Technical Overview

Agilent
Trusted Answers

Agilent ICP-MS Interface Cones

Competitive comparison

Agilent inductively coupled plasma-mass spectrometer (ICP-MS) systems utilize innovative technology to deliver excellent sensitivity, accuracy, ease-of-use, and productivity. Agilent 7800 and 7900 quadrupole ICP-MS systems offer the highest matrix tolerance, widest dynamic range, and most effective interference removal for trace elements across most typical applications. The Agilent 8900 triple quadrupole ICP-MS (ICP-QQQ) adds MS/MS operation, providing precise control of reaction cell processes to ensure the most consistent and accurate results. This ability resolves interferences that are beyond the capability of traditional single quadrupole and sector-field high resolution ICP-MS.

Plasma source and vacuum interface design is vitally important to the overall performance of any ICP-MS. To achieve great results, high-quality interface cones are key elements contributing to the sensitivity and stability of an ICP-MS system. The Agilent range of nickel (Ni) and platinum (Pt)-tipped interface cones provide the level of performance that our single quadrupole and triple quadrupole ICP-MS range demands (Figures 1 and 2).

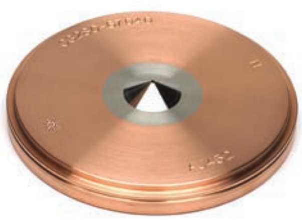


Figure 1. Genuine Agilent Ni sampling cone with copper base.

Figure 2. Genuine Agilent Ni skimmer cone.

Interface cone performance factors

A key requirement for interface cones is to have accurate and precise dimensions at their tip and orifice to ensure instrument sensitivity.The cone material should be of sufficient purity to avoid elevated background signal and contamination. The mass of each cone should be well-controlled and consistent to ensure the correct operating temperature at the tip, which ensures good long-term stability of the signal.

For these reasons, the performance of interface cones from different manufacturers can show significant variation, which can also adversely impact the accuracy and reliability of the ICP-MS results. Typical performance issues may include:

- Low sensitivity, which leads to elevated detection limits.
- Elevated background, which degrades background equivalent concentration (BEC).
- Instrument drift over the course of a sample batch analysis, which can cause QC failures and require recalibration and sample reruns.
- Increased cleaning requirement due to excess matrix deposition on the cone, which can increase instrument downtime and reduce the productivity of the laboratory.
- Lower cone lifetime, which increases the cost of analysis and impacts laboratory profitability.

This overview compares interface cones (sampling and skimmer) from different suppliers, focusing on the aspects that are critical to ICP-MS analytical performance.

Development of Agilent interface cones

The ICP-MS interface comprises a step-down vacuum stage located between a pair of conical metal plates, known as interface cones (Figure 3). Interface cones sample the ions produced in the atmospheric pressure argon plasma and transmit them through to the extraction lenses, which transmit the positively charged ions into the low-vacuum mass spectrometer. The first and second cones are referred to as the sampling cone and skimmer cone, respectively.

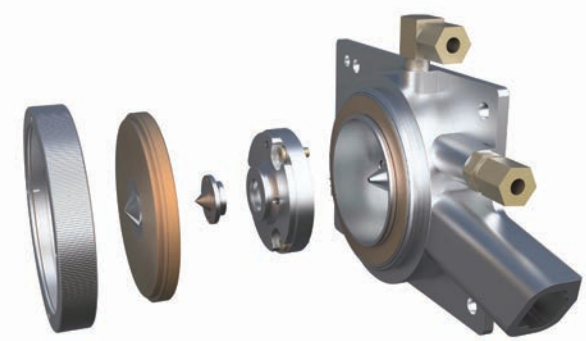


Figure 3. Interface region of Agilent ICP-MS showing the interface cones (sampling and skimmer) and skimmer base.

Being such a critical part of ICP-MS performance, Agilent interface cones are designed and manufactured to stringent specifications. The cones are rigorously tested to ensure the highest quality, maximize instrument performance, and ensure reproducibility from batch to batch.

Drawing on over 30 years of experience in ICP-MS system design, Agilent engineers design interface cones together with the extraction lenses to increase ion transmission and improve matrix tolerance. The dimensions of the cone orifice and tip geometry are optimized and tightly controlled. Our standard Ni, or optional Pt-tipped, cones use high-purity materials to minimize any background signal and ensure suitability and stability during operation within the aggressive acidic, high-temperature plasma conditions.

Production of Agilent interface cones

Production of ICP-MS cones is an intricate process that involves manufacturing the cone to the tightest tolerances, and where multiple alloys are used, permanently attaching the tip to the cone base material.

Genuine Agilent cones are produced by experienced machinists using state-of-the-art equipment. Sophisticated lathes, mills, and electrical discharge machining are used to ensure that all cones meet our rigorous specifications.

Secure and accurate attachment of the tip is integral to the design and is achieved by electron beam welding to ensure permanent contact of the tip and base material.

External analysis of all platinum raw materials is performed to ensure that the material purity meets Agilent specifications. Analytical samples of both Pt and Ni material from each lot are retained for any future inspection. Full traceability of each finished cone is provided by the serial number back to the raw material and through all manufacturing processes, including full chain of custody.

Finally, all cones are subject to a 100% quality inspection, before dispatch.

Interface cone testing methodology

The results presented here are based on testing completed in 2018 at the Agilent Spectroscopy Technology and Innovation Centre in Melbourne, Australia. This evaluation was also supported by the Agilent ICP-MS Instrument Research and Development team located in Hachioji, Japan (Figure 4).

A production model 7900 ICP-MS system in standard configuration with x-lens was used for all testing (Figure 5). Qualification testing of this system has been completed using the standard instrument factory and installation tests.

Figure 5. An Agilent 7900 single quadrupole ICP-MS system was used for performance testing of the sampling and skimmer cones.

Figure 4. Agilent facilities in Melbourne, Australia (left), and Hachioji, Tokyo, Japan (right).

