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Report by the Analytical Methods Committee Evaluation of Analytical Instrumentation.

Part X Inductively Coupled Plasma Mass Spectrometers

Analytical Methods Committee
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A method is provided for comparing the features of inductively coupled plasma mass spectrometry instrumentation.

The Analytical Methods Committee has received and approved the following report from the Instrumental Criteria Sub-Committee.

Introduction

The following report was compiled by the above Sub-Committee of the AMC, which consisted of Professor S. Greenfield (Chairman), Mr. R. Brown, Dr. C. Burgess, Dr. K. E.

instances it will quickly become clear that a number of different instruments could be satisfactory and non-instrumental criteria may then be important. However, in some specialized cases only one or two instruments will have the ability or necessary features to carry out the assay. The guidelines are intended to be used as a check list of features to be considered, mostly of the instrument itself, but some also of its service requirements and of the relationship of the user with the manufacturer. Their relative importance will depend on the installation requirements of the instrument as well as the uses to which it will be put. Therefore, to some extent, the selection process will inevitably be subjective, but if all the points have been considered it should be an informed choice.

Finally, as many laboratories are now working to quality protocols and standards such as GLP/UKAS(NAMAS)/ISO9000/FDA/EPA, some consideration should given to third party recognition of the manufacturer to standards such as appropriate ISO 9000 series. Such accreditation should extend to the service organization, which is particularly important when working to UKAS (NAMAS) or GLP criteria.

Previous Reports in this Series from the Analytical Methods Committee

Evaluation of Analytical Instrumentation

Part 1. Atomic-absorption Spectrophotometers, Primarily for Use with Flames, *Anal. Proc.*, 1984, **21**, 45.
Part 2. Atomic-absorption Spectrophotometers, Primarily for Use with Electrothermal Atomizers, *Anal. Proc.*, 1985, **22**, 128.
Part 3. Polychromators for Use in Emission Spectrometry with ICP Sources, *Anal. Proc.*, 1986, **23**, 109.
Part 4. Monochromators for Use in Emission Spectrometry with ICP Sources, *Anal. Proc.*, 1987, **24**, 3.
Part 5. Inductively Coupled Plasma Sources for Use in Emission Spectrometry, *Anal. Proc.*, 1987, **24**, 266.
Part 6. Wavelength Dispersive X-ray Spectrometers, *Anal. Proc.*, 1990, **27**, 324.
Part 7. Energy Dispersive X-ray Spectrometers, *Anal. Proc.*, 1991, **28**, 312.
Part 8. Instrumentation for Gas–Liquid Chromatography, *Anal. Proc.*, 1993, **30**, 296.
Part 9. Instrumentation for High-performance Liquid Chromatography, *Analyst*, 1997, **122**, 387.

Instrument evaluation form. Subject: ICP-MS

Manufacturer/Model number								
Feature	Definition and/or test procedures and guidance for assessment	Importance	Reason	Score				
Non-instrumental criteria								
Selection of manufacturer	Laboratories in possession of other spectrometers should score highest for the manufacturer with the best past record based on the following sub-features:							
(*a*) Previous instruments								
(*i*) Innovation	Company's record for instruments with innovative features.	I	The manufacturer should be aware of new techniques in ICP-MS.	PS WF ST				
(*ii*) Reliability record	Company's record for instrument reliability.	I	Reflects the company's ability to employ good design and manufacturing practices.	PS WF ST				
(*iii*) Confidence in the supplier	Confidence gained from past personal experience.	I	Good working relationship already in place.	PS WF ST				
(*b*) Servicing	Score according to manufacturer's claims and past record, judged by the sub-features (*i*) to (*v*) below:							
(*i*) Service contract	Availability of suitable service contracts from the supplier, agent or third party contractor.	I/NVI	Suggests long-term commitment to user. This often ensures preferential service and guarantees a specific response time to call-outs.	PS WF ST				
(*ii*) Availability and delivery of spares	Range of stock carried by, or quickly available to, the manufacturer/agent/contractor.	(VI)	Rapid delivery of spares reduces down time and operating cost.	PS WF ST				
(*iii*) Call-out time	Adequate service personnel readily available, minimising the call-out time.	I(VI)	Keeps laboratory in operation by reducing down time [see also (*i*)].	PS WF ST				
(*iv*) Effectiveness of service engineers	The ability of the service engineers, as judged from previous experience and reports of others, including the carrying of adequate spares.	I	Ability to repair on-site avoids return visit or removal of equipment for off-site repair, so reducing down time and may reduce service cost.	PS WF ST				
(*v*) Cost of call-out and spares	Score for reasonable cost per hour and spares.	I	The proximity of the service centre may be a factor in travel costs.	PS WF ST				

