The Analyst

Report by the Analytical Methods Committee

Evaluation of analytical instrumentation. Part XI Instrumentation for molecular fluorescence spectrometry

Analytical Methods Committee

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A method is provided for comparing the features of molecular fluorescence spectrometers.

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

Introduction

The following report was complied by the above Sub-Committee of the AMC, which consisted of Professor S. Greenfield (Chairman), Professor J. N. Miller, Dr. P. J. Potts, Mr. D. C. M. Squirrell, Dr. C. Burgess, Dr. K. E. Jarvis, Professor S. J. Hill, Dr. N. Seare and Dr. M. Barnard, with Mr. C. A. Watson as Honorary Secretary. The initial input of the features for consideration was undertaken by a working party chaired by Dr. M. Barnard with Dr. G. E. Johnson to whom the Committee expresses its thanks.

The purchase of analytical instrumentation is an important function of many laboratory managers, who may be called upon to choose between a wide range of competing systems that are not always easily comparable. The objective of the Instrumental Criteria Sub-Committee is to tabulate a number of features of analytical instruments which should be considered when making a comparison between various systems. As is explained below, it is possible then to score these features in a rational manner, which allows a scientific comparison to be made between instruments.

The over-all object is to assist purchasers in obtaining the best instrument for their analytical requirements. It is also hoped that this evaluation will, to some extent, also help manufacturers to supply the instrument best suited to their customers' needs. It is perhaps pertinent to note that a number of teachers have found the reports to be of use as a teaching aid.

No attempt has been made to lay down a specification. In fact, the Committee considered that it would be invidious to do so; rather it has tried to encourage the purchasers to make up their own minds as to the importance of the features that are on offer by manufacturers.

The XIth report of the Sub-Committee deals with fluorescence spectrometry.

Notes on the use of this document

Column 1. The features of interest.

Column 2. What the feature is, and how it can be evaluated.

Column 3. The Sub-Committee has indicated the relative importance of each feature and expects users to decide on a weighting factor according to their own application.

Column 4. Here the Sub-Committee has given reasons for its opinion as to the importance of each feature.

Column 5 onwards. It is suggested that scores are given for each feature of each instrument and that these scores are modified by a weighting factor and sub-totals obtained. The addition of the sub-totals will give the final score for each instrument.

Notes on scoring

1. (PS) Proportional scoring. It will be assumed, unless otherwise stated, that the scoring of features will be by proportion, *e.g.*, Worst/0 to Best/100.
2. (WF) Weighting factor. This will depend on individual requirements. An indication of the Sub-Committee's opinion of the relative importance of each feature will be indicated by the abbreviations VI (very important), I (important); NVI (not very important). A scale is chosen for the weighting factor which allows the user to discriminate according to needs, *e.g.*, $\times$l to $\times$3, or $\times$1 to $\times$10. The factor could amount to total exclusion of the instrument.
3. (ST) Sub-total. This is found by multiplying PS by WF.

Molecular fluorescence spectrometry is a well established analytical technique with applications in many areas especially in biochemistry and the environment. An often bewildering range of instrumentation is available from a large number of different manufacturers. Systems range from simple instruments, with filters to select the excitation and emission wavelengths, to monochromator sytems with variable spectral bandwidths and microcomputer control of the spectrometer, accessories and autosamplers. Selection of a suitable instrument for purchase is, therefore, not an easy task and the purpose of these notes is to provide some guidance to areas which should be considered, so that the choice is based on a full consideration of the available options. However, the performance of any fluorescence method depends primarily on the experimental conditions and thus on the nature of the spectroscopic parameters necessary to yield satisfactory data. The nature of the analyte and the requirements for sensitivity and selectivity will influence the choice of spectrometer.

The first task in the selection of an instrument is to examine the range of analyses that it will be expected to perform. Care should be taken not to specify these requirements too closely, as uses change with time. The analytical scientist should also not try to envisage every potential application or the selection criteria may become too detailed. The choice of fluorescence HPLC dectectors and fluorescence lifetime systems are outside the scope of these guidance notes but any specific requirements should be noted, such as special accessories or software.

