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CERTIFICATE OF ANALYSIS

51X G00H4 (batch C)

Certified Reference Material Information

Type: RESIDUALS IN ALUMINIUM (CAST)

Form and Size: Disc ~50mm diameter

Produced by: MBH Analytical Ltd

Certified and Supplied by: MBH Analytical Ltd

Assigned Values

Percentage element by weight

Element	Cu	Mg	Si	Fe	Mn	Ni	Zn	Pb
Value [1]	**0.0465**	**0.054**	**(0.04)**	**0.082**	**0.0792**	**0.0323**	**0.197**	**0.0204**
Uncertainty [2]	0.0014	0.002	-	0.003	0.0013	0.0010	0.003	0.0006

Element	Sn	Ti	Cr	Co	V	Zr	Sb
Value [1]	**0.0285**	**0.0292**	**0.0602**	**0.0109**	**0.0220**	**0.0278**	**0.0077**
Uncertainty [2]	0.0010	0.0006	0.0010	0.0004	0.0012	0.0013	0.0006

Element	Cd	Bi	As	Be	Ga	Hg	Ag
Value [1]	**0.0267**	**0.0246**	**(0.0026)**	**0.0011**	**0.0315**	**0.0011**	**0.0208**
Uncertainty [2]	0.0008	0.0013	-	0.0001	0.0015	0.0002	0.0012

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 _____ on 5th December 2018

C Eveleigh

Method of Preparation

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

Sampling

Samples for chemical analysis were taken from various positions throughout the casting process. Approximately 10% of all discs were selected for non-destructive homogeneity testing.

Homogeneity

Samples representative of the batch were checked for uniformity using an optical emission spectrometer.

From this test data, through-batch variation values were derived for each element as an indicator of any minor compositional variation (as determined for the specific sample size and other limitations of the spectrometer).

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 EN ISO/IEC 17025, using documented standard reference methods and validated by appropriate reference materials. The individual values listed overpage are the average of each analyst's results.

Estimation of Uncertainties

The uncertainty values are generated from the 95% half-width confidence interval $C_{(95\%)}$, which is derived from the wet analysis results, in accordance with the following 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.

As a separate exercise, the degree of compositional variation of the batch for each element has been quantified by a programme of non-destructive application testing, described above. These values have been combined, using the square-root of the summed squares, to derive the final uncertainty values.

Traceability

Much of the analytical work performed to assess this material has been carried out by laboratories with proven competence, as indicated by their accreditation to ISO 17025. It is an implicit 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 reference materials.

Of the individual results herein, some have traceability (to the mole) via primary analytical methods. Some are traceable to substances of known stoichiometry. Most have traceability via commercial solutions. Furthermore, some results have additional traceability to NIST standards, as part of the analytical calibration or process control.

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 five consistent replicate analyses is recommended to provide the necessary sample size. 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	0.0425	0.0501	0.0250	0.0790	0.0761	0.0297	0.1880	0.0192
2	0.0430	0.0502	0.0252	0.0796	0.0768	0.0298	0.1894	0.0195
3	0.0440	0.0515	0.0256	0.0799	0.0771	0.0299	0.1908	0.0196
4	0.0443	0.0519	0.0264	0.0800	0.0780	0.0305	0.1958	0.0197
5	0.0447	0.0525	0.0277	0.0804	0.0781	0.0306	0.1972	0.0198
6	0.0457	0.0534	0.0295	0.0806	0.0788	0.0315	0.1972	0.0200
7	0.0460	0.0545	0.0305	0.0811	0.0789	0.0326	0.1972	0.0200
8	0.0460	0.0546	0.0316	0.0813	0.0799	0.0329	0.1989	0.0202
9	0.0473	0.0553	0.0394	0.0813	0.0800	0.0331	0.1991	0.0206
10	0.0474	0.0561	0.0496	0.0826	0.0803	0.0333	0.2008	0.0211
11	0.0474	0.0564	0.0498	0.0829	0.0805	0.0336	0.2010	0.0211
12	0.0487	0.0581	0.0501	0.0833	0.0816	0.0336	0.2044	0.0213
13	0.0494	0.0584	0.0510	0.0851	0.0833	0.0339	0.2050	0.0214
14	0.0503		0.0522	0.0862		0.0344		0.0221
15	0.0509		0.0534	0.0865		0.0351		
Mean	**0.0465**	**0.0541**	**(0.038)**	**0.0820**	**0.0792**	**0.0323**	**0.1973**	**0.0204**
Std Dev	0.0026	0.0028	-	0.0024	0.0020	0.0018	0.0053	0.0009
$C_{(95\%)}$	0.0014	0.0017	-	0.0013	0.0012	0.0010	0.0032	0.0005

