DEPARTMENT OF COMMERCE * NATIONAL BUREAU OF STANDARDS *

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U.S. DEPARTMENT OF COMMERCE/National Bureau of Standards

Standard Reference Materials:

Summary of the Biological and Botanical Standards Issued by the National Bureau of Standards

R. Mavrodineanu and R. Alvarez

The National Bureau of Standards[1] was established by an act of Congress on March 3, 1901. The Bureau's overall goal is to strengthen and advance the nation's science and technology and facilitate their effective application for public benefit. To this end, the Bureau conducts research and provides: (1) a basis for the nation's physical measurement system, (2) scientific and technological services for industry and government, (3) a technical basis for equity in trade, and (4) technical services to promote public safety. The Bureau's technical work is performed by the National Measurement Laboratory, the National Engineering Laboratory, the Institute for Computer Sciences and Technology, and the Institute for Materials Science and Engineering.

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Provides the national system of physical and chemical measurement; coordinates the system with measurement systems of other nations and furnishes essential services leading to accurate and uniform physical and chemical measurement throughout the Nation's scientific community, industry, and commerce; provides advisory and research services to other Government agencies; conducts physical and chemical research; develops, produces, and distributes Standard Reference Materials; and provides calibration services. The Laboratory consists of the following centers:

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- Manufacturing Engineering
- Building Technology
- Fire Research
- Chemical Engineering[2]

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- Computer Systems Engineering

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Conducts research and provides measurements, data, standards, reference materials, quantitative understanding and other technical information fundamental to the processing, structure, properties and performance of materials; addresses the scientific basis for new advanced materials technologies; plans research around cross-country scientific themes such as nondestructive evaluation and phase diagram development; oversees Bureau-wide technical programs in nuclear reactor radiation research and nondestructive evaluation; and broadly disseminates generic technical information resulting from its programs. The Institute consists of the following Divisions:

- Ceramics
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- Metallurgy
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[3] Located at Boulder, CO, with some elements at Gaithersburg, MD.

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Preface

Standard Reference Materials (SRM's) as defined by the National Bureau of Standards (NBS) are well-characterized materials, produced in quantity and certified for one or more physical or chemical properties. They are used to assure the accuracy and compatibility of measurements throughout the Nation. SRM's are widely used as primary standards in many diverse fields in science, industry, and technology, both within the United States and throughout the world. They are also used extensively in the fields of environmental and clinical analysis. In many applications, traceability of quality control and measurement processes to the national measurement system is carried out through the mechanism and use of SRM's. For many of the Nation's scientists and technologists it is therefore of more than passing interest to know the details of the measurements made at NBS in arriving at the certified values of the SRM's produced. An NBS series of papers, of which this publication is a member, called the NBS Special Publication - 260 Series, is reserved for this purpose.

This 260 Series is dedicated to the dissemination of information on different phases of the preparation, measurement, certification and use of NBS SRM's. In general, much more detail will be found in these papers than is generally allowed, or desirable, in scientific journal articles. This enables the user to assess the validity and accuracy of the measurement processes employed, to judge the statistical analysis, and to learn details of techniques and methods utilized for work entailing the greatest care and accuracy. These papers also should provide sufficient additional information not found on the certificate so that new applications in diverse fields not foreseen at the time the SRM was originally issued will be sought and found.

Inquiries concerning the technical content of this paper should be directed to the author(s). Other questions concered with the availability, delivery, price, and so forth, will receive prompt attention from:

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Gaithersburg, MD 20899

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Office of Standard Reference Materials

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* Send order with remittance to Superintendent of Documents, US Government Printing Office Washington, DC 20402. Remittance from foreign countries should include an additional one-fourth of the purchase price for postage.

** May be ordered from: National Technical Information Services (NTIS). Springfield Virginia 22161.

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Abstract

This publication is a summary of the biological and botanical Standard Reference Materials and Research Materials issued by the National Bureau of Standards. The material, composition, certification, use, and remarks concerning each of the ten materials described are presented in tabular form. Copies of the Certificates of Analysis for these materials are contained in the appendix for more detailed information.

Key Words: Biological materials; botanical materials; chemical compositions; Research Material; Standard Reference Material.

Introduction

Since its inauguration in 1901, the National Bureau of Standards (NBS) has issued nearly 2000 different Standard Reference Materials (SRM's). Many of these have been renewed several times, many have been replaced or discontinued as technology changed. Today, over 900 SRM's are available, together with a large number of scientific publications related to the fundamental and applied characteristics of these materials. Each material is certified for chemical composition, chemical properties, or its physical or mechanical characteristics. Each SRM is provided with a Certificate or Certificate of Analysis that contains the essential data concerning its properties or characteristics. The SRM's currently available cover a wide range of chemical, physical, and mechanical properties, and a corresponding wide range of measurement interests in practically all aspects of fundamental and applied science. These SRM's constitute a unique and invaluable means of transferring to the user accurate data obtained at NBS, and provide essential tools that can be used to improve accuracy in practically all areas where measurements are performed.

In addition to SRM's, the National Bureau of Standards issues a variety of Research Materials (RM's) having various properties described in individual "Reports of Investigation." They are intended primarily to further the scientific or technical research on that particular material. Other materials, called Special Reference Materials (GM's), are also available from NBS. These are materials produced and certified by other Government agencies, standard organizations, or other nonprofit organizations, that are considered useful to the public and for which no alternate method of national distribution exists.

The various categories of materials available from NBS are given in Table 1. This table lists these materials according to their chemical composition, physical properties, or engineering characteristics. A more detailed alphabetic enumeration of these materials is given in Appendix I. Table 1 and Appendix I were taken from NBS Special Publication 260, NBS Standard Reference Materials Catalog, 1984-85 Edition[1]. This publication lists every material available from the NBS Office of Standard Reference Materials.

Further information on the reference materials available from NBS may be obtained from the Office of Standard Reference Materials, National Bureau of Standards, Gaithersburg, MD 20899. Information on other NBS services may be obtained from the Technical Information and Publications Division, National Bureau of Standards, Gaithersburg, MD 20899.

In addition to these types of materials, NBS provides many additional services. These include: Measurement Assurance Programs, Calibration and Related Measurement Services, Proficiency Sample Programs, a National Voluntary Laboratory Accreditation Program, Standards Information Services, Standard Reference Data, and Technical Information and Publications.

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[1]For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, under Stock No. 003-003-02558-5 (Price $5.50, add 25 percent for foreign orders.)

Table 1. Categories of Standard Reference Materials available from the National Bureau of Standards.

CERTIFIED CHEMICAL COMPOSITION STANDARDS

Steels (chip form)

- Plain carbon
- Low alloy
- High alloy
- Stainless
- Tool

Steels (granular form)

Steels (solid form)

- Ingot iron and low alloy
- Special ingot irons and low alloy
- Stainless
- Specialty
- High-temperature alloys
- Tool

Steelmaking Alloys

Cast Irons (chip form)

Cast Steels, White Cast Irons, Ductile Irons, and Blast Furnace Irons (solid form)

Nonferrous Alloys (chip form)

- Aluminum "Benchmarks"
- Cobalt
- Copper
- Copper "Benchmarks"
- Lead
- Magnesium
- Nickel
- Nickel Superalloy, Trace Elements
- Nickel oxide
- Selenium
- Tin
- Titanium
- Zinc
- Zirconium

Nonferrous Alloys (solid form)

- Aluminum "Benchmarks"
- Copper
- Copper "Benchmarks"
- Lead
- Nickel
- Titanium
- Zinc
- Zirconium

Gases in Metals

High-Purity Metals

Electron Probe Microanalytical Standards

Primary, Working, and Secondary Standard Chemicals

Microchemical Standards

Clinical Laboratory Standards

Biological Standards

Environmental Standards

- Analyzed gases
- Analyzed liquids and solids
- Permeation tubes

Industrial Hygiene Standards

Forensic Standards

Hydrocarbon Blends

Metallo-Organic Compounds

Fertilizers

Ores

Minerals, Refractories, Glasses, and Carbides

Cement

Trace Element Standards

Nuclear Materials

- Special nuclear materials
  - Plutonium assay
  - Plutonium isotopic
  - Uranium assay
  - Uranium isotopic
- Neutron density standards
- Fission track glass standards

Isotopic Reference Standards

Table 1. continued.

CERTIFIED PHYSICAL PROPERTY STANDARDS

Ion Activity Standards

- pH standards
- pD standards
- Ion selective electrodes

Mechanical and Metrology Standards

- Magnification
- Coating thickness
- Glass
- Elasticity
- Density
- Polymer
- Rheology

Heat Standards

- Superconductive thermometric fixed point devices
- Freezing Points
  - Defining fixed points
  - Determined reference points
- Melting points
- Calorimetric
  - Combustion
  - Solution
  - Heat source
  - Enthalpy and heat capacity
- Vapor pressure
- Thermal expansion
- Thermocouple materials
- Thermal resistance

Magnetic Standards

- Magnetic susceptibility
- Magnetic moment
- Paramagnetic resonance

Optical Standards

- Spectrophotometric
- Thermal emittance
- Refractive index

Radioactivity Standards

- Alpha-particle standards
- Beta-particle and gamma-ray gas standards
- Alpha-particle, beta-particle, gamma-ray, and electron-capture solution standards
- Contemporary standard for carbon-14 dating laboratories
- Environmental standards
- Low energy photon sources
- Gamma-ray "point-source" standards
- Radium gamma-ray solution standards
- Radium solution standards for random analysis
- Radioactivity standard reference materials currently not in stock

Metallurgical

Mössbauer

X-ray Diffraction

Gas Transmission

Permittivity

Reference Fuels

Resistivity

ENGINEERING TYPE STANDARDS

Standard Rubber and Rubber-Compounding Materials

Reference Magnetic Tapes

Centerline Drawings, OCR-B

Sizing Standards

- Glass spheres for particle size
- Turbidimetric and fineness (cement)

X-ray and Photographic Standards

Surface Flammability Standards

Smoke Density Chamber Standards

Water Vapor Permeance

Tape Adhesion Testing Standards

Color Standards

RESEARCH MATERIALS

SPECIAL REFERENCE MATERIALS

Biological and Botanical Standards

The first NBS biological and botanical Standard Reference Material designed specifically for the analytical laboratory use was issued in January 1971. This standard, SRM 1571, Orchard Leaves, was developed in response to requests from numerous analytical chemists.

Since then, the number of biological and botanical SRM's has grown to 10, and during the next decade this growth is expected to continue at much the same rate.

This publication is an attempt to describe in general terms the composition, certification, and use of these biological and botanical SRM's.

Table 2 contains the essential information concerning the material, composition, the certification parameters, and use. Under "Remarks," additional data such as storage conditions and stability is provided.[1] All the data and information contained in this table were extracted from the Certificates of Analysis issued for the SRM's included in the table. An examination of this table gives the reader a general view of these SRM's. For more detailed information, the individual certificates reproduced in Appendix II should be consulted as well as the references cited in each certificate.

A summary of the quantitative distribution of the 47 chemical elements determined in the 9 Standard Reference Materials and 1 Research Material from Table 2 is presented in Table 3. The values with an asterisk are expressed in wt. %, the others are expressed in μg/g, and the data in parantheses are non-certified values.

The certificates in Appendix II are arranged in numerical order. The SRM's listed in the table include all of the biological and botanical standards that were issued or were in preparation by the end of 1984. These SRM's are the result of the concerted efforts of a number of scientists from the NBS National Measurement Laboratory as well as those from cooperating institutions. Each certificate lists the individuals who contributed to the certification of the SRM.

In addition to the SRM's and their certificates, NBS issues a series of Special Publications (SP), called the "260 Series," that relate directly to Standard Reference Materials as stated in the Preface. The list of available publications in the "260 Series" is given in the beginning of this publication.[2]

Other NBS publications, not in the "260 Series," and a number of NBS staff authored papers have been published that deal with specific SRM's or measurement techniques. Some of these are: SP 148, The Role of Standard Reference Materials in Measurement Systems; SP 378, Accuracy in Spectrophotometry and Luminescence Measurements (255 pp., 1973); and SP 466, Standardization in Spectrophotometry and Luminescence Measurments (150 pp., 1977), contains papers of interest to analytical chemists. Another publication that should be of particulate interest to the users of the SRM's described in Table 2 is SP 492, "Procedures Used at the National Bureau of Standards to Determine Selected Trace Elements in Biological and Botanical Materials."

This work consists of a collection of analytical procedures used in the Center for Analytical Chemistry, National Measurement Laboratory of the National Bureau of Standards for the determination of trace levels of Ag, Al, As, Be, Bi, Ca, Cd, Cr, Cu, Fe, Hg, K, Mg, Mn, Mo, Na, Ni, Pb, Pt, Sb, Se, Te, Tl, V, and Zn in biological and botanical materials. These procedures were critically selected or adapted, and often specially developed, by the scientific staff members of the Center for Analytical Chemistry to provide measurements with the best obtainable accuracy. They were considered to be most appropriate for the analysis and certification of various Standard Reference Materials issued by NBS such as SRM 1577a, Bovine Liver, SRM 1567, Wheat Flour, etc.

The description of these procedures is given with sufficient detail to permit the analyst to use them as a protocol for routine analyses in the laboratory.

They are assembled according to the analytical disciplines involved in the measuring process: sample preparation, neutron activiation analysis, spark source mass spectrometric isotope dilution, atomic absorption and flame emission spectrometry, molecular absorption spectrometry, fluorescence spectrometry, and polarography.

Special Publication 492 contains also a detailed description of the methods and instrumentation used to produce high-purity reagents, including the analytical techniques used to test their purity.

The important subject of blanks, a determining factor common to all analytical measurements, is examined including a detailed description of the environmental conditions necessary to control this essential factor, and to insure a maximum protection against contamination.

The lyophilization method for preconcentration and drying of various analytical samples is also discussed in this work.

The analytical procedures assembled in these publications are believed to provide the best measuring capabilities available at this time. They are, however, continuously being revised, improved, or replaced by more accurate ones.

Hence, it is recommended that the analyst who desires to be informed of these advancements maintain a contact with the scientific staff of the Center for Analytical Chemistry at NBS.

Another work, NBS Special Publication 422, "Accuracy in Trace Analysis: Sampling, Sample Handling, Analysis," Vol. I and II, P. D. LaFleur, Editor, issued in 1976 as a proceeding of the 7th Materials Research Symposium held at NBS in 1974, contains valuable information on the subject, to the analytical chemist.

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[1] NOTE: The use of proprietary designations in Table 2 is for information only, and should not be construed as an endorsement of the product by either the Department of Commerce or the National Bureau of Standards.

[2] For complete bibliographic reference and ordering information, see "Other NBS Publications in This Series," pp. iv.

