Trace elemental analysis

Thermo Scientific iCAP MTX ICP-MS

Key benefits

- Optimized sample introduction system for best analytical performance
- Enhanced matrix tolerance and improved robustness with increased sensitivity
- Increased flexibility with tailored hardware components for various applications
- Reduced user interaction with instrument maintenance and simplified consumable management
- Enhanced productivity with automated hardware and software solutions for entire workflow, covering from instrument readiness to the reporting of results

Introduction

The Thermo Scientific™ iCAP™ MTX ICP-MS is designed to exceed the requirements of research laboratories demanding cutting edge interference removal and flexibility to challenge the boundaries of known and novel applications. At the same time, the instrument offers the performance and flexibility needed to perform cutting-edge applications in research-oriented and testing laboratories. Combined with unmatched ease of use, the iCAP MTX ICP-MS sets a new standard for triple quadrupole inductively coupled plasma mass spectrometry.

Innovative features in both hardware and software bring the user experience to new levels: The all-new electronics of the system enable IntelliLens™, a feature that applies optimized voltage settings for every individual analyte to provide exceptional sensitivity across the entire mass range.

With an optimized sample introduction system, including a built-in solution for diluting high matrix containing samples using argon gas dilution (AGD), the system ensures consistent and stable analytical performance no matter the sample type. In combination with effective handling of sample matrices during non-analytical steps (sample uptake and wash), the unnecessary introduction of matrix during sample uptake and wash out can be reduced and therefore the intervals between sample introduction system maintenance can be increased. All features are completely integrated in field-proven Thermo Scientific™ Qtegra™ Intelligent Scientific Data Solution™ (ISDS) Software.

Leverage advanced interference removal using a wide variety of reactive gases and rely on complete interference removal using intelligent mass spectrometer control. Comprehensive interference removal using kinetic energy discrimination is complemented with powerful and selective ion/molecule reactions using oxygen, ammonia, or hydrogen, as well as other reactive gases. This allows you to overcome interferences while breaking through the noise with sensitivity. Rely on the proven Reaction Finder method development assistant or build up new methods with full flexibility.

The combination of these hardware and software features makes the iCAP MTX ICP-MS the best-in-class solution for analysts and researchers looking for ultimate performance in ICP-MS.

- Leverage best-in-class sensitivity for cutting edge research in emerging application fields, such as nanoparticle or single cell analysis, or laser ablation imaging.
- Use automatic dilution of samples using AGD for accurate, robust, and reliable analysis of samples containing TDS up to 35% (tested with 35 g of NaCl in 100 mL of water at 25 °C).
- Perform your day-to-day analytical work with enhanced simplicity, productivity, and robustness in high throughput demanding laboratories.
- Ensure that instrument uptime is used for analytical work and not for maintenance.

Hardware details

Sample introduction system

All components of the sample introduction system are positioned for easy access to the user, simplifying removal and re-fitting of each component. The kitchen area contains a built-in argon humidifier to facilitate humidification of nebulizer gas to ensure trouble-free, long-term analysis of high TDS-containing samples. It also offers dedicated positions to store bottles containing tune and calibration solutions and the cone removal tool for easy access during daily operation.

Spray chamber

- Peltier-cooled high-purity quartz, low volume, baffled cyclonic spray chamber efficiently filters out larger aerosol droplets for improved plasma stability.
- Software controlled temperature in the range of –10 °C to +20 °C.
- Low volume and reduced surface area improve sample washout with reduced carryover.
- PFA version is available as optional for HF and other aggressive sample matrices.
- Dedicated connections for AGD dilution gas and additional gas supply, enabling hardware readiness for easy switch-over between various applications.

Nebulizers

- PFA concentric nebulizer with ≈400 $\mu L \cdot min^{-1}$ sample flow rate.
- Optional nebulizers with different sample flow rates and different types are available for enhanced dissolved solid tolerance, organics, and HF-containing samples.
- Intelligent Matrix Optimization to reduce the amount of sample introduced during uptake and washout to extend intervals between sample introduction system maintenance.

Torch

- Easy to install with push-in, demountable single piece quartz torch as standard.
- Option to use the PLUS torch, offering improved lifetime and improved backgrounds for critical analytes such as silicon.
- All gas connections are located into the torch holder, reducing design complexity and need of maintenance.
- Horizontal and vertical position: ±2 mm, 0.02 mm step width.
- Sampling depth: 0–15 mm, 0.01 mm step width.

