Analysis of Iron and Steel with ARL easySpark Optical Emission Spectrometer

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Key Words

ARL easySpark, CCD optics, iron, steel, optical emission, OES, metal analyzer

Goal

Perform reliable and fast quantitative determination of trace and alloying elements in solid iron and steel samples

Introduction

For over 80 years, our company has set the standard of quality for optical emission spectrometer used for analysis of metals. Performance, stability and reliability have been the key attributes of our instruments, typically designed for metals producers and labs. The Thermo Scientific™ ARL easySpark™ metals analyzer continues this tradition of experience and technical innovation to bring our customers the best value based solution.

The ARL easySpark is able to determine all the elements necessary in your current and future applications, in all possible qualities of iron and steel: white or grey cast iron, alloyed cast iron, low alloy steel and high alloy steel. It is the answer to your analytical needs, whether for incoming goods control, metal sorting, process QC, final product QC, certification or investigation. With maximum uptime, the ARL easySpark metals analyzer delivers dependable performance year after year. Specific performance is detailed in this application summary.

ARL easySpark - Revolution in benchtop OES

The ARL easySpark is a compact bench-top spectrometer based on an innovative multi grating / CCD optical design operated under argon environment at controlled temperature. It provides full elemental coverage, optimal resolution and stability, and delivers high performance for all the critical elements.

The ARL easySpark benefits also from the same advanced features already used in bigger floor standing instruments of the Thermo Scientific OES product line, among which:

- Advanced CCD signal acquisition and processing for improved performance and accuracy
- Compact version of the intelliSource, a digital spark source with increased flexibility and efficiency
- Spark stand with optimal operator safety and minimize argon consumption during the analysis
- ECOmode and super ECOmode allowing significant argon savings when the instrument is idle
- Optimal design increasing the instrument functionality

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ARL easySpark - Typical precision values (1 sigma) for iron matrix

Elements	Al	As	B	Bi	C	Ca	Ce	Co	Cr	Cu	La	Mg	Mn	Mo	N	Nb
Level %	Precision															
0.0001																
0.0002						0.00004						0.00002				
0.0005						0.00007						0.00004				
0.001	0.00012		0.0001			0.0001		0.00014		0.00007	0.00014	0.00007				
0.002	0.00017		0.00015	0.0006		0.00015		0.00018		0.0001	0.0002	0.0001	0.00015			0.00025
0.005	0.0003	0.0004	0.0002	0.001	0.0004	0.0003	0.0012	0.0002	0.0004	0.0002	0.0003	0.0002	0.0003	0.0003	0.0015	0.0004
0.01	0.0004	0.0005	0.0003	0.0013	0.0005	0.0004	0.0013	0.0003	0.0006	0.0002	0.0005	0.0004	0.0004	0.0004	0.0018	0.0005
0.02	0.0005	0.0006	0.0004	0.0018	0.0008		0.0014	0.0004	0.0008	0.0004	0.0007	0.0006	0.0006	0.0007	0.002	0.0008
0.05	0.0008	0.0008	0.0005	0.0028	0.0015		0.0014	0.0005	0.0013	0.0006		0.001	0.001	0.001	0.0026	0.0014
0.1	0.0012	0.0011	0.0007	0.0038	0.0023		0.0015	0.0007	0.002	0.0009		0.002	0.0015	0.0017	0.0032	0.0024
0.2	0.0017	0.0014			0.0037			0.0009	0.0027	0.0014		0.0032	0.0023	0.0024	0.0047	0.0038
0.3	0.0024				0.0047			0.0017	0.0033	0.0017			0.0028	0.003	0.006	0.005
0.5	0.0034				0.0064			0.0025	0.0044	0.0024			0.0038	0.0042	0.0075	0.007
1	0.0055				0.01			0.0042	0.0055	0.0046			0.006	0.007	0.011	0.011
2	0.009				0.019			0.0073	0.0083	0.0083			0.0098	0.01		0.017
3					0.026			0.01	0.011	0.011			0.013	0.016		0.023
4					0.033			0.013	0.013	0.014			0.016	0.019		0.027
5					0.039			0.015	0.015	0.017			0.019	0.023		
10								0.026	0.023	0.03			0.03	0.036		
20								0.045	0.036				0.048			
30									0.047				0.064			
40									0.056							

