



**Malvern
Panalytical**
a spectris company

EPSILON 1

Easiest analysis of sulfur in fuels





QUANTIFICATION OF SULFUR IN FUELS

In compliance with international test methods

Looking for an easy and economical method for compliant analysis of sulfur in fuels?

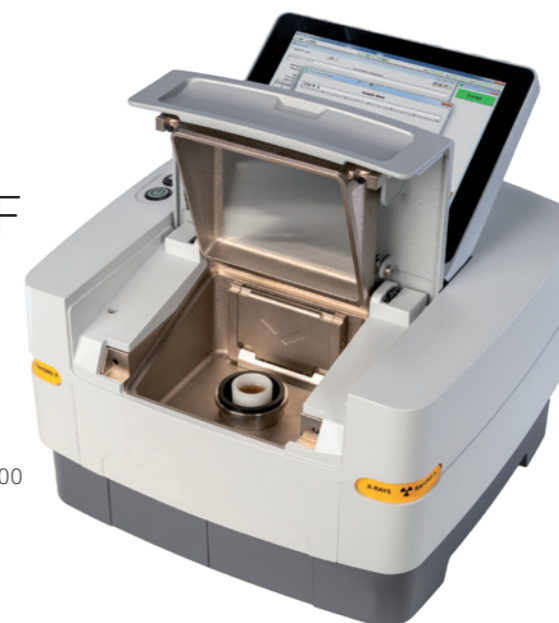
Epsilon 1 is the ideal analytical solution. The system is pre-calibrated in the factory and is an out-of-the-box solution with guaranteed performance in compliance with ASTM D4294, ISO 20847 and 8754, IP 496 and 336, and JIS K2541-4. These methods describe the testing for sulfur in petroleum and petroleum products like fuels by XRF.

Epsilon 1 produces fast, cost-effective, precise and accurate data with minimal operator dependence and sample preparation. The total running cost is therefore relatively low at about only € 1.- per sample. This is far less than techniques such as AAS, ICP and wet-chemical methods that are costly and also require a dedicated skilled operator.

Malvern Panalytical has a strong reputation for high-end X-ray instrumentation. Epsilon 1 is built using our market-leading technology with superior quality, worldwide service and application support.

THE TOTAL SOLUTION CONSISTS OF

- Epsilon 1 instrument with user software
- Factory pre-calibration for sulfur in fuels
- A validation standard
- A starting kit for preparing 100 liquid cups for analysis



- ASTM D4294
- ISO 8754
- ISO 20847
- IP 336
- IP 496
- JIS K2541-4



Sample preparation foils



Preparation tool



Liquid cups



Validation standard

RESULTS IN JUST 4 STEPS

Easy sample preparation



Use the handy tool for preparing the liquid cup.



Fill the cup two thirds full.

Easy analysis



Place your sample for measurement.



Enter sample name and touch the 'measure' icon.

COMPLIANT RESULTS



MEASURE IN YOUR OWN LANGUAGE

Ten most common languages are available for the operator:

- 測量
- Measure
- 測定
- Mesurer
- Messung
- Mesure
- Zmierzyć
- Medida
- Измерить
- Médir

BUILT FOR COMPLIANCE

The Epsilon 1 is a fully integrated energy dispersive XRF analyzer consisting of a spectrometer, built-in computer and analysis software. Powered by the latest advances in excitation and detection technology the Epsilon 1 is a star performer in the low-cost benchtop instrument class. A well-designed optical path, a wide range of excitation capabilities ranging from 7 to 50 kV for light and heavier elements and a highly sensitive SDD detector system contribute to the Epsilon 1's uniqueness.

Self-contained system

Built-in computer running Microsoft Windows 10 with a powerful CPU and 120 GB hard drive ensures flexibility to store and handle thousands of results.

Repeatability for years

A low-drift X-ray tube and a handy drift correction routine give compliant results for years without the need for time-consuming re-calibration.

Maximum sensitivity

The thin-window Ag anode X-ray tube, designed and manufactured by Malvern Panalytical, ensures high quality and sensitivity. The selection of Ag anode material is ideal for the accurate quantification of S without interference of possible line overlaps in the XRF spectrum, leading to more reliable results.

Spillage protection

In order to shield the delicate heart of the system from spillage, a protection foil is in place. In case of spillage, the foil can be replaced easily by the operator.

Economical footprint

Compact design with a built-in computer and touch screen reduces the requirement of valuable lab space to less than 0.15 m².

Easy operation

High-resolution (1024 x 768), 10.4" LCD touchscreen for easy walk-up and operation.

Easy communication / connection

USB and network connections for use of standard computer peripherals enable extended use, application development and seated operator.