The comparison focused on the standard Ni sampling and skimmer cones for the 7900 ICP-MS, as these cone types are most commonly used for routine ICP-MS applications. Each sampling and skimmer cone was tested in a matched pair from a single supplier. Parts were procured from global suppliers who are active in supplying cones for Agilent ICP-MS instruments. To ensure that the results presented here are representative of the level of performance provided and to check reproducibility, multiple cones from each manufacturer were sourced and tested analytically. In addition, the manufacturing tolerances were assessed to verify what effect they had on instrument performance. The interface cones tested in this comparison are listed in Table 1.

Table 1. Interface cones tested in this comparison study.

Supplier	Cone Type	Quantity	Serial Numbers
Agilent	Ni sampling	5	FE760, FF092, FF068, FF070, FE785
	Ni skimmer	5	EL568, EV784, FA648, FB975, GE895
Competitor E	Ni sampling	3	85864, 85867, 85868
	Ni skimmer	3	87640, 87641, 90112
Competitor G	Ni sampling	5	S281859, S281855, S281849, S281854, S281848
	Ni skimmer	5	S281928, S281931, S281952, S281929, S281934
Competitor I	Ni sampling	3	74537, 74538, 74539
	Ni skimmer	3	74534, 74535, 74536
Competitor S	Ni sampling	1	Ni72280
	Ni skimmer	1	Ni71833

Each cone was initially subjected to an as-received quality inspection and compared in terms of packaging. As part of the quality inspection, the weight and critical dimensions of each cone were measured and compared with those of the genuine Agilent cones.

Pairs of interface cones were tested on the 7900 ICP-MS and compared against published performance criteria listed in Table 2. The instrument conditions used for the performance tests are listed in Table 3.

Table 2. Performance test criteria and specifications for the 7900 ICP-MS against which the pairs of interface cones are compared.

Specification (Units)	Element (*m/z*)	7900 Factory Specifications	7900 Typical Performance
Sensitivity (Mcps/ppm)	Li (7)	>55	>140
	Co (59)	-	>400
	Y (89)	>320	>600
	In (115)	-	>700
	Tl (205)	>250	>520
	U (238)	-	>720
Background (cps)	(9)	<1	<0.3
Detection limits (ppt)	Be (9)	<0.2	<0.05
	In (115)	<0.05	<0.02
	Bi (209)	<0.08	<0.02
Oxide ratio (%)	(156/140)	<1.5	<1.8
Doubly charged ratio (%)	(70/140)	<3	<2.5
Short-term stability [20 minutes] (%RSD)	Li (7), Y (89), Tl (205)	<2.0	<1.0
Long-term stability [2 hours] (%RSD)	Li (7), Y (89), Tl (205)	<3.0	<1.2

Table 3. Instrument conditions used for testing Ni interface cones on the Agilent 7900 ICP-MS with x-lens.

	Sensitivity	Sensitivity - Oxide ratio profile	Background	Short-Term Signal Stability	Long-Term Signal Stability
Plasma preset condition	Low matrix	N/A	Low matrix	Low matrix	Low matrix
ORS mode	No gas	N/A	No gas	No gas	No gas
Ion lens tuning	Autotune	N/A	Autotune	Autotune	Autotune
Solution	1 ppb tune solution p/n 5185-5959	1 ppb tune solution p/n 5185-5959	Ultrapure water	1 ppb tune solution p/n 5185-5959	1 ppb tune solution p/n 5185-5959
Measuring mass	^{7}Li, ^{59}Co, ^{89}Y, ^{115}In, ^{140}Ce, ^{205}Tl, ^{238}U, ^{70}Ce^{++}, ^{156}CeO	^{140}Ce, ^{156}CeO	Full spectrum	^{7}Li, ^{9}Bkgd, ^{59}Co, ^{89}Y, ^{140}Ce, ^{205}Tl	^{7}Li, ^{9}Bkgd, ^{59}Co, ^{89}Y, ^{140}Ce, ^{205}Tl
Method	Signal monitor tune report	Plasma correction	SemiQuant analysis	Batch – 20 minutes	Batch – 2 hours

Cones were first tested as received straight out of the box and then retested again after conditioning the cones using the procedure recommended for environmental laboratories with high sample matrix. Table 4 lists the conditioning procedure used.

Table 4. Cone conditioning procedure.

Step	Solution	Conditions	Time
1	10% (v/v) 6020 Interference Check Solution A (p/n 5188-6526) diluted with ultrapure water	Preset plasma mode "General Purpose"	30 minutes
2	Rinse 5% (v/v) HNO_3		10 minutes

Results and discussion

Packaging

Agilent cone packaging is designed to provide excellent shipping protection for the cones (Figure 6). This packaging features custom foam inserts that prevent movement and eliminate any contact with the delicate cone tip. A flip-top biodegradable cardboard package is used, secured with a magnetic clasp, and further protected in transit with an Agilent tamper-proof seal. This design:

- Enables clear and prominent labeling, making it easier for the user to identify the cone type from the part number, description, and serial number printed on the label.
- Enables easy removal of the cones from the package, reducing the chance that cones may be caught in the packaging material, inducing damage, or accidentally dropped during removal.
- Enables safe, ongoing storage of used cones.
- Reduces the chance of cone damage by providing better protection for the cones in transit and preventing the package from rolling.

A silica desiccant pouch is included in the package, physically separated from contact with the cone surface, to prevent any moisture damage during transport/storage (more critical in humid environments).

Instructions for recommended handling and conditioning procedures are also included within the package for ready reference.

The packaging used for Competitor G's cones is based on a similar package design, including a desiccant pouch, which affords many of the same benefits (Figure 7). Competitor G's package design features a reusable slide-out tray; however, there is no tamper seal on the package. In addition, no instructions for handling/conditioning were supplied.

Figure 6. Packaging used for the Agilent sampling (top) and skimmer (bottom) cones ensures excellent shipping protection.

Figure 7. Packaging used for Competitor G's sampling (lower right) and skimmer (lower left) cones provides similar shipping protection.

The packaging used for the cones from Competitor E is based on a cylindrical plastic container with foam inserts (Figure 8). This form makes storage more difficult as the packages cannot be stacked together on a shelf, unlike a regular rectangular box. This also presents an increased risk of falling and rolling during shipment. The cylindrical plastic container is packed inside an outer cardboard box, presumably to overcome this issue, but at the same time adding extra packaging and generating extra waste. In addition, there was no desiccant pouch in the package, and no instructions for handling/conditioning were supplied with the package.

