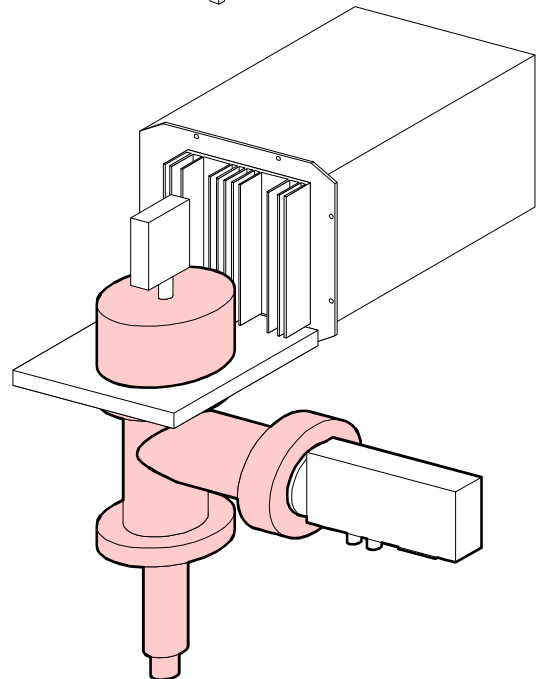
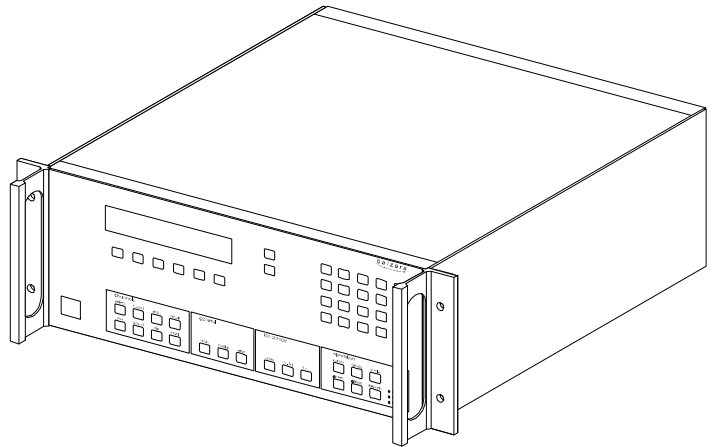


QMG 422 Analyzers

QMA 400

QMA 410

QMA 430



Product identification

In all communications with Balzers Instruments, please specify the information on the product nameplate.

For convenient reference please copy that information into the nameplate replica below:

Typ:	<i>balzers</i>
No:	-----
F-No:	-----

Validity

This document applies to the QMA 400, QMA 410, QMA 430 with Faraday cup or 90° off-axis SEM and Faraday cup and with the ion sources described in this document.

Illustrations

If not indicated otherwise in the legends, the illustrations in this document correspond to the QMA 400 with 90° off-axis SEM. They apply to other types by analogy.

Designations

The short designation "QMA" is used for the QMA 400, QMA 410 and QMA 430. The short designation "QMH" is used for the QMH 400 and QMH 410.

In contrast to the Operating manual for the QMG 422, this manual follows the same conventions as the Balzers QuadStar™ 422 Software documentation. The parameters are marked by quotation marks ("...") e.g. "Resolution".

Technical changes

We reserve the right to make technical changes without prior notice.


Intended use

The QMA 400, QMA 410 and QMA 430 Analyzers are used for gas analysis in high vacuum.

They are part of the QMG 422 mass spectrometer system and may only be used in connection with equipment belonging to that system.

The operating instructions of all system components must be strictly followed.



Functional principle

→  [1] for the fundamental and functional principles and use of quadrupole mass spectrometers.

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For cross-references within this document, the symbol (→  XY) is used, for cross-references to other documents, the symbol (→  [Z]).

1 Safety

1.1 Symbols used



Information on preventing any kind of physical injury.



Information on preventing extensive equipment and environmental damage.



Information on correct handling or use. Disregard can lead to malfunctions or minor equipment damage.

1.2 Personnel qualifications



Skilled personnel

All work described in this document may only be carried out by persons who have suitable technical training and the necessary experience or who have been instructed by the end-user of the product.

1.3 General safety instructions

Process media

- Adhere to the applicable regulations and take the necessary precautions for the process media used.
- Consider possible reactions between the materials (→ 13) and the process media.
- Consider possible reactions of the process media due to the heat generated by the product.
- Post the warning signs required by the national and local regulations at the appropriate places.
- If toxic or flammable gases are measured with the QMA, the exhaust gases must be treated in accordance with the applicable regulations.

Safety measures

- Adhere to the applicable regulations and take the necessary precautions for all work you are going to do and consider the safety instructions in this document.
- Follow the instructions and consider the data given in the documentation of all system components.

Contamination

- Before beginning to work, find out whether any components are contaminated. Adhere to the relevant regulations and take the necessary precautions when handling contaminated products.
- Products returned to Balzers Instruments for service or repair should preferably be free of harmful substances (e.g. radioactive, toxic, caustic, or micro biological). Do always enclose a completed and signed declaration of contamination (→ 55).

- Adhere to the forwarding regulations of all involved countries and forwarding companies.

Communication of safety instructions

- Communicate the safety instructions to all other users.

1.4 Liability and warranty

Balzers Instruments assumes no liability and the warranty becomes null and void if the end-user or third parties

- disregard the information in this document
- use the product in a non-conforming manner
- make any kind of interventions (modifications, alterations etc.) on the product
- use the product with accessories, options, and add-ons not listed in the corresponding product documentation.

The end-user assumes the responsibility in conjunction with the process media used.

Note



Caution: improper use

Improper use of the product may lead to contamination or destruction of the cathode or secondary electron multiplier.

Adhere to the instructions in this manual to prevent such damages, which are not covered by the warranty.



Training

Balzers Instruments offers application, operating and maintenance courses for the best use of this product. Please contact your local Balzers Instruments representative.

2 Description

The fundamental principles of quadrupole mass spectrometers are explained in [1].

Chapter "Overview" in [2] shows the complete system and contains short descriptions of the individual components.

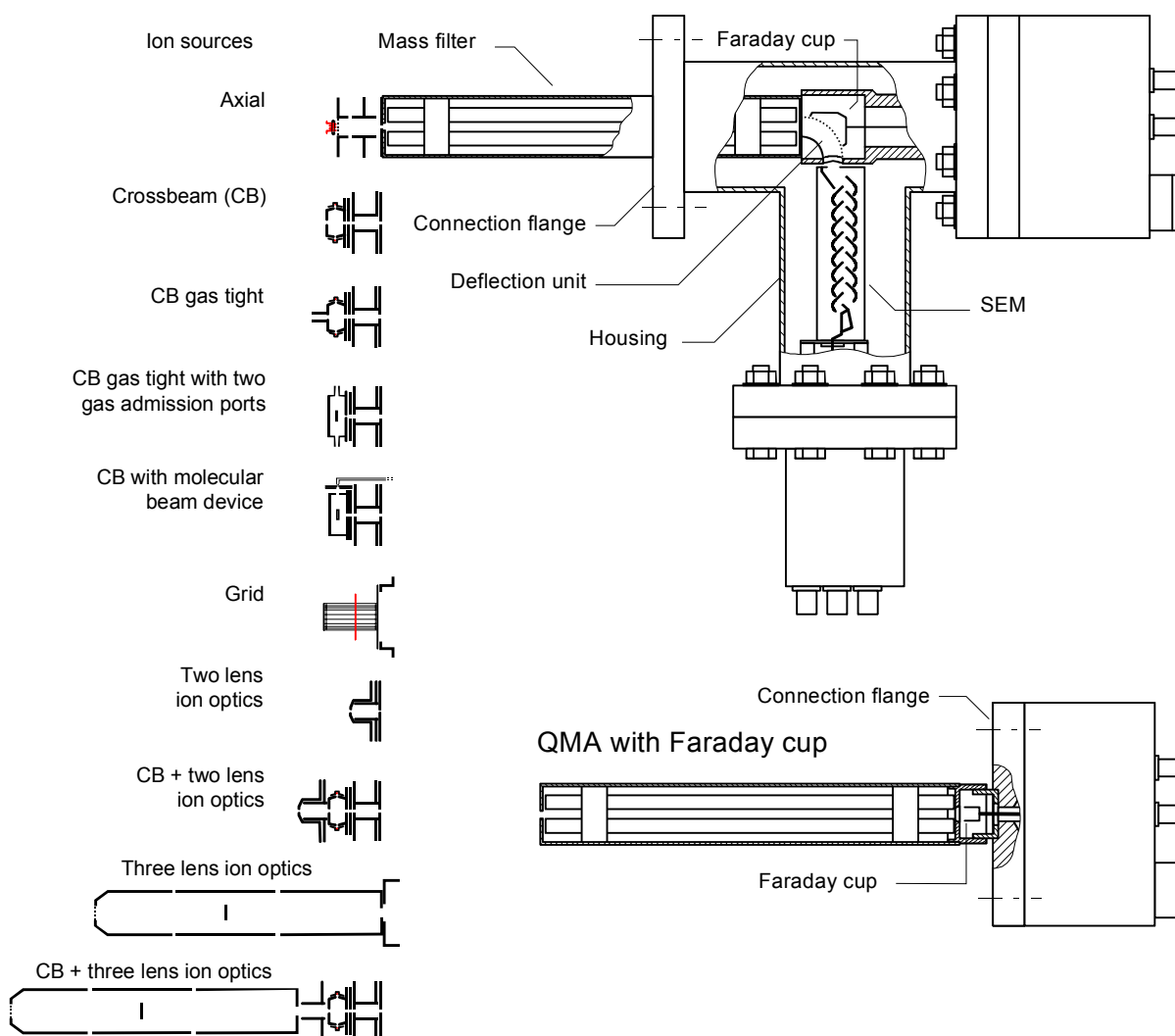
The analyzers QMA 400, QMA 410, and QMA 430 are the sensors of the QMG 422 mass spectrometer system.

2.1 Design

A quadrupole analyzer consists of:

- ion source and/or ion optics
- mass filter with rod system
- ion detector (SEM and ion deflection unit with Faraday or Faraday only)
- housing with flanges

QMA with 90° off axis SEM



The high mechanical precision combined with optimum cooperation between the ion source and rod system, forming the ion optical unit, yield high resolution and transmission with low mass discrimination.

Its high resolution and wide mass range make this instrument suitable for analytical measurement problems.


The various designs, with Faraday cup or with 90° off-axis SEM plus Faraday cup, as well as the ample choice of ion sources and ion optics ensure an optimum adaptation to the individual measurement problem.

The open design and low degassing rate of the analyzers, conceived as immersing systems, allow exact partial pressures analyses from the high vacuum up to the extreme ultra high vacuum range.

2.1.1 Ion sources

The ionization is achieved by electron impact. Electrons are thermally emitted by a cathode and focused by electrical extraction fields so that they reach the ionization area.

The ionization process is crucial for the overall quality of the analysis. Errors occurring in this part of the process are virtually irreversibly. Therefore, the ion source must be selected very carefully.

For more details on the individual ion source types: →  33 ff.

Closed (gas tight) ion sources allow gas analyses with a minimum contribution from the residual vacuum. They are virtually fractionation-free, have a high signal to noise ratio, a low gas consumption, and a small time constant.

Ion optics are used for focusing ions which are generated independently of the QMA (e.g. plasma technology, laser, SIMS, thermal desorbed ions) to the mass filter.

2.1.2 Mass filter

The proper material selection and very precise manufacturing methods ensure a high measure of linearity and reproducibility.

QMA 430: For masses up to 300 amu the economic 8 mm rod system made of stainless steel can be used.

QMA 400: For higher mass ranges as well as optimum stability and reproducibility, 8 mm molybdenum rods are used because of the superior electrical and thermal properties of the material.

QMA 410: The 16 mm molybdenum rod system is used for this analyzer. At constant frequency, the transmission increases as a function of the rod diameter while the mass range narrows. In parallel, the impact of the filtered ions on the rod surfaces and thus the contamination of the rod system is reduced.

2.1.3 Secondary electron multiplier

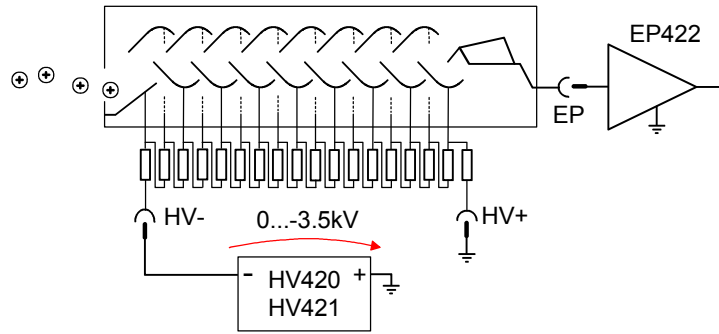
The secondary ion multiplier with its 17 discrete stages and focusing dynode geometry is a fast ion current amplifier between the quadrupole filter and the preamplifier.

