

# Brammer Standard Company, Inc.

## Certificate of Analysis

### BS T-24A

Certified Reference Material for Titanium Alloy

	Certified Value <sup>1</sup>	Estimate of Uncertainty <sup>2</sup>	<b>Certified Values<sup>3</sup></b>	Certified Value <sup>1</sup>	Estimate of Uncertainty <sup>2</sup>	
<b>Al</b>	<b>0.0029</b>	0.0007		<b>N</b>	<b>0.0054</b>	0.0008
<b>C</b>	<b>0.010</b>	0.001		<b>O</b>	<b>0.079</b>	0.008
<b>Cr</b>	<b>0.51</b>	0.03		<b>S</b>	<b>0.0023</b>	0.0006
<b>Fe</b>	<b>0.54</b>	0.02		<b>Sn</b>	<b>0.020</b>	0.002
<b>H</b>	<b>0.0077</b>	0.0009		<b>Ti</b>	<b>91.7</b>	0.2
<b>Mn</b>	<b>4.7</b>	0.1		<b>V</b>	<b>1.29</b>	0.05
<b>Mo</b>	<b>0.51</b>	0.02		<b>W</b>	<b>0.60</b>	0.03
	Reference Value <sup>1</sup>	Estimate of Uncertainty <sup>2</sup>	<b>Reference Values<sup>3,4</sup></b>	Reference Value <sup>1</sup>	Estimate of Uncertainty <sup>2</sup>	
<b>Cu</b>	<b>0.03</b>	0.01		<b>Si</b>	<b>&lt;0.03</b>	
<b>Ni</b>	<b>0.005</b>	0.002				

### Informational Values<sup>3,5</sup>

B (0.0003)      Co (0.004)      Mg (0.0006)      Nb (0.003)      P (0.0008)  
Zr (0.002)

<sup>1</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 4 for more information on its calculation.

<sup>2</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 4 for more information on its calculation.

<sup>3</sup> Values are given in weight percent. Values in brackets are reported by difference.

<sup>4</sup> Reference values are not certified and are provided for information only.

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

Trace element information values for As, Bi, Ce, Cl, Ga, Nd, Pb, Re, Sb, Th, U, and Zn are shown on page 4.

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

BS T-24A

\* Code for method

Certified values listed as weight percent

Analysis	*	Al	*	C	*	Cr	*	Fe	*	H	*	Mn	*	Mo	*	N	*	O	*	S
1	5	0.0018	1	0.0073667	3	0.455	4	0.5153333	2	0.00596667	4	4.578333	4	0.47825	2	0.003854	2	0.0661	1	0.0014
2	5	0.0020367	1	0.008	10	0.466	4	0.5223333	2	0.00686667	4	4.603667	4	0.479	2	0.004	2	0.07504	3	0.0015
3	4	0.0025333	1	0.0084333	4	0.4746667	4	0.5235	2	0.0072	4	4.671	4	0.496667	2	0.004833	2	0.0752	1	0.0015667
4	11	0.0026	1	0.0084667	4	0.4803333	4	0.5338733	2	0.00725	10	4.673333	10	0.503333	2	0.0049	2	0.0755	1	0.002
5	3	0.0027	1	0.0086667	4	0.5033	4	0.5363333	2	0.00736667	4	4.675167	14	0.505667	2	0.005133	2	0.078	1	0.002
6	4	0.0029567	1	0.008992	14	0.5063333	4	0.5363333	2	0.00749	10	4.683	4	0.5109	2	0.005513	2	0.0795	1	0.00208
7	4	0.0030667	1	0.00935	4	0.515	10	0.539	2	0.00780733	4	4.693333	4	0.5112	2	0.005617	2	0.080233	1	0.0025
8	10	0.0032	1	0.0101	4	0.5196667	3	0.543	2	0.00787333	3	4.71	4	0.511333	2	0.005633	2	0.080233	1	0.0026667
9	14	0.0033	1	0.0103333	4	0.5301333	10	0.5466667	2	0.00813333	4	4.7105	4	0.512233	2	0.005633	2	0.085267	11	0.0027
10	4	0.0034667	1	0.0107667	4	0.5323333	4	0.5499	2	0.00842	4	4.735533	10	0.513	2	0.0062	2	0.086267	1	0.0027333
11	5	0.0036	1	0.0110333	4	0.5323333	14	0.5513333	2	0.00863333	4	4.7702	4	0.514	2	0.006433	2	0.087	12	0.0027667
12	12	0.0041333	3	0.0111	11	0.533	4	0.5546333	2	0.0102	4	4.807067	11	0.514	2	0.006467			1	0.003288
13			1	0.0112667	4	0.5388	11	0.56			14	4.83	3	0.514						
14			1	0.0122333	10	0.542					11	4.85	4	0.5205						
15					10	0.5433333														
Average		0.002949		0.009722		0.511482		0.5445		0.00768		4.713652		0.506006		0.005351		0.078940		0.002267
Std Dev		0.000091		0.000085		0.000082		0.0058		0.00029		0.000085		0.000085		0.000091		0.000095		0.000091
H		0.00065		0.0011		0.0075		0.0077		0.0010		0.027		0.0074		0.00083		0.0028		0.0005835
U <sub>1</sub>		0.00065		0.0011		0.0075		0.0097		0.0010		0.027		0.0074		0.00083		0.0028		0.00059
t-statistic		2.20		2.16		2.14		2.18		2.20		2.16		2.16		2.20		2.23		2.20
U <sub>2</sub>		0.0014		0.0023		0.016		0.021		0.0022		0.058		0.016		0.0018		0.0063		0.0013
U <sub>3</sub>		0.00042		0.00062		0.0041		0.0058		0.00064		0.015		0.0043		0.00053		0.0019		0.00038
Certified		<b>0.0029</b>		<b>0.010</b>		<b>0.51</b>		<b>0.54</b>		<b>0.0077</b>		<b>4.7</b>		<b>0.51</b>		<b>0.0054</b>		<b>0.079</b>		<b>0.0023</b>
Uncertainty		0.0007		0.001		0.03		0.02		0.0009		0.1		0.02		0.0008		0.008		0.0006
Tolerance		0.0021		0.003		0.09		0.06		0.0027		0.3		0.06		0.0024		0.024		0.0018