Feature	Definition and/or test procedures and guidance for assessment	Importance	Reason	Score				
(*d*) Frequency of operation	The usual frequency of operation of generators for ICP-MS instrumentation is 27 MHz, but some operate at higher frequencies. Scoring may be inappropriate. There is some evidence to suggest that lower frequency operation may offer some advantages in ICP-MS.	NVI	In an ICP, the eddy currents induced by the magnetic field flow more closely to the outer portions of the plasma, known as the skin depth. This is defined as the depth at which the inductive current is 1/e of the surface value (e is the base of natural logarithms) and is inversely proportional to the square root of the frequency. The higher the frequency, the smaller the skin depth and consequently there is a decrease in the transfer of energy towards the central channel, which results in a lower temperature and a lower electron number density. Therefore the background emission will decrease, which is advantageous in emission as the limits of detection are usually improved, but is a disadvantage in ICP-MS as the dissociation of analyte oxide species is obviously more difficult at low temperatures.					
(*e*) Power available	The power in kilowatts which can be developed in a plasma by the generator. Score according to application, bearing in mind that a high power generator may offer more flexibility if it can also be run at low power.	I	The power required will depend on the application. All commercial systems use a Fassel type torch and normally operate at around 1300 W, although higher powers of up to 1800 W may be required in the analysis of organic solvents to ensure adequate breakdown of solvent molecules.	PS WF ST				
(*f*) Selection and indication of power settings	The power developed in the plasma should be indicated by a meter or calibrated control. According to application, score maximum for the system which gives the most accurate and complete information. Score additionally for reproducibility and the ability to select several power settings.	I	For comparison purposes in research work, as well as for method development, it is important to know the power developed in the plasma. For routine use, it is sufficient to know the power developed at the work coil and to set this reproducibly. Most generators have a reflected power meter, which gives the power into the impedance matched circuit. All meters and/or controls should have accompanying information which gives the power in the plasma from either calculation or calibration.	PS WF ST				
(*g*) Coupling efficiency	The fraction of power supplied to the coil which is transferred to the plasma. The power in the plasma can be determined directly by calorimetric measurement or indirectly by use of a dummy load and calorimetry. Score maximum for the highest efficiency.	I	For maximum efficiency, it is desirable to transfer the maximum amount of power available to the plasma.	PS WF ST				
(*h*) Power stability	The degree to which the power in the plasma varies from a set value. Score maximum for the highest degree of stability for a given mains variation. This figure should always be given by the manufacturer.	VI	Fluctuations are brought about by variations in line voltage and some form of feedback control should be incorporated in the generator. The number of ions produced is strongly dependent on the power delivered to the plasma. Short term fluctuations in power are, therefore, highly undesirable.	PS WF ST				

