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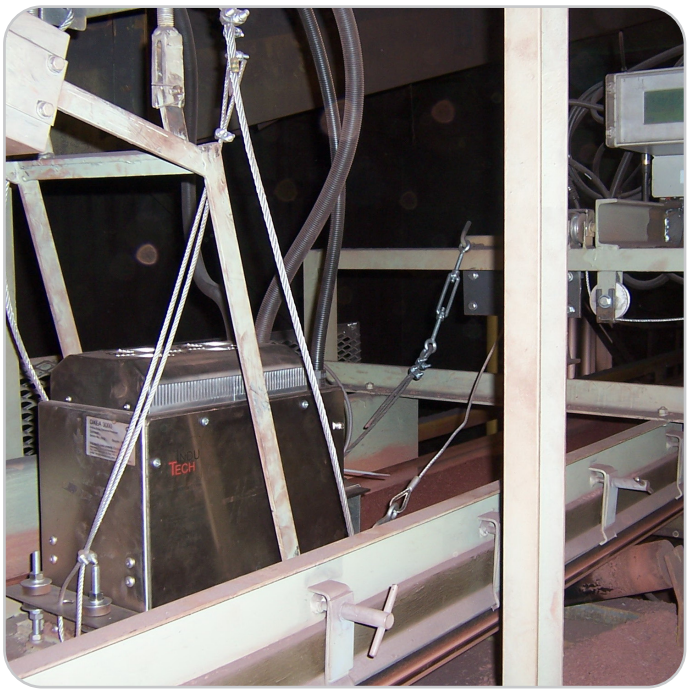
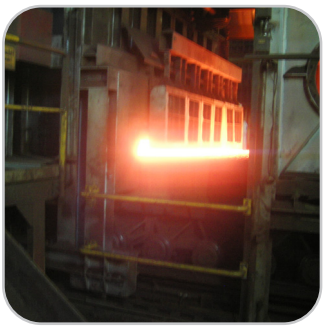
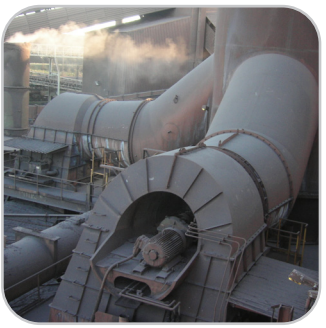
OXEA®

Online X-ray Elemental Analyzer

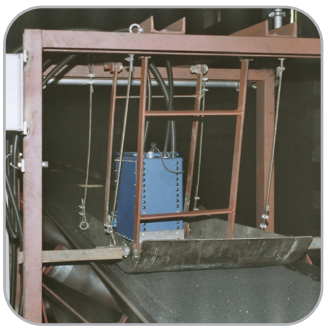






Features

- Fast quality control
- For elements from Sodium upwards
- No radioactive sources
- Reliable and safe
- Low operating costs
- Fast amortization



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OXEA® - Online Elemental Analyzer

OXEA (**O**nline **X**-ray **E**lemental **A**nalyzer) is based on the X-ray fluorescence technology (XRF) which is well known in the laboratory field.

With the aid of a patented procedure, this method was made online capable. The instrument is available in different versions and is used successfully on all kinds of materials, e.g. coal, ore and cement, and also in the food industry.

The OXEA instruments include a very powerful software package to detect and exactly analyze X-ray fluorescence spectra. The measured concentrations are depicted graphically, saved to a database and are available to the user on request as data telegram.

Optionally, the XRF analyzer may be combined with the microwave moisture meter PMD 2450. The data of both instruments are evaluated by the software. As a result of the demands on the measurement geometry, the measurement is preferably carried out on a representative bypass, where the partial flow taken is supplied to the measurement device on a small conveyor belt.

An installation above the main conveyor belt using a special sledge is also possible.

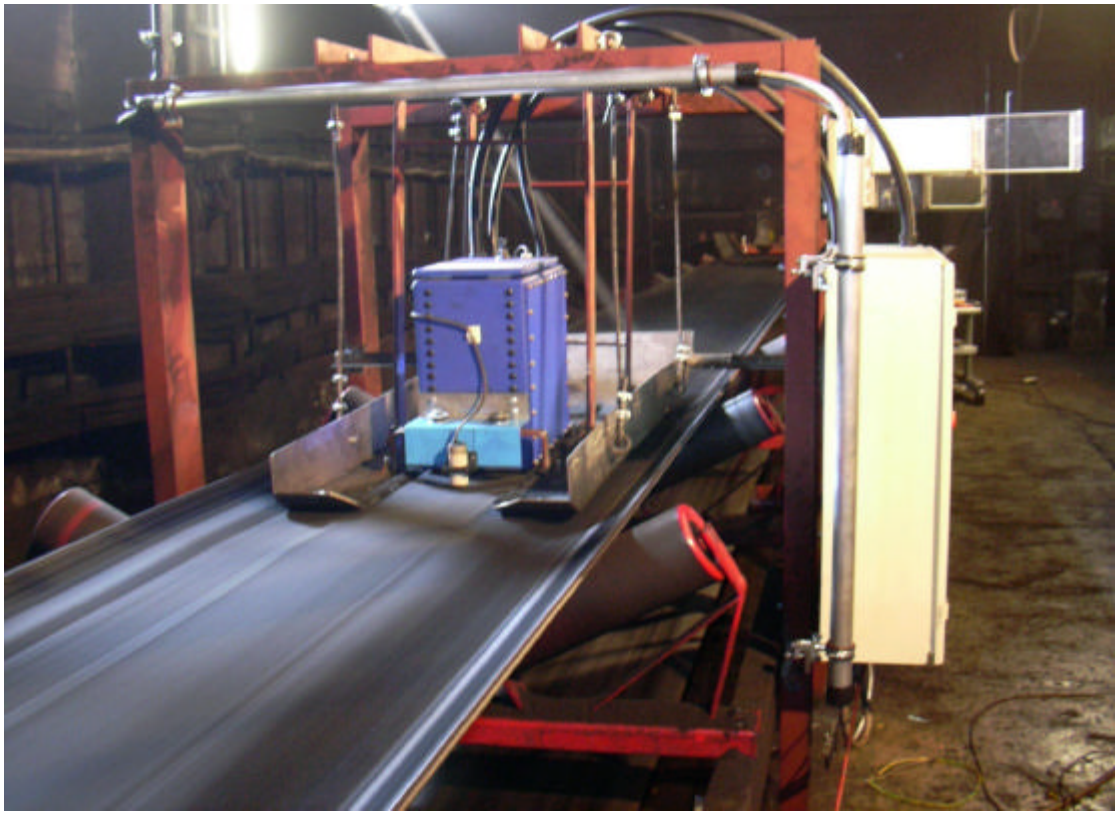


Figure 1: OXEA **3000 on a sledge**

The Principle of Measurement

Irradiated matter is ionized by X-ray radiation. If sufficient excitation energy is available, the inner electrons will be extracted from the atomic compound. The created gaps in the inner electron shell are filled by electrons from the outer shells. The energy being released in the course of this process will be emitted as photons, i.e. as X-ray radiation. The energy of this radiation is characteristic for the element which the respective photon has created.

