

Bundesanstalt für Materialforschung und -prüfung (BAM)

in cooperation with the International Commission on Glass (ICG) and Deutsche
Glastechnische Gesellschaft e.V. (DGG)

Certified Reference Material

BAM-S006

Multielement Glass

Certified Values

Element		Mass fraction ¹⁾ in %		Uncertainty ²⁾ in %
Al	(Al ₂ O ₃)	1.081	(2.042)	0.015
Ca	(CaO)	7.660	(10.72)	0.016
Mg	(MgO)	1.163	(1.929)	0.010
Na	(Na ₂ O)	8.79	(11.85)	0.11
K	(K ₂ O)	0.577	(0.695)	0.008
Fe	(Fe ₂ O ₃)	0.468	(0.669)	0.008
Cr	(Cr ₂ O ₃)	0.382	(0.558)	0.006
Mn	(MnO)	0.213	(0.275)	0.004
Si	(SiO ₂)	33.10	(70.83)	0.12
		in mg/kg		in mg/kg
As	(As ₂ O ₃)	9.0	(11.8)	1.7
Ba	(BaO)	456	(509)	23
Cd	(CdO)	0.21	(0.24)	0.06
Co	(CoO)	172	(219)	5
Ni	(NiO)	19.3	(24.6)	1.4
P	(P ₂ O ₅)	85	(195)	16
Pb	(PbO)	103	(111)	5
S	(SO ₃)	201	(502)	9
Sb	(Sb ₂ O ₃)	10.8	(12.9)	1.5
Ti	(TiO ₂)	391	(652)	6

¹⁾ Unweighted mean value of the means of accepted sets of data (consisting of at least 1 single results), each set being obtained by a different laboratory and/or a different method of measurement. The values in brackets were calculated from the mass fractions of the elements using the atomic weights.

²⁾ Estimated expanded uncertainty *U* with a coverage factor of *k* = 2, corresponding to a level of confidence of approx. 95 %, as defined in the Guide to the Expression of Uncertainty in Measurement, (GUM, ISO/IEC Guide 98-3:2008). The stated measurement uncertainties refer only to the mass fractions of the elements.

This certificate is valid until there is a revocation from the producer of the material.

Sample Description

The Reference Material is available in the form of discs (approx. 38 mm diameter and 4 mm height) and in form of cullet.

Values for Information

Element	Mass fraction ¹⁾ in mg/kg	Uncertainty ²⁾ in mg/kg
Cl	180	28
Cu (CuO)	26 (33)	10
Sr (SrO)	130 (154)	82
Zn (ZnO)	61 (76)	7
Zr (ZrO ₂)	139 (188)	28

¹⁾ Unweighted mean value of the means of accepted sets of data (consisting of at least 2 single results), each set being obtained by a different laboratory and/or a different method of measurement. Values were not certified, but given for information, because the uncertainty from the inter-laboratory certification was too large. The values in brackets were calculated from the mass fractions of the elements using the atomic weights.

²⁾ Estimated expanded uncertainty U with a coverage factor of $k = 2$, corresponding to a level of confidence of approx. 95 %, as defined in the Guide to the Expression of Uncertainty in Measurement, (GUM, ISO/IEC Guide 98-3:2008). The stated measurement uncertainties refer only to the mass fractions of the elements.

Recommended Use

The CRM is intended for establishing or checking the calibration of X-ray spectrometers for the analysis of samples of similar matrix composition. The minimum sample size for wet chemical analysis is 0.2 g.

Instructions for Use

Before use of the disc, the surface of the material must be cleaned. After multiple measurements with XRF, discolouration of the glass may occur. This can be reversed by heat treatment at 300 - 400 ° C.

Participating Laboratories

Ardagh Glass Packaging - Europe, Nienburg/Weser, Germany
 Bundesanstalt für Materialforschung und -prüfung (BAM), Berlin, Germany
 Cetim, Illkirch-Graffenstaden, France
 Corning European Technology Center (CETC), S&T European Laboratory, Fontainebleau, France
 Corning US, Corning, NY, USA
 Glashütte Freital GmbH, Freital, Germany
 Glass Technology Services Ltd, Sheffield, South Yorkshire, United Kingdom
 IGR Institut für Glas- und Rohstofftechnologie GmbH, Göttingen, Germany
 INISMa (Institut Interuniversitaire des Silicates, Sols et Matériaux, Mons, Belgium
 NSG, Lathom, United Kingdom
 Schott AG, Jena, Germany
 Schott AG, Mainz, Germany
 Stazione Sperimentale del Vetro, Murano, Italy
 Saint-Gobain Sekurit Deutschland GmbH, Herzogenrath, Germany
 Stoelzle Oberglas GmbH, Köflach, Austria
 T. Şişe ve Cam Fab. A.Ş. Science and Technology Center, Gebze Kocaeli, Turkey
 Wiegand-Glashüttenwerke GmbH, Steinbach am Wald, Germany
 Zentrum für Glas- und Umweltanalytik GmbH, Ilmenau-Unterpörlitz, Germany