Injectors

- Proprietary, screw-in, self-aligning injector without O-ring for ease of use and reliability.
- Quartz injector with 2.5 mm ID as standard.
- Optional quartz injectors (1.0 mm, 2 mm ID), sapphire injector (2 mm ID), and platinum injector (2 mm ID) are available.
- Specific injectors designed for laser ablation application with single and dual inlet capabilities are available as optional.

Peristaltic pump

- Innovative, automatically tensioning, easy access design, which requires no manual adjustment, eliminates sample introduction variables for simple operation and longer pump tubing lifetime.
- Software controlled compact, low pulsation, 12-roller, four-channel minipump with inert rollers for improved reliability.
- Computer controlled pump speed 0–100 rpm with interval of 1 rpm.

Argon Gas Dilution (AGD)

- Built-in gas supply for AGD with variable flow rates in the range of 0–1,000 $mL \cdot min^{-1}$ is provided as standard.
- Different dilution levels (model dependent) can be selected in the instrument control software.
- Addition of the dilution gas through a nozzle at the spray chamber elbow to ensure efficient dilution and complete aerosol transfer to the plasma.

Additional gas kit

- Built-in gas supply for AGD with variable flow rates in the range of 0–1,000 mL·min^{-1} is provided as standard.
- Up to two additional mass flow controllers with variable flow rates in the range of 0–250 mL·min^{-1} and 0–1,000 mL·min^{-1} are available as optional. The fully software-controlled operation allows the introduction of different gases as per the need of application (e.g., O_2 for the analysis of organic solvents or He for analysis using coupled accessories like Laser Ablation).
- Easy coupling with the sample introduction system through a quick-fit connection.
- Additional gases can be connected to the spray chamber elbow independently of the AGD gas supply, meaning no need to change gas connections for different applications.

Inductively coupled plasma

- The plasma ion source in the iCAP MTX ICP-MS adapts to changing matrix load rapidly, enabling handling of most challenging matrices, such as highly volatile organic solvents and high solid containing samples, effectively with proven robustness.

RF generator

- Digital, solid state RF generator operating with dynamic frequency impedance matching plasma at ≈27.12 MHz.
- Low ion energy spread for optimum ion focusing and transmission, without the need of a grounded shield between torch and load coil.
- Highly stable and robust cold plasma operation.

Load coil

- Water cooled load coil for improved lifetime and reliable plasma ignition.
- Teflon™ coated RF coil for better performance and improved lifetime.
- Accessible at bench height for ease of maintenance.

Plasma TV

- Remote monitoring of plasma status via integrated HD camera, displayed directly inside the Qtegra ISDS Software dashboard.

Inert tubing

- Deactivated inert gas transfer tubing for lower backgrounds.

Interface

- Unique front opening interface provides rapid, simultaneous access to cones and extraction lens to facilitate routine maintenance and minimize downtime.
- Variable and optimized skimmer potential to deliver best performance.

Cones

- Optimized sample (1.1 mm diameter orifice) and skimmer (0.5 mm diameter orifice) cone geometries for reduced matrix deposition and maintenance.
- Ni cones as standard; Pt tipped as option for specialized applications.
- Cones are rapidly removed by a single (magnetic) tool.

Extraction lens

- Single extraction lens operated at low voltages for optimum ion extraction and focusing into the ion optics; bayonet mounted for easy handling.

Slide valve

- Software controlled: defaults to closed position when plasma is off or in the event of a power failure, maintaining vacuum in the analyzer housing. This allows cones maintenance without venting vacuum, reducing system downtime.

Ion optics

- Uses IntelliLens for optimized voltage applied for individual analytes to provide exceptional sensitivity across the entire mass range, fully integrated in Qtegra ISDS Software.
- Unique 90° cylindrical ion lens, the RAPID lens (Right Angular Positive Ion Deflection), providing high ion transmission across the entire mass range.
- Open geometry, meaning that residual ions do not interact with active lens surfaces, delivering a maintenance-free mass spectrometer.
- Off-axis design delivers significantly reduced background noise.
- Electrical connections with gold spring contacts from the analyzer housing to ions optics improve reliability.

Q1 quadrupole

- High frequency (4 MHz) quadrupole mass analyzer with pre- and post-filter for isolation of desired ions.
- User-definable resolution in all TQ modes. Switch between intelligent Mass Selection (iMS) and High Resolution (<1 u) mass resolution for optimal performance in all matrices.
- Mass calibration automatically assessed and updated.