The detectors used convert the X-ray radiation into electrical pulses, with the pulse height being proportional to the energy of the photons. Energy-dispersive X-ray spectroscopy means that the pulse height of each photon is now determined and assigned as an event to one channel each. This device is called multi-channel analyzer. If one reads out – after an adequate time of measurement – the data stored in the multi-channel analyzer and plots the number of events versus the channel number, then one gets the spectrum.

This spectrum can be divided into background and characteristic lines. The intensity of the line is a measure of the concentration of the respective element. When determining the concentration, however, one has to take into account that characteristic photons may be absorbed by other elements on the way from the emitting element to the detector. The line of the analyzed element will thus be reduced and the lines of the low energy element will be depicted inflated.

This reciprocal action is called matrix effect. The matrix effect can be compensated for by means of mathematical methods. The respective correction factors can be determined for a specific product during calibration of the instrument. If one knows the measurement geometry and the required data of the X-ray tube and the detector exactly, one may also calculate these correction factors on the basis of so-called fundamental parameters which can be taken from tables.

OXEA utilizes the energy-dispersive method of X-ray fluorescence using high resolution detectors and thus allows product-specific matrix compensation as well as the use of fundamental parameters.

Comparison with other Measurement Methods

The measurement accuracy of the OXEA instrument can be compared with those of PGNAA-instruments which are much more costly and complex and which require high energy neutron radiation for excitation.

The table below shows the variables or elements that are relevant for coal. As you can see, only a few elements at the beginning of the periodic system cannot be measured with the XRF system OXEA. All other elements are detected with similar accuracy by both methods. To determine the calorific value, an online water content determination is required for both methods.

Measurement	PGNAA	XRF
Standard Analysis		
▪ Moisture	✓	✓
▪ Ash	✓	✓
▪ Sulphur	✓	✓
▪ Calorific value (Btu/lb.)	✓	✓
▪ lb. SO_2/MBtu	✓	✓
Elemental Analysis		
▪ Hydrogen	✓	
▪ Carbon	✓	
▪ Nitrogen	✓	
▪ Sodium	✓	✓
▪ Aluminium	✓	✓
▪ Silicium	✓	✓
▪ Sulphur	✓	✓
▪ Chlorine	Oversensitive!	✓
▪ Potassium	✓	✓
▪ Calcium	✓	✓
▪ Titan	✓	✓
▪ Iron	✓	✓

Instruments working according to the dual-energy method can only determine the ash content. This principle of measurement is based on the absorption of Am- and Cs-rays by ash-producing chemical elements. Since a general absorption is being measured, the measurement is significantly dependent on the variations in ash composition.

These variations can only be compensated for partially, even if a third energy source is used. In any case, a XRF measurement device is to be preferred for determination of the ash content, because it offers a lot more opportunities and higher measurement accuracies.

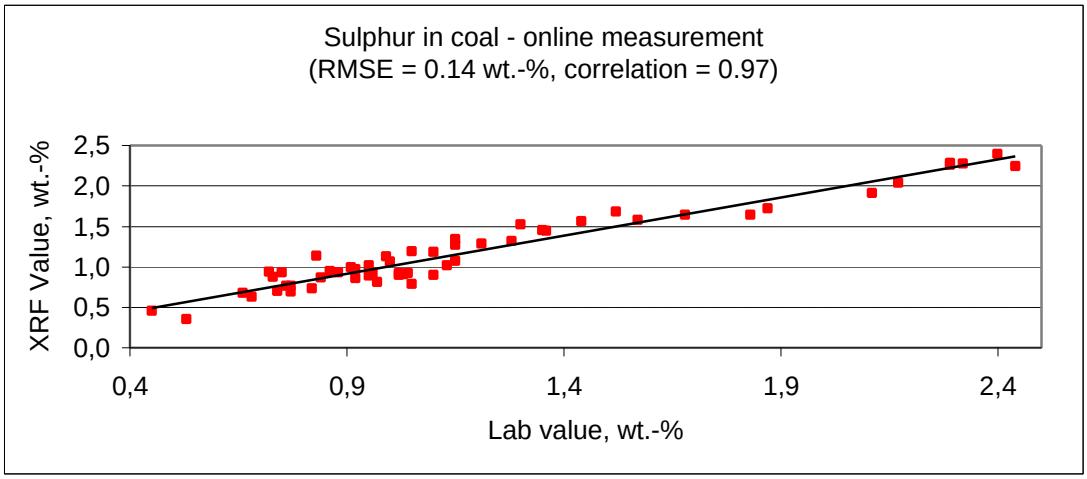
Application Examples

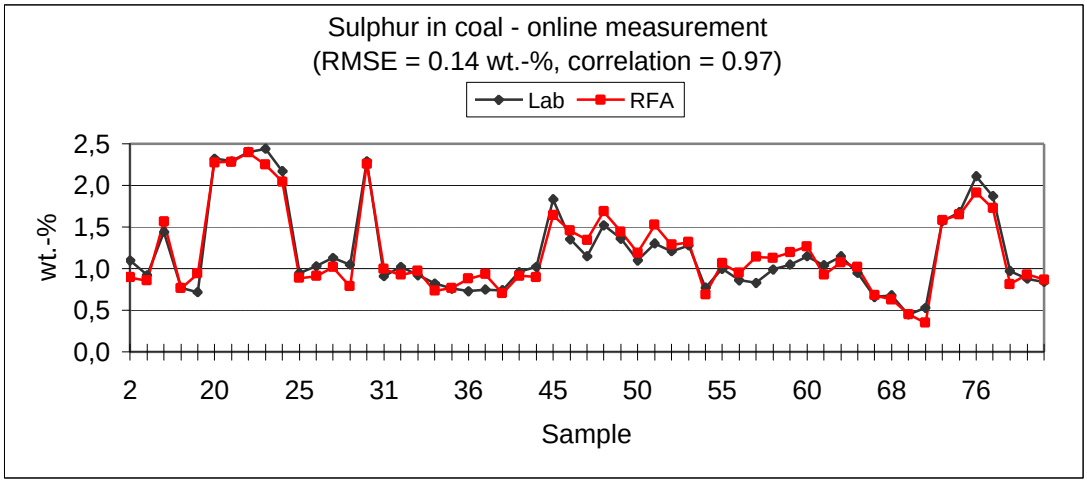
1 Coal

1.1 Sulphur Content

The „end of the pipe" method, i.e. the detection of the SO_2-content of flue gases, does not allow any optimum utilization of the flue gas desulphurization, since the sulphur content of the fuel which is already stored in the bunker cannot be influenced any more and provisions to reduce SO_2 can be taken only with a significant delay. Through continuous monitoring of the coal mixture with OXEA in front of the bunkers, these provisions can be carried out in due time and variations of the sulphur content in flue gas can be corrected much better.

The OXEA measuring system can be installed behind the main sampling device which takes standard samples for quality assurance. These may also be used for calibration of the online instrument. Further harmful substances of coal, such as chlorine or arsenic can be determined, and thus controlled, at the same time. Below you see a sulphur content measurement in coal.





