

CERTIFICATE OF ANALYSIS

71X SR0 (batch D)

Certified Reference Material Information

Type: TIN WITH IMPURITIES (CAST)
Form and Size: Disc ~40mm diameter
Manufactured by: MBH Analytical Ltd
Certified and Supplied by: MBH Analytical Ltd

Assigned Values

Percentage element by weight

Element	Sb	As	Bi	Pb	Cu	Fe	Co	Ni	Ag	Al
Value ¹	0.0284	(0.0006)	(0.0007)	0.0380	0.0049	0.0011	0.0006	0.0009	0.0101	0.0057
Uncertainty ²	0.0016	-	-	0.0012	0.0002	0.0002	0.0001	0.0002	0.0002	0.0004

Element	Cd	Zn	In	S	P	Ga	Au	Te	Hg	Ge
Value ¹	0.0020	0.0022	0.0119	(0.0047)	0.0007	0.0070	0.0039	0.0019	0.0083	(0.0005)
Uncertainty ²	0.0001	0.0002	0.0007	-	0.0002	0.0005	0.0005	0.0001	0.0003	-

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 uncertainties are value judgements, 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 29th July 2019

C Eveleigh

Method of Preparation

This reference material was produced from commercial tin; the major alloys and traces were added as single elements, binaries, or as master alloys. The melt was cast by sequential transfer of aliquots into individual iron moulds. At least 1mm has been removed from the working 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

The discs were checked for sample and batch uniformity using an optical emission spectrometer.

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 turnings taken from samples representative of the product. It was performed by participating laboratories mostly operating within the terms of EN ISO/IEC 17025 using documented standard methods of analysis.

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

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: Tin is generally prepared by machining on 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	Sb	As	Bi	Pb	Cu	Fe	Co	Ni	Ag	Al
1	0.0255	0.0002	0.0002	0.0360	0.0043	0.0009	0.0003	0.0005	0.0092	0.0049
2	0.0264	0.0003	0.0003	0.0361	0.0044	0.0009	0.0004	0.0006	0.0096	0.0049
3	0.0267	0.0004	0.0004	0.0361	0.0045	0.0011	0.0004	0.0006	0.0097	0.0055
4	0.0276	0.0004	0.0005	0.0363	0.0047	0.0011	0.0005	0.0008	0.0098	0.0056
5	0.0278	0.0005	0.0005	0.0364	0.0047	0.0011	0.0005	0.0008	0.0100	0.0056
6	0.0280	0.0006	0.0006	0.0371	0.0048	0.0011	0.0005	0.0008	0.0100	0.0056
7	0.0282	0.0008	0.0008	0.0373	0.0049	0.0012	0.0006	0.0008	0.0101	0.0057
8	0.0282	0.0009	0.0010	0.0378	0.0049	0.0012	0.0008	0.0008	0.0102	0.0057
9	0.0283	0.0010	0.0011	0.0382	0.0049	0.0012	0.0008	0.0009	0.0102	0.0058
10	0.0285	0.0012	0.0012	0.0388	0.0050	0.0014	0.0008	0.0010	0.0102	0.0059
11	0.0289			0.0392	0.0050		0.0008	0.0010	0.0103	0.0059
12	0.0294			0.0396	0.0050		0.0009	0.0012	0.0103	0.0060
13	0.0296			0.0397	0.0050			0.0012	0.0105	0.0061
14	0.0311			0.0406	0.0052			0.0012	0.0106	0.0062
15	0.0317			0.0408	0.0058			0.0013		0.0063
Mean	0.0284	0.0006	0.0007	0.0380	0.0049	0.0011	0.0006	0.0009	0.0101	0.0057
Std Dev	0.0016	0.0003	0.0003	0.0017	0.0004	0.0001	0.0002	0.0002	0.0004	0.0004
C_(95%)	0.0009	0.0002	0.0002	0.0009	0.0002	0.0001	0.0001	0.0001	0.0002	0.0002

