

CERTIFICATE OF ANALYSIS

54X G25D2 (batch K)

Certified Reference Material Information

Type: ALUMINIUM/SILICON (CAST)
Form and Size: Disc 40-50mm diameter x 15-20mm thick
Produced by: Coleshill Laboratories Limited
Certified and Supplied by: MBH Analytical Limited

Certified Analysis

Percentage element by weight

| Element | Cu | Mg | Si | Fe | Mn | Ni | Zn | Pb |
|--------------------------|-------|------|------|-------|-------|-------|-------|-------|
| Value ¹ | 0.130 | 0.59 | 3.93 | 0.576 | 0.479 | 0.139 | 0.169 | 0.073 |
| Uncertainty ² | 0.008 | 0.02 | 0.09 | 0.015 | 0.017 | 0.009 | 0.007 | 0.006 |

| Element | Sn | Ti | Cr | Co | V | Be | Bi | Cd |
|--------------------------|-------|-------|-------|-------|---------|-------|------|-------|
| Value ¹ | 0.042 | 0.152 | 0.150 | 0.105 | (0.006) | 0.049 | 0.22 | 0.011 |
| Uncertainty ² | 0.002 | 0.006 | 0.006 | 0.006 | - | 0.003 | 0.04 | 0.001 |

Note: values given in parentheses are not certified - they are provided for information only.

Definitions

- ¹ The certified values are the present best estimates of the true content for each element. Each value is a panel consensus, based on the averaged results of an interlaboratory testing programme, detailed on page 3.
- ² The uncertainty values are generated from the 95% confidence interval derived from the wet analysis results, in combination with a statistical assessment of the homogeneity data, as described on page 2.

Certified by:

MBH ANALYTICAL LIMITED _____

C Eveleigh

on 23rd September 2002



Method of Preparation

This reference material was produced from commercial-purity aluminium, with the main and trace elements added as master alloys or pure elements. The melt was degassed using sodium-free flux, and was cast into iron chill moulds. 2mm has been removed from the cast face to minimise any surface effects.

Sampling

Samples for chemical analysis, and discs for homogeneity checks, were taken from several positions throughout the casting process. At least 5% of all discs were incorporated into the schedule for homogeneity checking.

Homogeneity

The discs were checked for batch uniformity using an optical emission spectrometer. One additional disc was checked for vertical uniformity using the same method. Multiple measurements were taken from each surface under test.

For each of the surfaces checked, the differences between the averaged result and the overall mean value were evaluated to ensure that the overall homogeneity of the material comprising the batch satisfied the definition given in ISO guide 30 - 1992.

Using the individual data from each check, standard deviation values were derived for each element. These values were combined with the 95% half-width confidence intervals ($C_{(95\%)}$) obtained from the wet analysis programme, using the square-root of the summed squares, to derive the final uncertainty values.

The results from the vertical uniformity check indicated that these samples are within homogeneity acceptance limits for at least the first 10mm of depth.

Chemical Analysis

Analysis was carried out on millings taken from samples representative of the product. It was performed by a panel of laboratories mostly operating within the terms of ISO Guide 25-1990, or EN ISO/IEC 17025-2000, using documented standard reference methods and validated by appropriate reference materials.

The individual values listed overpage are the average of each analyst's results.

Traceability

Most of the analytical work performed to assess this material has been carried out by laboratories with proven competence, as indicated by their accreditation to a national authority. It is part of the requirement for this accreditation that analytical work should be performed with due traceability, via an unbroken chain of comparisons, each with stated uncertainty, to primary standards such as the mole, or to nationally- or internationally-recognised primary reference materials.

Usage

Intended use: With optical emission and X-ray fluorescence spectrometers.

Recommended method of use: Aluminium alloys are generally prepared by machining on a mill or a lathe. However, users are recommended to follow the calibration and sample preparation procedures specified by the relevant instrument manufacturer.

Preparation should be the same for reference materials and the samples for test.