Feature	Definition and/or test procedures and guidance for assessment	Importance	Reason	Score				
(*i*) Tuning (for crystal controlled generators)	Crystal controlled generators require re-tuning if the impedance in the plasma changes. Re-tuning is accomplished by a 'match box' which should incorporate automatic tuning. Score maximum for the most rapid response to changes and the widest range over which this can be achieved with minimal overshoot.	VI	With crystal controlled generators, unless matching is automatic and rapid, the plasma will be extinguished. A wide tuning range will accommodate the greatest changes in impedance, permitting the use of the widest range of gases. Free running oscillators have their frequency fixed by the value of the components in the tank circuit. Any change in impedance will result in a small change in the frequency of oscillation, but no retuning is possible or necessary.	PS WF ST				
(*j*) Cooling	In most, if not all, plasma generators, the work coil and, in some cases, the oscillator valve, are water cooled. Score maximum for the system that requires the lowest flow and pressure of water and calls for the least treatment of the cooling water. Some generators are air, rather than water, cooled. In such instances, score maximum for the generator which achieves cooling with the lowest heat dissipation requirement.	I	It is expensive to install high pressure mains supplies and to install water treatment in areas of hard water. Failure to treat water in such areas can lead to failure owing to blocking of work coils. Instruments designed with air cooling generators that have high power requriements for cooling, may be noisy and uneconomical.	PS WF ST				
(*k*) Interlocks	The operator must not be able to gain access to the generator while the power is turned on whether the oscillator is producing Hf or not. Score zero if this interlock is not effective.	VI	The voltages and currents involved in Hf generation are dangerous!	PS WF ST				
2. *Torch boxes*								
(*a*) Ease of access	Score according to the ease with which torches can be removed and refitted to the box and the ease with which load coils can be removed and refitted. Score additionally for ease of alignment of the torch within the coil.	VI	Breakage of torches can occur if it is difficult to remove or refit them. Water leakage resulting from difficulty in tightening connections on work coils can cause damage. It is essential to ensure that the torch tube is centrally placed in the coil if a good, well positioned plasma is to be obtained. Off-centre torches will cause off-axis plasmas and consequent melting of the torch tube.	PS WF ST				
(*b*) Ease of observation	It is desirable to be able to observe the plasma through an observation window which must be screened to suppress Hf leakage and equipped with UV filters. Score according to the degree of convenience offered.	I	This facility allows observation of any malfunction of the plasma torch, which can cause damage and will lead to unsatisfactory performance.	PS WF ST				
(*c*) Sampling depth	The distance between the load coil and the sampling cone. It is essential to be able to set the sampling depth in the plasma reproducibly. Score according to the ease with which this adjustment can be made.	VI	There is a significant spatial variation in the density of ions in the plasma. Incorrect positioning results in reduced sensitivity and increased interferences from refractory oxides and M(2+) species.	PS WF ST				
(*d*) Mounting of the plasma torch	Score according to the ease with which the plasma torch can be held in position centrally within the work coil of the generator. Mounting devices with orthogonal adjustment consistent with accurate positioning are preferable.	VI	The region of maximum ion density in the plasma must be accurately aligned in relation to the sampling cone to maximise the analytical signal and minimise interfering signals. If the mounting device has many degrees of movement, it becomes very difficult to ensure that off-axis sampling does not occur. Most instruments in current production use a similar type of torch. However, other torches may have advantages in some circumstances and a mounting that permits their use is advantageous.	PS WF ST				

Feature	Definition and/or test procedures and guidance for assessment	Importance	Reason	Score
(*ii*) Ultrasonic nebulisation	A device that substantially increases the efficiency of solution nebulisation by incorporating an ultrasonic frequency oscillator as the nebulisation medium. Such a device must be coupled to a desolvation unit. otherwise the low power plasma used in ICP-MS will be extinguished by the high load of solvent that is injected.		Ultrasonic nebulisation increases the nebulisation efficiency to an extent that, in many cases, the limits of detection obtainable are improved by an order of magnitude over those obtainable by most common nebulisers. This device has the additional advantage that the aerosol production is independent of the carrier gas flow rate. It will not handle particulates and, unless removed, the high water loading will take power from the plasma and affect such properties as electron densities, ionisation and excitation temperatures. Also, a high water content, because of its oxygen content, leads to oxide formation. This water content can be reduced by desolvation (normally using either membrane separation or cryogenic cooling).	PS WF ST
(*iii*) Thermo-spray nebuliser	In this device, the nebulisation is obtained by introducing the liquid sample into a heated capillary. The solvent boils near the outlet of the capillary and the vapour acts as a nebulising and carrier gas.		This nebuliser is said to be as efficient as an ultrasonic nebuliser and the aerosol production is independent of the gas flow, but it also has a similar high solvent load.	PS WF ST
(*iv*) Hydraulic high-pressure nebuliser	A high pressure pump is used to produce a constant flow of liquid sample through a nozzle having an orifice of 10–30 μm. The jet of liquid partially disintegrates into an aerosol and is further converted into an aerosol cloud upon collision with an impact bead.		The droplet generation is independent of the gas flow; however, the nebuliser will not tolerate particles because of the small orifice. *82[illegible]124 T0Tj /F17 1 Tf 0.ct0ee4 TD (()T7r.13st* WF(	

