

BRAMMER STANDARD COMPANY, INC.

Certificate of Analysis

BS 179C

Certified Reference Material for Ferralium 255 - UNS Number S32550

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values³	Certified Value ¹	Estimate of Uncertainty ²
Al	0.0078	0.0006		Sb	0.0002
As	0.0034	0.0004		Si	0.004
B	0.0015	0.0002		Sn	0.0003
C	0.0164	0.0006		V	0.001
Co	0.0386	0.0008		W	0.001
Cr	25.9	0.1			
Cu	1.53	0.01			
Mn	0.878	0.006			
Mo	3.34	0.01			
N	0.236	0.004			
Nb	0.009	0.001			
Ni	6.10	0.03			
O	0.0038	0.0005			
P	0.0236	0.0006			
S	0.0003	0.0001			

Informational Values^{3,4}

Ca (0.0003)	Fe [61.6]	Mg (0.0004)	Pb (0.00002)	Ta (0.0006)
Ti (0.0005)	Zr (0.0042)			

¹ 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 4 for more information on its calculation.

² For each element, the uncertainty listed is based on a statistical evaluation of the contributions of homogeneity and the interlaboratory testing program. See page 4 for more information on its calculation.

³ Values are given in weight percent.

⁴ Values in parentheses are not certified and are provided for information only.

Trace element information values for Cl, Ga, Ge, K, Na, Re, and Zn are shown on page 4.

The requirements of ISO Guides 31, 34, and 35 were followed for the preparation of this Certified Reference Material and certificate of analysis. This is a Certified Reference Material as defined by ISO Guide 30.

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* Code for method Certified values listed as weight percent

Analysis	*	Al	*	As	*	B	*	C	*	Co	*	Cr	*	Cu	*	Mn
1	4	0.006167	5	0.0027	4	0.001033	1	0.01545	4	0.0358	10	25.75	4	1.5	4	0.866
2	4	0.007	5	0.0028	5	0.0013	1	0.015533	4	0.035867	4	25.8	8	1.502333	4	0.869667
3	4	0.0075	5	0.003033	3	0.001353	3	0.016	5	0.0359	13	25.81	4	1.513333	4	0.87
4	4	0.007633	15	0.003573	5	0.0014	3	0.016025	3	0.0363	10	25.82	4	1.514333	10	0.87
5	5	0.007767	5	0.0036	5	0.0014	1	0.016333	10	0.037575	3	25.82	4	1.52	3	0.87
6	4	0.0080	5	0.003967	4	0.0016	1	0.016547	4	0.037667	4	25.85373	10	1.521275	4	0.872
7	3	0.00845	12	0.0040	7	0.001677	1	0.016933	5	0.0380	4	25.87567	4	1.531	4	0.874
8	10	0.008825	5	0.004133	5	0.0017	1	0.017	5	0.0381	13	25.91667	4	1.5513	3	0.8745
9					4	0.0017	1	0.0175	4	0.0383	13	25.91733	4	1.558567	7	0.879
10					3	0.001965	1	0.0190	4	0.0405	4	25.92367	10	1.56	10	0.88
11					4	0.002			8	0.0406	4	25.93333	10	1.57	4	0.883367
12									12	0.0410	4	26.1	3	1.58	10	0.890075
13									10	0.041					4	0.90
14									4	0.041533						
15									4	0.041667						
Average		0.00776		0.00336		0.00150		0.01639		0.03861		25.877		1.5320		0.8780
Std dev		0.00047		0.00028		0.00014		0.00054		0.00089		0.051		0.0088		0.0066
H		0.00050		0.00036		0.00027		0.00071		0.0011		0.16		0.013		0.008
U ₁		0.00069		0.00046		0.00031		0.00089		0.0014		0.17		0.015		0.011
t-statistic		2.36		2.36		2.23		2.26		2.14		2.20		2.20		2.18
U ₂		0.0016		0.0011		0.00068		0.0020		0.0030		0.37		0.034		0.023
U ₃		0.00057		0.00038		0.00021		0.00064		0.00078		0.11		0.010		0.0064
Certified		0.0078		0.0034		0.0015		0.0164		0.0386		25.9		1.53		0.878
Uncertainty		0.0006		0.0004		0.0002		0.0006		0.0008		0.1		0.01		0.006
Tolerance		0.0016		0.0011		0.0007		0.0020		0.0030		0.4		0.03		0.023

