

REPORT ON
STANDARD SAMPLES AND
RELATED MATERIALS FOR
SPECTROCHEMICAL ANALYSIS
1955

Compiled by
ROBERT E. MICHAELIS
NATIONAL BUREAU OF STANDARDS
FOR
ASTM COMMITTEE E-2 ON EMISSION SPECTROSCOPY

ASTM Special Technical Publication No. 58-C

**REPORT ON
STANDARD SAMPLES AND
RELATED MATERIALS FOR
SPECTROCHEMICAL ANALYSIS**

1955

Compiled by
ROBERT E. MICHAELIS
NATIONAL BUREAU OF STANDARDS

ASTM COMMITTEE E-2 ON EMISSION SPECTROSCOPY



Reg. U.S. Pat. Off.

ASTM Special Technical Publication No. 58-C

Price: \$2.75; to Members, \$2.00

Published by the
AMERICAN SOCIETY FOR TESTING MATERIALS
1916 Race St., Philadelphia 3, Pa.

Copyright, 1956
by the
AMERICAN SOCIETY FOR TESTING MATERIALS

NEW INFORMATION

New information concerning the availability of standard samples, reference samples, and high-purity materials should be directed to Robert E. Michaelis, Chairman, Task Group on Standards Report, Room 6, Chemistry Building, National Bureau of Standards, Washington 25, D. C.

FOREWORD

Quantitative spectrochemical analysis is based on comparison of unknown samples with standard samples of similar composition. Standard samples frequently are prepared by the analyst for the particular problem in hand; but, for the analysis of many common materials, particularly metals and alloys, standard samples have been prepared in quantities adequate for general distribution. The rapid growth of spectrochemical analysis and a corresponding increase in available standard samples call for a periodic compilation of types and sources of standards for the information of analysts.

In 1943 a report on available standard samples was prepared under the sponsorship of the War Metallurgy Committee by W. R. Brode. The report was revised by W. R. Brode and B. F. Scribner and published in October, 1944, by the American Society for Testing Materials. Since then Subcommittee IV on Standards and Pure Materials of the ASTM Committee E-2 on Emission Spectroscopy has undertaken to keep the report up to date. Revisions compiled by C. H. Corliss in 1947 and by C. H. Corliss and Alan Goldblatt in 1950 have been published. The current revision presents the results of a new survey conducted for Subcommittee IV by Robert E. Michaelis, National Bureau of Standards. The information is published to provide ready reference to the availability and sources of standard samples, reference samples, and high-purity materials. The numbers of available standard samples listed in the series of reports are as follows:

Year	Spectrographic Standards	Chemical Standards	Total
1944	210	103	313
1947	435	113	548
1950	632	120	752
1955	979 ^a	169	1148 ^a

^a An additional 152 standards are reported in the preparation stage.

The expanded listing of high-purity materials in the 1950 revision provided useful information to the analyst, particularly in the preparation of standards in the laboratory when other suitable standard samples were not available. The listings of high-purity materials in the series of reports are as follows:

Year	Entries	Sources
1950	325	43
1955	648	54

A new section has been added in the current revision to cover the available reference samples which are used principally for semiquantitative spectrochemical analysis. Some 150 reference samples are listed in this section.

The total number of entries of standard samples, reference samples, and high-purity materials in this report is 2100; this represents a twofold increase in the five-year period between revisions.

December, 1955

CONTENTS

Introduction:	
Scope and Form of the Report.....	1
Definitions and Nomenclature.....	1
Available Standard Samples:	
Aluminum and Aluminum-Base Alloys.....	5
Iron and Iron-Base Alloys.....	7
Magnesium-Base Alloys.....	9
Zinc, Lead, Tin, and Their Alloys.....	10
Copper and Copper-Base Alloys.....	12
Nickel-Base and Cobalt-Base Alloys.....	13
Miscellaneous Standard Samples.....	14
Standards of Steel-Making Alloys, Ores, Refractories, and Ceramic Materials Issued by the National Bureau of Standards.....	14
Standards of Steel-Making Alloys, Ores, Refractories, and Ceramic Materials Issued by the Bureau of Analysed Samples, Ltd.....	14
Ceramic Standards Issued by the Applied Research Laboratories.....	14
Diesel-Oil Contaminant and Metallo-Organic Compound Standards Issued by the National Spectrographic Laboratories.....	15
Tree-Leaf Standards Issued by Michigan State College.....	15
Summary of Suppliers and Types of Standard Samples.....	16
Available Reference Samples:	
Semiquantitative Reference Samples Issued by the Applied Research Labora- tories.....	59
Steel Reference Samples Issued by Hilger and Watts, Ltd.....	59
Nickel-Base Reference Samples Issued by the International Nickel Co.....	59
Reference Samples Issued by Johnson, Matthey and Co., Ltd.....	60
Metal Powders and Their Suppliers.....	60
Semiquantitative Reference Samples Issued by Spex Industries.....	60
Available High-Purity Materials.....	65
Appendices: Standard Samples in Preparation:	
I.—Apex Smelting Co. Spectrographic Aluminum Standards in Preparation..	85
II.—National Bureau of Standards Spectrographic Standards of Ingot Iron and Low-Alloy Steel in Preparation.....	86
III.—Bureau of Analysed Samples, Ltd., Spectrographic Standards of Mild Steels in Preparation.....	86
IV.—National Bureau of Standards-General Motors Corp. Spectrographic Zinc Standards in Preparation.....	87
V.—National Bureau of Standards Spectrographic Nickel-Oxide Standards in Preparation.....	87