Sample	Cd	Zn	In	S	P	Ga	Au	Te	Hg	Ge
1	0.0018	0.0017	0.0096	0.0023	0.0003	0.0052	0.0032	0.0016	0.0075	0.0002
2	0.0018	0.0018	0.0104	0.0042	0.0004	0.0062	0.0033	0.0017	0.0080	0.0002
3	0.0018	0.0018	0.0113	0.0042	0.0005	0.0062	0.0034	0.0017	0.0081	0.0002
4	0.0019	0.0019	0.0116	0.0045	0.0005	0.0066	0.0034	0.0017	0.0082	0.0004
5	0.0019	0.0020	0.0116	0.0062	0.0006	0.0067	0.0039	0.0017	0.0082	0.0004
6	0.0019	0.0021	0.0118	0.0068	0.0006	0.0067	0.0039	0.0018	0.0085	0.0006
7	0.0019	0.0021	0.0120		0.0008	0.0068	0.0043	0.0018	0.0085	0.0009
8	0.0020	0.0022	0.0120		0.0009	0.0069	0.0044	0.0019	0.0086	0.0009
9	0.0020	0.0022	0.0121		0.0009	0.0073	0.0047	0.0019	0.0089	0.0010
10	0.0020	0.0023	0.0121		0.0010	0.0075	0.0048	0.0020		
11	0.0020	0.0024	0.0133			0.0077		0.0021		
12	0.0021	0.0024	0.0133			0.0081		0.0021		
13	0.0021	0.0024	0.0135			0.0086		0.0021		
14	0.0021	0.0024						0.0022		
15	0.0021	0.0026						0.0024		
Mean	0.0020	0.0022	0.0119	(0.0047)	0.0007	0.0070	0.0039	0.0019	0.0083	(0.0005)
Std Dev	0.0001	0.0003	0.0011	-	0.0002	0.0009	0.0006	0.0002	0.0004	-
C_(95%)	0.0001	0.0001	0.0007	-	0.0002	0.0005	0.0004	0.0001	0.0003	-

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

Element Ltd
Sheffield Analytical Services Ltd
Anchorcert Analytical
Universal Scientific Laboratory Pty Ltd
Genitest Inc
Luo Yang Copper
Shanghai Jinyi Test Tech Co
TCR Engineering Services Ltd
Raghavendra SpectroMet Laboratory
Institute of Non-Ferrous Metals
Tec-Eurolab
AIM Metals and Alloys LP
INCDMNR-IMNR
Intertek (Laboratory Services International) BV
Mineral & Metallurgical Laboratories
AMG Superalloys UK Ltd
Analyticka Laborator Lithea sro

Middlesbrough, England
Sheffield, England
Birmingham, England
Milperra, NSW, Australia
Montreal, Canada
Luo Yang, He Nan, China
Shanghai, China
Mumbai, India
Bangalore, India
Gliwice, Poland
Campogalliano, Italy
Montreal, Canada
Pantelimon, Romania
Rotterdam, Netherlands
Bangalore, India
Rotherham, England
Brno, Czech Republic

UKAS accreditation 0239
UKAS accreditation 0012
UKAS accreditation 0667
NATA accreditation 0492
PJ accreditation L17-153
CNAL accreditation 0173
CNAS accreditation L0041
NABL accreditation 0367
NABL accreditation T371
PCA accreditation AB274
ACCREDIA accreditation 52

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
Antimony	1, 2, 6, 8-15	-	3, 4, 7	5 photometric
Arsenic	1, 3, 4, 6-10	5	2	
Bismuth	1, 2, 5, 7-10	6	3, 4	
Lead	1, 3, 5, 6, 9, 12-15	8	2, 4, 10, 11	
Copper	2-5, 7, 8, 11-15	1	3, 9, 10	6 photometric (BCO)
Iron	1, 2, 4-6, 9, 10	7	3, 8	
Cobalt	1, 5, 6, 8-11	4	2, 3, 7, 12	
Nickel	1-3, 5-10, 13-15	11	4, 12	
Silver	2-4, 6-11, 14	1	5, 12, 13	
Aluminium	2, 5-13, 15	1	4, 14	3 photometric (chrome azurol S)
Cadmium	1-6, 9, 10, 14, 15	8	7, 11-13	
Zinc	2-6, 9-12, 15	1	7, 8, 13, 14	
Indium	3-6, 8-13	2	1, 7	
Sulfur	2, 3, 5, 6	-	-	1, 4 combustion (IR detection)
Phosphorus	2-10	1	-	
Gallium	1-13	-	-	
Gold	1, 4-6, 10	3	2, 8, 9	7 fire assay
Tellurium	1-4, 6-10, 12-15	-	5, 11	
Mercury	1-6, 8, 9	-	7	
Germanium	1-3, 5-9	4	-	

Notes

This Certified Reference Material has been produced and certified in accordance with the requirements of ISO 17034 and the associated Guides, 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. The above certification is therefore only applicable from the front face of the disc to a depth of ~12mm. The rear portion of the disc, to a depth of ~3mm, is not certified.

This material is liable to superficial corrosion. There is also a possibility for microstructural changes due to recrystallisation, and diffusion effects may lead to the concentration of some elements at the surface. For X-ray and other superficial sampling techniques, it is therefore recommended that the surface is refreshed immediately prior to use. In all other respects, this sample 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 this certificate. This certification will therefore expire in July 2039, 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.