Lab Report OES 24

Q4 POLO

Analysis of Iron and Steel

The analysis of iron and steel is the most prominent analytical application for today's spark spectrometers. Besides the traditional commercial applications for steel, a more demanding automotive industry has recently led to rapid alloy developments. These alloys have become popular in automotive manufacturing thanks to their light weight and improved properties.

The Q4 POLO is an ideal tool for the accurate analysis of steel and cast iron. With the new optimized MultiVision™ optics, the Q4 POLO provides excellent analytical performance, enabling the instrument to monitor the nitrogen content in low-alloy steels and iron casting processes, to determine other trace elements, and of course to deliver trustable results on all relevant alloying elements.

Sampling and Sample Preparation

The chemical composition of different stages of the steel-refining process and casting are monitored by determining the composition of the steel samples taken from the liquid steel. The samples are prepared by grinding or milling to have a flat and homogeneous surface. All samples in this lab report were prepared following sample preparation procedure with a grinding machine.

Certified Reference Material (CRM)

Certified Reference Materials (CRM) are reference materials characterized by a metrologically valid procedure for one or more specified properties, accompanied by a certificate that provides the value of the specified property, its associated uncertainty, and a statement of metrological traceability.

CRMs are certified by a recognized certifying organization using approved certification procedures, as instructed in the most recent ISO Guide 35. The organization is usually a function of a federal government or recognized by a federal government or an accreditation organization. A CRM is the highest level to which an analytical reference material can be elevated because it is directly traceable to SI units and because of the attributed confidence in the company or organization which produced the material.

Statistics

Population is the entire group about which you want to draw conclusions.

Sample is the specific group from which you will collect data.

Average ($\overline{X}$) is a number expressing the central or typical value in a set of data, in particular the mode, median, or (most commonly) the mean, which is calculated by dividing the sum of the values in the set by their number.

$$\overline{X} = \frac{1}{n}\sum_{i=1}^{n} X_i$$

Standard Deviation (σ) is a measure of the amount of variation or dispersion of a set of values.

$$\sigma(r) = \sqrt{\frac{1}{N-1}\sum_{i=1}^{n}(X_i - r)^2}$$

Precision and Accuracy

The International Organization for Standardization (ISO) defines **precision** as the closeness of agreement between independent test results obtained under stipulated conditions. Precision depends only on the distribution of random errors and does not relate to the true value or the specified value, while **accuracy** is defined as the closeness of agreement between a test result and the accepted reference value

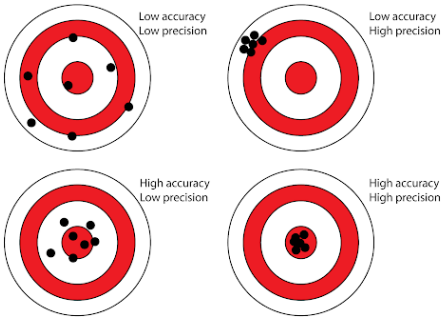


Table 1 – Calibration ranges with typical detection limits (3 sigma), and precision values (1-sigma) for Fe-base alloys

Element	Al	As	B	C	Ca	Ce	Co	Cr	Cu	La	Mg	Mn	Mo	N
min %	0.0006	0.0030	0.0005	0.0035	0.0001	0.0060	0.0015	0.0008	0.0005	0.0018	0.0005	0.0010	0.0020	0.0020
max %	9	0.09	2.2	4.5	0.015	0.25	32	48	8	0.11	0.2	30	11	1.1
Conc. Level %														
0.001	0.0001		0.0001		0.0001			0.0005	0.0002		0.0001			
0.005	0.0001	0.0005	0.0002	0.0010	0.0001	0.0015	0.0004	0.0005	0.0002	0.0005	0.0001	0.0005	0.0004	0.0003
0.01	0.0002	0.0008	0.0002	0.0012	0.0002	0.0020	0.0005	0.0005	0.0002	0.0005	0.0005	0.0005	0.0005	0.0003
0.02	0.0003	0.0020	0.0003	0.0013		0.0040	0.0008	0.0008	0.0005	0.0008	0.0010	0.0005	0.0008	0.0003
0.05	0.0004	0.0040		0.0015			0.0010	0.0010	0.0005		0.0020	0.0010	0.0010	0.0005
0.1	0.0005			0.002			0.0012	0.0012	0.0008		0.0025	0.0015	0.0012	0.0010
0.2	0.0010			0.0025			0.0015	0.0013	0.001			0.0015	0.0015	0.0015
0.5	0.0025			0.003			0.0025	0.0025	0.003			0.002	0.0030	0.0035
1	0.005			0.005			0.0030	0.0030	0.006			0.0040	0.0045	
2	0.010		0.05	0.008			0.0050	0.0038	0.01			0.008	0.01	
3	0.015			0.02			0.008	0.0089				0.01		
4	0.025			0.03			0.010	0.010				0.015	0.04	
5	0.030						0.020	0.012	0.06			0.015	0.05	
10							0.035	0.020				0.05	0.10	
20								0.030				0.1		
30								0.080						

