NBS SPECIAL PUBLICATION 260-25

Standard Reference Materials:

A STANDARD REFERENCE MATERIAL CONTAINING NOMINALLY FOUR PERCENT AUSTENITE

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards

UNITED STATES DEPARTMENT OF COMMERCE • Maurice H. Stans, *Secretary*
NATIONAL BUREAU OF STANDARDS • Lewis M. Branscomb, *Director*

Standard Reference Materials:

A Standard Reference Material Containing Nominally Four Percent Austenite

G. E. Hicho, H. Yakowitz,
S. D. Rasberry, and R. E. Michaelis

Institute for Materials Research
National Bureau of Standards
Washington, D.C. 20234

U.S. National Bureau of Standards Special Publication 260-25

Nat. Bur. Stand. (U.S.), Spec. Publ. 260-25, 22 pages, (Feb. 1971)
CODEN: XNBSA

Issued February 1971

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402
(Order by SD Catalog No. C13.10:260-25), Price 30 cents.

PREFACE

Standard Reference Materials (SRM) as defined by the National Bureau of Standards are "well-characterized materials, produced in quantity, that calibrate a measurement system to assure compatability of measurement in 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. In many industries traceability of their quality control process 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 all phases of the preparation, measurement, and certification 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. It is also hoped that these papers will 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 concerned with the availability, delivery, price, and so forth will receive prompt attention from:

Office of Standard Reference Materials
National Bureau of Standards
Washington, D.C. 20234

J. Paul Cali, Chief
Office of Standard Reference Materials

NBS Misc. Publ. 260, Standard Reference Materials: Catalog and Price List of Standard Materials Issued by the National Bureau of Standards, January 1968. 45 cents.* (Supersedes NBS Misc. Publ. 241, March 1962.)

NBS Misc. Publ. 260-1, Standard Reference Materials: Preparation of NBS White Cast Iron Spectrochemical Standards, June 1964. 30 cents.*

NBS Misc. Publ. 260-2, Standard Reference Materials: Preparation of NBS Copper-Base Spectrochemical Standards, October 1964. 35 cents.*

NBS Misc. Publ. 260-3, Standard Reference Materials: Metallographic Characterization of an NBS Spectrometric Low-Alloy Steel Standard, October 1964. 20 cents.*

NBS Misc. Publ. 260-4, Standard Reference Materials: Sources of Information on Standard Reference Materials, February 1965. 20 cents.*

NBS Misc. Publ. 260-5, Standard Reference Materials: Accuracy of Solution X-Ray Spectrometric Analysis of Copper-Base Alloys, March 1965. 25 cents.*

NBS Misc. Publ. 260-6, Standard Reference Materials: Methods for the Chemical Analysis of White Cast Iron Standards, July 1965. 45 cents.*

NBS Misc. Publ. 260-7, Standard Reference Materials: Methods for the Chemical Analysis of NBS Copper-Base Spectrochemical Standards, October 1965. 60 cents.*

NBS Misc. Publ. 260-8, Standard Reference Materials: Analysis of Uranium Concentrates at the National Bureau of Standards, December 1965. 55 cents.*

NBS Misc. Publ. 260-9, Standard Reference Materials: Half Lives of Materials Used in the Preparation of Standard Reference Materials of Nineteen Radioactive Nuclides Issued by the National Bureau of Standards, November 1965. 15 cents.*

NBS Misc. Publ. 260-10, Standard Reference Materials: Homogeneity Characterization on NBS Spectrometric Standards II: Cartridge Brass and Low-Alloy Steel, December 1965. 30 cents.*

NBS Misc. Publ. 260-11, Standard Reference Materials: Viscosity of a Standard Lead-Silica Glass, November 1966. 25 cents.*

NBS Misc. Publ. 260-12, Standard Reference Materials: Homogeneity Characterization of NBS Spectrometric Standards III: White Cast Iron and Stainless Steel Powder Compact, September 1966. 20 cents.*

NBS Misc. Publ. 260-13, Standard Reference Materials: Mössbauer Spectroscopy Standard for the Chemical Shift of Iron Compounds, July 1967. 40 cents.*