Figure 8. Packaging used for Competitor E's sampling (lower left) and skimmer (lower right) cones, based on a cylindrical plastic container.

The packaging used for the cones from Competitor I and Competitor S were similar to each other, using a rectangular cardboard box for the sampling cone and cylindrical plastic container for the skimmer. The sampling cone box does not have a custom foam insert and, therefore, the cone is free to move within the larger package (Figure 9). The foam is in direct contact with the tip. This increases the chance of damage to the sampling cone during transit, affording less protection from rough handling.

Figure 9. The sampling cone is loosely packed into the foam insert of the cardboard package used by Competitors I and S, which means the cone may be damaged with rough handling.

No tamper seals are used and no desiccant is included. Figure 10 shows how the sampling cones are subject to moisture damage prior to delivery.

Again, as with all non-Agilent cones, no instructions for handling/conditioning were supplied with the package.

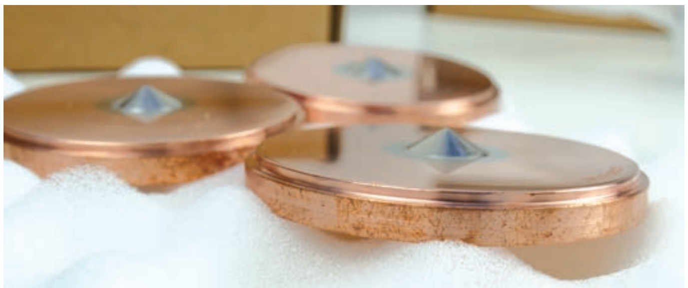


Figure 10. Moisture damage on the sampling cones from Competitor I.

Quality inspection of interface cones as received

Marking

Agilent cones are marked with the Agilent branding, an indicator for the material type (N = Ni tip, P = Pt tip), and part number is also listed ensuring easy identification and reordering. A unique serial number is also listed, ensuring full traceability back to the manufacturing date and material lots used (Figures 1 and 2). All cones are subject to a 100% quality inspection before dispatch.

Generally, the cones from other suppliers follow similar marking conventions, including manufacturer name, part number, and serial number, except for the cones from Competitors I and S, which do not have any manufacturer identification.

Weights and dimensions

On receipt, each of the cones was weighed using a calibrated four-decimal-place analytical balance. The weights for both sampling and skimmer cones are differentiated by manufacturer, indicating that the manufacturing methods are different (Figures 11 and 12). It is noted that all of the non-Agilent cones are outside the weight range of the genuine Agilent cones. Therefore, there is a strong potential that non-Agilent cones will operate at different temperatures in the plasma environment, leading to differences in performance and lifetime.

The dimensions of the orifices of all the cones were measured under a microscope with a calibrated reticule and compared with those for genuine Agilent cones. Of the sampling cones, two out of the three cones sourced from Competitor I and one out of the five cones sourced from Competitor G failed with undersized orifices. Sampling cones that have an undersized orifice can be expected to produce lower sensitivity. The dimensions and tolerances on the skimmer cone orifice are even more critical to the performance of the ICP-MS. Of the skimmer cones, two of the cones sourced from Competitor G and every skimmer cone sourced from Competitors I, E, and S was undersized. Again, this undersizing can be expected to reduce sensitivity and also makes the cones more prone to blockage and result in instability.

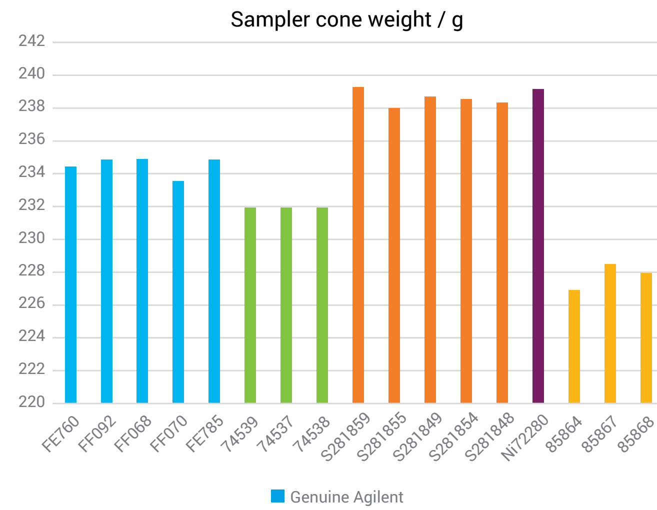


Figure 11. Comparison of as received sampling cone weight.

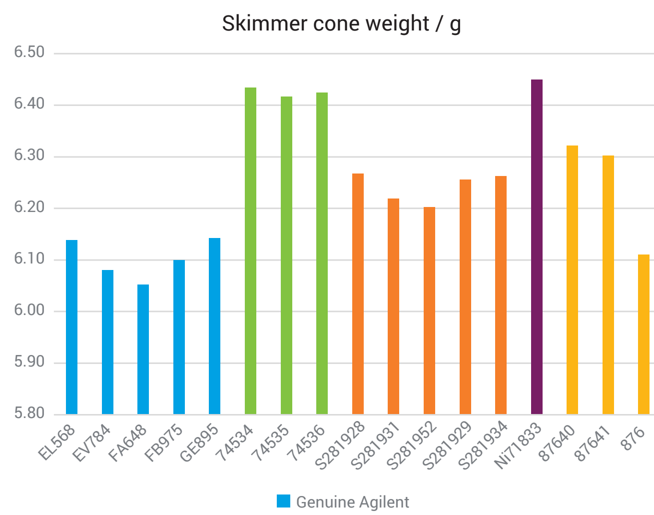


Figure 12. Comparison of as received skimmer cone weight.

