

# Brammer Standard Company, Inc.

## Certificate of Analysis

### BS T-5B

Certified Reference Material for ASTM B348(5) Grade 6Al-4V Titanium Alloy - UNS Number R56400

	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>6.25</b>	0.06		<b>O</b>	0.007
<b>Cr</b>	<b>0.018</b>	0.002		<b>S</b>	0.0004
<b>Fe</b>	<b>0.23</b>	0.01		<b>Sn</b>	0.001
<b>H</b>	<b>0.0018</b>	0.0004		<b>Ti</b>	0.1
<b>N</b>	<b>0.026</b>	0.003		<b>V</b>	0.09
<b>Ni</b>	<b>0.025</b>	0.002			
	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>C</b>	<b>0.054</b>	0.009		<b>Mo</b>	0.002
<b>Co</b>	<b>0.003</b>	0.002		<b>Si</b>	0.004
<b>Cu</b>	<b>0.004</b>	0.002		<b>W</b>	<0.005
<b>Mn</b>	<b>&lt;0.05</b>			<b>Zr</b>	0.004

<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 3 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 3 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.

Trace element information values for As, Nb, P, and Sb are shown on page 3.

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

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\* Code for method

Certified values listed as weight percent

Analysis	*	Al	*	Cr	*	Fe	*	H	*	N	*	Ni	*	O	*	S	*	Sn	*	Ti
1	4	6.1999	4	0.0153667	4	0.2200667	2	0.0014667	2	0.022667	14	0.0154333	2	0.15	1	0.00017	5	0.007667	4	88.893333
2	4	6.2007667	5	0.0159667	4	0.2203333	2	0.00159	2	0.023433	3	0.0162	2	0.154333	1	0.00052	5	0.009077	3	88.933333
3	4	6.2185333	4	0.0171	4	0.2206667	2	0.0016	2	0.023833	5	0.0229333	2	0.156333	1	0.0006	3	0.0091	16	[88.97]
4	11	6.24	4	0.0171	10	0.224	2	0.0016667	2	0.025833	10	0.0236667	2	0.158833	1	0.00096	14	0.009233	16	[88.98967]
5	4	6.2416667	3	0.0173	4	0.224	2	0.0017333	2	0.026133	4	0.0240333	2	0.160333	1	0.001	10	0.010	4	88.991
6	4	6.2466667	11	0.0174	14	0.2256667	1	0.0021333	2	0.0268	4	0.0241667	2	0.162	3	0.001	4	0.0101	14	89
7	10	6.2466667	5	0.0175	10	0.23	2	0.0022333	2	0.0274	5	0.0252	2	0.162	1	0.00133	4	0.010167	10	89.036667
8	10	6.25	4	0.0177	5	0.235	2	0.0024333	2	0.0285	3	0.0252333	2	0.162667	11	0.0015	11	0.0104	16	[89.06]
9	10	6.2533333	4	0.0179	11	0.237	2	0.0035667	2	0.02875	10	0.0264	2	0.166			4	0.010633	16	[89.09]
10	3	6.26	4	0.018	3	0.237	2	0.0051333	2	0.03	4	0.0269	2	0.1669			4	0.010667	4	89.207333
11	4	6.2666667	4	0.0184667	4	0.2406667					4	0.0269667	2	0.16875			4	0.011167	16	[89.27]
12	14	6.27	10	0.019	3	0.2413333					10	0.027					10	0.012133		
13	3	6.27	14	0.0192333	4	0.2497667					4	0.0271					3	0.012433		
14	4	6.2753333	3	0.0193333	4	0.2514					4	0.0285667					10	0.013		
15	4	6.2766667	4	0.0196667	4	0.2533333					11	0.0296								
16	4	6.3016667									4	0.031								
Average		6.251117		0.01783		0.234016		0.001845		0.0259		0.02499		0.160741		0.00089		0.010413		89.038
Std Dev		0.000079		0.00067		0.000082		0.000099		0.0013		0.00084		0.000095		0.00011		0.000085		0.038
H		0.0317873		0.001399		0.0049117		0.0005382		0.00166		0.0016324		0.004043		0.00041		0.001101		0.1788028
U <sub>1</sub>		0.032		0.0016		0.0049		0.00055		0.0021		0.0018		0.0040		0.00042		0.0011		0.18
t-statistic		2.1314495		2.1447867		2.1447867		2.2621572		2.262157		2.13		2.228139		2.36462		2.160369		2.2281389
U <sub>2</sub>		0.068		0.0033		0.011		0.0012		0.0047		0.0039		0.0090		0.0010		0.0024		0.41
U <sub>3</sub>		0.017		0.00086		0.0027		0.00039		0.0015		0.00098		0.0027		0.00035		0.00064		0.12
Certified		<b>6.25</b>		<b>0.018</b>		<b>0.23</b>		<b>0.0018</b>		<b>0.026</b>		<b>0.025</b>		<b>0.161</b>		<b>0.0009</b>		<b>0.010</b>		<b>89.0</b>
Uncertainty		0.06		0.002		0.01		0.0004		0.003		0.002		0.007		0.0004		0.001		0.1
Tolerance		0.18		0.006		0.03		0.0012		0.009		0.006		0.021		0.0008		0.003		0.4

