



LAB REPORT OES 26

Q4 POLO

Analysis of Aluminum Alloys

Aluminum alloys are soft and lightweight alloys with physical properties that make them ideal for a wide range of applications. Mainly aerospace, automotive, and marine industries use aluminum alloys as they can have excellent heat transfer rate, corrosion resistance, and high strength, depending on the alloy type.

The Q4 POLO is an ideal tool for the accurate analysis of all common aluminum alloys. With the new optimized MultiVision™ optics, the Q4 POLO provides excellent analytical performance, enabling the instrument to monitor the main chemical elements, to determine other trace elements, and, of course, to deliver trustworthy results on all relevant alloying elements.

| Element | Fe | Ga | Hg | In | La | Li | Mg | Mn | Mo | Na | Ni |
|----------------------|--------|---------|--------|---------|--------|---------|---------|--------|---------|---------|--------|
| min % | 0,0008 | 0,0002 | 0,0020 | 0,0005 | 0,0008 | 0,0001 | 0,00005 | 0,0002 | 0,0002 | 0,00005 | 0,0005 |
| max % | 5,5 | 0,07 | 0,08 | 0,12 | 0,035 | 2 | 11 | 12 | 0,85 | 0,025 | 5,2 |
| Conc. Level % | | | | | | | | | | | |
| 0.001 | 0,0002 | 0,00005 | | 0,00005 | 0,0001 | 0,00001 | 0,00005 | 0,0001 | 0,00005 | 0,00002 | 0,0001 |
| 0.005 | 0,0005 | 0,00007 | 0,0005 | 0,00008 | 0,0005 | 0,0001 | 0,00005 | 0,0001 | 0,0001 | 0,00005 | 0,0001 |
| 0.01 | 0,0005 | 0,0001 | 0,0010 | 0,0001 | 0,0009 | 0,0002 | 0,00007 | 0,0003 | 0,0003 | 0,0003 | 0,0001 |
| 0.02 | 0,0010 | 0,0002 | 0,0020 | 0,0003 | 0,0018 | 0,0002 | 0,0001 | 0,0005 | 0,001 | 0,0006 | 0,0003 |
| 0.05 | 0,0015 | 0,0002 | 0,0025 | 0,0006 | | 0,0006 | 0,0003 | 0,0005 | 0,002 | | 0,0004 |
| 0.1 | 0,0020 | | | 0,0012 | | 0,0015 | 0,0010 | 0,0015 | 0,015 | | 0,0010 |
| 0.2 | 0,0025 | | | | | 0,0030 | 0,0025 | 0,0040 | 0,030 | | 0,0015 |
| 0.5 | 0,0040 | | | | | 0,0075 | 0,0050 | 0,0050 | 0,080 | | 0,0090 |
| 1 | 0,0060 | | | | | 0,015 | 0,0080 | 0,0080 | | | 0,010 |
| 2 | 0,010 | | | | | 0,030 | 0,0085 | 0,016 | | | 0,020 |
| 3 | 0,030 | | | | | | 0,015 | 0,024 | | | 0,025 |
| 4 | 0,045 | | | | | | 0,020 | 0,035 | | | 0,025 |
| 5 | 0,065 | | | | | | 0,035 | 0,060 | | | 0,030 |
| 10 | | | | | | | 0,080 | 0,080 | | | |
| 20 | | | | | | | | | | | |
| 30 | | | | | | | | | | | |