Sample	Sn	Ti	Cr	Co	V	Zr	Sb
1	0.0254	0.0267	0.0574	0.0098	0.0200	0.0249	0.0067
2	0.0262	0.0278	0.0577	0.0099	0.0202	0.0255	0.0067
3	0.0272	0.0285	0.0581	0.0099	0.0206	0.0262	0.0069
4	0.0275	0.0285	0.0591	0.0103	0.0208	0.0270	0.0072
5	0.0275	0.0288	0.0592	0.0106	0.0210	0.0270	0.0076
6	0.0278	0.0288	0.0598	0.0106	0.0216	0.0271	0.0079
7	0.0279	0.0290	0.0600	0.0107	0.0220	0.0272	0.0079
8	0.0287	0.0293	0.0601	0.0111	0.0222	0.0275	0.0082
9	0.0292	0.0298	0.0601	0.0115	0.0223	0.0298	0.0086
10	0.0295	0.0299	0.0611	0.0115	0.0225	0.0301	0.0089
11	0.0300	0.0299	0.0614	0.0116	0.0233	0.0302	
12	0.0306	0.0301	0.0615	0.0116	0.0238	0.0312	
13	0.0308	0.0304	0.0615	0.0117	0.0241		
14	0.0311	0.0309	0.0631	0.0120	0.0241		
15			0.0633				
Mean	**0.0285**	**0.0292**	**0.0602**	**0.0109**	**0.0220**	**0.0278**	**0.0077**
Std Dev	0.0017	0.0011	0.0018	0.0008	0.0014	0.0020	0.0008
$C_{(95\%)}$	0.0010	0.0006	0.0010	0.0004	0.0008	0.0013	0.0006

Sample	Cd	Bi	As	Be	Ga	Hg	Ag
1	0.0252	0.0225	0.0013	0.0009	0.0282	0.0008	0.0171
2	0.0255	0.0232	0.0015	0.0009	0.0290	0.0009	0.0185
3	0.0255	0.0243	0.0018	0.0010	0.0298	0.0010	0.0196
4	0.0258	0.0244	0.0022	0.0011	0.0302	0.0010	0.0200
5	0.0261	0.0245	0.0029	0.0011	0.0304	0.0012	0.0205
6	0.0261	0.0249	0.0032	0.0011	0.0305	0.0012	0.0207
7	0.0270	0.0249	0.0033	0.0012	0.0313	0.0013	0.0210
8	0.0271	0.0249	0.0036	0.0012	0.0317	0.0015	0.0211
9	0.0273	0.0251	0.0037	0.0012	0.0331		0.0215
10	0.0274	0.0255		0.0012	0.0339		0.0217
11	0.0277	0.0265		0.0012	0.0352		0.0227
12	0.0277			0.0013	0.0352		0.0246
13	0.0281						
Mean	**0.0267**	**0.0246**	**0.0026**	**0.0011**	**0.0315**	**0.0011**	**0.0208**
Std Dev	0.0010	0.0011	0.0009	0.0001	0.0023	0.0002	0.0019
$C_{(95\%)}$	0.0006	0.0007	0.0007	0.0001	0.0015	0.0002	0.0012