Feature	Definition and/or test procedures and guidance for assessment	Importance	Reason	Score
(*viii*) Direct insertion	In this technique, the sample is placed in the bored-out end of a graphite electrode, dried ashed and inserted axially into the plasma.		Detection limits are said to be improved by an order of magnitude but the method is discontinuous.	PS WF ST
(*ix*) Hydride generation	An accessory which incorporates a reaction vessel in which the sample solution is reacted with a reagent such as sodium borohydride causing selected analytes to form volatile hydrides which are swept into the plasma for analysis.		Hydride generation offers the advantage of significantly increasing the sensitivity and simultaneously reducing interference effects (in comparison with normal solution nebulisation) for elements which react to form volatile hydrides, including As, Bi, Cd, Ge, Pb, Se, Sb, Sn, Te. Other elements, including Hg, Os and I_2 can be determined by similar 'cold vapour' generating techniques.	PS WF ST
(*b*) Solid samples	Methods which involve the direct analysis of solid samples offer the advantages of no sample preparation, minimization of contamination effects (*e.g.*, from reagents) and the capability of analysing very small sample masses. However, depending on the nature of the material, methods are likely to be inherently imprecise, and because of inhomogeneity effects, the small samples taken for analysis may not be representative of the bulk material. The availability of matrix-matched calibration samples may be restricted and selective volatilisation is also a problem for electrothermal vaporisation as well as for the direct insertion devices, details of which are summarised below.			
(*i*) Electro-thermal vaporisation	Similar instrumentation to that described for the introduction of liquids can be used to introduce solids into the plasma.		See 4(*a*)(*vii*)	PS WF ST
(*ii*) Direct insertion	As with liquids, solid material is introduced into the plasma by means of a bored-out electrode.		Selective volatilisation can be a problem with this method.	PS WF ST
(*iii*) Arc and spark ablation	Aerosol generation using a dc/ac or an ac spark in a closed chamber. The aerosol produced is transported to the plasma by a flow of argon through connective tubing which can be a few centimetres or metres long.		The material must be electrically conductive or made so by the addition of graphite.	PS WF ST
(*iv*) Laser ablation	A facility for the analysis of solid samples in which a selected area on the surface of the sample is ablated by the energy imparted by a laser. The ablated material is then swept into the plasma by the nebuliser carrier gas.		Laser ablation offers the advantage of the d seleeneity0 -4.5 TDplasma.smTselecteduj 0D (6c6 TD (of thsy the nebuliss tran7	

Feature	Definition and/or test procedures and guidance for assessment	Importance	Reason	Score
(*v*) Slurry nebulisation	The introduction of finely powdered material suspended in liquid media using a high solids nebuliser such as the V-groove type.		Aqueous standards can be used if particles are small. However, it is not a general solution to the problem of solids introduction. The method may be prone to problems of density settling and consequent segregation, and the density of the liquid should be near that of the solid. In short, the particles should be very fine and uniform in size and the material under investigation should be homogeneous. Given these requirements, the physical preparation of samples (*e.g.*, grinding) may not offer many advantages in comparison with dissolution procedures.	PS WF ST
(*vi*) Direct introduction of powders	Powders have been introduced into plasmas by means of direct injection from swirl chambers and fluidised beds, and by injection using pneumatic nebulisers. None of these methods have been successful quantitatively.	VI	These methods are prone to an inability to maintain a constant uniform feed of the powdered sample as well as segregation effects which can lead to inhomogeneity.	
5. *Interface*	Part of instrument between plasma (operated at atmospheric pressure) and mass spectrometer (operated at high vacuum). The interface section comprises differentially pumped stages through which plasma gases are transmitted to the mass spectrometer *via* sampling and skimmer orifices. All instruments are fitted with this device.		The interface is the key component of ICP-MS instrumentation for which design and manufacturing tolerances have a critical influence on the	