Table 2. Summary of the Biological and Botanical Standards

SRM	Material	Composition
RM50 Albacore Tuna	Tuna fish muscle tissue from albacore tuna caught in the San Diego, California area. It was frozen, ground, mixed, lyophilized, ground again, placed in polyethylene bags, and canned under nitrogen. To improve homogeneity the material was reground, re-blended and recanned.	Minor elements: K 1.22%, Na 0.11%. Trace elements (ppm): Hg 0.95; Se 3.6; Zn 13.6; As 3.3; Pb 0.46; Mn 1.3. Organic constituents (ppm): heptadiene 0.6; toluene 0.7; limonene 0.4; 2-nonanone 0.7; 2-undecanone 0.1; 2,6-di-t-butyl-p-cresol 1.0; hexadecane, trace; heptadecane, trace; pristane, 0.03.
1549 Non-Fat Milk Powder	This material was obtained from a commercial source as a portion of a single lot. The moisture content of the material was reduced to a low level by the spray process.	Certified constituents: (wt. %) Ca 1.30; Cl 1.09; Mg 0.120; P 1.06; K 1.69; Na 0.497; S .351; (μg/g) Cd .0005; Cr .0026; Cu .7; Fe 1.78; I 3.38; Pb 0.019; Mn .26; Hg .0003; Se .11; Zn 46.1. Non-certified values given for 11 elements; also for lactose and ascorbic acid.
1566 Oyster Tissue	The oysters were obtained by the FDA Bureau of Shellfish Sanitation from a commercial source, frozen in sealed plastic bags. The material was ground, freeze-dried and powdered at the U.S. Army Natick Research & Development Command, Mass., blended and bottled at NBS and freeze-dried again.	Certified minor constituents: Ca 0.15%; Mg 0.128%; K 0.969%; Na 0.51%. Trace constituents (μg/g): As 13.4; Cd 3.5; Cr 0.69; Cu 63.0; Fe 195; Pb 0.48; Mn 17.5; Hg 0.057; Ni 1.03; Rb 4.45; Se 2.1; Ag 0.89; Sr 10.36; U 0.116; V 2.3; Zn 852. Non-certified information: Cl (1.0%); S (0.76%); P (0.81%); (μg/g) Br (55); Co (0.4); F (5.2); I (2.8); Mo (≤0.2); Tl (≤0.005); Th (0.1). Homogeneity was determined by neutron activation and atomic absorption spectrometry on Na, Cl, V, Mn, Mg, K, Cu, Zn, Cd. Calcium exhibits some inhomogeneity.

Certification	Use	Remarks
RM 50 is not an SRM, hence, none of the data presented are certified. For further information see the Report of Investigation describing this Research Material.	RM 50 is intended to be used in the measurement of inorganic and organic chemical species in marine tissue at trace concentrations. It should be useful to scientists interested in evaluating analytical methods and interlaboratory comparisons.	RM 50, sealed in metal cans, should have an indefinite storage life under normal room conditions. The open sample can be kept for 6 months to 2 years in a polyethylene bag at 0 °C.
The analytical methods used in the certification were: atomic absorption spectrometry; atomic emission spectrometry; ion chromatography, isotope dilution mass spectrometry, neutron activation, and photon activation. All measurements are based on a minimum 500 mg of the dried material.	SRM 1549 is intended for use in calibrating instrumentation and evaluating the reliability of analytical methods for the determination of constituents in milk, milk powders, and other biological matrices.	The material should be kept in its original bottle and stored at temperatures between 10-30 °C. It should not be exposed to intense sources of radiation. The bottle should be kept tightly closed and stored in a desiccator in the dark. This certification is invalid after 3 years from date of shipping.
The analytical methods used in the certification were: atomic absorption, flame and spark emission spectrometry, inductively coupled plasma, thermal ionization and isotope dilution, isotope dilution mass spectrometry, spark source mass spectrometry; neutron activation, and polarography. All measurements are based on a minimum 250 mg of the dried material.	SRM 1566 is intended for calibrating instrumentation and validating methodology for the chemical analysis of marine animal tissue for minor and trace elements.	The material should be kept in its original bottle, stored at 10-30 °C in a dark desiccator. Under these conditions it should be stable for 5 years from date of shipping.

Table 2. Biological and Botanical Standards.

SRM	Material	Composition
1567 Wheat Flour	Wheat flour was milled from a blend of Hard Red Spring and Hard Red Winter wheat grown in South Dakota and subjected to 2.5 megarads of Co-60 radiation for microbiological control at Neutron Products, Inc., Dickerson, Md. The material was passed through a sieve with openings of 425 μm and blended.	Certified minor constituents: K 0.136%; Ca 0.019%. Trace constituents (μg/g): Fe 18.3; Zn 10.6; Mn 8.5; Na 8.0; Cu 2.0; Se 1.1; Cd 0.032; Hg 0.001. Non-certified information (μg/g): Br (9); Rb (1); Mo (0.4); Ni (0.18); As (0.006); Te ($\leq$0.002). Homogeneity was determined by instrument neutron activation measurements on Mn, K, Zn, Na, and Br.
1568 Rice Flour	Rice flour was prepared from 100% long grain from Arkansas and subjected to 2.5 megarads of Co-60 radiation for microbiological control at Neutron Products, Inc., Dickerson, Md. The material was passed through a sieve with openings of 425 μm and blended.	Certified minor constituents: K 0.112%; Ca 0.014%. Trace constituents (μg/g): Mn 20.1; Zn 19.4; Fe 8.7; Na 6.0; Cu 2.2; As 0.41; Se 0.4; Cd 0.029; Co 0.02; Hg 0.0060. Non-certified information (μg/g): Rb (7); Mo (1.6); Br (1); Ni (0.16); Te ($\leq$0.002) Homogeneity was determined by instrumental neutron activation measurements on Mn, K, Zn, Na, and Br.
1569 Brewers Yeast	Yeast was obtained from the Nutrition Institute, U.S. Dept. of Agriculture, Beltsville, Md. It was sieved (0.15 mm) and blended.	Cr, 2.12 ± 0.05 μg/g determined on the sample without drying and calculated on a dry weight basis. Homogeneity was determined by a neutron activation technique.
1572 Citrus Leaves	The plant material was collected from the Lake Alfred area of central Florida and prepared at Michigan State University. It was air-dried, ground to pass a 425 μm sieve, dried at 85 °C and mixed. It was sterilized with Co-60 radiation at the U.S. Army Research & Development Command, Natick, Mass.	Certified major and minor constituents (wt. % on dry weight basis): Ca 3.15; Mg 0.58; P 0.13; K 1.82; S 0.407. Trace constituents (μg/g): Al 92; As 3.1; Ba 21; Cd 0.03; Cr 0.8; Cu 16.5; I 1.84; Fe 90; Pb 13.3; Mn 23; Hg 0.08; Mo 0.17; Ni 0.6; Rb 4.84; Na 160; Sr 100, Zn 29. Non-certified values (μg/g): Sb (0.04); Br (8.2); Ce (0.28); Cs (0.098); Cl (414); Co (0.02) Eu (0.01); La (0.19); Sm (0.052); Sc (0.01); Se (0.025); Te (0.02) Tl ($\leq$0.01); Sn (0.24); U ($\leq$0.15); N (2.86 wt. %).

Certification	Use	Remarks
The analytical methods used in the certification were: atomic absorption, flame emission, and isotope dilution spark source mass spectrometry, neutron activation, and polarography. All measurements are based on a minimum 400 mg sample and are reported on a "dry-weight" basis. Selenium and mercury are determined on the material without drying.	SRM 1567 is intended for calibrating instrumentation and evaluating the reliability of analytical methods for the determination of minor and trace elements in wheat flour and similar food products.	The material should be kept in its original bottle, stored at 10-30 °C in a dark desiccator. Under these conditions it should be stable for 5 years from date of shipping.
Same as SRM 1567.	Same as SRM 1567.	Same as SRM 1567.
Chromium was determined by neutron activation and by isotope dilution mass spectromtry. The analyses were performed on the sample without drying and the results expressed on a dry weight basis established on separate samples heated at 85 °C for 3 hrs. The samples should not be dissolved in open vessels.	SRM 1569 is intended for use in calibrating instrumentation and evaluating the accuracy of analytical methods for the determination of chromium in Brewers Yeast and other biological materials containing a volatile chromium component which presents an especially difficult problem.	The material should be kept in its original bottle tightly capped, and stored at 10-23 °C in a dark desiccator.
The analytical methods used in the certification were: atomic absorption and flame emission spectrometry, atomic emission spectrometry using inductively coupled plasma, ion chromatography, isotope dilution thermal source mass spectrometry, isotope dilution spark source mass spectrometry, Kjeldahl method for nitrogen, neutron activation, photon activation, polarography, spectrophotometry.	SRM 1572 is intended for use in calibrating instrumentation and evaluating the analytical methods used for the determination of major, minor, and trace elements in botanical materials, agricultural food products, and similar matrices.	The material should be kept tightly closed in its original bottle, stored in a dark desiccator at a temperature between 10-30 °C. A minimum sample of 500 mg of the dried material should be used for analyses.

Table 2. Biological and Botanical Standards.

SRM	Material	Composition
1573 Tomato Leaves	The leaves were obtained from a field of direct seeded tomatoes at the Horticultural Research Center of the Michigan State University. The air-dried leaves were ground, dried at 85 °C, mixed, packaged in polyethylene-lined drums, and sterilized with Co-60 radiation at the U.S. Army Research & Development Command, Natick, Mass.	Certified major and minor constituents (wt. %): K 4.46; Ca 3.00; P 0.34. Trace constituents (μg/g): Fe 690; Mn 238; Zn 62; Sr 44.9; Rb 16.5; Cu 11; Pb 6.3; Cr 4.5; As 0.27; Th 0.17; U 0.061. Non-certified information, major and minor constituents (wt. %): N (5.0); Mg (0.7); Al (0.12). Trace constituents (μg/g): B (30); Br (26); Cd (3); Ce (1.6); La (0.9); Co (0.6); Sc (0.13); Hg (0.1); Tl (0.05); Eu (0.04) Homogeneity was evaluated by determining P, Fe, Mn, Zn, Rb, Cu, Cr, As, and U.
1575 Pine Needles	Collected from the Manistee State Park, Mich., Air-dried, ground, and dried again at 85 °C. It was mixed, passed through a 0.25 mm sieve, packaged in polyethylene drums, and sterilized with Co-60 radiation at the U.S. Army Research & Development Command, Natick, Mass.	Certified minor elements: Ca 0.41%; K 0.37%; P 0.12%. Trace constituents (μg/g): Mn 675; Al 545; Fe 200; Rb 11.7; Pb 10.8; Sr 4.8; Cu 3.0; Cr 2.6; As 0.21; Hg 0.15; Th 0.037; U 0.020. Non-certified information: N (1.2%); and Br (9); Ni (3.5) Ce (0.4); Cd (<0.5); Sb (0.2); La (0.2); Co (0.1); Tl (0.05); Sc (0.03); Eu (0.006) μg/g. Homogeneity was established by determining P, Al, Fe, Mn, Rb, Cu, Cr, As, Hg, U, K, Ca, Sr, Pb, and Th.
1577a Bovine Liver	The liver was obtained in the Portland, Oregon area. It was ground, mixed, and lyophilized in polyethylene trays by Oregon Freeze Dry Food Inc., Albany, Oregon. The material was then powdered and packaged in moisture-proof bags.	Certified elements (wt. %): Cl 0.28; P 1.11; K 0.996; Na 0.243; S 0.78. Trace elements (μg/g): As 0.047; Cd 0.44; Ca 120; Co 0.21; Cu 158; Fe 194; Pb 0.135; Mg 600; Mn 9.9; Hg 0.004; Mo 3.5; Rb 12.5; Se 0.71; Ag 0.04; Sr 0.138; U 0.00071; V 0.099; Zn 123. Non-certified information: N (10.7 wt. %); and (μg/g); Al (2); Sb (0.003), Br (9); Tl (0.003). Homogeneity was tested by analyzing randomly selected samples and found to be satisfactory.

Certification	Use	Remarks
The analytical methods used in the certification were: atomic absorption and optical emission spectroscopy, isotope dilution and spark source mass spectrometry, Kjeldahl, neutron activation, nuclear track technique, spectrophotometry, polarography. A minimum of 500 mg of the dried material should be used for the analysis.	SRM 1573 is intended for calibrating instrumentation and validation of analytical methods for the determination of major, minor, and trace elements in botanical materials and other agricultural products.	The material should be kept in the original bottle stored at 10-30 °C in a dark desiccator. Under these conditions SRM 1573 should be stable for 5 years after shipping date.
The analytical methods used in the certification were: atomic absorption spectroscopy, isotope dilution mass spectrometry, isotope dilution spark source mass spectrometry, Kjeldahl method, neutron activiation, nuclear track technique, optical emission spectroscopy, spectrophotometry, polarography. A minimum of 500 mg of the dried material should be used for the analysis.	Same as SRM 1573.	Same as SRM 1573.
The analytical methods used in the certification were: atomic absorption and flame emission spectrometry, ion chromatogrphy, inductively coupled plasma emission spectrometry, isotope dilution thermal and spark source mass spectrometry, Kjeldahl method for nitrogen, neutron activation, polarography, and spectrophotometry. A minimum of 250 mg of the dried material should be used for the analysis.	SRM 1577a is intended for calibration of instrumentation and validation of methods in the chemical analysis of animal tissue for major, minor, and trace elements.	Same as SRM 1573.

Table 3. Summary of the Analytical Data Obtained for the Biological and Botanical Standard Reference Materials and Research Material.

SRM	1549 Non-Fat Milk Powder	1566 Oyster Tissue	1567 Wheat Flour	1568 Rice Flour	1569 Brewers Yeast	1572 Citrus Leaves	1573 Tomato Leaves	1575 Pine Needles	1577a Bovine Liver	RM 50† Albacore Tuna
Element										
Ag	(<0.0003)	0.89	----	----	----	----	----	----	0.04	----
Al	(2)	----	----	----	----	92	(0.12)*	545	(2)	----
As	(0.0019)	13.4	(0.006)	0.41	----	3.1	0.27	0.21	0.047	(3.3)
B	----	----	----	----	----	----	(30)	----	----	----
Ba	----	----	----	----	----	21	----	----	----	----
Br	(12)	(55)	(9)	(1)	----	(8.2)	(26)	(9)	(9)	----
Ca	1.30*	0.15*	0.019*	0.014*	----	3.15*	3.00*	0.41*	120	----
Cd	0.0005	3.5	0.032	0.029	----	0.03	(3)	(<0.5)	0.44	----
Ce	----	----	----	----	----	(0.28)	(1.6)	(0.4)	----	----
Cl	1.09*	(1.0)*	----	----	----	(414)	----	----	0.28*	----
Co	(0.0041)	(0.4)	----	0.02	----	(0.02)	(0.6)	(0.1)	0.21	----
Cr	0.0026	0.69	----	----	2.12	0.8	4.5	2.6	----	----
Cs	----	----	----	----	----	(0.098)	----	----	----	----
Cu	0.7	63.0	2.0	2.2	----	16.5	11	3.0	158	----
Eu	----	----	----	----	----	(0.01)	(0.04)	(0.006)	----	----
F	(0.20)	(5.2)	----	----	----	----	----	----	----	----
Fe	1.78	195	18.3	8.7	----	90	690	200	194	----
Hg	0.0003	0.057	0.001	0.0060	----	0.08	(0.1)	0.15	0.004	(0.95)
I	3.38	(2.8)	----	----	----	1.84	----	----	----	----
K	1.69*	0.969*	0.136*	0.112*	----	1.82*	4.46*	0.37*	0.996	(1.22)*
La	----	----	----	----	----	(0.19)	(0.9)	(0.2)	----	----
Mg	0.120*	0.128*	----	----	----	0.58*	(0.7)*	----	600	----
Mn	0.26	17.5	8.5	20.1	----	23	238	675	9.9	(1.3)
Mo	(0.34)	(≤0.2)	(0.4)	(1.6)	----	0.17	----	----	3.5	----
N	----	----	----	----	----	(2.86)*	(5.0)*	(1.2)*	(10.7)*	----

SRM	1549	1566	1567	1568	1569	1572	1573	1575	1577a	RM 50†
	Non-Fat Milk Powder	Oyster Tissue	Wheat Flour	Rice Flour	Brewers Yeast	Citrus Leaves	Tomato Leaves	Pine Needles	Bovine Liver	Albacore Tuna
Element										
Na	0.497*	0.51*	8.0	6.0	----	160	----	----	0.243*	(0.11)*
Ni	----	1.03	(0.18)	(0.16)	----	0.6	----	(3.5)	----	----
P	1.06	(0.81)*	----	----	----	0.13*	0.34*	0.12*	1.11*	----
Pb	0.019	0.48	0.020	0.045	----	13.3	6.3	10.8	0.135	(0.46)
Rb	(11)	4.45	(1)	(7)	----	4.84	16.5	11.7	12.5	----
S	0.351*	(0.76)*	----	----	----	0.407*	----	----	0.78*	----
Sb	(0.00027)	----	----	----	----	(0.04)	----	(0.2)	(0.003)	----
Sc	----	----	----	----	----	(0.01)	(0.13)	(0.03)	----	----
Se	0.11	2.1	1.1	0.4	----	(0.025)	----	----	0.71	(3.6)
Si	(<50)	----	----	----	----	----	----	----	----	----
Sm	----	----	----	----	----	(0.052)	----	----	----	----
Sn	(<0.5)	----	----	----	----	(0.24)	----	----	----	----
Sr	----	10.36	----	----	----	100	44.9	4.8	0.138	----
Te	----	----	(≤0.002)	(≤0.002)	----	(0.02)	----	----	----	----
Th	----	(0.1)	----	----	----	----	0.17	0.037	----	----
Tl	----	(≤0.005)	----	----	----	(≤0.01)	(0.05)	(0.05)	(0.003)	----
U	----	0.116	----	----	----	(≤0.15)	0.061	0.020	0.00071	----
V	----	2.3	----	----	----	----	----	----	0.099	----
Zn	46.1	852	10.6	19.4	----	29	62	----	123	(13.6)

REMARKS

*The certified data with an asterisk are expressed in wt. %; those in parentheses are non-certified values. The remaining certified data are expressed in μg/g.