NBS Misc. Publ. 260-14, Standard Reference Materials: Determination of Oxygen in Ferrous Materials -- SRM 1090, 1091, and 1092, September 1966. 30 cents.*

NBS Misc. Publ. 260-15, Standard Reference Materials: Recommended Method of Use of Standard Light-Sensitive Paper for Calibrating Carbon Arcs Used in Testing Textiles for Colorfastness to Light, June 1967. 20 cents.*

NBS Spec. Publ. 260-16, Standard Reference Materials: Homogeneity Characterization of NBS Spectrometric Standards IV: Preparation and Microprobe Characterization of W-20% Mo Alloy Fabricated by Powder Metallurgical Methods, January 1969. 35 cents.*

NBS Spec. Publ. 260-17, Standard Reference Materials: Boric Acid; Isotopic and Assay Standard Reference Materials, February 1970. 65 cents.*

NBS Spec. Publ. 260-18, Standard Reference Materials: Calibration of NBS Secondary Standard Magnetic Tape (Computer Amplitude Reference) Using the Reference Tape Amplitude Measurement "Process A", November 1969. 50 cents.*

NBS Spec. Publ. 260-19, Standard Reference Materials: Analysis of Interlaboratory Measurements on the Vapor Pressure of Gold (Certification of Standard Reference Material 745), January 1970. 30 cents.*

NBS Spec. Publ. 260-20, Standard Reference Materials: Preparation and Analysis of Trace Element Glass Standards, (in process).

NBS Spec. Publ. 260-21, Standard Reference Materials: Vapor Pressure, Silver and Cadmium, (in process).

NBS Spec. Publ. 260-22, Standard Reference Materials: Homogeneity Characterization of Iron - 3 Wt. Pct. Silicon Alloy, (in process).

NBS Spec. Publ. 260-23, Standard Reference Materials: Viscosity of a Standard Borosilicate Glass, (in process).

NBS Spec. Publ. 260-24, Standard Reference Materials: Comparison of Redox Standards, (in process).

*Send orders with remittance to: Superintendent of Documents, U.S. Government Printing Office, Washington, D. C. 20402. Remittance from foreign countries should include an additional one-fourth of the purchase price for postage.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

A STANDARD REFERENCE MATERIAL CONTAINING NOMINALLY FOUR PERCENT AUSTENITE

G. E. Hicho, H. Yakowitz,
S. D. Rasberry and R. E. Michaelis

Institute for Materials Research
National Bureau of Standards
Washington, D. C. 20234

This standard was produced by powder metallurgical techniques using known amounts of austenite. Using these techniques, 134 specimens were prepared. Because these standards are expected to be used primarily for the calibration of X-ray diffraction equipment, only one surface of each standard is certified, and these surfaces range from 3.1 percent to 5.2 percent in austenite content. To make the specimens, 310 stainless steel powder (austenitic) was blended with 430 stainless steel powder (ferritic) to make a mixture of 5 percent austenite in ferrite. The material was compacted, sintered, polished and etched so the austenite appears white and the ferrite, a deep brown. Then quantitative microscopy methods were used to determine the percentage of austenite near the surface. Furthermore, the 310 powder contains 20 percent of nickel while the 430 powder contains virtually no nickel. Therefore, after establishing a meaningful calibration curve, X-ray fluorescence analysis for the nickel content was also used as a direct measurement of the amount of austenite on the surface of the compact. Both procedures were carried out on fifteen specimens statistically selected from the total number of compacts produced. Agreement, within experimental error limits, was obtained between the X-ray fluorescence results and quantitative microscopy results. The X-ray fluorescence method was used to characterize all additional compacts. X-ray diffraction determinations of austenite content are in good agreement with the X-ray fluorescence and quantitative microscopy results. The compacts may be used as X-ray diffraction standards for austenite or in special cases as X-ray fluorescence standards for nickel content.

Key words: Austenite in ferrite; electron microprobe; powder metallurgy; quantitative microscopy; SRM: X-ray fluorescence analysis.