The diameter of the tip on the rear face of the sampler cone is significantly larger for all nongenuine Agilent cones. This indicates that a different tip geometry and production method have been used during manufacture. On nongenuine sampling cones, the tip diameter is the same on the front and rear face, indicating that the tip is manufactured from a cylinder that is inserted straight into a round hole in the copper (Cu) base. Genuine Agilent cones feature a lip in the base that the tip is seated against, to ensure more secure placement and attachment.

One of the skimmer cones supplied by Competitor S (Ni71833) had a thread diameter that was outside tolerance, which meant it was not possible to fit it onto the skimmer base of the 7900 ICP-MS. Therefore, Competitor S's sampling and skimmer cones could not be installed and tested as a pair during this study.

The surface finish at the tip of the cones was generally comparable across the cones from each of the manufacturers. Exceptions were the cones from Competitor I, which had a rougher finish and clearly visible surface scratches (Figure 13).

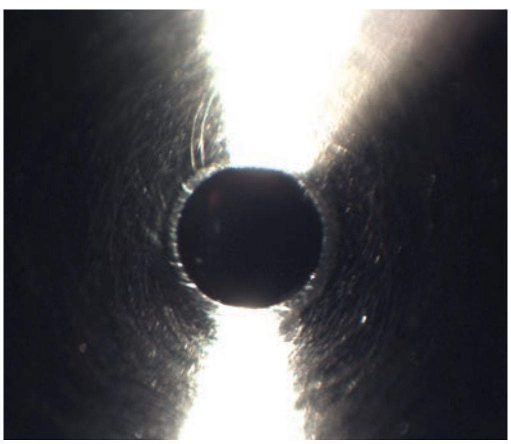


Figure 13. Photomicrograph of the sampling cone manufactured by Competitor I (serial number 74537). This has a rough finish with notable scratches.

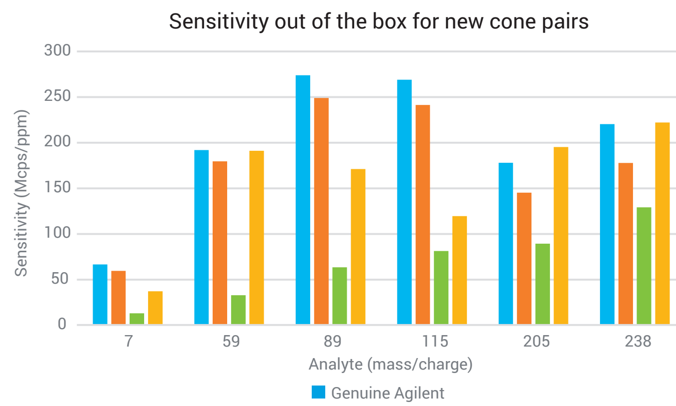
These differences in the manufacture and finish of competitive cones compared with genuine Agilent cones can be expected to have a detrimental impact on analytical performance. These differences may also require more frequent maintenance/cleaning of the cones.

Sensitivity

A fundamental performance indicator for ICP-MS is sensitivity, which is commonly defined as counts per second (cps) for pulse detection at the electron multiplier. Sensitivity is greatly influenced by the interface cones due to their ability to sample analyte ions from the plasma source and transmit them through the interface region. This should be routinely checked using the performance report function as part of the routine start ignition sequence.

Pairs of interface cones were tested both straight out of the box and then following the conditioning procedure outlined in Table 4. Low matrix preset plasma conditions and autotuning in no gas mode were used.

The average performance for each manufacturer's pair of sampling and skimmer cones is shown in Figure 14.



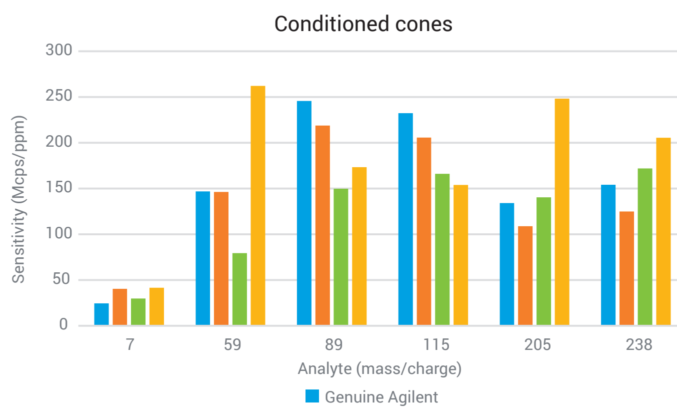


Figure 14. Comparative sensitivity of the 7900 ICP-MS when tested with each manufacturer's pair of sampling and skimmer cones.

It is obvious that straight out of the box, genuine Agilent interface cones offer superior sensitivity across the mass range. The cones from Competitor G provide lower sensitivity across the mass range, both before and after conditioning. The cones from Competitor I provided extremely low sensitivity, and performance is unacceptable for many analyses. Sensitivity improves after conditioning, but the cones from Competitor I still suffer with low mid-mass sensitivity. The cones from Competitor E suffer from poor midmass sensitivity performance new out of the box, and this low sensitivity does not improve with conditioning.

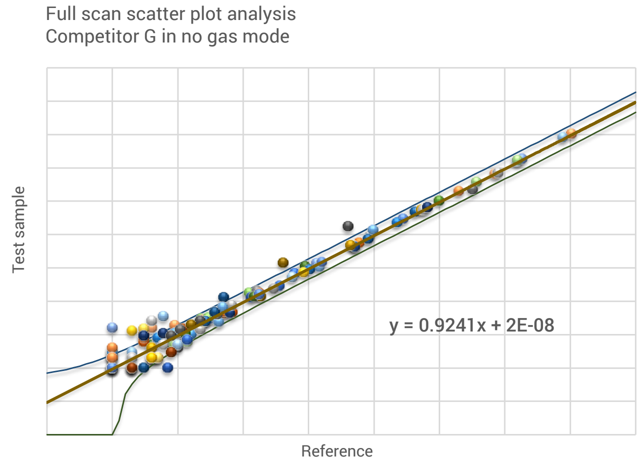
The sensitivity test was then repeated using ORS collision gas (helium mode) and again with aerosol dilution provided by UHMI with HMI-4 plasma setting (no ORS cell gas). Similar performance issues were found for each of the third-party manufacturers.

