NexION® 2200 ICP-MS Comprehensive Specifications

SPECIFICATIONS

ICP - Mass Spectrometry

KEY BENEFITS:

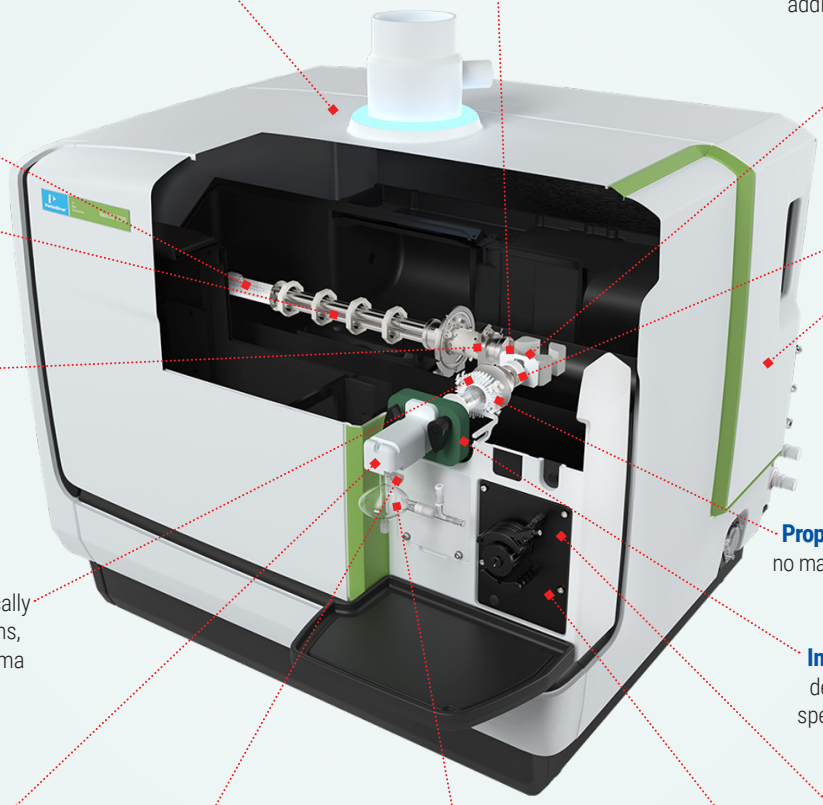
- Outstanding sensitivity
- Superior interference removal
- High throughput with low maintenance
- Unmatched matrix tolerance
- Sustainability and low cost of operation
- Ease of use

PerkinElmer, a renowned leader in ICP-MS technology for over four decades, has continually driven advancements in the field, delivering exceptional analytical performance to laboratories worldwide performing trace-elemental analyses. Among the latest innovations, the NexION® 2200 ICP-MS system utilizes the second-generation Triple Cone Interface featuring OmniRing™ technology, revolutionizing flexibility without the requirement of inserts or lenses. This groundbreaking design offers increased sensitivity in extraction and cold plasma modes, while also enabling improved background equivalent concentrations (BECs) in focusing mode through three stages of vacuum pumping. Plus, the system's Universal Cell enables Standard mode with correction equations, Collision mode with kinetic energy discrimination (KED), or Reaction mode with dynamic reaction cell (DRC). In Reaction mode, the quadruple-based Universal Cell incorporates dynamic bandpass tuning, which provides active mass filtering in the reaction cell using RPa and RPq parameters. These capabilities effectively eliminate spectral interferences, preventing the formation of new interferences (run-away reactions) and providing comprehensive analytical flexibility.

At the core of the NexION 2200 ICP-MS lies its three-quad design. The three quads are comprised of the Quadrupole Ion Deflector (QID - Q0), Universal Cell Technology (UCT - Q1), and the Transmission Analyzer Quadrupole (Q2). This design enables the system to effortlessly remove interferences and unwanted masses in three ways: Analyzing Quad + UCT (ion guide) + QID (ion guide), Analyzing Quad + UCT (fixed mass) + QID (ion guide), and Analyzing Quad + UCT (fixed mass) + QID (fixed voltage).

These unique capabilities of the NexION 2200 ICP-MS are complemented by additional proprietary features, which you will learn more about further in this document.

PerkinElmer®
For the Better



Discrete Dynode Detector with the fastest data acquisition rates, essential for applications involving the analysis of transient signals. Linear dynamic range of 10^{10}, which can be increased to 10^{14} with Extended Dynamic Range (EDR) capability.

Triple-inlet Four-stage Turbomolecular Pump

Combined TCI and QID enable no routine maintenance beyond the cones.

Quadrupole Ion Deflector (QID) eliminates photons and neutral species by turning the ion beam 90 degrees with the added benefit of serving as an additional mass filter by selecting the mass range of interest.

Wide-aperture Triple Cone Interface (TCI) with OmniRing delivers flexibility – high sensitivity or low BECs.

Full-length Transmission Analyzer Quadrupole provides custom resolution < 0.3 amu.

Panels and gas lines designed in such a way that the instrument can be pushed directly back against a wall to save your laboratory space and allow easy access for maintenance.

Universal Cell Technology (UCT) with dynamic bandpass tuning to control the reaction inside the cell, complete with three cell gas lines with online gas mixing

Proprietary LumiCoil RF Coil requires no maintenance, replacement or cooling.

34-MHz RF Generator specifically designed for ICP-MS applications, delivering the most robust plasma on the market with switching time < 50 ns.

Interchangeable Torch Cassettes designed to meet your application-specific needs at the turn of a knob.

PC3 Peltier Cooler can be added for the analysis of organic solvents.

Four-channel Peristaltic Pump with rollers and a software-integrated Tubing Saver setting.

All Matrix Solution (AMS) port for up to 200x aerosol dilution.

Baffle-type Cyclonic Spray Chamber with AMS port comprised of high-grade materials.

Compatible with fully integrated **Flow Injection Modules,** such as HTS.

Figure 1. Key hardware components of the NexION 2200 ICP-MS system.

Overview: NexION 2200 Single Analyzer Quadrupole ICP-MS

Among the most recent technological advancements in ICP-MS, in 2023 PerkinElmer introduced its NexION 2200 ICP-MS which inherited the three stages of mass filtration from the NexION 2000, namely the Quadrupole Ion Deflector (QID – Q0), Universal Cell Technology (UCT – Q1) and the Transmission Analyzer Quadrupole (Q2). This instrument surpasses the interference removal capabilities of conventional single-quadrupole ICP-MS systems, delivering outstanding accuracy and robustness.

The NexION 2200 harnesses a full suite of innovative and novel technologies to maximize signal-to-noise analytical performance, minimize instrument maintenance, increase throughput and matrix tolerance, and lower cost of operation in an exceptionally user friendly ICP-MS solution.

These unique technologies will future-proof your ICP-MS purchase, delivering:

- Outstanding sensitivity
- Superior interference removal
- Excellent stability
- Unmatched matrix tolerance
- High throughput
- Lowest maintenance
- Ease of use
- Sustainability and low cost of operation

Outstanding Sensitivity

The proven Triple Cone Interface technology in the NexION series produces the most tightly focused ion beam in the industry, reducing sample deposition on internal components which would otherwise lead to extensive maintenance needs. The proprietary second-generation Triple Cone Interface with OmniRing, available on the NexION 2200 ICP-MS, builds on the original interface geometry and provides unique solutions to space-charge effects based on the simple yet highly effective patent-pending OmniRing technology, delivering enhanced sensitivity and stability. Its design focuses on many attributes of an ideal interface for ICP-MS, most notably improved transmission by reducing the ion current while at the same time providing a controlled acceleration of the ions through the interface without transmitting high energy ions into the downstream ion optics.

