

# BRAMMER STANDARD COMPANY, INC.

## Certificate of Analysis

### BS 100A

Reference Material for Iron-making Slag<sup>1</sup>

	Certified Value <sup>2</sup>	Estimate of Uncertainty <sup>3</sup>	Certified Values <sup>4</sup>	Certified Value <sup>2</sup>	Estimate of Uncertainty <sup>3</sup>
Al	5.35	0.3	Al <sub>2</sub> O <sub>3</sub>	10.10	0.06
Ca	26.6	0.6	CaO	37.0	0.8
Fe	0.29	0.01			
Mg	7.75	0.05	MgO	12.85	0.08
Mn	0.24	0.01	MnO	0.33	0.01
Na	0.137	0.006			
P	0.0014	0.0005	P <sub>2</sub> O <sub>5</sub>	0.0034	0.0007
S	1.77	0.08			
Si	16.49	0.08	SiO <sub>2</sub>	35.3	0.2
Ti	0.29	0.01	TiO <sub>2</sub>	0.48	0.02

### Informational Values<sup>4,5</sup>

C (0.2)

K (0.4)

K<sub>2</sub>O (0.5)

Na<sub>2</sub>O (0.2)

<sup>1</sup> This certificate is a revision. For more information on the nature and extent of the revision, see the revision statement on page 5.

<sup>2</sup> For each element, the certified value listed is the present best estimate of the true value based on the mean of the weighted results of an interlaboratory testing program. See page 3 for more information on its calculation.

<sup>3</sup> For each element, the uncertainty listed is based on a statistical evaluation of the contributions of homogeneity and the interlaboratory testing program. See page 3 for more information on its calculation.

<sup>4</sup> Values are given in weight percent.

<sup>5</sup> Values in parentheses are not certified and are provided for information only.

The requirements of ISO Guides 30, 31, and 35 were followed for the preparation of this Reference Material and certificate of analysis.

**BS 100A**

\* Code for method      Certified values listed as weight percent

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Analysis	*	Al	*	Al <sub>2</sub> O <sub>3</sub>	*	Ca	*	CaO	*	Fe	*	Mg	*	MgO	*	Mn
1	16	5.2025	16	9.83	16	25.5933	16	35.60	16	0.2448	16	7.5992	16	12.60	4	0.185871
2	16	5.3295	16	10.07	16	26.0436	16	35.81	16	0.27	16	7.63538	16	12.66	16	0.1928
3	16	5.3454	16	10.10	16	26.7869	16	36.44	16	0.28	4	7.713788	4	12.79	16	0.24
4	16	5.3719	16	10.15	4	26.91736	16	37.48	16	0.296	16	7.73188	16	12.82	16	0.249357
5	4	5.374551	4	10.155	16	26.994	4	37.6625	16	0.31	16	7.79219	16	12.92	16	0.2788
6	16	5.6983	16	10.20	16	27.13151	16	37.7	16	0.31	16	8.036197	16	13.32457	16	0.28
7	16	5.4089	16	10.22				37.96213	4	0.3175					16	0.2865
Average		5.34729		10.10357		26.57778		36.96066		0.28976		7.75144		12.85243		0.24476
Std dev		0.00012		0.00012		0.00013		0.00012		0.00012		0.00013		0.00013		0.00012
H		0.035637		0.059556		0.135994		0.182472		0.004581		0.04795		0.072767		0.00413
U <sub>1</sub>		0.036		0.060		0.14		0.18		0.0046		0.048		0.073		0.0041
t-statistic		2.45		2.45		2.57		2.45		2.45		2.57		2.57		2.45
U <sub>2</sub>		0.087		0.15		0.35		0.45		0.011		0.12		0.19		0.010
U <sub>3</sub>		0.033		0.055		0.14		0.17		0.0042		0.050		0.076		0.0038
<b>Certified</b>		<b>5.35</b>		<b>10.10</b>		<b>26.6</b>		<b>37.0</b>		<b>0.29</b>		<b>7.75</b>		<b>12.85</b>		<b>0.24</b>
<b>Uncertainty</b>		<b>0.03</b>		<b>0.06</b>		<b>0.6</b>		<b>0.8</b>		<b>0.01</b>		<b>0.05</b>		<b>0.08</b>		<b>0.01</b>
Tolerance		0.09		0.15		1.8		2.4		0.03		0.12		0.19		0.03

