Improved Plasma Robustness and Reduced Operating Costs with a Ceramic Torch

Ryan Brennan, Jerry Dulude, Jol Desmarchelier, and Vesna Dolic

GLASS EXPANSION
Analysis Made Easy

Glass Expansion D-Torch Demountable Torch

Agilent (Varian) Radial ICP-OES | Perkin Elmer Elan/NexION ICP-MS | Perkin Elmer Optima DV ICP-OES | Perkin Elmer Optima V ICP-OES | Spectro Radial ICP-OES | Thermo iCAP Duo ICP-OES | Thermo iCAP Radial ICP-OES

The D-Torch is a revolutionary new demountable torch design. It provides the benefits of a fully demountable torch at a significantly lower cost. The D-Torch is available for a range of ICP models, including those from PerkinElmer, Spectro, Thermo and Agilent (Varian) all shown above. Our newest D-Torch release is for the Agilent 7500 and 7700 ICP-MS, and we will soon be releasing a D-Torch for other ICP models.

The ICP torch is a relatively high cost consumable item that requires regular maintenance and replacement when performing more demanding applications, e.g. hydrofluoric acid (HF), organic solvents and high dissolved solids. The D-Torch has an interchangeable outer tube so that you can replace the outer tube when it fails rather than replacing the entire torch. Outer tubes made of quartz or ceramic are available (ceramic not available for all models). The ceramic outer tube is of particular benefit for the analysis of wear metals in engine oils, where quartz outer tubes often suffer from short lifetime. It is also beneficial for Si determinations, where quartz outer tubes often produce high background signals. In general, the ceramic outer tube has a much longer lifetime, greatly reducing interruptions and downtime due to torch failure. In addition to outer tubes, the D-Torch also features an interchangeable injector. This allows the analyst to have a specific injector for each application whether it be for aqueous, organics, high dissolved solids or HF. Injectors made from high quality quartz, alumina and sapphire are available in a variety of internal diameters to suit your application needs.

Options Suited To Your Application Needs*

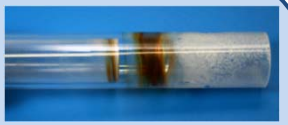
D-Torch Base and Inner Tube | Ceramic Outer Tube | Quartz Outer Tube | Quartz Injector | Alumina Injector | Sapphire Injector

*Products shown above are available for the Thermo iCAP 6000 series Radial ICP, ceramic outer tube not available for all ICP models.

Customer Comments

- "The ceramic torch is quite excellent, it forms much less deposits on it and that which forms is usually very easy to clean. I do think we'll continue buying ceramic torches mostly because they last much longer and are so much easier to keep clean." - *Environmental laboratory - Sweden*
- "I am quite pleased with the D-Torch. It's quite excellent for analyzing silica in a hydrofluoric digestion, I noticed my blanks were much lower and stable." - *Contract laboratory - Sweden*
- "The ceramic outer has been in almost constant service 22 hours a day, 6 days a week since we purchased the D-Torch and we have had no issues." - *Lubricating oils laboratory - Australia*

Ceramic Outer Tube



The outer tube of the ceramic D-Torch is made from sialon, which is a ceramic material derived from silicon nitride. Sialon is one of the most durable and strongest ceramic materials known and maintains these properties at high temperatures.

A combination of high temperature and salt deposit causes a quartz torch to devitrify. Higher concentrations of salt in the samples lead to more rapid devitrification. The quartz torch in the photo (above right), was run for only 6 hours with samples containing 10% NaCl and is already badly degraded. By contrast, the ceramic outer tube of the D-Torch does not devitrify and is not affected by salt deposits. The ceramic D-Torch in the photo (above left) was run for the same period and with the same samples as the quartz torch but shows no degradation at all.

The sialon material of the outer tube of the ceramic D-Torch also eliminates premature failures of the torch when analyzing organic solvents. The sialon material has a thermal conductivity of 28 W/(m·K), meaning that heat is conducted more evenly along the axis of the torch. The temperature gradient from one end to the other of the ceramic is, therefore, lower when compared to quartz (thermal conductivity 1.4 W/(m·K)). This reduces the thermal stress on the torch, which results in a lower rate of failure.