The high gain permits operation of the succeeding electrometer amplifier with a lower gain setting, which results in shorter time constants and thus facilitates the observation of rapid variations of the ion current.

SEV 217

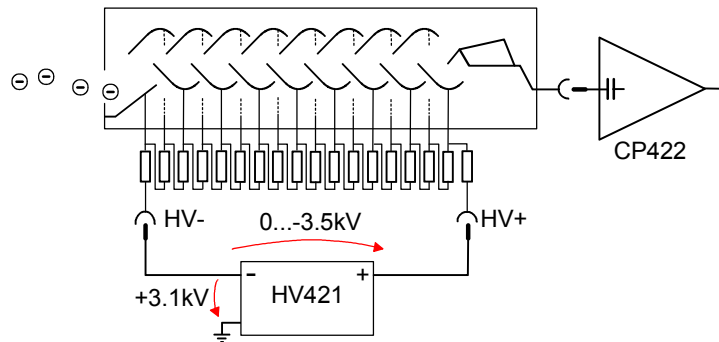
Positive ions are detected in normal operation with a negative high voltage applied to HV- and ground connected to HV+ of the secondary electron multiplier SEV 217.

The operating voltage "SEM Voltage" determines the gain and is at the same time the energy for additionally accelerating the ions.



Negative ions

For detection of negative ions, +3.1 kV supplied by the HV 421 are applied to the first dynode (HV-) (-3.1 kV for positive ions). This means that up to 6.6 kV are applied to the HV+. In this case, the ion counter must be used instead of the electrometer amplifier.

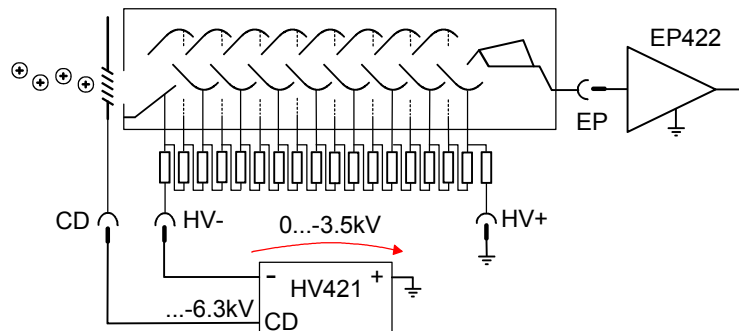


In counting mode, ions of 1 pulse per 10 s (which corresponds to an ion current of 10^{-20} A) up to 10^7 pulses per s can be detected.

In this case, the energy for additional acceleration is independent of the operating voltage and thus from the gain setting.

SEV 218

The SEV 218 corresponds to the SEV 217. Additionally, it has a conversion dynode, which is separate from the dynode chain and fed by an invariable high voltage source (-6.3 kV at the CD connector of the HV 421), which is independent of the operating voltage of the secondary electron multiplier.




The gain of the SEM can be selected independent of the additional acceleration.

The high additional acceleration allows for a strong reduction of possible mass discrimination due to the conversion. The independent setting of conversion rate and gain has also considerable advantages for ratio measurements (e.g. isotopes) with high dynamics.

2.2 Versions

2.2.1 Cathode materials

The ion sources can be equipped with cathodes (filaments) which are best suited for the planned application. Certain cathode materials are not available for all source types →  [5] "Spare parts lists".

Rhenium

In contrast to tungsten (W), rhenium (Re) does not form any stable carbides, since no CO₂ cycle as known with W takes place. In addition, Re is not embrittled by recrystallization.

The vapor pressure of Re is approximately 50 times higher than that of W, and the filament life is accordingly shorter. Getter effects may occur due to the evaporation rate.

Tungsten

Tungsten is used when the higher vapor pressure of Re is undesirable, when a long filament life is required, or when the advantages of Re are not important to the application.

Yttrated iridium

Since yttrated iridium (YO_x-Ir) does not form oxides, it is quite insensitive to air inrushes.

The emission temperature of yttrated iridium filaments is lower than that of Re and W filaments. Reactions with residual gas are weaker because the ion source temperature remains low.

The contamination may be stronger when substances with a low vapor pressure are admitted.

2.2.2 Electron collimation magnet

The crossbeam ion source can be equipped with a magnet unit. This is recommended for applications in high mass ranges, for molecular beam detection, and in the QMA 410 for separating He and D₂.

The magnet increases the electron density in that part of the volume of the ion source, from which ions can be easily focused into the mass filter.

This results in higher sensitivity and better injection conditions. In addition, the magnet prevents the majority of the electrons from hitting critical locations of the formation area. However, the linearity (measurement signal vs. pressure) is reduced.

Analyzers with integrated collimation magnets may only be baked to 300°C.

2.2.3 90° deflection

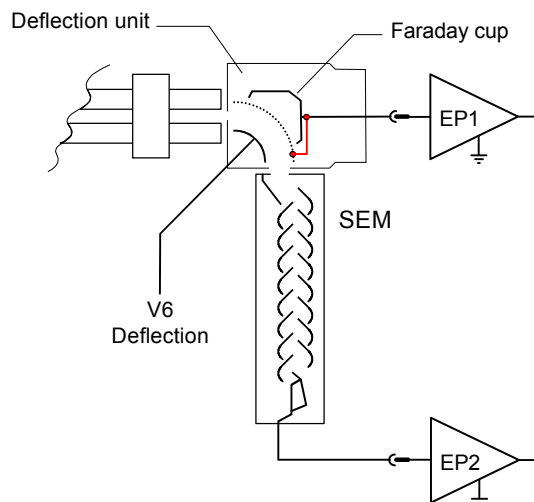
The 90° off-axis arrangement of the secondary electron multiplier has a very low signal background because the electrostatic 90° deflection prevents fast or excited neutrals and photons from hitting the SEM.

There are two deflection versions:

One deflection voltage

Normal version (axial, crossbeam, grid ion source, possibly ion optics).

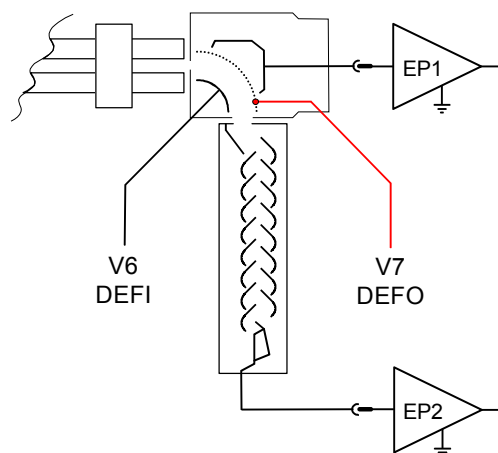
The inner deflection plate is on potential V6 "Deflection", the outer deflection plate is directly connected to the Faraday cup and electrometer amplifier EP1 and is thus on ground potential. If there is no EP1 in the configuration, a shorting connector is used.



Two deflection voltages

Special versions (mostly with ion optics, → enclosed diagram of the QMA).

The inner deflection plate is on potential V6 "DEFI", the outer deflection plate is on potential V7 "DEFO". The Faraday cup is isolated from the deflection plate and connected to the electrometer amplifier EP1.



Depending on the application, the deflection of this version is more efficient, as accelerating potentials are applied to both deflection plates.

In Faraday operation, the sensitivity is slightly lower than with one deflection voltage because less ions reach the Faraday cup.

2.2.4 Faraday cup

Faraday cup operation (QMA with Faraday or SEM types operated in Faraday mode) reduces system related conversion errors of the SEM (e.g. mass discrimination).

Faraday operation can also be used for error detection.

The drawback of Faraday operation is the lower sensitivity, which requires a higher gain and thus limits the response speed.


2.2.5 Isolated design

Some versions (e.g. with ion optics) have an isolated design i.e. the filter housing and thus ion optics, mass filter, and deflection unit are isolated from the ground. A potential can be applied to the filter housing in order for ions formed close to the ground potential (e.g. in a plasma) to be transferred through the fringe fields with sufficient velocity.

These versions may have an additional SHV connector for the corresponding voltage on the QMA


- BIAS as input
- TARGET as output for SIMS analyzers

STOP
DANGER



Caution: shock hazard

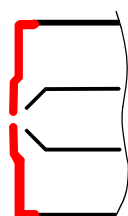
The voltages of the IS 420 and the additional voltage can be extremely hazardous.

Consider the technical specifications of the IS 420 (→  [2]) and use only properly made cables.

2.2.6 Vacuum annealed QMA

The QMA with the vacuum annealed grid ion source has a very low degassing and desorption rate ($< 10^{-10}$ mbar l/s).

2.2.7 Extraction hood

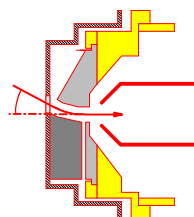


For extracting ions from a plasma, an extraction hood can be installed.

As the versions with extraction hood are customized, a corresponding description is enclosed with the test protocol.

Further information →  [4]

2.2.8 Beam deflection device

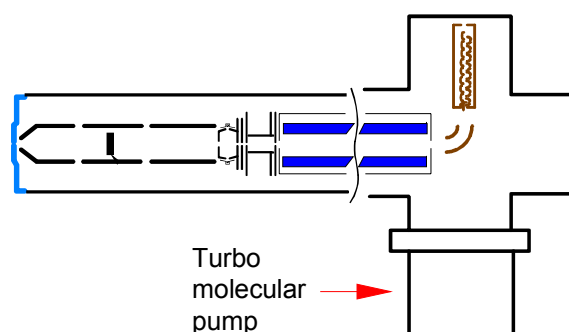


For detecting ions which are not focused in the axis of the analyzer, a beam deflection device is installed. It is based on a sector field and can be combined with an extraction hood. There is a variety of possible detection angles.

As the versions with beam deflection device are customized, a corresponding description is enclosed with the test protocol.

2.2.9 Differential pumping

If the pressure of the gas or plasma to be analyzed exceeds the admissible maximum pressure of the QMA, the analyzer is differentially pumped with a turbo-molecular pump.



The T-piece of the housing is replaced with a crosspiece. Diaphragm glands having a much smaller conductance than the orifice are used as seals.

The pressure drops because of the limited conductance at the entrance orifice, the extraction hood, or the beam deflection device.

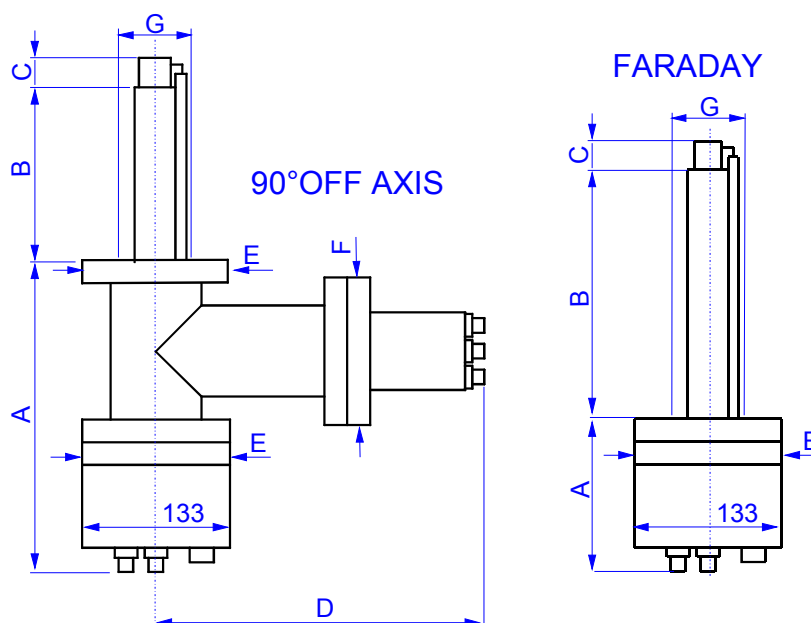
The pressure range can be further increased with a dual-stage differential pump system.