A minimum of four consistent replicate analyses is recommended to optimise precision and accuracy. Users are advised to check against possible bias between reference materials and production samples due to differences in metallurgical history, and be aware of possible inter-element effects.

Analytical Data

Percentage element by weight

| Sample | Cu | Mg | Si | Fe | Mn | Ni | Zn | Pb |
|--------------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| 1 | 0.12 | 0.56 | 3.83 | 0.56 | 0.459 | 0.13 | 0.16 | 0.0628 |
| 2 | 0.12 | 0.57 | 3.84 | 0.57 | 0.47 | 0.13 | 0.16 | 0.07 |
| 3 | 0.12 | 0.592 | 3.85 | 0.572 | 0.47 | 0.139 | 0.16 | 0.07 |
| 4 | 0.123 | 0.598 | 3.90 | 0.58 | 0.47 | 0.14 | 0.17 | 0.070 |
| 5 | 0.132 | 0.60 | 3.95 | 0.58 | 0.472 | 0.14 | 0.170 | 0.073 |
| 6 | 0.139 | 0.60 | 3.99 | 0.581 | 0.485 | 0.143 | 0.174 | 0.074 |
| 7 | 0.14 | 0.601 | 4.02 | 0.587 | 0.499 | 0.152 | 0.176 | 0.079 |
| 8 | 0.143 | | 4.04 | | 0.51 | | 0.18 | 0.082 |
| Mean | 0.130 | 0.589 | 3.928 | 0.576 | 0.479 | 0.139 | 0.169 | 0.073 |
| Std Dev | 0.010 | 0.017 | 0.084 | 0.009 | 0.017 | 0.008 | 0.008 | 0.006 |
| C_(95%) | 0.008 | 0.015 | 0.070 | 0.008 | 0.014 | 0.007 | 0.007 | 0.005 |

| Sample | Sn | Ti | Cr | Co | V | Be | Bi | Cd |
|--------------------------|--------------|--------------|--------------|--------------|----------------|--------------|--------------|--------------|
| 1 | 0.04 | 0.144 | 0.14 | 0.10 | 0.005 | 0.044 | 0.17 | 0.01 |
| 2 | 0.04 | 0.15 | 0.14 | 0.104 | 0.005 | 0.0456 | 0.20 | 0.011 |
| 3 | 0.04 | 0.15 | 0.149 | 0.104 | 0.0062 | 0.046 | 0.22 | 0.011 |
| 4 | 0.041 | 0.15 | 0.15 | 0.106 | 0.01 | 0.049 | 0.235 | 0.011 |
| 5 | 0.044 | 0.153 | 0.15 | 0.11 | <0.01 | 0.049 | 0.25 | 0.013 |
| 6 | 0.044 | 0.154 | 0.152 | | <0.01 | 0.051 | | |
| 7 | 0.045 | 0.16 | 0.156 | | <0.01 | 0.0518 | | |
| 8 | | | 0.16 | | | 0.053 | | |
| Mean | 0.042 | 0.152 | 0.150 | 0.105 | (0.006) | 0.049 | 0.215 | 0.011 |
| Std Dev | 0.002 | 0.005 | 0.007 | 0.004 | 0.002 | 0.003 | 0.031 | 0.001 |
| C_(95%) | 0.002 | 0.005 | 0.006 | 0.005 | - | 0.003 | 0.039 | 0.001 |

Note: C_(95%) is the 95% half-width confidence interval derived from the equation:

$$C_{(95\%)} = (t \times SD) / \sqrt{n}$$

where n is the number of available values, t is the Student's t value for n-1 degrees of freedom, and SD is the standard deviation of the test results.