Analysis	*	Mo	*	N	*	Nb	*	Ni	*	O	*	P	*	S	*	Sb
1	10	3.26	2	0.222667	4	0.008	10	6.01	2	0.003333	4	0.020967	1	0.0002	5	0.000337
2	4	3.293333	2	0.226	4	0.008	4	6.014667	2	0.00346	10	0.02265	1	0.0002	5	0.0004
3	4	3.303767	2	0.231	4	0.0093	6	6.037333	2	0.003824	5	0.022833	12	0.0002	5	0.000433
4	3	3.31	2	0.231347	3	0.010225	4	6.07	2	0.003867	3	0.0230	1	0.0002	5	0.0005
5	4	3.31	2	0.234	4	0.01026	13	6.079	2	0.0041	10	0.023	1	0.000267	5	0.00052
6	4	3.315467	2	0.2405	10	6.0809	2	6.0809	5	0.004467	5	0.0232	1	0.0003	12	0.00055
7	7	3.319333	2	0.244667	4	6.087	4	6.087	4	0.023267	1	0.023267	1	0.00035	5	0.000567
8	10	3.32			3	6.12	3	6.12	10	0.0233	1	0.0233	1	0.0004		
9	4	3.320667			4	6.12	4	6.12	3	0.0235	1	0.0235	1	0.00046		
10	4	3.322667			4	6.124133	5	6.124133	5	0.0240	1	0.0240	1	0.000533		
11	4	3.323333			4	6.133333	4	6.133333	4	0.024033	1	0.024033	1	0.0006		
12	10	3.3317			10	6.14	7	6.14	7	0.024033						
13	4	3.363333			3	6.1625	4	6.1625	4	0.024233						
14	3	3.3675			4	6.178633	7	6.178633	7	0.024767						
15	13	3.368667			4	6.20	4	6.20	4	0.025125						
16									4	0.026667						
Average		3.337		0.2357		0.00921		6.105		0.00378		0.02361		0.000330		0.000481
Std dev		0.011		0.0028		0.00061		0.021		0.00032		0.00060		0.000052		0.000072
H		0.024		0.0032		0.00054		0.041		0.00038		0.0008		0.00019		0.00020
U ₁		0.027		0.0043		0.00082		0.046		0.00050		0.0010		0.00019		0.00021
t-statistic		2.14		2.45		2.78		2.14		2.57		2.13		2.23		2.45
U ₂		0.057		0.010		0.0023		0.10		0.0013		0.0022		0.00043		0.00052
U ₃		0.015		0.0040		0.0010		0.025		0.00052		0.00055		0.00013		0.00020
Certified		3.34		0.236		0.009		6.10		0.0038		0.0236		0.0003		0.0005
Uncertainty		0.01		0.004		0.001		0.03		0.0005		0.0006		0.0001		0.0002
Tolerance		0.06		0.010		0.002		0.10		0.0013		0.0022		0.0003		0.0005

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* Code for method Certified values listed as weight percent

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Analysis	* Si	* Sn	* V	* W
1	10 0.36	4 0.0015	4 0.073967	10 0.05
2	4 0.364	10 0.001525	5 0.0761	4 0.050467
3	10 0.365	12 0.0017	4 0.077	12 0.0510
4	10 0.369775	5 0.0017	12 0.0790	4 0.051733
5	4 0.370	5 0.002033	3 0.079075	5 0.0542
6	4 0.37	5 0.002167	5 0.0800	4 0.054867
7	3 0.37	5 0.0023	10 0.08	10 0.056825
8	4 0.3703		4 0.080367	3 0.060225
9	4 0.38		5 0.0807	5 0.060633
10	3 0.382		4 0.080867	5 0.0610
11	4 0.385667		4 0.0828	4 0.061133
12	4 0.3917		10 0.08285	
13			4 0.0840	
14			4 0.0846	
Average	0.3728	0.00183	0.0797	0.0559
Std dev	0.0040	0.00019	0.0012	0.0014
H	0.0044	0.00029	0.0016	0.0013
U ₁	0.0060	0.00035	0.0020	0.0019
t-statistic	2.20	2.45	2.16	2.23
U ₂	0.013	0.00085	0.0044	0.0043
U ₃	0.0038	0.00032	0.0012	0.0013
Certified	0.373	0.0018	0.080	0.056
Uncertainty	0.004	0.0003	0.001	0.001
Tolerance	0.013	0.0009	0.004	0.004

BS 179C * Code for method Informational values listed as weight percent

Analysis	* Ca	* Fe	* Mg	* Pb	* Ta	* Ti	* Zr
1	3 0.000263	4 61.3433	5 0.0002	12 0.000015	5 0.0003	12 0.0004	10 0.0026
2	4 0.000333	3 61.53	12 0.00042	5 0.0000167	5 0.000547	3 0.000475	5 0.0027
3		4 61.59313	5 0.000437	5 0.00003	3 0.0012	5 0.000563	3 0.00485
4		10 61.78	4 0.000533			4 0.001	4 0.005567
Average	0.00028	61.55	0.000390	0.000020	0.00059	0.00053	0.00415
Std dev	0.00012	0.18	0.000093	0.000016	0.00020	0.00012	0.00035
H	0.00018	0.39	0.00019	0.00014	0.00021	0.00021	0.00039
U ₁	0.00022	0.43	0.00021	0.00014	0.00029	0.00024	0.00053
t-statistic	12.71	3.18	3.18	4.30	4.30	3.18	3.18
U ₂	0.0027	1.36	0.00068	0.00060	0.0012	0.00076	0.0017
U ₃	0.0019	0.68	0.00034	0.00035	0.00072	0.00038	0.00084
(Informational)	(0.0003)	[61.6]	(0.0004)	(0.00002)	(0.0006)	(0.0005)	(0.0042)

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_L), calculated from its standard deviation (S_L) and its uncertainty estimate (U_L), is used as the weight (W_L) for its mean (M_L). The standard deviation (S) is calculated as the square root of the reciprocal of the sum of the weights. U₁ is the combined uncertainty from homogeneity and labs. U₂ is U₁ times the coverage factor (95 % t-statistic). U₃ is U₂ 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 U₃ 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.

