Perkin Elmer ELAN DRC II ICP-MS

Performance Specifications

Features:

- SimulScan: Simultaneous dual-stage detector with 9 orders of dynamic range
- Dynamic Reaction Cell (DRC) with Dynamic Bandpass Tuning: Efficiently screens out interferences while maximizing analyte transmission. DRC with Axial Field Technology provides superior interference removal and performance for all applications.
- Axial Field Technology Optimizes performance and speed in all matrices
- AutoRes™ Custom resolution minimizes spectral interferences and improves detection limits
- PlasmaLok Easy optimization and extended cone life
- All-quartz Sample Introduction System Minimizes contamination
- Platinum Quick-change Interface Cones Easy maintenance, maximum uptime

The Ultimate Tool for the World's most difficult Applications

When your applications extend beyond the capabilities of conventional ICP-MS or the ELAN® DRC-e systems, you need the power of the ELAN DRC II. The ELAN DRC II combines the power of patented Dynamic Reaction Cell™ (DRC) technology, performance- enhancing Axial Field™ Technology (AFT) and a high-performance sample introduction system with the ability to run any reaction gas. The result is the ultimate analytical tool, providing uncompromised sensitivity and performance in all matrices for the world's most difficult applications. Unlike collision cell, high-resolution or cool-plasma systems, the ELAN DRC II completely eliminates polyatomic interferences, minimizing background equivalent concentrations, while maintaining analyte sensitivity, providing ultratrace- level detection limits in virtually any sample.

The ELAN DRC II uses chemical resolution to eliminate plasma-based polyatomic species **before** they reach the quadrupole mass spectrometer. This ion-molecule chemistry uses a gas to "chemically scrub" polyatomic or isobaric species from the ion beam before they enter the analyzer, resulting in improved detection limits for difficult elements such as Fe, Ca, K, Mg, As, Se, Cr, V and others.

Unlike other cell-based systems, patented DRC technology not only reduces the primary interference – it eliminates sequential side reactions before they can occur to create new interferences. Unless kept in check by DRC technology, these uncontrolled reactions increase spectral complexity and create unexpected interferences.

The lowest detection limits

The superior interference reduction and maximum analyte transmission provided by the ELAN DRC II produces excellent signal-to-background ratios. Background levels measured on-peak are typically less than 1 count per second – 50 to 150 times better than those reported by users of collision-cell based systems.

The ELAN DRC II does not use high-voltage ion-extraction lenses that can become contaminated. This results in lower on-peak background levels and more importantly, a lower background equivalent concentration (BEC) – the real measure of detectability. If the signal falls below the BEC, it is masked by the background. In situations where ultratrace measurements are made, the BEC actually limits the analysis, not the detection limit. Lower BECs mean that ultratrace levels can be accurately quantitated, not just detected.

How the DRC works

The DRC is located between the ion optics and the mass analyzer quadrupole. It consists of a quadrupole placed inside an enclosed reaction chamber. This quadrupole eliminates polyatomic interferences caused by the combination of plasma gases and sample-matrix constituents before they can enter the analyzing quadrupole.

Gas inlets pressurize the reaction chamber with a low flow of reaction gas, such as ammonia, methane, oxygen or other gases and gas mixtures. The reaction gas is selected based on its predictable ability to undergo a gasphase chemical reaction with the interfering species and remove the interference. Interference removal can occur through various processes, including collisional dissociation, electron transfer, proton transfer and oxidation. Analyte and interfering ions from the ICP enter the DRC. The reaction gas combines with the interfering ions, creating a non-interfering reaction product at a different mass. For extremely demanding applications, the DRC also provides the unique ability to carry out controlled reactions that can be used to predictably and reliably convert the analyte of interest to a different species, moving it away from the interference. No other system offers this level of predictable, controllable, reproducible or transferable chemistries, facilitating maximum interference removal in virtually any matrix.