STANDARD SAMPLES FOR SPECTROCHEMICAL ANALYSIS

INTRODUCTION

SCOPE AND FORM OF THE REPORT

This introduction presents a discussion of definitions and nomenclature. It is followed by the results of the survey on standard samples and related materials applicable in spectrochemical analysis. The survey on available materials is divided into three main sections:

Standard Samples

Reference Samples

High-Purity Materials

Descriptive information is given for the samples and materials currently available and also for those in the preparation stage. References are made to tables that list the compositions of the samples; for convenience, an alphabetical list of suppliers with addresses is given at the end of the descriptive sections on standard samples and high-purity materials.

The section on standard samples is subdivided into seven groups, as follows:

Aluminum and Aluminum-Base Alloys

Iron and Iron-Base Alloys

Magnesium-Base Alloys

Zinc, Lead, Tin, and Their Alloys

Copper and Copper-Base Alloys

Nickel-Base and Cobalt-Base Alloys

Miscellaneous Standard Samples

The standard samples appearing under the miscellaneous group include ceramic materials, steel-making alloys, ores, refractories, horticultural materials, and oil additives.

The new section on reference samples lists the available samples in this class and presents data on the elements, concentration ranges, and matrices.

The main portion of the section on high-purity materials is comprised of a table which lists in alphabetical order the high-purity materials available, the purity if known, a brief description of the material, and the supplier.

DEFINITIONS AND NOMENCLATURE

It is recognized that standard samples for spectrographic analysis differ in their accuracy and reliability and in the purposes for which they are designed. Accordingly, various terms applying to standard samples have come into general use. A complete system of terms has not yet been defined by official action and, therefore, the definitions and nomenclature presented in this report are subject to review and modification.

Materials used for comparison and reference purposes in spectrographic analysis may be divided into three groups:

1. Primary standard samples.
2. Secondary standard samples.
3. Reference samples.

The designation "standard" is reserved for samples that satisfy the rigid requirements of the following definition: A *standard sample* is a material closely resembling in chemical and physical nature the materials with which the analyst expects to deal, and one that has been analyzed and tested by a sufficient number of methods and analysts to establish its composition and reliability for the intended use.

Standard samples are divided into two classes, primary standards and secondary

standards, depending on the degree of general acceptability.

A standard sample is classified as a *primary standard sample* when the composition is certified by a recognized standardizing agency or group, generally as the weighted result of the work of two or more independent laboratories, and when, in addition, the reliability and limitations of its application for the intended analytical procedures have been determined.

The preparation of primary standards necessarily requires a considerable amount of work and usually involves the sponsorship of a recognized independent agency such as the National Bureau of Standards. However, a standard issued by a standardizing agency, while falling within the primary class for one intended use, may not satisfy this classification for other uses. For example, steel samples are issued in chip form with a certificate of analysis as primary standards for chemical analysis. It is not advisable to assume for another purpose—for example, spectrographic analysis—that an individual chip will have the average composition of a larger quantity of the standard. This use was not intended in establishing the standard, and further work would be necessary to investigate its reliability in the new application. The primary standard is issued with the intended use stated or implied, and care must be taken to insure that the standard is properly employed.

A standard sample is classified as a *secondary standard sample* when the composition is furnished by a single reputable source without independent check, or when the composition is well established but the standard has not been investigated thoroughly to determine the reliability and limitations under varied conditions of application.

Secondary standards are usually set up by an individual laboratory or company.

Standards of this class should not be considered necessarily inferior to primary standards but, rather, they lack independent check and the sanction of a recognized group. The criterion of a standard sample is its general acceptability as a reliable measure of composition in its intended use; and this, in the absence of further evidence, depends on the reputation and integrity of the source issuing the standard.