†This is not an SRM, hence the values given for this Research Material are not certified. Several organic compounds are also identified.

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Nitric Oxide in Nitrogen	1684b
Nitric Oxide in Nitrogen	1685b
Nitric Oxide in Nitrogen	1686b
Nitric Oxide in Nitrogen	1687b
Nitric Oxide in Nitrogen (Mobile Source Emission Gas Standard)	2627
Nitric Oxide in Nitrogen (Mobile Source Emission Gas Standard)	2628
Nitric Oxide in Nitrogen (Mobile Source Emission Gas Standard)	2629
Nitric Oxide in Nitrogen (Mobile Source Emission Gas Standard)	2630
Nitric Oxide in Nitrogen (Mobile Source Emission Gas Standard)	2631
Nitrogen Dioxide in Air (Stationary Source Emission Gas Standard)	2653
Nitrogen Dioxide in Air (Stationary Source Emission Gas Standard)	2654
Nitrogen Dioxide in Air (Stationary Source Emission Gas Standard)	2655
Nitrogen Dioxide in Air (Stationary Source Emission Gas Standard)	2656
Nitrogen Dioxide Permeation Device	1629a
4-Nitrophenol	938

Name	SRM
Nodular Cast Iron	342a
Nominal One Micrometer Polystyrene Spheres	1690
Non-Fat Powdered Milk	1549
Nonmagnetic Coating on Magnetic Substrate (Copper and Chromium on Steel)	1359
Nonmagnetic Coating on Magnetic Substrate (Copper and Chromium on Steel)	1360
Nonmagnetic Coating on Magnetic Substrate (Copper and Chromium on Steel)	1361b
Nonmagnetic Coating on Magnetic Substrate (Copper and Chromium on Steel)	1362a
Nonmagnetic Coating on Magnetic Substrate (Copper and Chromium on Steel)	1363a
Nonmagnetic Coating on Magnetic Substrate (Copper and Chromium on Steel)	1364a
NPL GM Alpha Alumina	8005
NPL GM Alpha Alumina	8006
NPL GM Alpha Alumina	8007
NPL GM Alpha Alumina	8008
NPL GM Graphitized Carbon Black	8001
NPL GM Graphitized Carbon Black	8002
NPL GM Melting Point Set	8000
NPL GM Non-porous Silica	8003
NPL GM Non-porous Silica	8004
N-tertiary-Butyl-2-benzothiazolesulfen-amide Rubber Compound	384d
Obsidian Rock	278
Octaphenylcyclotetrasiloxane	1066a
Oil Furnace Black Rubber Compound	378b
Opal Glass Powder	91
Optical Emission and X-ray Spectroscopic Analysis	1102
Optical Microscope Linewidth Measurement Standard	474
Optical Microscope Linewidth Measurement Standard	475
Optical Microscope Linewidth Measurement Standard	476
Organics in Shale Oil	1580
Oxalic Acid	4990C
Oxygen in Ferrous Materials Ingot Iron	1090
Oxygen in Ferrous Materials (Stainless Steel AISI 431)	1091
Oxygen in Ferrous Materials Vacuum Melted Steel	1092
Oxygen in Maraging Steel	1094
Oxygen in Nitrogen (Gas Standard)	2657
Oxygen in Nitrogen (Gas Standard)	2658
Oxygen in Nitrogen (Gas Standard)	2659
Oxygen in Titanium-Base Materials	355
Oxygen in Valve Steel	1093
Oyster Tissue	1566
Palladium, Magnetic Gram Susceptibility	765
Penetrant Test Block	1850
Peruvian Soil, Environmental Radioactivity	4355
Petroleum Crude Oil	1582
Phosphate Rock (Florida)	120b
Phosphor Bronze (CDA 521)	871
Phosphor Bronze (CDA 544)	872
Phosphorized Copper, Cu VIII	C1251
Phosphorized Copper, Cu IX	C1252
Phosphorized Copper, Cu X	C1253
Phosphorus-32 Radioactivity Standard	44061 G
Photographic Step Tablet	1008
Pine Needles	1575
Plastic Clay	98a
Platinum, Magnetic Gram Susceptibility	764
Plutonium-238 Alpha-Particle Standard	4906B
Plutonium-240 Alpha-Particle Emission-Rate Solution Standard	4338
Plutonium-239 Alpha-Particle Solution Standard	4331
Plutonium-242 Alpha-Particle Solution Standard	4334B
Plutonium Isotopic Standard	946
Plutonium Isotopic Standard	947
Plutonium Isotopic Standard	948
Plutonium Metal	949f
Plutonium Metal (Standard Matrix Material)	945
Plutonium-244 Spike Assay and Isotopic Standard	996
Polychlorinated Biphenyls in Oil	1581
Polycrystalline Alumina Elasticity Standard	718
Polyester Plastic Film for Oxygen Gas Transmission	1470
Polyisobutylene Solution in Cetane	1490
Polystyrene	1478
Polystyrene	1479
Polystyrene (Broad Molecular Weight)	706
Polystyrene (Narrow Molecular Weight)	705
Polystyrene Spheres	1691
Portland Cement (Black)	1880

Name	SRM
Portland Cement (Blue)	635
Portland Cement (Clear)	639
Portland Cement (Gold)	634
Portland Cement (Green)	638
Portland Cement (Pink)	637
Portland Cement (Red)	633
Portland Cement (White)	1881
Portland Cement (Yellow)	636
Portland Cement Fineness Standard	114n
Potassium Chloride	2202
Potassium Chloride (Clinical Standard)	918
Potassium Chloride (Primary Chemical)	999
Potassium Chloride for Solution Calorimetry	1655
Potassium Dichromate	136d
Potassium Dihydrogen Phosphate	200
Potassium Dihydrogen Phosphate	186Ic
Potassium Dihydrogen Phosphate	2186I
Potassium Erucate	1076
Potassium Feldspar	607
Potassium Fluoride	2203
Potassium Hydrogen Phthalate	185e
Potassium Hydrogen Tartrate	188
Potassium Iodide with Attenuator	2033
Potassium Nitrate	193
Potassium Tetroxalate	189
Powdered Lead Based Paint	1579
Priority Pollutant Polynuclear Aromatic Hydrocarbons (in Acetonitrile)	1647
Propane in Air	1665b
Propane in Air	1666b
Propane in Air	1667b
Propane in Air	1668b
Propane in Air	1669b
Propane in Nitrogen (Mobile Source Emission Gas Standard)	2643
Propane in Nitrogen (Mobile Source Emission Gas Standard)	2644
Propane in Nitrogen (Mobile Source Emission Gas Standard)	2645
Propane in Nitrogen (Mobile Source Emission Gas Standard)	2646
Propane in Nitrogen (Mobile Source Emission Gas Standard)	2647
Propane in Nitrogen (Mobile Source Emission Gas Standard)	2648
Propane in Nitrogen (Mobile Source Emission Gas Standard)	2649
Propane in Nitrogen (Mobile Source Emission Gas Standard)	2650
Propane in Nitrogen and Oxygen (Mobile Source Emission Gas Standard)	2651
Propane in Nitrogen and Oxygen (Mobile Source Emission Gas Standard)	2652
Quartz Cuvette for Spectrophotometry	932
Quartz for Hydrofluoric Acid Solution Calorimetry	1654

Name	SRM
Quartz on Filter Media	2679a
Quinine Sulfate Dihydrate	936
Radiogenic Lead Isotopic Standard	983
Radium-226 Gamma-ray Standard	4956
Radium-226 Gamma-ray Standard	4957
Radium-226 Gamma-ray Standard	4958
Radium-226 Gamma-ray Standard	4959
Radium-226 Gamma-ray Standard	4960
Radium-226 Gamma-ray Standard	4961
Radium-226 Gamma-ray Standard	4962
Radium-226 Gamma-ray Standard	4963
Radium-226 Gamma-ray Standard	4964B
Radium Standard (Blank Solution)	4952B
Radon-226 for Radon Analysis	4953C
Red Brass	1109
Red Brass	C1109
Red Brass	1110
Red Brass	C1110
Red Brass	1111
Red Brass	C1111
Reduced Iron Oxide	691
Reference Fuel Isooctane	1816a
Reference Fuel n-Heptane	1815a
Reflection Step Tablet	2061
Refractive Index Glass	1820
Refractive Index Silicone Liquids	1823
Refractive Index, Soda-Lime Glass	1822
Relative Stress-Optical Coefficient Glass	708
Resulfurized-Rephosphorized Steel	C1221
Rice Flour	1568
River Sediment	1645
River Sediment, Environmental Radioactivity	4350B
Rocky Flats Soil Number 1, Environmental Radioactivity	4353
Rubidium Melting Point	1969
Rutile Ore	670
Scanning Electron Microscope Magnification Standard	484e
Scanning Electron Microscope Performance Standard	2069
Secondary Standard Flexible Disk Cartridge (Computer Amplitude Reference)	3210
Secondary Standard Magnetic Tape	3200
Secondary Standard Magnetic Tape Cassette	1600
Secondary Standard Magnetic Tape Cartridge (Computer Amplitude Reference)	3216
Second Surface Aluminum Mirror for Specular Reflectance	2023

Name	SRM
Second Surface Aluminum Mirror for Specular Reflectance	2024
Second Surface Aluminum Mirror with Wedge for Specular Reflectance	2025
Selenium-Bearing Steel	1170b
Selenium-75 Radioactivity Standard	4409L-D
Sheet Brass	37E
Silica Brick	198
Silica Brick	199
Silicon-Aluminum Alloy	87a
Silicon Bronze	158A
Silicon Density Standard	1840
Silicon Density Standard	1841
Silicon Metal	57a
Silicon Powder, Spacing Standard for X-ray Diffraction	640a
Silicon Power Device Level Resistivity Standard	1522
Silicon Resistivity Standard for Eddy Current Testers	1523
Silver 2-Ethylhexanoate	1077a
Silver-Gold Thermocouple Wire	733
Silver, Vapor Pressure	748
Sintered and Arc-Cast Tungsten, Thermal Conductivity and Electrical Resistivity	1465
Sintered and Arc-Cast Tungsten, Thermal Conductivity and Electrical Resistivity	1466
Sintered and Arc-Cast Tungsten, Thermal Conductivity and Electrical Resistivity	1467
Sintered and Arc-Cast Tungsten, Thermal Conductivity and Electrical Resistivity	1468
Smoke Density Chamber Standard (Flaming Exposure Condition)	1007a
Smoke Density Chamber Standard (Non-flaming Exposure Condition)	1006b
Soda-Lime Container Glass	621
Soda-Lime Flat Glass	620
Soda-Lime Float Glass	1830
Soda-Lime Glass	1826
Soda-Lime Glass Powder	92

Name	SRM
Soda-Lime Sheet Glass	1831
Soda-Lime Silica Glass	622
Soda-Lime Silica Glass	710
Soda-Lime Silica Glass for Liquidus Temperature	773
Sodium Bicarbonate	191a
Sodium Bicarbonate	2191
Sodium Carbonate	192a
Sodium Carbonate	2192
Sodium Chloride	2201
Sodium Chloride (Clinical Standard)	919
Sodium Cyclohexanebutyrate	1069b
Sodium Oxalate Reductometric Standard	40h
Sodium Pyruvate	910
Sodium Tetraborate Decahydrate (Borax)	187b
Solder	127b
Solder	1131
Special Nuclear Container DOT 6M, 15 gal.	9940
Special Nuclear Container, 55 gal.	9941
Special Nuclear Container Type A, 10 gal.	9942
Special Nuclear Container, Type A, 55 gal.	9943
Special Nuclear Material Package	9910
Spectrographic Ingot Iron and Low-Alloy Steel Standard (Rod)	461
Spectrographic Ingot Iron and Low-Alloy Steel Standard (Rod)	462
Spectrographic Ingot Iron and Low-Alloy Steel Standard (Rod)	463
Spectrographic Ingot Iron and Low-Alloy Steel Standard (Rod)	464
Spectrographic Ingot Iron and Low-Alloy Steel Standard (Rod)	465
Spectrographic Ingot Iron and Low-Alloy Steel Standard (Rod)	466
Spectrographic Ingot Iron and Low-Alloy Steel Standard (Rod)	467
Spectrographic Ingot Iron and Low-Alloy Steel Standard (Rod)	468
Spectrograhic Ingot Iron and Low-Alloy Steel Standard	1166
Spectrographic Stainless Steel Standard	442
Spectrographic Stainless Steel Standard	443
Spectrographic Stainless Steel Standard	444
Spectrographic Stainless Steel Standard (Disc)	D849
Spectrographic Stainless Steel Standard (Disc)	D850
Spectrographic Stainless Steel Standard (Group II)	445

