two stoppers into the pump with the connection to the wash cup facing upwards. Connect the other end of the tubing (1b) with the aspiration tubing for the wash solution.
7. Attach the new waste tubing (2a) at the upper outlet connection of the wash cup and clamp the tubing between two stoppers into the pump with the connection to the wash cup facing downwards. Connect the other end of the tubing (2b) with the waste tubing for the wash solution and place the waste tubing in the waste container on the floor.

Notice! Note the pump direction! The pump moves in a clockwise direction.
8. Close the pressure bars over the pump tubing.

1a inlet connector for the pump tubing  
1b connection to the wash solution  
2a outlet connector for the waste tubing  
2b connection to the waste container  
3 pressure bar  
4 pressure bar screw  
5 Speed controller  
6 wash cup

Fig. 67 Autosampler pump

11.3.3 Clean-up after cup overflow

If the wash cup has overflowed during an analysis run, immediately interrupt the workflow and clean the device.

1. Stop the workflow immediately.
2. Take up the liquid with cellulose wadding or a cloth. Wipe the surface dry.
3. Ensure that the outlet can be drained, i.e., remove any sharp bends in the draining tubing or make sure that the draining tubing does not dip into the liquid in the waste bottle.
11.3.4 Replacing the fuses

Replace the fuses of the autosampler as follows:

1. Switch off the autosampler at the power switch and pull the mains cable from the connection on the autosampler.

2. Pull out the fuse holder. To do so, insert a screwdriver blade into the slot in the fuse holder and carefully pry out the holder.

3. Replace defective mains fuses. Use only fuses of the type T 5A H 250V, 5 x 20mm.
12 Troubleshooting

Plasma Will Not Light
If the plasma wouldn’t light but there are no error messages indicating a hardware fault, check the following:

- Has anything changed on the instrument since the plasma was last operated? Faulty connections anywhere in the sample introduction system can introduce air leaks into the torch, which prevent it from igniting the plasma.
- Is the argon supply OK? A contaminated argon tank can contain enough impurities (usually oxygen and or water) that the plasma cannot light.

Little or No Signal
If no significant signal is observed for selected isotopes when performing an instrument setup task, then check the following:

- Inspect the sample introduction system and ensure that the test solution is being pumped into the nebulizer and the solution waste from the spray chamber is draining properly.
- Make sure that a correct system setup solution is prepared and used. The solution must contain the isotopes that were selected for the instrument setup (see section “Tuning solution preparations” p. 55).
- Ensure that a correct system setup worksheet is selected, and re-tune the method parameters of the setup worksheet (if necessary) to achieve an adequate sensitivity for the selected isotope/s, typically over 10,000 c/s per isotope (see section “Method optimization” p. 75).
- If there is still no or very little signal, try a more concentrated version of the tuning solution (e.g., 100 µg/L instead of 1 µg/L); this may provide enough signal to enable the fault to be identified and corrected before resuming calibration with the 1 µg/L solution.

It is recommended that the same method (or setup worksheet) should be selected to perform the plasma alignment, resolution and trim, mass calibration, and detector setup routines.

Mass Calibration Fails
- Check that the instrument has adequate sensitivity; make sure that a correct system setup worksheet and solution are used, as described above (see section “Method optimization” p. 75).
- If the instrument sensitivity is too low, re-tune the method parameters of the setup worksheet (or if necessary prepare a new setup solution), and then repeat the mass calibration. Otherwise you must perform a peak resolution and trim (see section “Peak resolution and trim” p. 60).

Peak Resolution and Trim Fails
- Do not save the best values found by the calibration, if prompted.
- Check the instrument sensitivity and the setup solution. Re-tune the instrument.
- Repeat the resolution and trim routine, after re-tuning the method or changing to a new solution as appropriate.
- If the process fails again, then re-set the resolution value (e.g., select 0.75 AMU instead of 0.8 AMU) and repeat the resolution and trim routine.
If the process fails after re-setting the resolution, then click the [DEFAULTS] button to restore the default values set by the Analytik Jena service personnel during the last installation or service, and repeat the resolution and trim routine.

After the resolution and trim has been reset, you must perform a mass calibration again.