Standard samples prepared in chip form for chemical analysis have found considerable application as secondary standards in spectrochemical analysis in procedures in which the samples to be analyzed and the standards are converted to the same form; that is, pellets, solutions, or powders. To illustrate, it may be necessary on occasion to establish a point-to-plane (or point-to-point) technique of spectrochemical analysis for the determination of one or more elements for which solid spectrographic standards are not available but chip chemical standards are. By preliminary spectrochemical examination of the solid samples to be analyzed, a few may be selected that will provide a concentration range for the particular element or elements in question. Drillings or millings of the selected samples then may be analyzed in the form of pellets, solutions, or powders relative to the available chemical standards prepared in the same form. Finally, the results may be applied to the solid samples from which the drillings or millings were obtained, and the solid samples may be used in the point-to-plane technique for further spectrochemical analysis.

In the absence of primary or secondary standard samples it may be necessary to rely on reference samples of varying or unknown degrees of reliability. A *reference sample* is a material that may be employed usefully for comparison purposes

in analysis, but that has not been investigated to the extent that it falls within the class of either a primary or secondary standard.

A reference sample can be considered to act as a standard sample only in the sense that it supplies the need for a comparison material when a primary or secondary standard sample is not available. Reference samples would include those analyzed chemically by a routine method, alloys for which only the nominal compositions are available, samples prepared by synthesis and not checked by chemical analysis, samples supplied for comparison purposes to distinguish between "satisfactory" and "unsatisfactory" compositions, and samples for which the composition may have been carefully determined but which differ in the matrix or in the physical condition of the material or which have important differences in shape and size from the samples to be examined.

Terms have been defined here to distinguish between classes of standards and reference samples on the basis of their degree of general acceptability as comparison materials. In addition to these terms, descriptive or modifying names have been applied to such materials to indicate their specific applications in analytical procedures. The following examples may be cited:

1. Nominal-composition standards.
2. Analytical-range standards.
3. Specification-limit standards.
4. Working standards.
5. Control standards.

Standards having a composition representing a close approach to the desired or average composition are called *nominal-composition standards*.

Analytical-range standards are those in which the composition of the material is varied from the nominal composition of

the material for the the purpose of covering an expected range of composition.

Specification-limit standards or "go, no-go" standards are those selected or prepared so that the composition represents limiting specification values. Determinations falling within the limiting values are acceptable, while those falling outside of the limiting values are not acceptable. Standard samples used in this way for spectrographic analysis often permit rapid comparisons to determine the acceptability of samples under test.

A *working standard* is one employed in repeated applications where a considerable supply of the standard is required. Reference to the working standard usually serves to correct for small changes in the analytical procedure. This standard usually will be established by the laboratory engaged in the analysis and checked where possible against a primary or secondary standard from another source. It is not sufficient to make a cursory comparison of a material with other standards and then to use the material as a working standard; its homogeneity and composition should be well established. A working standard employed particularly in analysis for control of composition in large-scale production has been called a *control standard*.

In quantitative spectrochemical analyses, the importance of selecting standards that match closely the samples to be analyzed in size, shape, and metallurgical history cannot be overemphasized. For example, standards having the metallurgical structure resulting from hot or cold working may give erroneous results if applied to samples having a chill cast or unworked structure. Caution must be observed to evaluate any differences existing between standards and samples that may affect the reliability of the standards for the particular application.

AVAILABLE STANDARD SAMPLES

ALUMINUM AND ALUMINUM-BASE ALLOYS

A total of 549 standard samples is available for the spectrochemical analysis of aluminum and its alloys; in addition, 122 standards are reported in the preparation stage. Only four primary standards are available, and these are in the form of disks issued by the National Bureau of Standards. The remainder are secondary standards and consist of 201 disk samples from the Aluminum Company of America; 97 disk and rod samples from the Apex Smelting Co.; 99 rod samples from the Aluminum Laboratories Limited; 26 disk samples from Morris P. Kirk and Son, Inc.; 22 rod samples from Johnson, Matthey and Co., Ltd.; 5 chip samples from the Bureau of Analysed Samples, Ltd.; and 2 chip samples from the National Bureau of Standards.

Aluminum Standards Issued by the National Bureau of Standards:

The National Bureau of Standards has issued a set of four primary spectrographic standards of nominal composition for the analysis of aluminum alloys. The samples are in the form of disks $2\frac{1}{2}$ in. in diameter and approximately $\frac{3}{4}$ in. thick. The certified chemical compositions of the standards, given in Table 1,¹ are the average values of chemical determinations made at the National Bureau of Standards and the Aluminum Research Laboratories. Two aluminum-base alloy standards prepared in the form of turnings, primarily for chemical analysis, also are available from this source. The standards, listed in Table 2, have been employed in analyses involv-

ing solutions, powders, or pelleted forms. Full information concerning the values that are certified, the weights and the prices of all National Bureau of Standards standard samples, and the procedure to be followed in purchasing is contained in National Bureau of Standards Circular 552. This circular is obtainable upon application to the Standard Sample Clerk, National Bureau of Standards, Washington 25, D. C.