With these requiremens in mind, the user should then evaluate the instruments available on the market while bearing in mind the guidelines and any financial limitations. In many 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 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 to 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.

In addition, because the sensitivity of a specific fluorescence assay depends so much on the solvent, temperature and operating conditions, it may sometimes be difficult to assess the actual operating performance of a particular feature from the manufacturer's specifications. For some applications it may be necessary to evaluate the performance of the instruments under consideration using a system suitability test sample chosen for a particular application. The purpose of this is to demonstrate the system's ability to give the manufacturers' sensitivity under the recommended instrumental conditions using the manufacturers' recommended test sample. The Committee considers that, in general, fluorescence spectrometers are safe in operational use, but eye protection should be worn when aligning or changing the lamp. Protection from high voltages is required when the unit is open for servicing.

Finally, as many laboratories are now working to quality standards such as GMP/GLP/NAMAS/ISO Guide 25, some consideration should be given to third party recognition by the manufacturer to standards such as ISO 9001. Such accreditation should extend to the service organisation, which is particularly important when working to NAMAS(UKAS) or GLP criteria.

Previous reports in this series from the Analytical Methods Committee

Part 1. Atomic Absorption Spectrophotometers, Primarily for use with Flames. *Anal. Proc*., 1984, **21**, 45. Revised in *Analyst,* 1998, **123**, 1407.

Part 2. Atomic Absorption Spectrophotometers, Primarily for use with Electrothermal Atomizers, *Anal. Proc.,* 1985, **22**, 128. Revised in *Analyst,* 1998, **123**, 1415.

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.

Part 10. Instrumentation for Inductively Coupled Plasma Mass Spectrometry, *Analyst,* 1997, **122**, 393.

Instrument Evaluation Form

Type of instrument: Fluorescence spectrometer

Maufacturer:

Model No.:

Feature	Definition and/or test procedure and guidance for assessment	Importance	Reason	Score				
Non-instrumental criteria								
Selection of manufacturer	Laboratories in possession of other instruments 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 developing instruments with relevant innovative features.	I	The manufacturer shold be aware of new techniques in fluorescence.	PS WF ST				
(*ii*) Reliability record	Company's record for instrument reliability.	I	Reflects the company's 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 manufacturers' claims and past record, judged by the subfeatures (*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. Often ensures preferential service and guarantees a specific response time to call-outs.	PS WF ST				

Feature	Definition and/or test procedure and guidance for assessment	Importance	Reason	Score				
(*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 downtime and cost of operating.	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 reduces 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				
(*c*) Technical support	As in (*b*) score in consideration of sub-features (*i*)–(*iv*) below.	I						
(*i*) Advice and training from the manufacturer	The quality of advice and training on the operation of the instrument from the manufacturer's applications department.	VI for new user	This helps in-house staff to make the most effective use of the equipment.	PS WF ST				
(*ii*) Technical literature	The range and quality of technical literature including the operating manual.	I	Guidance on optimum use of instrument suggests manufacturer's awareness of applications.	PS WF ST				
(*iii*) Telephone assistance	Willingness of the manufacturer or supplier or contractor to give effective advice over the telephone. This can normally only be evaluated by reference to existing users.	I	Rapidly available technical help reduces the number of call outs and enhances productivity.	PS WF ST				
(*iv*) Maintenance by a customer	Score for the facilities for the user to do verification and routine maintenance, *e.g.*, change a consumable.	I	Reduces call out cost for a simple procedure.	PS WF ST				
Instrumental criteria *1 General features* (*a*) Facilities required for:								
(*i*) Access and location of connections and controls on instrument	Score according to convenient access, taking into account the proposed location of the instrument.	I	Depending on bench position and layout, connections and controls may limit accessibility for servicing and installation, particularly at the rear of the instrument.	PS WF ST				
(*ii*) Power requirements	Many systems require multiple power input. Score maximum for instruments with the minimum of separate power leads.	NVI	Excessive numbers of power cables may create hazards and make servicing more difficult.	PS WF ST				
(*iii*) Power failure effects	Score highest for systems that allow recovery from power failure with minimal data/control loss.	I(VI)	Downtime is increased if power failure necessitates manual resetting of instrument control parameters.	PS WF ST				
(*iv*) Size of equipment *i.e.*, 'benchprint'	Score according to convenience of installation.	I(VI)	Dimensions may be critical if space is limited.	PS WF ST				
(*v*) Ventilation requirements	Score highest for system which does not need special additional ventilation.	I	High pressure xenon lamps generate ozone in the atmosphere which must be ventilated.	PS WF ST				
2 Fluorescence excitation (*a*) Excitation source	This can be a line source which provides a few excitation wavelengths or a continuum which, with suitable filters or a monochromator, will allow the analysis of a wide range of fluorophones.							