Analysis	*	MnO	*	Na	*	P	*	P <sub>2</sub> O <sub>5</sub>	*	S	*	Si	*	SiO <sub>2</sub>	*	Ti
1	16	0.249	16	0.109965	16	0.000219	16	0.000833	1	1.63	16	16.25489	16	35.04	4	0.25179
2	16	0.31	4	0.120551	16	0.000436	16	0.001	1	1.673333	16	16.3791	16	35.1076	16	0.2518
3	16	0.321967	16	0.13	16	0.0017	4	0.004	1	1.745	16	16.4165	16	35.12	16	0.28176
4	16	0.36	16	0.145	4	0.001746	16	0.004	1	1.77	16	16.4819	16	35.26	16	0.285461
5	16	0.361546	16	0.18	16	0.003	16	0.007	1	1.78	4	16.49948	4	35.305	16	0.29075
6	16	0.37							1	1.81	16	16.6596	16	35.64	16	0.30394
7									1	1.82	16	16.7296	16	35.79	16	0.3057
8									1	1.84					16	0.3117
9									1	1.843333						
Average		0.32875		0.13710		0.00142		0.00337		1.76796		16.48872		35.32323		0.28536
Std dev		0.00013		0.00014		0.00014		0.00014		0.00011		0.00012		0.00012		0.00011
H		0.004955		0.00293		0.000388		0.000518		0.01543		0.089859		0.175182		0.004538
U <sub>1</sub>		0.0050		0.0029		0.00041		0.00054		0.015		0.090		0.18		0.0045
t-statistic		2.57		2.78		2.78		2.78		2.31		2.45		2.45		2.36
U <sub>2</sub>		0.013		0.0081		0.0011		0.0015		0.036		0.22		0.43		0.011
U <sub>3</sub>		0.0052		0.0036		0.00051		0.00067		0.012		0.083		0.16		0.0038
<b>Certified</b>		<b>0.33</b>		<b>0.137</b>		<b>0.0014</b>		<b>0.0034</b>		<b>1.77</b>		<b>16.49</b>		<b>35.3</b>		<b>0.29</b>
<b>Uncertainty</b>		<b>0.01</b>		<b>0.006</b>		<b>0.0005</b>		<b>0.0007</b>		<b>0.08</b>		<b>0.08</b>		<b>0.2</b>		<b>0.01</b>
Tolerance		0.03		0.018		0.0011		0.0015		0.24		0.22		0.4		0.03

Analysis	*	TiO <sub>2</sub>
1	16	0.42
2	4	0.42
3	16	0.47
4	16	0.476167
5	16	0.485
6	16	0.507
7	16	0.51
8	16	0.52
Average		0.47602
Std dev		0.00011
H		0.006273
U <sub>1</sub>		0.0063
t-statistic		2.36
U <sub>2</sub>		0.015
U <sub>3</sub>		0.0052
<b>Certified</b>		<b>0.48</b>
<b>Uncertainty</b>		<b>0.02</b>
Tolerance		0.06

**BS 100A** \* Code for method Informational values listed as weight percent

Analysis	*	C	*	K	*	K <sub>2</sub> O	*	Na <sub>2</sub> O
1	1	0.058	16	0.261	16	0.31439	16	0.148233
2	1	0.067	16	0.28225	16	0.34	4	0.1625
3	1	0.0725	4	0.375646	4	0.4525	16	0.1752
4	1	0.090	16	0.398308	16	0.4798	16	0.195446
5	1	0.11	16	0.41	16	0.493882		
6	1	0.120	16	0.42	16	0.5059		
7	1	0.28						
8	1	0.346667						
9	1	0.639667						
Average		0.20		0.40		0.48		0.170
Std dev		0.73		1.27		1.31		1.060
H		0.003656		0.005609		0.006307		0.003321
U <sub>1</sub>		0.73		1.28		1.31		1.060
t-statistic		2.31		2.57		2.57		2.78
U <sub>2</sub>		1.67		3.28		3.38		2.95
U <sub>3</sub>		0.56		1.34		1.38		1.32
<b>(Certified)</b>		<b>(0.2)</b>		<b>(0.4)</b>		<b>(0.5)</b>		<b>(0.2)</b>