| Element | P | Pb | Sb | Sc | Si | Sn | Sr | Ti | V | Zn | Zr |
|----------------------|--------|--------|--------|--------|--------|--------|---------|--------|--------|--------|---------|
| min % | 0,0035 | 0,0010 | 0,0030 | 0,0002 | 0,0003 | 0,0005 | 0,00005 | 0,0005 | 0,0005 | 0,0008 | 0,0005 |
| max % | 0,018 | 1,7 | 0,6 | 0,8 | 25 | 22 | 0,15 | 0,6 | 0,18 | 56 | 0,85 |
| Conc. Level % | | | | | | | | | | | |
| 0.001 | | | | 0,0001 | 0,0001 | 0,0001 | 0,00001 | 0,0001 | 0,0001 | | 0,00005 |
| 0.005 | 0,0003 | 0,0002 | 0,0008 | 0,0002 | 0,0002 | 0,0001 | 0,00005 | 0,0002 | 0,0001 | 0,0002 | 0,0001 |
| 0.01 | 0,0004 | 0,0003 | 0,0010 | 0,0003 | 0,0002 | 0,0003 | 0,0001 | 0,0003 | 0,0002 | 0,0002 | 0,0002 |
| 0.02 | 0,0004 | 0,0004 | 0,0012 | 0,0003 | 0,0003 | 0,0006 | 0,0002 | 0,0003 | 0,0002 | 0,0005 | 0,0002 |
| 0.05 | 0,0005 | 0,0006 | 0,0020 | 0,0005 | 0,0003 | 0,0010 | 0,0004 | 0,0006 | 0,0015 | 0,0006 | 0,0010 |
| 0.1 | 0,0007 | 0,0020 | 0,0025 | 0,0008 | 0,0010 | 0,0015 | 0,0008 | 0,0015 | 0,0020 | 0,0015 | 0,0015 |
| 0.2 | | 0,0050 | 0,0035 | 0,0035 | 0,0010 | 0,0020 | | 0,0060 | | 0,0020 | 0,0025 |
| 0.5 | | 0,012 | 0,0075 | 0,0055 | 0,0015 | 0,0030 | | 0,010 | | 0,0035 | 0,010 |
| 1 | | 0,025 | | | 0,0085 | 0,0040 | | | | 0,0045 | |
| 2 | | | | | 0,015 | 0,0080 | | | | 0,010 | |
| 3 | | | | | 0,020 | 0,010 | | | | 0,015 | |
| 4 | | | | | 0,025 | 0,015 | | | | 0,020 | |
| 5 | | | | | 0,040 | 0,020 | | | | 0,025 | |
| 10 | | | | | 0,080 | 0,1 | | | | 0,050 | |
| 20 | | | | | 0,12 | | | | | 0,100 | |
| 30 | | | | | | | | | | 0,150 | |

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 customers.

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 2
RM 121/02 – Al110 (low alloys)

| Element % | Si | Fe | Cu | Mn | Mg | Cr | Ni | Zn | Ti | Ag | B | Be |
|-------------------------|--------|--------|--------|--------|---------|--------|--------|--------|--------|---------|---------|-----------------|
| MEAN ¹⁾ | 0.0204 | 0.0303 | 0.0096 | 0.0097 | 0.0077 | 0.0096 | 0.0099 | 0.0102 | 0.0096 | 0.0052 | 0.0002 | 0.0005 |
| STD ²⁾ | 0.0006 | 0.0007 | 0.0001 | 0.0001 | 0.00004 | 0.0002 | 0.0002 | 0.0003 | 0.0003 | 0.00008 | 0.00005 | 0.00001 |
| 1 | 0.0207 | 0.0309 | 0.0098 | 0.0098 | 0.0077 | 0.0095 | 0.010 | 0.0099 | 0.0099 | 0.0052 | 0.0003 | 0.0005 |
| 2 | 0.0208 | 0.0310 | 0.0094 | 0.0097 | 0.0077 | 0.0097 | 0.010 | 0.0101 | 0.0094 | 0.0052 | 0.0003 | 0.0005 |
| 3 | 0.0209 | 0.0300 | 0.0096 | 0.0096 | 0.0077 | 0.0095 | 0.010 | 0.0099 | 0.0093 | 0.0051 | 0.0002 | 0.0005 |
| 4 | 0.0195 | 0.0293 | 0.0096 | 0.0097 | 0.0077 | 0.0094 | 0.0096 | 0.0105 | 0.0097 | 0.0051 | 0.0002 | 0.0005 |
| 5 | 0.0203 | 0.0304 | 0.0095 | 0.0097 | 0.0078 | 0.0098 | 0.0098 | 0.0105 | 0.0098 | 0.0053 | 0.0002 | 0.0005 |
| Certified Values | | | | | | | | | | | | |
| Value | 0.020 | 0.030 | 0.010 | 0.010 | 0.0075 | 0.010 | 0.010 | 0.010 | 0.010 | 0.005 | 0.0002 | 0.0006 - 0.0007 |