The result is much improved analyte signal intensities without the cost of elevated background levels. The ability to analyze complex matrices at sub-ppt BECs and with robust plasma conditions is a direct consequence of the design of this novel interface. In addition to high sensitivity, the interface design significantly contributes to the unmatched stability of the NexION 2200 ICP-MS with challenging matrices. This is attributed to three stages of differential pumping and a design that minimizes surfaces prone to sample deposition and ion sputtering, such as those using extraction cones and lenses.

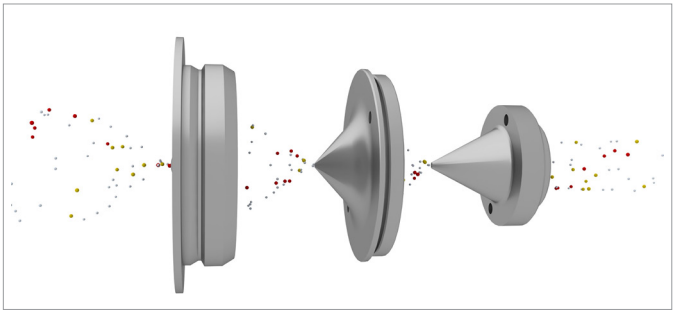


Figure 2. Illustration of second-generation Triple Cone Interface with OmniRing technology.

Superior Interference Removal

Unlike traditional single-quad systems, the NexION 2200 ICP-MS delivers three stages of mass resolution. A clean, focused ion beam is introduced into the ion optics, enabling you to control interferences as early as the Quadrupole Ion Deflector (QID – Q0). In the NexION 2200 ICP-MS, the ion beam is shaped and directed within Q0 with the additional benefit of being able to reduce ions outside the mass range of interest, thereby preventing additional interferences from forming in the cell. Thereafter, the ion beam is passed into the quadrupole Universal Cell (Q1) for either reaction, collision, or no reaction. Reactions can happen in a controlled environment where NexION 2200 uses quadrupole Universal Cell Technology to fix the bandpass to eliminate reaction by-products that could cause new interferences. The mass of interest is separated by its mass-to-charge ratio in the Transmission Analyzer Quadrupole (Q2). This combination allows the system to deliver outstanding background equivalent concentrations (BECs) and detection limits (DLs) for most elements and delivers repeatable and reliable cluster formation, reducing the risk of interferences at the cluster mass due to the mass cut-off which occurs in the QID. The system comes standard with pre-cleaned stainless steel cell-gas lines, and if even lower detection limits are required for Si and S, cleaned argon gas lines and a high-purity argon regulator are available for purchase. These outstanding design characteristics set the new standard for achievable levels for elements which suffer from polyatomic interferences, meeting the demanding needs of semiconductor, life science, petrochemical, pharmaceutical and other application areas.

Also, the NexION 2200 ICP-MS comes standard with three gas channels and the option to choose from up to three reaction gases as well as a variety of collision gases, delivering enhanced analytical flexibility and minimized run times.

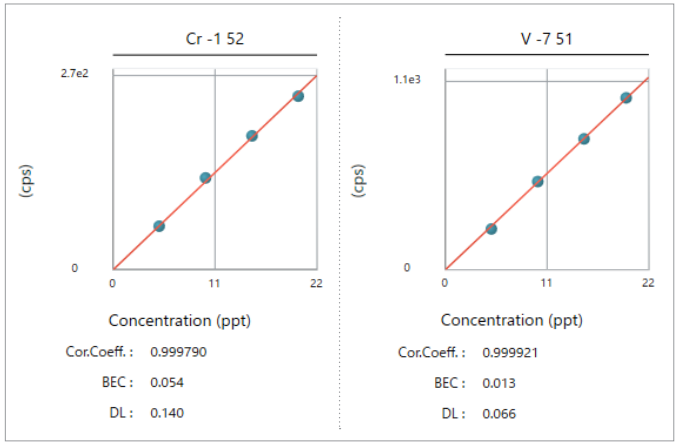


Figure 3. Vanadium and chromium calibration curves demonstrating superior interference removal in 20% HCl with pure ammonia and dynamic bandpass tuning.

Excellent Stability

Everything about the NexION 2200 ICP-MS says stability – for your instrument and your results (Figure 4). For example, its free-running 34-MHz RF Generator delivers the fastest impedance matching on the market. Plus, its Triple Cone Interface with wide-aperture cones offers unparalleled resistance to clogging even for tough matrices. And finally, the ability to use pure gases in its Universal Cell, a true quadrupole, ensures that the reaction is stable and reproducible.

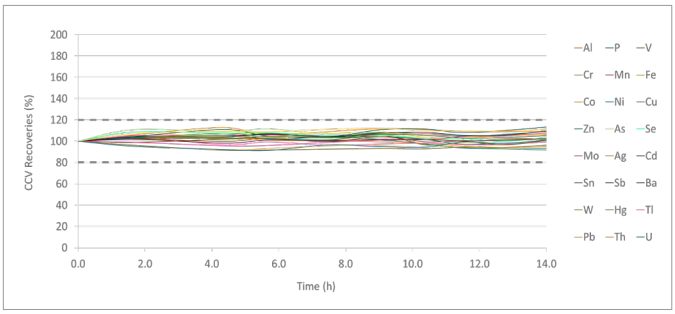


Figure 4. Continuing calibration verification (CCV) recoveries for a 14-hour seawater analysis.

Unmatched Matrix Tolerance

The NexION 2200 ICP-MS is perfect for laboratories requiring low detection limits (DLs) and background equivalent concentrations (BECs) in a variety of different matrices, from aqueous to organic, from ultrapure water (UPW) to high total dissolved solids (TDS). The powerful All Matrix Solution (AMS) sample introduction system is able to deliver up to 200x dilution and support samples even with 35% TDS without the need for off-line dilution. Moreover, alternative gases, such as oxygen, can be introduced into the spray chamber to burn-off excess carbon in organic samples, thereby reducing cone clogging in these matrices. Plus, the innovative solid-state, free-running RF Generator with unique LumiCoil™ technology provides accurate impedance matching to easily handle even the most difficult matrices. Furthermore, the patented design of its wide-aperture Triple Cone Interface (TCI) dramatically reduces clogging of cones, allowing for outstanding matrix tolerance.

High Throughput

PerkinElmer has pioneered a variety of online dilution techniques for ICP-MS to boost the throughput of samples with low and high analyte concentrations.

The NexION 2200 ICP-MS comes standard with the Extended Dynamic Range (EDR) capability, leveraging the unique quadrupole Universal Cell. With EDR, the NexION 2200 allows you to adjust signal transmission by changing the electric field applied to the Universal Cell on a per mass basis, so low and high concentrations of analytes can be analyzed in a single run.

To overcome the matrix suppression and deposition on the cones from high matrix samples, especially those with high total dissolved solids, the NexION 2200 offers the All Matrix Solution (AMS) system to minimize manual dilution. By introducing a flow of argon into the spray chamber neck, the aerosol stream is diluted. The flows of the dilution and nebulizer argon gases can be adjusted while maintaining a constant flow to the torch, where the ratio of the flows determines the dilution factor. By varying the flows, dilutions up to 200 times can be achieved.

Apart from its online dilution capabilities, the NexION 2200 further improves throughput by means of rapid Collision mode gas switching of under three seconds. Also, the High Throughput System (HTS) flow-injection sample introduction module on the NexION 2200 further enhances productivity to handle any lab's testing capacity.