Q2 QCell collision/reaction cell (CRC)

- Zero maintenance, small volume collision/reaction cell with proprietary flatapole rods.
- High transmission, low mass cut off, and highly flexible gas usage provides powerful interference removal for a cleaner mass spectrum in all sample types.
- Four gas-specific mass flow controllers with dedicated flow ranges deliver H_2, NH_3, O_2, and He in a safe and compliant manner. (Additional 15 CRC gases are supported based on request.)

Q3 quadrupole

- Quadrupole mass analyzer driven by a solid state 2 MHz supply ensures low abundance sensitivity and class leading mass stability.
- User-definable mass resolution in the mass range 2–290 U (above *m/z* 225 only enabled with intelligent Mass Resolution (iMR)).
- Mass calibration assessed and automatically updated.
- Scan speed of >3,700 amu·s^{-1} Li to U with 40 interval masses.
- Mass stability < ± 0.025 u per day.
- Abundance sensitivity in TQ mode <0.005 ppm at m-1 and m+1 (m = ^{133}Cs).

Vacuum system

- Three stage, differential vacuum.
- High vacuum is maintained in the event of a power failure: the rotary and turbo pumps automatically restart as soon as power is restored.
- A stable vacuum, obtained in less than 15 minutes pumping time, enables fast return to service after routine maintenance, reducing instrument downtime.

Turbo pump

- Single split flow turbo molecular pump.

Interface pump

- External, high-performance pump to provide backing to the turbo pump and evacuation of the expansion region for improved sampling from the plasma.
- Choice between a rotary pump using synthetic, chemically stable, and temperature-resistant oil or dry pump.
- Software-controlled variable pump speed for either option, delivering variable interface vacuum for optimized sensitivity and matrix tolerance.

Detector

- Dual mode discrete dynode electron multiplier.
- Long lifetime detector designed for ICP-MS requirements.
- Dwell times of 100 µs in both analog and counting detection modes. Optional data acquisition using 5 µs dwell time to support research orientated applications like single cell and nano particle analysis.
- Linear dynamic detection range: >11 orders of magnitude (<1 to >5·10^{10} cps).
- Automated optimization of operating voltages and cross-calibration.
- Cradle design for ease of detector exchange.

iCAP MTX ICP-MS instrument configuration and performance specification

Nebulizer	PFA concentric (400 µL·min^{-1})	
Spray chamber	Quartz, cyclonic	
Torch	Quartz, demountable	
Injector	Quartz, 2.5 mm ID	
Cones/interface	Ni -tipped sample and skimmer	
No cell gas		
Sensitivity (kcps/ppb)	^{7}Li	65
	^{59}Co	180
	^{115}In	400
	^{209}Bi	340
	^{238}U[a]	550
Detection Limits (ppt)[b]	^{9}Be	<0.3
	^{115}In	<0.1
	^{209}Bi	<0.1
Oxides (%)[c]	^{140}Ce^{16}O/^{140}Ce	<2.0
Doubly charged (%)[c]	^{140}Ce^{++}/^{140}Ce^{+}	<3.0
Background (cps)[c]	*m/z* 4.5	<1.0
Stability (%RSD)	Short term[c]	<2 (10 min)
	Long term	<3 (2 h)
Isotope ratio precision (%RSD)	^{107}Ag/^{109}Ag	<0.1
SQ KED mode		
Sensitivity (kcps/ppb)[b]	^{59}Co	60
Interference removal	^{59}Co/^{35}Cl.^{16}O	18
Background (cps)[b]	*m/z* 4.5	<0.5
TQ-O_2 mode		
Detection limits (ppt)[b]	^{28}Si (as SiO^{+})	<50[d]
	^{32}S (as SO^{+})	<50
	^{31}P (as PO^{+})	<15
	^{78}Se (as SeO^{+})	<1
Isotope Ratio Precision (%RSD)	^{107}Ag/^{109}Ag	<0.1

Note: Unless stated all measurements are made using sensitivity mode.

[a]Not demonstrated during installation, determined in XS mode.

[b]Typical values, dependent on cleanliness of chemicals.

[c]Demonstrated on installation. Note that installation specifications are only conducted with the default sample introduction components listed in the table above.