Unlike collision-cell instruments, which pass all the reaction products into the analyzer quadrupole where they may cause interferences for other analytes, the DRC eliminates reaction by-products using the Bandpass Tuning (DBT) mechanism. The DBT function ejects the precursor ions **before** they can react to form new interferences – a real concern with complex sample matrices. The ELAN DRC II is able to eliminate interferences by up to 9 orders of magnitude, while retaining analyte sensitivity. This provides exceptional detection limits and the ability to use ICP-MS to determine more elements than previously thought possible. The Dynamic Reaction Cell chemically scrubs interfering species from the ion beam, using a reaction gas. The DRC can eliminate 40Ar+ interference on 40Ca+, as is shown by the reaction-gas optimization plot. The red line shows the reduction of the 40Ar+ signal by over 7 orders of magnitude. Bandpass Tuning (DBT) mechanism. The DBT function ejects the precursor ions **before** they can react to form new interferences – a real concern with complex sample matrices. The ELAN DRC II is able to eliminate interferences by up to 9 orders of magnitude, while retaining analyte sensitivity. This provides exceptional detection limits and the ability to use ICP-MS to determine more elements than previously thought possible.

Leaves cool plasma out in the cold

DRC technology always uses high-temperature or “hot” plasma for analysis, eliminating the recognized drawbacks of cool- or warm-plasma approaches. Cooler temperature plasmas have limited ability to ionize all but the most easily ionizable elements. As a result, cool plasmas also suffer from severe suppression of the analyte signal by matrix constituents and often require the use of standard additions calibration. This decreases sensitivity, degrades detection limits and restricts the number of interferences that can be removed.

Using the cool-plasma approach, elements which benefit from cool-plasma conditions must be run in a separate analysis from normal plasma elements, requiring each sample to be run twice. The ELAN DRC II can run all these elements in the same run, increasing productivity. And, the ELAN DRC II provides interference-free determination of elements that cold plasma cannot, such as Cr, V, As and Se.

In addition to eliminating interferences in traditionally difficult-to-determine elements, the ELAN DRC II system has been specifically designed for the world's most difficult applications, including semiconductor analyses, providing unsurpassed levels of performance for ICP-MS.

The ELAN DRC II utilizes a low-background quartz sample introduction system that has been field-proven in hundreds of laboratories around the world, including semiconductor, clinical and research facilities. The quartz concentric nebulizer and cyclonic spray chamber maximize analyte transmission, while minimizing the possibility of background contamination, providing the lowest possible background signal levels. The open architecture design makes switching to different sample introduction devices quick and simple. The ELAN DRC II can utilize a variety of alternate sampling devices, including laser ablation, ultrasonic or low-flow nebulization systems or even liquid- or ion-chromatography systems for speciation analysis.

The unique single-ion lens simplifies operation with automatic optimization and specific on-the-fly mass settings for each element, minimizing undesirable spacecharge effects that can lead to signal and performance loss. The ELAN DRC II has unsurpassed detection limits, specificity and sensitivity – all requirements for the laboratory pushing the limits of detection.

Axial Field Technology maximizes performance for all matrices
Innovative Axial Field Technology, developed specifically for ICP-MS, applies a linearly accelerating axial field to the ions inside the Dynamic Reaction Cell. This technology decreases matrix effects, improves stability and increases the speed of the DRC. This makes the ELAN DRC II the ultimate analytical tool for all applications including semiconductor, environmental, clinical and geochemical, where unsurpassed performance in challenging matrices is required.

Collisional focusing provides improved sensitivity and precision
The ELAN DRC II offers exceptional sensitivity and stability. Using collisional focusing (Figure 1), sensitivity can be enhanced by up to 5 times, when compared to a standard ICP-MS. Collisions with the reaction gas allow ions to spend more time in the DRC, reducing short-term signal fluctuations. This lowers plasma noise, leading to improvements in short-term precision. This excellent short-term precision dramatically improves isotope-ratio measurements performed on the ELAN DRC II. Relative standard deviations for isotope ratios of less than 0.03% are routinely achievable.