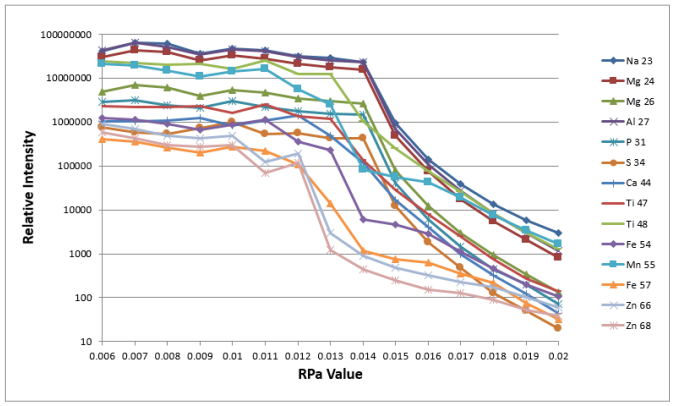


Figure 5. Example of signal attenuation provided by Extended Dynamic Range (EDR).

Lowest Maintenance

Whatever your industry, uptime is key to keeping your lab running at peak productivity. That's why the NexION 2200 system eliminates virtually all non-routine maintenance requirements for unsurpassed instrument uptime. First, our LumiCoil technology is guaranteed for the life of your instrument and requires no water or gas cooling. The system's Triple Cone Interface reduces ion beam spread through a three-step drop in pressure between the atmosphere and the high-vacuum regions of the ICP-MS and produces a tightly focused ion beam – plus, cones are located outside the vacuum for quick, easy access. The wide-aperture cones maximize signal stability and minimize cone clogging during extended high-TDS sample runs. What's more, the patented combination of the Triple Cone Interface and Quadrupole Ion Deflector controls and focuses the beam in the downstream ion optics, ensuring that there is no routine cleaning beyond the cones. Furthermore, in contrast to many collision cells on the market, the Universal Cell does not require frequent replacement over the instrument's lifetime, ensuring you can rely on the robustness of the system for years to come.

In addition to all its low-maintenance features, the NexION 2200 ICP-MS is also designed for better serviceability to further optimize your uptime. And PerkinElmer factory-trained service engineers will be at your disposal for all your maintenance and repair requirements.

Ease of Use

The NexION ICP-MS series has always strived to deliver a streamlined user experience, providing a quick and smooth hands-on.

Syngistix™ for ICP-MS software is designed to mirror the actual user workflow with an icon-based, left-to-right navigation pane that walks users through day-to-day operation from startup, optimization, method development, and sample analysis to data review and reporting.

What's more, the NexION 2200 brings an all-new experience to its users. The instrument comes with a powerful, yet simple, built-in LCD touchscreen. The touchscreen houses complementary information while the graphical user interface is designed to be so simple that users can perform critical day-to-day missions, including hardware control, real-time data review, instrument parameter diagnostics, analytics and even access embedded training videos, for a PC-less experience. Plus, with the LED lighting on the instrument, users can monitor the instrument and check status without going into the control software.

Figure 6. Example of LCD touchscreen, displaying Analytics window.

Sustainability and Low Cost of Operation

Among the highest running costs for laboratories using ICP-MS are plasma and cell gases as well as power consumption from both the instrument and the cooling device.

The NexION 2200 ICP-MS boasts a host of features that help laboratories reduce running costs, improving their bottom line – while at the same time be much more sustainable.

Thanks to its efficient plasma generation and LumiCoil RF coil design, the NexION 2200 consumes as low as 12 L/min argon gas and doesn't require special torch or hardware. At the same time, the unique quadrupole collision/reaction Universal Cell with dynamic bandpass tuning can control the reaction in the cell and prevent higher-order product ions from forming, while using low flows of gas to remove interferences. In Collision mode, typical helium gas flow can be less than 4 mL/min, generating less gas waste than traditional collision cells. And in Reaction mode, typical reaction gas consumption is less than 1 mL/min.

Accompanying the NexION 2200 is the optional innovative GreenCT™ cooling system. Unlike conventional chillers, GreenCT uses a cleaner, greener and more affordable coolant, while consuming much less power and generating less waste.

And last but certainly not least, All Matrix Solution (AMS), Extended Dynamic Range (EDR) and High Throughput System (HTS) capabilities all reduce sample and washout runtime and lower the chance for sample reruns, in turn minimizing the consumption of instrument power as well as chemical waste.

Figure 7. GreenCT cooling system.

Specifications

The three quadrupoles of the NexION 2200 ICP-MS can be outlined as follows:

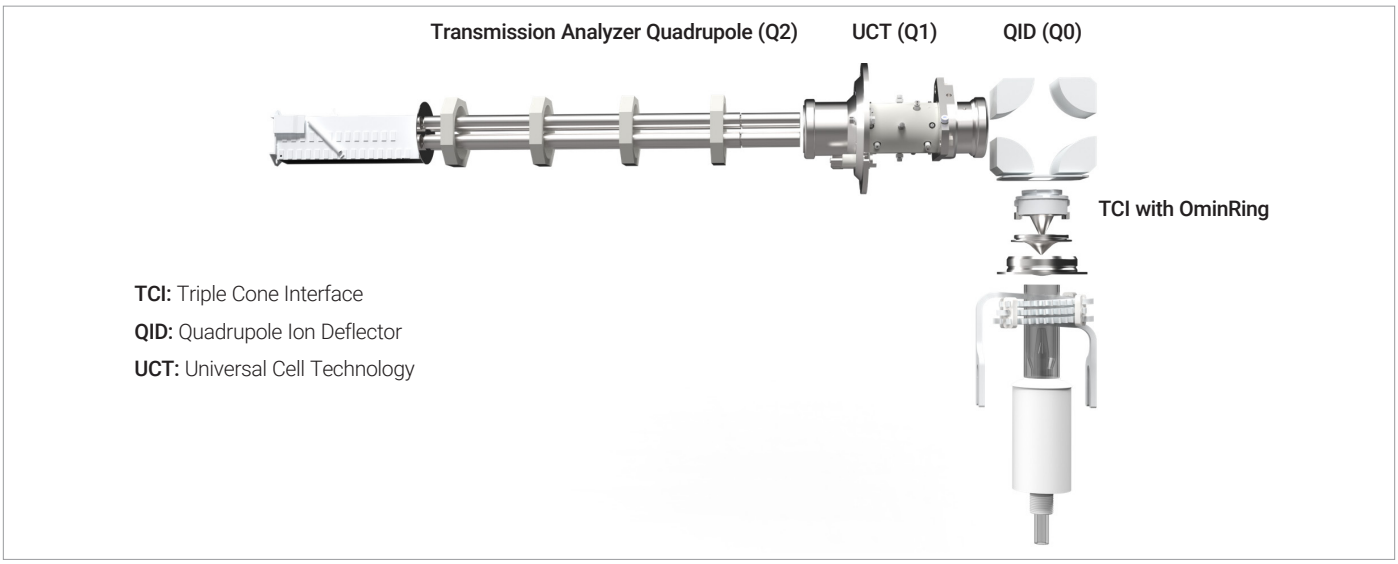


Figure 8. NexION 2200 ICP-MS ion optics with three quadrupoles designated by Q0, Q1 and Q2 respectively.

- ***First:*** Quadrupole Ion Deflector (Q0) directs ions to the Universal Cell (Q1) and Transmission Analyzer Quadrupole (Q2) while reducing unwanted masses.
- ***Second:*** Quadrupole Universal Cell (Q1), empowered by dynamic bandpass tuning, creates a controlled environment for effective interference removal through dynamic reactions with reactive gases or collisions using non-reactive gases.
- ***Third:*** Transmission Analyzer Quadrupole (Q2, full-sized with < 0.7 amu mass resolution for normal operation and custom resolution to < 0.3 amu), with the highest duty cycle on the market, is ideal for applications requiring short dwell times.

Q0: Quadrupole Ion Deflector

The Quadrupole Ion Deflector (QID) is an electrostatic analyzer that turns the analyte ion beam 90 degrees. The QID can operate with either a non-fixed or fixed voltage. With a non-fixed voltage, the transmission of ions across the low-, mid- and high-mass ranges is optimized. In the case of a fixed voltage, a software-controlled fixed voltage is applied to the QID to maximize the transmission of target ions within a specific mass range into the Universal Cell, thereby improving sensitivity for the analyte of interest while reducing ions outside the mass range of interest and eliminating the transmission of photons and neutral species to the mass spectrometer via the vacuum.