Feature	Definition and/or test procedure and guidance for assessment	Importance	Reason	Score				
(*i*) High pressure mercury lamp instruments	Score only if the Hg line spectral output will excite the fluorophores to be analysed.	I	This lamp produces a line spectral output which can restrict the ability to optimise the analysis.	PS WF ST				
(*ii*) High pressure xenon source instruments	Score highest if one needs a high intensity continuum.	I	This is required to excite compounds at any chosen wavelength, but these lamps are very expensive to replace.	PS WF ST				
(*iii*) Pulsed xenon source instruments	Score highest if a continuum source is needed and photo-decomposition must be minimised. Time resolved measurements can be made without special accessories.	I	This type of lamp produces short bursts of high energy. These lamps are relatively inexpensive to replace.	PS WF ST				
(*iv*) NIR sources LED and laster instruments	Score only if the emission matches the excitation bands of the analyte.	I	Specific wavelength excitation is often used in biochemical studies and food analysis.	PS WF ST				
(*b*) Wavelength selection								
(*i*) Using filters	Score maximum for the widest selection of suitable interference filters for routine fixed wavelength analyses.	VI	Routine analyses are performed at fixed wavelength. Simple filter spectrometers provide good sensitivity and selectivity.	PS WF ST				
(*ii*) Wavelength selection using a monochromator	Score as appropriate for the resolution and a good signal to noise ratio.	VI	The choice of monochromator will depend upon the spectral characteristics of the compound to be measured.	PS WF ST				
(*c*) Monochromator selection	See Part XI, UV–VIS–NIR Report, for details of the different types of monochromator.							
(*i*) Double monochromator	Score maximum for highest resoluton and lowest stray radiant energy.	I	Stray radiant energy arises from imperfections in the optical system and is best removed with a double monochromator system. This does reduce the sensitivity.	PS WF ST				
(*ii*) Moderate resolution	Score maximum for highest light throughput and the fastest optical response. This type of monochromator produces good signal to noise ratio.	VI	The spectral properties of few molecules require a high resolution system. A good signal to noise ratio is usually much more important in routine analysis.	PS WF ST				
(*iii*) Slit width	Score highest either for a good selection of fixed slits or reproducible variable slits.	VI	It is essential that the slit setting is reproducible as the fluorescence intensity is a function of the light reaching the sample and the detector. This is the only way to compare assays.	PS WF ST				
(*iv*) Monochromator range	Score maximum for a system covering the wavelength range needed for the compounds being studied without the need for changing any of the optical components.	VI	Naturally fluorescent compounds are usually excited by UV light. The system needs to cover as wide a wavelength range as possible.	PS WF ST				
3 Fluorescence emission								
(*a*) Wavelength selection using filters	Choose the system for the application, *i.e.*, fixed wavelength, band pass or ‘Cut-off’ filters for specific assays. *N.B.* These systems are not able to provide spectral information.		Simple filter instruments give high sensitivity and reproducible results.					
(*i*) Discrete wavelength filters	Score highest for the system with the most useful selection of bandpass filters.	VI	Bandpass filters provide good selectivity and sensitivity for routine assays.	PS WF ST				
(*ii*) Continuous interference filter	Score highest for the most accurate peak location.	I	This feature offers the possibility of obtaining a spectrum which could help in the optimisation of the assay.	PS WF ST				
(*iii*) ‘Cut-off’ filters	Score highest if these filters are available for the system.	VI	These are used to allow light of wavelengths longer than the excitation wavelength to reach the detector. This can result in improved detection limits.	PS WF ST				