For the definition of $C_{(95\%)}$ see page 2

Participating Laboratories

Exova Ltd	Middlesbrough, England	UKAS accreditation 0239
Sheffield Assay Office	Sheffield, England	UKAS accreditation 0012
Anchorcert Analytical	Birmingham, England	UKAS accreditation 0667
Universal Scientific Laboratory Pty Ltd	Milperra, NSW, Australia	NATA accreditation 0492
Luo Yang Copper Co	Luo Yang, HeNan, China	CNAS accreditation 0173
Shandong Metallurgical & Science Research	Jinan, Shandong, China	CNAS accreditation 1461
Genitest, Inc	Montreal, Canada	PRI accreditation 123077
Raghavendra Spectromet Laboratory	Bangalore, India	NABL accreditation 0371
TCR Engineering Services Pvt Ltd	Mumbai, India	NABL Accreditation 0367
Institute of Non-Ferrous Metals	Gliwice, Poland	PCA accreditation AB274
INCDMNR-IMNR	Pantelimon, Romania	RENAR accreditation 1056
Tec-Eurolab	Campogalliano, Italy	ACCREDIA accreditation 52
Mineral & Metallurgical Laboratories	Bangalore, India	
AMG Superalloys UK Ltd	Rotherham, England	
Analyticka Laborator Lithea sro	Brno, Czech Republic	

Note: to achieve the above accreditation (UKAS, etc), test houses must demonstrate conformity to the general requirements of EN ISO/IEC 17025.

Analytical Methods Used

ELEMENT	RESULT No. & METHOD			
	ICP-AES	FAAS	OTHER	
Copper	1-4, 6, 9, 10, 12-15	5, 7, 8, 11		
Magnesium	1-8, 11	9, 10, 12	13	gravimetric (oxine)
Silicon	2-4, 6-11, 13, 15	-	1, 5, 12, 14	photometric (molybdenum blue)
Iron	1-3, 6-9, 11, 13, 14	4, 10, 15	5	photometric (orthophenanthroline)
			12	volumetric (redox)
Manganese	2, 4, 5, 7-10, 12	3, 6, 13	1	photometric (periodate)
			11	volumetric (bismuthate)
Nickel	1-6, 8, 9, 11, 12, 15	7, 10, 14	13	gravimetric (DMGO)
Zinc	1, 4-10, 13	2, 3, 11, 12		
Lead	1-5, 9, 11-13	6-8, 10	14	photometric (sulfide)
Tin	1-8, 10, 12	9, 11	13	volumetric (iodine)
			14	photometric (phenyl fluorone)
Titanium	2, 4-7, 10-12, 14	1, 8, 9	3, 13	photometric (DAP, peroxide)
Chromium	2, 4-6, 8-10, 12-14	1, 3, 7, 11	15	volumetric (ferrous ammonium sulfate)
Cobalt	1-4, 6-10, 13, 14	11, 12	5	gravimetric
Vanadium	1, 2, 4-6, 8-10, 12, 13	7, 11	3	volumetric (ferrous ammomium
			14	sulfate)
				photometric (5 Br-PADAP))
Zirconium	1-3, 5-12	4		
Antimony	1-6, 8, 10	7, 9		
Cadmium	1-7, 9, 12, 13	8, 10, 11		
Bismuth	1-5, 7-11	6		
Arsenic	1, 2, 4-9	3		
Beryllium	1, 2, 4-6, 8-12	3, 7		
Gallium	1-12			
Mercury	1-8			
Silver	3-6, 8-12	1, 2, 7		

Notes

This Certified Reference Material has been produced and certified, wherever possible, in accordance with the requirements of ISO Guide 34, ISO Guide 31 and ISO Guide 35, taking into account the requirements of the ISO Guide to the Expression of Uncertainty in Measurement (GUM).

The unidirectional solidification effects associated with this method of chill casting have led 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 to a depth of 15mm. Material to the rear of the disc, to a depth of ~5 mm, is not certified.

This material will remain stable indefinitely, 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. Technical support for this certification will therefore expire in December 2038, although we reserve the right to make changes as issue revisions, in the intervening period.

Revision 1 detail: additional values included for Si. Si value revised and downgraded to ‘not certified’.

The 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.