Element	Nb	Ni	P	Pb	S	Sb	Se	Si	Sn	Ti	V	W	Zn	Zr
min %	0.0010	0.0015	0.0020	0.0030	0.0020	0.0168	0.0030	0.0023	0.0020	0.0005	0.0005	0.0150	0.0002	0.0010
max %	2.8	52	2.2	0.184	1.3	0.22	0.35	6	0.4	2.5	11	19	0.03	0.22
Conc. Level %														
0.001	0.0002									0.0002	0.0001		0.0005	
0.005	0.0003	0.0005	0.0003		0.0003		0.0004	0.0007	0.0008	0.0002	0.0001		0.0007	0.0003
0.01	0.0004	0.0008	0.0004	0.0010	0.0005		0.0006	0.0008	0.0011	0.0003	0.0003		0.0010	0.0005
0.02	0.0005	0.0008	0.0004	0.0020	0.0005	0.0030	0.0020	0.0010	0.0017	0.0003	0.0003	0.0020	0.0010	0.0015
0.05	0.0006	0.001	0.0008	0.0030	0.001	0.0035		0.0015	0.0015	0.0004	0.0005	0.0025		0.0035
0.1	0.0015	0.0015	0.0010	0.0050	0.0015	0.0050		0.0025	0.0015	0.0010	0.0010	0.0030		0.0050
0.2	0.0020	0.0025	0.0010		0.0050	0.0065		0.0030	0.0030	0.0041	0.0015	0.0050		
0.5	0.0020	0.0035	0.0015		0.04			0.0035		0.005	0.0020	0.0075		
1		0.0080			0.08			0.0050		0.010	0.0025	0.0095		
2		0.010						0.0080				0.015		
3		0.015						0.025			0.030	0.030		
4		0.030						0.075				0.040		
5		0.035										0.050		
10		0.05										0.075		
20		0.08												
30		0.25												

Performance Disclaimer and Remarks

The published values have been acquired from quite different types of materials and should be regarded as “typical” values.
The given performances only apply for homogeneous samples, appropriately prepared and are subject to technical modification.
Calibration ranges can be extended with samples provided by the customer.

Q4 POLO – Certified Reference Material

Results

The reproducibility of the Q4 POLO and the method outlined is demonstrated by a series of repetitive measurements of certified reference materials in different alloy groups and element concentrations.

Table 2 – CRM Low Alloy Steel – Fe110 – 181A

Element [%]	C	Si	Mn	P	S	Cr	Mo	Ni	Cu	Al	V	W	N
MEAN[1)]	0.224	0.434	0.973	0.039	0.0071	0.660	0.385	0.727	0.092	0.016	0.303	0.186	0.0057
STD[2)]	0.0031	0.0032	0.0074	0.0008	0.0003	0.0038	0.004	0.0011	0.0019	0.0005	0.0013	0.005	0.0006
1	0.224	0.431	0.975	0.038	0.0075	0.662	0.387	0.727	0.090	0.017	0.304	0.189	0.0051
2	0.221	0.434	0.981	0.039	0.0069	0.654	0.386	0.729	0.091	0.016	0.304	0.188	0.0054
3	0.226	0.432	0.967	0.039	0.0072	0.662	0.382	0.726	0.092	0.017	0.302	0.18	0.0053
4	0.221	0.439	0.963	0.038	0.0073	0.658	0.381	0.727	0.095	0.016	0.305	0.192	0.0064
5	0.228	0.436	0.977	0.04	0.0067	0.663	0.391	0.728	0.093	0.016	0.302	0.182	0.0064
	Certified Values												
Value	0.225	0.435	0.971	0.039	0.007	0.660	0.385	0.725	0.093	0.016	0.302	0.188	0.005
Error	0.008	0.013	0.022	0.002	0.001	0.011	0.009	0.011	0.003	0.001	0.006	0.005	-