Analysis	*	Sn	*	Ti	*	V	*	W												
1	5	0.0167667	14	91.5	4	1.224	3	0.558												
2	4	0.0175	4	91.540	4	1.2548333	11	0.571												
3	10	0.0183	16	[91.5533]	4	1.2596667	10	0.594												
4	10	0.019	16	[91.58]	4	1.2609667	4	0.5957667												
5	5	0.0191	10	91.59	4	1.2786667	4	0.5993												
6	4	0.0197333	16	[91.6]	4	1.2835	10	0.6033333												
7	4	0.0199333	16	[91.633833]	10	1.29	14	0.604												
8	10	0.0201	16	[91.6614]	11	1.29	4	0.611												
9	4	0.0201333	16	[91.72]	4	1.2960	4	0.612												
10	5	0.0218	4	91.846667	4	1.3017333	4	0.6142												
11	3	0.0219	16	[91.95]	10	1.3033333	4	0.6275333												
12	14	0.0222667			10	1.306	4	0.6413333												
13	11	0.027			14	1.32														
14					4	1.338														
15					3	1.39														
Average		0.020272		91.651		1.2920		0.602622												
Std Dev		0.000088		0.037		0.0062		0.000091												
H		0.0015		0.1823924		0.013		0.0082												
U <sub>1</sub>		0.0015		0.19		0.014		0.0082												
t-statistic		2.18		2.23		2.14		2.20												
U <sub>2</sub>		0.0032		0.41		0.030		0.018												
U <sub>3</sub>		0.00090		0.12		0.0077		0.0052												
Certified		<b>0.020</b>		<b>91.7</b>		<b>1.29</b>		<b>0.60</b>												
Uncertainty		0.002		0.2		0.05		0.03												
Tolerance		0.006		0.6		0.15		0.09												