Analysis	*	V																			
1	4	4.0966667																			
2	11	4.1																			
3	10	4.12																			
4	10	4.1233333																			
5	10	4.1533333																			
6	14	4.17																			
7	3	4.18																			
8	4	4.1853667																			
9	4	4.1968																			
10	4	4.1999333																			
11	4	4.2002333																			
12	4	4.2113333																			
13	4	4.2163333																			
14	4	4.2233333																			
15	4	4.247																			
16	3	4.27																			
Average		4.1909																			
Std Dev		0.0068																			
H		0.0249256																			
U <sub>1</sub>		0.026																			
t-statistic		2.1314495																			
U <sub>2</sub>		0.055																			
U <sub>3</sub>		0.014																			
Certified		<b>4.19</b>																			
Uncertainty		0.09																			
Tolerance		0.27																			

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\* Code for method

Reference values listed as weight percent

Analysis	*	C	*	Co	*	Cu	*	Mn	*	Mo	*	Si	*	W	*	Zr
1	1	0.0389	5	0.0016233	5	0.0015667	5	0.00007	14	0.007067	4	0.0138333	5	0.000453	11	0.0051
2	11	0.0417	10	0.0047	5	0.0016167	11	0.0007	11	0.0098	10	0.014	10	0.0026	3	0.0078
3	1	0.0444333			11	0.002	14	0.0010667	5	0.011033	14	0.0152667			14	0.00867
4	1	0.0479333			14	0.0022	3	0.0025	5	0.0127	4	0.016			4	0.00877
5	1	0.0495			4	0.0024333	4	0.0092	4	0.012867	5	0.0164			4	0.00893
6	1	0.05			3	0.0026333			4	0.013067	4	0.0167667			4	0.00917
7	3	0.0516			4	0.0030			4	0.013667	4	0.0169			4	0.00997
8	1	0.0530667			4	0.005			10	0.014	4	0.0170333			10	0.01173
9	1	0.0598333			3	0.0089			3	0.0143	4	0.0182333			3	0.01183
10	1	0.06			4	0.0100333			4	0.014333	3	0.0194333			10	0.012
11	1	0.0620333			4	0.0100667			4	0.014933	3	0.0198			5	0.0128
12	1	0.063							4	0.015067	4	0.0206			5	0.01333
13	1	0.0651667							10	0.015233	11	0.0208			4	0.01367
14	1	0.074							4	0.015533	10	0.0213333			4	0.01417
15									10	0.017	4	0.0216667			4	0.01797
16									3	0.0218						
Average		0.054369		0.003		0.004495		0.003		0.013900		0.017871		0.002		0.01002
Std Dev		0.000085		0.035		0.000095		0.017		0.000079		0.000082		0.011		0.00042
H		0.0023566		0.0006526		0.00077		0.0006526		0.001251		0.0014005		0.000555		0.00108
U <sub>1</sub>		0.0024		0.035		0.00078		0.017		0.0013		0.0014		0.011		0.0012
t-statistic		2.16		12.706205		2.2281389		2.7764451		2.13145		2.1447867		12.7062		2.14479
U <sub>2</sub>		0.0051		0.44		0.0017		0.048		0.0027		0.0030		0.14		0.0025
U <sub>3</sub>		0.0014		0.31		0.00052		0.021		0.00067		0.00078		0.098		0.00064
Reference		<b>0.054</b>		<b>0.003</b>		<b>0.004</b>		<b>&lt;0.05</b>		<b>0.014</b>		<b>0.018</b>		<b>&lt;0.005</b>		<b>0.010</b>
Uncertainty		0.009		0.002		0.002		0.002		0.002		0.004				0.004
Tolerance		0.027		0.002		0.003				0.006		0.012				0.009

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<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 its 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> multiplied by 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 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-5B**

\* Code for analytical method

Trace analysis listed as mg/kg (ppm)

Analysis	*	As	*	Nb	*	P	*	Sb
1	5	7.0	5	14.1	5	4.6	5	3.0
2	5	7.9	5	14.3	5	5.6	5	3.1
3	5	8.1	5	14.5	5	5.9	5	3.4

## 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
Dirats Laboratories	Westfield, MA	ANAB	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
Luvak Inc.	Boylston, MA	PRI	17025
Element Materials Technology	Glendale Heights, IL	A2LA	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Shiva Analyticals Private Limited	Hoskote, Bangalore	NABL	17025
TUV Rheinland Pvt Ltd	Bangalore, India	NABL	17025
APL, Inc	Milwaukee, WI	A2LA	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	17025

A2LA = American Association for Laboratory Accreditation

ANAB = ANSI-ASQ National Accreditation Board

CNAS = China National Accreditation Service

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 114C, 582, 586, 589, 592, 631, 637, 641, 642, 647, 649, 650, 651, 892, 911K, 1218A; BAS 331, 356; BS T-2A, T-5, T-5A, T-19, T-20, T-23, T-24; DSZU CA017, CA018, CA019; IARM Ti1023-18, Ti64, Ti64-18, Ti662-18, 175A, 175C, 176A, 271B; LECO 502-201, 502-888, 502-891, 502-947, 503-511; SRM 173A, 173B, 173C, 174, 176, 647, 649, 654.

**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: BS T-5, T-19, T-20; IARM Ti1023-18, Ti64-18; ICRM Ti662-18.

**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-5B 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 Carpenter Titanium by Dynamet; Washington, PA.

**Form:** This CRM is machined in the form of a disc, approximately 38mm 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-5B-120122. 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  
Fax: (281) 440-4432

Web: [www.brammerstandard.com](http://www.brammerstandard.com)  
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 December 1, 2022.

Beau R. Brammer  
President