LAB REPORT OES 27

Q4 POLO

Analysis of Copper Alloys

Copper and its alloys are among the most widely used metals in the world and have been used in a variety of applications since ancient times. Alloying copper with elements such as zinc and tin creates brass and bronze, which are indispensable in our daily lives. Due to its good electrical and thermal conductivity and its workability, pure copper is not only irreplaceable in electrical engineering, but also finds numerous applications in the construction sector.

The Q4 POLO is an ideal tool for the accurate analysis of all common copper alloys. With the new optimized MultiVision™ optics, the Q4 POLO provides excellent analytical performance, enabling the monitoring of the main chemical elements and the determination of other trace elements, delivering, of course, trustable results on all relevant alloying elements.

Sampling and Sample Preparation

The molten metal must be sampled in a manner representative for the entire furnace melt and is poured or drawn into a specified mold to produce a chill-cast disk. The samples are prepared by milling to have a flat and homogeneous surface.

All samples in this lab report were prepared following the sample preparation procedure with a milling machine.

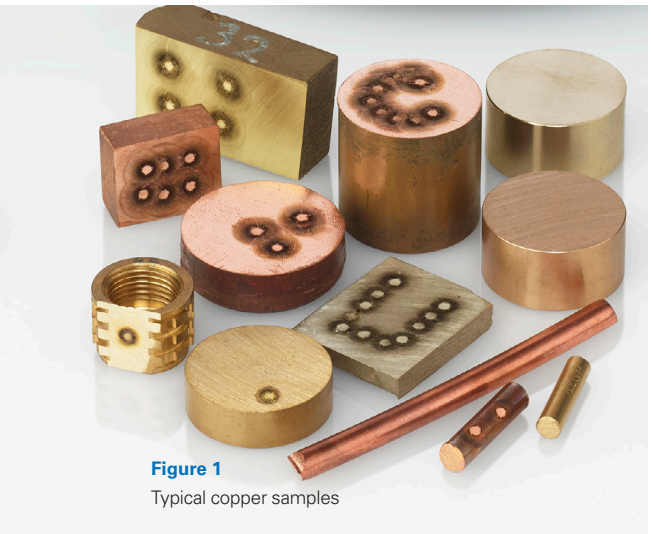


Figure 1
Typical copper samples

Certified Reference Material (CRM)

Certified Reference Material (CRM) are reference material 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 at a stated confidence level, 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. A CRM is the highest level which an analytical reference material can be elevated to because it is directly traceable to SI units and because of the attributed confidence in the company or organization which produced the material.

In contrast, reference materials (RMs) are material whose property values are sufficiently homogeneous and well established to be used for calibration. RMs have been through interlaboratory testing using many analysts.

Statistics

Population: the entire group that you want to draw conclusions about.

Sample: a specific group that you will collect data from.

Average (*X*): 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): a measure of the amount of variation or dispersion of a set of values.

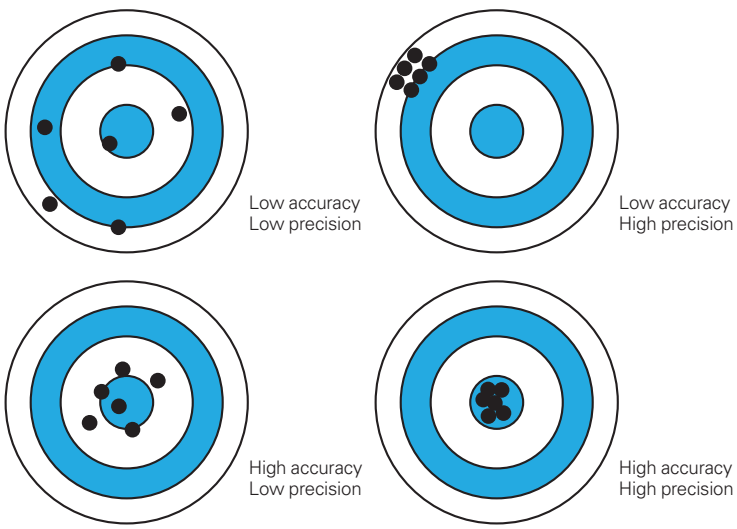
$$\sigma(r) = \sqrt{\frac{1}{N-1}\sum_{i=1}^{n}(X_i - r)^2}$$

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.

Figure 2
Precision and accuracy



Q4 POLO – Certified Reference Material and Reference Materials

Results

The reproducibility of the Q4 POLO and the method outlined is demonstrated by a series of repetitive measurements of CRMs or RMs in different alloy groups and element concentrations. Only chemical elements with certified reference values are shown in the following tables. The number of chemical elements analyzed varies according to the method (analytical program) selected.