Name	SRM
Spectrographic Stainless Steel Standard (Group II)	446
Spectrographic Stainless Steel Standard (Group II)	447
Spectrographic Stainless Steel Standard (Group II)	448
Spectrographic Stainless Steel Standard (Group II)	449
Spectrographic Stainless Steel Standard (Group II)	450
Spectrographic Stainless Steel Standard (Rod)	849
Spectrographic Stainless Steel Standard (Rod)	850
Spectrographic Steel Standard (Disc)	D803a
Spectrographic Steel Standard (Disc)	D807a
Spectrographic Steel Standard (Rod)	803a
Spectrographic Steel Standard (Rod)	804a
Spectrographic Steel Standard (Rod)	805a
Spectrographic Steel Standard (Rod)	807a
Spectrographic Steel Standard (Rod)	808a
Spectrographic Steel Standard (Rod)	809a
Spectrographic Steel Standard (Rod)	817b
Spectrographic Steel Standard (Rod)	820a
Spectrographic Steel Standard (Rod)	821
Spectrographic Steel Standard (Rod)	827
Spectrographic Tool Steel Standard	436
Spectrographic Tool Steel Standard	437
Spectrographic Tool Steel Standard	438
Spectrographic Tool Steel Standard	439
Spectrographic Tool Steel Standard	440
Spectrographic Tool Steel Standard	441
Spectrographic Tool Steel Standard	837
Spectrographic Tool Steel Standard	840
Spectrographic Tool Steel Standard (Disc)	D837
Spectrographic Tool Steel Standard (Disc)	D840
Spectrographic Tool Steel Standard (Disc)	D841
Spectrographic Zinc-Base Die-Casting Alloy A	625
Spectrographic Zinc-Base Die-Casting Alloy B	626
Spectrographic Zinc-Base Die-Casting Alloy C	627
Spectrographic Zinc-Base Die-Casting Alloy D	628
Spectrographic Zinc-Base Die-Casting Alloy E	629
Spectrographic Zinc-Base Die-Casting Alloy F	630
Spectrographic Zinc Spelter Standard	631
Spectroscopic Titanium-Base Standard	641
Spectroscopic Titanium-Base Standard	642
Spectroscopic Titanium Base Standard	643

Name	SRM
Spectroscopic Titanium-Base Standard	644
Spectroscopic Titanium-Base Standard	645
Spectroscopic Titanium-Base Standard	646
Spheroidized Iron Carbide in Ferrite	493
Spreading Resistance Calibration (100) n-Type Silicon	2529
Spreading Resistance Calibration (100) p-Type Silicon	2528
Spreading Resistance Calibration (111) n-Type Silicon	2527
Spreading Resistance Calibration (111) p-Type Silicon	2526
Stabilized Wine	1590
Stainless Steel	121d
Stainless Steel	123c
Stainless Steel	160b
Stainless Steel (AISI 446)	367
Stainless Steel (AISI 446)	1267
Stainless Steel, 13% Chromium	73c
Stainless Steel, Cr-Ni	C1151
Stainless Steel, Cr-Ni	1151a
Stainless Steel, Cr-Ni	C1152
Stainless Steel, Cr-Ni	1152a
Stainless Steel, Cr-Ni	C1153
Stainless Steel, Cr-Ni	1153a
Stainless Steel, Cr-Ni	C1154
Stainless Steel, Cr-Ni	1154a
Stainless Steel, Cr-Ni-Mo	1155
Stainless Steel, Cr-Ni-Nb	1172
Stainless Steel, Cr-Ni-Ti	1171
Stainless Steel for Pitting or Crevice Corrosion	1890
Stainless Steel Thermal Expansion	738
Stearic Acid Rubber Compound	372h
Steel (AISI 1211)	368
Steel (Lead-Bearing)	1169b
Strontium Cyclohexanebutyrate	1070a
Strontium-85 Radioactivity Standard	4403L-B
Strontium-89 Radioactivity Standard	4945D
Styrene-butadiene Rubber (Type 1500)	386h
Succinonitrile Freezing Point	1970
Sucrose	17c
Sulfate and Nitrate on Filter Media	2673
Sulfur Dioxide in Nitrogen	1661a
Sulfur Dioxide in Nitrogen	1662a
Sulfur Dioxide in Nitrogen	1663a
Sulfur Dioxide in Nitrogen	1664a
Sulfur Dioxide in Nitrogen	1693
Sulfur Dioxide in Nitrogen	1694

Name	SRM
Sulfur Dioxide in Nitrogen	1696
Sulfur Dioxide Permeation Tube (2 cm tube)	1627
Sulfur Dioxide Permeation Tube (5 cm tube)	1626
Sulfur Dioxide Permeation Tube (10 cm tube)	1625
Sulfur in Coal	2682
Sulfur in Coal	2683
Sulfur in Coal	2684
Sulfur in Coal	2685
Sulfur in Residual Fuel Oil	1619
Sulfur in Residual Fuel Oil	1620a
Sulfur in Residual Fuel Oil	1621b
Sulfur in Residual Fuel Oil	1622b
Sulfur in Residual Fuel Oil	1623a
Sulfur in Residual Fuel Oil	1624a
Sulfur Rubber Compound	371g
Superconductive Thermometric Fixed Point Device	767a
Superconductive Thermometric Fixed Point Device	768
Surface Flammability Standard	1002c
Synthetic Sapphire	720
Technetium-99 Radioactivity Standard	4288
Technetium-99m Radioactivity Standard	4410H-I
Tetrachloroethylene in Nitrogen	1808
Thallium-201 Radioactivity Standard	4404L-F
Thermal Resistance, Fibrous Glass Batt	1451
Thermal Resistance, Fibrous Glass Board	1450b
Thorium-228, Thallium-208 Gamma-ray Point-Source Standard	4206C
Tin-Base Bearing Metal	54D
Tin, Freezing Point	741
Tin-113-Indium-113m Radioactivity Standard	4402L-C
Tin-121m Point-Source Gamma-ray Emission-Rate Standard	4264B
Tin, Secondary Freezing Point Standard	42g
Titanium Alloy	654a
Titanium-Base Alloy	173b
Titanium-Base Alloy	176

Name	SRM
Titanium-Base Alloy (Unalloyed)	650
Titanium-Base Alloy (Unalloyed)	651
Titanium-Base Alloy (Unalloyed)	652
Titanium Dioxide	154b
Toluene	211c
Tomato Leaves	1573
Tool Steel (AISI M2)	132b
Tool Steel (AISI M2)	1157
Tool Steel Abrasive Wear Standard	1857
Tracealloy (Nickel-Base High-Temperature Alloy)	897
Tracealloy (Nickel-Base High-Temperature Alloy)	898
Tracealloy (Nickel-Base High-Temperature Alloy)	899
Trace Elements in a Glass Matrix	610
Trace Elements in a Glass Matrix	611
Trace Elements in a Glass Matrix	612
Trace Elements in a Glass Matrix	613
Trace Elements in a Glass Matrix	614
Trace Elements in a Glass Matrix	615
Trace Elements in a Glass Matrix	616
Trace Elements in a Glass Matrix	617
Trace Elements in Coal (Bituminous)	1632a
Trace Elements in Coal (Sub-bituminous	1635
Trace Elements in Coal Fly Ash	1633a
Trace Elements in Fuel Oil	1634a
Trace Elements in Water	1643a
Trace Mercury in Coal	1630
2,2,4-Trimethylpentane	217c
Tripalmitin	1595
Tris, Basimetric	723a
Tris, for Solution Calorimetry	724a
Tris(hydroxymethyl)aminomethane	922
Tris(hydroxymethyl)aminomethane hydrochloride	923
Tris(1-phenyl-1, 3-butanediono) Chromium (III)	1078b
Tris(1-phenyl-1, 3-butanediono) Iron (III)	1079b
Triphenyl Phosphate	1071b
Tungsten Carbide	276a
Tungsten-Chromium-Vanadium Steel	50c
Tungsten Concentrate	277
Tungsten, Heat Capacity	782
Tungsten-20% Molybdenum Alloy Electron Microprobe Standard	480
Tungsten Thermal Expansion	737
Unalloyed Copper	1034
Unalloyed Copper, Cu "O"	393
Unalloyed Copper, Cu IV	457
Unalloyed Copper, Cu XI	454
Unalloyed Copper, Cu I (Chip)	394
Unalloyed Copper, Cu II (Chip)	395
Unalloyed Copper, Cu III (Chip)	396
Unalloyed Copper, Cu V (Chip)	398
Unalloyed Copper, Cu VI (Chip)	399
Unalloyed Copper, Cu VII (Chip)	400
Unalloyed Copper, Cu I (Rod)	494

Name	SRM
Unalloyed Copper, Cu II (Rod)	495
Unalloyed Copper, Cu III (Rod)	496
Unalloyed Copper, Cu V (Rod)	498
Unalloyed Copper, Cu VI (Rod)	499
Unalloyed Copper, Cu VII (Rod)	500
Unalloyed Titanium	354
Uranium Isotopic Standard (Nominally depleted to 0.02%)	U-0002
Uranium Isotopic Standard	U-005a
Uranium Isotopic Standard (Nominally 1% Enriched)	U-010
Uranium Isotopic Standard (Nominally 1.5% Enriched)	U-015
Uranium Isotopic Standard	U-020
Uranium Isotopic Standard	U-030a
Uranium Isotopic Standard (Nominally 5% Enriched)	U-050
Uranium Isotopic Standard (Nominally 10% Enriched)	U-100
Uranium Isotopic Standard (Nominally 15% Enriched)	U-150
Uranium Isotopic Standard (Nominally 20% Enriched)	U-200
Uranium Isotopic Standard (Nominally 35% Enriched)	U-350
Uranium Isotopic Standard (Nominally 50% Enriched)	U-500
Uranium Isotopic Standard (Nominally 75% Enriched)	U-750
Uranium Isotopic Standard (Nominally 80% Enriched)	U-800
Uranium Isotopic Standard (Nominally 85% Enriched)	U-850
Uranium Isotopic Standard (Nominally 90% Enriched)	U-900
Uranium Isotopic Standard (Nominally 93% Enriched)	U-930
Uranium Isotopic Standard (Nominally 97% Enriched)	U-970
Uranium Metal	960
Uranium Oxide	950b
Uranium Oxide	969
Uranium-233 Spike Assay and Isotopic Solution Standard	995
Uranium-235 Spike Assay and Isotopic Solution Standard	993
Urban Dust/Organics	1649
Urban Particulate Matter	1648
Urea	912a
Urea	2141
Urea	2152
Uric Acid	913
Vanadium and Nickel in Residual Fuel Oil	1618
Vanadium in Curde Oil	8505
Vanadium-49 Low-Energy Photon Standard	4266
Waspaloy	349
Wear-Metals in Lubricating Oil (100 ppm)	1084

Name	SRM
Wear-Metals in Lubricating Oil (300 ppm)	1085
Wheat Flour	1567
White Cast Iron	338
White Cast Iron (Disc)	1145
White Cast Iron (Disc)	1146
White Cast Iron (Disc)	1150
White Ceramic Tile for Directional Hemispherical Reflectance	2019b
White Ceramic Tile for Directional Hemispherical Reflectance	2020
White Iron	3d
White Opan Glass Diffuse Spectral Reflectance Standard for the Visible Spectrum	2015
Xenon-127 Gaseous Radioactivity Standard	4309G
Xenon-133 Gaseous Radioactivity Standard	4307I
Xenon-133 Gaseous Radioactivity Standard	4415L-I
Xenon-133, Xenon-137, Krypton-85 Mixed Gaseous Radioactivity Standard	4310B
X-ray Film Step Tablet	1001
X-ray Powder Diffraction Intensity Standard	674
X-ray Powder Diffraction (Mica) Low 2 Theta	675
Ytterbium-169 Radioactivity Standard	4419L-B
Zinc-Base Alloy (Die Casting)	94c
Zinc Concentrates	113a
Zinc Concentrates	329
Zinc Cyclohexanebutyrate	1073b
Zinc, Freezing Point	740
Zinc, Freezing Point Standard	43h
Zinc Metal	683
Zinc Oxide Rubber Compound	370e
Zircaloy-2	360a
Zircaloy-4 Metal	1237
Zircaloy-4 Metal	1238
Zircaloy-4 Metal	1239
Zirconium-Barium Chromate Formulation for Heat-Source Powder Calorimetry	1651
Zirconium-Barium Chromate Formulation for Heat-Source Powder Calorimetry	1652
Zirconium-Barium Chromate Formulation for Heat-Source Powder Calorimetry	1653
Zirconium Metal	1234
Zirconium Metal	1235
Zirconium Metal	1236

U.S. Department of Commerce
Juanita M. Kreps
Secretary
National Bureau of Standards
Ernest Ambler, Acting Director

National Bureau of Standards
Report of Investigation
Research Material 50
Albacore Tuna

P. D. LaFleur and W. P. Reed

A lyophilized (freeze-dried) marine biological tissue sample has been prepared in an attempt to satisfy many of the analytical requirements for a base line marine reference material.

Tuna fish muscle tissue was chosen for this purpose because of availability, use as a fish foodstuff, and its oceanographic interest.

The tuna is available as a Research Material (RM), in sets of two cans. Each can contains approximately 35 grams of lyophilized tuna tissue in a polyethylene bag, inside the hermetically-sealed, nitrogen filled can.

Material Application

This particular RM is intended to be used in the measurement of elements present at trace concentrations. In addition, some measurements of trace hydrocarbons have been made. The material represents a typical marine tissue that has been lyophilized. It should prove useful to those scientists who may wish to evaluate analytical methods, or to use a generally available "real" sample matrix in interlaboratory comparisons. It is important to note, however, that this is not a Standard Reference Material and none of the data presented here are certified. For the convenience of the analyst using this material, we have included a discussion for each component reported. It is apparent that there is significant heterogeneity for some elements, specifically the "bone-seeking" elements. The homogeneity of other elements appears to be acceptable. In most instances the heterogeneity of the material is observed between samples from the same can. There is some evidence that this heterogeneity is due primarily to fine particles of cartilage or bone present with the tissue in this RM.

Material Preparation

The tuna tissue used in this research material is from albacore tuna caught in the San Diego area in July of 1971. The tuna was cleaned, filleted, frozen and transported to a lyophilization facility. It was thawed, ground, and mixed using stainless steel equipment. For the final mixing, the entire lot was held in a single stainless steel container. The tuna was then lyophilized in aluminum trays lined with polyethylene. After lyophilization, the material was again ground in a stainless-steel mill, carefully transferred to new, individual polyethylene bags, and canned under nitrogen for storage.

Preliminary studies performed on these canned samples raised serious problems about the homogeneity of the material. In an effort to improve this condition the material was reground, reblended and recanned under the same conditions, as before. Except where stated, all measurements provided in this report were made on the reprocessed material.. During the second regrinding, fibrous material tended to "float" to the top due to the action of the mixer. This material was discarded.

(over)

Material Use

The lyophilized tuna tissue, sealed in metal cans, should have an indefinite storage life under normal room conditions. Thus far, no evidence exists to indicate deterioration of the material with time as long as the can remains sealed. Once opened, the possibility exists that the raw material will turn rancid. Researchers using only a portion of the material have successfully stored the remainder by placing the polyethylene bag in a glass jar with lid and storing at or below 0°C. A shelf life of 6 months is not unusual under these circumstances and a 2 year stability has been reported. The freeze-dried material represents only about 30% of the original weight of the tuna tissue. Consequently, for direct comparisons with fresh tissue the researcher may wish to adjust the sample weight for this difference. Please note, however, that all values in this "Report of Investigation" are based on the lyophilized weight of the tuna tissue.

The dissolution of this material is not difficult and researchers have reported using a variety of techniques. These techniques include nitric and perchloric acid digestion, nitric-sulfuric-perchloric (4:1:1) acid digestion, low temperature ashing, and oxygen combustion. Because of the apparent presence of small bits of cartilage and/or bone in the sample, the sample size for analysis should be 250 mg or greater to obtain reproducible results. For "bone-seeking" elements (e.g., Pb, U, Ca, Sr) the sample may be nonhomogeneous even with much larger sample sizes.