1.2 Ash Content and Elemental Compensation of Coal

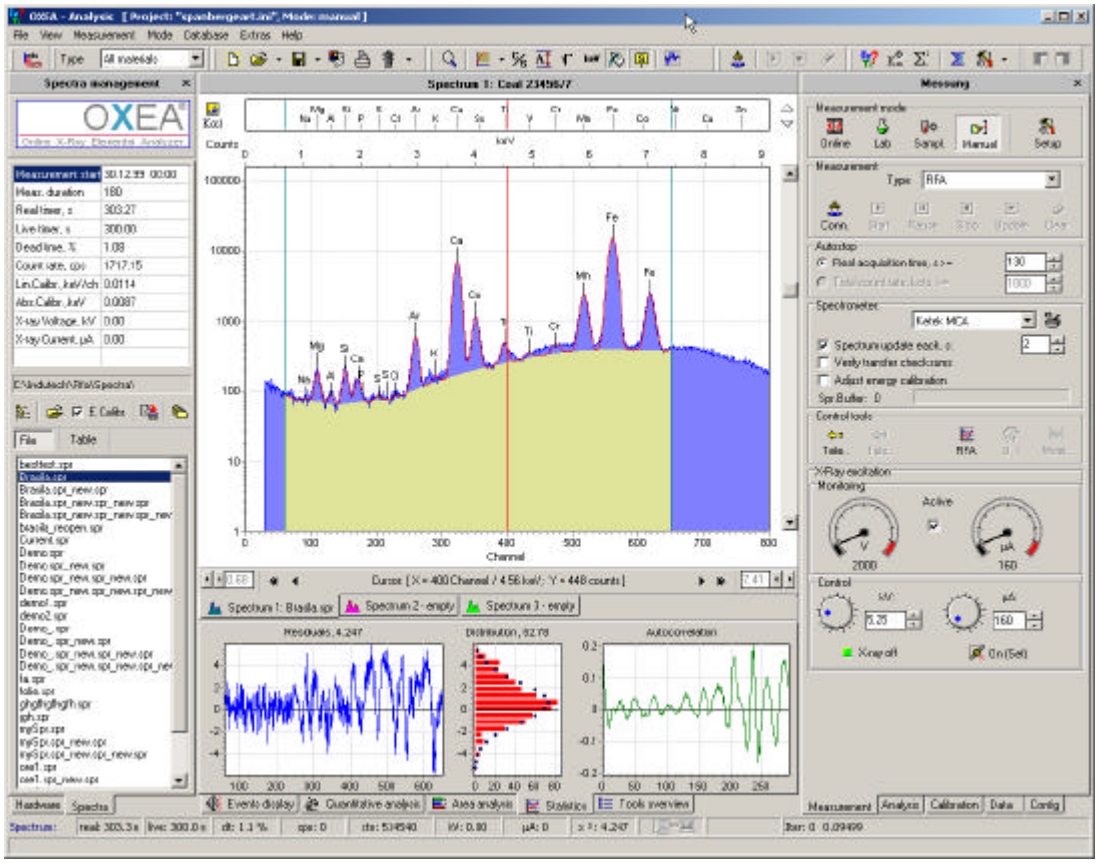


Figure 2: User interface of the OXEA Analyse software

OXEA covers the entire ash composition. Typically, the processed coal is checked online. An empirical value for the attainable accuracy is 0.3 – 0.7%. In some cases it may be a better approach to check the tailings in order to get an impression of the losses. Figure 2 shows a typical tailings spectrum. The ash content is determined using special algorithms. Optionally, one can also monitor elements online that are of particular interest, e.g. chlorine. Figure 3 shows the calibration of the tailings measurement carried out with OXEA Labor. The calibration curve is in addition shown as trend line.

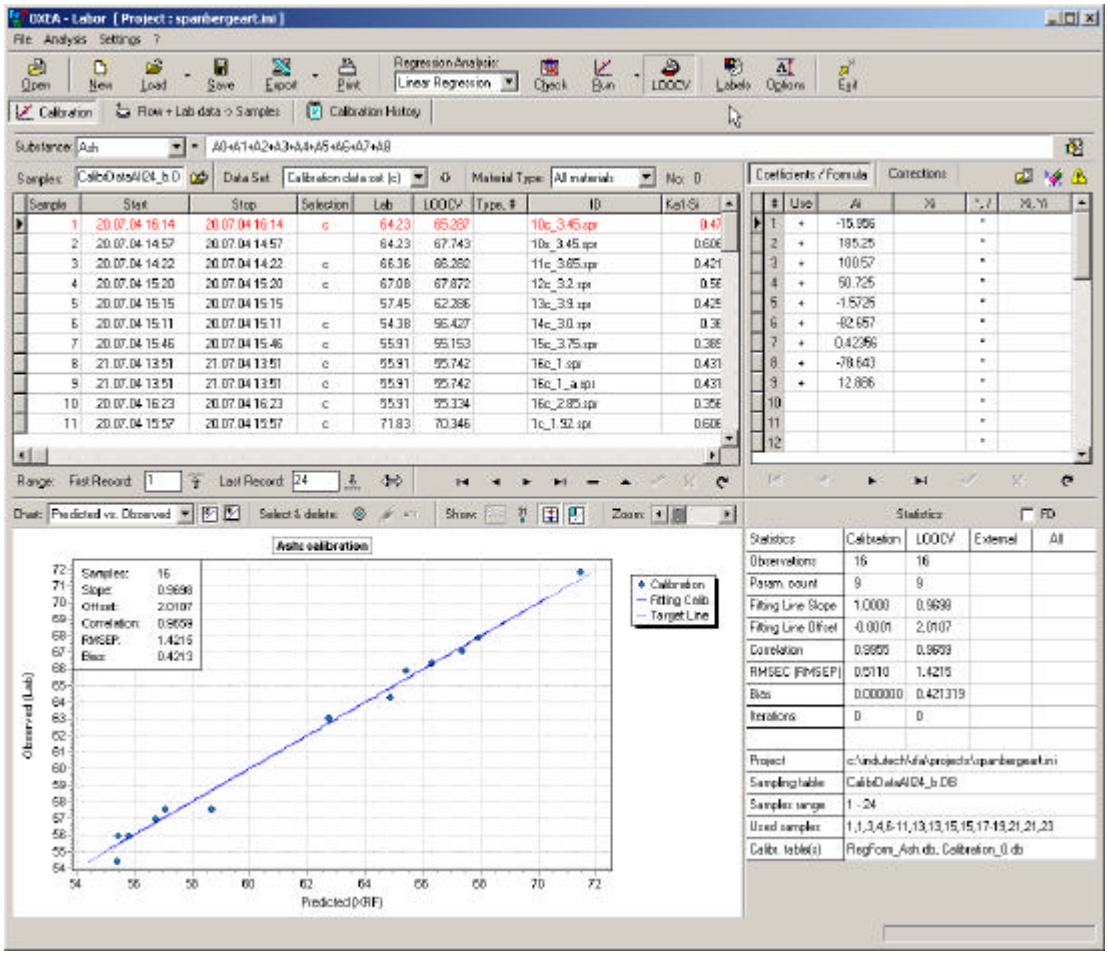
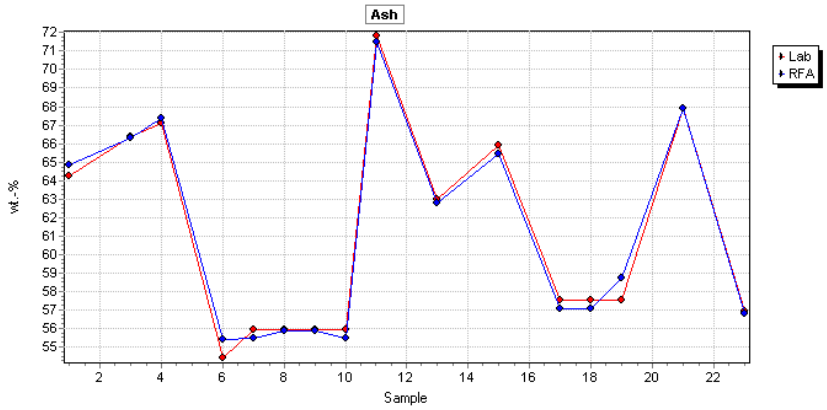


