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Foreword to the Print Edition

ASM International is proud to mark the 75th anniversary of ASM Handbooks. In 1923, the American Society for Steel Treating (later the American Society for Metals, now ASM International) published a small loose-leaf collection of data sheets—the first edition of what became known as Metals Handbook. The series has developed over the years into a multivolume collection of reference books—each volume a thorough, comprehensive, and authoritative treatise on the subject to which it is devoted. The series—now titled ASM Handbook—continues to evolve and expand to serve the changing needs of metallurgy professionals throughout the world. One example of this evolution is the release this year of the ASM Handbook on CD-ROM.

This year also marks the 50th anniversary of the classic 1948 edition of Metals Handbook—the last “regular” edition to be contained in one volume. The 1948 edition was the inspiration for the first Metals Handbook Desk Edition, published almost 15 years ago. This Second Edition is intended to serve the same function as its two predecessors: to provide an accessible, convenient, and practical single-volume first reference to all of metals technology.

It was with some trepidation that ASM International entered into the project to revise and update the Desk Edition. The task seemed overwhelming. The ASM Handbook series had grown to 20 current volumes—almost twice as many as were in existence when the first Desk Edition was compiled. Would it be possible to create a work that included all of the vital information from the first edition, plus the most significant knowledge and data compiled in the years since its release, and still remain within the physical limits of a single volume?

We believe that the new Metals Handbook Desk Edition more than meets that objective. The credit for this monumental achievement belongs to Joseph R. Davis. Joe was Handbook Editor for many years at ASM, and his extraordinary knowledge of the handbooks along with his considerable editorial skills made him uniquely qualified to oversee this project. We are grateful to Joe for his hard work and for his commitment to creating the best Desk Edition possible. To assist in this effort, Joe assembled an outstanding Editorial Advisory Board, made up of many longtime handbook contributors and friends of ASM, and we extend our thanks to them as well. We also wish to recognize the ASM editorial and production staff members for their dedicated efforts on this Volume.

Of course, we are especially grateful to the thousands of metallurgy professionals who have contributed to ASM Handbooks over the past 75 years. Their willingness to share their knowledge and expertise—as authors, reviewers, volume organizers, and Handbook Committee members—has made this book possible. With their ongoing support, ASM Handbooks will continue to thrive for at least another 75 years.
Preface

The Metals Handbook Desk Edition is intended to serve as a comprehensive single-volume reference source on the properties, selection, processing, testing, and characterization of metals and their alloys. Although the information presented in this Volume is drawn principally from the 20 volumes of the ASM Handbook series, it should not be considered simply an abridged version of the larger work. Instead, the Metals Handbook Desk Edition draws upon the complete arsenal of ASM products--both print and electronic--as well as other key sources of information originating from other publications, company literature, technical societies, and government agencies.

Volume Content

Because of the familiarity, success, and ease-of-use of the original Desk Edition published in 1984, it was determined from the outset of the project that the editorial approach and outline for the new edition should follow in a similar manner. The challenge in successfully revising the first edition was to determine what strategic additions (or reductions) and improvements should be made. Complicating this task was the fact that a complete edition cycle of the ASM Handbook (including completely new volumes on corrosion, tribology, materials characterization, and other topics) had been published since the earlier edition was produced. To ensure that the best product possible resulted from the revision/updating process, a 12-member Editorial Advisory Board representing industry, academia, and research laboratories was formed. All board members have been key contributors to the Handbook series or have been involved with other important ASM activities over the past decade. Under their guidance, an outline was established for the second edition that divided the book into five major parts: General Information; Irons, Steels, and High-Performance Alloys; Nonferrous Alloys and Special-Purpose Materials; Processing; and Testing, Inspection, and Materials Characterization.

General Information contains a glossary of more than 3000 terms, a collection of common engineering tables, and graphs comparing properties of metals and nonmetals. It also includes contributions on crystal structure, practical uses of phase diagrams, engineering design, and factors to be considered in the materials selection process.

Irons, Steels, and High-Performance Alloys. Emphasis is placed on properties and selection of ferrous alloys and heat-resistant superalloys. Important relationships between structure and properties in irons and steels are described. The effects of modern steelmaking practices on properties are examined, as is the influence of improved melting/refining methods on superalloy performance. New or expanded information is presented on austempered ductile irons, high-strength low-alloy steels, stainless steels (including duplex stainless steels), and powder metallurgy steels.