3 Technical data

Overpressure	Maximum admissible overpressure	2 bar (absolute)		
Vacuum	Maximum operating pressure			
	with Faraday	1×10 ⁻⁴ mbar		
	with SEM	1×10 ⁻⁵ mbar		
Sensitivity	Smallest detectable partial pressure			
	with Faraday	< 10 ⁻¹¹ mbar		
	with 90° off-axis SEM and ion counter electronics	< 10 ⁻¹⁵ mbar		
	Sensitivity for air			
	with Faraday	> 3×10 ⁻⁴ A/mbar		
	with SEM	> 200 A/mbar		
	Applies to QMA 400 without SEM, crossbeam ion source with magnet, emission 1 mA, ΔM ₁₀ = 1 u ¹			
	Refer to the Test protocol for your individual configuration.			
Mass filter		QMA 400	QMA 410	QMA 430
	Rod diameter	ø 8 mm	ø 16 mm	ø 8 mm
	Rod length	200 mm	300 mm	200 mm
	Rod material	molybdenum	molybdenum	st. steel
SEV 217	Gain (new)	> 10 ⁸ at 3.5 kV		
	Operating voltage	1 ... 3.5 kV		
	Bias voltage	max. ±3.2 kV at SEV-		
	Number of stages	17		
	Voltage divider	18 MΩ		
	Max. admissible output voltage	10 ⁻⁵ A		
	Max. bakeout temperature	400 °C		
	of dynode material	Cu-Be		
SEV 218	As SEV 217, however, with separate conversion dynode CD			
	CD voltage	max. - 6.3 kV		
Connection flange	QMA 400	DN 63 CF		
	QMA 410	DN 100 CF		
	QMA 430	DN 63 CF		
Bakeout temperatures	without cables and connector plates	max. 400 °C		
	with electron collimation magnet	max. 300 °C		
	with cables and connector plates	max. 180 °C		
	with preamplifier or electrometer	max. 50 °C		
Materials in vacuum	Stainless steel, Mo, Al ₂ O ₃ , Cu-Be, Ni, W, Re, yttrated iridium			
Filament life	Rhenium	> 2,000 h		
	Tungsten	≈ 10,000 h		
	Yttrated iridium	> 10,000 h		
	Valid for p < 10 ⁻⁵ mbar, emission 1 mA and electron energy ≥ 70 eV in a non oxidizing atmosphere			
Standards	→ 56 Declaration of conformity			

¹ Peak width = 1 u on 10% of peak height

Dimensions and weight



(The illustrations are not to scale.)

	90° off-axis			Faraday	
	QMA 400	QMA 430	QMA 410	QMA 400	QMA 410
A	244	244	245	104	245
B	162	162	267,5	223	269,2
D	251	251	251		252
E	DN63CF	DN63CF	DN100CF	DN63CF	DN100CF
F	DN63CF	DN63CF	DN63CF	---	---
G	ø63	ø63	ø100	ø63	ø100
Weight	10.7 kg	10.7 kg	17.2 kg	2.9 kg	6.5 kg

Ion sources	C	H
Axial	26	---
Crossbeam (CB)	35.5	23.5
CB gas tight ¹⁾	48 ²⁾	23.5
Grid	27	---
2 lens ion optics	17.5	---
CB with 2 lens optics	43.5	23.5
3 lens ion optics	129	---
CB with 3 lens optics	171	23.5

¹⁾ With axial gas connection

²⁾ Without gas admission line (outer diameter of gas admission line 3 mm)

Gas connections	
CB gas tight with 1 axial connection	Bore in glass ceramic for tube with outer diameter 3 mm
CB gas tight with 2 lateral connections	2 gas admission lines according to drawing BK 355 107 -Z are enclosed
CB with molecular beam device	DN16CF with Swagelok fitting ø ¼"

4 Installation

4.1 Preparation



DANGER

Caution: hazardous electrical voltages

Hazardous voltages up to 600 V are applied to the QMA.

Make sure the QMA, the vacuum chamber, and the whole system are always correctly connected to ground.

If accidental contact to the QMA is possible when the vacuum system is opened, additional protective measures have to be taken, for instance:

- Mechanical protection against accidental contact
- Forced disconnection of the QMS 422 from the mains power source through door contact.



DANGER

Caution: hazardous electrical voltages

Under unfavorable conditions (arcs, plasma, vacuum problems), voltages up to 600 V can be fed to other equipment in the vacuum chamber (e.g. gauges).

If there is a possibility that such pieces of equipment become sources of shock hazard (consider also the conductors and connected equipment!) they must be arranged or protected in such a way that any risk of accidental contact, arcs, or flow of charged particles is excluded.



DANGER

Caution: hazardous external voltages

Under unfavorable conditions (arcs, plasma, vacuum problems), voltages of other equipment installed in the vacuum system (e.g. ionization gauges, plasma sources, electron beam evaporators etc.) can be supplied to the QMA. Open connectors, connected equipment and cables are potential sources of shock hazard.


If there are such potential sources of shock hazard in the vacuum system, protective measures have to be taken (layout, grounding, shielding etc.) to prevent such influences.

The QMS 422 must also be permanently connected to ground (not via a connector). The contact is inside, behind the mains plug. Make a grounding conductor of yellow/green stranded copper wire if necessary:

- 2.5 mm² if mechanically protected (according to DIN VDE 110 T540)
- 4.0 mm² if not mechanically protected

Consider the specific standards of your system.

Mounting orientation

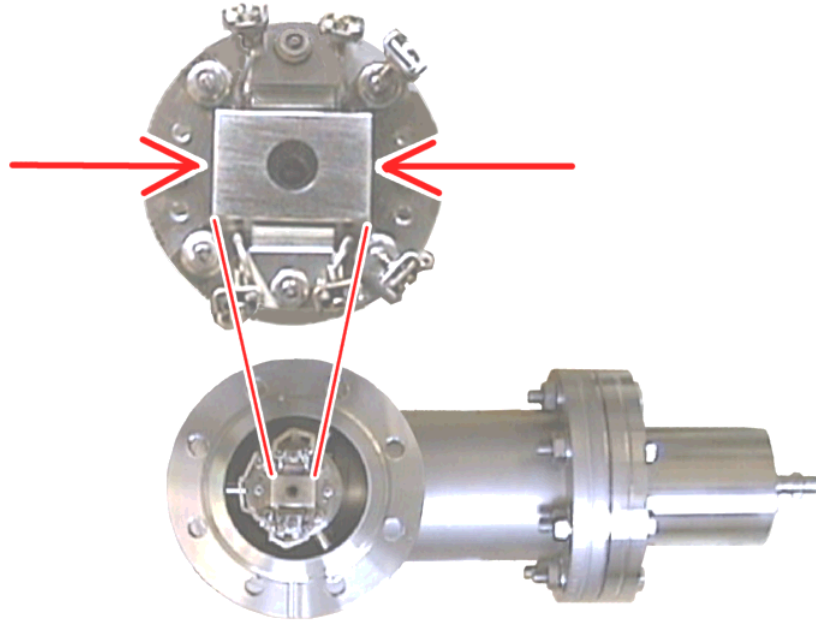
In most cases, the mounting orientation can be chosen irrespective of the function. Select the mounting orientation which is best suited to the arrangement of the radio frequency generator, QMH and cables (→  [3]).

The position of the ion source should be selected according to the requirements of the analytical task. For instance, reliable residual gas analysis is not possible if the analyzer is connected to the measuring chamber only via a tube with a small diameter.

Gas inlet system

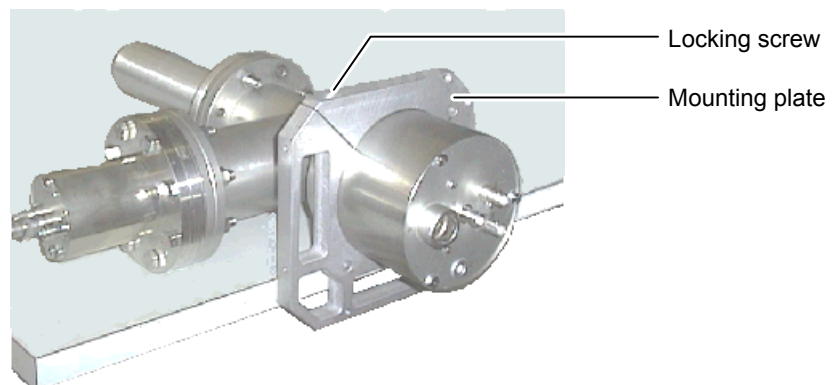
Prepare the gas inlet system (if necessary) in order to ensure easy connection to the ion source.

The crossbeam ion source might have to be aligned with the gas inlet system. In that case mark the correct mounting orientation (direction of the arrows) on the flange of the QMA and the system.



Installing the mounting plate

- Place the analyzer on the edge of a workbench (→ illustration)
- Unfasten the locking screw on the mounting plate with a screw driver No. 6
- Slide the mounting plate on the analyzer flange.
- Position the mounting plate so that you can easily hold the analyzer and introduce it into the vacuum system in its correct orientation (→ 20).



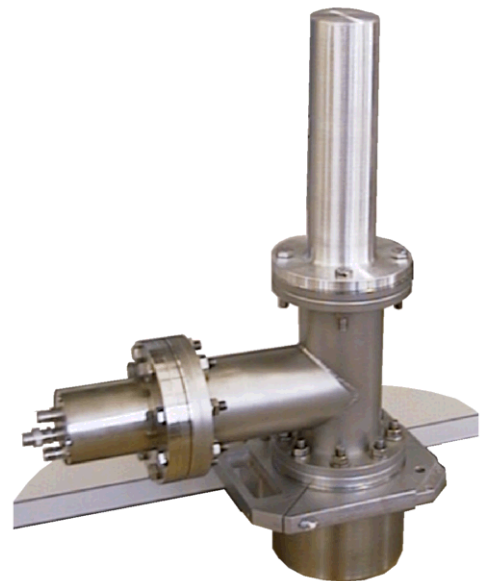
- Tighten the locking screw.

Using the assembling trestle

- Mount the assembling trestle to a stable workbench.



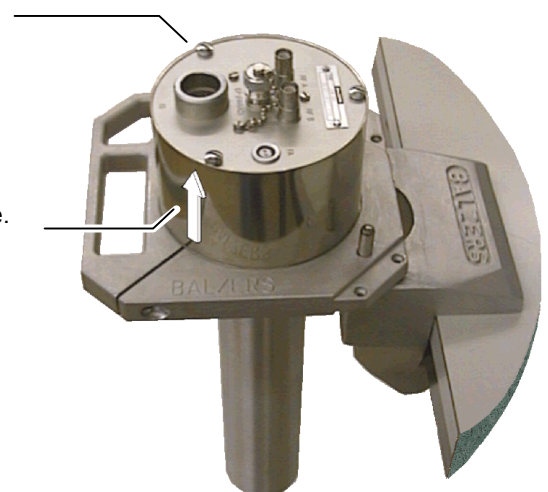
- Insert the analyzer with the installation plate into the assembling trestle.



Removing the protective tube

Only for QMA 400/430 without SEM:

- Remove the three screws.
- Remove the protective tube.



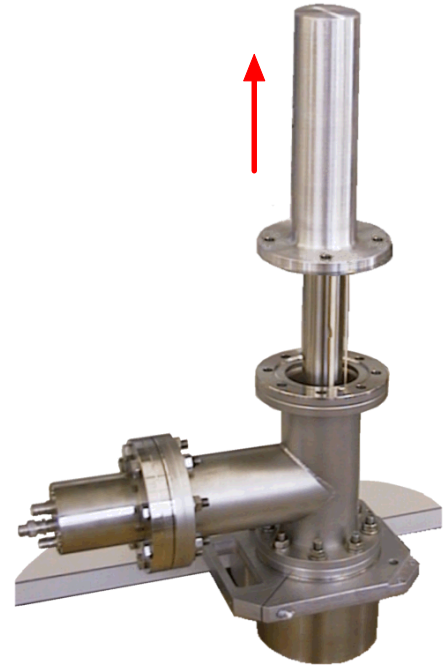
Removing the transport protection

 **Note**



Caution: dirt sensitive area
Dirt distorts the measurement results.
Always wear clean, lint-free gloves and use clean tools when working in this area.

- Carefully remove the transport protection and keep it for later use.
- Check the inside for damages and short circuits of the wiring.



4.1.1 Installing the electron collimation magnets

The magnet unit of the crossbeam ion source is delivered in a separate package. If the conditions for use are fulfilled (→ 10 and 37) mount it on the ion source as described below.

 **Note**



Caution: dirt sensitive area
Dirt distorts the spectra.
Always wear clean, lint-free gloves and use clean tools when working in this area.

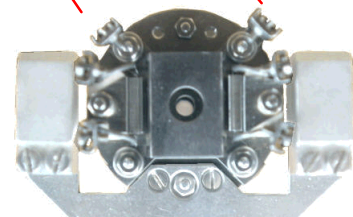
 **WARNING**



Caution: The magnets are aligned.
If the magnets are detached from the installation plate, correct alignment is no longer possible.
Do not detach the magnets from the installation plate!

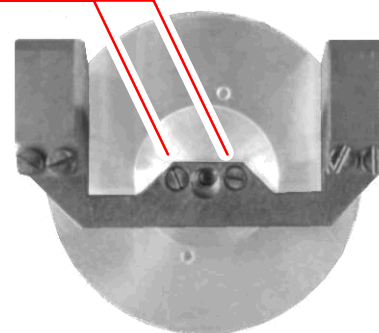
Terminals

- 1 Position the analyzer so that the magnet unit can easily be mounted.

