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CERTIFICATE OF ANALYSIS

65X MGA11 (batch B)

Certified Reference Material Information

Type:	MAGNESIUM / ALUMINIUM / ZINC (CAST)
Form and Size:	Disc 40mm or 50mm diameter
Produced by:	KRR Metals Ltd
Certified and supplied by:	MBH Analytical Ltd

Assigned Values

Percentage element by weight

Element	Al	Zn	Mn	Cu	Si	Fe	Ni	Ca
Value [1]	**3.63**	**1.59**	**0.047**	**0.0496**	**(0.024)**	**0.0048**	**0.0134**	**(0.09)**
Uncertainty [2]	0.07	0.03	0.003	0.0015	-	0.0006	0.0006	-

Element	Sn	Pb	Be	Ag	Cd	Ce	La	Hg
Value [1]	**0.093**	**0.0183**	**0.0022**	**(0.0002)**	**0.0014**	**(0.0005)**	**(0.0005)**	**0.006**
Uncertainty [2]	0.002	0.0012	0.0002	-	0.0001	-	-	0.002

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. They are derived from the 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 (page 3). When appropriate, these values have been modified to account for additional information from the material homogeneity checks.

Certified by:

MBH ANALYTICAL LIMITED _____ on 5th February 2018

C Eveleigh

Method of Preparation

This reference material was produced from commercial-purity magnesium, with the addition of major alloying ingredients and traces as pure elements or binaries. All discs are the product of one melt, which was cleaned under a low-melting flux and sequentially cast into iron chill moulds. The first 2mm has been removed from the working face of the discs, to minimise surface effects.

Sampling

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

Homogeneity

The discs were checked for sample and batch uniformity using an optical emission spectrometer. One additional disc was tested to assess the vertical uniformity of the product. Using the meaned data from each surface, standard deviation values were derived for each element as an indicator of any non-homogeneity (as determined for the specific sample size taken by 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

Each element certified has been analysed by several laboratories, and 95% half-width confidence intervals ($C_{(95\%)}$) for the resultant mean values have been derived by the method shown on page 3.

As a separate exercise, the degree of non-homogeneity of the batch for each element has been quantified by a programme of non-destructive application testing, discussed above.

The final certified uncertainty for each element has been derived by combining these two factors, using the square-root of the summed squares.

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:	Magnesium and magnesium alloys are generally prepared by milling or turning on a lathe, avoiding the use of lubricants and ensuring that 'sparking' does not occur during the process. 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, and should be done immediately prior to analysis to minimise the effects of surface oxidation. 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.

Safety

Finely-divided magnesium may ignite. Sand should be available in the event of a fire. Water should never be used.

In OES the sample should be of sufficient mass to prevent excessive heating during sparking and the discharge chamber should be regularly cleaned as directed by the instrument manufacturer.

Analytical Data

Percentage element by weight

Sample	Al	Zn	Mn	Cu	Si	Fe	Ni	Ca
1	3.554	1.52	0.0420	0.0467	0.0185	0.0038	0.0116	0.0650
2	3.571	1.541	0.0428	0.0470	0.0186	0.0039	0.0122	0.0769
3	3.579	1.551	0.0437	0.0475	0.0189	0.0040	0.0128	0.0887
4	3.58	1.56	0.0440	0.0482	0.021	0.0041	0.0128	0.0959
5	3.580	1.591	0.0445	0.0484	0.0248	0.0044	0.0131	0.0975
6	3.621	1.601	0.0465	0.0490	0.0262	0.0046	0.0132	0.101
7	3.666	1.615	0.0465	0.0495	0.027	0.0050	0.0136	
8	3.67	1.620	0.0476	0.0496	0.0272	0.0051	0.0136	
9	3.671	1.63	0.048	0.0506	0.0328	0.0056	0.0140	
10	3.69	1.63	0.0525	0.0508		0.0060	0.0141	
11	3.705		0.0550	0.054		0.0065	0.0145	
12				0.0540			0.0147	
Mean	**3.626**	**1.586**	**0.0466**	**0.0496**	**0.0239**	**0.0048**	**0.0134**	**0.0875**
Std Dev	0.055	0.040	0.0040	0.0024	0.0050	0.0009	0.0009	-
C (95%)	0.037	0.029	0.0027	0.0015	0.0038	0.0006	0.0006	-