Aluminum Standards Issued by the Aluminum Company of America:

The aluminum standards of the Aluminum Company of America (Alcoa standards) are divided into three general classifications distinguished by the letters prefixing the numerical designation of the individual standards. The prefix "SA" denotes standards for the analysis of primary or wrought aluminum alloys, or both; "SAC" indicates standards for casting alloy analysis; and "SS" marks standards prepared specifically for continual analytical curve checking or instrument calibration in the analysis of the more important grades of aluminum.

Standards are usually stocked in sets containing as few as three or as many as nine individual standards. Each set consists of one "SS" standard having a composition typical of the alloy and two or more "SA" or "SAC" standards containing higher and lower amounts of each element ordinarily determined in the alloy. The range of composition covered by a set is, in most cases, slightly greater than that encountered in commercial production. A list of the sets of standards available is given in Table 3.

¹ Tables 1 to 43 appear on pp. 18 to 58.

The "SS" standards may be obtained individually, and the alloys and the standard designations for these are listed in Table 4. The "SA" and the "SAC" standards used as members of the regular sets are not listed individually because they are usually ordered in sets and because of the rapid turnover of the small quantity of any one standard produced.

A group of miscellaneous "SA" and "SAC" standards is listed in Table 5. The group is subject to frequent change and is included only to provide an example of the assortment that may be obtained from this source.

All three types of the standards are in the form of disks $2\frac{1}{2}$ in. in diameter and 1 in. thick. With few exceptions, the standards are prepared from rapidly chilled "continuous cast" ingots. The standards are of almost ideal uniformity within the areas recommended for sparking. Each standard is carefully screened by spectrochemical examination to pass rigid requirements with respect to precision. The assignment of composition is based on chemical analyses of the standard as determined by umpire-type chemical methods and on spectrochemical comparison with previously prepared standards of the same type.

All of these spectrochemical standards are intended for the analysis of chill-cast disk samples with a high-voltage spark and a graphite counter electrode according to the methods of the Aluminum Company of America. These methods are described in the following literature:

- (1) "Selected Topics in Modern Instrumental Analysis," edited by David F. Bolz, Prentice Hall (1952).
- (2) Method of Spectrochemical Analysis of Aluminum and Aluminum-Base Alloys by the Point-to-Plane Spark Technique (ASTM Designation: E 101 - 53 T).²
- (3) Suggested Method for Spectrochemical Analysis of Aluminum and Its Alloys

by the Point-to-Plane Spark Technique, Using a Tape-Indicating Spectrometer (E-2 SM 7-6).²

All orders for Alcoa spectrochemical standards should be placed through Aluminum Company of America sales offices. A booklet, "Alcoa Spectrochemical Standards Bulletin," available from any sales office, contains a list of those standards currently available, technical information about the standards, and instructions for ordering.

Aluminum Standards Issued by the Apex Smelting Co.:

The Apex Smelting Co. has prepared sets of standards for the analysis of aluminum-base alloys. They are available in disk form $2\frac{1}{2}$ in. in diameter and $\frac{1}{2}$ in. thick and in rods 4 mm in diameter and 2 to 3 in. long. The disks have been cast in an iron mold. To maintain the matrix material nearly constant in each set of standards, no single standard contains all of the maximum impurities. The standards are listed in Table 6, which includes the Apex and ASTM designations of the alloy types, and the chemical analysis. The standards may be obtained from the Apex Smelting Co., 2537 W. Taylor St., Chicago 12, Ill.; 6700 Grant Ave., Cleveland 5, Ohio; and 2211 E. Carson St., Long Beach 10, Calif.

In addition to the standards listed in Table 6, a large number of new aluminum standards are in the preparation stage at Apex and are listed in Appendix I.

Aluminum Standards Issued by Aluminium Laboratories Limited:

A typical list of standard samples prepared by Aluminium Laboratories Limited is given in Table 7. Table 8 is a list of standards prepared in sets particularly for the determination of the minor elements indicated. The standard samples are in the form of chill-cast rods $\frac{1}{4}$ in. in diameter and approximately 1 in. long,

² "Methods for Emission Spectrochemical Analysis," Am. Soc. Testing Mats. (1953).

and are issued in pairs. They are prepared for the analysis of samples of comparable metallurgical history by either self-electrode or counter-electrode spectrochemical techniques. Actual chemical compositions are quoted. The standards may be obtained from the Analytical Division, Aluminium Laboratories Limited, P. O. Box 645, Arvida, Quebec, Canada. The specific standard samples desired should be specified in ordering, but qualified with "or their equivalent" so that the current series may be substituted when necessary.