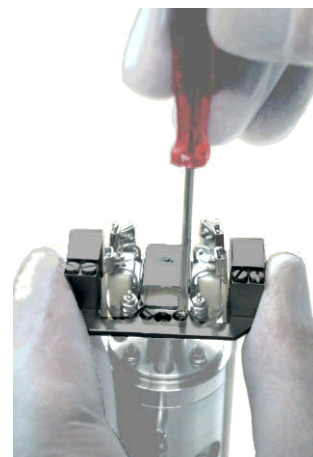


2 Unfasten the two screws without removing them.

3 Remove the magnet unit and the screws from the package.



4 Mount the magnet unit onto the ion source.



4.2 Installation

- Check the installation area is unobstructed.

 **Note**



Caution: difficult installation
Depending on the installation angle it might be difficult to mount the magnet assembly.
In order to prevent installation damages, have a second person assist you.

- Insert an OFHC copper seal into the analyzer or system flange.

 **Note**



Caution: vertical seals
Vertical seals easily drop out of the groove and thus damage the ceramic capillaries of the wiring.
Hold the vertical seal stationary when installing the magnet assembly!

Holding the seal

- Hold the vertical seal stationary with a knife blade.



Making the flange connection

- Carefully introduce the analyzer into the vacuum system. The ion source and wiring must not touch any parts.
- Insert one of the upper screws and tighten it with your fingers.
- Insert the screw on the opposite side and tighten it with your fingers.
- Insert the remaining screws and tighten them with your fingers.
- Tighten all screws properly.





Evacuating the system

Evacuate the system and check that the expected vacuum is reached.

4.3 Gas inlet system


If the ion source is to be equipped with a gas inlet system connect the latter properly. The admission line must be electrically isolated from the ion source.


	DANGER
	<p>Danger: hazardous gases Process gases can be detrimental to health. Before admitting the process gas, check that the connection is leak tight. Make sure the exhaust system is suited for the admitted gases.</p>

4.4 QMH 400/410

Install the RF generator →  [3].

4.5 EP 422

Connect the electrometer preamplifier EP 422 to the Faraday cup connector EP(FARAD) on the QMA if applicable →  [2].

Mount the second electrometer preamplifier EP 422 to the SEM collector connector EP(SEM) if applicable →  [2].

4.6 CP 400

Install the ion counter preamplifier CP 400 if applicable →  [2].

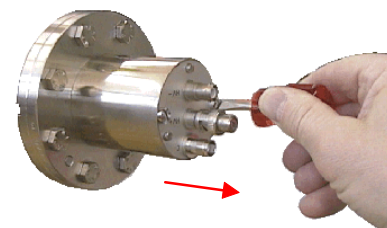
Before installing the CP 400 remove the SEM connector plate of the QMA or the cover if it is not equipped with a SEM connector plate.

4.6.1 Removing / installing the SEM connector plate

- Turn the equipment off and disconnect the EP 422 and cable from the connector plate.

- Remove the two big screws.

- Remove the protective tube.



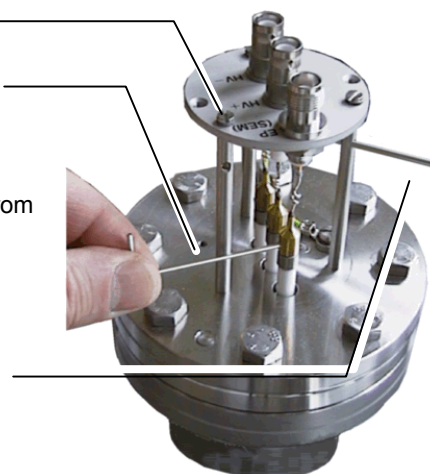
- Remove the three screws.

- Unfasten the three hex socket screws (size 1.5 mm) by ½ turn.

- Detach the cable lug of the yellow/green ground conductor from the flange.

- Detach the connector plate.

- Unscrew the three studs using a suitable pin.



Keep all parts because they will be needed when the equipment is converted for electrometer operation.

Reassemble the equipment by performing the above steps in reverse order. Don't forget to reinstall all lock washers at the appropriate places.

4.7 Mounting the protective tubes



STOP DANGER

Caution: hazardous electrical voltages

The voltages under the connector plates are extremely hazardous.
Before installing the cables mount all protective tubes.

4.8 Cabling

→ [2] "Cabling with QMA 400" and [3] "Electrical connections".

For special ion sources (e.g. optics) consider the notes in the corresponding chapters (→ 41 ff.).

Notes

5 Operation

5.1 First time operation

- Before switching the equipment on check that all components are correctly installed and wired.



DANGER

Caution: hazardous electrical voltages

The voltages under the connector plates are extremely hazardous.

Before putting the equipment into operation make sure the protective tubes are installed.

- Only when the pressure in the system is below the highest admissible total pressure
 - 10^{-4} mbar with Faraday,
 - 10^{-5} mbar with SEM
 the control unit may be switched on, however, the emission must not be switched on yet.
- Check that the values stored in the unit correspond with the supplied test protocol (which indicates the optimum values for your analyzer). If the values differ, make the appropriate settings via the software or directly with the unit. If you do not have a test protocol at hand, activate the default settings of your ion source and optimize them according to the following chapters.
- If your system has been delivered as a complete assembly, the radio frequency generator has been adjusted to the analyzer at the factory → [3].
- Select the "Det. Type: Faraday" (except if you use only an ion counter as detection unit). If you have only one EP 422 mount it to the EP(FARAD) connector and to the EP(FARAD) connection of the QMH.
- Switch the emission on and measure a few spectra with the Faraday.
- If you have only one EP 422 and no CP 400 mount the EP 422 to the EP(SEM) connector and attach it to the EP(SEM) connection of the QMH.
- When the pressure in the system is below the highest admissible total pressure for SEM operation (10^{-4} mbar), switch the SEM on.
- Measure a few spectra with "Det. Type: SEM" with the EP 422 or CP 400.
- Check the "tune" adjustment of the RF generator (→ [3]).
- If your analyzer was not delivered together with the RF generator, optimize the "Resolution" setting. If no regular peak width is achieved for small and large masses, adjust the peak width on the QMH (→ [3]). Additionally calibrate the mass scale if necessary.

Do only modify the factory parameter settings (→ [27]) if required for your application.

5.2 High temperature operation

The analyzer can be heated to a maximum of 180 °C during operation, but the temperature of the EP 422, CP 400, and QMH 400 / 410 must not exceed 50 °C.

For this reason the electrometer amplifier EP 422 and RF generator are removed and placed outside the heating zone for bakeout.


A 0.5 m Teflon cable (→ [2] "Accessories") is supplied to make the connection to the socket EP of the connector plate.

The RF cables between the QMA and the QMH must not be extended under any circumstances.

At a baking temperature > 150 °C the SEM can be operated only with 1000 V.



5.3 Baking the analyzer

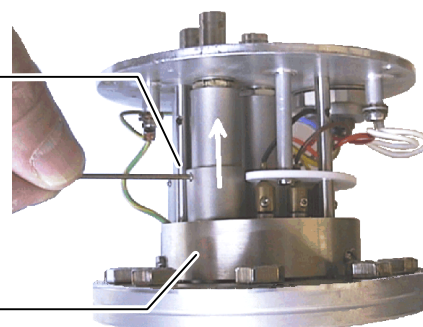
The analyzer can be baked at up to 400 °C.

The EP 422 and CP 400 have to be removed for that purpose (→  [2]). They can only be mounted when the flange has cooled down to < 50 °C.

For baking temperatures > 200 °C remove the connector plates as follows:

5.3.1 Removing the connector plates

- If you have a 90° SEM, remove the connector plate (→  21), however, leave the three studs in place.
- Remove the protective tube from the large connector plate.
- Loosen the hex socket screws (size 1.5 mm) of the shielding sleeves by ½ turns each.
- Slide the shielding sleeves up to the connector plate and fasten them in that position.
- Further procedure →  21. Do not remove the protective ring and the studs.



5.3.2 Mounting the connector plates

- Check that the three studs are screwed in firmly.
- Carefully position the connector plates so that the connectors fit the corresponding feedthroughs.
- Secure the connector plates using the three screws and lock washers.
- Carefully tighten the hex socket screws at all connectors, however, without applying force to the feedthroughs.
- Slide the shielding sleeves over the feedthroughs (they must slide into the countersink of the flange) and tighten their screws.
- Reinstall the protective tubes.

5.4 Assessing the sensitivity

The supplied test protocol shows how the sensitivity has been assessed at the factory (with and without SEM).

It is indicated in A/mbar for a reference gas. N₂ or air are recommended as test gases.

For air, use 80% of the total pressure as N₂ pressure and add the ion currents of masses 14 and 28.

Subtract the corresponding residual gas peak levels unless they are negligible.

Make sure the reference pressure is correctly measured, e.g. with an ionization gauge installed at an appropriate place.

5.5 Secondary electron multiplier SEM

The gain and thus the sensitivity can be roughly adjusted with the SEM high voltage "SEM Volt". Avoid values below 1 kV as well as ion currents $> 1 \mu\text{A}$ for more than a few minutes, as in these ranges the gain is not stable.

5.5.1 Contamination

When the gas composition is unfavorable (hydrocarbons and other organic vapors), prevent contamination of the SEM by operating it with a low current.

Operate the equipment in Faraday mode, if that makes sense for your application.

5.5.2 Low partial pressures

At very low partial pressures (very small peaks) the ion current consists of single pulses. At a very high SEM gain setting, these pulses can overmodulate the stage of the electrometer preamplifier and thus cause measurement errors (e.g. non-linearity) which are not obvious.

Considerable deviations ($> 10\%$) of the values measured within various electrometer ranges, discontinuities of the measured value curves in autorange mode, flattened peaks, incorrect isotope ratios etc. may be due to this effect.

In such cases, reduce the "SEM Volt.", select a less sensitive "Range" or use "Range-L" to lock the most sensitive measurement ranges.

With the ion counter, this problem does usually not occur.

5.5.3 Gain factor

Register the range to be considered of the mass spectrum in SEM and Faraday mode. The ratio of the currents of two corresponding peaks is the gain with the current operation settings.

With this method, the influence of the 90° ion deflection device is taken into consideration.

5.6 Surface ions

Due to electron impacts on the ion source surfaces, adsorbed contaminants are desorbed as so-called EID ions, which are represented in the spectrum, e.g. with masses 16 (O^+), 19 (F^+), 23 (Na^+), 35/37 (Cl^+) and 39/41 (K^+).

EID ions appear especially under UHV conditions. They can be reduced by degassing (Degas or temporary operation with high emission).

In order to distinguish between EID ions and ions from the volume, reduce the field axis voltage "Field Axis". The peak level of normal ions is thus strongly reduced whereas the peak level of EID ions is less affected as they are formed on the highest potential.

Therefore, to prevent suppression of the normal ions, do not select a too low "Field Axis" value

5.7 Degas

Degas is chiefly intended for UHV measurements (with a grid ion source). Degas must not be activated at pressures $> 10^{-7}$ mbar as otherwise, the ion source will be contaminated.

Consider the specifications of the individual ion sources (→ 33 ff.).

Optimize the filament protection "Protect" for the degas mode.

To lock the degas mode, set "Protect" to 0 A.

Notes

6 Optimization

For certain applications the factory settings should be modified. The following sections explain how to determine the optimum parameter values.

With increasing contamination or after revision work, the settings should be modified according to the following sections.

The potentials and their denominations are listed in [2], "Technical Data".

It should be possible to measure a spectrum with the default values of the equipment (→ [2] Appendix A) – except for the "SPEC(ial)" ion source type. The values should always be optimized for the analyzer used.

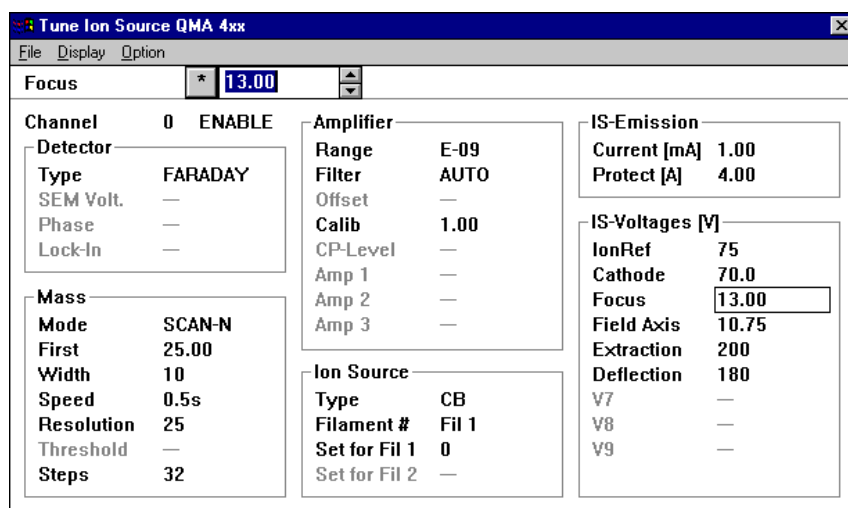
The objective of the ion source parameters is to achieve a high sensitivity, a good peak shape, and a low mass discrimination. Possibly, other conditions should be fulfilled, too (see below).