Figure 3: ‘OXEA Labor’ software with ash calibration of mountains



2. Recyclable Material and Harmful Substance Content in Mineral Raw Materials

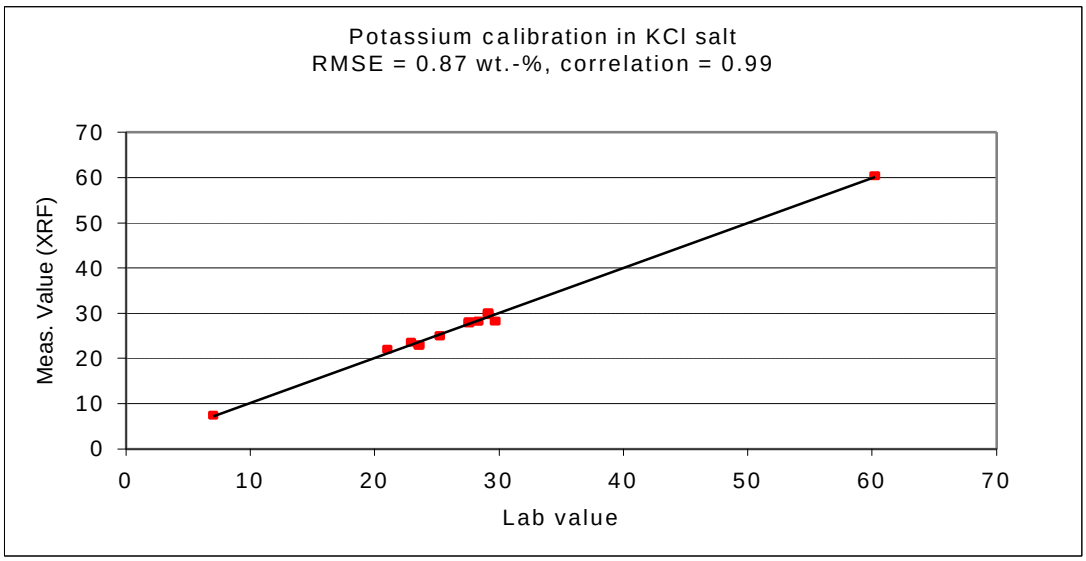
OXEA can be used to determine chemical elements with an atomic number >10. Thus, OXEA is ideally suited to check the recyclable material content of mineral raw materials in processing plants. Importent elements which helps to assess quality may also be determined. It is important to have information on harmful substances such as silicium in magnesite, mercury in iron ore or lead in lime.

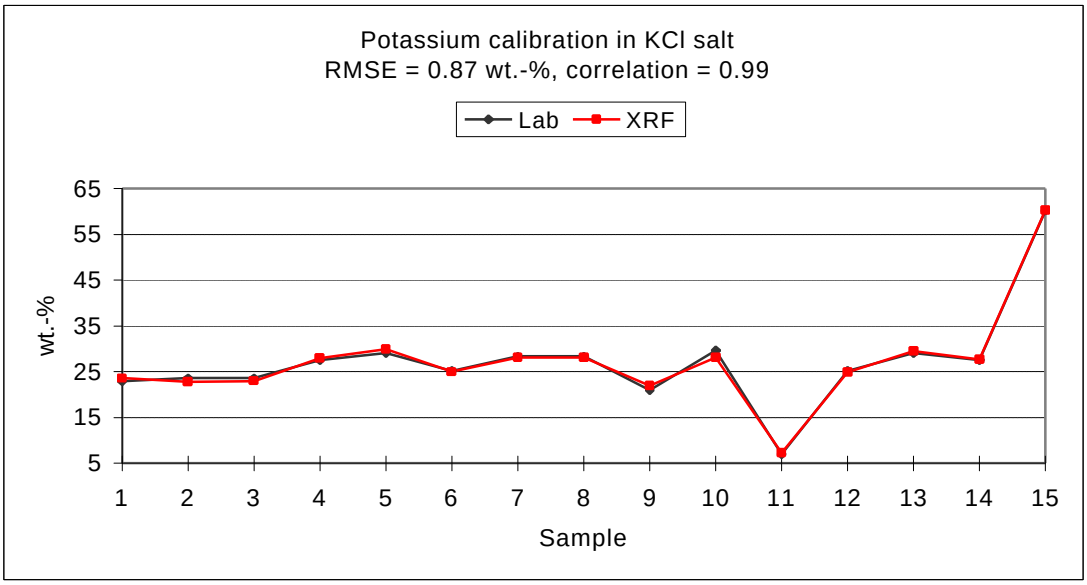
2.1 Potassium Content

The common method for determination of the potassium content is the measurement of the natural Gamma radiation of the isotope K-40.

However, with high concentrations this method is inaccurate. In particular for concentrate we recommend the use of OXEA.

Below you see OXEA measurements in the range of 8-60% K2O.