Aluminum Standards Issued by Morris P. Kirk and Son, Inc.:

Morris P. Kirk and Son, Inc., has prepared sets of standards for the spectrochemical analysis of some of the popular types of aluminum alloys. The standards are available in disk form $2\frac{1}{2}$ in. in diameter and $\frac{1}{2}$ in. thick, and are recessed in the center portion, leaving a raised ring for sparking. The ring extends inward $\frac{1}{2}$ to $\frac{3}{8}$ in. from the periphery of the disk. Table 9 gives the composition of the standards, which are issued only in sets for the particular alloy type. The standards may be obtained from Morris P. Kirk and Son, Inc., 2717 So. Indiana St., Los Angeles 23, Calif.

Aluminum Spectrographic Standards Issued by Johnson, Matthey and Co., Ltd.:

Five sets of aluminum alloys have been specially prepared by the British Aluminium Co., Ltd., and are available for issue from Johnson, Matthey and Co., Ltd., Hatton Garden, London, England; the standards also are distributed by the Jarrell-Ash Co., 26 Farwell St., Newtonville 60, Mass. The sets consist of a graded series of standards designed for the analysis of chill-cast rod samples of aluminum and aluminum alloys. The standards are in the form of rods $\frac{1}{2}$ in. in diameter and approximately $5\frac{1}{2}$ in. long.

The ranges of concentration for elements contained in the standards are shown in Table 10. The results of chemical analyses made by the British Aluminium Co., Ltd., are quoted in a report accompanying the standards. In addition, full details are provided on the techniques adopted in the Johnson-Matthey spectrographic laboratory for intercomparison of the standards, together with a statement of the results obtained.

Aluminum Standards Issued by the Bureau of Analysed Samples, Ltd.:

Five aluminum-base standards in chip form, designed primarily for chemical analysis, are available from the Bureau of Analysed Samples, Ltd., and are listed in Table 11. These may be useful for spectrochemical analyses involving solutions, powders, and pelleted forms. Information concerning the standards may be obtained by writing to: Bureau of Analysed Samples, Ltd., Newham Hall, Middlesbrough, Yorkshire, England; or to the Jarrell-Ash Co., 26 Farwell St., Newtonville 60, Mass.

IRON AND IRON-BASE ALLOYS

A total of 173 standard samples is available for the spectrochemical analysis of iron and steel; in addition, 23 standards are reported in the preparation stage. Both the available standards and those in preparation are from two sources, the National Bureau of Standards and the Bureau of Analysed Samples, Ltd. Primary spectrographic standards as well as primary chemical standards are available from the two sources. The various iron and steel standards are discussed in detail below.

Iron and Steel Standards Issued by the National Bureau of Standards:

National Bureau of Standards Ingot Iron and Low-Alloy Steel Spectrographic

Standards.—The standards for the spectrochemical analysis of ingot iron and low-alloy steel are listed in Table 12. The groups of standards with sample numbers 401 to 421 and 801 to 821 consist of 37 samples, of which 22 are rods $\frac{7}{8}$ in. in diameter and 4 in. long, and 15 are rods $\frac{1}{2}$ in. in diameter and 2 in. long. The steel standards, which have a carbon content between 0.1 and 0.9 per cent, are intended for primary checking of Mn, Si, Cu, Ni, Cr, V, Mo, Al, Sn, Co, and W in the various types of steels involved. In addition, the ranges of concentration permit the establishing of analytical curves for all of the elements listed except for Co and W.

The standards with sample numbers 425 to 430 and 825 to 830 provide, respectively, a set of four rod samples $\frac{7}{8}$ in. in diameter and a set of five rod samples $\frac{1}{2}$ in. in diameter for the determination of boron in steel in the range of concentrations given in Table 12.

The $\frac{7}{8}$ -in. rods are intended for use as self electrodes in the analysis of rods prepared in closely matching size and shape for the point-to-point technique of spectrochemical analysis.

The $\frac{1}{2}$ -in. rods are intended for use in the analysis of samples by the point-to-plane technique of spectrochemical analysis. Samples with cross-sections larger than $\frac{1}{2}$ in. in diameter may be analyzed with the $\frac{1}{2}$ -in. standards, provided that the latter are mounted in a supporting piece such as a disk $2\frac{1}{2}$ in. in diameter and $\frac{3}{4}$ in. thick, drilled near the edge with holes to fit the standard closely and equipped with set screws to lock the standard in place. The standards should be mounted with the circular cross-section flush in one surface of the disk and may be cleaned and spacked in this position.

Eight new ingot iron and low-alloy primary steel standards are in the preparation stage. These standards, when

available (1956), will be issued as rods $\frac{7}{8}$ in. in diameter, and in a new size—disks $1\frac{1}{2}$ in. in diameter and $\frac{3}{4}$ in. thick. The standards have been designed to supplement and extend existing National Bureau of Standards standards; certification is planned for 22 elements in the concentration ranges indicated in Appendix II.