Table 1
CRM BAM-376 – Cu110 (pure & low alloyed copper)

Element %	Zn	Pb	Sn	P	Mn	Fe	Ni	Si	Mg	Cr	Al	S	As
MEAN [1]	0.0218	0.0239	0.0248	0.0206	0.0208	0.0236	0.0207	0.0278	0.0124	0.0399	0.0181	0.0134	0.0199
STD [2]	0.0005	0.0012	0.0004	0.0009	0.0008	0.0002	0.0017	0.0010	0.0005	0.0012	0.0005	0.0007	0.0005
1	0.0215	0.0239	0.0249	0.0213	0.0198	0.0238	0.0204	0.0271	0.0130	0.0394	0.0179	0.0126	0.0202
2	0.0223	0.0219	0.0246	0.0193	0.0210	0.0233	0.0200	0.029	0.0128	0.0412	0.0179	0.0136	0.0193
3	0.0213	0.0244	0.0248	0.0210	0.0216	0.0237	0.0189	0.0283	0.0122	0.0405	0.0185	0.0142	0.0201
4	0.0222	0.0253	0.0243	0.0202	0.0200	0.0238	0.0209	0.0279	0.0120	0.0380	0.0175	0.0128	0.0193
5	0.0215	0.0238	0.0255	0.0212	0.0215	0.0234	0.0234	0.0266	0.0121	0.0405	0.0186	0.0137	0.0205
Certified Values													
Value	0.0217	0.0236	0.0247	0.0203	0.0206	0.0235	0.0209	-	0.0124	0.0400	0.0182	0.0133	0.0200
Error [3]	0.0003	0.0004	0.0003	0.0005	0.0003	0.0003	0.0006	-	0.0019	0.0060	0.0010	0.0019	0.0003

Element %	Be	Ag	Co	Bi	Cd	Sb	Zr	Ti	Au	Se	Te	B	O
MEAN [1]	0.0039	0.0164	0.0200	0.0197	0.0185	0.0205	0.0045	<0.0006	<0.0015	0.0214	0.0215	0.0028	<0.0700
STD [2]	0.0001	0.0004	0.0021	0.0053	0.0004	0.0021	0.0005			0.0011	0.0029	0.0002	
1	0.0040	0.0160	0.0175	0.0198	0.0189	0.0231	0.0042	<0.0006	<0.0015	0.0199	0.0215	0.0028	<0.0700
2	0.0040	0.0171	0.0215	0.0198	0.0188	0.0182	0.0052	<0.0006	<0.0015	0.0219	0.0167	0.0030	<0.0700
3	0.0038	0.0164	0.0220	0.0202	0.0181	0.0200	0.0045	<0.0006	<0.0015	0.0222	0.0244	0.0028	<0.0700
4	0.0039	0.0163	0.0179	0.0188	0.0181	0.0190	0.0040	<0.0006	<0.0015	0.0206	0.0227	0.0025	<0.0700
5	0.0039	0.0162	0.0212	0.0199	0.0186	0.0223	0.0044	<0.0006	<0.0015	0.0223	0.0221	0.0029	<0.0700
Certified Values													
Value	0.0041	0.0163	0.0208	0.0200	0.0186	0.0202	0.0042	0.0005	-	0.0210	0.0215	-	-
Error [3]	0.0006	0.0003	0.0002	0.0005	0.0003	0.0005	0.0002	0.0002	-	0.0004	0,0007	-	-

[1] **MEAN** = arithmetic average
[2] **STD** = absolute standard deviation (1σ)
[3] **Error** = short for the absolute uncertainty of the certified value at the specified confidence level

Table 2
CRM IMN WN1 – Cu120 (Cu-Zn alloys, brass)

Element %	Zn	Pb	Sn	P	Mn	Fe	Ni	Si	Cr	Al
MEAN [1]	38.28	0.509	1.008	0.033	0.576	0.237	0.290	0.161	0.0009	0.331
STD [2]	0.138	0.0082	0.0075	0.0023	0.0062	0.0018	0.0072	0.0034	0.0001	0.0015
1	38.36	0.511	0.997	0.033	0.578	0.239	0.289	0.162	0.0008	0.330
2	38.23	0.517	1.013	0.030	0.570	0.235	0.285	0.167	0.0009	0.334
3	38.09	0.517	1.015	0.036	0.582	0.238	0.281	0.158	0.0008	0.330
4	38.26	0.499	1.003	0.033	0.582	0.238	0.298	0.159	0.0007	0.331
5	38.45	0.503	1.013	0.031	0.569	0.235	0.296	0.159	0.0010	0.331
Certified Values										
Value	38.28	0.51	1.000	0.031	0.57	0.23	0.29	-	-	0.33
Error [3]		0.0072	0.018	0.0007	0.0072	0.01	0.0072			0.0058