DRC gets the right answer, faster
Unlike "cool plasma" and high-resolution analyses where optimization of analytical conditions is done for each analyte and multiple runs are required to determine several analytes, the DRC II removes multiple interferences during the same analytical run. The ELAN DRC II significantly improves productivity by reducing the number of runs required. You can combine different sets of DRC conditions for different elements in the same analytical method along with conditions for elements run in standard mode, providing faster, more accurate results. In the DRC, the ions collide with the reaction gas, causing them to lose energy and focus their motion on axis. This allows the ions to spend more time in the DRC, reducing short-term signal fluctuations. This collisional energy damping reduces the energy spread, while collisional focusing (migration of ions towards the quadrupole axis) results in improved ion transmission and sensitivity.

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Dynamic Bandpass Tuning
Unlike other systems that use rf-only hexapoles and octapoles as simple ion guides, the quadrupole used in the patented DRC technology provides both high- and low-mass cutoffs – defining a precise mass bandpass window. The mass bandpass window ejects all ions with masses outside the window **before** they can react inside the DRC, **preventing** the formation of new interferences. The bandpass window is selected via the automated setup procedures based on the specific chemistry that needs suppression or promotion. And, since a specific bandpass range can be selected for each analyte, the bandpass filter can be dynamically tuned to best suit the analyte of interest. As a result, species falling outside of the analytical bandpass are completely eliminated, preventing the formation of new species and possible interferences (Figure 2). In contrast, competitive systems use energy filtering, which only allows new interferences to be reduced **after** they are formed. This restricts interference removal, since the number of collisions in other systems must be limited in order to maintain a sufficient kinetic-energy spread between the analyte and interfering species for the filter to be effective. And, since energy filtering is non-selective, both interferent and analyte intensities are reduced.

DBT optimizes chemical specificity
Differentiation between the analyte and an interfering species is critical to success in ICP-MS. The ELAN DRC II provides greater accuracy by eliminating false positives due to interferences. The presence of an isobaric or molecular interference can lead to an elevated signal at the analyte mass. For example, ArCl+ and CaCl+ are two molecular species that interfere with arsenic determinations at mass 75. In some cases, these interferences are extremely difficult to resolve, either because the analyte is monoisotopic (such as in the case of arsenic) or the interference is too large.

While other cell systems can partially remove some plasma-based interferences such as the ArCl+ interference on 75As+, they are limited in their ability to remove many matrix-based interferences, such as the CaO+ interference on 75As+. In contrast, the ELAN DRC II allows the interference to be removed, whether plasmaor matrix-based, giving you confidence that the correct results for the analyte – and not a matrix interference – are reported. Using the ELAN DRC II, molecular interferences that have plagued trace-level determination of many elements by ICP-MS can be completely eliminated. Also, the superior specificity achieved with the ELAN DRC II through the use of Dynamic Bandpass Tuning (DBT) means reaction by-products are eliminated, **preventing** new interferences from forming. Left unchecked in all other systems, these by-products produce new interferences, which must be reduced by increasing the kinetic-energy filter – leading to additional analyte signal loss.

Method development on the ELAN DRC II using the powerful ELAN software is now easier than ever. Use one of our predeveloped methods and you will be up and running quickly. For more unique applications, automated procedures determine the best reaction-gas flow conditions and DBT settings, making the system easy to use. Unlike other cell instruments, where reaction- gas selection must be restricted in order to reduce formation of reaction by-products, the ELAN DRC II allows you to use virtually any reaction gas for interference removal. The ability to use more reactive gases including NH3, CH3F, CH4, CO2, O2 and others provides superior interference reduction and improved detection limits in a wide variety of sample types.

Not only does the ELAN DRC II include the industry's most effective method of eliminating interferences – it features a wealth of proven capabilities that make it superior to other ICP-MS systems.

• **Quick-change cones** – The platinum interface cones have large diameter orifices (1.1 mm sampler and 0.9 mm skimmer) to resist clogging and signal drift. The easy-in, easy-out design makes routine maintenance simple and easy.

