National Institute of Standards & Technology

Certificate of Analysis

Standard Reference Material® 654b

Titanium-Base Alloy (6Al-4V)

This Standard Reference Material (SRM) is primarily intended for use in X-ray fluorescence and optical emission spectrometric methods of analysis. A unit of SRM 654b consists of a disk 31 mm in diameter and 19 mm thick.

Certified Mass Fraction Values: Certified values for elements of SRM 654b are reported in Table 1 as mass fractions [1]. A NIST-certified value is a value for which NIST has the highest confidence in its accuracy in that all known or suspected sources of bias have been investigated or taken into account [2]. A certified value is the present best estimate of the true value based on the results of analyses performed at NIST and collaborating laboratories using instrumental and classical test methods.

Reference Mass Fraction Values: Reference values for elements of SRM 654b are reported in Table 2. Reference values are non-certified values that are the present best estimates of the true values; however, the values do not meet the NIST criteria for certification and are provided with associated uncertainties that may not include all components of uncertainty [2].

Information Mass Fraction Values: Information values for elements of SRM 654b are listed in Table 3. An information value is considered to be a value that will be of interest and use to the SRM user, but insufficient information is available to assess the uncertainty associated with the value.

Expiration of Certification: The certification of **SRM 654b** is valid indefinitely, within the measurement uncertainties specified, provided the SRM is handled and stored in accordance with the instructions given in this certificate (see "Instructions for Use"). Accordingly, periodic recalibration or recertification of this SRM is not required. The certification is nullified if the SRM is damaged, contaminated, or otherwise modified.

Maintenance of SRM Certification: NIST will monitor this material over the period of its certification. If substantive technical changes occur that affect the certification, NIST will notify the purchaser. Registration (see attached sheet) will facilitate notification.

Coordination of technical measurements for the certification of this SRM was performed by J.I. Shultz, Research Associate, ASTM/NIST Research Associate Program, and J.R. Sieber of the NIST Chemical Sciences Division.

Analytical measurements for certification of this SRM were performed by R.L. Paul, J.A. Norris, and P.A. Pella of the NIST Chemical Sciences Division; R.E. Swartz and C.K. Deak, Analytical Associates, Inc., Detroit, MI; L.E. Creasy, Axel Johnson Metals, Inc., Lionville, PA; C.J. Ritchard, Howmet Corp., Whitehall, MI; and K.E. Weiss, Timet Metals Corp., Henderson Process Laboratory, Henderson, NV.

Statistical consultation was provided by A.N. Heckert and H.-K. Liu of the NIST Statistical Engineering Division.

Support aspects involved in the issuance of this SRM were coordinated through the NIST Office of Reference Materials.

Carlos A. Gonzalez, Chief
Chemical Sciences Division

Gaithersburg, MD 20899
Certificate Issue Date: 24 June 2013
Certificate Revision History on Last Page

Robert L. Watters Jr., Director
Office of Reference Materials

INSTRUCTIONS FOR USE

The test surface is the surface opposite to the side marked with the SRM number and NIST logo. The entire thickness of the unit is certified. Each packaged disk has been prepared by finishing the test surface using a milling machine. The user must determine the correct surface preparation procedure for each analytical technique. The user is cautioned to use care when either resurfacing the disk or performing additional polishing as these processes may contaminate the surface. When not in use, the material should be stored in its original container in a cool, dry location. This material was tested using both the solid disks and chips prepared from the disks. The certified values are considered to be representative of the overall average composition of the material.

PREPARATION AND ANALYSIS[(1)]

The material for SRM 654b is an alloy fitting the description of Universal Numbering System (UNS) R56400 and was provided by Oremet Titanium, Oregon Metallurgical Corporation, Albany, OR. It was processed to final form by D.K. Associates, Buffalo, NY. Homogeneity testing was performed at NIST by spark ablation optical emission spectrometry and X-ray fluorescence spectrometry, and by G.F. Boesenecker, Timet Metals Corporation, Henderson, NV, using spark ablation optical emission spectrometry. Test methods used for value assignment of SRM 654b are listed in Table 4.

Certified Mass Fraction Values: The values for all elements in Table 1 are unweighted means of the results from NIST and collaborating laboratories. The uncertainty listed with each value is an expanded uncertainty, $U = ku_c$, calculated according to the method in the ISO/JCGM Guide [3], where u_c is a combined uncertainty based on the combined effects of replicate measurement variability, variability, possible systematic errors among methods, and material variability. For all elements, the expansion factor is $k = 2.78$, based on an approximate 95 % confidence level and estimated effective degrees of freedom for u_c of 4.