Element %	S	As	Be	Ag	Co	Bi	Cd	Sb	Se	B	Cu
MEAN [1]	<0.0008	0.036	0.0013	<0.0005	<0.0035	0.022	<0.0015	0.096	0.0038	0.0026	58.42
STD [2]		0.0009	0.00006			0.0005		0.0072	0.0004	0.0003	0.126
1	<0.0008	0.037	0.0013	<0.0005	<0.0035	0.022	<0.0015	0.090	0.0042	0.0025	58.36
2	<0.0008	0.037	0.0013	<0.0005	<0.0035	0.022	<0.0015	0.089	0.0037	0.0025	58.47
3	<0.0008	0.037	0.0013	<0.0005	<0.0035	0.022	<0.0015	0.107	0.0041	0.0021	58.58
4	<0.0008	0.035	0.0014	<0.0005	<0.0035	0.022	<0.0015	0.095	0.0032	0.0026	58.43
5	<0.0008	0.037	0.0014	0.0006	<0.0035	0.021	<0.0015	0.097	0.0039	0.0030	58.24
Certified Values											
Value	-	0.035	-	-	-	0.023	-	0.099	-	-	58.44
Error [3]		0.001				0.001		0.0043			0.069

[1] **MEAN** = arithmetic average
[2] **STD** = absolute standard deviation (1σ)
[3] **Error** = short for the absolute uncertainty of the certified value at the specified confidence level

Table 3

Production Sample: CuSn12, 2.1052 - Cu160 (Cu-Sn alloys, bronze)

Element %	Zn	Pb	Sn	P	Mn	Fe	Ni	Si
MEAN [1]	0.171	0.575	11.74	0.018	<0.0005	0.013	1.208	0.0059
STD [2]	0.0075	0.0095	0.092	0.0005		0.0004	0.0087	0.0001
1	0.173	0.574	11.76	0.018	<0.0005	0.014	1.202	0.0059
2	0.169	0.574	11.72	0.018	<0.0005	0.014	1.215	0.0061
3	0.175	0.567	11.78	0.018	<0.0005	0.013	1.213	0.0059
4	0.176	0.560	11.70	0.018	<0.0005	0.013	1.206	0.0061
5	0.176	0.566	11.64	0.017	<0.0005	0.013	1.195	0.0058
6	0.179	0.588	11.80	0.018	<0.0005	0.013	1.201	0.0058
7	0.177	0.576	11.60	0.018	<0.0005	0.013	1.213	0.0057
8	0.160	0.592	11.73	0.018	<0.0005	0.014	1.225	0.0060
9	0.162	0.573	11.93	0.018	<0.0005	0.013	1.210	0.0060
10	0.159	0.577	11.77	0.018	<0.0005	0.013	1.203	0.0059

Typical Chemical Composition of BS EN 1982-2008 CC483K - DIN CuSn12 – Sn Bronze - UNS C90800

Element %	Zn	Pb	Sn	P	Mn	Fe	Ni	Si
Min	-	-	11.20	-	-	-	-	-
Max	0.40	0.60	13.00	0.20	0.02	0.15	2.00	0.01

Element %	Mg	Al	S	As	Ag	Sb	Cu
MEAN [1]	<0.00010	<0.0006	0.011	<0.0040	0.048	0.098	86.11
STD [2]			0.0003		0.0004	0.0023	0.09
1	<0.00010	<0.0006	0.011	<0.0040	0.049	0.099	86.09
2	<0.00010	<0.0006	0.011	<0.0040	0.049	0.096	86.13
3	<0.00010	<0.0006	0.011	<0.0040	0.048	0.094	86.08
4	<0.00010	<0.0006	0.010	<0.0040	0.048	0.099	86.16
5	<0.00010	<0.0006	0.010	<0.0040	0.048	0.097	86.23
6	<0.00010	<0.0006	0.011	<0.0040	0.049	0.098	86.04
7	<0.00010	<0.0006	0.010	<0.0040	0.048	0.097	86.24
8	<0.00010	<0.0006	0.011	<0.0040	0.049	0.101	86.09
9	<0.00010	<0.0006	0.011	<0.0040	0.049	0.099	85.93
10	<0.00010	<0.0006	0.010	<0.0040	0.049	0.102	86.09

Typical Chemical Composition of BS EN 1982-2008 CC483K - DIN CuSn12 – Sn Bronze - UNS C90800

Element %	Mg	Al	S	As	Ag	Sb	Cu
Min		-	-			-	85.50
Max		0.01	0.05			0.15	88.50

[1] **MEAN** = arithmetic average

[2] **STD** = absolute standard deviation (1σ)

Table 4

Production Sample: CuSn7Zn4Pb7, 2.1090, CC493K - Cu150 (Gunmetal alloys)