This chapter applies to virtually all ion sources; certain potentials are not needed for all ion sources.

Please refer to the information on the individual ion sources (→ 33 ff.).

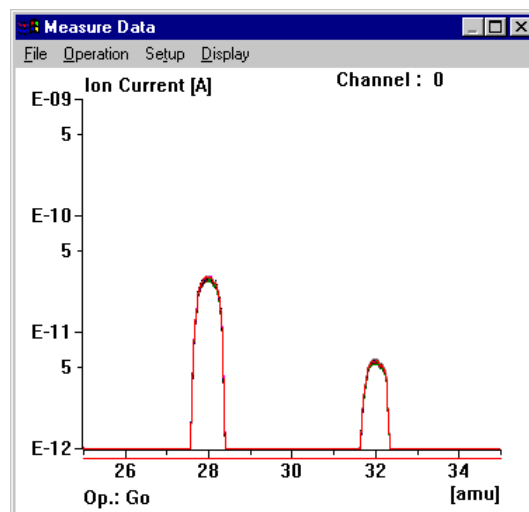
6.1 Recommended operating modes

For optimizing the settings, use the TUNE ION SOURCE program of the Balzers Quadstar™ Software.



- For optimization the "Mode SCAN-N" mode is best suited because in this mode, the peaks are not filtered.
- Set the "Amplifier Range" to AUTO.
- Select a small "Width" (5 ... 10 u).
- Activate "Display Measured Data" and position the two windows so that parameters settings can be made while the measurement data are visible.
- Use "Steps": 64 if you like to optimize for a low contribution to the neighboring mass.

- Adjust "First" so that the peaks you are interested in are in the center of the displayed range.
- In the three-decade representation of the ion current showed in the illustration the resolution, peak shape, and peak height are clearly visible.
- Depending on the objective of the optimization, linear or logarithmic representation, for instance over six decades, may be preferable.



- First optimize with "Det. Type: FARADAY" and only then with "SEM". After that, only the deflection voltage ("Deflection V6 / V7") and possibly the "Field Axis" have to be adjusted.
- Before optimization, allow the equipment to warm up for about 30 minutes with the emission switched on. At the beginning, a degassing process is to be expected.

6.2 Test gas

Admit a suitable gas with a pressure of $\approx 5 \times 10^{-6}$ mbar (for special ion source types (→ 33 ff.).

If you like to optimize the analyzer for higher masses, your test gas should contain the corresponding components. Otherwise, air will do.

If you cannot admit a gas, optimize with a suitable residual gas peak. Note variation in the degassing due to peak changes, e.g. when using H_2O .

For sensitivity optimization, frequently gas admission systems are used in which the pressure in the ion source is higher than the pressure in the environment. Definition of the sensitivity in A/mbar does not make sense in these cases.

6.3 Ion source parameters

6.3.1 Emission

A typical emission "Current" is 1 mA, which is the maximum value for ion sources with yttrated cathodes.

In certain cases (e.g. grid ion source) the sensitivity is higher with 2 mA. However, sometimes, the maximum sensitivity is reached at lower emission settings, e.g. for crossbeam ion sources with electron collimation magnets. This is due to volume charge effects.

Consider the specifications of your individual ion source type (→ 33 ff.).


At a low electron energy (e.g. "Cathode" < 50 V), the "Emission" has to be reduced to 0.1 ... 0.2 mA in order for electron volume charge and thus filament overload to be avoided.

At pressures > 10^{-5} mbar, reduce "Emission" to < 0.2 mA. The linearity of the peak height is thus improved as a function of the pressure.

If you modify the emission ("Current"), adjust "Protect" as well.

6.3.2 Protection

When the pressure in the ion source rises, the heating current of the filament rises, too. This effect is used to turn the cathode off when the pressure rises.

"Protect" defines the switching off threshold. To achieve optimum protection set the threshold as low as possible. The setting is optimal if you can just switch on the emission without triggering the protection (→  [2] "Filament protection").

If it is not possible to turn on the emission, the "Protect" threshold setting might be too low.

6.3.3 V1 IonRef

"IonRef" is the nominal potential on which the ions are formed. The actually effective potential is somewhat lower because of the penetration coefficient of the extraction field and the electron volume charge.

"IonRef" is the reference potential for all other potentials (→ [2] "Technical Data").

In general, the "IonRef" should be set slightly higher (approx. 20 V) than the electron energy ("V2 Cathode"). The cathode is thus on a positive potential with regard to ground so that no electrons are emitted to the environment. This prevents interferences with the Faraday cup of the system and nearby measurement equipment (e.g. ionization manometer). Moreover, gases adsorbed in the environment could be emitted through electron impact, which could influence the measurement.

At lower electron energies (e.g. 40 V), less double charged ions are formed. This prevents for instance contribution of $^{36}\text{Ar}^{++}$ to mass 18, which would complicate the detection of water vapor traces in argon.

The following effects of the "IonRef" setting are also influenced by the mechanic tolerances, e.g. of the exact cathode position:

- At low values (25 ... 40 V) the sensitivity for lower masses is higher, whereas the maximum sensitivity for higher masses is reached with higher values.
- The higher the "IonRef" setting the lower the mass discrimination, i.e. the sensitivity decreases with higher mass numbers.
- These relationships become even clearer with higher mass ranges and smaller filter dimensions.
- If you like to minimize the mass discrimination, select a peak with the highest possible mass for optimizing the ion source parameters.

For the ion optics select an "IonRef" value which is slightly lower than the energy of the (positive) ions to be detected.

6.3.4 V2 Cathode

The cathode voltage determines the acceleration voltage of the electrons and thus the nominal ionization energy. The actual ionization energy deviates slightly from that value, inter alia due to the extraction field. Calibration measurements are required for applications for which the exact ionization energy has to be known.

The reference data in spectra libraries are usually referenced to 70 eV.


At lower V2 values, there are less dissociation peaks and multiply ionized peaks (e.g. Ar^{++} , N^+).

Note



Caution: filament overload

At a reduced ionization energy ("Cathode" e.g. 40 eV) the cathode temperature required for the emission rises and the filament could thus burn out.

In that event reduce the emission to e.g. 0.1 mA and adjust "Protect" →  [2] "Filament protection".

6.3.5 V3 Focus

Adjust "Focus" to the maximum peak level.

If there are several maxima, select the one with the lowest voltage value while considering the information which applies to your ion source (→ 33 ff.).

When "Focus" is modified "Extraction" must be optimized accordingly (if applicable).

6.3.6 V4 Field Axis

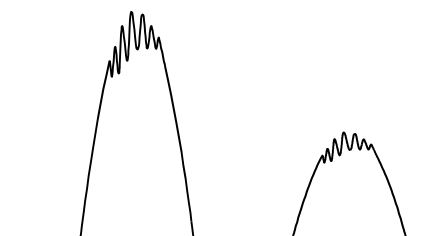
The field axis voltage ("V4-Field Axis") is the potential in the axis of the quadrupole field. It acts as decelerating voltage for the ions to remain in the rod system long enough to be resolved.

The field axis voltage is the nominal energy E_{nom}^2 of the ions in the rod system.

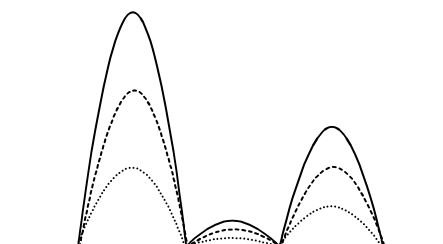
The optimum value of "Field Axis" depends inter alia on the frequency (QMH Type) and the QMA type. Lower frequencies (higher mass ranges) or shorter rod systems require lower ion energies because the ions must stay longer in the mass filter to be resolved.

The higher the value, the higher the peaks. However, the resolution is lower and the peak shape deteriorated.

Exceedingly high "Field Axis" values result in "frayed" peaks.



If with "Resolution" the resolution is not improved and the peak level is decreased, lower the "Field Axis" value.



The combined optimization of "Field Axis" and "Resolution" should result in a maximum peak level with the desired resolution and a sufficiently good peak shape.

If an insufficient peak shape cannot be improved by reducing the "Field Axis" value, there may be contamination or mechanical problems (e.g. ion source not correctly centered or tilted).

Chapter "Surface ions" (→ 25) shows how to distinguish between normal and so-called EID ions by means of "Field Axis".

6.3.7 V5 Extraction

The extraction voltage ("V5-Extraction") accelerates the ions from the ionization area towards the rod system. If the extraction voltage is modified, "Focus" must also be optimized.

6.3.8 V8 Reserve

The potential V8 is used for special cases (e.g. in combination with certain optics).

6.3.9 V9 Wehnelt

The Wehnelt voltage is only used for the axial ion source (→ 33).

² The actual value of the ion energy E_{eff} is slightly lower. For calculating the deviation, reduce the "Field Axis" value until the measured peak just disappears (i.e. decreases to <1%). You thus obtain the value E_o .


$$E_{eff} = E_{nom} - E_o$$

6.4 V6 / V7 Deflection

Die deflection voltages ("Deflection", "DEFI" and "DEFO") direct the ions through the 90° deflection condenser.

In the QMG 422, in Faraday operation, they are automatically switched to ground potential.

The polarity of the two potentials is opposite to the ion polarity. The ions are accelerated from the mass filter to the deflection unit and directed to the SEM.

There are two deflection versions (→  10):

One deflection voltage

The inner deflection plate is on potential "V6 Deflection", outer is directly connected to the Faraday cup and the electrometer amplifier EP1 and is thus on ground potential.

The optimum value is determined by the ion formation potential "IonRef" and to a certain extent by the SEM voltage.

Approximate values:	IonRef	120 V	40 V
	Deflection	300 V	200 V

Adjust "Deflection" so that a normal peak level is reached.

When the "SEM Volt" is modified, the "Deflection" has to be adjusted, too.

Two deflection voltages

The inner deflection plate is on V6 and the outer on V7.


Alternatingly adjust "DEFI" and "DEFO" to the maximum peak level.

If the "SEM Volt" is modified, the two potentials have to be adjusted, too.

6.5 Resolution

Do not select a better "Resolution" than required for the measurement task. The wider the peaks are the better are the sensitivity and stability of the measured values.

Consider the interdependence of "Field Axis" and "Resolution" (→  30).

If the peak width is irregular over the whole mass range it can be corrected by adjusting the settings of the radio frequency generator QMH (→  [3]).

6.6 RF cable polarity

The resolution and peak shape might be improved by interchanging the RF cables at the analyzer. Optimize with both polarities and choose the better version.

Before exchanging the RF cables, set "First" to 0 and "Mode" to "SAMPLE".

If by reversing the polarity, the sensitivity is improved or deteriorated by more than 50 %, there is contamination or a mechanic fault.

Notes

7 Ion sources

7.1 Axial ion source

By focusing the ions in axial direction, the axial ion source supplies ions with a narrow energy distribution and a small speed component transversely to the axis so that excellent resolution, high sensitivity, and good linearity are achieved.

The open design allows registration of rapid changes in the partial pressure with minimum distortion due to outgassing and surface reactions.

Standard filament material: Re. W and YO_x -Ir filaments are also available.

Application examples

- General gas analyses
- Residual gas analysis

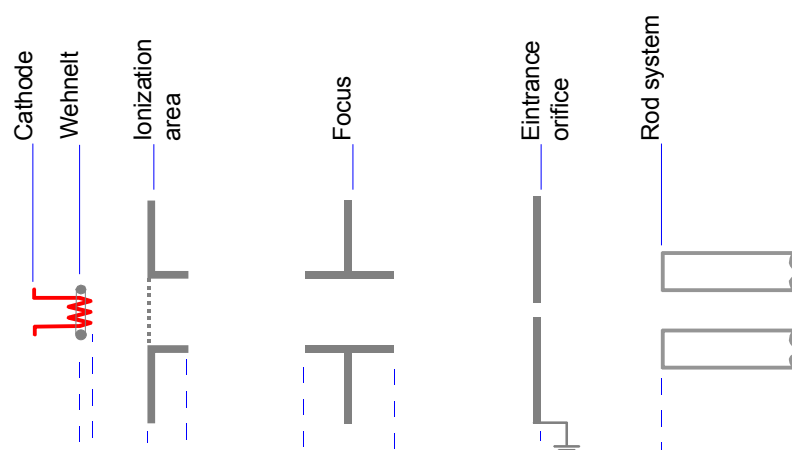
Function

The electrons emitted by the cathode are accelerated toward the grid of the ionization area. The Wehnelt electrode, which is negative to the cathode, focuses the electrons. Most of the electrons pass through the grid and reach the lens (focus) or return to the grid.