Table 3 – CRM Stainless Steel – Fe130 – 463/1

Element [%]	C	Si	Mn	P	S	Cr	Mo	Ni	Cu	B	Co	N
MEAN[1)]	0.019	0.272	1.402	0.025	0.019	18.44	0.267	10.24	0.277	0.0021	0.116	0.062
STD[2)]	0.0007	0.0025	0.0063	0.0008	0.0011	0,027	0,0033	0.030	0.0014	0.0002	0.0013	0.0024
1	0.018	0.273	1.402	0.025	0.019	18.48	0.265	10.20	0.276	0.0022	0.116	0.062
2	0.019	0.276	1.408	0.024	0.018	18.46	0.264	10.23	0.278	0.0018	0.117	0.060
3	0.019	0.270	1.408	0.024	0.017	18.44	0.272	10.25	0.279	0.0019	0.117	0.059
4	0.020	0.272	1.396	0.025	0.020	18.43	0.265	10.25	0.276	0.0021	0.114	0.063
5	0.019	0.270	1.395	0.026	0.019	18.41	0.268	10.28	0.276	0.0024	0.115	0.065
	Certified Values											
Value	0.019	0.270	1.400	0.025	0.019	18.46	0.265	10.20	0.276	0.0022	0.116	0.063
Error	0.002	0.008	0.011	0.002	0.002	0.05	0.007	0.06	0.005	0.0003	0.005	0.001

Table 4 – CRM Cast Iron – Fe120 – 238A

Element [%]	C	Si	Mn	P	S	Cr	Mo	Ni	Cu	Co	Mg	V	Zn
MEAN[1)]	3.5142	1.511	0.440	0.053	0.0060	0.017	0.0021	1.101	0.977	0.0065	0.040	0.112	0.024
STD[2)]	0.0063	0.0066	0.0009	0.0008	0.0002	0.0008	0.0005	0.0046	0.0044	0.0004	0.0013	0.0004	0.0004
1	3.520	1.509	0.441	0.054	0.0066	0.017	0.0019	1.098	0.976	0.0069	0.039	0.112	0.024
2	3.521	1.521	0.439	0.052	0.0065	0.017	0.0021	1.099	0.973	0.0062	0.040	0.111	0.024
3	3.514	1.509	0.440	0.053	0.0060	0.018	0.0024	1.101	0.98	0.0062	0.039	0.112	0.024
4	3.509	1.512	0.439	0.053	0.0064	0.018	0.0029	1.109	0.983	0.0062	0.039	0.112	0.023
5	3.507	1.503	0.439	0.054	0.0065	0.016	0.0015	1.098	0.973	0.0069	0.042	0.112	0.024
	Certified Values												
Value	3.5	1.5	0.43	0.054	0.006	0.018	0.002	1.1	0.97	0.006	0.039	0.11	0.024
Error	0.02	0.02	0.007	0.001	0.0006	0.001	0.001	0.02	0.01	0.001	0.02	0.005	0.001

[1)] MEAN = arithmetic average
[2)] STD = absolute standard deviation (1σ)
[3)] %RSD = relative standard deviation in percent

Performance Disclaimer and Remarks

The published values have been acquired from quite different types of materials and should be regarded as “typical” values.
The given performances only apply for homogeneous samples, appropriately prepared and are subject to technical modification.
Calibration ranges can be extended with samples provided by the customer.

Q4 POLO – Long-term Stability – Stainless Steel

Results

The stability of the Q4 POLO is demonstrated by a series of repetitive measurements on a reference material, recorded over a period of several days without any intermediate drift correction.

Typical Chemical Composition of X2CrNiMo17-12-2 - 1.4404 – AISI/SAE 316L

	C	Si	Mn	P	S	Cr	Mo	Ni	N
min %	-	-	-	-	-	16.50	2.00	10.00	-
max %	0.030	1.00	2.00	0.045	0.030	18.50	2.50	13.00	0.10