3 Ores

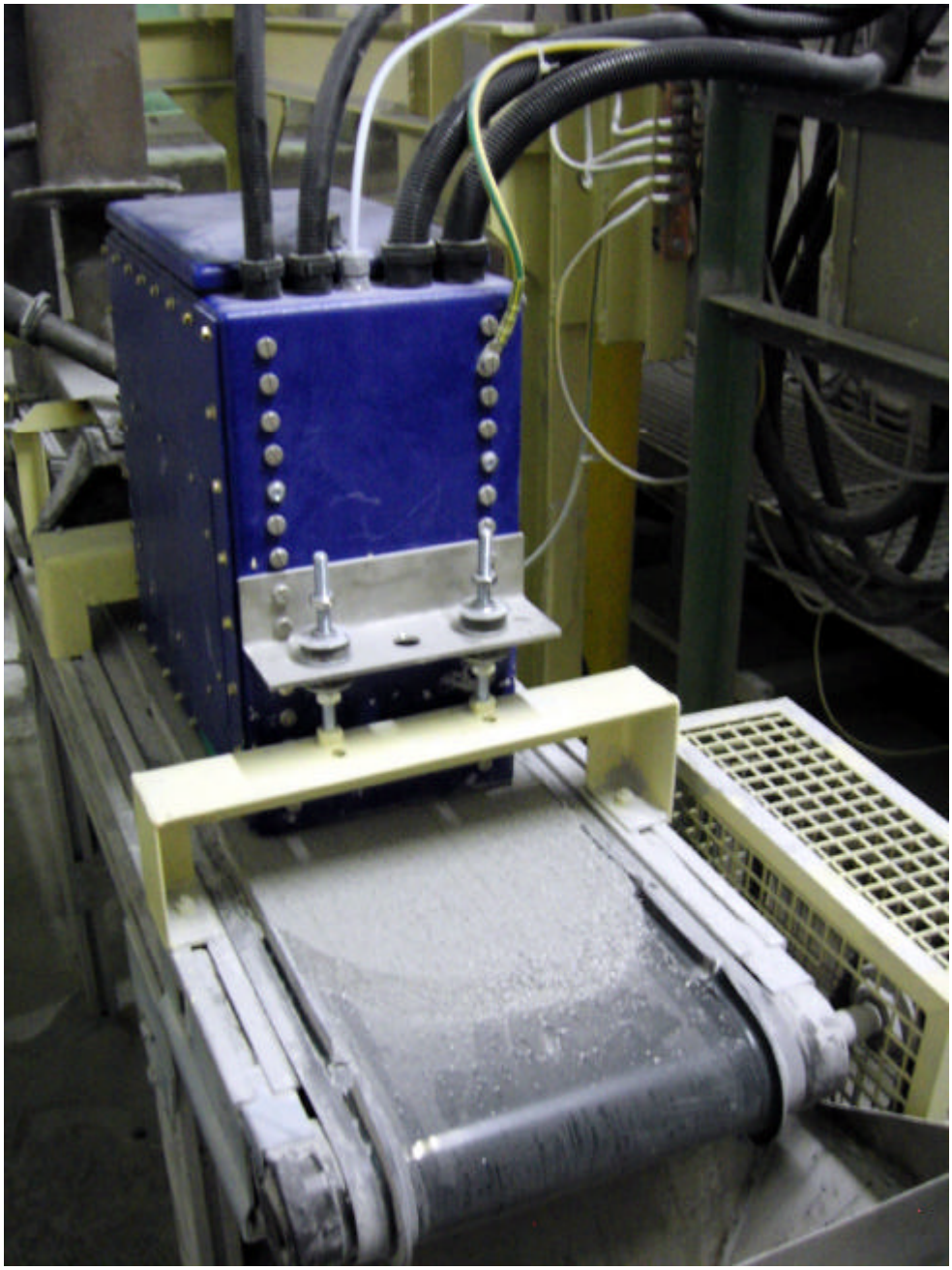
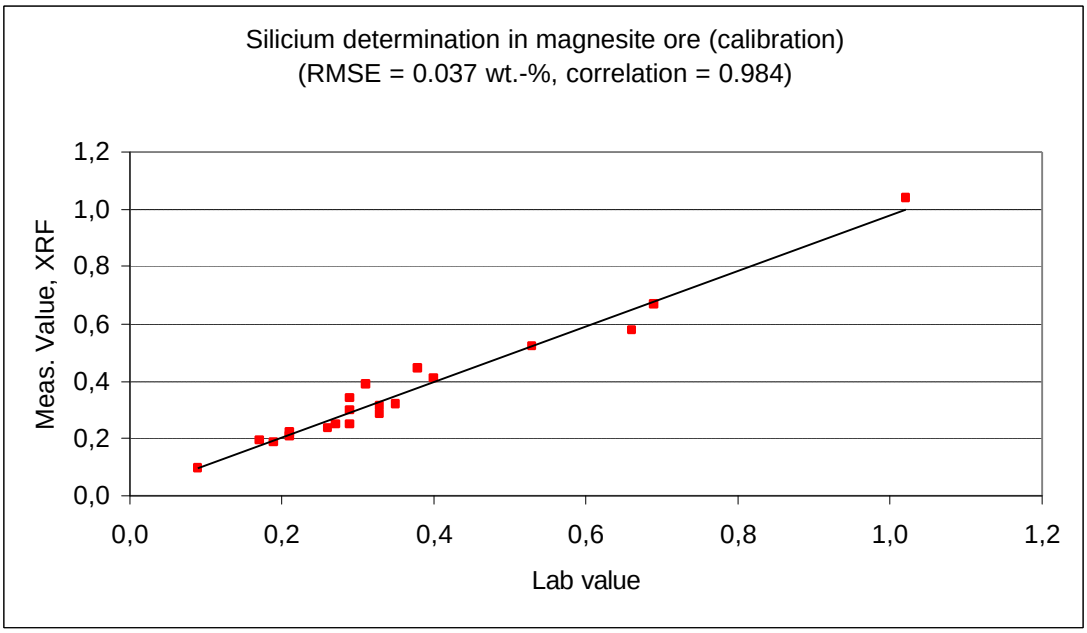
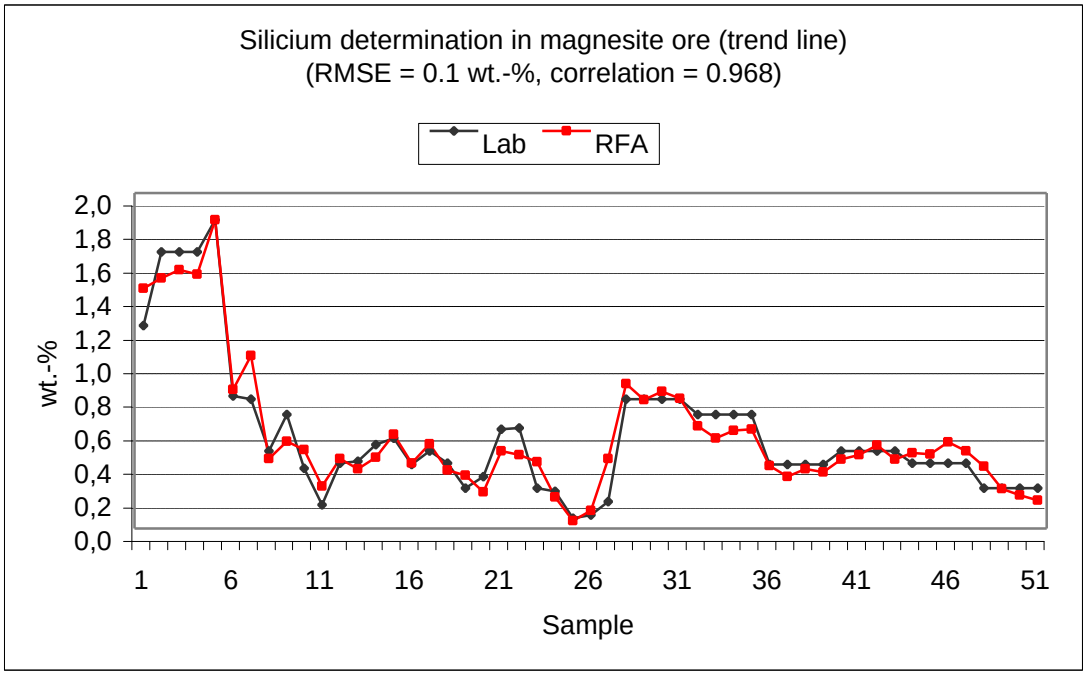


Figure 4: OXEA **3000 on bypass measurement belt**

OXEA is ideally suited to determine the recyclable material content or the concentration of accompanying minerals of ores. Below we will present the silicium content in magnesite ore as an example. Measurements were carried out online on the measurement belt, as shown in Figure 4. The only material preparation that was carried out was drying and reducing the partial flow to < 3 mm. The calibration curve is depicted as x-y-chart and as trend line. The accuracies obtained with the low energy element Si are excellent. A table shows, in addition, the accuracies obtained for this application for the major accompanying element.



