Role of Standard Reference Materials in Measurement Systems

In 1906 the National Bureau of Standards started to issue samples of materials for standardizing analytical techniques and methods. Today, the NIST inventory of standard samples, which are issued under a NIST-registered trademark, SRM®, consists of over 230,000 units of more than 1300 different products. Each year nearly 34,000 units are sold to over 7000 customers, 30 % of whom are foreign. Each of the 1300 current SRMs is the result of collaboration between NIST and representatives of science and industry; thus SRMs serve as crucial reference points in establishing a comprehensive measurement system for the United States.

NBS Monograph 148, *The Role of Standard Reference Materials in Measurement Systems* [1], provides SRM users with a systems approach to meaningful measurements through which SRMs can be used to produce measurement results that are precise and whose systematic errors are either eliminated or well understood. Monograph 148 presents five major components of this approach; their relationships are depicted in Fig. 1.

The authors of Monograph 148 recognized the need to articulate the role of SRMs in the U.S. measurement system, to explain how SRMs are certified, and to clarify what a NIST certification means in both a legal and technical sense. For many years this document has assisted the growing number of SRM users in the proper use of SRMs, especially in countries that were in the process of developing a national measurement system of their own based on reference materials and reference methodology. Although reference materials represent only one aspect of the total measurement system, NIST SRMs have always been a key mechanism for transferring NIST science and technology through channels of industry and commerce.

Monograph 148 describes the important role that NIST SRMs play in the U.S. measurement system, in terms of both general and specific uses across a broad spectrum of analytical disciplines and areas of impact. In today's technologically advanced world, standardization is essential as measurements are applied to an ever-growing list of properties and materials. The eight authors of this monograph brought years of experience and knowledge from eight different measurement disciplines, including statistics, to the composition of the document. Such diversity has made the monograph

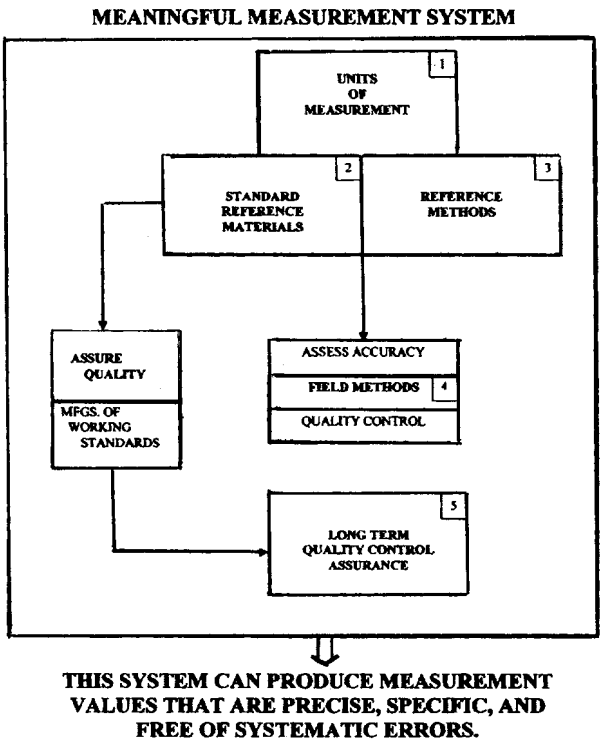

Fig. 1. Systems approach to the use of Standard Reference Materials in ensuring reliable measurements.

a classic reference among practitioners in the field of measurement systems.

The Role of Standard Reference Materials in Measurement Systems is divided into four sections plus appendices. The first section introduces the reader to the fundamentals of measurement and outlines a systematic approach to the process of obtaining measurements that are meaningful. Understanding such concepts allows one to understand the role that SRMs can play in a measurement system. While the introductory chapter provides the rationale for using SRMs, the second section discusses general concepts of usage, including the pitfalls that the user faces and their impact on measurement results. The third section provides users, especially new users, with a clear description of the SRM as a tool by which measurement methods, instruments, and systems can be validated or calibrated. The user is told how the pertinent information is condensed

into a certificate which provides qualitative statements and quantitative values, using data generated from tests and state-of-the-art measurements performed at NBS or a cooperating institution. The authors succinctly guide the users through the critical aspects of the SRM measurement and certification process. Realizing that the requirements for SRMs will become more exacting and complex in the future, the authors describe in section four the impact on standardization activities in five selected industries. Even today, those industries (metal, polymer, inorganic, clinical, nuclear) constitute areas where measurement needs are still in high demand or where requests for new types of reference materials have grown to unprecedented proportions.

The authors of NBS Monograph 148 provided the first documented account of a measurement system that would ensure meaningful measurements using standard Reference Materials as an integral part of the national measurement infrastructure. Monograph 148 continues to be used by practitioners and reference materials users, both nationally and internationally.