Feature	Definition and/or test procedures and guidance for assessment	Importance	Reason	Score
(*a*				

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(*ii*) Discrete dynode electron multiplier	Measures ion flux by conversion to electrons, which are multiplied by interaction with a series of discrete dynodes in a manner similar to a photomultiplier tube. Excellent tolerance to venting to air.		Long lifetime; individual dynodes can be replaced; initial cost is higher than the continuous dynode type.	PS WF ST				
(*iii*) Faraday cup	Measures ion flux *via* a cup-shaped metal electrode which has no intrinsic gain mechanism.		This type of detector has a relatively low sensitivity and is usually used to extend the upper dynamic range of detection. This type of detector is not suitable for fast scan rates owing to the time taken to respond. The Faraday cup has a long life and does not normally require replacement in normal use.	PS WF ST				
(*b*) Detector lifetime	Score highest for the least sensitivity to deterioration after atmospheric exposure and to the total accumulated count rate history.	I	All detectors age with use, and they suffer varying amounts of damage either when exposed to the atmosphere during routine maintenance or high ion count rate usage.	PS WF ST				
(*c*) Cost of replacement	Cost of replacement depends on both the capital cost of a replacement detector together with its expected operational life. These factors vary according to the choice of detector, appropriate to a particular application. Score according to the anticipated running cost.	I	The replacement cost of detectors can make a significant contribution to the running costs of an instrument: more specific details are listed under 8 (*i*).	PS WF ST				
(*d*) Detector characteristics								
(*i*) Linear dynamic range	Score maximum for the detection system (*i.e.*, detector and electronics) offering the widest linear dynamic range.	I	Permits the measurement of the widest range of concentration of analytes.	PS WF ST				
(*ii*) Dead time	Score maximum for the detection system with the shortest dead time (in the case of electron multiplier detectors) or the shortest time constant (in the case of Faraday cup detectors).	I	For any ion counting system, the detection system requires a finite time to measure and record an ion. During this dead time, subsequent ions cannot be detected, leading to dead time losses. All instruments employing electron multiplier detectors incorporate a numeric correction to account for these dead time losses. However, the shorter the dead time of the counting system, the higher the count rate that can be detected before the response of the counting system become saturated and uncertainties in the dead time corrected data becme excessive. For Faraday cup detectors, the response time will depend on the time constants used in the ion current measurement circuits.	PS WF ST				
(*iii*) Detector background noise	Score maximum for the detection system offering the lowest figure.	I	All noise decreases the signal-to-noise ratio and, therefore, degrades the detection limit.	PS WF ST				
(*iv*) Detector overload protection	Score zero if this feature is absent from detectors other than the Faraday cup.	I	Overload of the detector and associated electronic circuits by exposure to an excessively high ion count rate can reduce the operating life of some detector types, particularly electron multiplier detectors. Furthermore, in these circumstances, the detector may take some time to recover its normal operating characteristics.	PS WF ST				