Since the ion beam is focused through the use of the Triple Cone Interface (TCI), analyte ions and neutral species don't touch surfaces in the QID, ensuring cleanliness and no routine maintenance beyond the cones as well as superior stability and robustness. Moreover, the kinetic energies of the ions exiting the QID are similar (< 10 eV), ensuring that the ions entering the cell all have a similar kinetic energy to ensure more reproducible reactions.

Q1: Quadrupole Universal Cell

The Universal Cell, standard in all NexION ICP-MS systems, is a true quadrupole-based cell driven by frequency modulation.

Unlike higher-order multipoles which are designed to promote collision chemistry, the Universal Cell is aptly named due to its universal ability to effectively remove interferences via reaction with dynamic bandpass tuning (DBT) or collision with kinetic energy discrimination (KED). The Universal Cell has been designed to achieve the best out of reaction chemistry to deliver the best BECs and DLs for the application without suffering from the sensitivity losses typically experienced in interference removal via collision. The cell is further empowered by Axial Field Technology (AFT) which ensures that ions undergoing reaction do not lose kinetic energy, leading to improved sensitivity, reduced residence times for ions in the cell and keeping the formation of higher-order product ions in check.

The modes of operation of the cell are summarized as follows:

Reaction (DRC) mode with selection of up to three reaction gases via three gas channels at typical flows < 1 mL/min. The system is compatible with a variety of pure and mixed gases. Reaction gases may be combined in the cell to provide enhanced interference removal and detection capabilities. Reaction mode is ideal for applications demanding the best performance, with practically no loss of analyte sensitivity, and an unprecedented level of interference removal. Reactive gases – such as ammonia, oxygen, hydrogen, carbon dioxide, methane etc. – are introduced into the cell to create predictable chemical reactions with either the analyte or interferent ions, as well as predictable and reproducible cluster formation for cluster-forming ions, such as Ti, Zn, Ge etc. Reaction by-products are prevented through dynamic bandpass tuning, controlling side reactions from taking place by rapidly destabilizing

reaction by-products before they have a chance to form new interferences, a unique feature only available in quadrupole reaction cells. In the quadrupole Universal Cell, low and high mass cut-off windows can be applied as needed per analyte, allowing custom settings and providing full flexibility during the analysis, all of which contribute to more accurate results and lower BECs.

Collision (KED) mode is compatible with a variety of collision gases. For the removal of unknown spectral polyatomic interferences, Collision mode is especially useful. In this mode, non-reactive gases, such as helium, or slightly reactive gas mixtures can be introduced into the cell to collide with the ions that are travelling through it. Since many interfering polyatomic ions tend to have larger diameters (collisional cross section) than the analyte ion, they will be subjected to more collisions than the analyte. These extra collisions mean that the interfering ions lose more kinetic energy and, as such, are removed through kinetic energy discrimination (KED). This mode delivers better detection limits than Standard mode for some elements but may experience significant losses in sensitivity.

Standard mode (no gases added) is typically used for elements which do not have interferences or have isobaric and minor polyatomic interferences. There is no loss of sensitivity using this mode of operation and interferences are dealt with using correction equations, however this may result in the over- or under-estimation of results.

Q2: Transmission Analyzer Quadrupole

This full-length Transmission Analyzer Quadrupole (Q2) only allows ions of a specific m/z to be passed through to the detector, while all other ions not at the desired mass are removed. It has been engineered to deliver < 0.7 amu mass resolution (preferred for normal operation) with custom resolution to < 0.3 amu and is driven by a high-frequency 2.5-MHz power supply. Its carefully designed rods produce a perfect hyperbolic field, delivering optimal resolving power and ion-transmission efficiency. This quadrupole is designed using state-of-the-art alloy materials, exhibiting negligible thermal expansion. This guarantees rigid structural integrity along the entire length of the rod, ensuring exceptional mass calibration stability. All rods are carefully inspected prior to assembly and aligned to ensure maximum ion transmission for greater sensitivity.

Abundance Sensitivity

Abundance sensitivity is reduced with increasing mass. Therefore, for the NexION 2200 ICP-MS, abundance sensitivity is measured at the highest naturally occurring isotope, ^{238}U.

Owing to the unique design of the NexION 2200, the system delivers better than 5.0 x 10^{-7} at the low-mass side of the peak.

Cell Gas Channels

The NexION 2200 ICP-MS is equipped with a three-channel cell gas control manifold that allows the introduction of pure reaction and collision gases or gas mixtures. In addition, additional flexibility is provided by the ability to mix reaction gases inside the cell.

Vacuum System

Operating pressure is maintained in the event of an argon gas supply failure. In the event of a power failure, the ion optics backfill with argon to prevent contaminants from entering them.

Operating pressure is obtained in less than 15 minutes pumping time.

Turbo Pump: The triple-inlet turbomolecular pump maintains vacuum ≤ $1e^{-6}$ Torr (with no cell gases) during operation. This system is purged by an inert gas during operation to prevent damage by reactive gases and/or corrosive vapors, such as those generated by the analysis of phosphoric acid.

Interface Pump: The system is backed by a high-performance external roughing pump, ensuring that there is only a single roughing pump to support and maintain. It uses ultra-long-life PFPE fluid. This pump is fully computer-controlled and automatically shifts into power-saving mode when the plasma is off.

NOTE: A pump filter is highly recommended for applications involving high concentrations and the routine analysis of sulfur compounds. Please contact your PerkinElmer sales representative about available options.

Detector

The system uses a highly sensitive and stable dual-stage discrete-dynode electron multiplier, which covers a full 10 orders of magnitude of dynamic range in a single scan. The dual detector system operates from < 0.1 cps to > 10^9 cps. When used in combination with the NexION's unique Extended Dynamic Range (EDR) capability, the system offers up to 10^{14} orders of linear dynamic range. This allows for the accurate analysis of both low- and high-concentration analytes within a single analytical run, resulting in fewer re-runs and less chemical consumption, while ensuring longer detector lifetimes. Being applied selectively per analyte, the EDR functionality does not affect the signal response of other elements and does not call for the addition of gases into the cell.

The system delivers dwell times as short as 10 µs in both analogue and pulse-counting detection modes, essential to ensuring well-defined and resolved transient signals.

The system includes software-automated control of all operating voltages and the detector cross-calibration and has easy service access for detector exchange.

Sample Introduction System

SMARTintro Sample Introduction Modules

The SMARTintro™ sample introduction modules of the NexION family are compatible with the NexION 2200 ICP-MS and color-coded to ensure that parts do not get mixed up in the laboratory.

SMARTintro kits for specialized applications include options for HF resistance, organics and geological sample matrices.

4-Channel Peristaltic Pump

The NexION 2200 ICP-MS comes equipped with a fully software-controlled, high-precision peristaltic pump with four channels to draw sample through a capillary into the nebulizer for subsequent aspiration, droplet-filtration and ionization. The 36 mm peristaltic pump head has 12 inert rollers, improving flow consistency and reducing pulsations while also supporting a variety of different speeds from 0-100 rpm.

NOTE: The NexION 2200 ICP-MS is compatible with optional flow-injection sampling systems such as our High Throughput System (HTS) or ESI *FAST* systems. Please contact your PerkinElmer sales representative about available options.

Nebulizer

The sample is introduced into the plasma at a constant rate using a glass concentric nebulizer, greatly improving measurement precision and long-term stability.

NOTE: Optional compatible nebulizers are available, accommodating a variety of different flow rates, total dissolved solids concentrations and demonstrating resistance to organics or aggressive mineral acids. Please contact your PerkinElmer sales representative about available options.