For each element, in accordance with the requirements of ISO Guides 34 and 35, an effort must be made to account for the effects on the certified value of the uncertainty estimate from homogeneity testing (H) and the uncertainties of the contributing laboratories. The average (A) is calculated using a weighted mean where the reciprocal of the square of each laboratory's combined uncertainty (C<sub>L</sub>), calculated from its standard deviation (S<sub>L</sub>) and its uncertainty estimate (U<sub>L</sub>), is used as the weight (W<sub>L</sub>) for it's mean (M<sub>L</sub>). The standard deviation (S) is calculated as the square root of the reciprocal of the sum of the weights. U<sub>1</sub> is the combined uncertainty from homogeneity and labs. U<sub>2</sub> is U<sub>1</sub> times the coverage factor (95 % t-statistic). U<sub>3</sub> is U<sub>2</sub> divided by the square root of the number of determinations (n). Thus:

$$C_L = \sqrt{S_L^2 + U_L^2} \quad W_L = \frac{1}{C_L^2} \quad A = \frac{\sum_{i=1}^n W_L M_L}{\sum_{i=1}^n W_L} \quad S = \frac{1}{\sqrt{\sum_{i=1}^n W_L}} \quad U_1 = \sqrt{H^2 + S^2} \quad U_2 = t \times U_1 \quad U_3 = \frac{U_2}{\sqrt{n}}$$

All but the final reported values are taken to two significant figures as determined by each quantity's uncertainty estimate. The final reported Uncertainty is U<sub>3</sub> rounded to one significant figure and represents the half width of the 95 % confidence interval for the **Certified** value. The final reported **Certified** value is A rounded to the same decimal place as the Uncertainty. The Tolerance is the half width of the 95 % confidence interval for measurements rounded to the same decimal place as the Uncertainty. The Uncertainty is a measure of the quality of the **Certified** value. The Tolerance is a measure of the expected performance of an analysis.

For further information regarding the confidence interval for the certified value see ISO Guide 35:2006 section 6.

**Analytical Method Codes:**

- |                           |                           |                           |
|---------------------------|---------------------------|---------------------------|
| 1 Combustion (ASTM E1019) | 7 Photometric             | 13 Titrimetric            |
| 2 Fusion (ASTM E 1019)    | 8 Flame Atomic Absorption | 14 DCP Atomic Emission    |
| 3 Spark Atomic Emission   | 9 GF Atomic Absorption    | 15 HG Atomic Fluorescence |
| 4 ICP Atomic Emission     | 10 X-Ray Fluorescence     | 16 Wet                    |
| 5 ICP Mass Spectrometry   | 11 GD Atomic Emission     |                           |
| 6 Gravimetric             | 12 GD Mass Spectrometry   |                           |

ICP = Inductively Coupled Plasma      GF = Graphite Furnace      GD = Glow Discharge  
DCP = Direct Current Plasma      HG = Hydride Generation

<u>Laboratory</u>	<u>Location</u>	<u>Registrar</u>	<u>Accreditation</u>
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, Guide 34
VHG Labs, Inc.	Manchester, NH		
SKODA concern	Plzen, Czechoslovakia		
Andrew S. McCreath & Son, Inc.	Harrisburg, PA		
TCR Engineering Services PVT. LTD.	Bombay, India		
Timken	North Canton, OH		
LECO	St. Joseph, MI		
Carpenter Technology Corporation	Reading, PA		
Dirats Laboratories	Westfield, MA		
Hoesch Stahl	Dortmund, Germany		
Laboratory Testing, Inc.	Hatfield, Pa	PRI/Nadcap	17025

A2LA = American Association for Laboratory Accreditation

Nadcap = National Aerospace and Defense Contractors Accreditation Program

PRI =Performance Review Institute

**Analysis:** Chemical analyses were made on samples taken from bulk powder material. The original participating laboratories normally followed the requirements of ISO Guide 25. The laboratories participating in the stability testing followed the requirements of ISO Standard 17025. Methods of analysis used were those listed on pages 2-3.

**Traceability:** The following Certified Reference Materials were used to validate the analytical data listed on pages 2-3 — AR 878; LECO 502-318, 502-320.