Feature	Definition and/or test procedure and guidance for assessment	Importance	Reason	Score				
(*b*) Wavelength selection using a monochromator	Select system which provides 'corrected' spectra. Score only if it is important that spectral data will be compatible with published data or spectra recorded in other laboratories.	(VI)	The optical throughput as well as other factors will superimpose distortions on the spectrum of the compound being analysed, which need to be corrected easily.	PS WF ST				
(*i*) Array dectors	Score only if a diode array or charge coupled device provides the spectral response suitable for the system under investigation.	(I)	These detectors can have advantages of the species under investigation has changing spectral properties. They may have a slow readout time and low sensitivity.	PS WF ST				
4 Sampling accessories	Score highest for the system which provides the most comprehensive selection of easily installed accessories for the analyses to be performed. A higher score should be given if the accessories are software controlled.	I	If liquids and solids are to be studied, suitable accessories are needed to make these measurements. Software controlled accessories allow the system to be reset to the same state for each experiment. Data collection and manipulation can then be combined easily under identical conditions.	PS WF ST				
(*i*) Manual single and multiple cell holder for standard, micro- and flow cells	Score highest if the cell holders can be thermostatted. Score additionally if the temperature in the cuvette can be monitored.	VI	Fluorescence intensity varies with temperature. It is essential to accurately control the temperature for kinetic and biochemical studies.	PS WF ST				
(*ii*) Sample holder for solids	Score highest if this accessory can accommodate powders, films and if one cuvette can be reproducibly aligned.	I	Reflectance techniques are also used for highly absorbing samples to enable the fluorescence from the surface of the sample to be measured.	PS WF ST				
(*iii*) Phosphorescence accessory	Score only if this facility is required and available.	(I)	This accessory is usually not necessary for room temperature measurements if the system uses a pulsed source to gate the excitation and emission cycles.	PS WF ST				
(*iv*) Low temperature accessory	Score only if this facility is required and score highest if the accessory can be used at a user defined temperature.	(I)	In many analytical systems phosphorescence is observed only at low temperature.	PS WF ST				
(*v*) Single and multiple thermostatted cell holders which can be fitted with a stirrer.	Score highest if the stirrer speed and temperature settings can be software controlled and stored wth the data.	VI	Important if measuring biological cells in suspension or collecting kinetic data.	PS WF ST				
(*vi*) Flow cells	Score only if the system supports flow cells and score highest if the cell position is easily and reproducibly aligned.	VI	System can be used for routine assays with a sampler (sipper) or as an HPLC detector using a micro-flow cell.	PS WF ST				
(*vii*) Sipper system. Autosampler. Tablet dissolution. Flow injection system	Score only if the equipment is needed for a particular usage. The system must have suitable software for the device.	I/VI	System must be software controlled and support the flow cell with the correct sample volume for the application.	PS WF ST				
(*viii*) Polarisation accessory	Score only if this accessory is needed and score highest for software manipulated polarisers and temperature controlled sample holders. If rapid changes in polarisation are being followed, a 'T-format' system might be necessary.	I	Measurement must be made at a constant temperature which ideally should be stored with the polarisation data for further data manipulation. Rapid changes in polarisation can be followed using two emission monochromators, both perpendicular to the excitation monochromator in a 'T-format'. Simultaneously one measures the vertical and the other the horizontal polarisation. The software calculates the polarisation in the usual way.	PS WF ST				