INTRODUCTION

Standard reference materials for retained austenite determination are required because the amount of retained austenite in ferrous material critically affects metallurgical properties. The percentage of retained austenite in ferrous materials is usually determined by X-ray diffraction procedures requiring an accurate measurement of the integrated intensity under two or three selected diffraction peaks. As the amount of retained austenite decreases, however, the accuracy of the intensity measurement deteriorates. Therefore, the National Bureau of Standards has undertaken to produce a series of standards containing from 1 to 25 percent austenite. The first of these standards is now ready for issue. This standard was prepared by means of powder metallurgical methods.

The purpose of this report is to give a detailed description of the preparation and characterization of the present group of 134 specimens. Because completely homogenous blending of the austenite and ferrite powders used to make the compacts can not be achieved, despite considerable effort, each of the 134 specimens has been separately characterized for austenite content.

GENERAL DESCRIPTION OF THE STANDARD

This standard was prepared by mixing 5 percent by weight of fully austenitic stainless steel powder (type 310) with ferritic stainless steel powder (type 430). Large amounts of chromium and nickel are contained in the 310 stainless steel. Hence, the diffusion of a portion of these elements into the 430 stainless steel would not be expected to alter the austenite structure of the 310 stainless steel. The compact is 20.6 mm (13/16 in.) diameter by 2.54 mm (0.100 in.) thick. One surface is polished and etched so that the austenite is white and the ferrite is a deep brown.

It is this surface which has been characterized with respect to austenite content.

The standard is issued with one surface certified for austenite content. No surface preparation is necessary. In fact, damage to the certified face renders the sample useless. The lowest actual amount of austenite in the certified faces of the samples is 3.1 percent, and the highest value is 5.2 percent.

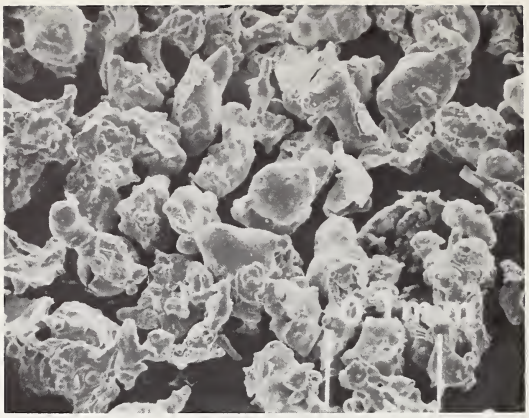
PREPARATION OF THE COMPACTS

The starting powders were irregularly shaped but uniformily sized. The entire lot of 310 powder passed through a 53 μm sieve but none passed through a 44 μm sieve. All the 430 powder passed a 44 μm sieve but none passed a 37 μm sieve. Figure 1 shows the starting powder particles in detail. The chemical analysis of the powders is shown in table 1.

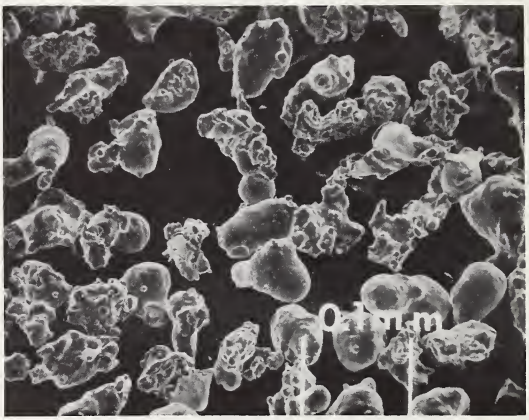
Table 1. Chemical Analysis of Starting Powder Particles - Content in Weight Percent.

Elements	310 Stainless Steel	430 Stainless Steel
Chromium	24.99	16.03
Nickel	20.41	0.09
Iron	53.5	83.5
Carbon	0.05	0.05
Manganese	0.20	0.10
Phosphorus	0.01	0.011
Sulfur	0.007	0.01
Silicon	0.75	0.40

Each step in the preparation of the compacts is shown in the flow diagram given in figure 2. The structure of the final compact was examined by optical and scanning electron microscopy. Figure 3 shows typical microstructural details. The compacts contain several percent porosity and



a



b

Figure 1. Scanning electron micrographs of the starting powders.
a. As received 310 stainless steel powder-fully austenitic.
b. As received 430 stainless steel powder-ferritic.

