NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
U.S. DEPARTMENT OF COMMERCE

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Standard Reference Material® 2165
Low Alloy Steel
(chip form)
CERTIFICATE OF ANALYSIS

Purpose: This Standard Reference Material (SRM) is low alloy steel intended for use in evaluation of chemical and instrumental methods of analysis of steel and materials of similar matrix.

Description: A unit of SRM 2165 consists of one glass 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 Values: Certified values of the total amounts of the elements in a low alloy steel matrix are listed below. 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 [1]. These values are traceable to the International System of Units (SI) derived unit of mass fraction expressed as percent (%) [1].

Certified Mass Fractions for SRM 2165 Low Alloy Steel (chip form)

Constituent	Mass Fraction (%)	Combined Standard Uncertainty[(a)] (%)
Antimony (Sb)	0.001 0	0.000 5
Arsenic (As)	0.001 0	0.000 5
Chromium (Cr)	0.050	0.002
Cobalt (Co)	0.001 2	0.000 2
Copper (Cu)	0.001 3	0.000 2
Lead (Pb)	0.000 3	0.000 1
Manganese (Mn)	0.144	0.003
Molybdenum (Mo)	0.005 5	0.000 5
Nickel (Ni)	0.155	0.002
Niobium (Nb)	0.000 4	0.000 1
Phosphorus (P)	0.005 2	0.000 2
Silver (Ag)	0.000 2	0.000 1
Sulfur (S)	0.003 643	0.000 013[(b)]
Tin (Sn)	0.002	0.001
Titanium (Ti)	0.005 1	0.000 2
Vanadium (V)	0.004 0	0.000 2

(a) The uncertainty is expressed as a combined standard uncertainty, u_c, for approximately 68 % coverage, based on effects of material variability, method variability and possible biases among methods [2,3]. The estimated effective degrees of freedom for u_c is three.

b) For sulfur, the combined standard uncertainty, u_c, is reported here. The combined standard uncertainty was derived from the reported expanded uncertainty for sulfur ($U = ku_c$) where u_c is the combined uncertainty at the level of one standard deviation, and the coverage factor, $k = 2.37$, which was determined from the Student's t-distribution corresponding to the associated degrees of freedom and 95 % confidence level [2,3].

Period of Validity: The certification of **SRM 2165** is valid indefinitely, within the measurement uncertainty specified. The certified values are nullified if the material is stored or used improperly, damaged, contaminated, or otherwise modified. Periodic recertification of this SRM is not required.

Non-Certified Values: Non-certified values are provided in Appendix A.

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Additional Information: Values of potential interest for additional elements, approximate mass fraction values and limits of quantification, all determined by single or multiple methods, are provided in Appendix B.

Maintenance of Certified Values: NIST will monitor this SRM over the period of its validity. If substantive technical changes occur that affect the certification, NIST will issue an amended certificate through the NIST SRM website (https://www.nist.gov/srm) and notify registered users. SRM users can register online from a link available on the NIST SRM website or fill out the user registration form that is supplied with the SRM. Registration will facilitate notification. Before making use of any of the values delivered by this material, users should verify they have the most recent version of this documentation, available through the NIST SRM website (https://www.nist.gov/srm).

Storage: The material should be stored in its tightly sealed, original bottle in a cool (10 °C to 25 °C), dry (relative humidity ≤60 %) location.

Use: To relate analytical determinations to the certified values in this Certificate of Analysis, a minimum sample quantity of 200 mg must be used. Specimens may be used directly from the bottle without pre-treatment.

Source and Preparation: See Appendix C for historical information as well as test methods for measuring various elements.

REFERENCES

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[2] 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/en/committees/jc/jcgm/publications (accessed Jan 2025).

[3] 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/nist-technical-note-1297 (accessed Jan 2025).

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[8] Paul, R.L.; *Determination of Boron in Materials by Cold Neutron Prompt Gamma-Ray Activation Analysis*; Analyst, Vol. 130, pp. 99–103 (2005)

Certificate of Analysis Revision History: **14 January 2025** (Editorial changes); **17 December 2024** (Added value of potential interest for Zr and revised value of potential interest for Al based on re-evaluation of the original analytical data; removed value of potential interest (formerly called "information value") for Ta and Te; corrected table of methods; updated format; editorial changes); **08 February 2018** (Title update; editorial changes); **07 June 2011** (Revised values for B, C and S 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 Office of Reference Materials 100 Bureau Drive, Stop 2300, Gaithersburg, Maryland 20899-2300; telephone (301) 975-2200; e-mail srminfo@nist.gov; or the Internet at https://www.nist.gov/srm.