• **Patented PlasmaLok technology** – Secondary discharges between the ICP torch and the interface cones can lead to signal drift and high background levels. PlasmaLok® technology essentially eliminates the possibility of secondary discharges, extending cone life, reducing background signal levels and stabilizing ion-energy distributions. As a result, switching between plasma conditions and sample matrices, including aqueous, organic and dry aerosols, is virtually transparent, with no special optimization required or consumable parts to replace.

• **Simple, effective Shadow Stop technology** – The ion optics in the ELAN were designed specifically for ICP-MS. Instead of bending the ion beam numerous times using complex multi-component lens systems to prevent uncharged species from entering the quadrupole, the ELAN DRC II uses a simple, grounded Shadow Stop. The result is minimal maintenance and the elimination of tedious ion-tuning adjustments required by other systems as lens components and cells become contaminated, causing resistivity changes and requiring subsequent tuning changes. Since it is grounded, the Shadow Stop never needs to be optimized or cleaned to maintain its performance.

• **The industry's only single ion lens** – Designed specifically for ICP-MS, the unique SwiftMount™ single ion lens used on the ELAN systems provides worry-free operation. Protected by the Shadow Stop, cleaning requirements for the SwiftMount lens are also minimized. In contrast, complex competitive systems may have as many as 30 to 40 pieces in the ion-optic system – making them time-consuming to clean and reassemble. Unlike these competitive systems, changing the exclusive SwiftMount ion lens on the ELAN ICP-MS is as easy as changing a light bulb. In fact, the process takes just a few minutes. And, since the SwiftMount lens is so economical, when it does need to be cleaned you can simply swap the dirty lens for a spare and clean the dirty lens while your samples are being processed. This maximizes system productivity – an important requirement in high-throughput labs.

• **The industry's only scanning, single ion lens with AutoLens™ one-touch adjustment** – Not only does it optimize itself at the click of a button, the unique SwiftMount single ion lens optimizes automatically for each specific mass – providing the best possible sensitivity for each analyte, at all times. In contrast, competitive systems must be tuned on a single midmass element, compromising analyte sensitivity and require frequent tuning as ion-lens settings change over time.

• **Integrated peristaltic pump with tubing saver –** The sample introduction system uses an integrated peristaltic pump to dramatically reduce sampleuptake time. The tubing-saver feature ensures optimum measurement precision and prolongs peristaltic tube lifetimes.

• **Simultaneous dual detector** – The SimulScan™ dual-stage detector measures both high- and low-level analytes simultaneously. This conserves valuable or limited samples, eliminates the need to perform time consuming sample dilutions and allows you to quickly analyze uncharacterized samples.
• **Powerful ELAN software** – Whether your lab performs qualitative, semi-quantitative, quantitative or specialized analyses such as isotope-ratio, isotope-dilution or even speciation analyses, the powerful ELAN software has all the features you need. Priority samples, flexible quality-control checks, transient-signal handling, speciation analysis, runlist build and customizable reporting are just a few of the features that will make your life easier (Figure 3). Plus, integrated maintenance videos and our new PathFinder™ HTML-based Help will make routine tasks even easier (Figure 4). And, if you're in a highly regulated environment, our Enhanced Security™ software provides all the features you need to comply, even with 21 CFR Part 11 requirements.
• **The SmartTune™ software wizard** automatically sets up all your tuning procedures, runs them in the sequence you select and prints out a final tuning report based on user-selected pass/fail criteria (Figure 5). The result is effortless operation, all day, every day.

Unrivalled DRC technology has provided hundreds of the world's best laboratories with significant improvements in their ability to perform a wide variety of challenging applications by ICP-MS. Whether using a single gas for maximum productivity or using specific, selected gases for unsurpassed interference removal, the ELAN DRC II provides the performance and flexibility for your needs today – and tomorrow.

Interference removal provides superior detection capabilities
Many elements suffer from common matrix-based interferences that can degrade BECs and detection capabilities. The ELAN DRC II can dramatically reduce or eliminate these interferences, providing enhanced analytical capabilities.

The ground-breaking DRC technology has already provided hundreds of users with significant improvements in their ability to perform a wide variety of applications.