[d]Value obtained when using the PLUS torch

Site requirements for installation

Lab environment		
Temperature	Range	15–35 °C
	Rate of change	<2 °C·h^{-1}
Humidity	Range	20–80% (non-condensing)
Utilities		
Electrical	Supply	200–240 V AC,50/60 Hz single phase
	Power (main instrument)	Apparent: 2,200 VA; Effective: 2,050 W
Cooling water	Supply temperature	20 to 30 °C, optimum at 21 °C
	Supply rate	>5.5 L·min^{-1}
	Pressure	0.25–0.6 MPa (2.5–6 bar; 36–86 psi)
Argon gas supply	Purity	> 99.996%
	Typical flow rate	16 L·min^{-1}
	Pressure	0.55–0.6 MPa (5.5–6.0 bar; 82.5–90 psi)
Cell gas supply	Purity	>99.999%
	Flow rate	max. 10 mL·min^{-1}
	Pressure	0.1–0.15 MPa (1–1.5 bar, 15–22.5 psi)
Exhaust	Port dimensions	140 mm (recommended 120 mm ID ducting)
	Flow rate	(60–150 m^3·h^{-1})

Instrument dimensions

Length × width × height	868 mm × 743 mm × 1102 mm
Weight	138 kg

Reducing the environmental impact of ICP-MS

The iCAP MTX ICP-MS features a series of innovations that reduce the impact on the environment while allowing operators to perform the analysis with more comfort. To help customers better understand the impact of a new iCAP MX ICP-MS on the environment, the instrument has been evaluated within the ACT label program of My Green Lab, a non-profit organization that helps consumers make smart, sustainable product choices. The virtual ACT label provides environmental Accountability, Consistency, and Transparency for each labeled product through an environmental impact score.

In addition to the ACT label certification, the iCAP MX Series ICP-MS provides the following features:

- ECO mode to lower the energy consumption in standby mode (>20% compared to previous models)
- Automatic start/shutdown of the instrument chiller, enabled for selected chiller models
- Option to use dry pump in place of a standard rotary pump

Qtegra Intelligent Scientific Data Solution (ISDS) Software

Qtegra ISDS Software with simplified and automated workflows for end-to-end analytical operation, including instrument get ready to data reporting, is a user friendly and intuitive software solution. Qtegra ISDS also provides effective tools that enable monitoring of instrument performance, maintenance scheduling, and consumable management. Qtegra ISDS Software supports fully automated operation of:

- Plasma ignition
- Plasma shutdown after analysis
- External water recirculators (chillers) for selected model

Supported languages

English is the default language. Support for additional languages is available using specific language packs.

Integrated control of peripherals

The unique architecture in Qtegra ISDS Software allows for the control of peripheral devices via plug-ins, ensuring full implementation of all features within a single window.

Regulatory compliance

Qtegra ISDS Software provides the toolset for compliance with 21 CFR Part 11 or equivalent. Features such as system audit trails, access control, e-signatures, and secured data enable full confidence in GxP compliant environments.

Licensing

One instrument seat and three desktop seats are provided with each software license. Additional desktop seats for data evaluation are available (optional).

Supported accessories and sample introduction kits

Autosamplers: Thermo Scientific™ iSC-65 autosampler for unattended and automated sample analysis. In addition, a wide range of Teledyne CETAC Technologies and Elemental Scientific autosamplers are supported with the iCAP MTX ICP-MS.

Auto and intelligent dilution accessories: Automated prescriptive and intelligent dilution for handling highly varied and complex sample matrices to facilitate unattended sample analysis without any manual intervention.

Laser ablation: Laser ablation systems are directly supported via a dedicated plug-in within the Qtegra ISDS Software. With both powerful data evaluation (trQuant) and flexible data export, the iCAP MTX ICP-MS is a truly routine laser ablation analysis solution.

Speciation: The trace level analysis of various elemental species by seamless integration of separation techniques powered by Thermo Scientific™ ChromControl plug-in.

Single cell characterization: Explore the level and the distribution of trace elements in single cells using the scQuant plug-in for Qtegra ISDS Software.

Nano particle characterization: Accurately and reliably characterize nanoparticles from single particle ICP-MS analysis utilizing the Thermo Scientific™ npQuant plug-in for Qtegra ISDS Software

Organic kit: Specialized sample introduction kit for effective and trouble-free handling of organic samples such as oil and petroleum products and organic solvents. Organic kit includes 1.0 mm ID quartz injector, 50 $\mu L \cdot min^{-1}$ PFA microflow nebulizer, and quartz torch for organics.

Acid resistant kit: For the analysis of aggressive sample matrices, for example HF or H_2SO_4, this kit contains a PFA cyclonic spray chamber, a 2.0 mm ID sapphire injector, Pt tipped cones, and a 100 $\mu L \cdot min^{-1}$ PFA microflow nebulizer.

Learn more at **thermofisher.com/icp-ms**