Malvern Panalytical
a spectris company

EPSILON 1 FOR ULTRA-LOW SULFUR

Compliance with low running costs

NO NEED FOR HELIUM!

QUANTIFICATION OF **ULTRA-LOW SULFUR IN AUTOMOTIVE FUELS**

In compliance with international test methods

Epsilon 1 is the ideal analytical solution. The system is pre-calibrated in the factory and is an out-of-the-box solution for the analysis of ultra-low sulfur content in fuels in compliance with ISO 13032. Epsilon 1 also complies with less-stringent sulfur test methods such as ASTM D4294 and ISO 8754.

We have a strong reputation for high-end X-ray instrumentation. Epsilon 1 is built using our market-leading, superior-quality technology and underpinned by our worldwide services and application support.

Epsilon 1 gives you precise and accurate data, starting at 5 ppm sulfur in fuels, with minimal sample preparation and running costs. Thanks to the high sensitivity of its excitation and detection components, you don't need helium gas to achieve ISO 13032-compliant results. The air pressure and temperature sensors in the instrument, combined with advanced software algorithms, make every measurement result stable and independent of the environmental conditions. This innovation keeps the total running cost to a minimum, at only € 1.- per analysis.

THE TOTAL SOLUTION CONSISTS OF

- Epsilon 1 instrument. with user software.
- Factory pre-calibration for sulfur in fuels in compliance with ISO 13032. Precalibrated for Chlorine analysis - optional.
- A validation standard.
- A starting kit for preparing 100 liquid cups for analysis.
- Monitor samples to keep the calibration up to date.

- ISO 13032
- 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:

测量
Measure
测定
Mesurer
Messung
Mesure
Zmierzyć
Medida
Измерить
Médir

BUILT **FOR HIGH SULFUR AND CHLORINE SENSITIVITY**

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 30 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 vanadium anode X-ray tube, designed and manufactured by Malvern Panalytical, ensures high quality and sensitivity. The selection of vanadium anode material is ideal for the accurate quantification of S and Cl 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 m^2.

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

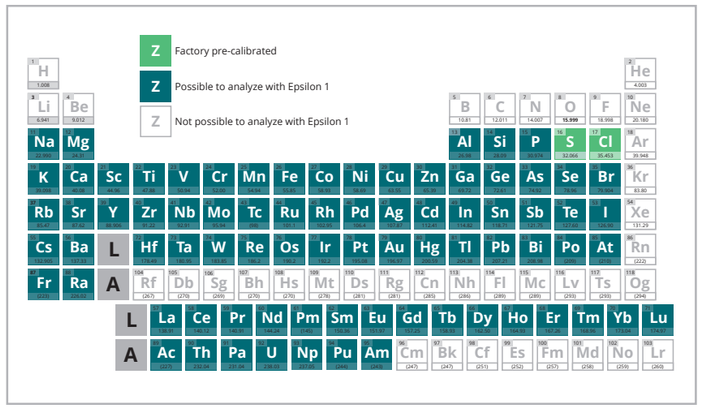
Easy communication / connection
USB and network connections for use of standard computer peripherals enable extended use, application development and seated operator.

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, sulfur and chlorine 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.



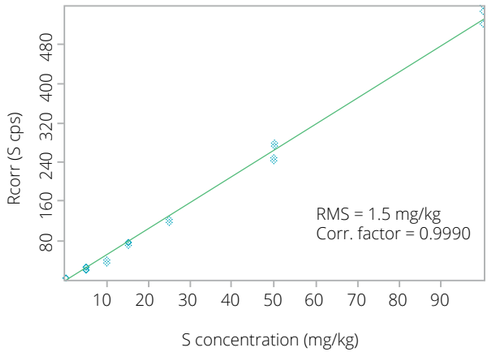
ADVANTAGES OF XRF FOR FUELS ANALYSIS

- 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**

ROBUST AND **ACCURATE QUANTIFICATION** OF SULFUR IN FUELS

Calibration

Commercially available fuel certified reference materials (CRM) from LGC-VHG Labs Inc (US) were used to pre-calibrate Epsilon 1 for sulfur using the ISO 13032 international test method. The gasoline and diesel CRMs for setting up the calibration were measured in duplicates. The measurement time was 10 minutes per sample. The calibration root mean square (RMS) value and correlation factor, together with the calibration graph, show a high degree of accuracy for the method.