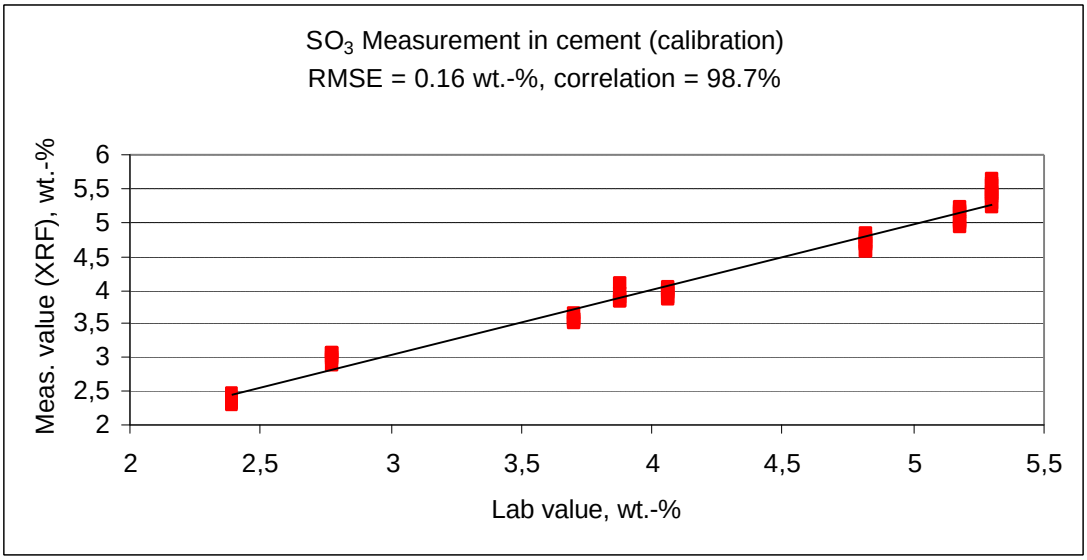


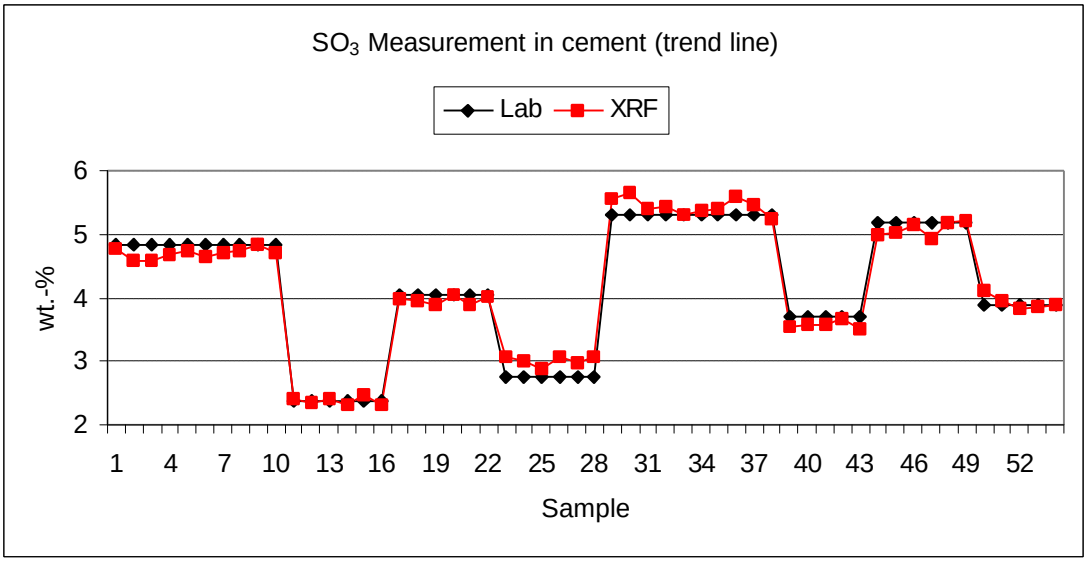
Std. dev.	Al_2O_3	SiO_2	CaO	TiO_2	Mn_2O_3	Fe_2O_3
Absolute, wt.-%	0.02	0.04	0.03	0.002	0.006	0.05
Relative, %	3.8	3.6	0.1	4.0	1.7	1.6

Table 1: Accuracies obtained with OXEA on magnesite ore

4 Elemental Analysis of Cement

OXEA with its online XRF technology is suited for the determination of different elements in cement. This is illustrated below using an SO_3-measurement as an example; the other elements are summarized in a table. The measurements were carried out under online-like conditions using the OXEA Atline, i.e. the measurements were carried out without sample preparation (pressing, melting). Only the measurement surface was smoothed using a special mechanical facility.





Std. dev.	Al_2O_3	SiO_2	SO_3	Cl	K_2O	CaO	Fe_2O_3
Absolute, wt.-%	0.14	0.35	0.16	0.04	0.05	0.38	0.08
Relative, %	2.3	1.6	2.9	4.6	3.2	0.6	1.8

Table 2: Accuracies obtained on cement with OXEA Atline without sample preparation

5 Trace Element Analysis

Even smallest amounts of various elements, for example, arsenic or mercury, can be determined online in a variety of materials.