BS 179C		* Code for analytical method		Trace analysis listed as mg/kg (ppm)							
Analysis	* Cl	* Ga	* Ge	* K	* Na	* Re	* Zn				
1	12 0.058	12 11	12 8.1	12 0.24	12 0.11	12 2.5	12 0.56				
2						5 3.033					

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 | |
| 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>
ATI Allvac	Lockport, NY	ACCLASS	17025
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, Guide 34
Carpenter Technology Corporation	Reading, PA	A2LA	17025
Dirats Laboratories	Westfield, MA	ACCLASS	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI/Nadcap	17025
LECO Corporation	St. Joseph, MI	A2LA	17025
NSL Analytical	Cleveland, OH	ACCLASS	17025
Shandong Metallurgical and Science Research	Jinan, China	CNAS	17025
Evans Analytical Group	Liverpool, NY	A2LA	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Exova	Glendale Heights, IL	A2LA	17025
Northern Analytical Laboratory, Inc.	Londonderry, NH	PRI/Nadcap	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	AB 554

A2LA = American Association for Laboratory Accreditation

ACCLASS = ANSI-ASQ National Accreditation Board

CNAS = China National Accreditation Service

Nadcap = National Aerospace and Defense Contractors Accreditation Program

PCA = Polish Center For Accreditation

PRI = Performance Review Institute

Analysis: Chemical analyses were made on solid pieces and chips prepared by a lathe from representative samples for the certified portion of the lot in accordance with ASTM Standard Practice E 1806. The laboratories participating in the testing followed the requirements of ISO Standard 17025. Methods of analysis used were those listed on pages 2-4.

Traceability: The following Certified Reference Materials were used to validate the analytical data listed on pages 2-4 — 11XSG2, 12X41300, 12X44220, 13X32100, 13X41001, 13XNSA9, 13XPH2S143, 28X7138; 501-024, 501-123, 501-320, 501-501, 501-502, 501-503, 501-504, 501-643, 501-644, 501-646, 501-674, 501-676, 501-952, 501-993, 502-072, 502-102, 502-257, 502-348; BAS 180/2, 260/3, 261, 261/1, 331, 334, 345, 363, 434, 464, 464/1, 474; BS CSN-4, SS-1, 179, 179A, 253, 318, 464, 690; CZ 2015A; ECRM 281, 296; IARM 5E, 15A, 15B, 52, 188A, 212B, 239A; IMZ1.7/4, 1.12/3, 130, 132, 139, 169, 176A, 177, 178; JK 37; SRM C1151, C1151A, C1152A, C2401, 1170B, 3109A, 3131A, 3155, 3162A.

Homogeneity: This Certified Reference Material (CRM) was tested for homogeneity using ASTM Standard Method E 826 and found acceptable. It was also examined by spark atomic emission spectrometry and found to be compatible with the following Reference Materials — BAS 464; BS CSN 2-1, CSN 4, SS-1, 179, 253, 318; ECRM 114-1; JK 37; SRM C2401, 2165, 2166.

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 179C is valid indefinitely. The certification is nullified if this CRM is damaged, contaminated, or otherwise modified.

Source: The bar stock for this CRM was produced by Langley Alloys, Newcastle, Staffordshire, UK.

Form: This CRM is machined in the form of a disc, approximately 38 mm in diameter and 19 mm thick by Brammer Standard Company, Inc.

Use: This CRM is intended for use in spark atomic emission and x-ray spectrometric methods of analysis. Refer to ISO Guide 33 for information about the use of Certified Reference Materials.

Certified Area: The entire depth of the CRM may be used.

Caution: As with any bar material, avoid spark atomic emission spectrometric burns in the center of the CRM (5 mm radius), as some segregation may be present.

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. Avoid overheating the sample during surface preparation.

Certificate Number: The unique identification number for this certificate of analysis is 179C-101813. You may obtain information on revisions of certificates from the internet at 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:

Brammer Standard Co., Inc. **Phone: (281) 440-9396** **Web: www.brammerstandard.com**
14603 Benfer Road
Houston, Texas 77069-2895 USA **Fax: (281) 440-4432** **Email: contact@brammerstandard.com**

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

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 30:1992 Terms and definitions used in connection with reference materials + 2008 amendment
- ISO Guide 31:2000 Reference materials - Contents of certificates and labels
- ISO Guide 33:2000 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

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 October 18, 2013.

Beau R. Brammer