**Homogeneity:** This Reference Material (RM) was tested for homogeneity using ASTM Standard Method E 826 and found acceptable.

**Validity statement:** ISO Guide 31 states that the certification should contain an expiration date for all materials where instability has been demonstrated or is considered possible, after which the certified value is no longer guaranteed by the certifying body. The certification of BS 100A is valid for 20 years from the date of this certificate. The certification is nullified if this RM is damaged, contaminated, or otherwise modified.

**Storage:** This RM will remain stable for twenty years, provided that the bottle remains sealed and is stored in a cool, dry atmosphere. When the bottle has been opened, the lid should be secured immediately after use. If the contents should become discolored (eg. Oxidized) due to atmosphere contamination, they should be discarded.

**Form:** This RM has been processed to pass a number 100 mesh sieve in 100 gram containers.

**Use:** This RM is intended for use in x-ray spectrometric and solution methods of analysis. Refer to ISO Guide 33 for information about the use of Reference Materials.

**Sample Preparation:** For best analytical results, use the same method for preparing the analytical surface on all reference materials as you use for production specimens.

**Certificate Number:** The unique identification number for this certificate of analysis is REV100A-031717. You may obtain information on revisions of certificates from the internet at [www.brammerstandard.com](http://www.brammerstandard.com).

**Safety Notice:** A Material Safety Data Sheet (MSDS) is not required for this material. This material will not release or otherwise result in exposure to a hazardous chemical, under normal conditions of use. Inquiries concerning this Reference Material should be directed to:

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**Email: [contact@brammerstandard.com](mailto:contact@brammerstandard.com)**

**Expiration:** 20 years from date of certification, which is March 17, 2037. This material is valid until that date.

**Revision:** This reference material was originally certified as a reference material on March 25, 1992. The documented validity for Brammer Standard Company powder products is 20 years. Additional interlaboratory testing was performed in 2016 to prove stability and has been included on this certificate. C, K, K<sub>2</sub>O, and Na<sub>2</sub>O have been changed from certified to informational. All values have been revised.

**Brammer Standard Company, Inc., is accredited by the American Association For Laboratory Accreditation (A2LA) to ISO Guide 34 as a Reference Material Producer for the production of Certified Reference Materials and Reference Materials (Certificate Number 656.02)**

**Brammer Standard Company's Chemical Laboratory is accredited by A2LA to ISO Standard 17025. (Certificate Number 656.01)**

**By Certificate Number 10539, the Quality System of Brammer Standard Company, Inc., is registered to ISO 9001:2008 by National Quality Assurance (NQA), U.S.A.**

The scopes of accreditation are listed on the website: [www.brammerstandard.com](http://www.brammerstandard.com)

### **References:**

Versions used were those available at the time of testing and characterization

- E 826 Standard Practice for Testing Homogeneity of a Metal Lot or Batch in Solid Form by Spark Atomic Emission Spectrometry
- E 1019 Standard Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel, Iron, Nickel, and Cobalt Alloys by Various Combustion and Fusion Techniques
- E 1806 Standard Practice for Sampling Steel and Iron for Determination of Chemical Composition
  
- ISO Standard 17025:2005 General requirements for the competence of testing and calibration laboratories
- ISO Standard 9001:2008 Quality Management Systems - Requirements
- ISO Guide 30:2015 Terms and definitions used in connection with reference materials + 2008 amendment
- ISO Guide 31:2015 Reference materials - Contents of certificates and labels
- ISO Guide 33:2015 Uses of certified reference materials
- ISO Guide 34:2009 General requirements for the competence of reference material producers
- ISO Guide 35:2006 Reference Materials - General and statistical principles for certification

*ASTM documents available from ASTM, 1916 Race Street, Philadelphia, PA, 19103.*

*ISO Guides and Standards available from Global Engineering - [www.global.ihs.com](http://www.global.ihs.com)*

*Other useful documents available from NIST, U.S. Department of Commerce, Gaithersburg, MD 20899.*

NIST Special Publication 260-100, Handbook for SRM Users

NIST Special Publication 829, Use of NIST Standard Reference Materials for Decisions on Performance of Analytical Chemical Methods and Laboratories

Certified by: \_\_\_\_\_ on March 17, 2017.

Beau R. Brammer

President

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