If no significant sensitivity is observed for selected isotope/s when running the detector calibration, then check the following (see also section "Attenuation factors calibration troubleshooting" p. 95):

- Inspect the sample introduction system and ensure that the testing solution is pumped into the spray chamber and the solution waste from the spray chamber is drained out properly.
- Make sure that a correct detector calibration solution is prepared and used. The solution must contain the isotope/s selected for the attenuation factor calibration (see section "Instrument initialization and solution preparations" p. 88).
- Ensure that a correct worksheet is selected and re-tune the method parameters (if necessary) to achieve an adequate sensitivity for the selected isotope/s, typically over 10,000 c/s per isotope (see section "Detector calibration worksheet" p. 89).
- If no detector attenuation factor is calibrated for some selected isotopes:
  - Un-calibrated attenuation factor is often due to a detector over-range. Open the detector calibration worksheet, start the time scan from the method optimization page, and ensure that the sensitivity for the isotope of interest is not over-ranged; if required, re-tune the instrument or, if necessary, dilute the appropriate calibration solution.
- If the RSD for some of the factors are poor, typically over 5 %:
  - Ensure that the instrument achieved an adequate sensitivity for the selected isotope/s, typically over 10,000 c/s per isotope.
  - Make sure the dwell time and scans per replicate are set up properly. It is recommended to use 50,000 µs dwell time per isotope and use 50 scans per replicate. Also, set the number of detector calibrations to be five from the detector calibration page.

If the iCRC system is going to be used for analysis, it is recommended to warm up the instrument using a time scan as you normally would, but to do so using a worksheet that has a iCRC flow enabled. This helps the system stabilize before you start your analysis. A time scan running for ~15 min adequately stabilizes the system before use.
13 Transport and storage

13.1 Preparing the PlasmaQuant MS for transport

CAUTION

The PlasmaQuant MS is very heavy (186 kg). Risk of injury if the device falls!

NOTICE

Use suitable transport packaging! Unsuitable packaging material may cause damage to the device! Only transport the PlasmaQuant MS in its original packaging!

1. Flush the nebulizer and spray chamber thoroughly by aspirating ultrapure water.
2. Shut down the plasma and the vacuum system of the PlasmaQuant MS:
   
   Click the [VACUUM] button on the Main Toolbar, or choose VACUUM OFF from the ACTIONS menu, or press [F6]. The vacuum chambers are brought to atmospheric pressure by initiating the venting sequence, which shuts down the vacuum system components and vents the vacuum chambers with argon gas. This process will take approximately 10 minutes.

3. Turn off the fore-line roughing pump.
4. Turn off the gas supply to the instrument, including iCRC gases.
5. Turn off the cooling water supply to the instrument.
6. Turn off the power to the PlasmaQuant MS.
7. Turn off the exhaust.
8. End ASpect MS software and switch off the PC.
9. Disconnect the mains power connection of the PlasmaQuant MS, PC and autosampler from the mains.
10. Disconnect the cooling water tubing from the rear of the PlasmaQuant MS. Place an absorbent cloth underneath the connections to catch dripping liquid.
11. Remove the gas tubing and copper gas lines from the rear of the PlasmaQuant MS.
12. Pull the plugs of the electrical components (vacuum pump, PC) from the connections on the rear of the ICP-MS. Disconnect the sampler from the PC.
13. Remove the vacuum tubing of the fore-line roughing pump from the fitting on the rear side of the ICP-MS.
14. Remove the capillary tubing of the autosampler from the peristaltic pump tubing.
15. Remove the flexible ducting of the exhaust system from the top of the ICP-MS.
16. Disassemble the torch, transfer tube, spray chamber and nebulizer and pack them separately.
17. Pack the PlasmaQuant MS in the original packaging.
13.2 Ambient conditions for transport and storage

Observe the safety instructions in the section "Safety instructions, transport and commissioning" p. 12. Transport the PlasmaQuant MS and its components very carefully to prevent damage from impact or vibration. The device should be transported in such a way that major temperature fluctuations are avoided and the formation of condensate is thus prevented.

The following requirements are placed on the climatic conditions during transport of the instrument:

<table>
<thead>
<tr>
<th>Temperature range:</th>
<th>+5 °C to +45 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative humidity:</td>
<td>20-80 %</td>
</tr>
</tbody>
</table>

Contact your Analytik Jena support before transporting the PlasmaQuant MS at temperatures below +5 °C. If the PlasmaQuant MS and add-on devices are not installed immediately after delivery or are not required for a prolonged period of time, they should be stored in their original packaging. A suitable desiccant should be added to the packaging to prevent damage from moisture.