Feature	Definition and/or test procedures and guidance for assessment	Importance	Reason	Score
(*v*) Operation at reduced sensitivity	Reduced sensitivity may be achieved by operating electron multiplier detectors in analogue mode, switching to a Faraday cup detector or reducing the ion transmission characterics of the ion extraction lenses. Score zero if this facility is absent.	I	This facility extends the linear dynamic range of the instrument, allowing analytes at higher concentrations to be measured.	PS WF ST
9. *Computer control and monitoring*				
(*a*) Instrument functions	Many manual controls on earlier instruments can now be set from the computer. In addition, safety interlocks can be monitored by the computer. Score highest for the comprehensiveness of computer automation, ease of use, clarity of operation and quality of display.	I	Optimisation of instrument functions should be more reproducible and interlocks more reliably monitored with computer automation.	PS WF ST
(*b*) On-line diagnostics	Capability of the instrument control computer to monitor the operating status of the instrument and to log faults and deviations from operating specification. Score for the availability of a user-friendly diagnostic information. Score additionally for the ability to connect the instrument by modem to the manufacturer's service department to enable remote interrogation of instrument faults to be carried out.	I	Downtime is kept to a minimum if faults can be diagnosed quickly. The availability of reliable diagnostic information may make an engineer's visit more effective or even unnecessary.	PS WF ST
10. *Data acquisition*				
(*a*) Scan rate of the mass spectrometer	Atomic mass units (amu) per second. Score highest for instruments with the highest scan rate aplicable over the entire mass range (6–240 *m/z*). This feature is not relevant to instruments fitted with multi-collector detectors.	VI	Transient signals from electrothermal vaporisation or coupled chromatography require fast scaning. Fast scan rates generally improve precision in isotope ratio determinations where data are accumulated by repetitively scanning over a restricted region of the mass spectrum.	PS WF ST
(*b*) Peak jumping	The capability of acquiring data by repetitively monitoring a number of mass peaks selected by the operator anywhere within the instrument's mass reponse range. Intermediate regions of the mass spectrum are scanned at maximum rate without acquiring data. Score zero if this feature is absent.	VI	Operation in this mode maximises the rate of data acquisition on mass peaks of interest, and prevents detector overload and ageing by avoiding regions of the mass spectrum containing intense mass peaks.	PS WF ST
(*c*) Integration	The capability of summing data for a complete mass peak or, alternatively, a selected number of the channels of an individual mass peak acquired in scanning mode. Score for the availability of this feature and additionally if it is possible to re-integrate stored spectra by selecting a different range of channels.	VI	Integrating the channels of a peak adjacent to the peak maximum (*e.g.*, ±0.35 *m/z*) is claimed to improve precision compared with integrating the whole peak area, particularly for measurements made at low count rates, because this method excludes data from the wings of the peak which contain a larger proportion of noise.	PS WF ST
11. *Data correction and manipulation*	Ability to process raw data and implement quality control procedures.			
(*a*) Data processing	Facilities available should include recalibration, use of internal standards, external drift correction and interference correction. Score maximum if all are present.	VI	These facilities are necessary to apply the appropriate correction (*e.g.*, for drift in instrument response, suppression of enhancement caused by sample matrix effects and spectrum overlap interference) to the raw analytical signal.	PS WF ST

Feature	Definition and/or test procedures and guidance for assessment	Importance	Reason	Score
(*b*) Isotope ratio measurement	The ability to measure the abundance of one isotope relative to another isotope of either the same, or a different element. Score for the availability of this feature. If relevant to the type of instrument and application, score additionally for the availability of specialised software that allows data to be acquired and processed to maximise precision.	I/VI	In some applications, isotope ratios must be measured rather than elemental abundances. Quadrupole instruments acquire data in a sequential manner and can achieve precisions of typically 0.1% RSD. If very precise measurements are required (*e.g.*, 0.001% RSD), so that small differences in isotopic composition can be distinguished with confidence, special considerations apply. Measurements must be made on a magnetic sector instrument fitted with multiple collectors. Special procedures are then required to acquire and analyse data in a way that maximises the precision of the measurement.	PS WF ST
(*c*) Reporting formats	Choice of hard copy formats for the output of raw data and/or analytical results. Score for a choice of output formats that suit the application. Score additionally for the option for the user to design customised formats.	I	Specific hard copy formats may be	