For the elements listed below, sufficient analytical work has been performed to permit some evaluation of the data. These brief evaluations are not certified values, but only judgments as to the amount of the element present. Problems encountered by analysts making these measurements are also described.

Mercury

The question of the mercury content of various foodstuffs has been studied by many investigators It is hoped that this material will provide a base line RM for environmental studies of mercury in food. A value of 0.95 ± 0.1 ppm encompasses the means of all of the reported values for mercury with one exception and extensive studies have indicated good homogeneity for this element.

Agreement among methods appears to be good. The data show very little bias among the three methods used. Sample sizes for these measurements have been 0.25 grams and larger.

The question of volatile mercury was explored by one investigator who reported the mercury content decreasing after opening the container. This decrease amounted to approximately 0.1 ppm over a period of 3 weeks after opening even though stored at −25 °C. This work has not been confirmed. Further work by several investigators has suggested that 80-90% of the mercury content is present as methylmercury.

Selenium

This element was determined by four laboratories using both neutron activation analysis and atomic absorption spectroscopy. The range of reported values ($\bar{x}$) is from 3.27 to 4.01 ppm. A most probable value is 3.6 ± 0.4. There has been very little indication of heterogeneity for this element.

Zinc

The analysis for zinc was performed by three laboratories using two analytical methods, neutron activation analysis and atomic absorption analysis. The range of mean values ($\bar{x}$) is 11.4 to 14.6 ppm. Our estimate of the probable value is 13.6 ± 1 ppm. No random behavior has been noted in the analysis of this element.

Arsenic

The analysis for arsenic was performed by 4 laboratories using both neutron activation and atomic absorption techniques. Data obtained within each laboratory appears to be consistent, although there appears to be some disagreement among laboratories analyzing for this element. The range of average values ($\bar{x}$) between laboratories is 2.74 to 4.6 ppm. The recommended value for the arsenic content is 3.3 ± 0.4 ppm.

Lead

There is a limited amount of data available for lead. The average value is 0.46 ppm. The homogeneity of the material for this element is questionable and the range of individual values is quite large. The use of this Research Material as a control, or for the development of methods for lead cannot be recommended. The isotopic composition, however, has been determined and is: ^{208}Pb 52.2%; ^{207}Pb 21.5%; ^{206}Pb 24.9%; and ^{204}Pb 1.38%.

Other Elements

Manganese was found to be distributed homogeneously and the measured value in the original lot of tuna (not the reblended material) was 1.3 ppm. Sodium also was found to be homogeneous in the original lot of material and the reported value was 0.11%.

Potassium was found to be distributed homogeneously and the measured value on the original lot of tuna (not the reblended material) was 1.22%. The following elements have been found to be heterogeneously distributed in the tuna tissue: uranium, thorium, calcium, and strontium.

Organic Materials

The tuna research material was subjected to headspace sampling and analysis. The concentrations given in the following table are to be considered only as order-of-magnitude estimates of the hydrocarbon compounds present, as they were calculated relative to the amount of naphthalene added to the sample and most of the compounds identified were not aromatic hydrocarbons.

The value for the largest constituent, 2,6-di-t-butyl-p-cresol, is an especially poor estimate. However, this compound is interesting because it is a common antioxidant used in food packaging. It probably has its origins in one of the handling steps between tuna collection and packaging in plastic. An indication of petroleum pollution in the tuna sample comes from the aliphatic hydrocarbons present.

The identification of the monoterpene, limonene, is reasonably certain. As with pristane this compound is composed of isoprene units, but limonene is generally considered to be a product of plant biosynthesis. Its origin in this sample is uncertain, but it may arise from plant material ingested by tuna.

Identification and Approximate Quantitation of Major Isolated Organic Constituents

Compound Identification*	Amount Present (ppm)
Heptadiene (?)	0.6
Toluene	0.7
Limonene	0.4
2-nonanone (?)	0.7
2-undecanone (?)	0.1
2,6-di-t-butyl-p-cresol	1.0
Hexadecane	trace
Heptadecane	trace
Pristane	0.03

*Identification followed by a (?) is probable but not definite.

Summary

The analytical values presented in this report represent the authors' evaluation of a considerable amount of data. For many elements where the reports were inconclusive, probable values are not given. If more information becomes available in the future, this report will be updated. Your help in reporting data will be appreciated.

Send any reports to:

Office of Standard Reference Materials (R-701)
B316, Chemistry
National Bureau of Standards
Washington, D.C. 20234

May 12, 1977

U. S. Department of Commerce
Malcolm Baldrige
Secretary

National Bureau of Standards
Ernest Ambler, Director

National Bureau of Standards

Certificate of Analysis

Standard Reference Material 1549

Non-Fat Milk Powder

This Standard Reference Material (SRM) is intended primarily for use in calibrating instrumentation and evaluating the reliability of analytical methods for the determination of constituents in milk, milk powders, and other biological matrices.

Certified Values of Constituents: The certified concentrations of the constituent elements are shown in Table 1. Certified values are based on results obtained by definitive methods of known accuracy; or alternatively, from concordant results by two or more independent analytical methods.

Additional Information on Composition: Noncertified concentrations of additional constituent elements are given for information only in Table 2. Noncertified concentrations of lactose and ascorbic acid were determined by high performance liquid chromatography; and for lactose only, by nuclear magnetic resonance.

Notice and Warnings to Users:

Expiration of Certification: This certification is invalid after 3 years from the date of shipping. Should it become invalid before then, purchasers will be notified by NBS.

Stability: The material should be kept in its original bottle and stored at temperatures between 10-30 °C. It should not be exposed to intense sources of radiation. The bottle should be kept tightly closed and stored in a desiccator in the dark.

Use: A minimum sample of 500 mg of the dried material (see Instructions for Drying) should be used for any analytical determination to be related to the certified values of this certificate.

Dissolution procedures should be designed to effect complete dissolution, but without losses of volatile elements, such as mercury. Dissolution for these determinations should be carried out in a closed system.

Statistical consultation was provided by K.R. Eberhardt of the Statistical Engineering Division.

The overall direction and coordination of the analyses were under the chairmanship of E.L. Garner, Chief of the Inorganic Analytical Research Division, and W.E. May, Chief of the Organic Analytical Research Division.

The technical and support aspects involved in the preparation, certification, and issuance of this Standard Reference Material were coordinated through the Office of Standard Reference Materials by R. Alvarez.

Gaithersburg, MD 20899
July 29, 1985
(Revision of Certificates
dated 4-17-84 and
1-14-85)

(over)

Stanley D. Rasberry, Chief
Office of Standard Reference Materials

<u>Instructions for Drying:</u> Samples of this SRM must be dried before weighing according to the following procedure: Dry for 48 hours at 20 to 25 °C in a vacuum oven at a pressure not greater than 30 Pa (0.2 mm Hg).

<u>Analysts:</u>

Center for Analytical Chemistry, National Bureau of Standards:

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14. J.R. Moody
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18. T.A. Rush
19. M.E. Watson
20. R.L. Watters, Jr.
21. L. Watts

<u>Cooperating Analysts:</u>

22. R.W. Dabeka, Food Research Division, Health Protection Branch, Tunney's Pasture, Ottawa, Ontario, Canada.
23. L. Kosta, A.R. Byrne, M. Dermelj, Institute "Josef Stefan", Ljubljana, Yugoslavia.
24. C. Veillon and K. Patterson, Beltsville Human Nutrition Research Center, U.S. Department of Agriculture, Beltsville, MD.

Table 1. Certified Concentrations of Constituent Elements

Element	Concentration, weight, %	Element	Concentration, weight, %
Calcium[2c,5a]	1.30 ± 0.05	Potassium[2b,5a]	1.69 ± 0.03
Chlorine[3,5a]	1.09 ± .02	Sodium[2c,5a]	0.497 ± .010
Magnesium[2c,5a]	0.120 ± .003	Sulfur[3,4a]	.351 ± .005
Phosphorus[2a,2c]	1.06 ± .02		

Element	Concentration, µg/g	Element	Concentration, µg/g
Cadmium[1b,5b]	0.0005 ± 0.0002	Lead[1b,4a]	0.019 ± 0.003
Chromium[4c,5b]	.0026 ± .0007	Manganese[1b,2a,5a]	.26 ± .06
Copper[1b,2a,5b]	.7 ± .1	Mercury[1a,5b]	.0003 ± .0002
Iodine[4a,6]	3.38 ± .02	Selenium[1d,4b,5a,5b]	11 ± .01
Iron[4a,5a]	1.78 ± .10	Zinc[1c,2c,4b,5a]	46.1 ± 2.2

1. Atomic absorption spectrometry
   a. cold vapor
   b. electrothermal
   c. flame
   d. hydride generation
2. Atomic emission spectrometry
   a. dc plasma
   b. flame
   c. inductively coupled plasma
3. Ion chromatography
4. Isotope dilution mass spectrometry
   a. thermal ionization
   b. spark source
   c. electron impact
5. Neutron activation
   a. instrumental
   b. radiochemical
6. Photon Activation

Notes: (1.) Analytical values are based on the "dry-weight" of material (see Instructions for Drying).

(2.) Except for Fe, the stated uncertainty includes the union of 95% confidence intervals computed separately for each analytical method. It includes the effects of measurement error, possible effects of known systematic errors, and between-method differences. The uncertainty for Fe is given as a 95% confidence interval for the weighted mean of the mass spectrometric and neutron activation values, and includes an allowance (added linearly) for systematic error in the methods. The weights were chosen to minimize the estimated mean squared error of the weighted mean, as described in "Approximately Linear Models," by J. Sacks and D. Ylvisaker, Annals of Statistics 6, pp. 1122-1137, 1978.

Table 2. Noncertified Concentrations of Constituent Elements

Element	Concentration, µg/g	Element	Concentration, µg/g
Aluminum	(2)	Molybdenum	(0.34)
Antimony	(0.00027)	Rubidium	(11)
Arsenic	(.0019)	Silicon	(<50)
Bromine	(12)	Silver	(<0.0003)
Cobalt	(0.0041)	Tin	(<0.02)
Fluorine	(.20)		

Table 3. Noncertified Concentrations of Organic Constituents

Compound	Number of Determinations	Concentration,[a] weight %	Method
Lactose	5	49 ± 3	High Performance Liquid Chromatography
	5	45 ± 2	Proton Nuclear Magnetic Resonance

Compound	Number of Determinations	Concentration,[a] µg/g	Methods
Ascorbic Acid	10	53 ± 5	High Performance Liquid Chromatography

[a]Uncertainties represent one standard deviation.

U. S. Department of Commerce
Malcolm Baldrige
Secretary

National Bureau of Standards
Ernest Ambler, Director

National Bureau of Standards

Certificate of Analysis

Standard Reference Material 1566

Oyster Tissue

This Standard Reference Material is intended primarily for use in calibrating instrumentation and validating methodology for the chemical analysis of marine animal tissue.

Certified Values of Constituent Elements: The certified values for the constituent elements are shown in Table 1. Certified values are based on results obtained by reference methods of known accuracy; or alternatively, from results obtained by two or more independent and reliable analytical methods. Non-certified values are given for information only in Table 2. All values are based on a minimum sample size of 250 mg of the dried material.

NOTICE AND WARNINGS TO USERS

Expiration of Certification: This certification is invalid after 5 years from the date of shipping. Should it become invalid before then, purchasers will be notified by NBS.

Storage: The material should be kept tightly closed in its original bottle and stored in a desiccator at temperatures between 10-30 °C. It should not be exposed to intense sources of radiation, including ultraviolet lamps or sunlight.

Use: A minimum sample weight of 250 mg of the *dried* material (see Instructions for Drying) is necessary for any certified value in Table 1 to be valid within the stated uncertainty. The bottle should be shaken well before each use, and closed tightly immediately after use.

The statistical analysis of the data was performed by K. R. Eberhardt and H. H. Ku of the Statistical Engineering Division.

The overall direction and coordination of the analytical chemistry measurements leading to this certificate were performed in the NBS Center for Analytical Chemistry by P. D. LaFleur.

The technical and support aspects involved in the preparation, certification, and issuance of this Standard Reference Material were coordinated through the Office of Standard Reference Materials by R. Alvarez.

Washington, D.C. 20234
February 22, 1983
(Revision of Certificate
Dated 12-12-79)

George A. Uriano, Chief
Office of Standard Reference Materials

(over)

Instructions for Drying: Before weighing, samples of SRM 1566 should be dried to constant weight by one of the following procedures:

1. Reduced-pressure drying at room temperature for 48 hours over $Mg(ClO_4)_2$ in a vacuum desiccator at approximately 1.3×10^4 Pa (100 mm Hg).
2. Vacuum drying at room temperature for 24 hours at a pressure of approximately 30 Pa (0.2 mm Hg) using a cold trap.
3. Freeze drying for 20 hours at a pressure of approximately 3 Pa (0.02 mm Hg).

Source and Preparation of Material: The oysters for this reference material were obtained by the FDA Bureau of Shellfish Sanitation from a commercial source. They had been shucked, frozen, and packaged in sealed plastic bags. The oyster material was ground, freeze-dried, and powdered at the U.S. Army Natick Research and Development Command, Natick, Mass., under the direction of L. Hinnegardt and G. C. Walker. At NBS, preliminary analyses of the material homogeneity indicated that an improvement in homogeneity would be required to establish more reliable certified values for a minimum sample size of 250 mg. Accordingly, the material was cryogenically ground by J. R. Moody and J. Matwey. It was then blended and bottled at NBS, after which it was again freeze-dried at the Natick, Mass., laboratory.

Homogeneity Assessment: Randomly selected bottles of SRM 1566 were sampled and tested for homogeneity by neutron activation and atomic absorption spectrometry. No inhomogeneity was observed for the following elements determined by neutron activation: Na, Cl, V, and Mn. The values for Mg, K, Cu, Zn, and Cd determined by atomic absorption spectrometry were within the imprecision of the method; however, Ca does exhibit some inhomogeneity--approximately 4% relative standard deviation.

Analysts:

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Cooperating Analysts:

34. University of Tokyo, Tokyo, Japan; Y. Dokiya (NBS Guest Worker).
35. Division of Chemistry, National Research Council of Canada, Ottawa, Canada; S. Berman, A. Desaulniers, J. McLaren, A. Mykytiuk, D. Russell, and S. Willie.
36. Ibaraki Electrical Communication Laboratory, Nippon Telegraph and Telephone Public Corporation, Tokai, Ibaraki, Japan; K. Kudo and K. Kobayashi.
37. Food Research Division, Health Protection Branch, Tunney's Pasture, Ottawa, Ontario, Canada; R. W. Dabeka, A. D. McKenzie, and H. B. S. Conacher.