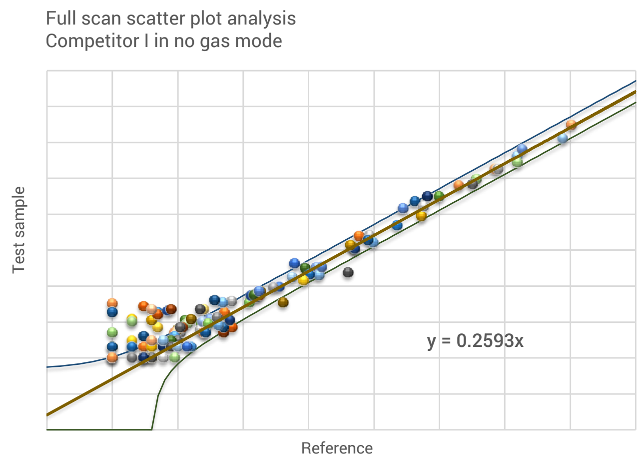
Background and background equivalent concentration (BEC)

To achieve the lowest limits of detection with the ICP-MS technique, both good sensitivity and a low background are required.

To assess the contribution of the interface cones to the background signal, a full mass scan was performed using the same sample introduction system (only swapping cones) and ultrapure water in a clean room. Cones were preconditioned and cleaned by sonication in ultrapure water for 20 minutes prior to testing. The background cps were measured between one set of each manufacturer's cones in as short a time as possible.

The following scatterplots show the correlation of background signal (cps) for the third-party cones (test sample, Y-axis) to a set of genuine Agilent cones (reference, X-axis) across the entire mass range (Figure 15). Comparisons were made with no gas mode, using ORS collision gas (helium mode) and using aerosol dilution provided by UHMI with HMI-4 plasma setting. Only no gas mode results are shown in Figure 15. A perfect correlation would show a straight line with equation y = x and no deviation across the mass range. Typical deviation would find all points within the upper and lower limit lines. For all third-party cones, in all conditions tested, there are numerous points falling outside of these limits. In particular, the cones from Competitor I show very poor correlation (y = 0.2593x), which is a result of their low sensitivity performance.





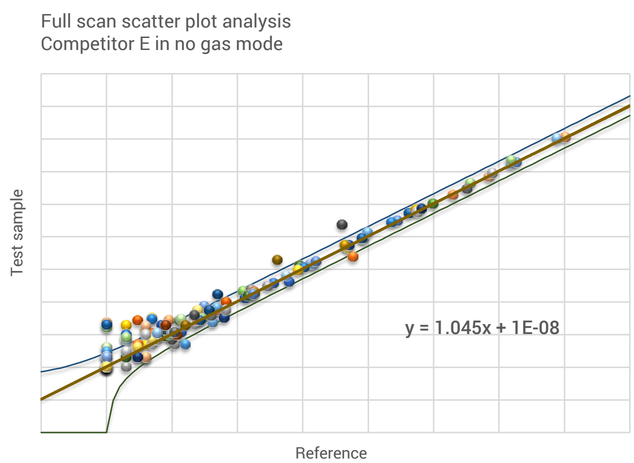


Figure 15. Scatterplots highlighting the correlation of background signal (cps) for the third-party manufactured cones (test sample, Y-axis) to a set of genuine Agilent cones (reference, X-axis) across the entire mass range.

The background signal at *m/z* 9 was monitored throughout performance testing and compared with the more stringent Agilent factory specification, but no significant deviations were found for any manufacturer's cones.

Finally, a brief study of the effect the cones have on the background equivalent concentration (BEC) was performed. Table 5 summarizes the results, which are normalized to the BEC result for genuine Agilent cones run during the same period. Gray coloring denotes results that are >20% higher than the result for the genuine Agilent cones (this difference is considered to be significant and will degrade the analytical performance of the ICP-MS). Green coloring denotes those masses that are >20% lower than the result for the genuine Agilent cones. Despite that enhancement, it can be concluded that any benefit is outweighed by the increased BEC found at other masses with the same set of cones.

Detection limits

The effect of the interface cone's sensitivity and background signal was evaluated further by determining the detection limits for the mass range (using ^{9}Be, ^{115}In, and ^{209}Bi). Additionally, detection limits were determined for contribution from Ni and Cu in the base materials of the cone (using ^{60}Ni and ^{63}Cu).

The 7900 ICP-MS was first calibrated using a 1% v/v HNO_3 (Suprapur, Merck Pty Ltd., Australia) blank and 1 µg/L (ppb) standard. The detection limits were determined based on three times the standard deviation of 10 replicate measurements of the blank. In each case, for each of the manufacturers, the set of cones that provided the best performance was selected for the study. The cones were precleaned by sonication in ultrapure water for 20 minutes. An extended instrument warmup time of 45 minutes was allowed prior to running the analysis.

Figure 16 summarizes the detection limit results, which are normalized to the results for genuine Agilent cones run during the same period. An improved detection limit (lower) is shown by result <1.

As shown in Figure 16, Competitor G's cones yield a significantly higher (worse) detection limit in the mid-mass range (^{115}In). They also exhibit a marginal increase for high-mass (^{209}Bi) and for Ni, which is the bulk material for the skimmer and tip of the sampling cones. Cones from Competitor I have much higher detection limits across the mass range, and also for ^{60}Ni and ^{63}Cu, which is a result of the

Table 5. Background equivalent concentration (BEC) determined for each of the manufacturers' cones across the entire mass range (concentration normalized to the reference value for the genuine Agilent cone).

