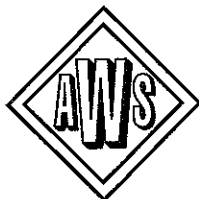


Welding Handbook

Ninth Edition

Volume 4

MATERIALS AND APPLICATIONS, PART 1



American Welding Society

Welding Handbook, Ninth Edition

Volume 1 *Welding Science and Technology*

Volume 2 *Welding Processes, Part 1*

Volume 3 *Welding Processes, Part 2*

Volume 4 *Materials and Applications, Part 1*

Volume 5 *Materials and Applications, Part 2*

Welding Handbook

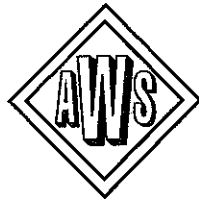
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MATERIALS AND APPLICATIONS, PART 1

Prepared under the direction of the
Welding Handbook Committee

Annette O'Brien, Editor
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American Welding Society

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The *Welding Handbook* is the result of the collective effort of many volunteer technical specialists who provide information to assist with the design and application of welding and allied processes.

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DEDICATION

Phillip I. Temple

This book is dedicated to Phil Temple in recognition of the guidance he has provided to the *Welding Handbook* as a contributor, reviewer, Chapter Chair, and as Chair of the Welding Handbook Committee from 1996 through 1999 and again from 2004 through 2007. He has been a Welding Handbook volunteer for the past 20 years, contributing to the publishing of several volumes of the 8th and 9th editions.

The leadership he brought to the *Welding Handbook* was gleaned from experience as he progressed from welder to welding instructor, welding superintendent to welding engineer, then to quality assurance management in the nuclear power industry. A graduate of LeTourneau University, he has been an active member of the American Welding Society for more than 35 years. In 2000, he received the National Meritorious Award for good counsel, loyalty, and dedication to the affairs of the Society.

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ACKNOWLEDGMENTS

The Welding Handbook Committee and the editors gratefully recognize the contributions of the volunteers who have created, developed, and documented the technology of welding and shared it in past editions of the *Welding Handbook*, beginning with the first edition published in 1938. The enthusiasm and meticulous dedication of the authors and technologists reflected in the previous eight editions of the *Welding Handbook* are continued in this volume of the Ninth Edition.

This volume was compiled by the members the Welding Handbook Volume 4 Committee and the WH4 Chapter Committees, with oversight by the Welding Handbook Committee. Chapter committee chairs, chapter committee members, and oversight persons are recognized on the title pages of the chapters.

The Welding Handbook Committee and the editors recognize and appreciate the AWS technical committees who developed the consensus standards that pertain to this volume, and acknowledge the work of W. R. Oates and A. M. Saitta, editors of Volume 4, Eighth Edition. The Welding Handbook Committee is grateful to members of the AWS Technical Activities Committee and the AWS Safety and Health Committee for their reviews of the chapters. The editors appreciate the AWS Technical Services staff for their assistance during the preparation of this volume.

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PREFACE

This is Volume 4 of the five-volume series in the Ninth Edition of the *Welding Handbook*. It is *Materials and Applications*, Part 1, presented in ten peer-reviewed chapters covering the metallurgical properties of various forms of ferrous metals and how these properties affect welding. The titles of the chapters in this book, which includes two applications chapters, indicate the variety of challenges presented to welders, designers, welding engineers, and others in the welding workplace.

The ability of scientists to examine the microstructures of the metals, identify constituent elements, and determine how the properties of the metals can be used and controlled during welding is reflected in the updated and expanded information in this book. Many of the best scientists in the welding industry from university, government or other research laboratories, metals producing companies, fabricators, consulting firms, and testing facilities have stepped forward as volunteers to update this volume. These highly regarded experts are recognized on the title pages of their respective chapters.

Three basic chapters of this volume, Chapter 1, Carbon and Low-Alloy Steels; Chapter 2, High-Alloy Steels; and Chapter 5, Stainless and Heat-Resistant Steels contain detailed sections on the metallurgy, composition and properties of steels, and methods of producing high-integrity welds in carbon steels, alloy steels, and stainless steels.

Different sets of welding conditions, challenges, and solutions are presented for the specialized steels represented in Chapter 3, Coated Steels; Chapter 4, Tool and Die Steels; Chapter 6, Clad and Dissimilar Metals; Chapter 7, Surfacing Materials; and Chapter 8, Cast Irons. The chapters provide information on the composition, metallurgy, weldability, and recommended welding procedures for these metals.

Two major applications are included in this volume. Chapter 9, Maintenance and Repair Welding, contains a model for a systematic approach to the sometimes difficult procedures involved in repair welding. Chapter 10, Underwater Welding and Cutting, contains critical information on producing strong, durable welds, sometimes under very difficult welding conditions, for use in the severest of service conditions.

A table of contents of each chapter is outlined on the cover page, along with names and affiliations of contributors of the updated information. A subject index with cross-references appears at the end of the volume. Appendix A contains a list of safety standards and publishers. Frequent references are made to the chapters of Ninth Edition Volumes 1, 2, and 3. To avoid repetition of information published in these volumes, a reference guide is presented in Appendix B.

This book follows three previously published volumes of the Ninth Edition of the *Welding Handbook*: Volume 1, *Welding Science and Technology*, which provides prerequisite information for welding and the welding processes; Volume 2, *Welding Processes, Part 1*, which contains the technical details of arc welding and cutting, the gas processes, brazing, and soldering; and Volume 3, *Welding Processes, Part 2*, which is devoted to the resistance, solid state, and other welding processes, such as laser beam, electron beam, and ultrasonic welding.

The Welding Handbook Committee welcomes your comments and suggestions. Please address them to the Editor, *Welding Handbook*, American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126. www.aws.org.

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