Spray Chamber

The system comes standard with a baffle-type glass cyclonic high-sensitivity spray chamber with All Matrix Solution (AMS) gas port. This spray chamber is designed to deliver superior aerosol droplet filtration, outstanding sensitivity and low RSDs. The AMS port allows in-situ aerosol dilution of the sample > 200x or the introduction of oxygen while analyzing organics to prevent carbon deposits on the cones (described in detail below).

NOTE: Other compatible spray chambers are available on request. All spray chambers are compatible with the industry standard of 6 mm OD nebulizers. Please contact your PerkinElmer sales representative about available options.

High Matrix Samples and Organic Solvents with All Matrix Solution (AMS)

The NexION's All Matrix Solution allows users to run samples with high TDS (such as seawater: > 3.5%; brine: > 25%) without the need for off-line dilution. Also, AMS allows the user to run organic solvents (IPA, NMP etc.) with the addition of oxygen.

The AMS gas flow setup is optimized via Syngistix for ICP-MS software to either use argon as a dilution gas or introduce oxygen gas to burn-off excess carbon from the cones in organic solvents.

Peltier Cooler-Heaters

The Peltier cooler-heater (-10°C to 80°C) can be purchased as an option for the NexION 2200 to facilitate the analysis of organic solvents or if lower oxide levels are needed for certain applications.

NOTE: Peltier coolers/heaters which are compatible with either cyclonic or PFA spray chambers are available upon request. Please contact your PerkinElmer sales representative about available options.

Torch

The NexION 2200 ICP-MS sample introduction system comes standard with a quartz one-piece torch and a fixed 2 mm injector, ensuring excellent performance in different matrices. This torch is easily interchangeable with demountable torches, where the injector can be chosen to fit the application. The torch position is fully controlled via software which provides automated X, Y, Z positioning (± 3 mm with 0.05 mm reproducibility), ensuring that maximum ion transmission is achieved, thereby enhancing sensitivity.

NOTE: A variety of different torch designs (fixed and demountable), which accommodate injectors with varying diameters (including 1.0, 1.5, 2.0 and 2.5 mm ID) and material compositions, are available on request. Please contact your PerkinElmer sales representative about options.

Torch Cassette

A variety of torch cassettes are available, whereby each torch cassette is color-coded according to the application, taking the guesswork out of sample-introduction component selection. Optional torch and injector designs are available for:

- Organic solvents
- HF resistance
- Geological
- High TDS sample introduction/best BECs

The tool-free, ambidextrous design of the torch cassette allows the sample introduction system to be changed with minimal downtime. The self-aligning torch cassette has fully integrated gas and plasma ignition connections and a one-piece torch, providing exceptional ease of use for operators of all skill levels. The torch cassette has fully software-controlled and automated X, Y, Z torch positioning (+/- 3 mm with 0.05 mm reproducibility), ensuring that maximum ion transmission is achieved for optimal sensitivity.

Inductively Coupled Plasma

The NexION 2200 ICP-MS offers the most robust plasma on the market, allowing for the rapid transition between aqueous and organic matrices, cold and hot plasma, delivering unmatched performance and stability.

RF Generator

The NexION line of ICP-MS instruments offers the only RF Generator to be specifically designed for ICP-MS. The state-of-the-art 34-MHz free-running solid-state RF Generator with PlasmaLok™ delivers the best of both plasma power range and stability. It provides accurate impedance matching and adjustable power with 1 watt increments from 400 to 1600 watts and a response time of 50 nanoseconds, quickly adapting to changing plasma loading. With no moving parts aside from the cooling fans, it electrically decouples the plasma from the ion optics, allowing independent adjustment of the ion optic parameters and the plasma conditions.

The RF Generator is able to run in Cold Plasma mode (400-800 W) and Hot Plasma mode (1400-1600 W) in a single sample acquisition and can rapidly change between these modes without the need to create multiple methods.

LumiCoil RF Load Coil

The innovative design of the LumiCoil RF coil is unique in that it is air-cooled by the system exhaust and requires no additional infrastructure for water or gas cooling. This eliminates the need for maintenance or replacement of plasma load coils as is often needed with copper RF coils. This novel design ensures that the torch does not require any additional and costly consumables to prevent the secondary discharge of the plasma, such as torch shields, bonnets and screens, and is overall more sustainable than copper coils. Plus, the air-cooled load coil enables the use of the energy-efficient GreenCT™ cooling system without sacrificing instrument performance.

PlasmaLok Interface

PlasmaLok stabilizes energy distribution, thus maintaining excellent spectral resolution and simplifying ion-optic tuning. This is achieved even when the sample matrix dramatically changes, such as going from a wet-sample aerosol (conventional nebulization) to a dry-sample aerosol (laser sampling), from hot plasma to cold plasma, and from aqueous solutions to organics.

Furthermore, PlasmaLok eliminates damage to the interface cones by preventing uncontrolled arcing between the plasma and cones without the need for a plasma shield.

And finally, PlasmaLok minimizes deposition on the cones and reduces double-charged signals, guaranteeing excellent signal precision and long-term stability. Due to the lower amount of deposition on the cones, this feature dramatically reduces the need for routine maintenance and cleaning of the cones.

Clear Plasma View

A true reflection, full-color plasma view window allows for careful, unobstructed and real-time visual inspection of the cones, torch, load coil, sampling depth, and plasma color without needing to extinguish the plasma.

This feature simplifies the optimization of gases when running organic matrices and troubleshooting, allowing early diagnosis and quick response to issues via plasma observations.

Inert Tubing

Cleaned, high-purity stainless steel, low-sulfur cell gas tubing is provided as the standard configuration for lower sulfur backgrounds.

Interface

As with all NexION ICP-MS instruments, the NexION 2200 system offers easy cone access at the touch of a button. The wide-aperture cones ensure less clogging and maintenance. The Quadrupole Ion Deflector (QID) replaces the traditional lens systems adopted in older ICP-MS designs and turns the ion beam 90 degrees to eliminate photons, unionized material and neutral species, cleaning the beam for excellent BECs. With no lenses to clean or maintain after the cones, uptime is dramatically increased as routine maintenance decreases.

Triple Cone Interface

The second-generation wide-aperture Triple Cone Interface with OmniRing technology, produces the most tightly-defined ion beam in the industry while minimizing space-charge effects, delivering low maintenance and up to a five-fold increase in analyte sensitivity. By applying different voltages to the hyper-skimmer cone and OmniRing, analysis can take place in extraction or focusing modes. The Triple Cone Interface is easy to remove and clean without opening the vacuum chamber. The details of the cones which come with the NexION 2200 ICP-MS are provided below:

Sampler: Nickel. Used to sample ions from the plasma. 1.1 mm diameter orifice.

Skimmer: Nickel. 0.6 mm diameter orifice. This large diameter offers a nearly 1.5x larger aperture than 0.4 mm cone orifices, delivering improved signal stability and less cone-maintenance due to clogging during extended high TDS sample runs. 0.88 mm diameter orifice cones are optional to purchase.

Hyper-Skimmer: Nickel and charged. 1.0 mm diameter orifice to produce a tightly focused ion beam that helps the Quadrupole Ion Deflector to filter out neutrals and photons and ensures no routine maintenance beyond the cones.

OmniRing: The proprietary OmniRing technology applies a voltage behind the hyper-skimmer cone to optimize ion flow from the plasma, enhancing sensitivity and allowing analysis to take place in either extraction, focusing or cold plasma modes, without the need to change inserts or lenses. The unique design of OmniRing guarantees no frequent cleaning of this component.

Cones are easily removed using a magnetic cone removal tool which ensure that the cones do not drop and are protected as they are being removed.

