National Institute of Standards & Technology

Certificate of Analysis

Standard Reference Material® 2166

Low Alloy Steel
(chip form)

This Standard Reference Material (SRM) is low alloy steel intended primarily for use in evaluation of chemical and instrumental methods of analysis of steel and materials of similar matrix. It can be used to validate value assignment of in-house reference materials. A unit of SRM 2166 consists of one bottle containing approximately 150 g of chips sized to pass through sieve openings between 0.50 mm and 1.18 mm (35 mesh to 16 mesh).

Certified Mass Fraction Values: Certified values for constituents of SRM 2166 are listed in Table 1 as mass fractions of the total amounts of the elements in a steel matrix [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 taken into account [2]. A certified value is the present best estimate of the true value. The certified values are metrologically traceable to the SI derived unit of mass fraction expressed as percent. The uncertainty is expressed as the combined uncertainty, u_c, based on the effects of method variability, possible systematic errors among methods, and material variability. For sulfur, the expanded uncertainty is calculated as $U = ku_c$ where the coverage factor, $k = 2.43$, was determined from the Student's t distribution corresponding to the associated degrees of freedom and 95 % confidence level [3].

Expiration of Certification: The certification of **SRM 2166** 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 Storage, Handling and Use"). Reference values are expected also to remain valid within this period. 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 before the expiration of this certificate, NIST will notify the purchaser. Registration (see attached sheet or register online) will facilitate notification.

Coordination of the original certification of SRM 2166 was performed by J.I. Schultz, ASTM/NIST Research Associate, and W.P. Reed of the NIST Office of Reference Materials. Coordination of the reevaluation of boron and sulfur was performed by J.R. Sieber of the NIST Chemical Sciences Division.

Statistical consultation for this SRM was provided by W.F. Guthrie of the NIST Statistical Engineering Division.

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

Carlos A. Gonzalez, Chief
Chemical Sciences Division

Gaithersburg, MD 20899
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Certificate Revision History on Last Page

Steven J. Choquette, Director
Office of Reference Materials

Table 1. Certified Mass Fraction Values for SRM 2166 Low Alloy Steel

Constituent	Mass Fraction (%)	Combined Standard Uncertainty (%)
Aluminum (Al)	0.012	0.001
Antimony (Sb)	0.0005	0.0002
Arsenic (As)	0.0035	0.0005
Carbon (C)	0.015	0.001
Chromium (Cr)	0.024	0.001
Cobalt (Co)	0.0022	0.0002
Copper (Cu)	0.015	0.001
Lead (Pb)	0.003	0.001
Manganese (Mn)	0.066	0.001
Molybdenum (Mo)	0.0035	0.0005
Nickel (Ni)	0.022	0.001
Niobium (Nb)	0.005	0.001
Phosphorus (P)	0.0012	0.0002
Silicon (Si)	0.010	0.005
Silver (Ag)	0.0005	0.0001
Sulfur (S)	0.002164	0.000076
Tin (Sn)	0.0010	0.0005
Titanium (Ti)	0.0007	0.0002
Vanadium (V)	0.009	0.001

Constituent	Mass Fraction (%)	Expanded Uncertainty (%)
Sulfur (S)	0.002164	0.000076

INSTRUCTIONS FOR STORAGE, HANDLING AND USE

To relate analytical determinations to the certified values in this Certificate of Analysis, a minimum sample quantity of 200 mg is recommended. Specimens may be used directly from the bottle without pre-treatment. The material should be stored in its tightly sealed, original bottle in a cool, dry location.

PREPARATION AND ANALYSIS[(1)]

The material for SRM 2166 was vacuum induction melted at the Carpenter Technology Corp. (Reading, PA) and supplied in the form of rods. The material was cut and packaged at NIST in the NIST Office of Reference Materials Division. Homogeneity testing was performed at NIST and at Lukens Steel Co. (Coatesville, PA) using spark source optical emission spectrometry.

Measurements for the original value assignment of SRM 2166 were performed by J.A. Norris, D.E. Brown, and R.C. Gauer of the NIST Chemical Sciences Division. Analyses for the update were performed by W.R. Kelly, J.L. Mann, R.L. Paul, and R.D. Vocke of the NIST Chemical Sciences Division. Additional analyses were performed by collaborating laboratories including R.M. Crain G.L. Bergstrom, and C.C. Gabrielli of Allegheny Ludlum Steel Corp. (Brackenridge, PA), C.K. Deak of Analytical Associates, Inc. (Detroit, MI), C.C. Borland, D.E. Gillum, and H.P. Vail of Armco Research & Technology (Middletown, OH), M.P. Balogh, R.L. Passeno, W.S. Antos, and N.M. Potter of General Motors Research Laboratories (Warren, MI), D. Ravaine of Institut de Recherches de la Sidérurgie Française (Maizieres-Les-Metz, France), S. Kallmann and C.L. Maul of Ledoux & Co. (Teaneck, NJ).