Element [%]	C	Si	Mn	P	S	Cr	Mo	Ni	Cu
MEAN	0.019	0.329	1.70	0.039	0.026	16.57	2.013	10.211	0.441
STD	0.0013	0.0010	0.012	0.0010	0.0005	0.0308	0.0097	0.040	0.0029
1	0.020	0.329	1.69	0.041	0.026	16.59	2.014	10.22	0.443
2	0.018	0.329	1.69	0.039	0.025	16.62	2.019	10.20	0.443
3	0.020	0.329	1.69	0.038	0.026	16.59	2.027	10.25	0.441
4	0.020	0.331	1.69	0.040	0.026	16.59	2.003	10.20	0.441
5	0.018	0.330	1.69	0.039	0.025	16.57	2.022	10.22	0.441
6	0.020	0.330	1.71	0.040	0.025	16.52	2.004	10.25	0.439
7	0.020	0.328	1.72	0.040	0.026	16.57	2.017	10.16	0.441
8	0.017	0.330	1.69	0.039	0.025	16.59	2.020	10.14	0.446
9	0.017	0.328	1.71	0.038	0.025	16.53	1.998	10.27	0.436
10	0.020	0.328	1.72	0.038	0.026	16.55	2.005	10.20	0.437

Element [%]	Al	B	Co	Nb	Ti	V	W	N	Fe
MEAN	0.009	<0.0005	0.163	0.059	0.0066	0.037	0.049	0.047	68.28
STD	0.0002	0.0002	0.0008	0.0045	0.0004	0.0016	0.0032	0.0011	0.034
1	0.0094	<0.0005	0.162	0.055	0.0065	0.039	0.046	0.047	68.26
2	0.0094	<0.0005	0.163	0.055	0.0072	0.039	0.050	0.048	68.25
3	0.0096	<0.0005	0.163	0.062	0.0065	0.039	0.050	0.047	68.21
4	0.0096	<0.0005	0.164	0.056	0.0064	0.037	0.055	0.046	68.28
5	0.0092	<0.0005	0.164	0.055	0.0064	0.036	0.043	0.048	68.28
6	0.0092	<0.0005	0.164	0.064	0.0072	0.035	0.050	0.046	68.29
7	0.0091	<0.0005	0.163	0.065	0.0063	0.039	0.052	0.048	68.30
8	0.0092	<0.0005	0.163	0.055	0.0063	0.037	0.049	0.049	68.34
9	0.0091	<0.0005	0.162	0.055	0.0066	0.035	0.048	0.046	68.29
10	0.0096	<0.0005	0.164	0.064	0.0070	0.037	0.050	0.048	68.30

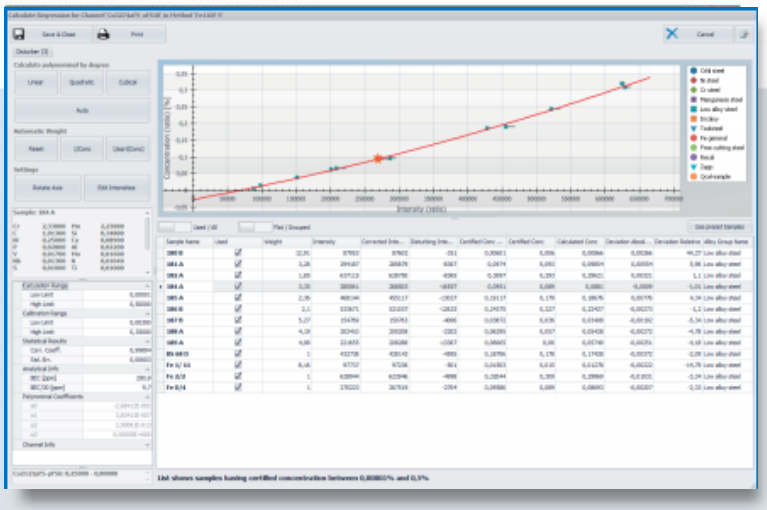
Summary

The Q4 POLO is a compact Spark Optical Emission Spectrometer (OES) combining high precision analysis capabilities with low cost of ownership and small footprint. It is the ready-to-analyze solution from day one, covering all relevant elements and wide concentration ranges. At the same time, the Q4 POLO provides high uptime, low maintenance, and hassle-free operation.

Reliable, high precision analysis is now available for every foundry and production floor to obtain results easier and more cost-effectively than ever before.

ELEMENTAL.SUITE software assists you in your daily work. Automated average and limit checks ensure safe operation. Saving, printing, and reporting your analyses can be done with one click.

Designed for maximum usability, the plug-in-based architecture of ELEMENTAL.SUITE provides maximum flexibility for your analytical requirements now and in the future.



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