National Bureau of Standards Stainless-Steel Spectrographic Standards.—Two groups of standards for the spectrochemical analysis of stainless steel are available from the National Bureau of Standards. The first group consists of three standards, in the form of rods $\frac{7}{8}$ in. in diameter and 4 in. long. The standards are of the 18 chromium-8 nickel type of stainless steel and are certified for the following nine minor and trace elements: Al, B, Cu, Mo, Nb, Pb, V, W, and Zn. Four additional elements—Co, Sn, Ti, and Zr—also are present in the standards and may be certified at a later date. The standards are shown in Table 13.

The second group of stainless steel standards consists of six standards in the form of rods $\frac{7}{8}$ in. in diameter and 4 in. long, and rods $\frac{1}{2}$ in. in diameter and 2 in. long. The standards are certified for the following six major and minor elements: Mn, Si, Cu, Ni, Cr, and Mo. Other elements present include Al, Nb, Sn, Ti, V, and W; some of these may be certified at a later date. The metallurgical condition of the standards is that resulting from hot-rolling and annealing. The standards, listed in Table 14, are designed for primary checking of the elements contained in the types of stainless steel indicated and for establishing analytical curves. The standards are intended for the analysis of stainless-steel samples with similar metallurgical history and dimensions. For the $\frac{1}{2}$ -in.-diameter standards, adapters such as those described earlier (see the section on iron and steel standards) may be necessary in the

analyses of samples of larger cross-section, particularly with arc-like excitation conditions.

National Bureau of Standards Tool-Steel Spectrographic Standards.—A group of six high-speed tool-steel standards, shown in Table 15, is available from the National Bureau of Standards in the form of rods $\frac{3}{8}$ in. in diameter and 4 in. long, and rods $\frac{1}{2}$ in. in diameter and 2 in. long. The standards are certified for Mn, Si, Cu, Cr, V, Mo, Co, and W. A wide concentration range is provided for these elements by combining three standard American Iron and Steel Institute types of tool steel with three tool steels of tailored compositions. The metallurgical condition of the standards is that resulting from hot-rolling and annealing. The standards are intended for the analysis of molybdenum and tungsten high-speed tool-steel samples having similar metallurgical history and dimensions.

National Bureau of Standards Iron and Steel Chemical Standards.—A wide variety of standards in chip form is available from the National Bureau of Standards. These standards, shown in Table 16, include cast iron, plain carbon steels, and low- and high-alloy steels. The standards are designed primarily for chemical standards. However, as described earlier, these may be useful as spectrographic standards.

Iron and Steel Standards Issued by the Bureau of Analysed Samples, Ltd.:

Bureau of Analysed Samples, Ltd., Low-Alloy Steel Spectrographic Standards.—A set of eight standards for the spectrochemical analysis of low-alloy steel, shown in Table 17, is available from the Bureau of Analysed Samples, Ltd., England. The standards may be obtained also through the Jarrell-Ash Co. The standards, available only in sets, are in the form of rods $\frac{1}{2}$ in. in diameter and 6 in. long, and are certified for Mn, Si, Cu,

Ni, Cr, V, Mo, Sn, Al, and Co. The ranges of concentration for the elements permit the establishing of analytical curves for the analysis of most low-alloy steel samples.

The same series of low-alloy steels also is available in the form of turnings and forms a useful set of standards for constructing graphs in photometric methods of analysis. The samples of turnings may be used as spectrographic standards for the analysis of samples prepared in the same form; that is, pellets, solutions, or powders.

Seven new spectrographic standards referred to as the "mild steel residual series" are in the preparation stage. These standards, when available in late 1955 or early 1956, will be issued in the form of rods $\frac{3}{4}$ in. in diameter and 3 in. long. The preliminary analyses of these proposed primary standards are listed in Appendix III.

Bureau of Analysed Samples, Ltd., Iron and Steel Chemical Standards.—A wide variety of standards in chip form is available from the Bureau of Analysed Samples, Ltd. The standards, listed in Tables 18 and 19, consist of 8 cast irons, 17 carbon steels, 13 alloy steels, and a special series of 8 low-alloy steels which are the turnings from the primary spectrographic standards described above. The chip standards are designed primarily for chemical analysis and as such are primary standards; however, they may be useful as spectrographic standards as described earlier.

MAGNESIUM-BASE ALLOYS

A total of 93 secondary standards is available for the spectrochemical analysis of magnesium alloys. The Dow Chemical Co. has available 24 standards in the form of extruded bars and 8 standards in two forms, chill-cast disks and rods. Two groups of standards are available from the Aluminum Company of America in

the form of chill-cast disks. These consist of 9 standards of nominal composition for specific alloys and 21 miscellaneous standards. The Apex Smelting Co. has eleven standards available in two forms, disks and rods. One standard in the form of turnings is available from the National Bureau of Standards. A* detailed description of the available standards follows.