| Element% | Bi | Ca | Cd | Co | Ga | Li | Na | Pb | Sb | Sn | V | Zr |
|-------------------------|--------|-----------------|--------|--------|--------|-----------------|--------|--------|--------|--------|--------|--------|
| MEAN ¹⁾ | 0.0096 | 0.0017 | 0.0019 | 0.0098 | 0.0096 | 0.0012 | 0.0032 | 0.0032 | 0.0096 | 0.0053 | 0.0107 | 0.0108 |
| STD ²⁾ | 0.0003 | 0.00004 | 0.0001 | 0.0002 | 0.0002 | 0.00004 | 0.0001 | 0.0002 | 0.0005 | 0.0003 | 0.0002 | 0.0002 |
| 1 | 0.010 | 0.0017 | 0.0020 | 0.010 | 0.0097 | 0.0012 | 0.0031 | 0.0033 | 0.010 | 0.0056 | 0.0109 | 0.0110 |
| 2 | 0.0092 | 0.0017 | 0.0020 | 0.010 | 0.0098 | 0.0012 | 0.0033 | 0.0033 | 0.0100 | 0.0056 | 0.0110 | 0.0109 |
| 3 | 0.0094 | 0.0017 | 0.0017 | 0.0097 | 0.0095 | 0.0012 | 0.0032 | 0.0031 | 0.0088 | 0.0051 | 0.0106 | 0.0106 |
| 4 | 0.0094 | 0.0018 | 0.0020 | 0.0096 | 0.0094 | 0.0012 | 0.0032 | 0.0032 | 0.0096 | 0.0053 | 0.0104 | 0.0109 |
| 5 | 0.0098 | 0.0017 | 0.0018 | 0.0098 | 0.0095 | 0.0011 | 0.0031 | 0.0029 | 0.0097 | 0.0051 | 0.0107 | 0.0105 |
| Certified Values | | | | | | | | | | | | |
| Value | 0.009 | 0.0015 - 0.0023 | 0.002 | 0.010 | 0.010 | 0.0008 - 0.0012 | 0.0018 | 0.0033 | 0.01 | 0.005 | 0.011 | 0.011 |

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

CRM 425/01 – Al120 (Al-Si alloys)

| Element % | Si | Fe | Cu | Mn | Mg | Zn | Ti | Sb |
|----------------------------|-------|--------|--------|--------|--------|--------|--------|--------|
| MEAN ¹⁾ | 7.127 | 0.103 | 0.0027 | 0.0078 | 0.565 | 0.022 | 0.111 | 0.114 |
| STD ²⁾ | 0.033 | 0.0021 | 0.0001 | 0.0001 | 0.0030 | 0.0007 | 0.0016 | 0.0028 |
| 1 | 7.149 | 0.104 | 0.0028 | 0.0078 | 0.566 | 0.022 | 0.112 | 0.113 |
| 2 | 7.124 | 0.105 | 0.0026 | 0.0079 | 0.568 | 0.022 | 0.112 | 0.11 |
| 3 | 7.169 | 0.100 | 0.0025 | 0.0077 | 0.566 | 0.021 | 0.111 | 0.111 |
| 4 | 7.110 | 0.101 | 0.0026 | 0.0076 | 0.560 | 0.022 | 0.110 | 0.111 |
| 5 | 7.084 | 0.103 | 0.0028 | 0.0079 | 0.564 | 0.023 | 0.112 | 0.116 |
| <i>Certified Values</i> | | | | | | | | |
| Value | 7.16 | 0.11 | 0.0030 | 0.0080 | 0.57 | 0.020 | 0.115 | 0.12 |
| Error ³⁾ | 0.15 | 0.01 | 0.0005 | 0.0005 | 0.02 | 0.002 | 0.006 | 0.01 |

Table 4

CRM KA 213 – Al130 (Al-Cu alloys)

| Element % | Si | Fe | Cu | Mn | Mg | Cr | Ni | Ti |
|----------------------------|--------|--------|-------|--------|--------|--------|--------|--------|
| MEAN ¹⁾ | 2.031 | 0.943 | 7.053 | 0.336 | 0.076 | 0.0015 | 0.190 | 0.058 |
| STD ²⁾ | 0.0081 | 0.0091 | 0.047 | 0.0047 | 0.0008 | 0.0001 | 0.0023 | 0.0009 |
| 1 | 2.037 | 0.955 | 7.054 | 0.334 | 0.075 | 0.0015 | 0.190 | 0.057 |
| 2 | 2.041 | 0.949 | 7.052 | 0.341 | 0.077 | 0.0015 | 0.190 | 0.057 |
| 3 | 2.030 | 0.938 | 7.075 | 0.332 | 0.077 | 0.0015 | 0.190 | 0.057 |
| 4 | 2.027 | 0.933 | 7.106 | 0.332 | 0.077 | 0.0015 | 0.190 | 0.057 |
| 5 | 2.021 | 0.937 | 6.977 | 0.341 | 0.076 | 0.0015 | 0.190 | 0.057 |
| <i>Certified Values</i> | | | | | | | | |
| Value | 2.02 | 0.93 | 7.05 | 0.3 | 0.079 | 0.001 | 0.2 | 0.06 |
| Error ³⁾ | - | - | - | - | - | - | - | - |