13.3 Recommissioning after transport or storage

NOTICE
Check that all requirements are met at the installation location (see the section "Installation conditions" p. 31). Observe the safety instructions in section "Safety instructions" p. 11.

1. Install the flexible ducting on the exhaust system of the PlasmaQuant MS.
2. Install the gas supply on the rear of the ICP-MS (see Fig. 17 p. 39). In the case of hydrogen and helium, insert the filters supplied between the PlasmaQuant MS and the copper lines. Switch on the gas supply.
3. Check the water level of the water cooler and the oil level of fore-line roughing pump SV40BL.
4. Connect the cooling water tubing to the rear of the PlasmaQuant MS.
5. Install the vacuum tubing of the vacuum pump on the fitting on the rear of ICP-MS.
6. Connect the fore-line roughing pump and PC to the connections on the rear of the PlasmaQuant MS. Connect the autosampler to the PC.
7. Electrically connect the water cooler, autosampler and PC.
8. Install the torch and the sample introduction system.
9. Install the autosampler (see section "Installation" p. 120).
10. Turn on the fore-line roughing pump, the water cooler, the exhaust and autosampler. Switch on the PlasmaQuant MS and start ASpect MS software.
14 Disposal

Typically, inductively coupled plasma mass spectrometry (ICP-MS) generates liquid waste which, besides metal or heavy metal ions, mainly contains various mineral acids that are involved in sample preparation procedures. For safe removal, such resulting waste solutions must be neutralized using, for example, diluted sodium hydroxide solution.

Once neutralized, such waste must be made available for proper disposal in accordance with currently valid rules of law.

Under currently binding legislation, the PlasmaQuant MS, including its electronic components, must be disposed as electronic waste upon decommission.
## 15 Specification

### 15.1 Technical data

#### 15.1.1 ICP-MS data

<table>
<thead>
<tr>
<th>Sample introduction system</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of sample</strong></td>
<td>Liquid</td>
</tr>
<tr>
<td><strong>Pump</strong></td>
<td>Four-channel variable-speed peristaltic pump (max. speed 100 rpm)</td>
</tr>
<tr>
<td><strong>Type of nebulizer</strong></td>
<td>Micromist concentric nebulizer (0.4 mL/min), optional PFA nebulizer (0.1 mL/min) for semiconductor or geochemical type applications</td>
</tr>
<tr>
<td><strong>Spray chamber</strong></td>
<td>Scott type, double pass spray chamber, Peltier-cooled</td>
</tr>
<tr>
<td><strong>Transfer tube</strong></td>
<td>Connection between Spray chamber and torch, optional gas port for sheath gas</td>
</tr>
<tr>
<td><strong>Torch</strong></td>
<td>Standard one-piece torch with 2.4 mm injector, optional semi-demountable torch with platinum or sapphire injector, torch with 1.5 mm injector for organic samples</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plasma generation, Interface and Interferences management</th>
<th></th>
</tr>
</thead>
</table>
| **Plasma generation** | Solid-state RF generator (300 V RMS, 27 MHz), water-cooled induction coil with three windings, virtually center grounded. No plasma shield needed.  
constant power delivery from 0.3 to 1.6 kW  
Nitrox option: integrated MFC gas control for online addition of nitrogen and oxygen to the plasma |
| **Interface** | water-cooled interface assembly with sampler and skimmer cone  
standard nickel cones, platinum tipped cones for use with corrosive samples |
| **Interference management** | iCRC (integrated Collision Reaction Cell)  
Introduction of gas (He or H₂) into the plasma interface, elimination of interfering ions like ArO⁺ by reactions and collisions |

| Vacuum system | Three chamber vacuum system, differentially pumped with 1 fore-line roughing pump and 2 integrated turbomolecular pumps  
first chamber:  
interface with sampler and skimmer cone, pressure 5 mbar  
the chamber can easily be brought to atmospheric pressure for maintenance after automatic closure of the gate valve  
second chamber:  
ion optics, pressure 10⁻⁴ mbar  
third chamber:  
mass analyzer and detector, pressure 7 x 10⁻⁵ mbar |
| Fore-line roughing pump | PlasmaQuant MS (Q): model SV40BI  
PlasmaQuant MS Elite (S): model XDS46i (oil-free)  
vacuum line up to 12 m for remote location |
### Mass spectrometer system