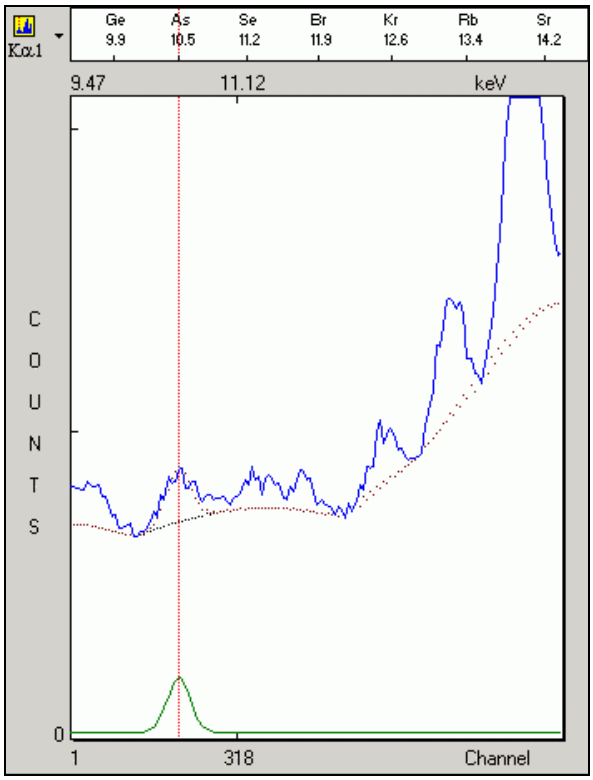
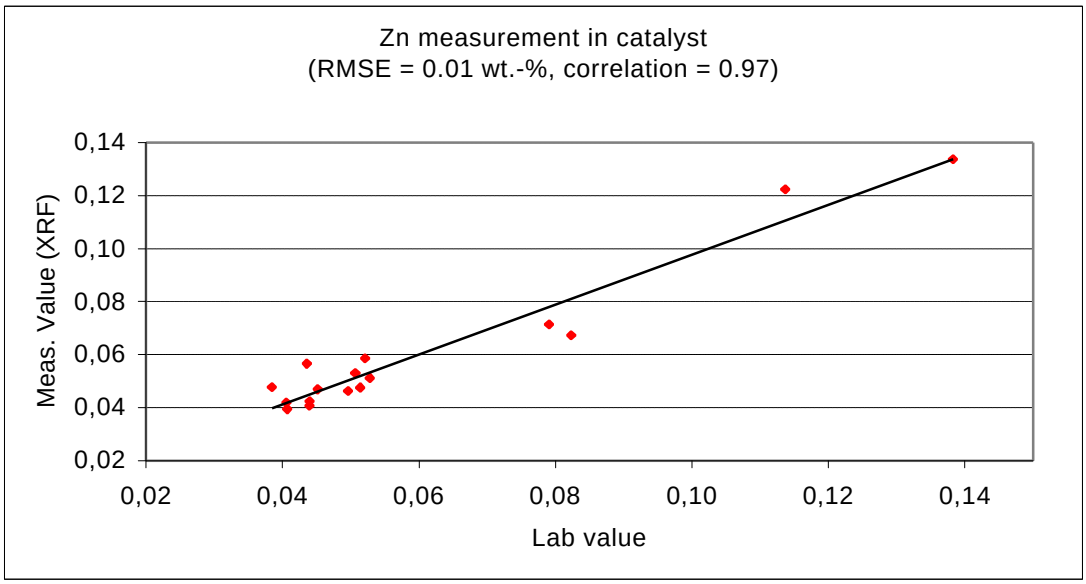


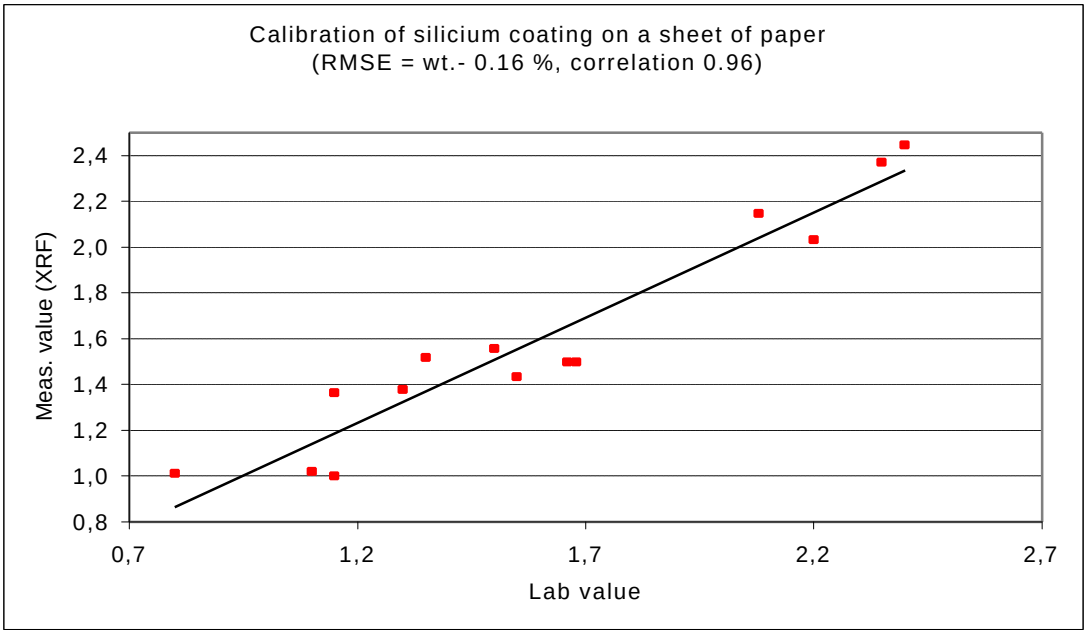
Figure 5: Section of XRF coal spectrum with arsenic line (20 ppm)

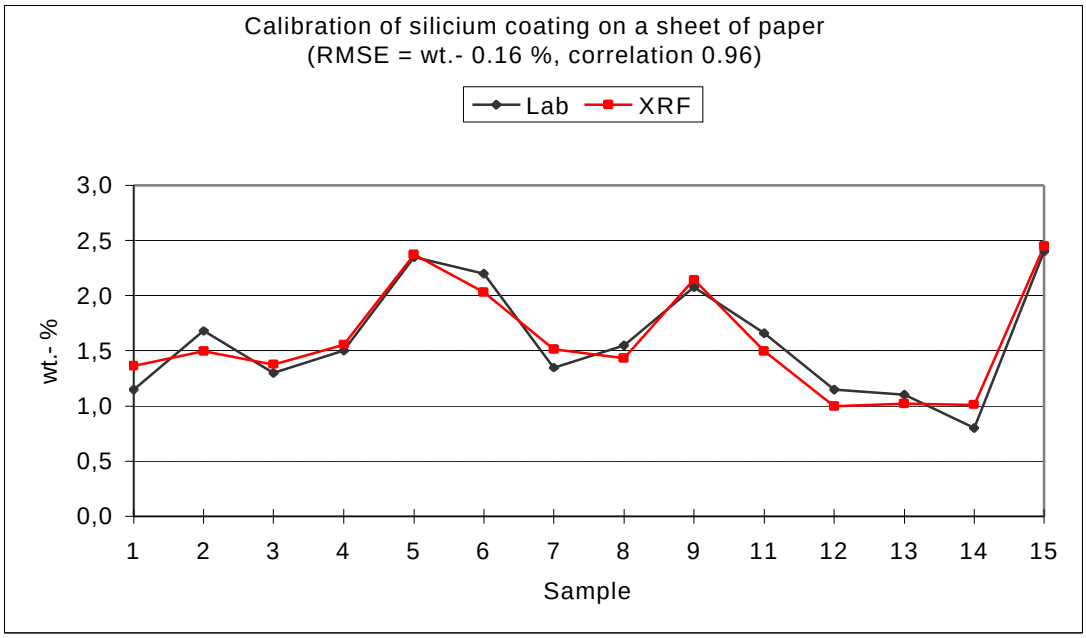
Another example is the zinc measurement in the range between 0.04 – 0.14 %.