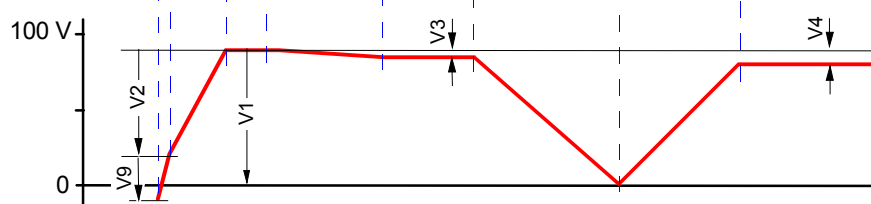
The ions produced by electron impact are drawn by the focus and entrance orifice and focused to the mass filter. The grid prevents the ions from being drawn to the cathode.

The field axis potential is a few Volt below the potential of the ionization area so that mainly ions from the ionization area enter the mass filter.

Electrode arrangement



Potentials



Typical values

	Emission	1 mA ¹⁾	
V1	IonREF	90 V	
V2	Cathode	70 eV ²⁾	
V3	Focus	20 V	
V4	Field Axis	10 V ³⁾	
V6	Deflection	300 V	
V9	Wehnelt	30 V (max. 40)	
	Protection W	4.2 A	
	YO _x -Ir / Re	3.5 A	

1) At $p > 5 \times 10^{-6}$ mbar reduce to 0.1 mA.

2) Before reduction of V2 to < 50 eV reduce the "Emission" to 0.1 mA and V9 to < 20 V, in order to prevent overload of the cathode.

3) 5 V at mass range 1024 or 2048

Adjustment

Start with the values which previously supplied good results, with the values in the test protocol or otherwise with the values of the above table.

- 1 Adjust "Focus" to the maximum peak level.
- 2 Adjust "Wehnelt" to the maximum peak level (if "Cathode" < 50 V maximum = 20 V!).
- 3 Search the combination of "Field Axis" and "Resolution" which yields the best peak level and shape.
- 4 Try which is the better RF cable polarity (\rightarrow 31).

Degas

With Degas, the outgassing rate of the axial ion source is reduced.

Pressure	$\leq 10^{-8}$ mbar
Emission	≤ 10 mA (at 550 V)
Time	≤ 5 minutes

7.2 Crossbeam ion source

Gas tight version

The open design of the crossbeam ion source allows quick reaction to changes in the gas composition.

The crossbeam ion source has two filaments and has a long service life.

Standard filament material: W. YO_x -Ir also available.

Molecular beams can be injected through the sensitive volume perpendicularly and parallel to the system axis.

Molecular beam device

The ionization chamber of the gas tight crossbeam ion sources is sealed.

The conductance is ≈ 1 l/s. Set the operating pressure to < 10 mbar.

The molecular beam device generates a directed gas beam from which only a few particles hit the ionization area. Therefore, no contamination layers are formed.

Using an electron collimation magnet is recommended.

Recommended inlet pressure: 0.5 mbar

Application examples

- Analysis of particle beams and general gas analysis.
- Qualitative and quantitative gas analyses (composition and time behavior)
- Analysis of reactive and aggressive gases (with special accessories)
- Detection of contaminants/impurities in gases
- Isotope measurements
- Residual gas analysis in vacuum processes (e.g. plasma etching)
- Process monitoring / process control (e.g. control of the gas composition or control of evaporation sources)
- Molecular beam applications
- Analysis of not easily volatilized substances (with inlet device for solids)

Because of their minimal gas consumption, low defractionation and small time constant, gas tight ion sources are ideal for:

- Measurement of gases and solvents in liquids
- Respiration analyses
- Analyses of gas mixtures
- Trace analyses with little influence of residual gases
- Analyses of corrosive or toxic gases (\rightarrow 5)

Function

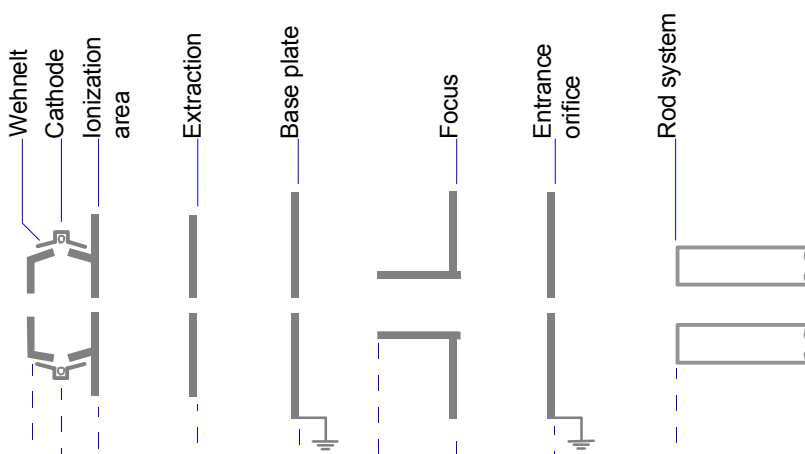
The electrons emitted by the cathode and focused by the Wehnelt electrode, which is connected to the cathode, enter the ionization area perpendicularly to the system axis through a gap and ionize the gas in the ionization area.

The ions are drawn out by the extraction electrode and focused into the mass filter through the ion lens (Focus).

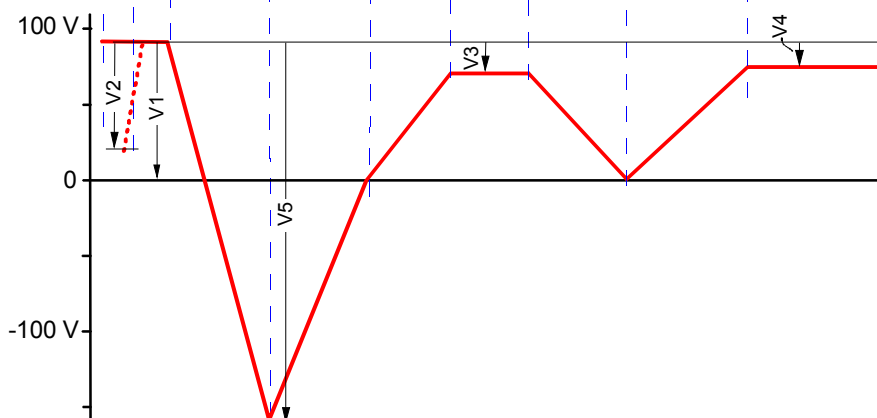
The electron beam, particle beam (if a molecular beam is admitted) and ion extraction are arranged perpendicularly to each other.

The field axis potential, which is a few Volt below the potential of the ionization area mainly focuses ions from the ionization area into the mass filter.

Electrode arrangement



Potentials



Typical values

	Emission	1 mA ¹⁾	
V1	IonRef	90 V	
V2	Cathode	70 eV ²⁾	
V3	Focus	20 V	
V4	Field Axis	15 V ³⁾	
V5	Extraction	250 V	
V6	Deflection	300 V	
	Protection W	4.2 A	
	YO _x -Ir / Re	3.5 A	

1) With magnet 0.7 mA / At p > 5 × 10⁻⁶ mbar reduce to 0.1 mA.

2) Before reduction of V2 to < 50 eV reduce the "Emission" to 0.1 mA and V9 to < 20 V in order to prevent overload of the cathode.

3) 5 V at mass range 1024 or 2048.

Adjustment without magnet

Start with the values which previously supplied good results, with the values in the test protocol or otherwise with the values of the above table.

- 1 Increase the "Field Axis" value by 1.5 V.
- 2 Increase the "Resolution" by ca. 15 %.
- 3 Alternatingly adjust "Focus" and "Extraction" to the maximum peak level.
- 4 Decrease "Field Axis" until the peak level drops by approx. 10 % and assess the peak shape and resolution.
- 5 Adjust "Resolution" so that it just suffices for the intended purpose. If the resolution is set higher than necessary, the sensitivity and stability may be reduced.

- 6 If the peak shape is unsatisfactory (spikes, tailings), try to improve it by lowering the "Field Axis".
- 7 Try to improve the sensitivity by gradually adjusting the "IonRef" setting (in steps of 5 V). After each step, readjust the parameters. Proceed systematically and record the parameters and the corresponding peak level and shape.
- 8 Repeat the procedure for the second cathode. After activating the cathode, wait until thermal stability is reached. If the sensitivity of the two cathodes is quite different, there might be mechanical deformation.
- 9 Try which is the better RF cable polarity (→ 31).

Adjustment with magnet

For analyses with different pressures we recommend removing the magnet unit or reducing the emission to 0.1 mA.

For low emissions (up to 0.1 mA) follow the procedure in section "Adjustment without magnet".

At a higher emission and for achieving maximum sensitivity, proceed as follows to find the best emission setting:

- 1 Set the pressure in the system to the value for which you like to optimize your ion source. This value should remain constant for all adjustments.
- 2 Set the "Field Axis" to 16 V and "Emission" to 0.5 mA.
- 3 Alternatingly adjust "Extraction" and "Focus" several times on the highest peak level.
- 4 Note the peak level and the corresponding values of "Emission", "Extraction" and "Focus".
- 5 If the emission is < 1 mA, increase it by 0.1 mA and repeat the procedure from step 3.
- 6 In the data records, look for the point with the highest peak and make the corresponding parameter settings.
- 7 Make the "Field Axis" and "Resolution" setting as described in section "Adjustment without magnet".
- 8 Determine which is the most favorable "IonRef" value and better cable polarity as described in section "Adjustment without magnet".
- 9 Increase "Extraction" until the sensitivity is 5 % lower; the stability becomes thus better.

The ion source is now optimized for the current pressure. For other pressures, it usually suffices to adjust "Extraction" and "Focus".

Degas

Degassing of the crossbeam ion source is recommended only for special cases.

Pressure	≤ 10 ⁻⁸ mbar
Emission	≤ 10 mA (at 550 V)
Time	≤ 5 minutes

Notes

7.3 Grid ion source

Because of its extremely open design the grid ion source has an extremely low outgassing rate and is easily degassed. It emits only a few surface ions.

It is always equipped with two W filaments.

Application examples

- Residual gas analysis in UHV
- Desorption measurements

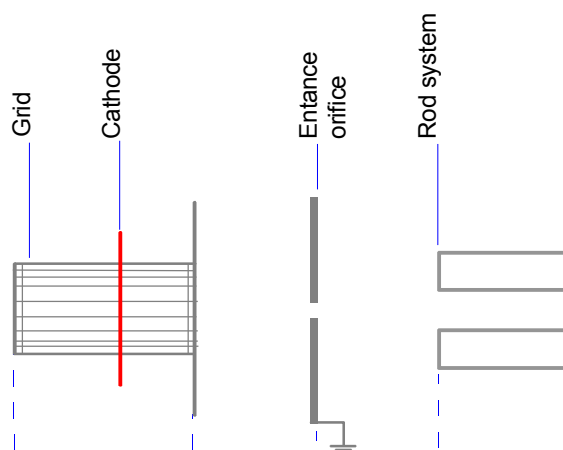
Function

The two electrons which are emitted by the ring cathode are accelerated toward the grid and mainly pass through the grid.

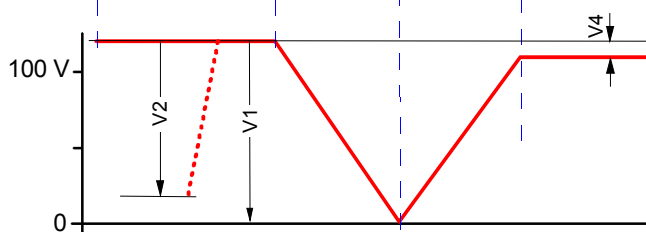
The ions formed inside the grid are drawn to the mass filter by the grounded entrance orifice.

The cathode is connected in the middle. Each half of it can thus be operated separately. In "Fil1+2" mode, the second half is heated so that a high desorption rate is avoided when "Fil2" is activated.

Electrode arrangement



Potentials



Typical values

	Emission	2 mA ¹⁾	
V1	IonREF	120 V	
V2	Cathode	100 eV ²⁾	
V4	Field Axis	10 V ³⁾	
V6	Deflection	200 V	
	Protection	W	4.2 A
		YO _x -Ir / Re	3.5 A

¹⁾ At $p > 5 \times 10^{-6}$ mbar reduce to 0.2 mA.

²⁾ Before reduction of V2 to < 50 eV reduce the "Emission" to 0.1 mA and V9 to < 20 V to avoid overload of the cathode.

³⁾ 5 V at mass range 1024 or 2048.

Adjustment

Start with the values which previously supplied good results, with the values in the test protocol or otherwise with the values of the above table.

- ❶ Adjust "IonRef" to the maximum peak level, however, below the "Cathode" value as otherwise, electrons hit grounded components and desorb ions.
- ❷ Increase "Field Axis" until the peaks "fray" (→ 30) and then reduce that value again until a clear peak shape is reached.
- ❸ Make the desired "Resolution" setting, ideally unit resolution $\Delta M_{10} = 1$.
- ❹ Repeat steps ❷ and ❸ if necessary.
- ❺ Try which is the better RF cable polarity (→ 31).