Table 5

CRM: 533/03 – Method: Al150 Al-Mg

| Element % | Si | Fe | Cu | Mn | Mg | Cr | Ni | Zn | Ti |
|----------------------------|-------|-------|--------|-------|-------|-------|--------|--------|--------|
| MEAN ¹⁾ | 0.314 | 0.212 | 0.0544 | 0.100 | 5.069 | 0.101 | 0.0112 | 0.0319 | 0.0183 |
| STD ²⁾ | 0.001 | 0.002 | 0.0005 | 0.002 | 0.033 | 0.002 | 0.0003 | 0.0007 | 0.0005 |
| 1 | 0.314 | 0.209 | 0.0542 | 0.102 | 5.067 | 0.103 | 0.0108 | 0.0319 | 0.0188 |
| 2 | 0.315 | 0.211 | 0.0552 | 0.100 | 5.107 | 0.101 | 0.0114 | 0.0321 | 0.0182 |
| 3 | 0.313 | 0.214 | 0.0541 | 0.098 | 5.083 | 0.098 | 0.0114 | 0.0321 | 0.0179 |
| 4 | 0.314 | 0.214 | 0.0541 | 0.099 | 5.017 | 0.100 | 0.0113 | 0.0308 | 0.0177 |
| 5 | 0.314 | 0.212 | 0.0543 | 0.101 | 5.071 | 0.103 | 0.0111 | 0.0326 | 0.0188 |
| <i>Certified Values</i> | | | | | | | | | |
| Value | 0.319 | 0.216 | 0.0544 | 0.102 | 5.03 | 0.102 | 0.0117 | 0.0311 | 0.0188 |
| Error ³⁾ | 0.010 | 0.006 | 0.0015 | 0.003 | 0.09 | 0.003 | 0.0006 | 0.0011 | 0.0009 |

| Element % | Be | Bi | Cd | Li | Pb | Sn | Sr | V | Zr |
|----------------------------|--------|--------|--------|---------|--------|--------|---------|--------|--------|
| MEAN ¹⁾ | 0.0041 | 0.0013 | 0.0016 | 0.00028 | 0.0023 | 0.0012 | 0.0010 | 0.0057 | 0.0053 |
| STD ²⁾ | 0.0001 | 0.0002 | 0.0001 | 0.00001 | 0.0005 | 0.0001 | 0.00001 | 0.0001 | 0.0001 |
| 1 | 0.0042 | 0.0012 | 0.0017 | 0.00026 | 0.0025 | 0.0011 | 0.0010 | 0.0055 | 0.0054 |
| 2 | 0.0041 | 0.0015 | 0.0016 | 0.00028 | 0.0030 | 0.0014 | 0.0010 | 0.0057 | 0.0054 |
| 4 | 0.0042 | 0.0014 | 0.0018 | 0.00029 | 0.0021 | 0.0012 | 0.0010 | 0.0057 | 0.0052 |
| 5 | 0.0040 | 0.0011 | 0.0015 | 0.00028 | 0.0018 | 0.0012 | 0.0010 | 0.0056 | 0.0051 |
| 6 | 0.0041 | 0.0015 | 0.0016 | 0.00030 | 0.0022 | 0.0012 | 0.0010 | 0.0058 | 0.0053 |
| <i>Certified Values</i> | | | | | | | | | |
| Value | 0.0041 | 0.0009 | 0.0015 | 0.00022 | 0.0022 | 0.0011 | 0.0010 | 0.0062 | 0.0055 |
| Error ³⁾ | 0.0002 | 0.0002 | 0.0002 | 0.00005 | 0.0002 | 0.0002 | 0.0002 | 0.0004 | 0.0004 |