Table 1. Certified Values of Constituent Elements

Element[1]	Content[2], Wt. Percent	Element[1]	Content[2], Wt. Percent
Calcium[b,d]	0.15 ± 0.02	Potassium[d]	0.969 ± 0.005
Magnesium[a,d]	0.128 ± 0.009	Sodium[b,f]	0.51 ± 0.03
Element[1]	**Content[2], μg/g**	**Element[1]**	**Content[2], μg/g**
Arsenic[a,f,g,h]	13.4 ± 1.9	Nickel[a,e,h]	1.03 ± 0.19
Cadmium[a,d,e,f,h]	3.5 ± 0.4	Rubidium[d,f]	4.45 ± 0.09
Chromium[d,e,f]	0.69 ± 0.27	Selenium[a,e,f]	2.1 ± 0.5
Copper[a,c,e,f]	63.0 ± 3.5	Silver[a,f]	0.89 ± 0.09
Iron[b,c,e,f]	195 ± 34	Strontium[b,d]	10.36 ± 0.56
Lead[a,d,e,h]	0.48 ± 0.04	Uranium[d]	0.116 ± 0.006
Manganese[a,c,f]	17.5 ± 1.2	Vanadium[d]	2.3 ± 0.1
Mercury[a,f]	0.057 ± 0.015	Zinc[a,c,d,e,f,h]	852 ± 14

1. Analytical Methods:
   - [a] Atomic absorption spectroscopy
   - [b] Atomic emission spectroscopy, flame
   - [c] Atomic emission spectroscopy, inductively coupled plasma
   - [d] Isotope dilution mass spectrometry, thermal ionization
   - [e] Isotope dilution mass spectrometry, spark source
   - [f] Neutron activation
   - [g] Photon activation
   - [h] Polarography

2. Based on dry weight. (For drying instructions, see the section of this certificate on Instructions for Drying.) The estimated uncertainty is given as 95 percent tolerance limits for coverage of at least 95 percent of the measured values of all bottles of SRM 1566. For a given element, the following statement can be made at a confidence limit of 95 percent. "If the concentrations were measured for all bottles, at least 95 percent of these measured values should fall within the indicated limits." The concept of tolerance limits is discussed in Chapter 2, Experimental Statistics, NBS Handbook 91, 1966, and page 14, The Role of Standard Reference Materials in Measurement Systems, NBS Monograph 148, 1975.

Table 2. Non-certified Values of Constituent Elements

Element	Content[1] (Wt. Percent)
Chlorine	(1.0)
Sulfur	(0.76)
Phosphorous	(0.81)
	(μg/g)
Bromine	(55)
Cobalt	(0.4)
Fluorine	(5.2)
Iodine	(2.8)
Molybdenum	(≤0.2)
Thallium	(≤0.005)
Thorium	(0.1)

[1] Based on dry weight. (For drying instructions, see the section of this certificate on Instructions for Drying.)

U.S. Department of Commerce
Juanita M. Kreps
Secretary

National Bureau of Standards
Ernest Ambler, Acting Director

National Bureau of Standards
Certificate of Analysis
Standard Reference Material 1567

Wheat Flour

This Standard Reference Material is intended primarily for calibrating instrumentation and evaluating the reliability of analytical methods for the determination of minor and trace elements in wheat flour and similar agricultural food products.

Certified Values of Constituent Elements: The certified values for the constituent elements are shown in Table 1. They are based on results obtained by two or more independent, reliable analytical methods. Non-certified values which are given for information only, appear in Table 2.

All values are based on a minimum sample size of 400 mg and are reported on a "dry-weight" basis.

Notice and Warnings to Users:

Expiration of Certification: This certification will be invalid after 5 years from the date of shipping. Should it be invalidated before then, purchasers will be notified by NBS.

Storage: The material should be kept in its original bottle and stored at temperatures between 10-30 °C. It should not be exposed to intense sources of radiation, including ultraviolet lamps or sunlight. Ideally, the bottle should be kept in a desiccator in the dark at the temperature indicated.

Use: The following procedures should be followed to relate the analytical determinations to the values reported in this Certificate. The bottle should be shaken well before each use, and a minimum sample of 400 mg of the material should be used. Selenium and mercury should be determined in the material without drying and the concentration values adjusted for the moisture content of the material using separate samples. Other elements may be determined either on samples without drying as indicated above or on samples vacuum-dried for 24 hr as indicated under "Instructions for Drying."

The overall direction and coordination of the technical measurements leading to this Certificate were performed under the chairmanship of H. L. Rook.

The technical and support aspects involved in the preparation, certification, and issuance of this Standard Reference Material were coordinated through the Office of Standard Reference Materials by R. Alvarez.

Washington, D.C. 20234
January 3, 1978

J. Paul Cali, Chief
Office of Standard Reference Materials

(over)

Table 1. Certified Values of Constituent Elements[a]

Minor Constituents

Element	Content Wt. Percent
Potassium	0.136 ± 0.004[b]
Calcium	0.019 ± 0.001

Trace Constituents

Element	Content µg/g	Element	Content µg/g
Iron	18.3 ± 1.0	Copper	2.0 ± 0.3
Zinc	10.6 ± 1.0	Selenium	1.1 ± 0.2
Manganese	8.5 ± 0.5	Cadmium	0.032 ± 0.007
Sodium	8.0 ± 1.5	Mercury	0.001 ± 0.0008

[a]Analytical values are based on the "dry-weight" of material (see Instructions for Drying). Selenium and mercury should be determined on samples without drying and the results adjusted to a "dry-weight" basis by determining moisture on separate samples.

[b]The estimated uncertainty is based on judgment and represents an evaluation of the combined effects of method imprecision, possible systematic errors among methods, and material variability for samples 400 mg or more. (No attempt was made to derive exact statistical measures of imprecision because several methods were involved in the determination of the constituents).

Table 2. Non-certified Values for Constituent Elements[a]

NOTE: The values shown in this table are not certified because they are not based on the results of two or more independent reliable methods. These values are included for information only.

Trace Constituents

Element	Content µg/g	Element	Content µg/g
Bromine	(9)	Nickel	(0.18)
Rubidium	(1)	Arsenic	(0.006)
Molybdenum	(0.4)	Tellurium	(≤0.002)

[a]Analytical values are based on the "dry-weight" of material (see Instructions for Drying).

Preparation of Material: The wheat flour for this Standard Reference Material was described by the supplier as milled from a blend of Hard Red Spring and Hard Red Winter wheat grown primarily in South Dakota. The flour was taken from the mill packer during the middle of a run to obtain homogeneous material. The flour had been bleached and brominated in accordance with standard treatments for commercial bakery use. At NBS, the material was passed through a sieve with openings of 425 μm (No. 40) and blended. The bottled material was then subjected to 2.5 megarads of Co-60 radiation for microbiological control at Neutron Products, Inc., Dickerson, Md.

Homogeneity Assessment: A preliminary evaluation of homogeneity was made by instrumental neutron activation using samples of 150 to 300 mg and counting the activities from radionuclides of Mn, K, Zn, Na, and Br. The homogeneity of other certified elements was evaluated using samples of 400 mg or less with the exception of mercury and calcium for which 500 mg and 1 g, respectively, were used. The uncertainties for the concentrations in Table 1 include these results.

Instructions for Drying: Except for selenium and mercury, elements may be determined on samples which have been dried as follows:

Vacuum-dry the material at approximately 25 °C for 24 hours at a pressure not greater than 70 Pa (0.5 mm Hg) with a cold trap at a temperature of about −30 °C or below.

Se and Hg should be determined on undried samples; other elements may be so determined. However, because the Certificate values are reported on a "dry-weight" basis, the elemental concentrations determined on undried samples should be adjusted for the moisture content of the samples. The moisture content, which was approximately 9% when bottled, should be determined on separate samples by either the vacuum-drying procedure described above or drying the sample in air in an oven at 85 °C for 24 hours. Both of these procedures yielded the same loss in weight. Samples for analysis should not be oven-dried lest elements be lost by volatilization.

Analytical Methods Used and Analysts

Analytical Methods

A. Atomic absorption spectrometry
B. Flame emission spectrometry
C. Isotope dilution spark source mass spectrometry
D. Neutron activation
E. Polarography

Analysts

Analytical Chemistry Division, National Bureau of Standards

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Cooperating Analysts

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U. S. Department of Commerce
Malcolm Baldrige
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National Bureau of Standards
Ernest Ambler, Director

Addendum to

National Bureau of Standards
Certificate of Analysis

Standard Reference Material 1567

Wheat Flour

Additional Certification

The following certified value is to be added to Table 1.

Table 1. Certified Values of Constituent Elements[a]

Element	Content, $\mu g/g$
Lead	0.020 ± 0.010[b]

[a] Lead should be determined on samples without drying and the results adjusted to a "dry-weight" basis by determining moisture on separate samples.
[b] The estimated uncertainty, based on judgment, is for samples 2 g or more.

Analytical Methods Used and Analysts

Inorganic Analytical Research Division, National Bureau of Standards.

Isotope dilution, mass spectrometry, I. L. Barnes and E. S. Beary;
Polarography, E. J. Maienthal.

Cooperating Analyst

R. W. Dabeka, Food Directorate, Health Protection Branch, Ottawa, Canada.

U.S. Department of Commerce
Juanita M. Kreps
Secretary
National Bureau of Standards
Ernest Ambler, Acting Director

National Bureau of Standards
Certificate of Analysis
Standard Reference Material 1568

Rice Flour

This Standard Reference Material is intended primarily for calibrating instrumentation and evaluating the reliability of analytical methods for the determination of minor and trace elements in rice flour and similar agricultural food products.

Certified Values of Constituent Elements: The certified values for the constituent elements are shown in Table 1. They are based on results obtained by two or more independent, reliable analytical methods. Non-certified values which are given for information only, appear in Table 2.

All values are based on a minimum sample size of 400 mg and are reported on a "dry-weight" basis.

Notice and Warnings to Users:

Expiration of Certification: This certification will be invalid after 5 years from the date of shipping. Should it be invalidated before then, purchasers will be notified by NBS.

Storage: The material should be kept in its original bottle and stored at temperatures between 10-30 °C. It should not be exposed to intense sources of radiation, including ultraviolet lamps or sunlight. Ideally, the bottle should be kept in a desiccator in the dark at the temperature indicated.

Use: The following procedures should be followed to relate the analytical determinations to the values reported in this Certificate. The bottle should be shaken well before each use, and a minimum sample of 400 mg of the material should be used. Selenium and mercury should be determined in the material without drying and the concentration values adjusted for the moisture content of the material using separate samples. Other elements may be determined either on samples without drying as indicated above or on samples vacuum-dried for 24 hr as indicated under "Instructions for Drying."

The overall direction and coordination of the technical measurements leading to this Certificate were performed under the chairmanship of H. L. Rook.

The technical and support aspects involved in the preparation, certification, and issuance of this Standard Reference Material were coordinated through the Office of Standard Reference Materials by R. Alvarez.

Washington, D.C. 20234
January 3, 1978

J. Paul Cali, Chief
Office of Standard Reference Materials

(over)

Table 1. Certified Values of Constituent Elements[a]

Minor Constituents

Element	Content Wt. Percent
Potassium	0.112 ± 0.002[b]
Calcium	0.014 ± 0.002

Trace Constituents

Element	Content µg/g	Element	Content µg/g
Manganese	20.1 ± 0.4	Arsenic	0.41 ± 0.05
Zinc	19.4 ± 1.0	Selenium	0.4 ± 0.1
Iron	8.7 ± 0.6	Cadmium	0.029 ± 0.004
Sodium	6.0 ± 1.5	Cobalt	0.02 ± 0.01
Copper	2.2 ± 0.3	Mercury	0.0060 ± 0.0007

[a]Analytical values are based on the "dry-weight" of material (see Instructions for Drying). Selenium and mercury should be determined on samples without drying and the results adjusted to a "dry-weight" basis by determining moisture on separate samples.

[b]The estimated uncertainty is based on judgment and represents an evaluation of the combined effects of method imprecision, possible systematic errors among methods, and material variability for samples 400 mg or more. (No attempt was made to derive exact statistical measures of imprecision because several methods were involved in the determination of the constituents).

Table 2. Non-certified Values for Constituent Elements[a]

NOTE: The values shown in this table are not certified because they are not based on the results of two or more independent reliable methods. These values are included for information only.

Trace Constituents

Element	Content µg/g	Element	Content µg/g
Rubidium	(7)	Nickel	(0.16)
Molybdenum	(1.6)	Tellurium	(≤0.002)
Bromine	(1)		

[a]Analytical values are based on the "dry-weight" of material (see Instructions for Drying).

Preparation of Material: The rice flour for this Standard Reference Material was described by the supplier as 100% long grain from Arkansas. At NBS, the material was passed through a sieve with openings of 425 μm (No. 40) and blended. The bottled material was then subjected to 2.5 megarads of Co-60 radiation for microbiological control at Neutron Products, Inc., Dickerson, Md.

Homogeneity Assessment: A preliminary evaluation of homogeneity was made by instrumental neutron activation using samples of 150 to 300 mg and counting the activities from radionuclides of Mn, K, Zn, Na, and Br. The homogeneity of other certified elements was evaluated using samples of 400 mg or less with the exception of mercury and calcium for which 500 mg and 1 g, respectively, were used. The uncertainties for the concentrations in Table 1 include these results.

Instructions for Drying: Except for selenium and mercury, elements may be determined on samples which have been dried as follows:

Vacuum-dry the material at approximately 25 °C for 24 hours at a pressure not greater than 70 Pa (0.5 mm Hg) with a cold trap at a temperature of about −30 °C or below.

Se and Hg should be determined on undried samples; other elements may be so determined. However, because the Certificate values are reported on a "dry-weight" basis, the elemental concentrations determined on undried samples should be adjusted for the moisture content of the samples. The moisture content, which was approximately 9% when bottled, should be determined on separate samples by either the vacuum-drying procedure described above or drying the sample in air in an oven at 85 °C for 24 hours. Both of these procedures yielded the same loss in weight. Samples for analysis should not be oven-dried lest elements be lost by volatilization.

Analytical Methods Used and Analysts

Analytical Methods

A. Atomic absorption spectrometry
B. Flame emission spectrometry
C. Isotope dilution spark source mass spectrometry
D. Neutron activation
E. Polarography

Analysts

Analytical Chemistry Division, National Bureau of Standards

1. J. R. Baldwin
2. T. J. Brady
3. M. G. Diaz
4. L. P. Dunstan
5. M. S. Epstein
6. M. Gallorini
7. T. E. Gills
8. R. R. Greenberg
9. R. M. Lindstrom
10. G. J. Lutz
11. E. J. Maienthal
12. R. Mavrodineanu
13. J. D. Messman
14. R. M. Morris
15. P. J. Paulsen
16. T. C. Rains
17. P. A. Sleeth

Cooperating Analysts

18. W. R. Wolf and J. Holden, Nutrition Institute, U.S. Department of Agriculture, Beltsville, Md

U. S. Department of Commerce
Malcolm Baldrige
Secretary
National Bureau of Standards
Ernest Ambler, Director

Addendum to

National Bureau of Standards Certificate of Analysis

Standard Reference Material 1568

Rice Flour

Additional Certification

The following certified value is to be added to Table 1.

Table 1. Certified Values of Constituent Elements[a]

Element	Concentration, μg/g
Lead	0.045 ± 0.010[b]

[a] Lead should be determined on samples without drying and the results adjusted to a "dry-weight" basis by determining moisture on separate samples.
[b] The estimated uncertainty, based on judgment, is for samples 2 g or more.

Analytical Methods Used and Analysts

Inorganic Analytical Research Division, National Bureau of Standards.

Isotope dilution, mass spectrometry, I. L. Barnes and E. S. Beary;
Polarography, E. J. Maienthal.

Cooperating Analyst

R. W. Dabeka, Food Directorate, Health Protection Branch, Ottawa, Canada.

U.S. Department of Commerce
Elliot L. Richardson,
Secretary

National Bureau of Standards
Ernest Ambler, Acting Director

National Bureau of Standards
Certificate of Analysis
Standard Reference Material 1569

Brewers Yeast

This Standard Reference Material is intended for use in calibrating instrumentation and evaluating the accuracy of analytical methods for the determination of chromium in brewers yeast and other biological materials. SRM 1569 and like materials contain a volatile chromium component which presents an especially difficult analytical problem. Care should be taken to avoid its loss; see, "Preparation of Biological Materials for Chromium Analysis," W. R. Wolf and F. E. Greene [1].