ADDITIONAL CONSTITUENTS: Noncertified values are provided for the following additional constituents in SRM 2166.

Reference Mass Fraction Value: The reference value for boron, listed in Table 2, is the mean of results obtained by NIST using prompt gamma-ray activation analysis. A reference value is a non-certified values that is the present best estimates of the true value. However, the value does not meet the NIST criteria for certification and is provided with

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

an associated uncertainty that may not include all sources of uncertainty [2]. The reference values as determined by the method used, are metrologically traceable to the derived SI unit for mass fraction expressed as percent. The expanded uncertainty is calculated as $U = ku_c$ where u_c is the combined uncertainty at the level of one standard deviation, and the coverage factor, $k = 1.98$, was determined from the Student's *t*-distribution corresponding to the associated degrees of freedom and 95 % confidence [3].

Table 2. Reference Mass Fraction Value for SRM 2166 Low Alloy Steel

Constituent	Mass Fraction (mg/kg)	Expanded Uncertainty (%)
Boron (B)	4.365	0.084

Information Mass Fraction Values: Information values for six constituents are reported in Table 3. An information value is considered to be a value that will be of interest to the SRM user, but insufficient information is available to assess the uncertainty associated with the value. Information values cannot be used to establish metrological traceability.

Table 3. Information Values for SRM 2166 Low Alloy Steel

Constituent	Mass Fraction (mg/kg)
Bismuth (Bi)	<1
Magnesium (Mg)	<1
Selenium (Se)	35
Tantalum (Ta)	110
Tellurium (Te)	30
Zirconium (Zr)	4

Table 4. Test Methods for SRM 2166

Combustion with infrared or thermal conductivity detection:	C
Direct current plasma optical emission spectrometry:	Ag, Al, Co, Cr, Cu, Mg, Mn, Mo, Nb, Ni, P, Si, Ti, V, Zr
Flame atomic absorption spectrophotometry:	Cr, Cu, Mn, Ni, Sn, Ti, V
Inductively coupled plasma optical emission spectrometry:	Ag, As, Co, Cr, Cu, Mn, Mo, Nb, Ni, P, Pb, Sb, Si, Sn, Ti, V
Inert gas fusion with infrared detection:	C, S
Isotope dilution thermal ionization mass spectrometry:	S
Photometric methods:	Mn, P
Prompt gamma-ray activation analysis:	B
Zeeman atomic absorption spectrophotometry:	Ag, As, Bi, Pb, Sb, S

NOTICE TO USERS

NIST strives to maintain the SRM inventory supply, but NIST cannot guarantee the continued or continuous supply of any specific SRM. Accordingly, NIST encourages the use of this SRM as a primary benchmark for the quality and accuracy of the user's in-house reference materials and working standards. As such, the SRM should be used to validate the more routinely used reference materials in a laboratory. Comparisons between the SRM and in-house reference materials or working measurement standards should take place at intervals appropriate to the conservation of the SRM and the stability of relevant in-house materials. For further guidance on how this approach can be implemented, contact NIST by email at srms@nist.gov.

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 https://physics.nist.gov/cuu/pdf/sp811.pdf (accessed Jun 2018).

[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 https://www.nist.gov/srm/upload/SP260-136.PDF (accessed Jun 2018).

[3] JCGM 100:2008; *Evaluation of Measurement Data — Guide to the Expression of Uncertainty in Measurement* (ISO GUM 1995 with Minor Corrections); Joint Committee for Guides in Metrology (JCGM) (2008); available at https://www.bipm.org/utils/common/documents/jcgm/JCGM_100_2008_E.pdf (accessed Jun 2018); 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); available at https://www.nist.gov/pml/pubs/tn1297/index.cfm (accessed Jun 2018).

Certificate Revision History: 27 June 2018 (Title update; editorial changes); 03 June 2011 (Revised assignment of values for boron and sulfur based on new analytical determinations; editorial changes); 12 June 1989 (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: telephone (301) 975-2200; fax (301) 948-3730; e-mail srminfo@nist.gov; or via the Internet at https://www.nist.gov/srm.