6 Layer Thickness Determination

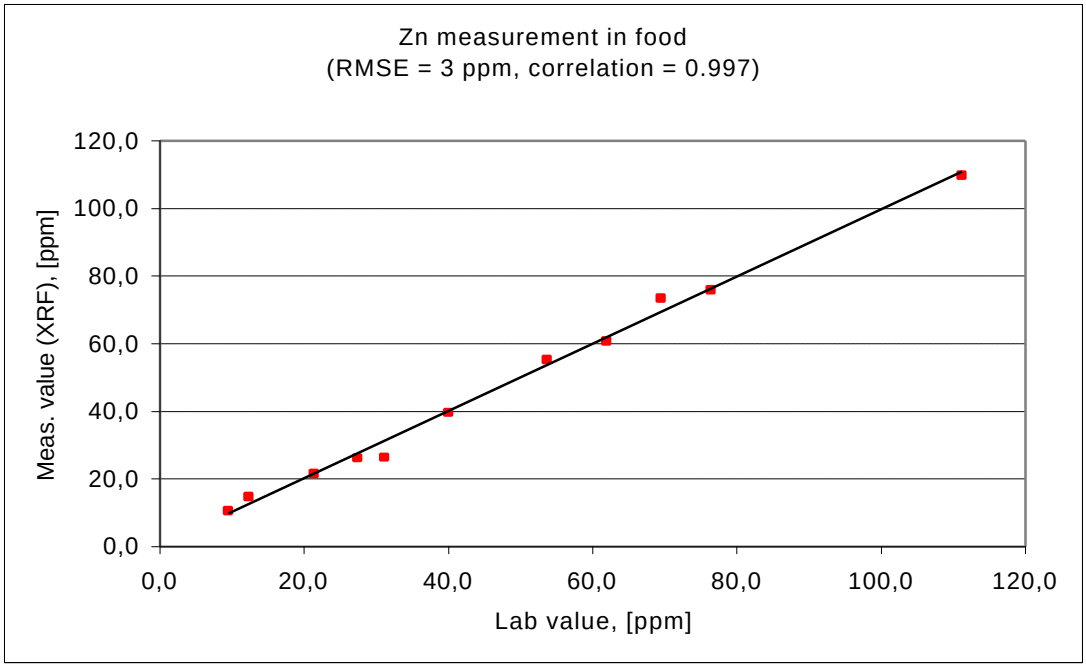
Layer thicknesses which contain a specific chemical element in a constant concentration can be determined very reliably with OXEA. For example, the charts diagrams below show the measurement of a silicium layer on paper. In combination with an optional traversing frame, the sensor can cover the layer thickness over the entire width of the paper track.

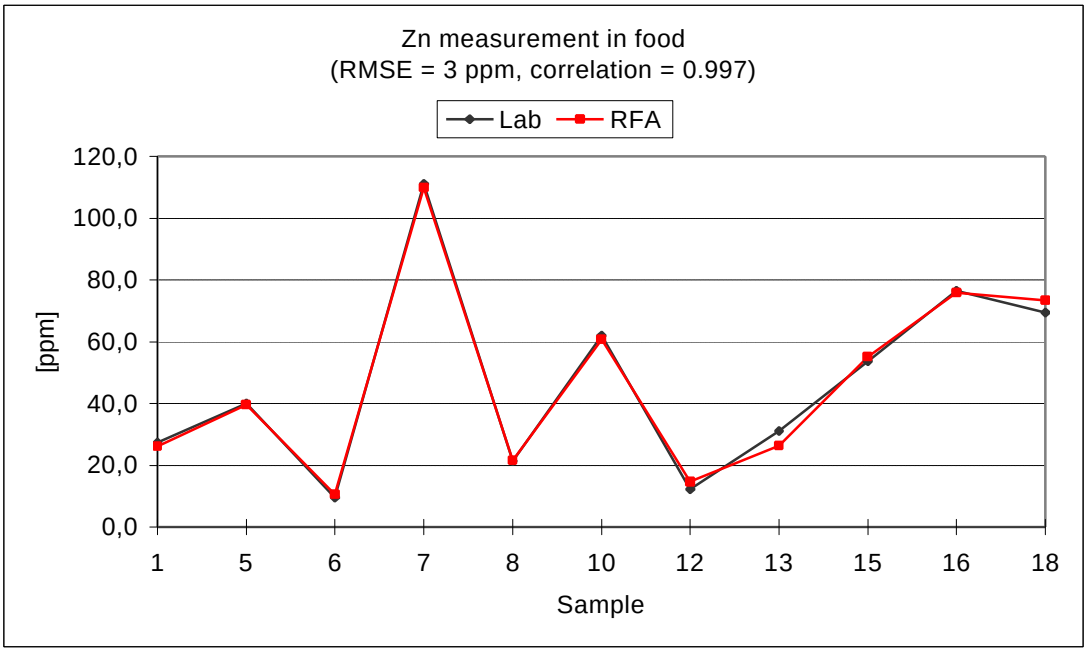




7 Application in the Food Industry

OXEA can be employed with success for quality control in the food industry. The diagram below shows that the Zink content can be determined very accurately in the ppm range. Other elements such as K, Ca, Fe can also be determined online without any problem.





8 OXEA Atline

Sometimes a measurement of individual samples which have been taken at different operating points is preferred to a fixed online measurement.

For this application we have developed OXEA-Atline which works according to the same principles as the online device.

In this case, the sensor is provided with a substructure which contains a rotary plate on which the sample can be moved. The maximum particle size should be < 10 mm, as for the online measurement.

The sample quantity may be in the range between 100 to 1000 cm^3. With the aid of a special evaluation routine the software can partially compensate for changes in particle size distribution, which normally have a very strong influence on the intensity of the spectrum.

The measuring instrument may be connected to the in-house network. Thus, the quality data of a quality management system become accessible. The quality data are logged in the program database. The built-in software modules allow the user to create daily or shift-related quality reports.

Figure 6: OXEA **Atline**

Technical Data for OXEA Online Devices

Sensor Unit / Atline Dimensions (L x W x H) Weight Protection type	 15.7 x 13.4 x 8.7 / 16.1 x 19.7 x 9.0 Inches 68,4 lbs / 99,2 lbs	 400 x 340 x 220 / 408 x 500 x 228 mm 31 kg / 45 kg
High voltage supply Dimensions Weight Protection type	 29.9 x 29.9 x 8.3 Inches 110,3 lbs IP 66	 760 x 760 x 210 mm 50kg IP 66
Avg. Particle Size	< 1"	< 25 mm
Max. particle size	< 2"	< 50 mm
Operating temperature	-22° F to 122° F	-30° C to 50° C
Power supply	100-240V VAC nominal, 16 A	
X-ray tube	Model: IT XR S1-25	25 kV 1,6 mA
X-ray detector	Peltier-cooled silicium drift detector Type: IT XR D2-5/155-8.0Be	155 eV FWHM resolution @5.9 keV, ^{55}Fe
Moisture meter	Precision microwave detector PMD 2450	Transmission measurement (attenuation and phase)
Computer	Intel Celeron® processor, 2000 MHz or better	80 GB hard drive or better
Monitor	17" flat screen or comparable device	
Software	OXEA evaluation software Microsoft® Windows XP Pro	Microsoft® Office (Option) LapLink®
Modem **Network interface card**	56 Kbps standard or network interface card	Requires a free phone line or internet connection for service
Analysis period	Short approximate value 1-2 minutes	
Licensing	Single licence	
Radiation outside the analyzer	Below the detection limit	
Accuracies under regular conditions	Typical RMSD for coal: 5% of measuring range but not < ± 0.4-0.7% ash ± 0.3-0.6% water content ± 0.05-0.15% sulphur ± 100-150 calorific value (Btu/lb.)	The achievable accuracy will be determined by measuring your samples.
Performance test	In accordance with ISO/DIS 15239	
Service (optional)	Service contract	Check / Calibration
Interfaces **PCS system**	DeviceNet, Modbus, DUST 3964R, Profibus	Optional