Best accuracy

Highly concentrated samples can cause detector saturation resulting in lower accuracy or longer measuring times. Epsilon 1 uses the latest in silicon drift technology to handle these highly concentrated samples without any loss of accuracy or increased measuring times.

Atmospheric variations

Low-energy X-ray photons, like those of phosphorus and sulfur are sensitive to air-pressure and temperature variations. Built-in temperature and air-pressure sensors compensate for these atmospheric variations, ensuring excellent results whatever the weather.

Sample positioning

Highly repeatable sample positioning reduces sample-to-sample variations.

Safety guaranteed

Epsilon 1 complies with the latest Machinery Directive, CSA, IEC, EMC, Vollschutz norms and standards for protection and radiation safety to guarantee a safe instrument for the operator.

ADVANTAGES OF XRF FOR FUELS ANALYSIS

- Quick quantification method
- Simple, fast and safe sample preparation
- Non-destructive analysis
- Wide analytical concentration range (ppm - %) reducing the necessity for dilution and associated errors
- Accurate and reproducible data compared to other techniques
- No need for helium

Z		Factory pre-calibrated	
Z		Possible to analyze with Epsilon 1	
Z		Not possible to analyze with Epsilon 1	

H	He	B	C	N	O	F	Ne												
Li	Be	Al	Si	P	S	Cl	Ar												
Na	Mg	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe		
Cs	Ba	L	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn		
Fr	Ra	A	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts	Og		
L		La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu			
A		Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr			





ROBUST AND ACCURATE QUANTIFICATION OF SULFUR IN FUELS

Calibration

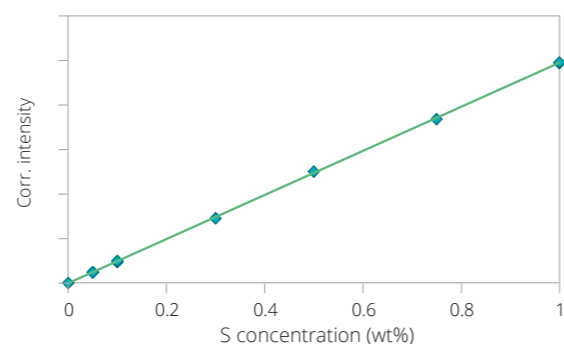
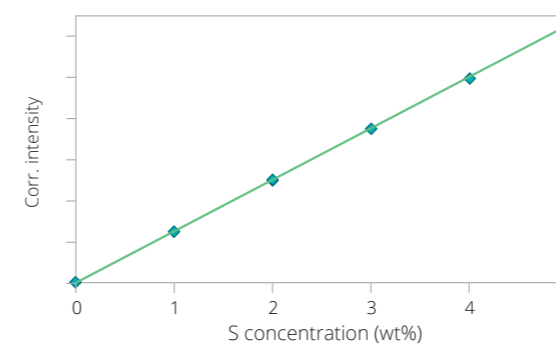
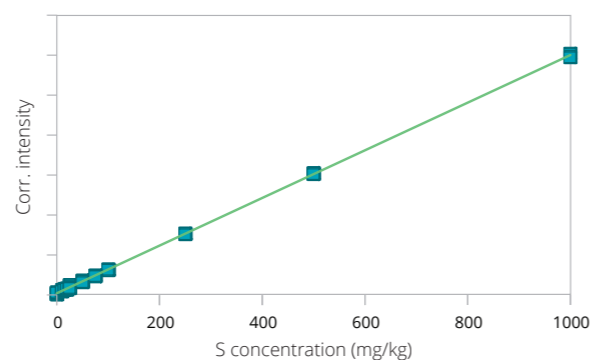
Commercially available fuel standards from VHG Labs Inc. (US) were used to pre-calibrate Epsilon 1 for sulfur according to the following international test methods: ASTM D4294, ISO 20847 and 8754, IP 496 and 336, and JIS K2541-4.

The gasoline, diesel, crude oil and kerosene standards for setting up the calibration were measured in duplicates. The measurement time was 5 minutes per sample for the first calibration. For the second and third calibration, only 2 minutes were used.

The calibration root mean square (RMS) values presented in the table and the calibration graphs demonstrate a high degree of accuracy for the methods.

Element	Concentration range	RMS (mg/kg)	Correlation
S	0 - 1000 mg/kg	1.8	0.99994
	0.1 - 1 (wt%)	47	0.99994
	1 - 5 (wt%)	127	0.99998

The RMS value is a measure of the difference between the calculated concentration and the chemical concentration and is therefore a measure of the accuracy of the method (standard deviation).



Accuracy

The accuracy of the method is demonstrated by measuring a diesel validation standard as unknown sample and comparing the measured concentration against the certified concentration. The data in the table demonstrate excellent accuracy.