Mass	Name	Competitor G	Competitor E	Competitor I
7	Li	1.1740	1.7471	–
9	Be	2.1383	1.7971	–
23	Na	1.8763	1.7004	1.7128
24	Mg	1.0350	0.9837	0.8802
27	Al	1.0322	1.0230	0.9364
39	K	1.1564	1.1084	1.0536
44	Ca	3.5708	3.9186	0.7141
51	V	1.4586	0.6661	–
52	Cr	1.0116	0.9234	0.9344
55	Mn	1.0250	1.3180	1.0204
56	Fe	0.9816	1.1833	0.4831
59	Co	1.4884	1.4174	0.7862
60	Ni	1.7184	1.2422	3.0303
63	Cu	1.0855	0.9755	1.1463
66	Zn	1.0037	1.0443	0.9426
71	Ga	1.1223	1.8291	2.2412
75	As	0.8906	0.6532	0.6132
82	Se	1.0162	1.0415	1.2694
83	[Se]	3.1509	–	–
85	Rb	1.3184	0.9593	1.0268
88	Sr	0.9943	0.6664	0.9866
95	Mo	1.2506	0.5000	–
107	Ag	0.9262	0.6766	0.9412
111	Cd	1.1390	1.9517	–
115	In	1.3678	1.0808	0.7170
123	Sb	–	0.8846	–
133	Cs	1.2488	0.7112	1.8327
137	Ba	0.4437	1.5211	–
201	Hg	9.4524	2.7130	2.2551
205	Tl	1.4042	1.3483	1.4804
206	[Pb]	1.0154	1.1641	1.1523
207	[Pb]	0.8583	0.9008	0.6206
208	Pb	1.0489	1.0464	1.0682
209	Bi	3.4131	1.5751	31.1312
232	Th	1.1391	1.0671	5.2316
238	U	0.5719	0.5399	–

lower sensitivity they provide. The cones from Competitor E exhibit similar detection limits for ^{60}Ni and ^{63}Cu, but they suffer from significantly higher detection limits for both mid- and high-mass elements (^{115}In, ^{209}Bi).

Oxide and doubly charged ratios

Polyatomic ions are the main source of spectral interferences in ICP-MS. The level of polyatomic interferences can be monitored using the production of refractory oxide ions of specific elements. Cerium (Ce) is an element commonly used for this purpose as it forms a strong oxide bond and therefore has one of the highest oxide formation rates. The M-O decomposition efficiency is typically expressed as the % MO^+, relative to the parent M^+ ion (e.g. the CeO^+/Ce^+ oxide ratio). An instrument that can be optimized at a low CeO/Ce level will produce fewer matrix interferences, which means that collision/reaction cells conditions may not require such highly specific optimization to give efficient interference removal, significantly improving data integrity.

Another measure of interferences in ICP-MS are the double-charged ratios. Doubly charged species result from ions created by the loss of two electrons instead of just one. Because the quadrupole separates ions based on *m/z*, a doubly charged ion (M^{2+}) will appear at mass *m/2*. An example of a doubly charged interference would be the $^{136}Ba^{2+}$ overlap on $^{68}Zn^+$.

Interface cone pairs produced similar oxide ratios (CeO/Ce) after instrument start-up procedures and autotuning in low matrix plasma conditions. Two pairs of interface cones from Competitor I exceeded the oxide specification (CeO/Ce <1.5%) with low matrix plasma conditions and autotuning (Table 6).

No cones exceeded the specification for doubly charged ratio (Ce^{2+}/Ce^+ <3.0%) with low matrix plasma condition and autotuning.

Detection Limits: Normalized to Genuine Agilent Cones

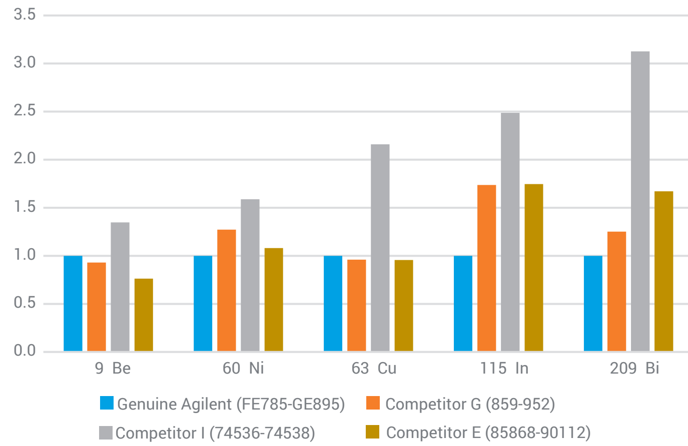


Figure 16. Detection limits achieved for the third-party cones relative to a set of genuine Agilent cones across the mass range.

Table 6. Interface cone pairs failing the oxide ratio specifications after conditioning.

Manufacturer	Competitor I	
Serial number	74536-74538	74534-74539
CeO/Ce ratio	1.628%	1.580%

Stability

To achieve consistent results and reduce the need for recalibration or remeasurement of samples, the ICP-MS system must provide good short- and long-term stability. Interface cones can positively or adversely influence instrument stability from matrix deposition on the tip and face of the cones. In the worst cases, this deposition can change the size or shape of the orifices through which the ions are extracted, impacting sensitivity. In addition, thermal instability or an incorrect operating temperature at the tip of cone will result in signal drift over time.

The short-term signal stability was evaluated over a 20-minute period by monitoring masses for the analytes specified in Table 2. To meet the Agilent performance specification, the result should be <2% RSD over a 20-minute test duration. All cones were tested as received, out of the box.

The short-term stability results are listed in Table 7, and have been normalized to the Agilent specification. Any cones that fail to meet this specification (i.e. >1.00) are highlighted in red letters. No failures were found with genuine Agilent cones, while one set of the three cones manufactured by Competitor E failed on almost every mass. The cones from Competitor G exhibited poor stability for Lithium on two out of five cones. The cones from Competitor I demonstrated failures on all three sets of the cones tested.

Long-term signal stability over two hours was also evaluated on all cones, after conditioning the cones using the procedure described earlier (Table 4). Conditioning of new cones is based on the assumption that initial instrument drift will be reduced by depositing a fine layer of the sample matrix on the surface of the clean cone. This aims to create a layer of matrix on the face of the cones that remains stable throughout analysis and only slowly builds over time. Once analytical performance has been impacted, there is a need for cone cleaning to remove excess matrix deposits.