<table>
<thead>
<tr>
<th>Ion Optics</th>
<th>Ion optics system with ReflexION, a 3D focusing, 90 degree ion mirror</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass analyzer</td>
<td>Low noise, double off-axis HD mass analyzer consisting of two assemblies – the fringe filter and the quadrupole filter (3 MHz). Self-cleaning, maintenance free.</td>
</tr>
<tr>
<td>Detector</td>
<td>AD Detector - All-digital detection system (10 MHz), with 11-orders linear dynamic range and long life time</td>
</tr>
<tr>
<td>Signal</td>
<td>Counts or counts/second</td>
</tr>
<tr>
<td>Mass range</td>
<td>3 to 260 amu</td>
</tr>
<tr>
<td>Resolution</td>
<td>0.5 to 1.2 amu, adjustable (device with AMR option: for m/z &gt; 230 amu resolution &gt; 2 amu)</td>
</tr>
</tbody>
</table>

### Power supply

| Supply voltage   | 200-240 V AC ± 5 % |
| Frequency        | 50/60 Hz |
| Line current     | 18 A max. |
| Typical power consumption | 2700 VA |
| Max. power consumption | 3700 VA |
| Overvoltage category | II according to DIN EN 61010-1 |
| Degree of contamination | 2 according to DIN EN 61010-1 |
| Protection class | I |
| Protection type  | IP 20 |

### Gas supply

<table>
<thead>
<tr>
<th>Type of Gas</th>
<th>Argon</th>
<th>Helium</th>
<th>Hydrogen</th>
<th>Nitrogen*</th>
<th>Oxygen*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purity</td>
<td>≥ 4.6 (99.996 %)</td>
<td>≥ 4.6 (99.996 %)</td>
<td>≥ 4.6 (99.996 %)</td>
<td>≥ 4.6 (99.996 %)</td>
<td>≥ 4.6 (99.996 %)</td>
</tr>
<tr>
<td>5 ppm O₂</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 ppm N₂</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 ppm H₂O</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 ppm H₂</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Pressure</td>
<td>550-700 kPa (80-100 psi) regulated</td>
<td>150 kPa (21.5 psi) regulated</td>
<td>100 kPa (14.5 psi) regulated</td>
<td>125 kPa (18.1 psi) regulated</td>
<td>125 kPa (18.1 psi) regulated</td>
</tr>
<tr>
<td>Max. Input Pressure</td>
<td>700 kPa (100 psi)</td>
<td>250 kPa (36.3 psi)</td>
<td>170 kPa (24.7 psi)</td>
<td>150 kPa (21.5 psi)</td>
<td>150 kPa (21.5 psi)</td>
</tr>
<tr>
<td>Flow Range</td>
<td>0-28 L/min</td>
<td>0-0.2 L/min</td>
<td>0-0.2 L/min</td>
<td>0-0.2 L/min</td>
<td>0-0.2 L/min</td>
</tr>
<tr>
<td>Typical flow range</td>
<td>9-12.5 L/min</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* for Nitrox option

### Environmental conditions

| Corrosion protection | The device is corrosion-proof against the samples used in the analysis |
| Operating temperature | +15 to 25 °C, optimum +20 to 24 °C (as constant as possible during measuring, maximum temperature drift ΔT = 2 K/h, air condition recommended) |
| Humidity | 20 to 80 % at 20 °C (non-condensing) |
### Altitude
0 to 2000 m

### Storage Temperature
+5 °C to +45 °C, use desiccant

For optimum analytical performance, it is recommended that positive air pressure be maintained in the laboratory at all times.

### Exhaust unit
- Material: Heat and corrosion resistant (recommended V2A steel)
- Extraction output: 3.0 m³/min (110 ft³/min) – 4.5 m³/min (160 ft³/min)
  - Recommended value: 3.5 m³/min (125 ft³/min)
- Adapter using flexible aluminum or plastic pipe
  - Internal pipe diameter \( \varnothing \) 100 mm (4 in)
  - Length: < 5000 mm (15 ft)

### Dimensions and weights
- Mass: 186 kg
- Dimensions (W x D x H): 660 mm x 589 mm x 1131 mm

Leave a clearance of 30 cm on the right-side of the ICP-MS for opening the interface door.

