

Welding Handbook

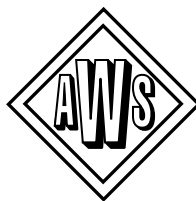
Ninth Edition

Volume 3

WELDING PROCESSES, PART 2

Prepared under the direction of the
Welding Handbook Committee

Annette O'Brien, Editor
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DEDICATION

Dr. John M. Gerken

This book is dedicated to Dr. John M. Gerken in recognition of his distinguished work in the field of metallurgical engineering and the transfer of its technology, and for his steadfast commitment to the *Welding Handbook*. Dr. Gerken served on the Welding Handbook Committee beginning in 1992 during the preparation of the two Eighth Edition volumes of the *Welding Handbook, Materials and Applications, Part 1 and Materials and Applications, Part 2*. He served as the Chair of the Volume 1 Committee, which prepared Volume 1 of the Ninth Edition, *Welding Science and Technology* for publication in 2001. He is known nationally for his dedication to the welding industry and his service to the American Welding Society as a volunteer.

Dr. Gerken had a distinguished career with TRW, directing several welding research and engineering development programs involving the use of newly developed aerospace metals and requiring expertise in the major welding processes. After retiring from TRW, he extended his career at the Lincoln Electric Company as Manager of Technology Transfer, where he revised the *Welding Procedure Handbook*.

Dr. Gerken is a past president of the American Welding Society and served on the Board of Directors. In 1995 he was made a Fellow of the American Welding Society. He has been an active member of various national technical standards committees for AWS, currently including the Subcommittee on Nickel Alloys, the Committee on Joining Metals and Alloys, the U.S. Tag for ISO/TC 44/SC6, Resistance Welding; the Committee on Resistance Welding, and the Subcommittee on Stainless Steel Alloys.

He began his education at Newark College of Engineering, but interrupted his studies to serve in the United States Army. He resumed his education at Rensselaer Polytechnic Institute, where he earned a doctorate in metallurgical engineering.

In addition to his public service, Dr. Gerken has privately served as a mentor to many in the welding community over the years. The Welding Handbook Committee is grateful for his guidance and friendship.

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ACKNOWLEDGMENTS

The American Welding Society Welding Handbook Committee and the editors recognize the contributions of the volunteers listed below 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 3 Committee and the 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 R. L. O'Brien, Editor of Volume 2, 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 express their appreciation to the AWS Technical Division staff for their assistance during the preparation of this volume.

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PREFACE

This is Volume 3 of the *Welding Handbook*, the third of the five-volume series in the Ninth Edition. Following the publication of *Welding Handbook* Volume 1, *Welding Science and Technology*, the Welding Handbook Committee determined that one volume could no longer contain the process technology described in the 29 chapters of Volume 2, Eighth Edition; thus Volume 2 and Volume 3 of the Ninth Edition were designed to accommodate the expanded information. *Welding Processes, Part 1* presented updated information on arc welding and cutting, the gas processes, brazing, and soldering. This volume, *Welding Processes, Part 2* is devoted to information on resistance welding, solid state processes and other joining and cutting methods. Volumes 4 and 5 of the Ninth Edition of the *Welding Handbook* will address welding materials and applications.

Volume 3 contains updated resistance welding chapters: spot and seam welding, projection welding, flash and upset welding, high-frequency welding, and resistance welding equipment. The chapter on friction welding has been updated, and new in this edition, a separate chapter on the developing process variation, friction stir welding, has been added. Other chapters are ultrasonic welding, explosion welding, adhesive bonding, thermal spraying and cold spraying, diffusion welding and diffusion brazing. The chapters on electron beam welding and laser beam welding and cutting contain significantly expanded technology. The last chapter, Other Welding and Cutting Processes, contains information on two new or revitalized processes, magnetic pulse welding, and electro-spark depositing. New information is presented on water jet cutting, which is reappearing in many current applications as a modern, efficient process.

A table of contents of each chapter is outlined on the cover page, and a subject index with cross-references appears at the end of the volume. A major subject index of this volume and previous editions of the *Welding Handbook* is included. Appendices A and B are lists of safety standards, and Appendix C presents a list of SI/inch-pound conversions of commonly used pressure units.

The chapters in this volume reflect the dramatic changes brought into welding processes over the past decade by the precise control of welding parameters made possible with digital controls and microprocessors as applied to new techniques and advanced materials. To meet the challenge of including this expanded technology, each chapter was prepared by a committee made up of highly qualified experts enthusiastic about the subject process, and headed by a chapter chair with an admirable dedication to the details of infusing state-of-the-art information into the basics of the processes. All committee members are volunteers who generously devoted countless hours of personal time to the chapters.

One hundred and ten American Welding Society volunteers contributed to this book, representing university, government, and private welding research and development institutions, manufacturers of welding equipment and materials, and manufacturers, fabricators, and welders who use this technology.

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.

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