The long-term stability results for preconditioned cones are listed in Table 8, and have been normalized to the Agilent specification. Any cones that fail to meet this specification (i.e. >1.00) are highlighted in red letters. Light masses are the most challenging for long-term stability; in this study, lithium was the first element to go out of specification. One set of cones from Competitor E and one set of genuine Agilent cones failed to achieve specification on ^{7}Li alone. The cones from Competitor I had poor stability across the mass range for one set of cones and another two sets showed slight instability for ^{7}Li only. For most of the cones tested, preconditioning helped to improve the long-term stability. However, the stability of the cones from Competitor G was significantly worse with preconditioning. Significant instrument drift was observed for three out of the five sets of cones tested.

An example of the long-term stabilities for the cones from Agilent and Competitor G are shown in Figures 17 and 18. It is obvious that the cones from Competitor G show poor long-term stability with a downward drift in sensitivity over the course of the two-hour period (Figure 18). It was found that Competitor G's cones had been overconditioned and needed cleaning to regain acceptable performance. Once cleaned, it was possible to achieve acceptable long-term stability with the Competitor G's cones. This variation from the behavior observed with genuine Agilent cones may indicate that Competitor G's cones have a lower operating temperature. As a result, it can be expected that Competitor G's cones will suffer from higher matrix buildup, impacting performance within a shorter time and requiring more frequent maintenance and cleaning. This may also lead to reduced lifetime of the cone.

Table 7. Short-term stability (%RSD over a 20-minute period) for each manufacturer's cones measured out of the box. Results are normalized to the Agilent specification.

Manufacturer	Cone Serial Numbers	^{7}Li	^{59}Co	^{89}Y	^{115}In	^{140}Ce	^{205}Tl	^{238}U
Agilent	FF070, EV784	0.75	0.18	0.17	0.15	0.20	0.17	0.28
Agilent	FF068, EL568	0.46	0.48	0.53	0.51	0.38	0.50	0.57
Agilent	FE785, GE895	0.78	0.41	0.37	0.31	0.25	0.31	0.25
Competitor E	85868, 90112	0.65	0.30	0.45	0.45	0.50	0.50	0.55
Competitor E	85864, 87640	1.05	1.35	1.45	1.30	1.35	1.15	1.00
Competitor E	85867, 87641	0.45	0.30	0.35	0.25	0.45	0.60	0.55
Competitor G	S281854, S281934	0.85	0.25	0.24	0.24	0.26	0.29	0.26
Competitor G	S281849, S281931	1.26	0.34	0.25	0.30	0.37	0.26	0.26
Competitor G	S281848, S281929	1.23	0.54	0.51	0.50	0.52	0.48	0.51
Competitor G	S281859, S281952	0.59	0.15	0.16	0.15	0.17	0.18	0.21
Competitor G	S281855, S281928	0.82	0.26	0.43	0.45	0.50	0.65	0.53
Competitor I	74537, 74535	1.58	1.75	1.71	1.63	1.24	1.29	1.13
Competitor I	74536, 74538	1.80	2.08	1.97	1.93	1.77	1.62	1.53
Competitor I	74534, 74539	1.04	0.85	0.85	0.90	0.84	0.83	0.97

Table 8. Long-term stability (%RSD over a 2-hour period) for each manufacturer's cones measured after preconditioning. Results are normalized to the Agilent specification.

Manufacturer	Cone Serial Numbers	^{7}Li	^{59}Co	^{89}Y	^{140}Ce	^{205}Tl
Agilent	FE760, FB975	0.29	0.47	0.53	0.49	0.80
Agilent	FF092, FA648	3.14	0.54	0.21	0.34	0.42
Agilent	FF068, EL568	0.96	0.24	0.33	0.32	0.24
Competitor E	85868, 90112	1.30	0.70	0.23	0.20	0.50
Competitor E	85864, 87640	0.63	0.83	0.83	0.67	0.60
Competitor E	85867, 87641	0.57	0.83	0.77	0.57	0.47
Competitor G	S281854, S281934	6.60	3.19	2.40	2.16	2.45
Competitor G	S281849, S281931	15.19	7.74	6.16	4.14	3.82
Competitor G	S281848, S281929	29.04	9.69	7.26	5.99	6.43
Competitor G	S281859, S281952	0.65	0.48	0.48	0.35	0.24
Competitor G	S281855, S281928	0.59	0.54	0.57	0.49	0.31
Competitor I	74537, 74535	1.76	1.39	1.35	1.02	0.77
Competitor I	74536, 74538	1.01	0.91	0.94	0.79	0.64
Competitor I	74534, 74539	1.13	0.81	0.79	0.58	0.52

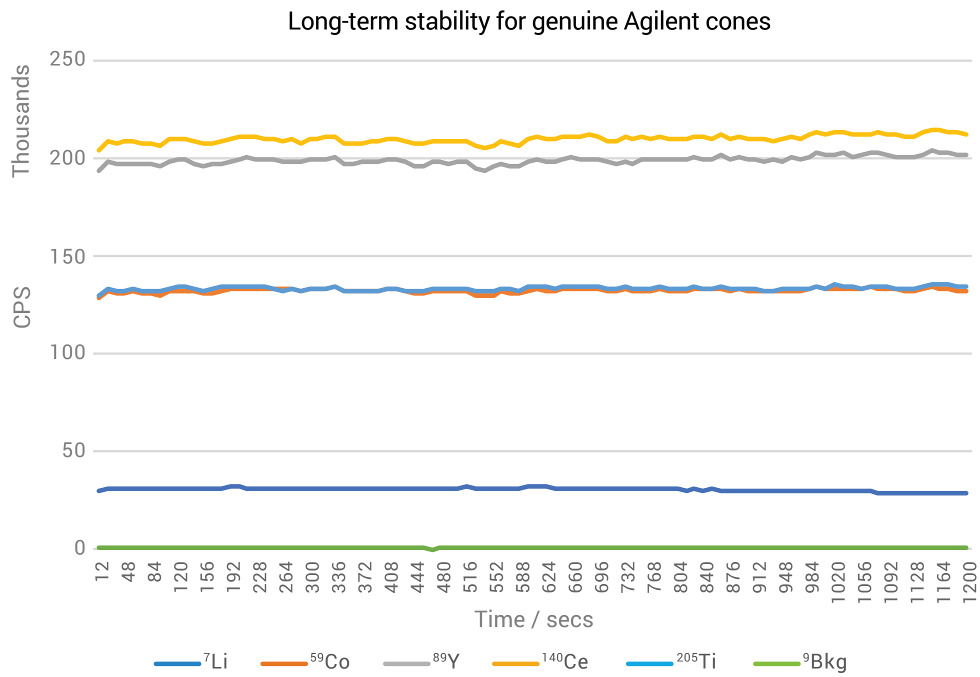


Figure 17. Long-term stability (over two hours) for genuine Agilent cones (serial numbers FF068, EL568) after preconditioning.