Elements	Ni	P	Pb	S	Sb	Se	Si	Sn	Ta	Te	Ti	V	W	Zn	Zr
Level %	Precision														
0.0001															
0.0002														0.00005	
0.0005											0.00005			0.00008	
0.001											0.00008			0.0001	
0.002			0.00022	0.00026							0.00014	0.00016		0.00014	0.0002
0.005	0.0003	0.0004	0.0004	0.0004			0.0004	0.0003		0.0005	0.0003	0.0002		0.0002	0.0004
0.01	0.0004	0.0005	0.0007	0.0007	0.001	0.001	0.0005	0.0004		0.0005	0.0005	0.0004		0.0003	0.0005
0.02	0.0006	0.0007	0.001	0.001	0.0014	0.0011	0.0007	0.0005	0.0083	0.0006	0.0008	0.0005	0.0022	0.0004	0.0008
0.05	0.0009	0.001	0.0022	0.0017	0.002	0.0012	0.001	0.0007	0.009	0.0007	0.0015	0.0008	0.0032	0.0006	0.0014
0.1	0.0013	0.0014	0.0036	0.0024	0.0024	0.0014	0.0014	0.001	0.009		0.0024	0.0012	0.004		0.0022
0.2	0.0018	0.0026	0.006	0.0036	0.003		0.0019	0.0013	0.01		0.004	0.0017	0.0055		0.0033
0.3	0.0022	0.0037	0.0083	0.0045	0.0035		0.0022	0.0015			0.0054	0.002	0.0065		0.0042
0.5	0.0029	0.0056		0.006			0.0029	0.0018			0.0075	0.0034	0.0083		
1	0.0044	0.01					0.005				0.013	0.0083	0.009		
2	0.0083	0.019					0.0083				0.022	0.014	0.013		
3	0.011						0.011				0.028	0.02	0.019		
4	0.014						0.013					0.026	0.024		
5	0.017						0.016					0.032	0.029		
10	0.029						0.027					0.056	0.053		
20	0.05												0.098		
30	0.07												0.135		
40	0.09														

- Homogeneity of the elements depends on the metallurgical structure obtained through the sampling procedure (cast, forged or rolled) and on the metallurgical history including mechanical deformation by forging or rolling and heat treatments. These values apply when homogeneously distributed elements are present in samples which are prepared by recommended sample preparation methods. A measured precision higher than the guaranteed precision indicates, with a probability higher than 95% that the element is segregated or has an inhomogeneous distribution over the sample's surface.
- The precision values (given in percent) are typical instrumental repeatability. The guaranteed precision values are twice higher.
- The precision values are based on ten repeated measurements.

Innovative CCD optical system

On the ARL easySpark the new multi grating / CCD optics allows a continuous spectral coverage combining optimal performance for every element as well as high flexibility for spectral investigations or future applications. It features an exclusive UV resistant CCD detector that has been developed specially for arc/spark OES and whose temperature is controlled by means of Peltier cooling device to ensure the best stability and precision.

IntelliSource digital spark source

The compact version of the patented Thermo Scientific intelliSource is a double current controlled source (CCS), the most innovative excitation source for Spark OES. It allows discharge shapes to be tailored for most efficient control of the sample surface preparation, material ablation and light emission in various metal matrices. Matrix-optimized pre-integration sparks significantly reduce the effects of matrix and metallurgical structure (in re-melting the sample surface before the integration spark), which improves the accuracy of the analysis.

Other innovative features contribute to the performance of the intelliSource, e.g. DISC (Discharge Interrupt by Short-Circuit) that improves the repeatability in trace analysis.

CCD signal acquisition and processing

Different techniques and methods are applied in order to improve performance with the CCD of the ARL easySpark like automatic dynamic dark current subtraction to enhance the signal to noise ratio. Spectrum alignment and digital resolution enhancement are also performed automatically during every acquisition to improve precision, accuracy and long-term stability.

Sample preparation

The sample is generally prepared by using a grinding machine (e.g. stone grinding for cast irons and paper for steels).

Performance guarantee

Our company guarantees the precision as shown on page 2. The precision expresses the closeness of the concentration values of the individual runs of an analysis. The lowest the precision value, the smallest the number of runs needed for high confidence in the average result.

Accuracy and factory calibration

The accuracy is the most important figure of merit of a spectrometer. It expresses the agreement between the result and the reference value. It depends on the quality of the reference materials used for calibration, on some instrumental attributes (e.g. the optical resolution, the spark source condition) and on the mathematical model used to calculate the calibration curves. The calibrations are performed by using thoroughly tested and well accepted certified reference materials (CRM's) and reference materials (RM's). The calibration curves are established utilizing very sophisticated multi-variable regression (MVR) software tool that corrects for matrix effects, spectral interferences and ensure the highest possible accuracy.