Table 1. Certified Mass Fraction Values for SRM 654b Titanium-Base Alloy (6Al-4V)

Element	Mass Fraction (%)
Aluminum (Al)	6.34 ± 0.06
Chromium (Cr)	0.025 ± 0.006
Iron (Fe)	0.23 ± 0.03
Molybdenum (Mo)	0.013 ± 0.003
Nickel (Ni)	0.028 ± 0.006
Silicon (Si)	0.045 ± 0.003
Vanadium (V)	4.31 ± 0.06
Zirconium (Zr)	0.008 ± 0.003

Reference Mass Fraction Value: The value for boron in Table 2 is the mean of the results from a single method performed at NIST. The uncertainty provided is an expanded uncertainty about the mean, with coverage factors $k = 2.00$, following the ISO/JCGM Guide [3]. The values for copper and tin in Table 2 are unweighted means of the results from a single method at NIST. The uncertainty listed with each value is an expanded uncertainty, $U = ku_c$, calculated following the ISO/JCGM Guide [3], where u_c is a combined uncertainty based on the combined effects of replicate measurement variability, variability, possible systematic errors among methods, and material variability. For copper and tin, the expansion factor is $k = 2.78$, based on an approximate 95 % confidence level and estimated effective degrees of freedom for u_c of 4.

Table 2. Reference Mass Fraction Value for SRM 654b Titanium-Base Alloy (6Al-4V)

Element	Mass Fraction (mg/kg)
Boron (B)	1.12 ± 0.13
Copper (Cu)	80 ± 30
Tin (Sn)	230 ± 60

[(1)] Certain organizations, commercial equipment, or materials are identified in this certificate to specify adequately the experimental procedure. Such identification does not imply recommendation or endorsement by the National Institute of Standards and Technology, nor does it imply that the materials or equipment identified are necessarily the best available for the purpose.

Information Mass Fraction Values: The values in Table 3 are intended to provide additional information on the composition of SRM 654b. Insufficient information is available to assess the uncertainties on these values.

Table 3. Information Mass Fraction Values for SRM 654b Titanium-Base Alloy (6Al-4V)

Element	Mass Fraction (%)
Hydrogen (H)	0.002
Oxygen (O)	0.17
Sulfur (S)	0.001

Table 4. Analytical Methods

Method	Elements Determined
Wavelength Dispersive X-Ray Fluorescence Spectrometry (WDXRF) at NIST	Al, Cr, Cu, Fe, Ni, Sn, V
WDXRF at Collaborating Laboratories	Cr, Mo, Ni, Si, V, Zr
Flame Atomic Absorption Spectrometry at Collaborating Laboratories	Cr, Mo, Ni, Si, Zr
Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) at Collaborating Laboratories	Al, Cr, Fe, Mo, Ni, Si, Zr
Direct Current Plasma Optical Emission Spectrometry (DCP-OES) at Collaborating Laboratories	Cr, Mo, Ni, Si, Zr
Spark Source Optical Emission Spectrometry at Collaborating Laboratories	Al, Fe, V
Inert Gas Fusion at Collaborating Laboratories	H, O
Combustion with Infrared Detection at Collaborating Laboratories	S
Prompt Gamma-Ray Activation Analysis at NIST	B

REFERENCES

[1] Thompson, A.; Taylor, B.N.; *Guide for the Use of the International System of Units (SI);* NIST Special Publication 811; U.S. Government Printing Office: Washington, DC (2008); available at http://www.nist.gov/pml/pubs/index.cfm/ (accessed June 2013).

[2] May, W.; Parris, R.; Beck, C.; Fassett, J.; Greenberg, R.; Guenther, F.; Kramer, G.; Wise, S.; Gills, T.; Colbert, J.; Gettings, R.; MacDonald, B.; *Definitions of Terms and Modes Used at NIST for Value-Assignment of Reference Materials for Chemical Measurements;* NIST Special Publication 260-136; U.S. Government Printing Office: Washington, DC (2000); available at http://www.nist.gov/srm/publications.cfm (accessed June 2013).

[3] JCGM 100:2008; *Evaluation of Measurement Data — Guide to the Expression of Uncertainty in Measurement* (GUM 1995 with Minor Corrections); Joint Committee for Guides in Metrology (JCGM) *(2008); available at* http://www.bipm.org/utils/common/documents/jcgm/JCGM_100_2008_E.pdf (accessed June 2013); see also Taylor, B.N.; Kuyatt, C.E.; *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*; NIST Technical Note 1297; U.S. Government Printing Office: Washington, DC (1994); avail*able at* http://www.nist.gov/pml/pubs/index.cfm (accessed June 2013).

Certificate Revision History: 24 June 2013 (Removed expiration of certification date; added reference value for boron; changed certified values for copper and tin to reference values; editorial changes); 19 August 2010 (Revised the certified value for copper; editorial revisions); 10 September 1991 (Addition of two certified values; change of three information values to certified values); 24 January 1991 (Original certification date).

Users of this SRM should ensure that the Certificate of Analysis in their possession is current. This can be accomplished by contacting the SRM Program at: telephone (301) 975-2200; fax (301) 948-3730; e-mail srminfo@nist.gov; or via the Internet at http://www.nist.gov/srm.