Instrument compliance

According to ISO 13032 test method, the peak-to-background ratio (Rs-Rb)/√Rb of a 10 mg/kg sulfur in oil CRM should be > 1.3 Without the need of helium, the peak-to-background ratio of this dedicated Epsilon 1 is 4.0.

Another criterion of the instrument compliance in the norm is that the relative standard deviation of a repeated measurement should be < 5 %. With the same sulfur in oil CRM, a relative standard deviation of 3 % was achieved.

Both results show that the Epsilon 1 instrument can analyze sulfur in fuels, well within the performance characteristics of the ISO 13032 test method.

Accuracy

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

Element	Certified concentration (mg/kg)	Measured concentration (mg/kg)
S	10	10.1 ± 0.3

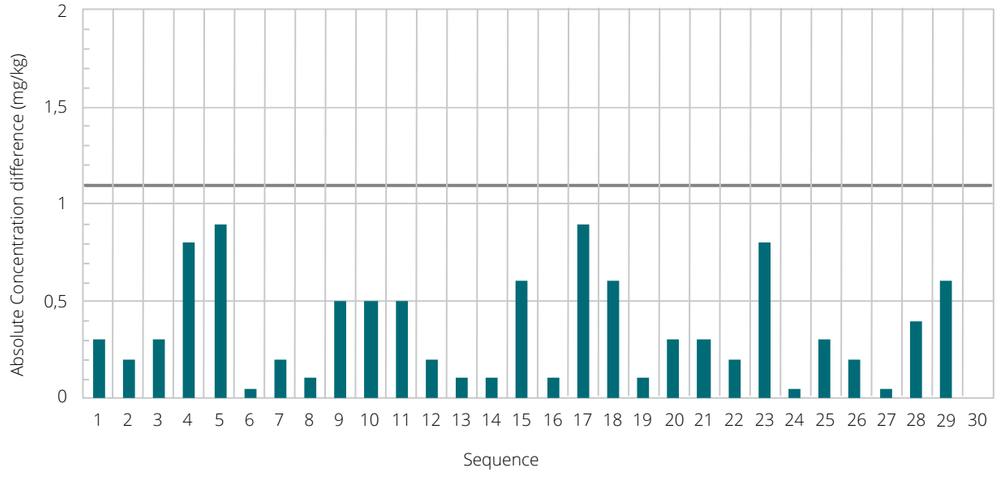
Repeatability

Repeatability is another important requirement of ISO 13032. Epsilon 1 easily passes the requirements set in the latest version of the test method.