Nonferrous Alloys and Special-Purpose Materials comprises 14 major sections that describe the properties and selection of conventional (structural) nonferrous alloys and materials used for such special-purpose applications as magnetic or electrical devices, biomedical devices, and advanced aircraft/aerospace components. Metal-matrix composites and structural intermetallics--more recently developed materials not covered in the previous Desk Edition--are also described.

Processing. Processes extending through the entire life-cycle of a component are described, including extractive metallurgy, casting, forming, heat treatment, joining, surface cleaning, finishing and coating, and recycling. An entirely new section on powder metallurgy has also been added. The increased coverage of recycling technology reflects the response of the metals industry to environmental concerns.

Testing, Inspection, and Materials Characterization. In addition to offering information on failure analysis, fractography, nondestructive testing, mechanical testing, and metallography, a new section describes in practical terms the selection of characterization methods for bulk elemental analysis, bulk microstructural analysis, and surface analysis. New information on wear testing and tests for evaluating stress-corrosion cracking and hydrogen embrittlement is also presented.

Acknowledgments
Before acknowledging contributors to the present volume, it is important to recognize the outstanding work of the first edition's editors: Timothy L. Gall and Howard E. Boyer (sadly, Howard passed away in 1990). Tim was truly the driving force behind the original Desk Edition. His vision, combined with Howard's superlative technical craftsmanship, resulted in what most consider the "flagship" publication of ASM.

In order to build upon the foundation of the first edition, the present editor had to call on many old friends and colleagues. In addition to serving on the Editorial Advisory Board, the following individuals were major contributors to the second edition: Kenneth H. Eckelmeyer (Sandia National Laboratories) authored the Section "Materials Characterization" and co-authored the article "Very High Density Metals." Ken, who has contributed numerous handbook articles over the years, was also a key member of the Organizing Committee for Materials Characterization, Volume 10 of the ASM Handbook, published in 1986. George F. Vander Voort (Buehler Ltd.) revised the Section "Metallography" and contributed to the Section "Fractography." George, who is the most prolific author in the 75 year history of the Metals/ASM Handbook, has contributed definitive reviews on embrittlement mechanisms in irons and steel, the use of light microscopy for metallographic and fractographic analysis, and image analysis for quantitative determination of microstructural constituents. Rodney R. Boyer (Boeing Commercial Airplane Group) revised the Section "Titanium and Titanium Alloys" and helped revise other articles throughout the Handbook that deal with titanium alloys. Rod also served as the principal editor of the Materials Properties Handbook: Titanium Alloys, published by ASM in 1994. Thomas S. Piwonka (University of Alabama) authored the Section "Casting," Tom also served as a section chairman and contributing author for Casting, Volume 15 of the ASM Handbook, published in 1988. Peter J. Blau (Oak Ridge National Laboratory) authored the article "Wear Testing." Peter also served as volume chairman of Friction, Lubrication, and Wear Technology, Volume 18 of the ASM Handbook, published in 1992.

Other notable contributors include Hugh Baker (Consulting Editor, ASM International), who authored the Section "Structure and Properties of Metals" and reviewed the Section "Magnesium and Magnesium Alloys." Hugh, who served on the Handbook staff from 1970 to 1979, was also the editor of Alloy Phase Diagrams, Volume 3 of ASM Handbook, published in 1992. Matthew J. Donachie (Rensselaer at Hartford) and Stephen J. Donachie (Special Metals Corporation) revised the Section "Superalloys." Matt, who edited the Superalloys Source Book published by ASM in 1984, also authored the article "Biomaterials." Erhard Klar (OMG Americas, retired) authored the Section "Powder Metallurgy" and reviewed several other P/M-related articles. Erhard also served as volume coordinator of Powder Metallurgy, Volume 7 of the ASM Handbook, published in 1984. Brajendra Mishra (Colorado School of Mines) authored the Sections "Steelmaking Practices and Their Influence on Properties" and "Extractive Metallurgy." John C. Bittence (Welshfield Studios) revised the Section "Recycling and Life-Cycle Analysis" and assisted in editing the Sections "Forming" and "Forging."