Calibration summary

The following calibrations are available for cast irons and steels:

- Low Alloy Steel
- Free Cutting Steel (with S and Pb ≤ 0.3 %)
- Chrome Steel (ferritic stainless steel)
- Chrome-Nickel Steel (austenitic stainless steel)
- Manganese Steel (Mn ≤ 20 %)
- High Speed Steel (Co ≤ 10%)
- Cast Iron - including nodular iron and Ni-hard (Ni ≤ 7 %)
- High Alloy Cast Iron (Cr ≤ 32 % and Ni ≤ 16 %)
- Nickel Resist (Ni ≤ 35 %)
- Global Iron (including all qualities except for free cutting steel)

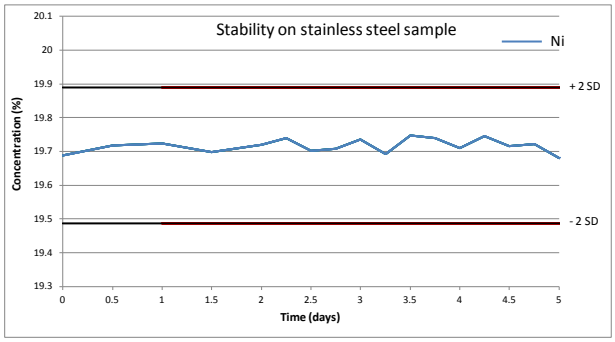
Our calibrations are delivered as turn-key, fully parameterized applications along with setting-up samples (SUS) to maintain the accuracy of the calibration. Please contact your nearest Thermo Fisher Scientific office for more specific information on our calibrations.

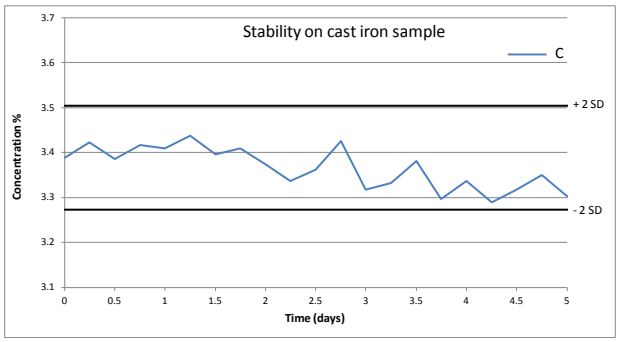
Based on the calibration curves and the repeatability of the measurements, the measurement uncertainty can be displayed for each sample.

Stability

Stability of the instrument is of the utmost importance when performing routine analysis. High stability reduces the frequency for maintenance and drift correction operations.

The examples below shows the long-term stability of nickel in a stainless steel sample and carbon in a cast iron sample recorded over a period of 5 days without any intermediate drift correction. No standardization was required, as the measured concentrations stayed within an interval of +/- 2 times the guaranteed precision value, which is excellent.





Memory effects

The memory effect is defined as the number of runs necessary to reduce the measured concentration to the expected one after analyzing high alloyed samples, such as stainless steels. The ARL easySpark measures accurately trace elements after 5 runs.

Conclusion

The ARL easySpark is a compact, desktop spectrometer for metals analysis, based on new CCD technology, which provides flexibility for the analysis. It can be installed and be operational on the same day it is delivered. Simple to handle, the ARL easySpark provides quick, precise and reliable analysis.

Its accuracy, associated with its excellent stability and reliability allows to have results you can rely on 24 hours a day, 365 days a year without spending a lot of time in long lasting and expensive drift corrections.

In addition, the ARL easySpark brings the following advantages:

- Simple and easy to use and maintain by unskilled opertor
- Unique safe open stand
- New icon based easyOXSAS software
- Low consumption of drift correction samples and simple maintenance
- Widest range of metals analysis
- Advanced technical/service support.

All these features allow you to optimize your productivity and to achieve the shortest payback times:

- Your investment costs are reduced by:
  - Exceptional instrument lifetime and continuous upgrade possibilities (software and hardware)
  - Instrument capability to cover your future needs
- Your production costs are reduced by:
  - More accurate and reproducible analyses made available faster
  - Increased instrument availability thanks to its high stability and less frequently required drift corrections
- Your operating and maintenance costs are reduced by:
  - Low consumption of drift correction samples and simple maintenance
  - Significant argon savings during analysis and in stand-by
- Your overall cost management is reduced by:
  - Optimum utilization of materials
  - Extremely low running costs compared to other methods

To know more on ARL easySpark visit www.thermoscientific.com/easyspark

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