Feature	Definition and/or test procedure and guidance for assessment	Importance	Reason	Score				
(*ix*) Plate reader	Score maximum for a system which can scan 96, 48, 24 and 12 well formats plates.	I	Different sized micro-plates are in use so the accessory should be capable of measuring all of them.	PS WF ST				
5 Instrument control and data collection								
(*i*) On-board computer	Score highly for a simple low cost effective routine instrument which has on-board software and is controlled from an integral keyboard. Score additionally for the facility to export the data to an external computer (for further data manipulation of this is needed).	VI	Simplifies the operation and ideally should be able to provide simple method storage and limited data manipulation routines, *e.g.*, linear quantitation using standards.	PS WF ST				
(*ii*) Data output	For routine analyses score for an instrument that can output data to a printer/plotter or as an ASCII or industry standard file to a computer. A scanning instrument may output an analog signal to a recorder or data logger.	I	A digital output is preferred so that if necessary further data processing can be easily performed. It should also enable all the data collection parameters to be stored with the data.	PS WF ST				
(*iii*) External control of instrumental parameters	For non-routine analyses or research, score highest for a comprehensive software package to control the spectrometer and collect the data.	VI	Ensures that the same analyses are always perfomed under identical conditions. This is vital if the system is used in a 'controlled' environment. Manufacturer's software will have been tested. *N.B.* It is rarely cost effective to write one's own software.	PS WF ST				
(*iv*) Instrument performance	Score maximum for an instrument which self-calibrates on power up and has a simple validation routine programmed into the software.	VI	As more instruments are used in regulated laboratories it is vital that the system performs an effective calibration routine on switch on. This information must be stored.	PS WF ST				
6 Data manipulation								
(*a*) Data collation software	Define the requirements before scoring these items. Most manufacturers offer software packages with routines for setting the instrument parameters and collecting the data. The choice of how the software runs can be a very personal choice. Make sure that the features offered are fully evaluated. The ease with which the data can be acquired and reports generated are of prime importance. Score only for the availability of essential routines.	VI	Control and data collection software options are essential for data integrity and must include all of the required routines. Software packages from the manufacturer are expensive, but the effort it will take to write and validate one's own software would prove to be extremely time-consuming and therefore much more expensive.	PS WF ST				
(*i*) Fixed wavelength data collection	Score highest if all parameters can be set and stored with the spectral data to ensure that all future analyses can be performed under the same instrumental conditions.	VI	Deviations must be flagged by the software. Essential for many regulatory requirements, *e.g.*, GLP, GMP and all regulated industries.	PS WF ST				
(*ii*) Spectral data collection of corrected excitation spectra	Score zero if there is no facility for correcting excitation spectra. Score for manual correcting and highest for automatic spectral correction.	VI	Most fluorescence spectrometers are single beam and instrumental characteristics are superimposed on the true spectral data. Corrected fluorescence excitation spectra are related to absorption spectra. Correction factors may be measured and stored in the software during manufacture. Alternatively the system may have a built in auto-gain mechanism which automatically compensates for instrumental artefacts.	PS WF ST				