Magnesium Standards Issued by the Dow Chemical Co.:

Two groups of standards are available from the Dow Chemical Co. for the spectrochemical analysis of magnesium alloys. The first group consists of 24 standards in the form of extruded bars $\frac{3}{4}$ in. wide, 6 in. long, and $\frac{1}{4}$ in. thick. The standards are listed in Table 20 in which concentrations are reported for Al, Ca, Cu, Fe, Mn, Ni, Pb, Si, Sn, Zn, Zr, Ce, La, Nd, and Pr. The second group consists of eight standards supplied in two forms: chill-cast disks $2\frac{1}{2}$ in. in diameter and rods $\frac{1}{4}$ in. in diameter and 2 in. long. Analyses are reported for Th, Zn, and Zr in this group, as shown in Table 21. Information concerning the use of the standards and procedure for ordering may be obtained from the Magnesium Sales Department, Dow Chemical Co., Midland, Mich.

Magnesium Standards Issued by the Aluminum Company of America:

Magnesium standards available from the Aluminum Company of America are chill-cast disks $2\frac{1}{2}$ in. in diameter and $\frac{1}{8}$ in. thick. The castings are made in a special mold having a centrally located gate, so that the castings may be sparked around a continuous ring area.

Table 22 lists a group of nine standards whose compositions are typical for the alloys shown. They are intended primar-

ily for the checking and correction of analytical curves.

The standards shown in Table 23 are available for the preparation of analytical curves. The availability of specific standards should be confirmed through an Alcoa sales office before ordering.

Magnesium Standards Issued by the Apex Smelting Co.:

Three sets of standards for the analysis of magnesium casting alloys are available from the Apex Smelting Co. in the form of disks $2\frac{1}{2}$ in. in diameter and $\frac{1}{4}$ in. thick, and rods 4 mm in diameter and 2 to 3 in. long. The Apex magnesium standards are listed in Table 24, with the Apex and ASTM designations of alloy types and chemical analysis of each standard.

Magnesium Standard Issued by the National Bureau of Standards:

One magnesium-base alloy standard in the form of turnings is available from the National Bureau of Standards. This standard is designed primarily for chemical analysis and, as such, is a primary standard. The composition is given in Table 25.

ZINC, LEAD, TIN, AND THEIR ALLOYS

Groups of 74 zinc standards, 55 lead standards, and 15 tin standards are available for use in spectrochemical methods of analysis. In addition, seven new zinc standards are reported in the preparation stage. Secondary standards in disk form are obtainable from Morris P. Kirk and Son, Inc., and include standards of zinc, lead, and tin. The National Bureau of Standards has available one zinc-base standard and one lead-base standard, both in chip form, and five primary standards of tin metal standards in the form of rods of two sizes. In addition, seven primary zinc standards are in

preparation. Secondary standards in both disk and rod form are available from the Apex Smelting Co. for a variety of zinc-base alloys. The Goldsmith Bros. Smelting and Refining Co. has available 18 secondary standards of lead-base alloys in disk form. Two standards in chip form may be obtained from the Bureau of Analysed Samples, Ltd., one a lead-base alloy and the other a tin-base alloy. A description of the standards follows.

Zinc, Lead, and Tin Standards Issued by Morris P. Kirk and Son, Inc.

Standards in the form of disks $2\frac{1}{2}$ in. in diameter and $\frac{1}{8}$ in. thick are available from Morris P. Kirk and Son, Inc., and include standards of zinc-base die-casting alloys, zinc metal, soft and chemical lead, lead-antimony alloys, linotype and electrolyte lead, and lead-base and tin-base babbitts. The disk standards are recessed in the center part, leaving a raised ring extending inward $\frac{1}{2}$ to $\frac{3}{4}$ in. from the periphery of the disk. The standards, listed in Table 26, include some that are issued only in sets of two or three as indicated. The standards are intended for the spectrochemical analysis of chill-cast disk samples of the various materials listed.

Zinc, Lead, and Tin Standards Issued by the National Bureau of Standards:

One zinc-base die-casting alloy standard and one lead-base alloy standard are available from the National Bureau of Standards. These standards, in the form of turnings, are designed primarily for chemical analysis and, as such, are primary standards; however, they may be used as secondary spectrographic standards as described earlier.³

A group of ten primary analytical-range standards is available for the spectrochemical analysis of tin metal. The standards were prepared by casting the molten metal in plaster molds followed

by rolling and swaging to the final cross-section. The rods were tested for homogeneity by spectrochemical means. Certified values of composition for ten elements were obtained from the cooperative efforts of four spectrographic and four chemical laboratories. The standards are available in two sizes: rods $\frac{1}{2}$ in. in diameter and 4 in. long, and rods $\frac{1}{2}$ in. in diameter and 2 in. long.