Degas

With Degas the outgassing rate of the grid ion source and the desorption of surface ions is reduced.

Pressure	$\leq 10^{-7}$ mbar
Emission	≤ 20 mA (at 550 V)
Time	10...15 minutes

During the degassing process, operate both filament parts (Fil1+2) to prevent adsorption on the cold part.

Recommendation:

- Degas 10 ... 15 minutes
- Wait until the final pressure is reached.
- Check the spectrum.
- Repeat the procedure if necessary.

7.4 Two lens ion optics

The two lens ion optics does not generate any ions. It transmits ions emitted elsewhere to the mass filter.

The ions can be emitted from a flat surface (e.g. solid surface) or a small volume.

The two lens optics are often combined with an isolated design. In some cases, both deflection voltages are operated at the same time. To check which version you have please refer to the supplied schematic drawing and additional sheets possibly enclosed with the test protocol.

Application examples

- Thermal desorbed ions
- Electron induced desorption
- Ions from plasmas

Installation

Place the entrance orifice centered at a distance of 5 mm (longer distances are admissible, however, they reduce the sensitivity) from the center of the emitting surface, which need not be perpendicular to the QMA axis. The beam, which excites the emission, should hit the desired spot without colliding with the optics.

If there is a TARGET connector at the QMA, connect the available voltage to your target.


If there is a BIAS connector at the QMA, connect the provided bias voltage there.



DANGER

Caution: shock hazard

The voltages of the IS 420 as well as the additional BIAS and TARGET voltages can be extremely hazardous.

Consider the technical specifications of the IS 420 (→  [2]) and use only properly made cables.

Function

From the spot where they are emitted 1 (→ illustration below, e.g. solid surface) the ions to be analyzed reach the inside of the optics via the entrance orifice 2. Their shapes and potentials have a combined effect, oscillating ions are focused to the entrance orifice of the mass filter.

Positive ions are detected in "SPEC+" mode, negative ions in "SPEC-" mode (in combination with the ion counter).

V1 is the surface potential of the sample, which can deviate from the connected potential due to surface charges.

The entrance energy of the ions is:

$$E_i = E_o + eV1 \text{ where: } E_o = \text{Initial energy of the ions (defined by the emitting mechanism)}$$

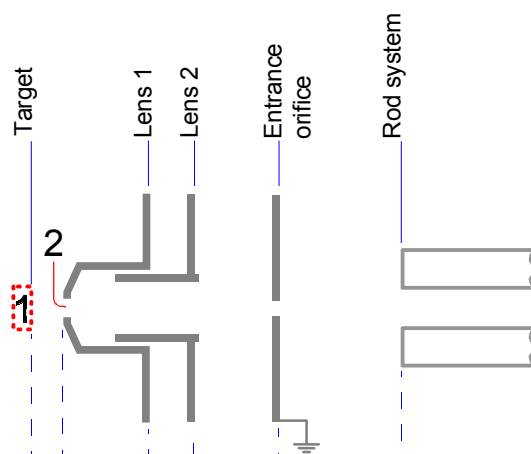
$$V1 = \text{Potential on which the ions are emitted}$$

For secondary ions E_o is not constant. For each kind of secondary ion, there is another probability of occurrence. 5 to 10 eV is a reasonable thumb value.

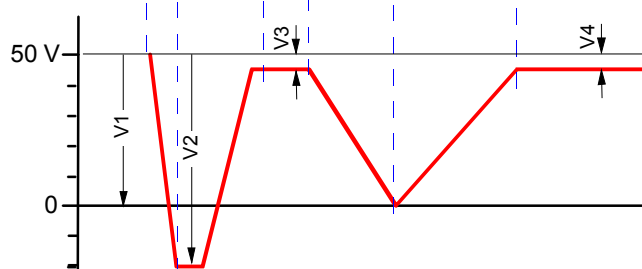
The potentials V2 and V3 are selected as a function of the energy of the entering ions and the desired energy interval of the ions which should pass.

Depending on the potential setting, certain energy ranges are discriminated. For quantitative analysis, comparison to other standards is necessary.

Electrode arrangement



Potentials



Typical values

The values and adjustment apply to ions, emitted on a target. For other applications, they may be quite different. Please note the values for your individual application in the table below.

V1	IonRef	50 V / Target ¹⁾	
V2	Lens 1	70 V	
V3	Lens 2	5 V	
V4	Field Axis	5 V	
V5			
V6	DEFI	350 V	
V7	DEFO	120 V	
V8			
V9			

¹⁾ Emission potential of the ions, e.g. connected to SIMS target.

Adjustment

Start with the values which previously supplied good results, with the values in the test protocol or otherwise with the values of the above table.

- 1** Adjust V1 to the maximum peak level (depending on target distance).
- 2** Alternatingly adjust V2 and V3 to the maximum peak level.
- 3** Adjust the V4 "Field Axis" setting so that a good peak shape and the resolution $\Delta M_{10} = 1$ are reached. If the peaks are still "frayed", reduce V1 and adjust V2 and V3.
- 4** Adjust V7 "DEFO" to the maximum peak level.
- 5** Find out which is the better RF cable polarity (→ 31).

7.5 Crossbeam ion source with two lens ion optics

This version offers the characteristics of the two lens ion optics combined with the features of the crossbeam ion source. It is used for detecting foreign ions and neutral particles ionized in the crossbeam ion source.



The crossbeam ion source with two lens ion optics is often combined with the open design. In some cases, both deflection voltages are operated at the same time. To check which version you have please refer to the supplied schematic drawing and additional sheets possibly enclosed with the test protocol.

The AS 400 adapted is included in the scope of delivery.

Application examples

- Thermal desorbed ions
- Electron induced desorption
- Ions from plasmas
- Applications which require a short distance between the gas source and ionization area
- Detection of unstable (thermal incited) particles


Function


→  41 and  35.

The AS 400 adapter converts some potentials (see the table below) depending on whether the equipment is operated in crossbeam or ion optics mode. The ion optics mode is activated by selecting the ion source type "SPEC+ / SPEC-" and "Emission = Off".


Installation

Place the entrance orifice centered at a distance of 5 mm (longer distances are admissible, however, they reduce the sensitivity) from the center of the emitting surface, which need not be perpendicular to the QMA axis. The beam, which excites the emission, should hit the desired spot without colliding with the optics.

The AS 400 adapter is incorporated in the control unit and is connected between the IS 400 and the QMA (for subsequent installation →  [2]).




DANGER



Caution: shock hazard

The voltages of the IS 420, AS 400 and QMA are extremely hazardous.

Consider the technical specifications of the IS 420 (→  [2]) and use only properly made cables.

There are 3 SHV connectors on the AS 400:

X10 BIAS IN: Input for external voltages for biasing the whole ion source supply in ion optics mode (maximum 200 V); in crossbeam mode, the supply is on ground potential.

X11 BIAS: Output with bias voltage for the "isolated design".
V3 "Focus" in ion optics mode, ground potential in crossbeam mode.

X12 Target: Output with V1 "Ionref". Connect the target here (e.g. for SIMS).

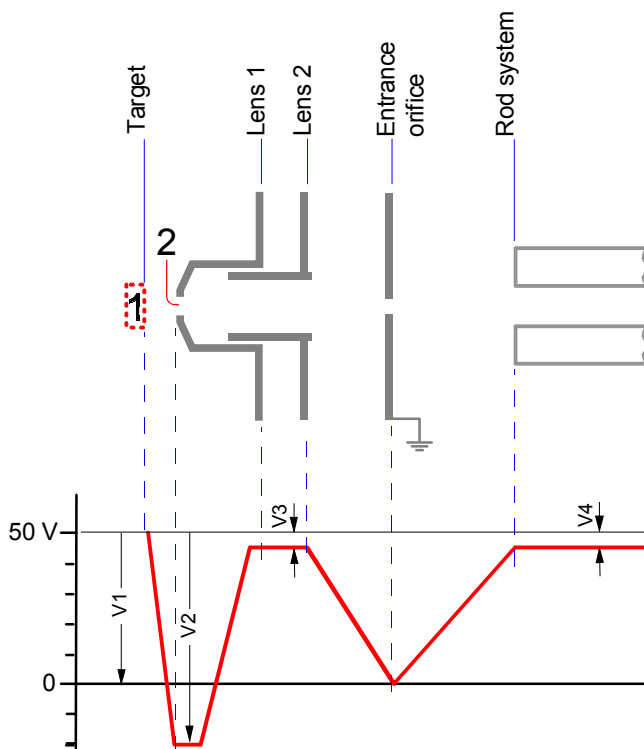
If there is a TARGET connector on the QMA, the voltage available there (→ supplied diagram) can be applied to the target; in general, it is not identical with the voltage at X12.

If there is a BIAS connector on the QMA, connect it to the X11 BIAS connector of the AS 400. If you are not using the BIAS connector of the QMA, plug in a shorting connector.

Electrode arrangement

The ion optics mode is shown here; for crossbeam operation → 35 ff.

Potentials



Typical values

The values and adjustment apply to ions, emitted on a target. For other applications, they may be quite different. Please note the values for your individual application in the table below.

Operating mode SPEC+/-		
	Emission	OFF
V0	X10 BIAS IN	0 V (shorting connector)
V1	X12 Target ¹⁾	80 V
V2	Lens 1 // Cathode	70 V
V3	Focus // Ionization area // X11 BIAS	20 V
V4	Field Axis	15 V
V5	Extraction	250 V
V6	Deflection	300 V
V7	Lens 2	5 V
V8	Target (QMA)	--
V9	--	--

1) Emission potential of the ions, e.g. connected to SIMS target.

Adjustment

Start with the values which previously supplied good results, with the values in the test protocol or otherwise with the values of the above table.

- 1** First optimize for crossbeam mode and use the corresponding values for V3, V4, V5.
- 2** Adjust V1 to the maximum peak level (depending on distance of target).
- 3** Alternatingly adjust V2 and V7 to the maximum peak level.
- 4** If the peak shape is not satisfactory ("frays") or if the resolution $\Delta M_{10} = 1$ is not reached, reduce V1 and readjust V2 and V7.

- 5 Adjust V6 "Deflection" to the maximum peak level.

Notes

7.6 Three lens ion optics

The three lens ion optics with beam stop is suited for detecting positive and negative ions in the presence of fast neutral particles.

The three lens ion optics have a high energy dispersion; they are used as energy filter in connection with the mass filter.

The optics are often combined with an extraction hood, e.g. to extract ions from a plasma.

The three lens optics are often combined with an isolated design. In some cases, both deflection voltages are operated at the same time.

For a number of applications, the analyzer is differentially pumped in order for the minimum pressure of 10^{-5} mbar (10^{-4} mbar with Faraday) to be reached.

To check which version you have please refer to the supplied schematic drawing and additional sheets possibly enclosed with the test protocol.

Application examples

- Secondary ion emission (SIMS).
- Analysis of thermal desorbed ions
- Detection of ions generated by photoionization
- Analysis of electron induced desorption
- Detection of positive and/or negative ions from plasmas
- Analysis of ion beams
- Energy analysis of ions from plasmas (PPM 400)

Installation

Place the entrance orifice centered at a distance of 5 mm (longer distances are admissible, however, they reduce the sensitivity) from the center of the emitting surface, which need not be perpendicular to the QMA axis. The beam, which excites the emission, should hit the desired spot without colliding with the optics.

If there is a TARGET connector on the QMA, connect the supplied voltage to your target.

If there is a BIAS connector on your QMA, connect the bias voltage of 0 ... 200 V there.

If there is a EXTR connector on the QMA, connect the voltage for the extraction hood 0 ... 60 V there.

DANGER

Caution: shock hazard

The voltages of the IS 420 as well as the additional BIAS, TARGET and EXTR voltages can be extremely hazardous.

Consider the technical specifications of the IS 420 (→ [2]) and use only properly made cables.