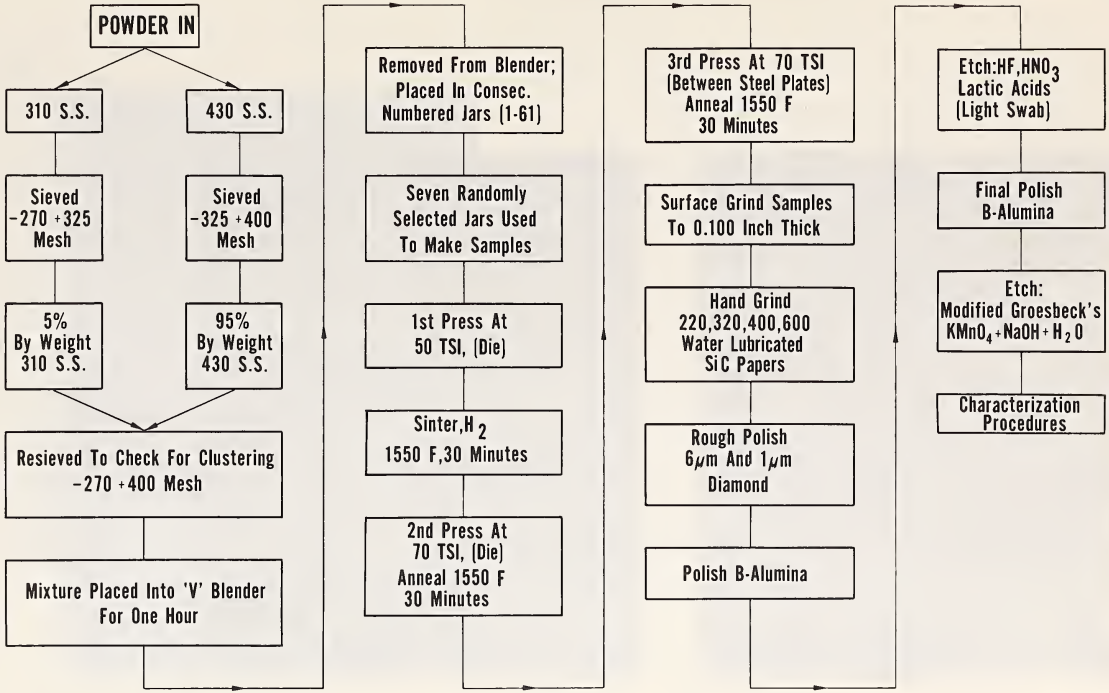
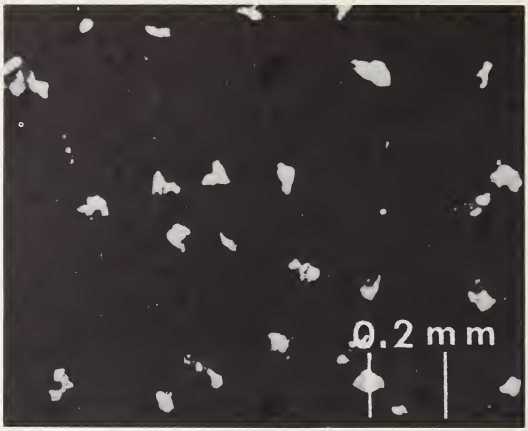


Figure 2. Fabrication steps for SRM-485.
(One TSI = 2000 lb/in.)



a

b

Figure 3. Structure of finished compacts - etched.
a. Optical micrographs showing austenite (white) and ferrite (black).
b. Scanning electron micrograph showing sharp delineation between large austenite particles and ferritic matrix.

the 310 particles are large islands in a matrix of ferritic material. Scanning electron microscopy shows that there is a sharp delineation between the austenitic particles and the ferritic matrix as is evident in figure 3b. Modified Groesbeck's etchant (sample immersed in boiling etchant of 30 g $KMnO_4$, 30 g NaOH, and 100 ml distilled H_2O) covers the ferritic material with a friable layer of what is perhaps a mixed oxide while the austenite is unaffected. The final compact then appears as a dark brown ferritic matrix with randomly placed austenite particles and some pores.