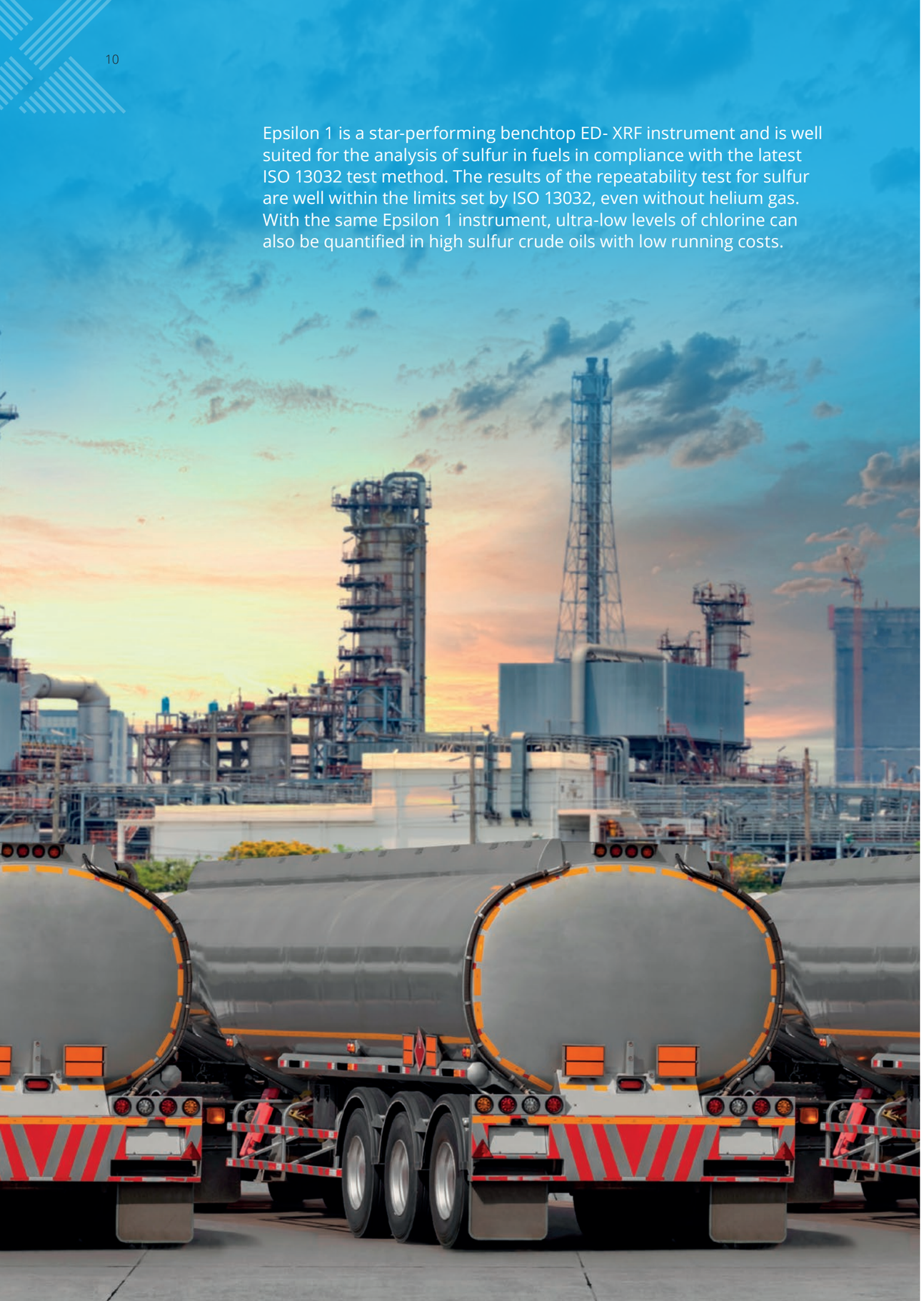
To test the repeatability of the method, 30 freshly prepared samples of a diesel CRM were measured consecutively. The repeatability of this method is illustrated graphically. The bar graph shows the absolute difference between successive measurements.

The line shows the maximum difference allowed by ISO 13032. The average concentration, largest difference between successive measurements and the maximum permitted difference allowed by the method, are shown in the table.

Element	Average concentration (mg/kg)	Largest difference (mg/kg)	Max. permitted difference by ISO 13032 (mg/kg)
S	10.2	0.9	1.1



Epsilon 1 is a star-performing benchtop ED- XRF instrument and is well suited for the analysis of sulfur in fuels in compliance with the latest ISO 13032 test method. The results of the repeatability test for sulfur are well within the limits set by ISO 13032, even without helium gas. With the same Epsilon 1 instrument, ultra-low levels of chlorine can also be quantified in high sulfur crude oils with low running costs.