Cone and OmniRing voltages can be adjusted within the software to deliver high sensitivity or the best BECs in hot or cold plasma. These cones are designed to offer both high sensitivity and high matrix tolerance without the need for any special inserts or different base materials. Since there are no additional lens assemblies based on the cone configuration or application being run, downtime is significantly reduced.

NOTE: Other cone materials and cones recommended for sulfur analysis are available on request. Please contact your local PerkinElmer sales representative about available options.

Interface Gate Valve

The software-firmware-controlled interface gate valve defaults to the closed position when the plasma is off and when the instrument is not powered. The gate valve remains closed for a few seconds after plasma ignition which maintains the high vacuum in the ion optics housing. There is no need to exchange the gate valve for the analysis of 10% H_2SO_4, saving on the cost of components and instrument downtime.

General

A streamlined user experience is achieved via several product enhancements. The following features aim to create a simple and guided user experience as well as provide best-in-class detection limits:

Refined, User-Friendly Software

Syngistix for ICP-MS software (v. 3.5 or higher) enables users to quickly harness the robust analytical capabilities of the NexION 2200 ICP-MS. The contemporary user interface offers an easy-to-understand workflow. With just a few mouse clicks, the user can quickly access and complete a suite of automated optimizations which tune the instrument to reach optimal performance. Also included with the software are a number of tried and tested methods based on published application notes, allowing users to get up and running quickly.

Moreover, the software includes a variety of features which provide a more streamlined user experience:

- Advanced QC options and intuitive graphs for improved QC tracking
- Interactive charting tools for advanced analytics
- Automated hands-free sample runs with Scheduler feature
- Customizable maintenance reminders
- Intuitive logbook for improved performance tracking of both default and laboratory specific parameters
- Method validation for regulated labs, delivering ease of method validation via Syngistix for ICP-MS Enhanced Security™ software

LCD Touchscreen

The NexION 2200 ICP-MS comes standard with a built-in LCD touchscreen with comprehensive operation data and control capabilities. Users can control the instrument hardware, including cones, plasma and vacuum, through the Control tab and view the intensity data results live in numeric and pre-defined dashboards. The touchscreen also displays common system diagnostic parameters and analytics dashboard to provide operator intelligence, including argon consumption. Moreover, training videos are stored and accessible directly through the LCD touchscreen.

Status Lighting

The NexION 2200 system has incorporated status lighting which provides visibility to the state of the instrument from afar and facilitates the quick response to and diagnosis of issues.

Regulatory and Safety Compliance

The NexION 2200 ICP-MS carries the CE Mark and fully meets the safety and regulatory standards below:

- EN 61010-1:2010 and EN 61010-2-081 Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use
- European EMC Directive 2014/30/EU and referenced standards EN 61326-1:2013
- WEEE Directive 2012/19/EU
- RoHS 2

Peripheral Equipment

The NexION family of instruments supports a wide range of PerkinElmer, ESI and CETAC autosamplers, autodilutors as well as laser ablation, field flow fractionation and speciation systems. PERSPEX® covers with extraction ports and easy-access doors are available for various autosampler models. A variety of bench options and pump-noise enclosures are also available on request. Please speak to your PerkinElmer sales representative about available options.

High Throughput Sampling Compatibility

The NexION 2200 also supports a wide range of PerkinElmer and ESI high-throughput and flow-injection systems.

Difference Between Conventional Single-Quadrupole ICP-MS Technology and the NexION 2200 ICP-MS with Three Quadrupoles

The NexION platform of ICP-MS instruments delivers unsurpassed interference removal thanks to its three-quad design. The three quads are comprised of the Quadrupole Ion Deflector (QID), the Universal Cell (UCT), and the Transmission Analyzer Quadrupole. This design enables the system to be effortlessly operated in three ways:

- Analyzing Quad + UCT (ion guide) + QID (ion guide)
- Analyzing Quad + UCT (fixed mass) + QID (ion guide)
- Analyzing Quad + UCT (fixed mass) + QID (fixed voltage)

At the heart is the quadrupole Universal Cell, a true reaction cell with dynamic bandpass tuning which allows for customizable upper and lower mass cut-off in the cell. Unlike instruments with a collision cell designed for collision chemistry, the NexION quadrupole Universal Cell is designed with both reaction chemistry and collision in mind, providing the most efficient removal of interferences with the added advantage of being able to operate in Standard, Collision (with KED) and Reaction modes.

Conventional Single-Quadrupole Technology

In conventional single-quadrupole ICP-MS, typically only the analyzer quad is a true quadruple with resolving capability. The ions of interest are focused and directed using an extraction lens.

Although a useful approach for removing photons and neutral species, these components of the original ion beam become deposited on the extraction lens surface, which consequently requires regular cleaning. Furthermore, since the extraction lens does not have the ability to destabilize ions outside the mass range of interest, all ions go through to the collision/reaction cell where some of the ions may be deposited on the rod and can lead to increased backgrounds over time. Moreover, since the kinetic energy spread of the ions is variable, this may cause highly accelerated ions to proceed through the lens to the cell, which can cause the sputtering of the cell material.

The ions entering the cell undergo collision/reaction in a passive multipole collision cell. Since there is no control over the ions in the cell, side reactions can take place from reaction by-products and gas impurities in the cell gases to form new interferences. In the following example of V, this can be seen as $NH_3(NH_3)_2^+$ and $ClNH_2^+$, which is an ion formed from the reaction by-product and the reaction gas and has the same nominal mass as the analyte (V) ion. Consequently, the $NH_3(NH_3)_2^+$ and $ClNH_2^+$ ion will not be able to be separated from the analyte in the analyzing quadrupole, resulting in a raised background and poorer detection limits for this analyte.

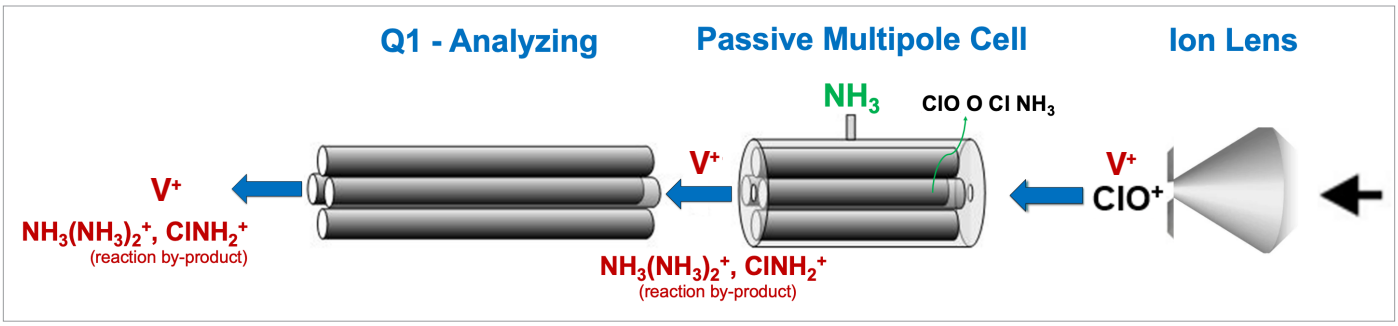


Figure 9. Diagram of a conventional single-quadrupole ICP-MS system demonstrating the determination of V using ammonia gas and a passive collision cell as is standard with these systems.

NexION 2200 ICP-MS with Three Quadrupoles

The three-quad NexION 2200 ICP-MS offers three stages of mass resolution. The key difference with this design is that the ions are controlled and have mass resolution at two additional areas in the system. The Quadrupole Ion Deflector (QID – Q0) acts as the first stage of mass resolution where it is possible to reduce ions outside the mass range of interest which results in lower BECs for the analyte, no maintenance beyond the cones, greater uptime and long-term stability that you can trust. Moreover, the QID acts as an electrostatic analyzer, reducing the kinetic energy spread of the ions ensuring that there is no sputtering of the Universal Cell, which could increase the BECs of certain elements.