Table 27 lists the available National Bureau of Standards zinc, lead, and tin standards.

The seven new zinc standards in the preparation stage consist of six for the spectrochemical analysis of ASTM die-casting alloys XXIII and XXV, and one for the spectrochemical analysis of zinc spelter. The latter standard also is designed to supplement the six die-casting standards for the determination of impurities. The standards, when available (1956), will be issued in the form of bar sections $1\frac{1}{2}$ in. square and $\frac{1}{4}$ in. thick, and will have a chill-cast structure resulting from a continuous casting process. These standards are being prepared in cooperation with the General Motors Corp. Appendix IV lists the concentration ranges for the die-casting alloy standards and the approximate analysis of the spelter standard.

Zinc Standards Issued by the Apex Smelting Co.:

Three sets of standards for the analysis of zinc-base die-casting alloys, one set of miscellaneous zinc standards, two sets for the analysis of pure zinc metal, and one set for the analysis of slush metal (for hollow castings) are available from the Apex Smelting Co. These standards are in the form of both disks and rods. The disks are $2\frac{1}{2}$ in. in diameter and $\frac{1}{4}$ in. thick, and were prepared by casting in an iron mold. The rods have been drawn up in Pyrex tubing and are approximately 4 mm in diameter and 2 to 3 in. long. The Apex

³ See p. 2.

zinc standards are listed in Table 28, together with the Apex and ASTM designations of the alloy types and the chemical analysis of each standard.

Lead Standards Issued by the Goldsmith Bros. Smelting and Refining Co.:

These standards for the analysis of mill-cast lead-base alloy samples are in the form of disks $2\frac{1}{2}$ in. in diameter and $\frac{1}{8}$ in. thick, and have a depressed center $\frac{1}{8}$ in. in diameter. The nominal compositions of the standards are given in Table 29; the exact analyses, which may vary slightly from the nominal values shown, accompany the standards on issue. The standards have been checked by spectrographic and chemical methods of analysis at the Goldsmith Bros. Smelting and Refining Co. and by at least one other private chemical or spectrographic laboratory. The standards may be obtained from the Goldsmith Bros. Smelting and Refining Co., 1300 West 59th St., Chicago 36, Ill.

Lead and Tin Standards Issued by the Bureau of Analysed Samples, Ltd.:

Two standards in chip form are available from the Bureau of Analysed Samples, Ltd., one a lead-base alloy and the other a tin-base alloy. These standards, designed primarily for chemical analysis, are listed in Table 30.

COPPER AND COPPER-BASE ALLOYS

A total of 46 secondary spectrographic standards is available for the spectrochemical analysis of copper and its alloys. Johnson, Matthey and Co., Ltd., has prepared three graded series of copper alloys for use in the analysis of high-purity and commercial-grade copper. Twenty-one standards are in the form of rods and three in the form of triangular segments. The Applied Research Laboratories has available a set of ten disk standards for the analysis of brass and

bronze alloys. Standards in chip form are available from both the National Bureau of Standards and the Bureau of Analysed Samples, Ltd. A detailed description of the available standards follows.

Copper Standards Issued by Johnson, Matthey, and Co., Ltd.:

Three graded series of copper alloys have been prepared by Johnson, Matthey and Co., Ltd., for use as standards in the spectrochemical analysis of high-purity and commercial-grade copper. To produce the standards, three master alloys containing (nominally) 0.05 per cent of each added element were prepared using lithium as a deoxidizer. Each series was obtained by successive dilutions with Matthey pure copper, the ingots being melted and cast in vacuum. The composition ranges covered by the three series of standards are shown in Table 31. Nine standards are included in each of the first two series and six in the third.

With the exceptions of the first three standards in the first series, the samples are in the form of rods $\frac{1}{8}$ in. in diameter and $3\frac{1}{2}$ in. long. However, some material also is available in the form of $\frac{1}{4}$ -in. diameter rods. It was found impossible to work the ingots for the first three standards in the first series, and these are supplied as 30-deg sectors having a radius of approximately 1 in. and a thickness of $\frac{1}{16}$ in. The standards may also be obtained through the Jarrell-Ash Co.

Copper Standards Issued by the Applied Research Laboratories:

The Douglas Aircraft Co. and the Applied Research Laboratories have prepared and standardized a group of ten brasses and bronzes that are being issued in the form of disk samples. They are intended primarily for the analysis of commercial rolled stock, and are guaranteed for such analysis only when used with the point-to-plane method of direct