

CERTIFICATE OF ANALYSIS

33X GM24 (batch A)

Certified Reference Material Information

Type: GUN METAL (CONTINUOUS CAST / WROUGHT)
Form and Size: Disc 44mm Diameter x 17mm Thickness
Produced by: Cerro Manganese Bronze Ltd
Certified and supplied by: MBH Analytical Limited

Certified Analysis

Percentage element by weight

Element	Sn	Pb	Zn	Fe	Ni	Al	Si	As
Value ¹	3.85	3.35	3.67	0.0083	0.0087	(0.0001)	0.0028	0.0010
Uncertainty ²	0.04	0.04	0.03	0.0014	0.0013	-	0.0005	0.0003

Element	Mn	Bi	Sb	P	Cr	Ag	S	Cu
Value ¹	<0.0005	0.0009	0.0012	0.190	(0.0013)	0.0046	0.003	88.88
Uncertainty ²	-	0.0002	0.0003	0.005	-	0.0005	0.001	0.09

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 11th May 2004

C Eveleigh



Method of Preparation

This reference material was produced from a single length of continuous-cast bar, cold worked down to final dimension as supplied.

Sampling

Samples for chemical analysis, and discs for homogeneity checks, were taken from several positions throughout the bar. At least 10% of all discs were incorporated into the schedule for homogeneity checking.

Homogeneity

The discs were checked for sample and batch uniformity using an optical emission spectrometer. 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 assessed to ensure that the overall homogeneity of the material comprising the batch satisfied the definition given in ISO guide 30 – 1992.

Some minor segregation for Pb and Sn was evident for the central portion of the bar, of ~6mm diameter.

Using the individual data from each check (excluding results from the central portion) 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.

Chemical Analysis

Analysis was carried out on millings taken from samples representative of the homogeneous portion of the product. It was performed by a panel of laboratories mostly operating within the terms of 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: Copper 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	Sn	Pb	Zn	Fe	Ni	Al	Si	As
1	3.76	3.284	3.63	0.0068	0.0062	0.0001	0.002	0.0006
2	3.793	3.30	3.638	0.0068	0.0067	0.0001	0.002	0.0006
3	3.817	3.316	3.640	0.007	0.0074	0.0001	0.0026	0.0007
4	3.84	3.33	3.65	0.008	0.0075	0.0001	0.0027	0.001
5	3.85	3.34	3.66	0.0080	0.008	<0.0005	0.003	0.001
6	3.85	3.34	3.670	0.0083	0.009	<0.0005	0.003	0.0010
7	3.862	3.347	3.67	0.010	0.0098	<0.001	0.0033	0.0013
8	3.88	3.39	3.68	0.0116	0.0102	<0.001	0.0037	0.0015
9	3.895	3.391	3.689		0.011			
10	3.91	3.399	3.70		0.011			
11		3.40	3.75					
Mean	3.846	3.349	3.671	0.0083	0.0087	(0.0001)	0.0028	0.0010
Std Dev	0.046	0.041	0.034	0.0017	0.0018	-	0.0006	0.0003
C_(95%)	0.033	0.028	0.023	0.0014	0.0013	-	0.0005	0.0003

Sample	Mn	Bi	Sb	P	Cr	Ag	S	Cu
1	0.000	0.0005	0.0007	0.18	0.001	0.0039	0.002	88.78
2	0.0001	0.0007	0.0009	0.184	0.001	0.0040	0.0027	88.81
3	0.0002	0.0008	0.001	0.184	0.0013	0.0041	0.0028	88.84
4	0.0002	0.0008	0.0013	0.188	0.0013	0.0043	0.003	88.84
5	0.0004	0.001	0.0014	0.191	0.0014	0.0044	0.0034	88.86
6	<0.0005	0.0011	0.0015	0.191	0.0015	0.0045	0.0035	88.90
7	<0.005	0.0011	0.0017	0.192	0.0018	0.0050	0.0042	89.00
8		0.0013		0.192		0.0050		89.0
9				0.193		0.0058		
10				0.198				
11				0.201				
Mean	<0.0005	0.0009	0.0012	0.190	0.0013	0.0046	0.0031	88.88
Std Dev	-	0.0003	0.0004	0.006	0.0003	0.0006	0.0007	0.08
C_(95%)	-	0.0002	0.0003	0.004	0.0003	0.0005	0.0006	0.07

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

Zurich Certification Ltd
Sheffield Assay Office
Bodycote Materials Testing
Laboratory Testing Inc
Universal Scientific Laboratory Pty Ltd
Central Iron & Steel Research Inst
Luo Yang Copper
Institute of Iron & Steel Technology
RWTUV Laboratory
Spectroscopic Solutions Ltd
Genitest Inc
Coleshill Laboratories Ltd

West Bromwich, England
Sheffield, England
Middlesbrough, England
Hatfield, PA, USA
Milperra, NSW, Australia
Beijing, China
Luo Yang, He Nan, China
Shanghai, China
Brno, Czech Republic
Johannesburg, South Africa
Montreal, Canada
Coleshill, England

UKAS accreditation 0854
UKAS accreditation 0012
UKAS accreditation 0239
A2LA accreditation 0117
NATA accreditation 492
CNAL accreditation 0435
CNAL accreditation 0173
CNAL accreditation 0783
CIA accreditation 1060

Note: to achieve National Accreditation (eg UKAS, NATA, A2LA, CNAL, CIA), test houses must demonstrate conformity to the general requirements of EN ISO/IEC 17025 and ISO9002.

Analytical Methods Used

ELEMENT	RESULT No. & METHOD		
	ICP-AES	FAAS	OTHER
Tin	1-3, 6-10	-	4, 5 volumetric (iodate)
Lead	1-4, 6, 7, 9-11	5, 8	
Zinc	1-3, 6-10	5	4, 11 volumetric (EDTA)
Iron	1-3, 5, 6	4, 7, 8	
Nickel	1-3, 5, 6, 8, 9	4, 7, 10	
Aluminium	1-4, 6-8	5	
Silicon	2-8	-	1 photometric (molybdenum blue)
Arsenic	1-3, 5-8	4	
Manganese	2-7	1	
Bismuth	1-5, 7, 8	6	
Antimony	1-4, 6, 7	5	
Phosphorus	4, 6-11	-	1, 2, 3, 5 photometric (molybdenum yellow)
Chromium	1-7	-	
Silver	1-5, 8, 9	6	7 ICP-MS
Sulfur	5	-	1-4, 7 combustion with infra-red detection 6 combustion with volumetric-iodate detection
Copper	5, 8	-	3, 7 electrogravimetric 1, 2, 4, 6 volumetric (thiosulphate)

Notes

This Certified Reference Material 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).

This certification is applicable to the whole of the disc excepting a small central portion. Hence in accordance with normal practice for OES analysis, it is appropriate to avoid use of the central area of ~6mm diameter.

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 this certificate. This certification will therefore expire in May 2024, 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.