Means of Accepted Data Sets

Certified values
Mass fraction in %

mass fraction in mg/kg

Line No.	Al	Ca	Mg	Na	K	Fe	Cr	Mn	Si	As	Ba	Cd	Co	Ni	P	Pb
1	1.023	7.619	1.140	8.649	0.549	0.428	---	0.201	32.83	4.3	394	0.11	---	15.2	74.0	90.0
2	1.047	7.619	1.143	8.703	0.549	0.443	---	0.202	32.93	4.6	408	0.13	157.0	16.6	76.5	91.5
3	1.060	7.633	1.145	8.718	0.550	0.446	0.353	0.202	32.97	7.2	425	0.20	161.5	17.5	84.3	92.8
4	1.062	7.640	1.146	8.748	0.562	0.452	0.365	0.203	33.00	7.6	446	0.23	163.2	17.5	85.2	93.5
5	1.076	7.653	1.151	8.753	0.564	0.461	0.371	0.209	33.05	8.1	451	0.25	166.8	17.7	90.0	94.7
6	1.079	7.654	1.153	8.758	0.565	0.463	0.373	0.209	33.05	8.9	453	0.25	169.2	17.8	91.7	95.4
7	1.082	7.659	1.156	8.776	0.566	0.469	0.375	0.212	33.10	9.5	464	0.29	170.0	18.0	93.5	99.1
8	1.083	7.663	1.162	8.790	0.571	0.471	0.382	0.214	33.12	9.9	470	---	171.6	18.1		102.8
9	1.085	7.674	1.163	8.796	0.575	0.473	0.382	0.214	33.14	10.0	472	---	173.8	18.9		103.5
10	1.087	7.675	1.164	8.801	0.576	0.475	0.383	0.215	33.17	10.6	474	< 1	177.4	20.5		106.0
11	1.087	7.678	1.164	8.802	0.580	0.475	0.384	0.215	33.18	12.3	477	< 1	178.3	21.6		108.1
12	1.093	7.680	1.167	8.803	0.580	0.475	0.385	0.217	33.20	14.4	538	< 2	179.4	21.8		108.3
13	1.094	7.681	1.170	8.810	0.581	0.476	0.387	0.217	33.26			< 2	179.8	21.8		109.5
14	1.094	7.710	1.173	8.830	0.581	0.477	0.388	0.220	33.35				179.9	21.9		109.6
15	1.095	---	1.175	8.861	0.582	0.478	0.388	0.221					180.4	24.4		110.3
16	1.100	---	1.175	8.870	0.590	0.483	0.389	0.223								111.6
17	1.105		1.188	8.892	0.596	0.484	0.390	0.229								114.7
18	1.106		1.197	8.925	0.593	0.489	0.390									120.3
19				---	0.595			0.395								
20					0.598			0.404								
21					0.621											
<i>M</i>	1.081	7.660	1.163	8.794	0.577	0.468	0.382	0.213	33.10	9.0	456	0.21	172.0	19.3	85.0	103.4
<i>s_M</i>	0.022	0.026	0.016	0.069	0.019	0.016	0.012	0.008	0.14	2.9	38	0.07	7.7	2.6	7.5	8.9
\bar{s}_i	0.020	0.027	0.008	0.048	0.006	0.005	0.003	0.002	0.04	1.5	23	0.03	1.8	0.8	5.7	2.0

Line No.	Certified values Mass fraction in mg/kg			values for information mass fraction in mg/kg				
	S	Sb	Ti	Cl	Cu	Sr	Zn	Zr
1	181	7.10	373	153	11.4	121.8	---	130.0
2	185	8.05	382	156	22.0	122.8	57.3	133.5
3	197	8.76	387	169	25.0	125.1	58.3	134.0
4	200	9.91	394	200	27.3	127.1	68.0	137.2
5	200	10.32	394	223	42.0	130.0		141.4
6	205	10.33	395	---		139.5		143.8
7	208	12.47	395			140.0		154.0
8	214	12.53	397					---
9	219	13.90	400					---
10	---	14.17						
11		14.40						
<i>M</i>	201	10.8	391	180	25.5	129.5	61.2	139.1
<i>s_M</i>	13	2.5	9	31	11.0	7.6	6.0	8.1
\bar{s}_i	10	1.2	9	25	4.3	1.8	5.3	6.3

The laboratory mean values have been examined statistically to eliminate outlying values. Where a " --- " appears in the table it indicates that an outlying value has been omitted. A data set consists of at least one single value of one laboratory.