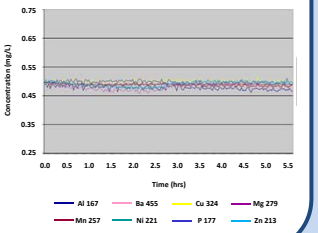
Analytical Performance

Comparison of Detection Limits*

	Detection Limit µg/L	
Element (λ)	Radial EMT Torch	Radial Ceramic D-Torch
Al 167	1.6	1.1
Ba 455	0.07	0.12
Cu 324	0.88	0.62
K 766	25.5	11.7
Mg 279	0.05	0.05
Mn 257	0.36	0.25
Ni 221	1.6	1.3
P 177	5.1	5.0
Zn 213	0.23	0.28

*Data taken from Thermo Scientific Technical Note: 43053

Analysis of Elements in 3% Brine Solution*



The D-Torch was featured in Thermo Scientific Technical Note #43053, to compare the analytical performance of the Radial EMT torch to the Radial ceramic D-Torch. The geometry of the two torches are identical. The key differences between the EMT torch and the ceramic D-Torch are the materials used for the outer tube and intermediate tube and that the ceramic D-Torch is fully demountable. The Table shown above compares the detection limits of the EMT torch and the ceramic D-Torch in an aqueous matrix for selected elements. The results show little difference between the detection limits obtained from the two torches. A key indicator of ICP torch performance is stability, the Figure above right shows a plot of selected elements at 0.5 mg/L in a 3 % NaCl matrix. The stability exhibited by the ceramic D-Torch over a period of 5.5 hours in this high matrix sample is exceptional. The ceramic D-Torch proves to provide equivalent analytical performance to the standard EMT torch with the added advantage of resistance to devitrification and premature failures with specific sample matrices, including organics and high dissolved solids samples such as fusions.

Improved Plasma Robustness

Typical ICP operating conditions require Argon flow rates of 15.0 L/min, this high flow is necessary to shield the quartz material of the torch assembly. However, the high flow rate also cools the plasma. Running at a reduced flow can result in a more robust plasma, but there is a danger of damaging the quartz torch. A ceramic torch has a heat resistance above 2000°C compared to quartz, which can begin to strain at 1200°C. With a ceramic D-Torch in place of the standard quartz torch, Argon flow rates can be reduced down to 10 L/min or lower. The ICP figures of merit obtained on a Thermo iCAP and Perkin Elmer Optima are compared at a plasma gas flow rate of 15.0 L/min and 10.0 L/min. Using a ceramic D-Torch, plasma robustness, atomization/ionization, excitation and stability were examined.

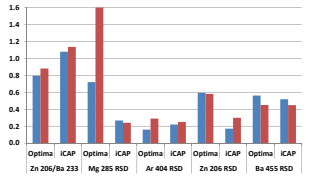
ICP Operating Conditions

ICP Parameter	Thermo iCAP 6500	PE Optima 2100 DV
RF Power (W)	1350	1350
Auxiliary gas flow (L/min)	0.20	0.20
Nebulizer gas flow (L/min)	0.65	0.65
Plasma gas flow (L/min)	10 & 15	10 & 15
Injector ID (mm)	2.0	2.0
Solution flow rate (mL/min)	0.55	0.55

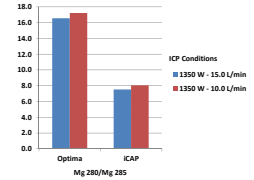
ICP Figures of Merit*

Test	Diagnostic
Mg 280(II)/Mg 285 (I)	Robustness
Zn 206 (II)/Ba 455(II)	Atomization/Ionization
Mg 285 (I) RSD	Nebulizer Efficiency
Ar 404 (I) RSD	Stability
Zn 206 (II) RSD	Stability
Ba 455 (II) RSD	Stability

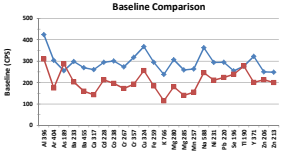
Nebulizer Efficiency and Stability



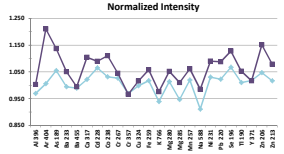
Plasma Robustness



Baseline Comparison



Normalized Intensity



Optima 1350 W – 15.0 L/min | Optima 1350 W – 10.0 L/min | Optima (10 L·min⁻¹/15 L·min⁻¹) | ICAP (10 L·min⁻¹/15 L·min⁻¹)

*Simple experiments for the control, the evaluation and the diagnosis of Inductively coupled plasma sequential systems, F. Poussel and J. M. Mermet, Spectrochimica Acta, 1993

At a plasma gas flow rate of 10.0 L/min a more robust plasma is formed on both the iCAP and Optima, resulting in a slight increase in sensitivity and a lower baseline for most wavelengths. The nebulizer efficiency and plasma stability results are nearly identical at both plasma gas flow rates. This proves that there is no loss in ICP performance at a lower plasma gas flow. In summary, the ceramic D-Torch provides the analyst with reduced Argon consumption and a more robust plasma, where a quartz torch would fail. The expected life time of the ceramic D-Torch is at least 5 times that of a quartz torch when dealing with difficult matrices, making the ceramic D-Torch a cost effective solution to reduce some of the traditional consumable costs associated with ICP.