Feature	Definition and/or test procedures and guidance for assessment	Importance	Reason	Score
(*c*) Background signal	Signal resulting from the detection of stray ions and photons. Test by measuring the signal from high purity water, analysed under relevant operating conditions at mass numbers 6–240 *m/z*. Score highest for the smallest background signal at each mass number.		The magnitude of and variations in the background signal will affect detection limits.	PS WF ST
(*d*) Polyatomic ion interference	The signal from specific molecular species formed from the plasma gas (Ar) and elements entrained either from air, or introduced *via* the sample solution (*e.g.*, H, C, N, O, S, Cl). An example is $^{40}\mathrm{Ar}^{16}\mathrm{O}$, which causes a background interference on Fe at 56 *m/z*. Score highest for the smallest signal relative to an adjacent mass peak obtained during a full mass range scan. Some instruments now have special features or devices (*e.g.*, shield torch) which reduce selectively certain polyatomic species; however, such features may also reduce the overall instrument sensitivity. Score for the presence of such features only if the application requires the determination at low levels of analytes that suffer polyatomic interferences that are reduced in severity by the feature. Measurements should be made using relevant operating conditions since the magnitude of this interference effect may change	PS WF		

Feature	Definition and/or test procedures and guidance for assessment	Importance	Reason	Score				
(*g*) Resolution	The mass peak width at 10% of the peak maximum, which should be measured for a number of elements selected across the mass range of the instrument. On multi-element quadrupole instruments, the minimum acceptable resolution is one mass unit. Since all instruments are likely to achieve this level of performance, it may be inappropriate to score this feature. On high resolution magnetic sector instruments, there is a compromise between increasing the mass resolution and a corresponding reduction in the intensity of the transmitted ion beam.		On multi-element quadrupole instruments, it is essential that adjacent mass peaks may be distinguished and wing overlaps avoided. On magnetic sector instruments, an evaluation of resolution is usually related to the analytical strategy to be used in a specific application.	PS WF ST				
(*h*) Abundance sensitivity	A parameter that measures the overlap interference from a specific mass peak of high intensity on an adjacent low intensity mass peak 1 amu away. In ICP-MS, abundance sensitivity can be measured as the ratio of concentrations between two adjacent isotopes where no significant interference effects from tailing can be detected. Score highest for the largest figure obtained from solutions of analytes of relevance to the intended application run under routine operating conditions. Note that the magnitude of this parameter will change with instrument operating conditions.		An example of where high abundance sensitivity is important is in the determination of an analyte mass peak situated 1 amu from an intense polyatomic ion interference. High abundance sensitivity is required to minimise interference on the analyte peak.	PS WF ST				
(*i*) Matrix effects	Effects derived from the sample matrix that suppress or enhance analyte sensitivity, causing differences in sensitivity when the signal from sample solutions are compared with simple aqueous standard solutions. These effects should be absent in dilute solutions and at a minimum in solutions of more complex matrices. Score highest for the least effect in the presence of a matrix typical of the intended application, run under relevant operating conditions. Note that the magnitude of this parameter may change with changes in instrument operating conditions.		Calibration using simple aqueous standards is possible if suppression or enhancement effects are not significant, so avoiding the necessity of preparing matrix-matched calibration samples.	PS WF ST				
(*j*) Sample signal stability	The change in the signal with time from a sample matrix representative of the application. Score highest for minimum drift.		Drift in the analytical signal from complex matrices can be caused by deposition of undissociated sample material in the sampling cone so obstructing the orifice. This drift must be corrected during a run to avoid calibration errors. This test is complementary to the test for instrument stability (13*b*), which would normally be undertaken using a sample at high dilution, and so not detect drift problems that may occur when real samples are run.	PS WF ST				
14. *Value for money* (*points per* £)	Sum of the previous sub-totals divided by the purchase price of the instrument. Subject to proportional scoring and weighting factors, including ST in grand total.	I	'Simple' instruments are often good value for money, whereas those with unnecessary refinements are often more costly.	PS WF ST				
				Grand Total				

Paper 7/00441A