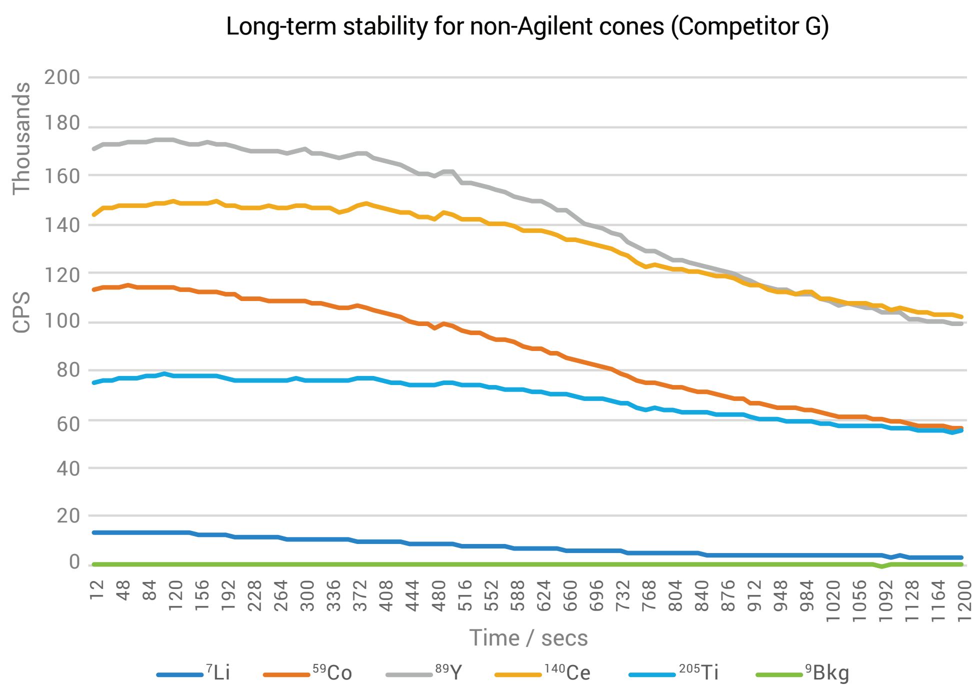


Figure 18. Long-term stability (over two hours) for Competitor G cones (serial numbers S281849, S281931) after preconditioning.

Ease of use

Agilent interface cones are designed to provide ease of use out of the box. Agilent is the only manufacturer to include handling and conditioning instructions, which reduce the risk of accidental damage to the cones and help you achieve great results straightaway.

The biodegradable pressed cardboard packaging used for Agilent cones is tamper proof, reusable, and environmentally friendly. It is designed to protect the cones from damage due to rough handling, especially in shipment. The desiccant insert provides further protection against moisture damage, especially in humid environments. Simply by checking the tamper-proof seal is intact, you can be confident that the cones are as clean as when they were produced.

Agilent also uses clear labeling to help you identify cone types, manage inventories, and easily reorder replacement cones when required.

It is good practice to keep the packaging and utilize this for ongoing storage of cones when not in use on your Agilent ICP-MS instrument. This ensures that the cones have the same protection while in storage. In addition, at the end of the cone lifetime, the packaging can also be used to return the used cone to Agilent for credit against your next order as part of the Agilent platinum cone trade-in program.*

What makes Agilent cones different?

This overview has presented a thorough comparison of genuine Agilent interface cones (sampling and skimmer) with those from different suppliers, focusing on the aspects that are critical to the ICP-MS analytical performance.

Cones sourced from other manufacturers showed significant weight differences to genuine Agilent cones, which indicate deviation from Agilent design. The cones examined also exhibited inferior surface finish and differences in critical dimensions, which degrade performance. In the worst case, a non-Agilent cone will not even fit onto the skimmer base.

Genuine Agilent cones offer superior sensitivity across the mass range. All non-Agilent cones tested gave lower sensitivity out of the box and after preconditioning.

Genuine Agilent cones also provided the lowest background. Differences in full scan scatterplot analysis of instrument background counts combined with sensitivity losses have shown that non-Agilent cones also degrade the achievable background equivalent concentrations (BECs) and detection limits.

Agilent ICP-MS instruments use automatic preset plasma conditions and autotuning to give you robust conditions and signal stability for matrix tolerance with your applications. Several factors influence the signal stability resulting from interface cones. Both short- and long-term stability are compromised using non-Agilent cones, introducing instrument drift and increasing the risk of QC failures. This costs you both time and money in reruns and lost productivity. Only genuine Agilent cones are designed and extensively tested on Agilent ICP-MS systems to ensure both sensitivity and stability with real-world applications.

Cones are typically the biggest supplies cost in routine operation of an ICP-MS. Protect your investment and ensure ease of use by choosing genuine Agilent cones. Genuine Agilent cones include handling and conditioning guidelines. Our 100% quality inspection and packaging ensure that your cones provide the level of performance that Agilent single quadrupole and triple quadrupole ICP-MS instrument range demands.

Additional Resources

Agilent web store interface cones

Cone care packages
- Online order
- Contact form

ICP-MS resource page

Troubleshooting video for the interface region

Pt cone recycling trade-in program

Spectroscopy supplies catalog

ICP-MS product page

* For more details, please see agilent.com/chem/PtCone or contact your local Agilent representative. This program is currently available in North America, EMEA, and Japan. The trade-in program is also available through authorized Agilent distributors in the areas listed above.

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