Function

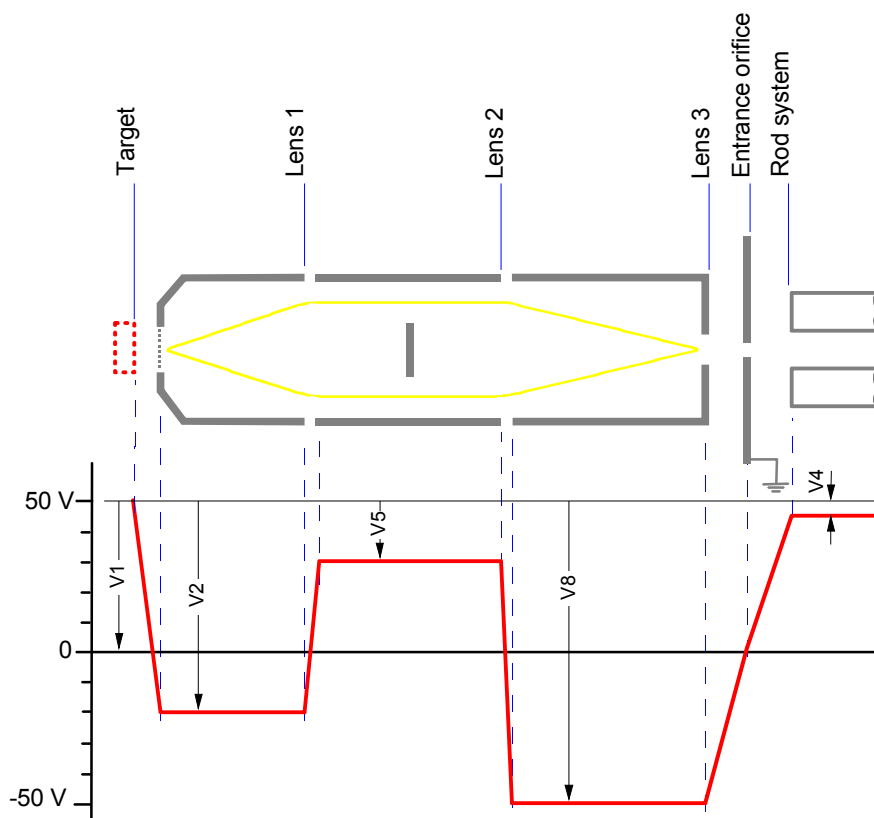
The ions to be analyzed pass from the formation area through the entrance orifice of Lens 1. The optics concentrate the diverging ions to the entrance orifice of the mass filter.

Fast neutrals are eliminated by the beam stop in Lens 2 and thus do not contribute to the background signal.

The three lens ion optics act as energy filter with an energy resolution of approx. 1.5 eV, depending on the entrance energy, bias voltage and potential distribution in the optics.

Electrode arrangement

Potentials



Typical values

The values and adjustment apply to SIMS measurements. The values for other analyses may be quite different. In the table below, please note the values for your individual application.

V1	IonRef	50 V / Target ¹⁾
V2	Lens 1	70 V
V3	---	---
V4	Field Axis	5 V
V5	Lens 2	20 V
V6	DEFI	350 V
V7	DEFO	100 V
V8	Lens 3	100 V
V9		

¹⁾ Emission potential of the ions, e.g. connected to a SIMS target.

Adjustment

Start with the values which previously supplied good results, with the values in the test protocol or otherwise with the values of the above table.

- 1** Adjust V1 to the maximum peak level (depending on the target distance).
- 2** Alternatingly adjust V2 and V5 to the maximum peak level.
- 3** Set V4 "Field Axis" so that a good peak shape and resolution $\Delta M_{10} = 1$ are reached. If the peaks are still "frayed", reduce V1 and readjust V2 and V5.
- 4** Adjust V8 to the maximum peak level.
- 5** Adjust V7 "DEFO" to the maximum peak level.

- 6 Try which is the better RF cable polarity (→ 31).

Notes

7.7 Crossbeam ion source with three lens ion optics

This version offers the characteristics of the three lens ion optics combined with the features of the crossbeam ion source. It is used for detecting foreign ions and neutral particles ionized in the crossbeam ion source.



The crossbeam ion source with three lens ion optics is often combined with the isolated design. In some cases, both deflection voltages are operated at the same time. To check which version you have please refer to the supplied schematic drawing and additional sheets possibly enclosed with the test protocol.

The AS 400 adapted is included in the scope of delivery.

Application examples

- Secondary ion emission (SNMS / SIMS)
- Analysis of thermal desorbed ions
- Detection of ions generated by photoionization
- Analysis of electron induced desorption
- Detection of positive and/or negative ions from plasmas
- Analysis of ion beams
- Energy analysis of ions from plasmas


Function


→  46 and  35.

The AS 400 adapter converts some potentials (see the table below) depending on whether the equipment is operated in crossbeam or ion optics mode. The ion optics mode is activated by selecting the ion source type "SPEC+ / SPEC-" and "Emission = Off".


Installation


Place the entrance orifice centered at a distance of 5 mm (longer distances are admissible, however, they reduce the sensitivity) from the center of the emitting surface, which need not be perpendicular to the QMA axis. The beam, which excites the emission, should hit the desired spot without colliding with the optics.

The AS 400 adapter is incorporated in the control unit and is connected between the IS 400 and the QMA (for subsequent installation →  [2]).



DANGER



Caution: shock hazard
The voltages of the IS 420, AS 400 and QMA are extremely hazardous.
Consider the technical specifications of the IS 420 (→  [2]) and use only properly made cables.

There are three 3 SHV connectors on the AS 400 :

X10 BIAS IN: Input for external voltages for biasing the whole ion source supply in ion optics mode (maximum 200 V); in crossbeam mode, the supply is on ground potential.

X11 BIAS: Output with bias voltage for the "isolated design".
V3 "Focus" in ion optics mode, ground potential in crossbeam mode.

X12 Target: Output with V1 "Ionref". Connect the target here (e.g. for SIMS).

If there is a TARGET connector on the QMA, the voltage available there (→ supplied diagram) can be applied to the target; in general, it is not identical with the voltage at X12.

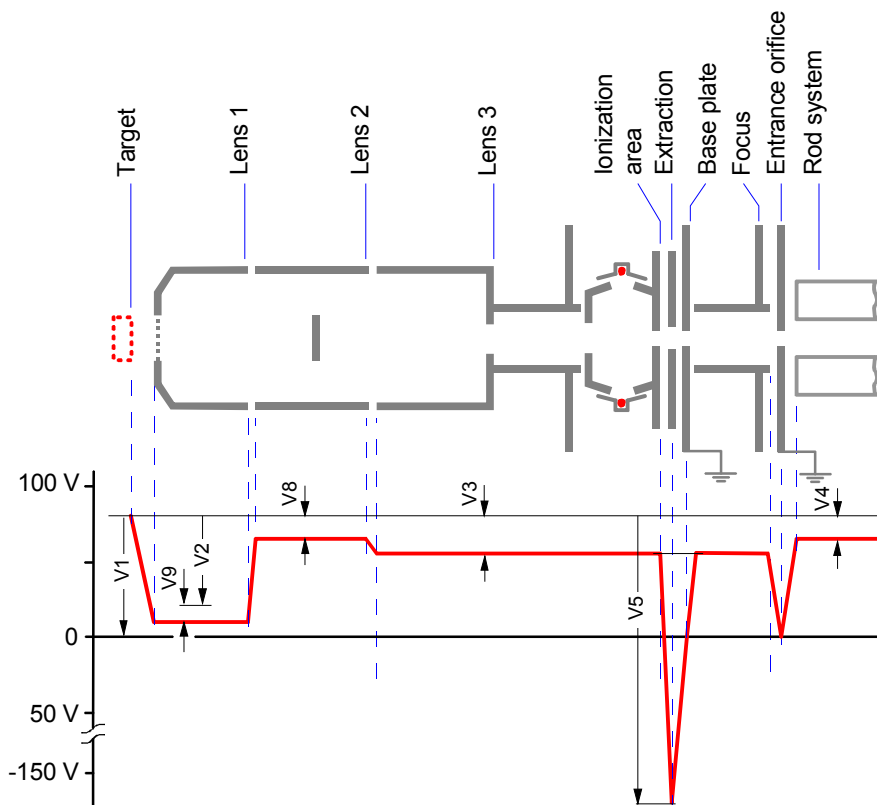
If there is a BIAS connector on the QMA, connect it to the X11 BIAS connector of the AS 400. If you are not using the BIAS connector of the QMA, plug in a shorting connector.

If there is an EXTR connector on the QMA, connect the voltage for the extraction hood (0 ... 60 V) there.

Electrode arrangement

The ion optics mode is shown here; for crossbeam operation → 35 ff.

Potentials



Typical values

The values and adjustment apply to SIMS measurements. The values for other applications may be quite different. Please note the values for your individual application in the table below:

Operating mode SPEC+/-		
	Emission	OFF
V0	X10 BIAS IN	0 V (shorting connector)
V1	X12 Target ¹⁾	80 V
V2	(Cathode)	60 V
V3	Lens 3 // Focus // Ionization area // X11 BIAS	25 V
V4	Field Axis	15 V
V5	Extraction	250 V
V6	DEFI	350 V
V7	DEFO	100 V
V8	Lens 2	10 V
V9	Lens 1	10 V ²⁾

¹⁾ Emission potential of the ions, e.g. connected to SIMS target.

²⁾ Lens 1 is on $V1 - (V2 + V9)$.

Adjustment

Start with the values which previously supplied good results, with the values in the test protocol or otherwise with the values of the above table.

- 1** First, optimize for crossbeam operation and use the corresponding values for V3, V4, V5.
- 2** Adjust V1 to the maximum peak level (depending on the target distance).
- 3** Alternatingly adjust V2+V9 and V8 to the maximum peak level.
- 4** If the peak shape is unsatisfactory ("frays") or if the resolution $\Delta M = 1$ is not reached, reduce V1 and readjust V2 + V9 and V8.
- 5** Adjust V6 "Deflection" to the maximum peak level.

Notes

8 Maintenance and spare parts

→  [5]

9 Disposal



DANGER

Caution: contaminated parts

Contaminated parts can be detrimental to health.

Before beginning to work, find out whether any parts are contaminated. Adhere to the relevant regulations and take the necessary precautions when handling contaminated parts.



WARNING

Caution: substances detrimental to the environment

Products, operating fluids etc. may require disposal in accordance with special regulations.

Dispose of such substances in accordance with the relevant local regulations.

Separating the components

After disassembling the product, separate its components according to the following criteria:

Contaminated components

Contaminated components (radioactive, toxic, caustic, or biological hazard etc.) must be decontaminated in accordance with the relevant national regulations, separated according to their materials, and recycled.

Other components

Such components must be separated according to their materials and recycled.

Appendix

A: Literature

- 📖 [1] Technical information
Partial pressure measurement in vacuum technology
BG 800 169 PE
Balzers Instruments, FL-9496 Balzers, Liechtenstein
- 📖 [2] Operating manual
QMG 422
BG 800 451 BE
Balzers Instruments, FL-9496 Balzers, Liechtenstein
- 📖 [3] Operating manual
QMH 400-1, -5, QMH 410-1, -2, -3
BG 800 409 BE
Balzers Instruments, FL-9496 Balzers, Liechtenstein
- 📖 [4] Operating manual
PPM 422
BG 803 813 BE
Balzers Instruments, FL-9496 Balzers, Liechtenstein
- 📖 [5] Service instructions
QMA 4xx
BG 800 118 KE
Balzers Instruments, FL-9496 Balzers, Liechtenstein

Declaration of contamination

The repair and/or service of vacuum equipment and components will only be carried out if a correctly completed declaration has been submitted. Non-completion will result in delay.

This declaration can only be completed and signed by authorized and qualified staff.

1 Description of product

Type _____

Article No. _____

Serial No. _____

2 Reason for return

3 Operating fluid(s) used

4 Process related contamination of product:

toxic	no <input type="checkbox"/>	yes <input type="checkbox"/>	
corrosive	no <input type="checkbox"/>	yes <input type="checkbox"/>	
biological hazard	no <input type="checkbox"/>	yes <input type="checkbox"/> *)	
explosive	no <input type="checkbox"/>	yes <input type="checkbox"/> *)	
radioactive	no <input type="checkbox"/>	yes <input type="checkbox"/> *)	
other harmful substances	no <input type="checkbox"/>	yes <input type="checkbox"/>	

*) Products thus contaminated will not be accepted without written evidence of decontamination!

The product is free of any substances which are damaging to health yes

5 Harmful substances, gases and/or by-products

Please list all substances, gases and by-products which may have come into contact with the product:

Trade/product name manufacturer	Chemical name (or symbol)	Dangerous material class	Measures if spillage	First aid in case of contact

6 Legally binding declaration:

I hereby declare that the information supplied on this form is complete and accurate. The dispatch of the contaminated product will be in accordance with the appropriate regulations covering packaging, transportation and labelling of dangerous substances.

Name of organization or company _____

Address _____ Post code, place _____

Phone _____ Fax _____

E-Mail _____

Name _____

Data and legally binding signature _____ Company stamp _____

Declaration of conformity

Product **QMG 422 Analyzers**
QMA 400
QMA 410
QMA 430

EU declaration of conformity as defined by the listed guidelines

We herewith declare that the products listed above comply with the provisions of the listed guidelines.

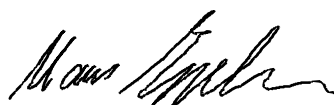
Guidelines, harmonized standards, national standards in languages and specifications which have been applied:

- 89/336/EEC (7/93).....
- 73/23/EEC (7/93).....
- EN 61010-1
- EN 50081-2
- EN 50082-2
-
-

Signatures

Balzers, 17 September 1999

Balzers, 17 September 1999



Hans Eppler
Product management

Dr. Norbert Müller
Product development