M : mean of laboratory means

s_M : standard deviation of laboratory means

\bar{s}_i : averaged repeatability standard deviation (square root of the mean of laboratory variances)

Analytical methods used for certification

Element	Line Number	Method
Al	1, 2, 4, 5, 6, 7, 8, 10, 11, 12, 14, 15, 16, 17	XRF
	3, 9, 13, 18	ICP-OES
Ca	1, 2, 3, 4, 7, 8, 9, 10, 11, 12, 13, 14	XRF
	5, 6	ICP-OES
Mg	1, 2, 8, 13	ICP-OES
	3, 4, 5, 6, 7, 9, 10, 11, 12, 14, 15, 17, 18	XRF
	16	FAAS
Na	1, 3, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 18	XRF
	2, 17	FAAS
	4, 13, 16	ICP-OES
K	1, 19	FAAS
	2, 3, 5, 6, 9, 10, 11, 12, 13, 14, 16, 17, 18, 20	XRF
	4	Laser Ablation ICP-MS
	7, 8, 15, 21	ICP-OES
Fe	1, 5, 7, 8, 10, 12, 13, 14, 15, 16, 17, 18	XRF
	2, 3, 6, 9, 11	ICP-OES
	4	Laser Ablation ICP-MS

Element	Line Number	Method
Cr	3, 4, 5, 6, 7, 8, 11, 12, 14 9, 10, 13, 15, 16, 17, 18, 20 19	ICP-OES XRF FAAS
Mn	1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 7 12, 13, 14, 15, 16, 17	ICP-OES ICP-MS XRF
Si	1, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 2 3	XRF Gravimetry ICP-OES
As	1, 6, 9, 12 2, 3, 5, 7, 10 4, 11 8	ICP-MS ICP-OES XRF Laser Ablation ICP-MS
Ba	1, 4 2, 3, 5, 6, 7, 8, 9, 10, 11, 12	ICP-OES XRF
Cd	1, 2, 10, 11 3, 6, 7, 12 4 5 13	ICP-MS ICP-OES Laser Ablation ICP-MS ETAAS XRF
Co	2, 5, 6, 8, 9, 12, 13, 14 3, 15 4, 7, 11 10	ICP-OES ICP-MS XRF Laser Ablation ICP-MS
Ni	1, 3, 10 2, 4, 5, 7, 8, 9, 13, 14 6 11, 12, 15	ICP-MS ICP-OES Laser Ablation ICP-MS XRF
P	1, 3, 4, 5, 6, 7 2	XRF ICP-OES
Pb	1, 5, 7, 8, 12, 18 2 3, 4, 6, 9, 10, 13, 14, 15, 16, 17 11	XRF Laser Ablation ICP-MS ICP-OES ICP-MS
S	1, 3, 5, 7, 8, 9 2, 4 6	XRF Combustion/IR ICP-OES
Sb	1, 2 3, 4, 6, 8 5, 7, 9, 11 10	XRF ICP-OES ICP-MS Laser Ablation ICP-MS
Ti	1 2, 3, 4, 5, 6, 7, 8, 9	ICP-OES XRF

Element	Line Number	Method
<i>Sr</i>	1, 2, 3, 4, 5, 7 6	<i>XRF</i> <i>ICP-OES</i>
<i>Zr</i>	1, 2, 3, 4, 5, 6 7	<i>XRF</i> <i>ICP-OES</i>
<i>Cu, Cl, Zn</i>		<i>XRF</i>

Abbreviations: FAAS – Flame atomic absorption spectrometry
ETAAS – Electrothermal atomic absorption spectrometry
ICP-OES – Inductively coupled plasma - optical emission spectrometry
ICP-MS – Mass spectrometry with inductively coupled plasma
IR – Infrared detection
XRF – X-ray fluorescence spectrometry

Transport and Storage

The material should be stored in a dry and clean environment at room temperature. Transport under normal ambient conditions.

Metrological Traceability

To ensure traceability of the certified mass fractions to the SI (Système International d'Unités) calibration for most of the data sets was performed using standard solutions prepared from pure metals or stoichiometric compounds or well checked commercial calibration solutions. Some of the datasets are traceable to other certified reference materials or reference materials.

Technical Report

A detailed technical report describing the analysis procedures and the treatment of the analytical data used to certify BAM-S006 is available on request or can be downloaded from BAM website (www.bam.de).

Accepted as BAM-CRM on 2023-10-23

Bundesanstalt für Materialforschung und -prüfung (BAM)

Dr. S. Richter
Committee for Certification

Dr. S. Recknagel
Project Coordinator

BAM holds an accreditation as a reference material producer according to ISO/IEC 17034. This accreditation is valid only for the scope as specified in the certificate D-RM-11075-01-00. DAkkS is a signatory of the multilateral agreement (MLA) between EA, ILAC and IAF for mutual acceptance.



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