**BS T-24A** \* Code for method Reference values listed as weight percent

Analysis	*	Cu	*	Ni	*	Si														
1	10	0.0258667	5	0.0038667	10	0.0015867														
2	4	0.0264667	5	0.0040333	11	0.0018														
3	14	0.0276	4	0.0044	4	0.0023333														
4	4	0.0276	10	0.0046	10	0.0031														
5	4	0.0283667	10	0.0046667	4	0.0031														
6	11	0.0291	4	0.00481	4	0.0038667														
7	4	0.0302	14	0.0050333	3	0.0044														
8	3	0.0306	12	0.0050667	4	0.0053333														
9	4	0.0345667	11	0.0059	5	0.0089667														
10	5	0.0390	4	0.0065333	14	0.0103667														
11	4	0.0413167	4	0.0066	4	0.0126333														
12	5	0.0426667	4	0.0070	4	0.0129367														
13	10	0.0468	10	0.0073	12	0.0130														
14					4	0.0142														
Average		0.0327		0.005355																
Std Dev		0.0012		0.000088																
H		0.0019		0.00083																
U <sub>1</sub>		0.0022		0.00083																
t-statistic		2.18		2.18																
U <sub>2</sub>		0.0048		0.0018																
U <sub>3</sub>		0.0013		0.00050																
Reference		<b>0.03</b>		<b>0.005</b>		<b>&lt;0.03</b>														
Uncertainty		0.01		0.002																
Tolerance		0.02		0.004																

**BS T-24A** \* Code for method Informational values listed as weight percent

Analysis	*	B	*	Co	*	Mg	*	Nb	*	P	*	Zr								
1	12	0.000032	5	0.0006167	12	0.0001867	5	0.000053	4	0.00033333	5	0.00002								
2	5	0.000043	12	0.00063	4	0.00053	10	0.0011333	12	0.00033333	4	0.0008								
3	4	0.0001	5	0.00063	3	0.0011	4	0.0019	5	0.00036667	10	0.001								
4	4	0.0005633	3	0.0045			4	0.0035	3	0.0009	4	0.002067								
5	3	0.0008	4	0.0048667			4	0.0040	4	0.0020	11	0.0025								
6			4	0.0050			11	0.0041			3	0.0065								
7			11	0.0061			3	0.0043												
8			4	0.0066333																
9			4	0.0074133																
Average		0.00031		0.004		0.0006		0.003		0.0008		0.002								
Std Dev		0.00032		0.023		0.0017		0.015		0.0021		0.011								
H		0.00028		0.001		0.0004		0.001		0.0004		0.001								
U <sub>1</sub>		0.00043		0.023		0.0017		0.015		0.0021		0.011								
t-statistic		2.78		2.31		4.30		2.45		2.78		2.57								
U <sub>2</sub>		0.0012		0.054		0.0073		0.036		0.0060		0.028								
U <sub>3</sub>		0.00053		0.018		0.0042		0.014		0.0027		0.012								
Informational		(0.0003)		(0.004)		(0.0006)		(0.003)		(0.0008)		(0.002)								

For each element, in accordance with the requirements of ISO 17034 and Guide 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.  $U_1$  is the combined uncertainty from homogeneity and labs.  $U_2$  is  $U_1$  multiplied by the coverage factor (95 % t-statistic).  $U_3$  is  $U_2$  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  $U_3$  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 Uncertainty is a measure of the quality of the **Certified** value.

The Tolerance is a measure of the expected performance of an analysis. This involves further expanding the sample uncertainty to include instrument and operator uncertainty, for those without access to such calculations.

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

#### BS T-24A

\* Code for analytical method

Trace analysis listed as mg/kg (ppm)

Analysis	*	As	*	Bi	*	Ce	*	Cl	*	Ga	*	Nd	*	Pb	*	Re	*	Sb	*	Th
1	12	89	12	0.04	12	0.01	12	1.7	12	0.74	12	0.02	12	2.3	12	0.04	12	4.9	12	0.15
2	12	91	12	0.04	12	0.02	12	1.9	12	0.85	12	0.03	12	2.8	12	0.06	12	5.5	12	0.21
3	12	93	12	0.05	12	0.03	12	2.3	12	0.92	12	0.03	12	2.9	12	0.06	12	5.6	12	0.22
Analysis	*	U	*	Zn																
1	12	0.01	12	0.34																
2	12	0.02	12	0.37																
3	12	0.02	12	0.45																

#### Analytical Method Codes:

- |   |                         |    |                         |    |                        |
|---|-------------------------|----|-------------------------|----|------------------------|
| 1 | Combustion (ASTM E1019) | 7  | Photometric             | 13 | Titrimetric            |
| 2 | Fusion (ASTM E1019)     | 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 | Difference             |
| 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