The efforts of the ASM staff must also be acknowledged. In particular, I would like to thank veteran technical editors Steven R. Lampman and Edward J. Kubel, Jr. for their help in completing the Sections "Failure Analysis," "Nondestructive Testing," and "Mechanical, Wear, and Corrosion Testing," and Scott D. Henry, Assistant Director of Technical Publications, for his unflagging support and patience throughout the project. The kind assistance of the ASM Library is also duly noted.

As a result of the collective experience and talent of all those listed above, the rich tradition of the Metals Handbook continues. Whether in print form, CD-ROM format, via the Internet, or some other remarkable vehicle made possible by the computer age, it will undoubtedly continue to serve the metallurgical community well into the next millennium. The best is yet to come!

Joseph R. Davis
Davis & Associates, Chagrin Falls, Ohio

Source Acknowledgments

Major sources for the Sections in this Handbook are listed below. Additional source information is provided in the reference lists that appear in many of the articles.

Structure and Properties of Metals

Much of this Section was adapted from Alloy Phase Diagrams, Volume 3, ASM Handbook, 1992, pages 1-1 to 1-29.

Design Considerations and Materials Selection
Much of this Section was adapted from various articles appearing in Materials Selection and Design, Volume 20, ASM Handbook, 1997.

Structure/Property Relationships in Irons and Steels

Much of this Section was adapted from various articles appearing in Materials Selection and Design, Volume 20, ASM Handbook, 1997, pages 357-382.

Carbon and Alloy Steels

This Section was condensed from Properties and Selection: Irons, Steels, and High-Performance Alloys, Vol 1, ASM Handbook, 1990, pages 105 to 822. Supplemental information was also adapted from the ASM Specialty Handbook: Carbon and Alloy Steels, 1996, and Fatigue and Fracture, Vol 20, ASM Handbook, 1996.

Cast Irons

This Section was condensed from the ASM Specialty Handbook: Cast Irons, 1996, p 3 to 130.

Ferrous Powder Metallurgy Materials

This Section was condensed from Properties and Selection: Irons, Steels, and High-Performance Alloys, Volume 1, ASM Handbook, 1990, pages 800 to 821 and from Powder Metallurgy, Volume 7, ASM Handbook, 1984, pages 79 to 99.

Tool Steels

This Section was condensed from the ASM Specialty Handbook: Tool Materials, 1995, pages 10 to 20, 21 to 31, 119 to 153, and 383 to 395.

Stainless Steels

Much of this Section was condensed from the ASM Specialty Handbook: Stainless Steels, 1994. Supplemental information was also adapted from the ASM Specialty Handbook: Heat-Resistant Materials, 1997, pages 123 to 178.

Superalloys

For more detailed information on superalloys, the reader is referred to the ASM Specialty Handbook: Heat-Resistant Materials (see, in particular, pages 219 to 344).

Aluminum and Aluminum Alloys

This Section was assembled from a variety of sources, including Properties and Selection: Nonferrous Alloys and Special-Purpose Materials, Volume 2, ASM Handbook, 1990, pages 3 to 215; the ASM Specialty Handbook: Aluminum and Aluminum Alloys, 1993, pages 3 to 159; and Corrosion, Volume 13, ASM Handbook, 1987, pages 583 to 609. Updated statistical information and property data were obtained from the Aluminum Association Inc.

Copper and Copper Alloys

This Section was assembled from a variety of sources, including Properties and Selection: Nonferrous Alloys and Special-Purpose Materials, Volume 2, ASM Handbook, 1990, pages 216 to 427, Corrosion, Volume 13, ASM Handbook, 1987, pages 610 to 640, and Materials Selection and Design, Volume 20, ASM Handbook, 1997, pages 389 to 393. Updated statistical information and composition/property data were obtained from the Copper Development Association Inc.

Magnesium and Magnesium Alloys

This Section was condensed from Properties and Selection: Nonferrous Alloys and Special-Purpose Materials, Volume 2, ASM Handbook, 1990, pages 455 to 479, and from Corrosion, Volume 13, ASM Handbook, 1987, pages 740 to 754.
Titanium and Titanium Alloys


Zinc and Zinc Alloys


Tin and Tin Alloys

This Section was condensed from Properties and Selection: Nonferrous Alloys and Special-Purpose Materials, Volume 2, ASM Handbook, 1990, pages 517 to 526.