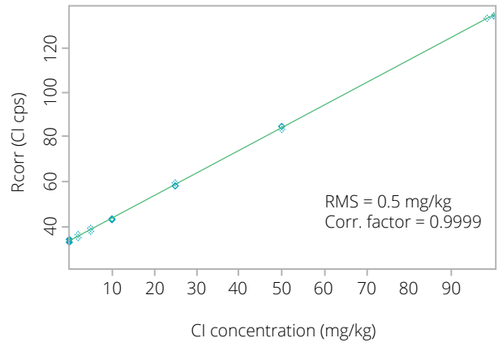
TRACE ANALYSIS OF **CHLORINE IN CRUDE OILS**

Another pre-calibrated application option available

Many applications can be set-up on the same Epsilon 1 instrument. In addition to sulfur in automotive fuels, traces of chlorine in crude oils can also be quantified.

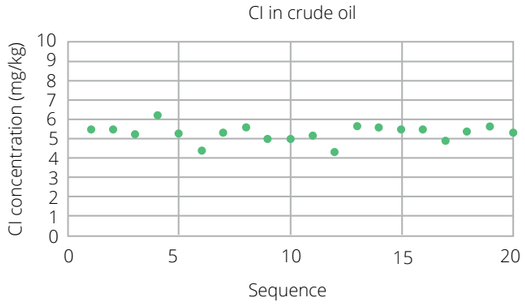
Calibration

Commercially available oil CRMs from VHG Labs Inc (US) were used to pre-calibrate Epsilon 1 for trace analysis of chlorine with high sulfur content of up to 1.5 wt%. The measurement time was 10 minutes per sample. The calibration root mean square (RMS) value and correlation factor, together with the calibration graph, demonstrate a high degree of accuracy for the method.



Repeatability

Measurement repeatability shows the stability of the benchtop instrument. To test the repeatability of the whole application method, 20 freshly prepared samples of an oil sample were measured consecutively. The repeatability of this method can be seen in the graph. The average concentrations and the RMS values for chlorine and sulfur are also visible in the graph. The results show a stable performance of the method, even with the presence of 0.8 wt% sulfur in the oil sample.



Accuracy

Commercially available oil CRMs from VHG Labs Inc (US) were used to pre-calibrate Epsilon 1 for trace analysis of chlorine with high sulfur content of up to 1.5 wt%. The measurement time was 10 minutes per sample. The calibration root mean square (RMS) value and correlation factor, together with the calibration graph, demonstrate a high degree of accuracy for the method.

Oil standard	Cl concentration (mg/kg)	S concentration (wt%)
5 mg/kg Cl with 0.5 wt% S	4.7	0.5
5 mg/kg Cl with 1 wt% S	5.6	1.0
10 mg/kg Cl with 0.5 wt% S	10.6	0.5
10 mg/kg Cl with 1 wt% S	10.9	1.0

Ultra-low chlorine levels in high sulfur crude samples

The detection limit is influenced by the measuring time, material type and the presence of neighboring elements in the XRF spectrum. The table shows detection capabilities for chlorine in crude samples with low and high sulfur concentrations, in 10 minute measuring times.

Crude oil sample	Detection limit for Cl (mg/kg)
with 0.5 wt% S	1.3
with 1.5 wt% S	1.5

Malvern Panalytical
a spectris company

WHY CHOOSE US?

When you make the invisible visible, the impossible is possible.

Our analytical systems and services help our customers to create a better world. Through chemical, physical and structural analysis of materials, they improve everything from the energies that power us and the materials we build with, to the medicines that cure us and the foods we enjoy.

We partner with many of the world's biggest companies, universities and research organizations. They value us not only for the power of our solutions, but also for the depth of our expertise, collaboration and integrity.

With over 2200 employees, we serve the world, and we are part of Spectris plc, the world-leading precision measurements group.

Malvern Panalytical. We're BIG on small™.

SERVICE & SUPPORT

Malvern Panalytical 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

MALVERN PANALYTICAL

Grovewood Road, Malvern,
Worcestershire, WR14 1XZ,
United Kingdom

Tel. +44 1684 892456
Fax. +44 1684 892789

Lelyweg 1,
7602 EA Almelo,
The Netherlands

Tel. +31 546 534 444
Fax. +31 546 534 598

www.malvernpanalytical.com/epsilon1