*Chromium concentration: 2.12 ± 0.05 μg/g

*Calculated on a dry weight basis from determinations made on samples *without drying*. (See "Precautions" below.) A minimum sample size of 150 mg should be used.

The certified value is based on concordant results by independent analytical methods; the uncertainty is estimated from the imprecision of the methods and inhomogeneity of the material.

The overall direction and coordination of the technical measurements leading to this certificate were performed under the chairmanship of L. McClendon.

The technical aspects leading to the preparation, certification and issuance of this material were coordinated through the Office of Standard Reference Materials by R. Alvarez.

[1] Wolf, W. R. and Greene, F. E., Preparation of Biological Materials for Chromium Analysis, Proceedings of the 7th Materials Research Symposium, Accuracy in Trace Analysis: Sampling, Sample Handling and Analysis, NBS Spec. Publ. 422, U. S. Government Printing Office, Washington, D.C. (August 1976).

Washington, D.C. 20234
September 7, 1976

J. Paul Cali, Chief
Office of Standard Reference Materials

(over)

Analyses were performed in the NBS Analytical Chemistry Division by L. McClendon (neutron activation) and by L. Dunstan and E. Garner (isotope dilution, mass spectrometry). Cooperative analyses were also made by W. R. Wolf, Nutrition Institute, U.S. Department of Agriculture, Beltsville, Md.

The material was furnished by the Nutrition Institute, U.S. Department of Agriculture, Beltsville, Md. At NBS, it was passed through a sieve having openings of 0.15 mm (U.S. Series 100 standard sieve) and blended.

Precautions:

(1) The analytical determinations should be made on samples *without drying*. The determinations should be corrected to a dry weight basis by heating separate samples at 85 °C for 3 hr to determine the weight loss.

(2) Samples should not be dissolved in open vessels.

Material Homogeneity was determined by a neutron activation technique using 150-mg random samples from bottled material representing different locations of the bulk material. The statistical test pattern was proposed by J. Mandel of the NBS Institute for Materials Research.

Stability:

The material should be kept in its original bottle and stored at temperatures between 10-23 °C. Exposure to moisture should be minimized by tightly capping the bottle immediately after use. Ideally, the bottle should be kept in a desiccator at the temperature indicated.

U. S Department of Commerce
Malcolm Baldrige
Secretary

National Bureau of Standards
Ernest Ambler, Director

National Bureau of Standards

Certificate of Analysis

Standard Reference Material 1572

Citrus Leaves

This Standard Reference Material (SRM) is intended primarily for use in calibrating instrumentation and evaluating the reliability of analytical methods for the determination of major, minor, and trace elements in botanical materials, agricultural food products, and similar matrices.

Certified Values of Constituent Elements: The certified values for the constituent elements are shown in Table 1. They are based on results obtained either by definitive methods of known accuracy or by two or more independent analytical methods. Non-certified values, which are given for information only, appear in Table 2.

Notice and Warnings to Users:

Expiration of Certification: This certification is invalid 5 years after the shipping date. Should it be invalidated before then, purchasers will be notified by NBS.

Stability: The material should be kept in its original bottle and stored at temperatures between 10-30 °C. It should not be exposed to intense sources of radiation. Ideally, the bottle should be kept tightly closed in a desiccator in the dark at the temperature indicated.

Use: The bottle should be shaken well before each use. A minimum sample of 500 mg of the dried material (see Instructions for Drying) should be used for any analytical determination to be related to the certified values of this certificate.

Statistical consultation was provided by K. Kafadar of the Statistical Engineering Division.

The overall direction and coordination of the analyses leading to this certification were performed under the chairmanship of E.L. Garner, Chief of the Inorganic Analytical Research Division.

The technical and support aspects involved in the preparation, certification, and issuance of this Standard Reference Material were coordinated through the Office of Standard Reference Materials by R. Alvarez.

Washington, D.C. 20234
December 20, 1982
(Revision of Certificate
dated 2-22-82)

George A. Uriano, Chief
Office of Standard Reference Materials

(over)

Table 1. Certified Values of Constituent Elements

Major and Minor Constituents

Element	Content,[1] (Wt. Percent)
Calcium	3.15 ± 0.10
Magnesium	0.58 ± 0.03
Phosphorus	0.13 ± 0.02
Potassium*	1.82 ± 0.06
Sulfur	0.407 ± 0.009

Trace Constituents

Element	Content,[1] μg/g	Element	Content,[1] μg/g
Aluminum	92 ± 15	Manganese	23 ± 2
Arsenic	3.1 ± 0.3	Mercury	0.08 ± 0.02
Barium	21 ± 3	Molybdenum	0.17 ± 0.09
Cadmium	0.03 ± 0.01	Nickel	0.6 ± 0.3
Chromium	0.8 ± 0.2	Rubidium*	4.84 ± 0.06
Copper	16.5 ± 1.0	Sodium	160 ± 20
Iodine	1.84 ± 0.03	Strontium*	100 ± 2
Iron	90 ± 10	Zinc	29 ± 2
Lead*	13.3 ± 2.4		

[1]Based on dry weight: For drying instructions, see the section of this certificate on Instructions for Drying. The uncertainties are based on judgment and represent an evaluation of the combined effects of method imprecision, possible systematic errors among methods, and material variability for samples weighing 500 mg or more.

*For those elements determined by definitive methods, the uncertainties are given as 95%/95% statistical tolerance intervals. See The Role of Standard Reference Materials in Measurement Systems, NBS Monograph 148, 1975 p 14.

Table 2. Non-certified Values for Constituent Elements

NOTE: The following values are not certified because they are not based on the results of either a definitive method of known accuracy or two or more independent methods. These values are included for information only.

Major Constituent

Element	Content,[1] (Wt. Percent)
Nitrogen	(2.86)

Trace Constituents

Element	Content,[1] μg/g	Element	Content,[1] μg/g
Antimony	(0.04)	Samarium	(0.052)
Bromine	(8.2)	Scandium	(0.01)
Cerium	(0.28)	Selenium	(0.025)
Cesium	(0.098)	Tellurium[a]	(0.02)
Chlorine	(414)	Thallium	(≤0.01)
Cobalt	(0.02)	Tin	(0.24)
Europium	(0.01)	Uranium	(≤0.15)
Lanthanum	(0.19)		

[1]Analytical values are based on the "dry weight" of material (See Instructions for Drying).
[a]Not sufficiently homogeneous for certification.

Instructions for Drying: Samples of this SRM must be dried before weighing and analysis by either of the following procedures:

1. Drying for 2 hours in air in an oven at 85 °C.

2. Drying for 24 hours at 20 to 25 °C and at a pressure not greater than 30 Pa (0.2 mm Hg).

Additional Information on Analyses: This SRM contains siliceous material, which is an integral part of the sample. The values in Tables 1 and 2 are based on analyses performed on the *entire* sample. Therefore, dissolution procedures should be capable of complete dissolution of the sample but should not result in losses of volatile elements, such as arsenic and mercury.

Source and Preparation of Material: The plant material for this SRM was collected and prepared under the direction of A. L. Kenworthy, Michigan State University. Its source was the Lake Alfred area of central Florida. The material was air-dried, ground in a comminuting machine to pass a 425-μm (No. 40) sieve, dried at 85 °C, and thoroughly mixed in a feed blender. After packaging the material in polyethylene-lined fiber drums, it was sterilized in situ with cobalt-60 radiation. The sterilization procedure was carried out at the U.S. Army Research and Development Command, Natick, Mass. under the direction of A. Brynjolfsson.

Analytical Methods Used and Analyses

Analytical Methods:

A. Atomic absorption spectrometry

B. Atomic emission spectrometry, flame

C. Atomic emission spectrometry, inductively coupled plasma

D. Ion chromatography

E. Isotope dilution thermal source mass spectrometry

F. Isotope dilution spark source mass spectrometry

G. Kjeldahl method for nitrogen

H. Neutron activation

I. Photon activation

J. Polarography

K. Spectrophotometry

Analysts:

Inorganic Analytical Research Division, National Bureau of Standards

1. I.L. Barnes
2. E.S. Beary
3. K.A. Brletic
4. T.A. Butler
5. E.R. Deardorff
6. J.W. Gramlich
7. R.R. Greenberg
8. S. Hanamura
9. E.F. Heald
10. W.R. Kelly
11. H.M. Kingston
12. W.F. Koch
13. G.M. Lambert
14. R.M. Lindstrom
15. G.J. Lutz
16. L.A. Machlan
17. E.J. Maienthal
18. J.R. Moody
19. T.J. Murphy
20. P.J. Paulsen
21. L.J. Powell
22. T.C. Rains
23. T.A. Rush
24. P.A. Sleeth
25. R.L. Watters, Jr.
26. R. Zeisler

Cooperating Analysts:

1. M. Ihnat, Chemistry and Biology Research Institute, Agriculture Canada, Ottawa, Canada.
2. M. Gallorini, E. Orvini, and M. DiCasa, Consiglio Nazionale delle Ricerche, Centro di Radiochimica e Analisi per Attivazione presso l'Instituto di Chimica Generale dell' Universitá, Pavia, Italy.
3. L. Kosta, A. R. Byrne, and A. Prosenc, Institute "Josef Stefan," Ljubljana, Yugoslavia.
4. J. B. Jones, Jr., Department of Horticulture, University of Georgia, Athens, Georgia.
5. U. M. Cowgill, Department of Biological Sciences, University of Pittsburgh, Pittsburgh, Pennsylvania.

U.S. Department of Commerce
Elliot L. Richardson,
Secretary

National Bureau of Standards
Ernest Ambler, Acting Director

National Bureau of Standards Certificate of Analysis

Standard Reference Material 1573

Tomato Leaves

This Standard Reference Material is intended primarily for calibrating instrumentation and evaluating the reliability of analytical methods for the determination of major, minor, and trace elements in botanical materials and other agricultural products.

Certified Values of Constituent Elements: The certified values for the constituent elements are shown in Table 1. They are based on results obtained either by reference methods of known accuracy or by two or more independent, reliable analytical methods. Non-certified values, which are given for information only, appear in Table 2. All values are based on a minimum sample size of 500 mg of the material dried as indicated under "Instructions for Drying."

Notice and Warnings to Users:

Expiration of Certification: This certification will be invalid 5 years after the shipping date. Should it be invalidated before then, purchasers will be notified by NBS.

Stability: The material should be kept in its original bottle and stored at temperatures between 10-30 °C. It should not be exposed to intense sources of radiation, including ultraviolet lamps or sunlight. Ideally, the bottle should be kept in a desiccator in the dark at the temperature indicated.

Use: The bottle should be shaken well before each use. A minimum sample of 500 mg of the *dried* material (see Instructions for Drying) should be used for any analytical determination to be related to the certified values of this certificate.

The overall direction and coordination of the technical measurements leading to this certificate were performed under the chairmanship of H. L. Rook. The overall coordination of the cooperative work performed by the Commission of European Communities, Joint Research Center, Ispra Establishment, Italy, was by G. Rossi of the Chemistry Division.

The technical and support aspects involved in the preparation, certification, and issuance of this Standard Reference Material were coordinated through the Office of Standard Reference Materials by T. W. Mears and R. Alvarez

Washington, D.C. 20234
October 18, 1976

J. Paul Cali, Chief
Office of Standard Reference Materials

(over)

Table 1. Certified Values of Constituent Elements[a]

Major and Minor Constituents

Element	Content Wt. Percent
Potassium	4.46 ± 0.03
Calcium	3.00 ± 0.03
Phosphorus	0.34 ± 0.02

Trace Constituents

Element	Content µg/g	Element	Content µg/g
Iron	690 ± 25	Lead	6.3 ± 0.3
Manganese	238 ± 7	Chromium	4.5 ± 0.5
Zinc	62 ± 6	Arsenic	0.27 ± 0.05
Strontium	44.9 ± 0.3	Thorium	0.17 ± 0.03
Rubidium	16.5 ± 0.1	Uranium	0.061 ± 0.003
Copper	11 ± 1		

[a]Analytical values are based on the "dry-weight" of material (See Instructions for Drying).

The uncertainties of the values shown in Table 1 include allowances for inhomogeneity, method imprecision, and an estimate of possible biases of the analytical methods used.

Table 2. Non-certified Values for Constituent Elements[a]

NOTE: The following values are not certified because they are not based on the results of either a reference method of known accuracy or two or more independent methods. These values are included for information only.

Major and Minor Constituents

Element	Content Wt. Percent
Nitrogen	(5.0)
Magnesium	(0.7)
Aluminum	(0.12)

Trace Constituents

Element	Content µg/g	Element	Content µg/g
Boron	(30)	Cobalt	(0.6)
Bromine	(26)	Scandium	(0.13)
Cadmium[b]	(3)	Mercury	(0.1)
Cerium	(1.6)	Thallium	(0.05)
Lanthanum	(0.9)	Europium	(0.04)

[a]Analytical values are based on the "dry weight" of material (See Instructions for Drying).

[b]Cadmium was not sufficiently homogeneous for certification.

Instructions for Drying: Samples of this Standard Reference Material *must* be dried before weighing by either of the following procedures:

1. Drying in air in an oven at 85 °C for 2 hours.
2. Lyophilization using a cold trap at or below −50 °C at a pressure *not greater* than 30 Pa (0.2 mm Hg) for 24 hours.

NOTE: Drying either in an oven at 105 °C or in a vacuum oven at 75°C causes large losses of volatiles other than water and should *not* be used.

Additional Information on Analyses: This Standard Reference Material contains siliceous material, which is an integral part of the sample. The analyses reported in Tables 1 and 2 were performed on the entire sample. Therefore, dissolution procedures should be capable of complete dissolution of the sample, but should not result in losses of volatile elements, such as arsenic and mercury.

Source and Preparation of Material: The plant material for this SRM was collected and prepared under the direction of A. L. Kenworthy of Michigan State University, East Lansing, Mich. Its source was a field plot of direct seeded tomatoes that had been established at the Horticultural Research Center of the University. For the preparation of the SRM, the terminal portions of the plants were clipped, air-dried, and ground in a comminuting machine. After grinding, the material was dried at 85 °C, thoroughly mixed in a feed blender, packaged in polyethylene-lined fiber drums, and sterilized in situ with cobalt-60 radiation. The sterilization procedure was carried out at the U.S. Army Research and Development Command, Natick, Mass. under the direction of A. Brynjolfsson. At NBS, a preliminary evaluation of the material homogeneity indicated that its improvement would be required to establish more reliable certified values. Therefore, the material was resieved and the portion that had passed a polypropylene sieve having openings of 0.25 mm (equivalent to a U.S. series 60 standard sieve) was retained for the SRM.

Homogeneity Assessment: Material homogeneity was evaluated by determining nine of the certified elements, P, Fe, Mn, Zn, Rb, Cu, Cr, As, and U on samples of 500 mg or less taken at various locations of the freeze-dried bulk material. The other certified elements, K, Ca, Sr, Pb, and Th were determined using sample weights not exceeding one gram. The uncertainties of the concentrations given in Table 1 include these results.