Lab Name	Location	Registrar	Accreditation
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, 17034
NSL Analytical	Cleveland, OH	ANAB	17025
Eurofins EAG Materials Science, LLC	Liverpool, NY	A2LA	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI	17025
LECO Corporation	St. Joseph, MI	A2LA	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Dirats Laboratories	Westfield, MA	ANAB	17025
Element Materials Technology	Glendale Heights, IL	A2LA	17025
Analytical Process Laboratories	Milwaukee, WI	A2LA	17025
Luvak Inc.	Boylston, MA	PRI	17025
Element Materials Technology	Huntington Beach, CA	A2LA	17025
TUV Rheinland Pvt Ltd	Bangalore, India	NABL	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	17025
Vitkovice Testing Center	Ostrava, Czech	ILAC	17025

A2LA = American Association for Laboratory Accreditation

ANAB = ANSI-ASQ National Accreditation Board

CNAS = China National Accreditation Service

ILAC = International Laboratory Accreditation Cooperation

NABL = National Accreditation Board for Testing and Calibration Laboratories

PCA = Polish Center For Accreditation

PRI = Performance Review Institute

**Analysis:** Chemical analyses were made on solid pieces and chips prepared by an end mill from representative samples for the certified portion of the lot in accordance with ASTM Standard Practice E1806. The laboratories participating in the testing followed the requirements of ISO Standard 17025.

**Traceability:** The following Certified Reference Materials were used to validate the analytical data: AR 215B, 585, 586, 589, 631, 637, 641, 644, 645, 647, 648, 649, 650, 651, 882, 892, 1647, 1653; BAS 61, 304/1, 331, 363; BS T-4, T-4A, T-13, T-14, T-19, T-20, T-23, T-24, T-24A, T-26, T-81; DSZU CA017, CA018; IARM 174B, 174C, 175B, 261C, 315A; JSS 653-13; LECO 502-876, 502-891, 502-916; SRM 173A, 173B, 173C, 174, 176, 641.

**Homogeneity:** This Certified Reference Material (CRM) was tested for homogeneity using ASTM Standard Method E826 and found acceptable. It was also examined by spark atomic emission spectrometry and found to be compatible with the following Reference Materials: AR 650; BS T-4, T-4A, T-13, T-14, T-19, T-20, T-23, T-26, T-81; DSZU CA017, CA018; SRM 173B, 641, 647.

**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 T-24A is valid indefinitely. The certification is nullified if this CRM is damaged, contaminated, or otherwise modified.

**Storage:** This CRM must be stored in a cool, dry, non-corrosive environment.

**Source:** The bar stock for this CRM was produced by Axel Johnson Metals, Inc.; Morgantown, PA.

**Form:** This CRM is machined in the form of a disc, approximately 32mm in diameter and 19mm thick by Brammer Standard Company, Inc.

**Use:** This CRM is intended for use in spark atomic emission, glow discharge, 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 used for production specimens. Avoid overheating the sample during surface preparation.

Caution: CRM contains significant insoluble soft metal inclusions. Surface smearing may occur. Spark atomic emission spectrometers may require extended preburns to compensate.

**Certificate Number:** The unique identification number for this certificate of analysis is T-24A-012821. You may obtain information on revisions of certificates from the internet at [www.brammerstandard.com](http://www.brammerstandard.com).

**Safety Notice:** A Safety Data Sheet (SDS) 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.**  
14603 Benfer Road  
Houston, Texas 77069-2895 USA

Phone: (281) 440-9396 Web: [www.brammerstandard.com](http://www.brammerstandard.com)

Fax: (281) 440-4432 Email: [contact@brammerstandard.com](mailto:contact@brammerstandard.com)

**Brammer Standard Company, Inc., is accredited by the American Association For Laboratory Accreditation (A2LA) to ISO Standard 17034 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 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

E826 Standard Practice for Testing Homogeneity of a Metal Lot or Batch in Solid Form by Spark Atomic Emission

Spectrometry

- E1019 Standard Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel, Iron, Nickel, and Cobalt Alloys by Various Combustion and Fusion Techniques
- E1806 Standard Practice for Sampling Steel and Iron for Determination of Chemical Composition

ISO Standard 17025:2017 General requirements for the competence of testing and calibration laboratories

ISO Standard 9001:2015 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 Standard 17034:2016 General requirements for the competence of reference material producers

ISO Guide 35:2017 Reference Materials - General and statistical principles for certification

*ASTM documents available from ASTM, 100 Barr Harbor Dr., West Conshohocken, PA 19428.*

*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 January 28, 2021.

Beau R. Brammer  
President