### 15.1.2 Control computer data
- Processor: 2.8 GHz, or better
- Hard Disk Drive: min. 80 GB hard disk drive storage capacity
- RAM: 4 GB of RAM
- Graphic resolution: 1280 x 1024 pixels
- CD/DVD Drive: 16x DVD RW+/− drive
- USB Ports: min. 2x USB 2.0 ports
- Serial Ports: min 1x
- Multimedia: Integrated video, audio, and network support
- Operating System: Windows 10 (32- or 64-bit), Windows 7 and 8.1 are supported

### 15.1.3 Water cooler data
- Supply voltage: 200-240 V AC
- Frequency: 50/60 Hz
- Cooling Capacity: Minimum of 1.8 kW
- Water Temperature: 20 °C ± 1 °C (68 °F ± 1.8 °F)
  (temperature of the water supplied to the instrument)
- Water Pressure: 440 ± 40 kPa (64 ± 6 psi)
  Pressure at the instrument water inlet
### Max. Water Pressure

500 kPa (72,5 psi)

Pressure at the instrument water inlet

### Water Purity

Conductivity: permitted range 75-150 µS/cm, target range 100-120 µS/cm (particle size < 0.1 mm)

pH: Between 7-9

Total Chlorine: < 20 mg/L (20 ppm), total Nitrate: < 10 mg/L (10 ppm), total Sulfate: < 100 mg/L (100 ppm)

#### 15.1.4 Autosampler ASPQ 3300 data

<table>
<thead>
<tr>
<th>Dimensions W x H x D</th>
<th>285 mm x 510 mm x 490 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>15 kg</td>
</tr>
<tr>
<td>Supply voltage</td>
<td>100-240 V AC</td>
</tr>
<tr>
<td>Frequency</td>
<td>50/60 Hz</td>
</tr>
<tr>
<td>Fuse</td>
<td>5 A</td>
</tr>
<tr>
<td>Typical average power consumption</td>
<td>75 VA</td>
</tr>
<tr>
<td>Racks</td>
<td>3 for sample cups</td>
</tr>
<tr>
<td>Sample cups</td>
<td>2 for special cups (standards and QC solutions)</td>
</tr>
<tr>
<td>Wash bottle</td>
<td>2 L</td>
</tr>
</tbody>
</table>

#### 15.1.5 Autosampler Cetac ASX-560

<table>
<thead>
<tr>
<th>Dimensions W x H x D</th>
<th>580 mm x 620 mm x 550 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>12 kg</td>
</tr>
<tr>
<td>Supply voltage</td>
<td>100-240 V AC</td>
</tr>
<tr>
<td>Frequency</td>
<td>47-63 Hz</td>
</tr>
</tbody>
</table>
15.2 Guidelines and standards

Protection class and protection type
- The PlasmaQuant MS belongs to protection class I.
- The housing has protection type IP 20.

Device safety
The PlasmaQuant MS conforms to the safety standards
- EN 61010-1 and 61010-2-61
- CAN/CSA-C22.2 No. 61010-1
- UL 61010-1

EMC compatibility
The PlasmaQuant MS has been tested for radio interference resistance and radio interference emissions in accordance with DIN EN 61326-1 and meets the requirements according to
- Radio interference resistance according to table 2 (industrial environment) with limitations. For electromagnetic fields in the frequency range 500 – 1000 MHz with field strengths up to 10 V/m there is no interference.
- Emitted interference according to class A

EC directives
The PlasmaQuant MS is built and tested according to standards that fulfill the requirements stipulated by the EC directives 2014/35/EU, 2014/30/EU, 2012/19/EU and 2011/65/EU.

Federal Communications Commission Advisory (U.S. only)
This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device doesn’t cause harmful interference, and (2) accepts any interference (including interference that may cause undesired operation). This device complies with Part 18 of the FCC Rules.

Guidelines for China
The PlasmaQuant MS contains restricted substances (according to directive "Management Methods for the Restriction of the Use of Hazardous Substances in Electrical and Electronic Products"). Analytik Jena guarantees, that those hazardous substances may not leak out during the next 25 years when the PlasmaQuant MS is used in accordance with its intended purpose.

Each device leaves the manufacturing facility in a technically safe state. To maintain this condition and to ensure safe operation, the operator must strictly observe the safety and operating instructions contained in this manual. For accessories which have also been supplied, and system components from other manufacturers, their operating instructions should be referred to.
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