Analytical Methods Used and Analysts

Analytical Methods

A. Atomic absorption spectroscopy
B. Isotope dilution mass spectrometry
C. Isotope dilution spark source mass spectrometry
D. Kjeldahl method for nitrogen
E. Neutron activation
F. Nuclear track technique
G. Optical emission spectroscopy
H. Spectrophotometry
I. Polarography

(over)

Analysts

Analytical Chemistry Division, National Bureau of Standards

1. R. W. Burke
2. B. S. Carpenter
3. E. R. Deardorff
4. B. I. Diamondstone
5. L. J. Dunstan
6. M. S. Epstein
7. R. H. Filby
8. E. L. Garner
9. T. E. Gills
10. J. W. Gramlich
11. S. H. Harrison
12. R. M. Lindstrom
13. L. A. Machlan
14. L. T. McClendon
15. L. J. Moore
16. T. J. Murphy
17. P. J. Paulsen
18. T. C. Rains
19. H. L. Rook

Cooperating Analysts

20. Chemistry Division, Standards and Reference Substances Secretariat, Commission of European Communities, Joint Research Center, Ispra Establishment, Italy.

G. Serrini	E. Orthmann	F. Colombo
G. Renaux	R. Pietra	F. Girardi
W. Leyendecker	G. Guzzi	N. Toussaint

21. Y. Nemoto, K. Okamoto, and K. Fuwa, Division of Chemistry and Physics, National Institute for Environmental Studies, Yatabe, Ibaraki, Japan.

22. L. Kosta, Institute "Josef Stefan," Ljubljana, Yugoslavia.

23. J. B. Jones, Jr. and R. Isaac, University of Georgia, Athens, Georgia.

U.S. Department of Commerce
Elliot L. Richardson,
Secretary

National Bureau of Standards
Ernest Ambler, Acting Director

National Bureau of Standards
Certificate of Analysis
Standard Reference Material 1575

Pine Needles

This Standard Reference Material is intended primarily for calibrating instrumentation and evaluating the reliability of analytical methods for the determination of major, minor, and trace elements in botanical materials and other agricultural products.

Certified Values of Constituent Elements: The certified values for the constituent elements are shown in Table 1. They are based on results obtained either by reference methods of known accuracy or by two or more independent, reliable analytical methods. Non-certified values, which are given for information only, appear in Table 2. All values are based on a minimum sample size of 500 mg of the material dried as indicated under "Instructions for Drying."

Notice and Warnings to Users:

Expiration of Certification: This certification will be invalid 5 years after the shipping date. Should it be invalidated before then, purchasers will be notified by NBS.

Stability: The material should be kept in its original bottle and stored at temperatures between 10-30 °C. It should not be exposed to intense sources of radiation, including ultraviolet lamps or sunlight. Ideally, the bottle should be kept in a desiccator in the dark at the temperature indicated.

Use: The bottle should be shaken well before each use. A minimum sample of 500 mg of the *dried* material (see Instructions for Drying) should be used for any analytical determination to be related to the certified values of this certificate.

The overall direction and coordination of the technical measurements leading to this certificate were performed under the chairmanship of H. L. Rook. The overall coordination of the cooperative work performed by the Commission of European Communities, Joint Research Center, Ispra Establishment, Italy, was by G. Rossi of the Chemistry Division.

The technical and support aspects involved in the preparation, certification, and issuance of this Standard Reference Material were coordinated through the Office of Standard Reference Materials by T. W. Mears and R. Alvarez.

Washington, D.C. 20234
October 18, 1976

J. Paul Cali, Chief
Office of Standard Reference Materials

(over)

Table 1. Certified Values of Constituent Elements[a]

Major and Minor Constituents

Element	Content Wt. Percent
Calcium	0.41 ± 0.02
Potassium	0.37 ± 0.02
Phosphorus	0.12 ± 0.02

Trace Constituents

Element	Content μg/g	Element	Content μg/g
Manganese	675 ± 15	Copper	3.0 ± 0.3
Aluminum	545 ± 30	Chromium	2.6 ± 0.2
Iron	200 ± 10	Arsenic	0.21 ± 0.04
Rubidium	11.7 ± 0.1	Mercury	0.15 ± 0.05
Lead	10.8 ± 0.5	Thorium	0.037 ± 0.003
Strontium	4.8 ± 0.2	Uranium	0.020 ± 0.004

[a]Analytical values are based on the "dry-weight" of material (See Instructions for Drying).

The uncertainties of the values of the constituents shown in Table 1 include allowances for material inhomogeneity, method imprecision, and an estimate of possible biases of the analytical methods used.

Table 2. Non-certified Values for Constituent Elements[a]

NOTE: The following values are not certified because they are not based on the results of either a reference method of known accuracy or two or more independent methods. These values are included for information only.

Major Constituent

Element	Content Wt. Percent
Nitrogen	(1.2)

Trace Constituents

Element	Content μg/g	Element	Content μg/g
Bromine	(9)	Lanthanum	(0.2)
Nickel	(3.5)	Cobalt	(0.1)
Cerium	(0.4)	Thallium	(0.05)
Cadmium[b]	(<0.5)	Scandium	(0.03)
Antimony	(0.2)	Europium	(0.006)

[a]Analytical values are based on the "dry-weight" of material (See Instructions for Drying).

[b]Cadmium was not sufficiently homogeneous for certification.

Instructions for Drying: Samples of this Standard Reference Material *must* be dried before weighing by either of the following procedures:

1. Drying in air in an oven at 85 °C for 2 hours.
2. Lyophilization using a cold trap at or below −50 °C at a pressure *not greater* than 30 Pa (0.2 mm Hg) for 24 hours.

NOTE: Drying either in an oven at 105 °C or in a vacuum oven at 75°C causes large losses of volatiles other than water and should *not* be used.

Additional Information on Analyses: This Standard Reference Material contains siliceous material, which is an integral part of the sample. The analyses reported in Tables 1 and 2 were performed on the entire sample. Therefore, dissolution procedures should be capable of complete dissolution of the sample but should not result in losses of volatile elements, such as arsenic and mercury.

Source and Preparation of Material: The plant material for this SRM was collected and prepared under the direction of A. L. Kenworthy of Michigan State University, East Lansing, Mich. Its source was Manistee State Park, approximately 65 km north of Muskegon, Mich. For the preparation of the SRM, the material was air-dried, and ground in a comminuting machine. After grinding the material, it was dried at 85 °C, thoroughly mixed in a feed blender, packaged in polyethylene-lined fiber drums, and sterilized in situ with cobalt-60 radiation. The sterilization procedure was carried out at the U.S. Army Research and Development Command, Natick, Mass. under the direction of A. Brynjolfsson. At NBS, preliminary evaluation of the material homogeneity indicated that its improvement would be required to establish more reliable certified values. Therefore, the material was resieved and the portion that passed a polypropylene sieve having openings of 0.25 mm (equivalent to a U.S. series 60 standard sieve) was retained for the SRM.

Homogeneity Assessment: Material homogeneity was evaluated by determining ten of the certified elements, P, Al, Fe, Mn, Rb, Cu, Cr, As, Hg, and U on samples of 500 mg or less taken at various locations of the freeze-dried bulk material. The other certified elements, K, Ca, Sr, Pb, and Th were determined using sample weights not exceeding one gram. The uncertainties for the concentrations given in Table 1 include these results.

Analytical Methods Used and Analysts

Analytical Methods

A. Atomic absorption spectroscopy
B. Isotope dilution mass spectrometry
C. Isotope dilution spark source mass spectrometry
D. Kjeldahl method for nitrogen
E. Neutron activation
F. Nuclear track technique
G. Optical emission spectroscopy
H. Spectrophotometry
I. Polarography

(over)

Analysts

Analytical Chemistry Division, National Bureau of Standards

1. R. W. Burke
2. B. S. Carpenter
3. E. R. Deardorff
4. B. I. Diamondstone
5. L. J. Dunstan
6. M. S. Epstein
7. R. H. Filby
8. E. L. Garner
9. T. E. Gills
10. J. W. Gramlich
11. S. H. Harrison
12. R. M. Lindstrom
13. L. A. Machlan
14. E. J. Maienthal
15. L. T. McClendon
16. L. J. Moore
17. T. J. Murphy
18. P. J. Paulsen
19. H. L. Rook

Cooperating Analysts

20. Chemistry Division, Standards and Reference Substances Secretariat, Commission of European Communities, Joint Research Center, Ispra Establishment, Italy.

    G. Guzzi
    A. Colombo
    F. Girardi
    R. Pietra
    N. Toussaint

21. Y. Nemoto, K. Okamoto, and K.Fuwa, Division of Chemistry and Physics, National Institute for Environmental Studies, Yatabe, Ibaraki, Japan.
22. R. Schelenz, Federal Research Center for Nutrition, Karlsruhe, West Germany.
23. L. Kosta, Institute "Josef Stefan," Ljubljana, Yugoslavia.
24. J. B. Jones, Jr. and R. Isaac, University of Georgia, Athens, Georgia.

U. S. Department of Commerce
Malcolm Baldrige
Secretary

National Bureau of Standards
Ernest Ambler, Director

National Bureau of Standards

Certificate of Analysis

Standard Reference Material 1577a

Bovine Liver

This Standard Reference Material (SRM) is intended primarily for use in calibrating instrumentation and evaluating the reliability of analytical methods for the determination of major, minor, and trace elements in animal tissue and other biological matrices.

Certified Values of Constituent Elements: The certified values for the constituent elements are shown in Table 1. Certified values are based on results obtained by definitive methods of known accuracy; or alternatively, from results obtained by two or more independent analytical methods. Noncertified values are given for information only in Table 2.

Notice and Warnings to Users:

Expiration of Certification: This certification is invalid after 5 years from the date of shipping. Should it become invalid before then, purchasers will be notified by NBS.

Stability: The material should be kept in its original bottle and stored at temperatures between 10-30 °C. It should not be exposed to intense sources of radiation. The bottle should be kept tightly closed and stored in a desiccator in the dark.

Use: A minimum sample of 250 mg of the dried material (see Instructions for Drying) should be used for any analytical determination to be related to the certified values of this Certificate.

Dissolution procedures should be designed to effect complete solution, but without losses of volatile elements, such as mercury. Dissolution for these determinations should be carried out in a closed system.

Statistical consultation was provided by K.R. Eberhardt and T.R. Crichton of the Statistical Engineering Division.

The overall direction and coordination of the analyses leading to this certification were under the chairmanship of E.L. Garner, Chief of the Inorganic Analytical Research Division.

The technical and support aspects involved in the preparation, certification, and issuance of this Standard Reference Material were coordinated through the Office of Standard Reference Materials by R. Alvarez.

Gaithersburg, MD 20899
February 1, 1985
(Revision of Certificates
dated 3-5-82, 6-15-82)

Stanley D. Rasberry, Chief
Office of Standard Reference Materials

(over)

Table 1. Certified Values of Constituent Elements

Element	Content,[a] (Wt. Percent)
Chlorine	0.28 ± 0.01
Phosphorus	1.11 ± 0.04
Potassium*	0.996 ± 0.007
Sodium	0.243 ± 0.013
Sulfur	0.78 ± 0.01

Element	Content,[a] (μg/g)	Element	Content,[a] (μg/g)
Arsenic	0.047 ± 0.006	Mercury	0.004 ± 0.002
Cadmium	0.44 ± 0.06	Molybdenum	3.5 ± 0.5
Calcium	120 ± 7	Rubidium*	12.5 ± 0.1
Cobalt	0.21 ± 0.05	Selenium	0.71 ± 0.07
Copper	158 ± 7	Silver	0.04 ± 0.01
Iron	194 ± 20	Strontium*	0.138 ± 0.003
Lead*	0.135 ± 0.015	Uranium*	0.00071 ± 0.00003
Magnesium	600 ± 15	Vanadium*	0.099 ± 0.008
Manganese	9.9 ± 0.8	Zinc	123 ± 8

[a]Dry weight: For drying instructions, see the section of this Certificate on Instructions for Drying.

The estimated uncertainties are based on judgment and represent an evaluation of the combined effects of method imprecision, possible systematic errors among methods, and material variability for samples weighing 250 mg or more.

*For those elements determined by definitive methods, the uncertainties are given as 95%/95% statistical tolerance limits. See "The Role of Standard Reference Materials in Measurement Systems," NBS Monograph 148, 1975 p 14.

Table 2. Noncertified Values of Constituent Elements

Element	Content,[a] (Wt. Percent)
Nitrogen	(10.7)

Element	Content,[a] μg/g
Aluminum	(2)
Antimony	(0.003)
Bromine	(9)
Thallium	(0.003)

[a]Dry weight: For drying instructions, see the section of this Certificate on Instructions for Drying.

Instructions for Drying: Samples of this SRM must be dried before weighing according to the following procedure: Dry for 24 hours at 20 to 25 °C in a vacuum oven at a pressure not greater than 30 Pa (0.2 mm Hg).

Source and Preparation of Material:

The liver for this standard was obtained in the Portland, Oregon, area. The gross fat, major blood vessels, and "skin" were removed and the liver was ground. The ground liver was then mixed, transferred to polyethylene-lined trays, and lyophilized by Oregon Freeze Dry Foods, Inc., Albany, Oregon. After lyophilization, the liver was powdered in a Tornado mill, packaged in moisture-proof bags, and then transported to the National Bureau of Standards.

Analysts and Analytical Methods Used

Analytical Methods:

A. Atomic absorption spectrometry
B. Atomic emission spectrometry, flame
C. Atomic emission spectrometry, inductively coupled plasma
D. Ion chromatography
E. Isotope dilution thermal source mass spectrometry
F. Isotope dilution spark source mass spectrometry
G. Kjeldahl method for nitrogen
H. Neutron activation
I. Polarography
J. Spectrophotometry

Analysts:

Analytical Chemistry Division, National Bureau of Standards:

1. J.V. Bailey
2. I.L. Barnes
3. E.S. Beary
4. C.G. Blundell
5. K.A. Brletic
6. T.A. Butler
7. E.R. Deardorff
8. M.S. Epstein
9. J.D. Fassett
10. J.W. Gramlich
11. R.R. Greenberg
12. S. Hanamura
13. S.H. Harrison
14. E.F. Heald
15. W.R. Kelly
16. H.M. Kingston
17. W.F. Koch
18. G.M. Lambert
19. R.M. Lindstrom
20. G.J. Lutz
21. L.A. Machlan
22. E.J. Maienthal
23. T.J. Murphy
24. P.J. Paulsen
25. L.J. Powell
26. T.C. Rains
27. T.A. Rush
28. R.L. Watters, Jr.
29. R. Zeisler

Cooperating Analysts:

30. M. Gallorini and E. Orvini, Consiglio Nazionale delle Ricerche, Centro di Radiochimica e Analisi per Attivazione presso l' Instituto di Chimica Generale dell'Universita, Pavia, Italy.

31. L. Kosta, A.R. Byrne, M. Dermelj, Institute "Josef Stefan", Ljubljana, Yugoslavia.

NBS Technical Publications

Periodical

Journal of Research—The Journal of Research of the National Bureau of Standards reports NBS research and development in those disciplines of the physical and engineering sciences in which the Bureau is active. These include physics, chemistry, engineering, mathematics, and computer sciences. Papers cover a broad range of subjects, with major emphasis on measurement methodology and the basic technology underlying standardization. Also included from time to time are survey articles on topics closely related to the Bureau's technical and scientific programs. Issued six times a year.

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NOTE: The Journal of Physical and Chemical Reference Data (JPCRD) is published quarterly for NBS by the American Chemical Society (ACS) and the American Institute of Physics (AIP). Subscriptions, reprints, and supplements are available from ACS, 1155 Sixteenth St., NW, Washington, DC 20056.

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