Element %	Zn	Pb	Sn	P	Mn	Fe	Ni	Si	Cr
MEAN [1]	4.075	5.854	6.884	0.030	<0.0004	0.069	1.083	0.0006	0.0007
STD [2]	0.019	0.063	0.023	0.0009		0.0005	0.0087	0.0001	0.00004
1	4.082	5.832	6.913	0.031	<0.0004	0.069	1.088	0.0006	0.0007
2	4.073	5.797	6.887	0.030	<0.0004	0.069	1.090	0.0006	0.0008
3	4.099	5.951	6.880	0.029	<0.0004	0.069	1.064	0.0006	0.0007
4	4.088	5.907	6.863	0.031	<0.0004	0.069	1.090	0.0006	0.0007
5	4.100	5.786	6.894	0.030	<0.0004	0.069	1.080	0.0007	0.0007
6	4.046	5.802	6.875	0.029	<0.0004	0.068	1.088	0.0007	0.0008
7	4.069	5.774	6.837	0.031	<0.0004	0.069	1.077	0.0006	0.0007
8	4.076	5.914	6.877	0.029	<0.0004	0.069	1.089	0.0007	0.0007
9	4.044	5.875	6.914	0.031	<0.0004	0.069	1.087	0.0006	0.0008
10	4.074	5.897	6.895	0.030	<0.0004	0.068	1.074	0.0007	0.0007

Typical Chemical Composition of Leaded Gunmetal - CuSn7Zn4Pb7 - BS EN 1982-2008 CC493K – RG7 – DIN 1705 2.1090

Element %	Zn	Pb	Sn	P	Mn	Fe	Ni	Si	Cr
Min	2.30	5.20	6.20	-		-	-	-	
Max	5.00	8.00	8.00	0.03		0.20	2.00	0.01	

Element %	Al	S	As	Ag	Bi	Sb	Se	Cu
MEAN [1]	0.0004	0.034	0.028	0.019	<0.0020	0.123	0.016	81.78
STD [2]		0.0009	0.0005	0.0002		0.0049	0.0004	0.075
1	<0.0004	0.034	0.027	0.019	<0.0020	0.113	0.015	81.78
2	<0.0004	0.034	0.028	0.019	<0.0020	0.129	0.016	81.83
3	<0.0004	0.035	0.028	0.019	<0.0020	0.124	0.016	81.68
4	<0.0004	0.034	0.027	0.019	<0.0020	0.119	0.016	81.73
5	<0.0004	0.033	0.028	0.019	<0.0020	0.126	0.016	81.82
6	<0.0004	0.036	0.028	0.019	<0.0020	0.122	0.016	81.87
7	<0.0004	0.034	0.027	0.019	<0.0020	0.118	0.015	81.93
8	<0.0004	0.033	0.028	0.019	<0.0020	0.127	0.016	81.72
9	<0.0004	0.033	0.029	0.019	<0.0020	0.125	0.016	81.76
10	<0.0004	0.033	0.028	0.019	<0.0020	0.125	0.016	81.74

Typical Chemical Composition of Leaded Gunmetal - CuSn7Zn4Pb7 - BS EN 1982-2008 CC493K – RG7 – DIN 1705 2.1090

Element %	Al	S	As	Ag	Bi	Sb	Se	Cu
Min	-	-				-		81.00
Max	0.01	0.08				0.30		84.50

[1] **MEAN** = arithmetic average

[2] **STD** = absolute standard deviation (1σ)

Summary

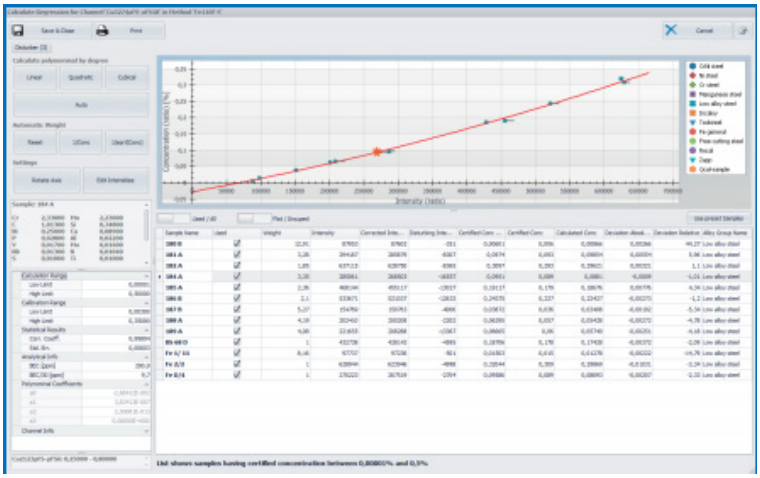
The Q4 POLO is a compact Spark Optical Emission Spectrometer (OES) combining high precision analysis capabilities with low cost of ownership and small footprint. It is the ready-to-analyze solution from day one, covering all relevant elements and wide concentration ranges. At the same time, the Q4 POLO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

ELEMENTAL.SUITE

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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