With the NexION 2200, the ions follow the same process as discussed above for conventional single-quadrupole technology, with the key difference that further control can be added in the Universal Cell (UCT - Q1) with dynamic bandpass tuning, which provides an additional mass filtering step. Here, the quadrupole Universal Cell quickly destabilizes reaction by-products before they have a chance to react and form new interferences. This ensures that a clean beam of analyte ions without interferences proceeds to the Transmission Analyzer Quadrupole (Q2) and then on to detection.

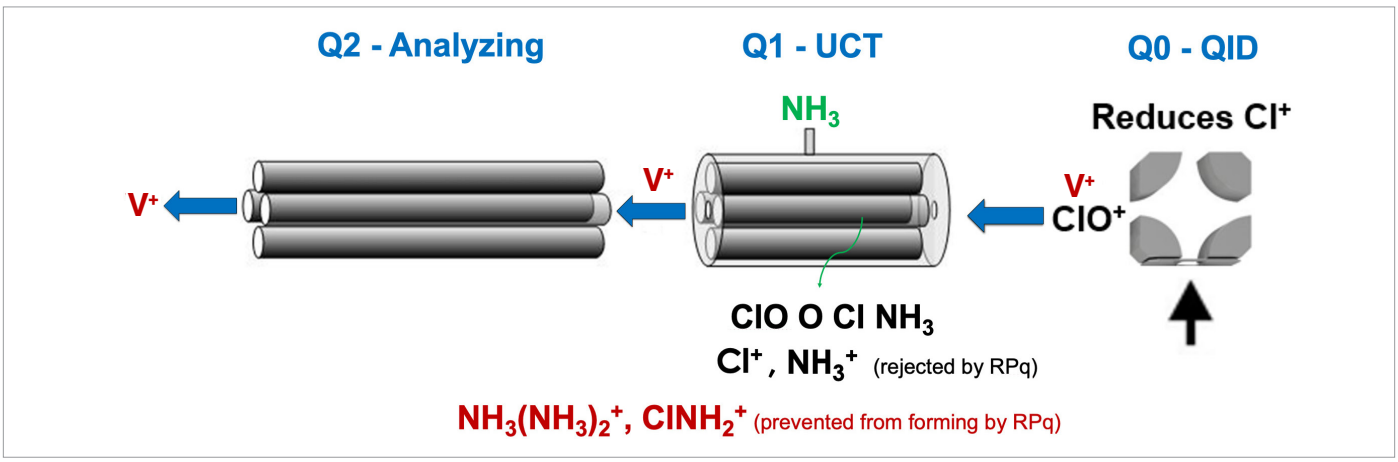


Figure 10. Diagram showing the ion path of the NexION 2200 ICP-MS with three quadruples, featuring a quadrupole Universal Cell with dynamic bandpass tuning capability.

SUMMARY TABLES

Figure 11. Standard NexION 2200 ICP-MS sample introduction system.

Standard Configuration

COMPONENT	STANDARD CONFIGURATION
Nebulizer	Glass concentric
Spray Chamber	Baffle-type glass cyclonic high sensitivity spray chamber with All Matrix Solution (AMS) gas port
Torch	Quartz
Injector	Quartz 2.0 mm (fixed)
Sampler and Skimmer Cones	Nickel
Hyper-Skimmer Cone	Nickel
Plasma Gas Flow Controllers	Three (plasma, auxiliary and nebulizer)
Universal Cell Gas Channels	Three mass flow controllers
Additional Gas Flow Controllers	One optional for All Matrix Solution (AMS)
Argon Supply Lines	Polyethylene
Interface Pump	Standard, rotary
Cooling Water Supply Fittings	Push-fit

Hardware Specifications

SAMPLE INTRODUCTION	
Access	Eye-level height (based on unit being placed on an appropriate bench)
	Quick exchange torch access via SMARTintro sample introduction modules and torch cassette
Peristaltic Pump	Close-coupled, software-controlled 12-roller 4-channel peristaltic pump which is fully integrated with the ICP-MS system. Inert rollers, low pulsation and noise. Speeds 0-100 rpm
	2-stop flared tubing as standard
Spray Chamber	Baffle-type glass cyclonic high sensitivity spray chamber with AMS gas port as standard option
	Optional quartz or SilQ cyclonic, PFA Barrel type or Asperon spray chamber available
Injector	Fixed, 2 mm ID. Optional 1 mm, 1.5 mm and 2 mm fixed injector, and self-aligning demountable torch injectors with various IDs and material compositions available
Service	O-ring free sample introduction system
PLASMA ION SOURCE	
Torch	Screw-in, single piece, quartz
	Variety of fixed and demountable torch injector designs available
	Automatic gas coupling
	Horizontal and vertical position: 3 to -3 mm, ± 0.05 mm steps, ± 2 mm accuracy
	Sampling depth: 3 to -3 mm, ± 0.5 mm step increments
Torch Mount	Ambidextrous cassette style torch mount, which supports single-hand removal of the torch and injector assembly
RF Generator	Free-running, specifically designed for ICP-MS, 34 MHz
	Accurate impedance matching
	RF power range: 400 - 1600 W
	PlasmaLok ensures plasma stability
	No plasma shield required
	Most robust plasma on the market for easy switching between cold and hot plasma, aqueous and organic samples
Load Coil	Novel LumiCoil design, passively air-cooled via the extraction
	Lifetime guarantee*
	Aluminum load coil
Ar Gar Flow Controllers	Three channels: plasma/coolant, auxiliary, nebulizer
Additional Gas Flow Controllers	Integrated AMS. MFC for single gas
Clear Plasma View	True reflection full-color plasma view window. No cameras and/or supporting infrastructure to maintain or replace.

** Assuming no misuse/damage caused by handling*

Hardware Specifications *continued...*

VACUUM SYSTEM	
Configuration	Four-stage differential pumping
Vacuum Pumps	Triple-inlet turbomolecular pump
	External backing rotary pump
Pump-Down Time	< 15 min after maintenance, which involves the breaking of vacuum and opening the vacuum chamber from atmospheric pressure (< 10^{-6} mbar)
INTERFACE	
Access	Cone access from the front at the push of a button, instrument front panel drops down and slightly to the left for easy cone access
Sampler Cone	Nickel, 1.1 mm ID. Pt tipped sampler cone available
Skimmer Cone	Nickel, 0.6 mm ID. 0.88 mm Ni and Pt cones available
Charged Hyper-skimmer Cone and OmniRing Assembly	Nickel cone, 1 mm ID, charged. OmniRing electrically isolated from hyper-skimmer cone
Interface Gate Valve	Software-firmware controlled, power failure, argon-depletion interlock
OPTICS	
Quadrupole Ion Deflector (Q0)	Quadrupole which actively turns ions 90 degrees while unionized materials, photons and neutrals are not deflected and carry on straight to be removed via vacuum
	Replaces traditional lens system in older ICP-MS designs
	Optimizes the transmission for the mass of interest and broadly reduces unwanted ions, therefore keeping the system cleaner than traditional linear lens systems
	No lenses to clean or maintain
	Ions exiting the QID have similar (< 10 ev) kinetic energies to prevent sputtering of the quad material
Quadrupole Universal Cell (Q1)	Not a consumable, no routine maintenance
	Three gas channels, which can be mixed in situ
	User-defined low- and high-mass cut-off window
	Can accommodate a wide variety of pure and mixed gases for extended periods of time
	Bandpass tuning of the cell is achieved by frequency modulation while keeping the RF amplitude constant to prevent unwanted chemical reactions occurring inside the cell
	Extended Dynamic Range (EDR) extends dynamic range up to 10^{14} by actively and selectively reducing ion signal on high-concentration elements
	EDR does not affect the signal response of other elements or require the pressurization of the cell with a gas
	Axial Field Technology (AFT) controls the speed of the ions through the cell
Transmission Analyzer Quadrupole (Q2)	Mass range: 1 - 285 amu
	2.5 MHz
	Resolution: Typical operating resolution 0.7 amu, custom resolution to < 0.3 amu
	Quadrupole peak hop (slew) speed: 1.6 M amu/sec
	Quadrupole scan speed: 5000 amu/sec
	Peak hopping settling time: < 0.2 ms regardless of mass change
	Mass stability for ^{7}Li, ^{24}Mg, ^{115}In and ^{238}U: < 0.05 amu over eight hrs of continuous operation
	Isotope ratio precision (^{107}Ag/^{109}Ag): < 0.08% RSD
	Thermal coefficient of expansion < 1.3 x 10^{-6}.K^{-1} at 25 °C for the best stability
Abundance Sensitivity	Better than 5.0 x 10^{-7} at low-mass side of peak measured at ^{238}U
ION DETECTION	
Detector	Dual-stage discrete dynode detector
	Simultaneous pulse/analogue over two orders of magnitude
	Detector dead time of 35 ns
	< 0.2 ms switching between pulse and analogue
	Both pulse and analog signals are captured simultaneously
	Cradle design for easy exchange
	Transient data acquisition speed: > 3000 temporal data points/sec maximum
Minimum Dwell Time	10 µs
Dynamic Range	14 orders of magnitude with EDR, > 10 orders of magnitude without EDR