The authors represented a wide range of technical expertise. The principal author, J. Paul Cali, was Chief of the Office of Standard Reference Materials at NBS from 1966 to 1978, with responsibility to manage the production and certification of SRMs. Cali was an analytical chemist and an international authority on certification of reference materials, especially those used in environmental protection and clinical chemistry. The kinds of materials certified under Cali's direction included steel, non-ferrous alloys, Portland cement, glass, plastics, environmental, and clinical types. In a time when accuracy in measurement was becoming critical to quality assurance efforts, these SRMs had a decided impact in tens of thousands of laboratories on every continent.

In 1976, Cali received the DOC Exceptional Service Award (Gold Medal) for "highly effective leadership of the NBS Standard Reference Materials Program and improving clinical measurement standardization throughout the world." In the same year he was the recipient of the Edward Bennett Rosa Award, NBS/NIST's highest award for contributions to measurement advances.

Thomas W. Mears, an organic chemist, joined the Office of Standard Reference Materials in 1968 and coordinated the development of reference materials for high-octane gasoline, jet fuels, dielectric materials, and other hydrocarbon fuels. He was awarded the Department of Commerce Silver Medal for Meritorious Service for his research in synthesis, purification, and analyses during his career at NBS and for the development of a number of superior Standard Reference Materials and analytical methods.

Robert E. Michaelis joined NBS as a physicist in charge of spectrographic standard samples in 1952, after previous service as an engineering officer with the U.S. Air Force from 1942 to 1946 and as a technologist in charge of spectrochemical analysis in the U.S. Steel Research & Development Laboratory from 1947 to 1952. Beginning in 1963, he was assigned the major responsibility for the planning, preparation, testing and characterization for all metal Standard Reference Materials, certified either as to their chemical composition or their physical properties. Michaelis received many awards and honors, including the Meritorious Service Award (Silver Medal) from the Department of Commerce in 1963.

William P. Reed was supervisor of the Analytical Quality Control Laboratory at Hercules Powder Company before joining NBS in 1963 as a research chemist working in the field of Neutron Activation Analysis. In 1967, he was reassigned to the Office of Standard Reference Materials, where he coordinated reference materials activities in the nuclear and environmental fields. He also served two years as Chief of the Office of Standard Reference Materials. He was instrumental in establishing and maintaining cooperative programs between NBS and a number of foreign laboratories and organizations, including the International Atomic Energy Agency and the Geel Laboratory of the European Economic Community.

Richard W. Seward received a B.S. degree in engineering from the U.S. Military Academy in 1957 and joined NBS in 1963 as a technical editor/writer; he served as Managing Editor of the NBS Technical News Bulletin from 1965 to 1970. He was Technical Representative for Standard Reference Materials from 1970 to 1984 and Project Manager from 1984 to 1989. In 1982 he was awarded the DOC Bronze Metal "for outstanding management of Standard Reference Materials marketing and customer service activities."

Connie L. Stanley joined the National Bureau of Standards in 1954, conducting research in electroplating in the Electrodeposition Section of the Chemistry Division. He later worked as an organic chemist in the Engine Fuels Section of the Heat Division, where he was involved with the preparation of pure hydrocarbons and the determination of their physical properties. He joined the Office of Standard Reference Materials in 1972 as an SRM Coordinator for environmental standards.

H. Thomas Yolken was engaged in corrosion research in the Metallurgy Division from 1960 until 1966 and later was Special Scientific Assistant to the Director, Institute for Materials Research, involved in technical program planning. He was Deputy Chief, Office of Standard Reference Materials from 1971 to 1975 and

also Manager of the NBS Measurements for Nuclear Safeguards program. He was the author of more than 20 journal articles dealing with corrosion of metals, optics, Standard Reference Materials, and nuclear safeguards.

Harry Ku was a leading NBS statistician, who joined the Statistical Engineering Laboratory in 1958. He was very active in statistical consulting with Bureau scientists, combining his engineering background with his graduate education in the field of statistics. Ku's varied experience in support of experiments included problems of sampling the design for collection and reduction of data and the proper statement of uncertainties. Technical areas in which his assistance was important include nuclear and environmental standards, radioactive isotopes, and reference materials for biological use. He paid particular attention to the problem of minimization of technical effort necessary to achieve the accuracy required.

Prepared by Thomas E. Gills.

Bibliography

[1] J. P. Cali, T. W. Mears, R. E. Michaelis, W. P. Reed, R. W. Seward, C. L. Stanley, H. T. Yolken, and H. H. Ku, *The Role of Standard Reference Materials in Measurement Systems,* NBS Monograph 148, National Bureau of Standards, Washington, DC (1975).