A section through one of the compacts is shown in figure 4. No important agglomeration of austenitic particles is seen throughout the section. However, it is clear that random cuts within the section may yield different percentages of austenite when a single surface is characterized - as is done in X-ray diffraction or optical microscopy. Consequently, one face of each specimen was characterized and that face only is certified with respect to its austenite content.

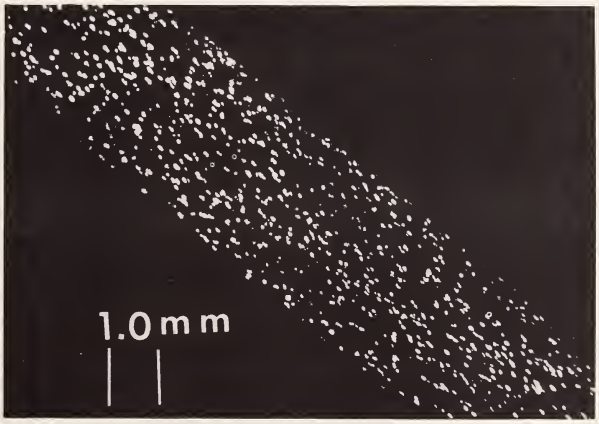


Figure 4. Cross-section of typical compact.

There is virtually no nickel in the ferritic powder while the austenitic powder contains 20.4 percent nickel by weight. Therefore, if there is no diffusion of nickel into the ferrite during the fabrication process, X-ray fluorescence analysis for the nickel content of the compact can be used as a direct measure of the austenite content. For X-ray fluorescence analysis to be successful however, a set of standards is required to calibrate nickel (austenite) content versus X-ray intensity.

The electron probe microanalyzer was used to determine whether or not any diffusion of nickel into the ferritic matrix had occurred. The microprobe operating voltage was 20 kV and the Ni-Kα peak was monitored with a LiF crystal-sealed proportional detector system. About fifteen separate austenite-ferrite interfaces were examined. The nickel count rate in the austenite was approximately 4500 counts/second. A typical trace through an austenite particle is shown in figure 5. The nickel signal goes from near zero (ferritic) to full signal (austenitic) in a space of about 3 μm. This value is approximately the spatial resolution of the X-ray signal from the microprobe. No measureable diffusion of nickel into the ferritic matrix was observed. Also it was noted that the nickel content within a given austenite particle and from particle-to-particle was nearly constant.

To establish the X-ray intensity versus nickel (austenite) content calibration curve, five special powder compacts were prepared. These nominally contained 0, 10, 15, 20, and 25 percent austenite. One of the compacts to be certified was also picked for this purpose. Except for the completely ferritic specimen, these compacts were evaluated by quantitative microscopy to determine their austenite content. The same austenite compacts also were examined by X-ray diffraction (1).

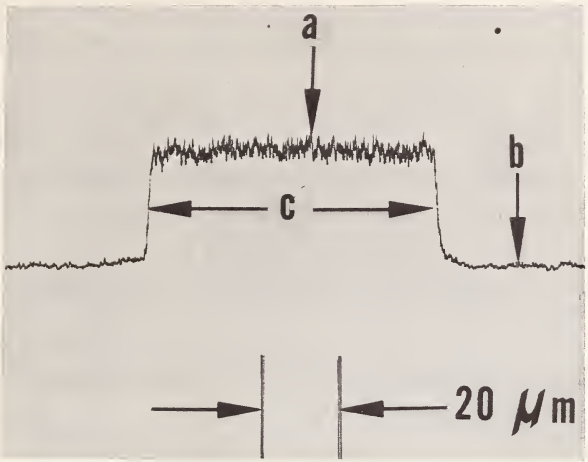


Figure 5. Strip-chart recording of Ni-Kα signal vs. position in microprobe trace: a = Ni-signal in austenite particle, b = Ni-signal in ferritic matrix, c = Ni-signal at austenite-ferrite matrix. Full scale about 10,000 counts/second.