Feature	Definition and/or test procedure and guidance for assessment	Importance	Reason	Score				
(*iii*) Software routines for checking and remeasuring the excitation correction factors	Score if this routine is available. A rhodamine dye is frequently used as a quantum counter, alternatively an electronic equivalent may be used for these measurements.	I	This may be necessary due to ageing of the source or detector, or if the system is upgraded. If the spectral properties of the compounds being investigated are outside the range of rhodamine then another quantum counter should be used.	PS WF ST				
(*iv*) Software routines for collecting and storing emission correction factors	Score if the routine is provided with instructions for performing the data collection and preparing the samples.	VI	Emission spectra should be corrected for instrumental artefacts to ensure that comparison of data from different instruments is possible. Corrected emission spectra are used if quantum yields of compounds are determined.	PS WF ST				
(*v*) Spectra and time dependent data to be stored as ASCII files	Score maximum for a system where all data collection parameters are also stored with this ASCII data.	VI	ASCII data can be exported to and manipulated by many software packages. This expands the scope of data manipulation and chemometric routines available to the user.	PS WF ST				
(*vi*) Display software routines	Score maximum for a comprehensive set of spectra display routines. Score additionally for the possibility of pseudo 3-D contour plotting if this feature is considered to be desirable.	VI	Simple versatile spectral display routines are vital. Pseudo 3-D contour plotting shows more features especially if studying mixtures.	PS WF ST				
(*vii*) Ability to perform synchronous scans	Score highly for a spectromer which offers the possibility of scanning with a constant wavelength difference between the monochromators. Score additionally if it can also scan with a constant energy difference between the monochromators.	VI	A synchronous scan can be used to ‘fingerprint’ mixtures. Constant energy scans often give the clearest picture for qualitative identification.	PS WF ST				
(*b*) Data handling								
(*i*) Software to perform all arithmetic functions, *e.g.*, area, smoothing, derivatives, averaging, calculation on single points or spectra	Score according to the availability of these routines, especially if quantum yields or polarisation measurements are to be made.	VI	The software enable routines to transform raw data without having to use third party software.	PS WF ST				
(*ii*) Quantitative analysis routines using single wavelength data or spectra for multi-component work	Score according to the availability of several routines for, *e.g.*, single wavelength quantitation. Score additionally if spectral data can be exported to be used in multi-component analysis software.	I	Linear and other non-linear functions should be provided for single wavelength quantitative analysis, as well as kinetic models, especially for biochemical assys.	PS WF ST				
(*iii*) Software to control any accessory and simultaneously collect associated data	Score maximum for the availability of routines, *e.g.*, to control a polarisation accessory and also calculate the polarisation or anisotropy functions.	I	Simplifies the measurements and ensures that all data are compatible when carrying out the calculations.	PS WF ST				
(*iv*) Specific application routines, the ability to customise and record the parameters	Score maximum if this feature is present and appropriate.	(VI)	This facility enables routines to be made so that less experienced staff can perform the analysis under optimum conditions routinely.	PS WF ST				
(*v*) Routines for checking the sensitivity of the spectrometer	Score maximum for the availability of a routine and the appropriate ‘standard’ samples to make these measurements.	VI	Keeping track of the instrument sensitivity is vital. For example, these measurements will show up a lamp nearing the useful end of its life	PS WF ST				

Feature	Definition and/or test procedure and guidance for assessment	Importance	Reason	Score				
(*vi*) Validation software	Score maximum for a system to comply with the regulating authorities' standards with validation routines as a standard feature.	(VI)	Essential in many laboratories.	PS WF ST				
6 Hardware and output requirements								
(*i*) Computer	Score for compatibility with either existing or company selected computer.	VI	There may be a company requirement for uniformity. Speed and ability to upgrade are important.	PS WF ST				
(*ii*) Output devices	Score maximum for a system which uses a standard printer, *e.g.*, laser, inkjet or dot matrix.	VI	This facility had become very important for uniformity.	PS WF ST				
(*iii*) Data storage	Score for possibility to store data on suitable media for future retrieval and use.	VI	This is very important as is the provision of a hard copy. Date and acquisition parameters must also be archived.	PS WF ST				
(*iv*) Data output from simple instruments	Score if printed data output from a digital readout on the instrument or analog output to a recorder is needed.	(I)	It is beneficial if the system can be coupled to a standard printer to produce a hard copy.	PS WF ST				
(*v*) Ability to be networked	Score if this feature is required.	I/VI	In most laboratories the instrument is run from a PC and at a suitable time the data is transferred to a server.	PS WF ST				
				Sum of sub-totals				
7 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				

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