Breaking the ppq barrier
Fe, Ca and K are three of the most critical elements in the manufacture of semiconductor devices. Unfortunately, detection limits for these elements are degraded by interferences from ArO+, Ar+ and ArH+ species. The ELAN DRC II completely eliminates these interfering species and others, allowing accurate determinations at ppq levels.

Unlocking selenium
Prior to the development of DRC technology, interferences from the Ar2 + dimer severely diminished the detection power of ICP-MS for selenium. Due to this large interference, selenium had to be determined at the less abundant 77Se and 82Se isotopes. The ELAN DRC II unlocks selenium, allowing ppt detection with an accurate isotopic signature, using the most abundant selenium isotope 80Se.

Simultaneous speciation of As, Se and Cr in natural waters
Speciation is an important environmental application, particularly the determination of arsenic and chromium species. Unfortunately, a spectral peak from ArCl+ interferes with arsenic while a ArC+ peak interferes with the determination of chromium. Selenium is also affected by the large Ar2 + background. While conventional interelement correction equations can be used, detection limits are compromised. In the ELAN DRC II, oxygen reaction gas can be used to move arsenic away from the interference (as 75As16O) under robust hotplasma conditions, allowing simultaneous detection of low ppt levels of As, Se and Cr species being separated in the same chromatographic run

Separation of 87Sr and 87Rb – fast geochronology

The use of the ELAN DRC II permits fast Rb/Sr geochronology. By using CH3F as a reaction gas to convert Sr+ ions into the corresponding SrF+ ions, the problem of isobaric overlap of 87Sr+ and 87Rb+ can be circumvented, a feat unachievable by high-resolution ICP-MS. Hence, chemical separation of Sr from Rb prior to analysis is no longer necessary and the amount of sample pre-treatment required is substantially reduced – dissolution and appropriate dilution only. By mixing the reaction gas CH3F with Ne as a collision gas, the isotoperatio accuracy and precision attainable are comparable to or even slightly better than the best values ever reported for single-collector ICP-MS instrumentation.

The ultimate challenge – seawater

The determination of trace metals in seawater is a difficult application. The high matrix concentrations present in seawater cause many interferences for elements such as As, Se, Ni and Cr. The ELAN DRC II takes the difficulty out of seawater analysis by removing these troublesome interferences, allowing parts-perbillion and parts-per-trillion level determinations.

Table 1, below: Typical detection limits (DLs) and background equivalent concentrations (BECs) on ELAN DRC II. * Unit: ppt Integration time: 1 sec. DRC mode Note: Data obtained on the ELAN DRC II for a 1% nitric-acid matrix. All units are in ng/L (ppt). Elements in blue were obtained in DRCmode using NH3 reaction gas. Elements in black were obtained in standard mode. All data obtained in Class-100 clean room

Element	DL	BEC	Element	DL	BEC
Li (7)	0.26	0.22	Ge (74)	0.58	0.57
Be (9)	1	0.87	As (75)	0.48	1.6
B (11)	1.93	1.5	Sr (88)	0.03	0.02
Na (23)	0.14	0.22	Zr (90)	0.05	0.04
Mg (24)	0.08	0.18	Mo (98)	0.11	0.12
Al (27)	0.05	0.09	Ag (107)	0.09	0.1
K (39)	0.27	2.6	Cd (114)	0.08	0.11
Ca (40)	0.1	0.1	In (115)	0.03	0.02
Ti (48)	0.92	1.7	Sn (120)	0.12	0.08
V (51)	0.12	0.04	Sb (121)	0.08	0.08
Cr (52)	0.12	0.12	Ba (138)	0.06	0.04
Mn (55)	0.17	0.54	Ta (181)	0.06	0.05
Fe (56)	0.12	0.4	W (184)	0.07	0.07
Ni (60)	0.1	0.2	Au (197)	0.15	0.05
Co (59)	0.04	0.04	Tl (205)	0.02	0.01
Cu (63)	0.05	0.1	Pb (208)	0.07	0.09
Zn (64)	0.45	1.2	Bi (209)	0.02	0.01
Ga (69)	0.06	0.05	U (238)	0.02	0.01

Table 1

• **Increased sensitivity** – Collision cells use a simple energy filter to attempt to stop new interferences from reaching the detector **after** they are formed. This passive technique also reduces analyte transmission and allows many interferences to still be detected. The ELAN DRC II uses the active massfiltering quadrupole inside the DRC to remove any precursor species that could form new interferences **before** reaction can occur. The result is superior interference rejection with full analyte transmission, resulting in higher analyte sensitivities.