Participating Laboratories

| | | |
|---|--------------------------|--------------------------|
| London & Scandinavian Met Co Ltd | Rotherham, England | NAMAS accreditation 1091 |
| Sheffield Assay Office Ltd | Sheffield, England | NAMAS accreditation 0012 |
| University Metals Advisory Centre | Sheffield, England | NAMAS accreditation 0041 |
| Metals Technology Testing Ltd | Sheffield, England | NAMAS accreditation 0963 |
| Sheffield Testing Laboratories Ltd | Sheffield, England | NAMAS accreditation 0136 |
| Coleshill Laboratories Ltd | Birmingham, England | NAMAS accreditation 0121 |
| Universal Scientific Laboratory Pty Ltd | Milperra, NSW, Australia | NATA accreditation 0492 |
| Laboratory Testing Inc | Hatfield, PA, USA | A2LA accreditation 0117 |
| Central Iron & Steel Research Inst | Beijing, China | CNACL accreditation 0435 |

Note: to achieve National Accreditation (eg NAMAS, NATA, A2LA, CNACL), test houses were required to demonstrate conformity to the general requirements of ISO Guide 25-1990, or EN ISO/IEC 17025 and ISO9002.

Analytical Methods Used

| ELEMENT | RESULT No. & METHOD | | | |
|------------|---------------------|---------|-----|--|
| | ICP-AES | FAAS | OES | OTHER |
| Copper: | 1, 2, 3, 6 | 5, 7 | 8 | 4 photometric (BCO) |
| Magnesium: | 1, 2, 3, 5, 6 | 4, 7 | - | |
| Silicon: | 1, 2, 3 | 5 | - | 4, 6, 7, 8 gravimetric (perchloric acid) |
| Iron: | 1, 2, 4, 5 | 3 | 6 | 7 photometric (orthophenanthroline) |
| Manganese: | 1, 2, 3, 4, 8 | 5 | 6 | 7 photometric (periodate) |
| Nickel: | 1, 2, 4, 5, 7 | 6 | - | 3 photometric (dimethyl glyoxime) |
| Zinc: | 2, 3, 4, 7, 8 | 1, 5, 6 | - | |
| Lead: | 2, 3, 5, 8 | 4, 6 | 7 | 1 polarographic |
| Tin: | 2, 3, 4, 7 | 1, 6 | 5 | |
| Titanium: | 2, 3, 4, 5, 7 | 6 | - | 1 photometric (di-antipyryl methane) |
| Chromium: | 1, 2, 5, 7, 8 | 3, 4 | - | 6 photometric (diphenyl carbazide) |
| Cobalt: | 1, 4, 5 | 3 | - | 2 photometric (nitroso-R) |
| Vanadium: | 2, 5 | 4 | - | 3 photometric (N-b-N-p) 1: GF-AAS |
| Beryllium: | 1, 2, 5, 7, 8 | 3, 6 | 4 | |
| Bismuth: | 1, 2, 5 | 3, 4 | 1 | |
| Cadmium: | 1, 3, 4 | 2, 5 | - | |

Notes

This Certified Reference Material was originally prepared and certified in November 2000. The certificate has been re-formatted to include statements of uncertainty. Otherwise, this product has been produced and certified in accordance with the requirements of ISO Guide 34-2000, ISO Guide 31-2000 and ISO Guide 35-1989, taking into account the requirements of ASTM E1724, ASTM E1831 and the ISO Guide to the Expression of Uncertainty in Measurement (GUM).

The combination of alloying elements used in a complex material of this type, coupled with the unidirectional solidification effects associated with chill casting, may lead to the formation of inhomogeneous segregates in the rear portion of the disc. The above certification is therefore only applicable from the front face of the disc. Material to the rear of the disc, to a depth of ~5-8mm, is not certified.

This material will remain stable provided adequate precautions are taken to protect it from cross-contamination, extremes of temperature and atmospheric moisture. All production records will be retained for a period of 20 years from the date of original analysis. This certification will therefore expire in November 2020, although we reserve the right to make changes as issue revisions, in the intervening period.

This sample is also available in the form of chippings.

The manufacture, analysis and certification of this product were supervised by C Eveleigh, PhD, Technical Director, MBH Analytical Ltd.

The material to which this certificate of analysis refers is supplied subject to our general conditions of sale.