Quantitative microscopy could be used because the modified Groesbeck's etchant provides a complete color separation of the austenite (white) and ferrite (brown). Thus, the percentage white phase (austenite) can be determined provided a porosity correction is made. Since the pores are "black" the porosity correction readily can be made. The porosity of the specimens averages about five percent.

Two quantitative microscopy devices were used to characterize the calibration specimens: a high-precision NBS drum-scanner (2); a quantitative television microscope, (QTM). The NBS drum-scanner required 203 x 254 mm (8 x 10 in.) high contrast micrographic prints as input. Final magnifications were at 125 diameters. Thus, a region 1.62 x 2.03 mm

on the specimen was examined. Five such areas were chosen for each specimen which is only about five percent of the total area of the specimen.

By means of the QTM, more than 95 percent of the surface could be sampled. In the QTM, an image of the actual specimen is observed on a television monitor. The QTM then reads percentage white, i.e., austenite in that field. The working frame size on the monitor is 198 mm x 225 mm and the specimen image is magnified 198 diameters. Under these conditions, 80 fields cover almost the entire surface. The average of the 80 austenite determinations gives the austenite percentage on the surface. Care is taken so that successive areas do not overlap.

Extensive tests over a period of two months using three different operators indicated that QTM drift was not a serious problem. However, the absolute white-black threshold did seem to vary with time and operator. Exhaustive studies of a previous set of four compacts having a nominal austenite content of 5 percent indicated a standard deviation of 0.23 percent.

The drum-scanner is far more precise than the QTM but the scanner samples only 5 percent of the surface. Hence, in establishing the calibration curve for X-ray fluorescence, the drum-scanner and QTM values are given equal weight. Table 2 gives the results.

Table 2. Determinations for Establishing X-ray Calibration Curve of Figure 6.

Method \ Nominal Austenite Weight Percentage	5	10	15	20	25
Drum scanner	-	8.83	15.37	19.04	31.44
QTM	4.90	10.04	16.04	18.05	27.11
Calibration curve value	4.90	9.6	15.7	18.0	29.8
X-ray diffraction	4.8	9.4	16.0	17.6	28.3

The calibration curve established with the results in table 2 is shown in figure 6. The equation of the least squares fitted curve is:

$$C_{Ni}(\%)=-0.0332+2.687\times10^{-4}I+3.156\times10^{-8}I^2-1.21\times10^{-12}I^3 \quad (1)$$

where I is the Ni-Kα signal in counts per second.

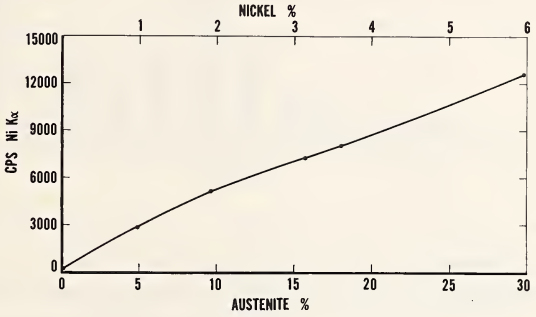


Figure 6. Calibration curve for X-ray fluorescence analysis characterization of SRM-485.

At low nickel (austenite) values, a definite departure from linearity exists. We believe that this is due to the pronounced grain size effect caused by having discrete nickel X-ray emitters scattered throughout the surface. These emitters vary considerably in size and distribution as the absolute nickel content increases. Claisse and Samson (3) have discussed similar effects. Because of this specific nickel distribution, more nickel intensity is observed than would be the case if the nickel were in solution in an iron-base matrix. The X-ray self absorption is considerably reduced by concentrating the nickel into discrete particles in the matrix.

Equation 1 was used to establish the nickel content and hence the austenite content of all 134 specimens. The X-ray fluorescence results were obtained on two different days, but all samples were run at least once on each day. The X-ray results are based on three determinations of Ni-Kα count rate. Standards were rerun approximately once every 90 minutes. No significant drift of the X-ray fluorescence unit was noted. The operating conditions were as follows:

X-ray tube: Tungsten
Crystal : LiF
Voltage : 44 kV
Current : 44 ma
Detector : Scintillator @ 1000 volts
Collimator: Fine

Specimens were placed in an air path. The primary X-ray beam nearly irradiated the entire specimen face.