Lead and Lead Alloys

This Section was condensed from Properties and Selection: Nonferrous Alloys and Special-Purpose Materials, Volume 2, ASM Handbook, 1990, pages 543 to 556, and from Corrosion, Volume 13, ASM Handbook, 1987, pages 784 to 792.

Nickel and Nickel Alloys


Cobalt and Cobalt Alloys

This Section was condensed from Properties and Selection: Nonferrous Alloys and Special-Purpose Materials, Volume 2, ASM Handbook, 1990, pages 446 to 454.

Zirconium and Hafnium

This Section was condensed from Properties and Selection: Nonferrous Alloys and Special-Purpose Materials, Volume 2, ASM Handbook, 1990, pages 661 to 669, and from Corrosion, Volume 13, ASM Handbook, 1987, p 707 to 721.

Precious Metals and Alloys

This Section was condensed from Properties and Selection: Nonferrous Alloys and Special-Purpose Materials, Volume 2, ASM Handbook, 1990, pages 688 to 719.

Refractory Metals and Alloys


Cemented Carbides and Cermets

This Section was condensed from Properties and Selection: Nonferrous Alloys and Special-Purpose Materials, Volume 2, ASM Handbook, 1990, pages 950 to 977, and from Friction, Lubrication, and Wear Technology, Volume 18, ASM Handbook, 1992, pages 795 to 800.

Special-Purpose Materials

Forming
This Section was condensed from Forming and Forging, Volume 14, ASM Handbook, 1988.

Forging
This Section was condensed from Forming and Forging, Volume 14, ASM Handbook, 1988.

Powder Metallurgy
More detailed information on powder metallurgy can be found in Powder Metal Technologies and Applications, Volume 7, ASM Handbook, 1998.

Machining

Heat Treating
This Section was condensed from Heat Treating, Volume 4, ASM Handbook, 1991.

Joining
This Section was condensed from Welding, Brazing, and Soldering, Volume 6, ASM Handbook, 1993.

Surface Engineering
This Section was condensed from Surface Engineering, Volume 5, ASM Handbook, 1994. Supplemental information was also taken from Materials Selection and Design, Volume 20, ASM Handbook, 1997, pages 470 to 490.

Recycling and Life-Cycle Analysis

Failure Analysis

Fractography
Parts of this Section were condensed from Fractography, Volume 12, ASM Handbook, 1987. Updated material from the previous Metals Handbook Desk Edition, 1984, is also included.

Nondestructive Testing
This Section was condensed from Nondestructive Evaluation and Quality Control, Volume 17, ASM Handbook, 1989.

Mechanical, Wear, and Corrosion Testing

This Section was condensed from Mechanical Testing, Volume 8, ASM Handbook, 1985, and from Fatigue and Fracture, Volume 19, ASM Handbook, 1996.

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ASM International staff who contributed to the development of the Volume included Scott D. Henry, Assistant Director of Reference Publications; Grace M. Davidson, Manager of Handbook Production; Bonnie R. Sanders, Manager of Copy Editing; Kathleen S. Dragolic, Production Coordinator; Erika K. Baxter and Alexandra B. Hoskins, Copy Editors; Alexandru Popaz-Pauna, Candace K. Mullet, and Jill A. Kinson, Production Assistants. Editorial assistance was provided by Denise Kelly, Heather Lampman, and Mary Jane Riddlebaugh. The Volume was prepared under the direction of William W. Scott, Jr., Director of Technical Publications.

Conversion to Electronic Files

Metals Handbook Desk Edition was converted to electronic files in 2000. The conversion was based on the first printing (1998). No substantive changes were made to the content of the Volume, but some minor corrections and clarifications were made as needed.

ASM International staff who contributed to the conversion of the Volume included Sally Fahrenholz-Mann, Bonnie Sanders, Marlene Seuffert, Gayle Kalman, Scott Henry, and Robert Braddock. The electronic version was prepared under the direction of William W. Scott, Jr., Technical Director, and Michael J. DeHaemer, Managing Director.

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This book is a collective effort involving hundreds of technical specialists. It brings together a wealth of information from world-wide sources to help scientists, engineers, and technicians solve current and long-range problems.

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Comments, criticisms, and suggestions are invited, and should be forwarded to ASM International.

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