Element	Certified concentration (mg/kg)	Measured concentration (mg/kg)
S	20	19.5 ± 1.3

Ultra-low sulfur levels

For quantifying ultra-low sulfur levels in fuels, a ten minutes measuring time is employed. This ensures more accurate sulfur results when approaching the detection capabilities of the Epsilon 1. The table shows detection capabilities in fuels when using 3.6 µm Mylar supporting foil for the liquid cups and the existing protection foil.

Sulfur in fuels	Detection capabilities (mg/kg)
LLD (5 min)	1.5
LLD (10 min)	1.0



COMPLYING WITH ASTM D4294 AND ISO 20847

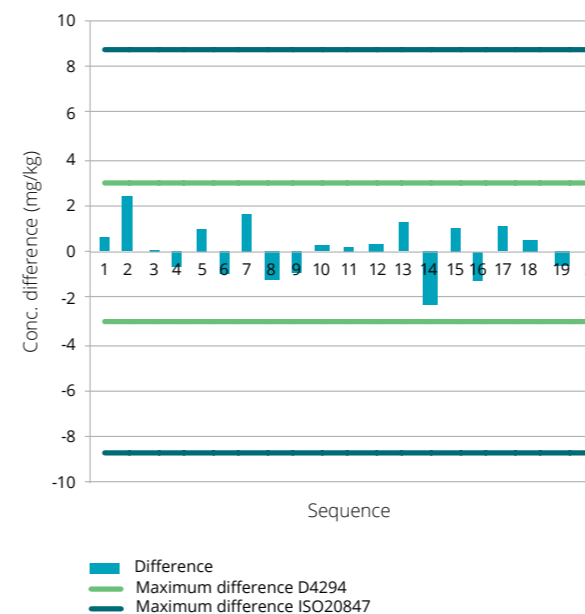
Precision

Measurement precision is an important requirement of ASTM D4294 and ISO 20847. Epsilon 1 readily passes the requirements set in the latest, most stringent ASTM and ISO norms.

To test the precision of the method, 40 freshly prepared samples of a diesel product were measured consecutively. For every two measurements the average concentration is reported. The precision of this method is illustrated graphically. The bar graph visualizes the difference between each reported average. The lines show the maximum difference allowed by ASTM D4294 and ISO 20847.

The average concentration, maximum achieved difference between successive measurements and the difference allowed by ASTM D4294 and ISO 20847, are presented in the table.

Element	Average concentration (mg/kg)	Largest difference (mg/kg)	Maximum permitted difference by ASTM D4294 (mg/kg)	Maximum permitted difference by ISO 20847 (mg/kg)
S	19.5	2.4	3.0	8.4



Epsilon 1 is a star-performing benchtop XRF instrument and is well suited for the analysis of sulfur in fuels according to the latest ASTM, ISO, IP and JIS test methods.

✓ The results of the repeatability test for sulfur are well within the limits set by ASTM D4294, being the most stringent method.

Another pre-calibrated petrochemical application option is available:

Additives in lubricating oils in compliance with ASTM D6481





WHY CHOOSE MALVERN PANALYTICAL?

We are global leaders in materials characterization, creating superior, customer-focused solutions and services which supply tangible economic impact through chemical, physical and structural analysis.

Our aim is to help you develop better quality products and get them to market faster. Our solutions support excellence in research, and help maximize productivity and process efficiency.

Malvern Analytical is part of Spectris, the productivity-enhancing instrumentation and controls company.

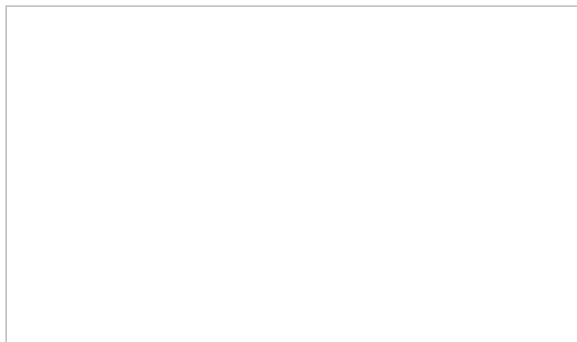
www.spectris.com

SERVICE & SUPPORT

Malvern Analytical provides the global training, service and support you need to continuously drive your analytical processes at the highest level. We help you increase the return on your investment with us, and ensure that as your laboratory and analytical needs grow, we are there to support you.

Our worldwide team of specialists adds value to your business processes by ensuring applications expertise, rapid response and maximum instrument uptime.

- Local and remote support
- Full and flexible range of support agreements
- Compliance and validation support
- Onsite or classroom-based training courses
- e-Learning training courses and web seminars
- Sample and application consultancy



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