As a final test, fifteen specimens were run individually on the QTM. The comparison of X-ray and QTM results is shown in table 3. The agreement is considered satisfactory.

Table 3. Comparison of QTM and X-ray Fluorescence Results.

Specimen Number	QTM[a] Results	Std. Error QTM	X-ray[a] Results	Std. Error X-ray
5	3.9	0.32	4.2	0.01
9	4.0	0.02	3.7	0.03
19	4.4	0.04	4.0	0.01
21	3.8	0.24	3.7	0.02
42	4.0	0.28	4.0	0.01
49	4.4	0.34	3.8	0.01
69	4.7	0.37	4.2	0.02
71	5.4	0.40	4.6	0.03
80	4.4	0.27	4.0	0.04
81	3.5	0.17	3.9	0.01
86	3.3	0.22	4.2	0.05
117	3.1	0.36	3.2	0.08
119	3.5	0.30	3.6	0.04
128	5.0	0.41	4.4	0.04
141	4.6	0.51	4.2	0.05

[a]Given in percent austenite.

To show the overall distribution of the results, a histogram of number of samples versus austenite composition was plotted for the entire population of 134 specimens as shown in figure 7.

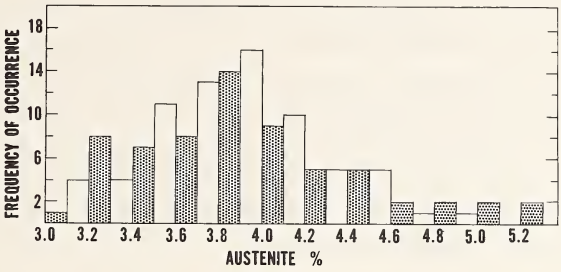


Figure 7. Number of samples in each composition range from 3.0 to 5.3 percent austenite. The total population of 134 standard samples is represented.

CONCLUSIONS

SRM-485 is satisfactory for issuance as a standard for X-ray diffraction determination of retained austenite at the 3 to 5 precent austenite range. In special cases, SRM-485 also may be used as an X-ray fluorescence standard for determining the nickel content in nickel-iron or nickel-chromium-iron composites.

SRM-485 should not be used as a standard for quantitative microscopy. For single field determinations, too few austenite particles are present for statistically meaningful results. Average values for many fields often give unacceptably large standard errors as shown in table 3.

In using SRM-485 care must be taken not to alter the certified face.

ACKNOWLEDGEMENTS

The authors thank Dr. M. R. Meyerson for his guidance in the initial stages of this program. His help in choosing appropriate steel powders, blending times, sintering temperatures, and die pressures, is greatly appreciated.

The authors also thank Dr. G. A. Moore for assistance with the NBS drum-scanner, and Dr. K. F. J. Heinrich for the use of the microprobe. Special thanks are due to D. Harne for extensive metallographic aid, to C. J. Bechtoldt for the X-ray diffraction determinations, and to D. B. Ballard for aid with the scanning electron microscope. Thanks also are given to Dr. E. Passaglia, Dr. J. Filliben and Dr. H. Ku for helpful discussions.

REFERENCES

[1] Ogilvie, R. E., Retained Austenite by X-rays, Norelco Reporter, VI, 3, 60 (1959).

[2] Moore, G. A., Automatic Scanning and Computer Processes for the Quantitative Analysis of Micrographs and Equivalent Subjects, Pictorial Pattern Recognition, p. 275 (Thompson Book Co., Washington, D. C., 1968).

[3] Claisse, F., and Samson, C., Heterogeneity Effects in X-ray Analysis, Advances in X-ray Analysis, 5, p. 335, (1962).

Latest developments in the subject area of this publication, as well as in other areas where the National Bureau of Standards is active, are reported in the NBS Technical News Bulletin. See following page.

HOW TO KEEP ABREAST OF NBS ACTIVITIES

Your purchase of this publication indicates an interest in the research, development, technology, or service activities of the National Bureau of Standards.