• **Uncompromising performance** – Innovative Axial Field Technology ensures maximum transfer of the ions from the DRC to the detector, while reducing scan times in difficult matrices. As a result, the ELAN DRC II provides unmatched ruggedness, reliability and performance for all applications, including multielement determinations in environmental, clinical, geological and semiconductor matrices.

• **No reaction by-products** – The ELAN DRC II not only reduces primary interferences – it eliminates sequential side reactions that create new interferences **before** they can occur. Only a system with an active mass bandpass filter inside the reaction cell can control the cell chemistry to this extent. Other systems attempt to limit side reactions by restricting the types of reaction gases used and by using a simple kinetic-energy filter to eliminate by-products. This results in compromised performance and uncontrolled reaction chemistries – requiring the use of tedious standards addition calibration procedures.

• **Proven quadrupole design** – Other systems use hexapoles and octapoles inside a low-pressure enclosed cell. Due to the complex nature of the mass-stability characteristics of these devices, these higher-order multipoles are only suitable for use as ion guides. In contrast, the quadrupole used in the ELAN DRC II provides a well-defined mass bandpass, resulting in superior selectivity through its unique massfiltering DBT function.

• **Use of multiple gases** – Different matrices may require different gases to optimize interference removal. Some analyses even require multiple gases on the same run to achieve uncompromised detection limits. Since collision cells don’t have Dynamic Bandpass Tuning, they must restrict operation to only one or two simple gases and may require specialized calibration techniques. The DBT function of the ELAN DRC II allows the use of a variety of reaction gases, providing a wide range of solutions for demanding applications. In addition, computer control allows automatic switching of reaction gases during analysis and provides complete control of any make-up gases used.

• **High-performance all-quartz sample introduction system** – The all-quartz sample introduction system used on the ELAN DRC II has been purposely designed to minimize background contamination levels, resulting in the lowest possible BECs. Combined with platinum interface cones, the system provides ultimate sensitivity and detection capabilities, in addition to being easy to use. The open architecture allows quick change-over if other sample introduction systems are used.

Why is the DRC better than high resolution?

For many years, high-resolution ICP-MS was the only option to resolving some interference problems. The ELAN DRC II provides a superior alternative:

• DRC technology eliminates interferences, including 40Ar+ from 40Ca+, 87Rb+ from 87Sr+ and 40Ar+ from 80Se+ that high-resolution ICP-MS cannot remove, because the required resolution is too great or the resulting analyte signal is too small.

• Unlike other cell-based and high-resolution systems, the DBT function used in the DRC system eliminates interferences without compromising sensitivity.

• The ELAN DRC II has 10 times better abundance sensitivity than high-resolution ICP-MS, providing the ability to measure small analyte signals next to large matrix peaks without peak overlap.

• The ELAN DRC II is less expensive and easier to operate than high-resolution systems that offer a fraction of the performance.

• Automated method development makes the ELAN DRC II easy to use, while its design provides a rugged, workhorse instrument for your lab.

The undisputed leader in ICP-MS
There are over 2000 ELAN ICP-MS systems and over 600 ELAN DRC systems installed in industries ranging from environmental and clinical to semiconductor, geochemical and metallurgical. Technology has evolved from standard ICP-MS to cold plasma to collision cells and now to the Dynamic Reaction Cell technology used in the ELAN DRC II. At each step in the technology development cycle, interference removal has improved, allowing the use of ICP-MS for more elements than previously imaginable.