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APPENDIX A

Non-Certified Values: Non-certified values are best estimates based on currently available information. However, they do not meet NIST's criteria for certification [1] and are provided with associated uncertainties that may not include all sources of uncertainty [2,3]. Non-certified values cannot be used to establish metrological traceability to the SI or another higher-order reference system. They may be used to establish traceability of test results to these values for this reference material. Non-certified values could be used in situations where metrological traceability to the SI is not necessary, for example method harmonization, method development or quality control.

Non-Certified Values for SRM 2165 Low Alloy Steel (chip form)

Constituent	Mass Fraction (mg/kg)	Expanded Uncertainty (mg/kg)	Coverage Factor, k
Boron (B)[(a)]	9.44	0.17	1.99
Carbon (C)[(b)]	63	12	2.07

a) The value for boron is the mean of results obtained by NIST. 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, $k = 1.99$, was determined from the Student's t-distribution corresponding to the associated degrees of freedom and 95 % confidence level [2,3].

b) Data from multiple laboratories using a single method was combined to estimate this non-certified value. To best account for the different sources of variation in the interlaboratory data, a Bayesian hierarchical model with non-informative prior distributions was used to establish the mean mass fraction and its expanded uncertainty, U, which is given as a symmetric 95 % probability interval [4-6]. The expanded uncertainty is expressed as $U = ku_c$, where $u_c = 5.58$ mg/kg is the combined standard uncertainty, and the coverage factor, $k = 2.07$, is determined from the Student's t-distribution corresponding to 22.9 degrees of freedom.

Period of Validity: The non-certified values are valid indefinitely, within the measurement uncertainty specified. The value assignments are nullified if the material is stored or used improperly, damaged, contaminated, or otherwise modified.

Maintenance of Non-Certified Values: NIST will monitor this material to the end of its period of validity. If substantive technical changes occur that affect the non-certified values during this period, NIST will update this Appendix and notify registered users. SRM users can register online from a link available on the NIST SRM website or fill out the user registration form that is supplied with the SRM. Registration will facilitate notification. Before making use of any of the values delivered by this material, users should verify they have the most recent version of this documentation, available through the NIST SRM website (https://www.nist.gov/srm).

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APPENDIX B

Additional Information: Values of potential interest to users for six elements are provided below. These values were obtained by one or more test methods. The uncertainties of these values have not been assessed. This information is provided to help the user assess possible measurement interferences and cannot be used to establish metrological traceability to the SI or another higher-order reference system. These values are not intended to be used to calibrate or validate test methods.

Values of Potential Interest

Constituent	Mass Fraction[(a)] (mg/kg)
Aluminum (Al)	40 to 70
Bismuth (Bi)	<1
Magnesium (Mg)	<1
Selenium (Se)	35
Silicon (Si)	40
Zirconium (Zr)	3 to 6

(a) The mass fraction values given as “less than” (<) values represent estimates of the limits

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APPENDIX C

Source and Preparation: The material for SRM 2165 was vacuum induction melted at the Carpenter Technology Corp. (Reading, PA) and supplied in the form of rods. The material was chipped, blended and packaged at NIST. Homogeneity testing was performed at NIST and at Lukens Steel Co. (Coatesville, PA) using spark source optical emission spectrometry.

Measurements for value assignments of SRM 2165 were performed in the NIST Chemical Sciences Division. Additional analyses were performed by collaborating laboratories including Allegheny Ludlum Steel Corp. (Brackenridge, PA), Analytical Associates, Inc. (Detroit, MI), Armco Research & Technology (Middletown, OH), General Motors Research Laboratories (Warren, MI), Institut de Recherches de la Sidérurgie Française (Maizieres-Les-Metz, France), and Ledoux & Co. (Teaneck, NJ).

See below for Test Methods Used in Value Assignments of SRM 2165.

Test Methods Used in Value Assignments of SRM 2165

Combustion with infrared or thermal conductivity detection [7]: 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:	Co, Cr, Cu, Mn, Ni, V
Inductively coupled plasma optical emission spectrometry:	Al, Co, Cr, Cu, Mo, Nb, Ni, P Si, Ti, V, Zr
Isotope dilution thermal ionization mass spectrometry:	S
Photometric methods:	Mn, P
Prompt gamma-ray activation analysis [8]:	B
Zeeman atomic absorption spectrophotometry:	Ag, As, Bi, Pb, Sb, Se, Sn

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