The best source of current awareness in your specific area, as well as in other NBS programs of possible interest, is the TECHNICAL NEWS BULLETIN, a monthly magazine designed for engineers, chemists, physicists, research and product development managers, librarians, and company executives.

If you do not now receive the TECHNICAL NEWS BULLETIN and would like to subscribe, and/or to review some recent issues, please fill out and return the form below.

(cut here)

Mail to: Office of Technical Information and Publications
National Bureau of Standards
Washington, D. C. 20234

Name _____

Affiliation _____

Address _____

City _____ State _____ Zip _____

☐ Please send complimentary past issues of the Technical News Bulletin.

☐ Please enter my 1–yr subscription. Enclosed is my check or money order for $3.00 (additional $1.00 for foreign mailing).
Check is made payable to: SUPERINTENDENT OF DOCUMENTS.

SP 260–25

NBS TECHNICAL PUBLICATIONS

PERIODICALS

JOURNAL OF RESEARCH reports National Bureau of Standards research and development in physics, mathematics, chemistry, and engineering. Comprehensive scientific papers give complete details of the work, including laboratory data, experimental procedures, and theoretical and mathematical analyses. Illustrated with photographs, drawings, and charts.

Published in three sections, available separately:

• Physics and Chemistry

Papers of interest primarily to scientists working in these fields. This section covers a broad range of physical and chemical research, with major emphasis on standards of physical measurement, fundamental constants, and properties of matter. Issued six times a year. Annual subscription: Domestic, $9.50; foreign, $11.75*.

• Mathematical Sciences

Studies and compilations designed mainly for the mathematician and theoretical physicist. Topics in mathematical statistics, theory of experiment design, numerical analysis, theoretical physics and chemistry, logical design and programming of computers and computer systems. Short numerical tables. Issued quarterly. Annual subscription: Domestic, $5.00; foreign, $6.25*.

• Engineering and Instrumentation

Reporting results of interest chiefly to the engineer and the applied scientist. This section includes many of the new developments in instrumentation resulting from the Bureau's work in physical measurement, data processing, and development of test methods. It will also cover some of the work in acoustics, applied mechanics, building research, and cryogenic engineering. Issued quarterly. Annual subscription: Domestic, $5.00; foreign, $6.25*.

TECHNICAL NEWS BULLETIN

The best single source of information concerning the Bureau's research, developmental, cooperative and publication activities, this monthly publication is designed for the industry-oriented individual whose daily work involves intimate contact with science and technology—*for engineers, chemists, physicists, research managers, product-development managers, and company executives.* Annual subscription: Domestic, $3.00; foreign, $4.00*.

* Difference in price is due to extra cost of foreign mailing.

NONPERIODICALS

Applied Mathematics Series. Mathematical tables, manuals, and studies.

Building Science Series. Research results, test methods, and performance criteria of building materials, components, systems, and structures.

Handbooks. Recommended codes of engineering and industrial practice (including safety codes) developed in cooperation with interested industries, professional organizations, and regulatory bodies.

Special Publications. Proceedings of NBS conferences, bibliographies, annual reports, wall charts, pamphlets, etc.

Monographs. Major contributions to the technical literature on various subjects related to the Bureau's scientific and technical activities.

National Standard Reference Data Series. NSRDS provides quantitative data on the physical and chemical properties of materials, compiled from the world's literature and critically evaluated.

Product Standards. Provide requirements for sizes, types, quality and methods for testing various industrial products. These standards are developed cooperatively with interested Government and industry groups and provide the basis for common understanding of product characteristics for both buyers and sellers. Their use is voluntary.

Technical Notes. This series consists of communications and reports (covering both other agency and NBS-sponsored work) of limited or transitory interest.

Federal Information Processing Standards Publications. This series is the official publication within the Federal Government for information on standards adopted and promulgated under the Public Law 89–306, and Bureau of the Budget Circular A–86 entitled, Standardization of Data Elements and Codes in Data Systems.

Order NBS publications from: Superintendent of Documents
Government Printing Office
Washington, D.C. 20402

U.S. DEPARTMENT OF COMMERCE
WASHINGTON, D.C. 20230

OFFICIAL BUSINESS

PENALTY FOR PRIVATE USE, $300

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF COMMERCE