Software Specifications

SOFTWARE	
System Operations	All analytical system operations (component optimization, methods development, calibration, analysis and reports) controlled using Syngistix for ICP-MS software
Automation	Syngistix software has automated system startup, shutdown, optimization and instrument tuning (including torch alignment)
Ease of Use	Scheduled user-defined alerts for routine maintenance
	Pre-set methods available
	Automated quality control checking
Analysis Options	Quantitative analysis: ▪ External calibration ▪ Additions (matrix matched) calibrations ▪ Method of standard additions ▪ Isotope ratios ▪ Isotope dilutions
	Semi-quantitative analysis
Real-time Features	Real-time graphics with the ability to display transient and continuous signal profiles
	Real-time plotting of internal standard response in Results, plot exported with results
Graphing Feature	Ability to graphically overlay, add or subtract mass spectra and view composite signals
Method Setup	Computer-controlled automatic selection of cell gas when multiple gases or mixed mode are specified within a single method
	Computer-controlled cell gas flows and optimization
	Fast switching between Cold and Hot Plasma settings, allowing both modes to be run within a single analytical method
	Operation in a number of different modes and plasma conditions in a single method
	Pre-integrated correction equations with the option to delete and/or modify the equation being used
	Custom correction equations to accommodate for doubly-charged ions (half-mass correction) and other custom analytical needs
Auto-dilutors	Supports syringe-pump-based auto-dilution systems
	Supports auto-dilutions by both a global dilution factor and serial dilutions for out-of-range samples
	Supports auto-dilution of samples where internal standard is out of range
Calibration Curve Fitting	The following curve-fitting options are available: ▪ Linear least squares calibration fitting ▪ Weighted linear least squares ▪ Linear forced-through-zero least squares ▪ Method of standard additions (matrix matched calibration) ▪ Additions calibration
Quality Control	QC protocol limits on measured values: ▪ Analyst to define when and how an action is taken ▪ Ability to specify a second QC action
Data Reprocessing	Data reprocessing for: ▪ Changes of calibration points ▪ Internal standard points ▪ Curve fit mode
	Reprocessing options: pulse, analog or dual detector modes
Data Export	Single-click to export analytical data as a Microsoft® Excel® file
Data Integrity	All analytical raw data is retained and stored on the hard disk and encrypted
	Time and date printed on each sheet of data
	Mass calibration on six elements (Be, Co, In, Mg, Pb, U)
Support	Online help with quick steps to reference entire instrument user manual
Operating System	Microsoft® Windows® 10 64-bit operating system
Software Package Add-Ons	TIBCO Spotfire® Data Visualization Software. Single Cell and Nano software modules. Clarity™ software for speciation analysis

Peripheral Equipment

PERIPHERAL SYSTEM COMPATIBILITY	
Autosampler Capacity	Available autosamplers are capable of holding 150 or more 15 mL sample vessels
Autosampler Compatibility	PerkinElmer AS93/S10/S23/S25 autosamplers (fully integrated)
	CETAC ASX series autosamplers
	ESI SC and DX series autosamplers
	AIM autosamplers
High Throughput Sampling Compatibility	PerkinElmer HTS system
	ESI prep*FAST* systems
	ESI *FAST* system
	CETAC ASXpress system
	GE Niagara Plus CM system
Hyphenated Techniques	Compatible with a wide variety of hyphenated techniques. Please contact your local PerkinElmer sales representative for details.

Site Description and Dimensions

ENVIRONMENTAL – LABORATORY			
Temperature	Optimal performance range		15 and 30 °C (59 - 86 °F)
	Rate of change		3 °C (5 °F)
Humidity	Range		20 - 80%
UTILITIES			
Electrical	Current		16 A max continuous
	Operating frequency		50/60 Hz
Cooling Water	Supply temperature		18 °C
	Supply rate		3.8 L/min (1.0 gpm) minimum 4.7 L/min (1.25 gpm) typical
	Pressure		@ 413 ± 14 kPa (60 ± 2 psig)
Argon Gas Supply	Purity requirements		≥ 99.996%
	Typical flow rate		15 - 20 L/min (typical), can go as low as 12 L/min
	Pressure		@ 586 - 690 kPa (85 - 100 psig) min-max
Cell Gas Purity Requirements	Purity	Ammonia (with getter)	≥ 99.9995%
		Helium	≥ 99.999%
		Methane	≥ 99.999%
		Oxygen	≥ 99.999%
	Flow rate	Ammonia	0.6 mL/min (typical)
		Helium	5 mL/min (typical)
		Methane	0.5 mL/min (typical)
		Oxygen	0.5 mL/min (typical)
	Pressure		@ 69-103 kPa (10- 15 psig)
System Exhaust Requirements	Port dimensions		9.2 cm (3.6 in.) ID
	Flow rate		110 to 150 CFM without instrument connected

Dimensions and Weight

No rear access required. All gas, exhaust, filter and electrical connections are on the front/side/top of the NexION 2200 ICP-MS. The instrument is designed to fit through all standard international door frames.

PARAMETER	VALUE
Width	81 cm (32 in.)
Height	73 cm (29 in.)
Depth	72 cm (28 in.)
Weight	150 kg (330 lb.)

Specific Criteria Tested and Verified During Production

The summary below describes specifications verified during NexION 2200 manufacturing testing.

PARAMETER	ELEMENT/VALUE	FACTORY SPECIFICATION
Sensitivity	^{7}Li	> 70 Mcps/(mg/L)
	^{115}In	> 400 Mcps/(mg/L)
	^{238}U	> 300 Mcps/(mg/L)
Detection Limit (ng.L^{-1})	^{9}Be	≤ 0.4
	^{56}Fe	≤ 1.5 (Reaction mode with ammonia in a cleanroom)
	^{115}In	≤ 0.05
	^{209}Bi	≤ 0.05
Oxides (%)	CeO/Ce	< 0.025
	Ce^{++}/Ce^{+}	< 0.03
System Background (cps)[+]	220.5	≤ 1 cps
Detector Background (cps)	220.5	≤ 0.1 cps
Short-term Precision	10 min	< 2%
Long-term Stability	2 hours (after 1 hour warm-up)	< 3 % (cycling between Standard and Reaction modes)

[+] Background signals are obtained under identical operating conditions with no changes to voltages during blank and background signal acquisitions

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