Sample	Sn	Pb	Be	Ag	Cd	Ce	La	Hg
1	0.089	0.0161	0.0020	0.0001	0.0013	0.0001	0.0002	0.0037
2	0.0895	0.0179	0.0020	0.0001	0.0013	0.0002	0.0003	0.0051
3	0.0910	0.0181	0.0021	0.0001	0.0013	0.0004	0.0003	0.0055
4	0.0912	0.0182	0.0022	0.0002	0.0014	0.0004	0.00055	0.0058
5	0.0921	0.0183	0.0022	0.0002	0.0014	0.0005	0.00063	0.0062
6	0.0925	0.0186	0.0023	0.0003	0.0014	0.0006	0.0008	0.0071
7	0.093	0.0187	0.0024	0.0003	0.0014	0.0009	0.0008	0.0073
8	0.0940	0.0192		<0.0005	0.0014	0.0010		0.0097
9	0.0953	0.0195		<0.0005	0.0014			
10	0.098			<0.001	0.0015			
11					0.0015			
12					0.0015			
Mean	**0.0926**	**0.0183**	**0.0022**	**(0.0002)**	**0.0014**	**(0.0005)**	**(0.0005)**	**0.0063**
Std Dev	0.0027	0.0010	0.0001	-	0.0001	-	-	0.0018
C (95%)	0.0019	0.0007	0.0001	-	0.0001	-	-	0.0015

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

Bodycote Materials Testing Ltd	Middlesbrough, England	UKAS accreditation 0239
Sheffield Assay Office	Sheffield, England	UKAS accreditation 0012
Universal Scientific Laboratory Pty Ltd	Milperra, NSW, Australia	NATA accreditation 0492
Laboratory Testing Inc	Hatfield, PA, USA	A2LA accreditation 0117
Luo Yang Copper	Luo Yang, He Nan, China	CNAL accreditation 0173
Institute of Iron & Steel Technology	Shanghai, China	CNAL accreditation 0783
South-West Aluminium Group	Jiulong Puo, Sichuan, China	CNAL accreditation T007
Laboratory TUV Nord-Czech	Brno, Czech Republic	CAI accreditation 1060
Sargam Metals Pvt Ltd	Chennai, India	NABL accreditation 0025
US Magnesium LLC	Salt Lake City, UT, USA	
Genitest Inc	Montreal, Canada	
Coleshill Laboratories Ltd	Coleshill, England	
Dead Sea Magnesium Research Institute	Beer-Sheva, Israel	

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	ICP-MS	FAAS	OTHER	
Aluminium	1, 2, 5-7, 9-11	-	3	4, 8	volumetric (EDTA)
Zinc	1-3, 5, 7, 9	-	4, 6, 10	8	volumetric (EDTA)
Manganese	2-4, 8-11	-	1, 5	6, 7	photometric (periodate)
Copper	1, 4-8, 11, 12	-	2, 3, 9, 10		
Silicon	1-4, 7	-	-	5, 6, 8	photometric (molybdenum blue)
Iron	1-3, 5-8, 10	-	4, 11	9	photometric (orthophenanthroline)
Nickel	1-5, 9, 11, 12	-	6, 7, 10	8	volumetric (dimethyl glyoxime)
Calcium	2, 6	-	1, 3-5		
Tin	1-3, 6, 8-10	-	4, 7	5	photometric (phenyl fluorone)
Lead	1, 2, 5-8	-	3, 4, 9		
Beryllium	3, 4, 6, 7	2	1	5	photometric (eriochrome cyanine R)
Silver	3, 4, 7-10	5	1, 2, 6		
Cadmium	1-3, 8-12	7	4, 5, 6		
Cerium	1-5, 7, 8	6	-		
Lanthanum	1-3, 5-7	4	-		
Mercury	1, 2, 6-8	-	-	3	conductimetric (gold film CVD)
				4, 5	CV-AAS

Notes

This Certified Reference Material has been produced 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 casting have led to the formation of inhomogeneous segregates in the rear portion of the disc. However, testing has shown that the above certification is applicable from the front face of the disc to a depth of about 12mm. Material to the rear of the disc, to a depth of ~6mm, is not certified.

This batch is a sub-lot from batch A, which was originally analysed and certified in July 2007.

Precautions should be taken to protect this material from extremes of temperature and atmospheric moisture. It is not chemically stable, and will quickly develop a non-metallic surface film under normal storage conditions. However, it will otherwise remain suitable for long-term use. All production records will be retained for a period of 20 years from the date of original analysis. This certification will therefore expire in July 2027, although we reserve the right to make further 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.