National Institute of Standards & Technology

Certificate of Analysis

Standard Reference Material® 173c

Titanium Alloy (6Al-4V)

This Standard Reference Material (SRM) is intended primarily for use in evaluating chemical and instrumental methods of analysis of titanium and its alloys. A unit of SRM 173c consists of a single bottle containing approximately 50 g of chips.

Certified Mass Fraction Values: Certified values for elements of SRM 173c are reported in Table 1 as mass fractions on an as-received basis [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.

Reference Mass Fraction Values: Reference values for elements 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]. The uncertainty listed with the value is calculated according to the method in the ISO/JCGM Guide [3] and is an expanded uncertainty (95 % confidence interval [4]).

Information Mass Fraction Values: Information values for elements of SRM 173c are reported 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 173c** is valid indefinitely, within the uncertainty 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 will be 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 the technical measurements for the certification of this SRM was performed by J.R. Sieber of the NIST Chemical Sciences Division.

Analytical measurements for certification of this SRM, including homogeneity testing, were performed by J.R. Sieber, A.F. Marlow, and R.L. Paul of the NIST Chemical Sciences Division; S. Bissell-Seymour and S. Cooper, Allegheny Ludlum, Brackenridge, PA; P. Cole, ATI Allvac, Monroe, NC; L. Trecani, CEZUS, Ugine, France; M. Chamberlain-Webber, TIMET UK, Ltd., Witton, Birmingham, UK; L. Creasy, J. Kiely, and G. Boesenecker, Titanium Metals Corp., Henderson, NV and Morgantown, PA; and G. Beck, ATI Wah Chang, Albany, OR.

Statistical consultation was provided by S.D. Leigh, 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.

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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

To relate analytical determinations to the values on this Certificate of Analysis, a minimum sample quantity of 250 mg should be used. The material may be used directly from the original container. Sampling and sample preparation procedures should be designed to avoid material segregation on the basis of chip size. It is recommended to thoroughly mix the contents of the bottle prior to sampling by turning the bottle end over end for one minute.

PREPARATION AND ANALYSIS[(1)]

The material for SRM 173c is an alloy fitting the description of Universal Numbering System (UNS) R56400 and was obtained from ATI Allvac, Monroe, NC. The material was chipped, blended and bottled at NIST under the supervision of M.P. Cronise of the NIST Office of Reference Materials. Analytical methods employed for quantitative analyses and homogeneity testing at NIST and collaborating laboratories are reported in Table 4.

Certified Mass Fraction Values: The values for all elements in Table 1, except copper, are weighted means of the results from two to seven analytical methods [5]. The uncertainty listed with each value is an expanded uncertainty about the mean, with a coverage factor 2 (approximately 95 % confidence), calculated by combining a between-source variance incorporating between-method bias with a pooled within-source variance following the ISO/JCGM Guide [3]. The assigned value for copper is the unweighted mean of the results from four analytical methods. The uncertainty listed with the value is an expanded uncertainty about the mean, with coverage factor 2, calculated by combining a between-method variance [6] with a pooled, within-method variance following the ISO/JCGM Guide [3].

Table 1. Certified Mass Fraction Values for SRM 173c Titanium Alloy (6Al-4V)

Element	Mass Fraction (%)
Aluminum (Al)	6.245 ± 0.036
Chromium (Cr)	0.0165 ± 0.0005
Copper (Cu)	0.0040 ± 0.0004
Iron (Fe)	0.2130 ± 0.0040
Nickel (Ni)	0.0203 ± 0.0009
Vanadium (V)	4.154 ± 0.016

Reference Mass Fraction Values: The values in Table 2 for carbon, molybdenum, and zirconium are weighted means of the results from two to seven analytical methods [5]. The uncertainty listed with each value is an expanded uncertainty about the mean, with a coverage factor 2 (approximately 95 % confidence), calculated by combining a between-source variance incorporating between-method bias with a pooled within-source variance following the ISO/JCGM Guide [3]. The assigned values for nitrogen, oxygen, silicon, and tin are the unweighted means of the results from two to five analytical methods. The uncertainty listed with each value is an expanded uncertainty about the mean, with coverage factor 2, calculated by combining a between-method variance [6] with a pooled, within-method variance following the ISO/JCGM Guide [3]. The values for boron and titanium are the means of the results from a single analytical method performed at NIST. The uncertainty listed with each value is an expanded uncertainty about the mean, with coverage factor 2, calculated by combining all known sources of uncertainty for the method, following the ISO/JCGM Guide [3].

[(1)] Certain commercial equipment, instruments, or materials are identified in this report to adequately specify 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.

Table 2. Reference Mass Fraction Values for SRM 173c Titanium Alloy (6Al-4V)

Element	Mass Fraction (%)
Carbon (C)	0.027 ± 0.002
Molybdenum (Mo)	0.0068 ± 0.0004
Nitrogen (N)	0.028 ± 0.005
Oxygen (O)	0.164 ± 0.003
Silicon (Si)	0.019 ± 0.005
Tin (Sn)	0.010 ± 0.002
Titanium (Ti)	89.15 ± 0.49
Zirconium (Zr)	0.0053 ± 0.0004

Element	Mass Fraction (mg/kg)
Boron (B)	0.45 ± 0.12

Information Mass Fraction Values: The values in Table 3 are intended to provide additional information on the composition of SRM 173c. Due to insufficient information, uncertainties are not assigned to these values.

Table 3. Information Mass Fraction Values for SRM 173c Titanium Alloy (6Al-4V)

Element	Mass Fraction (%)
Cobalt (Co)	0.002
Hydrogen (H)	0.006
Manganese (Mn)	0.002
Ruthenium (Ru)	0.0006
Tungsten (W)	0.002

Table 4. Analytical Methods

Method	Elements Determined
Wavelength Dispersive X-Ray Fluorescence Spectrometry (WDXRF) at NIST	Al, Cr, Cu, Fe, Ni, Ti, V
WDXRF at Collaborating Laboratories	Al, Cr, Cu, Fe, Ni, V, Zr
Inductively-Coupled Plasma Optical Emission Spectrometry (ICP-OES) at Collaborating Laboratories	Al, B, Co, Cr, Cu, Fe, Mn, Mo, Ni, Ru, Si, Sn, V, W, Zr
Direct Current Plasma Optical Emission Spectrometry (DCP-OES) at Collaborating Laboratories	Al, Cr, Cu, Fe, Mo, Ni, Si, V, Zr
Combustion with Infrared Detection at Collaborating Laboratories	C, N, O
Inert Gas Fusion at Collaborating Laboratories	H, N, O
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).

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[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).

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[5] Ruhkin, A.L.; Vangel, M.G.; *Estimation of a Common Mean and Weighted Mean Statistics*; J. Am. Statist. Assoc.; Vol. 93, pp. 303–308 (1998).

[6] Levenson, M.S.; Banks, D.L.; Eberhardt, K.R.; Gill, L.M.; Guthrie, W.F.; Liu, H.-K.; Vangel, M.G.; Yen, J.H.; Zang, N.F.; *An Approach to Combining Results from Multiple Methods Motivated by the ISO GUM*; J. Res. Natl. Inst. Stand. Technol.; Vol. 105, pp. 571–579 (2000).

Certificate Revision History: 24 June 2013 (Removed expiration of certification date; added reference value for boron; editorial changes.); 30 July 2004 (Editorial changes); 22 June 2004 (Original certificate 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.