

Effects of **RADIATION** on Materials

17th International Symposium

David S. Gelles, Randy K. Nanstad,
Arvind S. Kumar, and Edward A. Little
editors



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Effects of Radiation on Materials: 17th International Symposium

*David S. Gelles, Randy K. Nanstad, Arvind S. Kumar,
and Edward A. Little, Editors*

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The quality of the papers in this publication reflects not only the obvious efforts of the authors and the technical editor(s), but also the work of these peer reviewers. The ASTM Committee on Publications acknowledges with appreciation their dedication and contribution to time and effort on behalf of ASTM.

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Foreword

This publication, *Effects of Radiation on Materials: 17th International Symposium*, contains papers presented at the symposium of the same name, held in Sun Valley, Idaho on 20-23 June 1994. The symposium was sponsored by ASTM Committee E-10 on Nuclear Technology and Applications. David S. Gelles of Pacific Northwest National Laboratory in Richland, WA; Randy K. Nanstad of the Oak Ridge National Laboratory in Oak Ridge, TN; Arvind S. Kumar of the University of Missouri in Rolla, MO; and Edward A. Little of University College in Swansea, United Kingdom presided as symposium chairmen and are editors of the resulting publication.

DEDICATION



Peter Hedgecock
1931–1992

Peter D. Hedgecock contributed significantly to the success of ASTM Committee E-10 on Nuclear Technology and Applications. Peter has been the Chairman of Subcommittee E10.02, on Radiation Effects on Structural Materials until the time of his sudden death. His colleagues within ASTM acknowledge his high degree of professionalism, organization, and enthusiasm.

Peter was trained as a metallurgical engineer at the University of London and was licensed in the United States as a metallurgical, corrosion, and nuclear engineer. His knowledge and experience extended beyond that of nuclear structural materials, since he had extensive exposure in the aerospace industry and as an expert witness in accident reconstruction and component failures.

Peter was a gentleman and a friend. We will miss him.

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Overview

ASTM Committee E-10 on Nuclear Technology and Applications sponsors a biennial series of symposia on the effects of radiation on materials. The first symposium was held in 1960 and followed an earlier series begun in 1956 by ASTM Committee E-10, then called the Committee on Radioisotopes and Radiation Effects. Since that first meeting, these symposia have continued to grow in importance as nuclear energy has provided an increasingly larger fraction of the world's electrical capacity. The meetings have become a major international forum for the presentation and discussion of research on the influence of radiation on the microstructure and mechanical properties on structural materials. The proceedings of the Seventeenth International Symposium on the Effects of Radiation on Materials are published in two parts, in this ASTM special technical publication (STP) 1270 and in a special issue of the *Journal of Nuclear Materials*, Volume 225 (1995). The symposium was held in Sun Valley, Idaho on 20–23 June 1994.

The Seventeenth International Symposium is distinguished by the very large attendance attained. One hundred seventy-seven abstracts were submitted for presentation at the symposium, and 104 are now being published in the combined proceedings of the symposium. The size of this publication effort has proven to be too large to fit in an ASTM STP, and therefore, it was necessary to split the publication between two publishers. The basis chosen for the split was relevance to ASTM standards, with the underlying intent to include in each publication examples of the wide range of topics covered. As a result, the papers being published in this volume represent the full range of topics covered at the symposium, but emphasize those topics that are most closely related to ASTM standards.

The papers published in this STP have been organized into eight sections. The first four sections are devoted to behavior of low alloy reactor pressure vessel steels. Papers on pressure vessel steels constituted approximately half of the papers submitted, and topics range from discussions of modeling and mechanisms, to microstructure and welding effects, but the greatest number describe mechanical property response or mechanical property data base information. The next two sections describe research on two other major classes of material: ferritic and martensitic steels and austenitic steels and the seventh section includes papers on the remaining materials of interest. The final section contains papers concerning special procedures, such as development of low long-term activation steels for fusion applications, and special techniques, such as positron measurements, laser extensometry, and small angle neutron scattering measurements.

Recent improvement in our understanding of reactor pressure vessel steel embrittlement has advanced rapidly, so that this proceedings contains seven papers in section one that describe mechanisms controlling behavior and model the processes of radiation embrittlement and segregation. Section two focuses on the precipitation process that controls embrittlement, including reports on electron microscopy and small angle neutron scattering, and the improvements available from annealing procedures to recover properties by altering precipitate distributions. Section three includes thirteen papers that expand and organize the mechanical properties data base on irradiation embrittlement. Topics include the effects of annealing on properties, properties of irradiated welds and specific reactor parts, consequences of flux, irradiation temperature and gamma radiation, interpretation of data by

specialized data analysis procedures, use of small specimen technology and reconstitution, and data base summaries including round robin test results. Section four expands the mechanical properties data base on reactor pressure vessel steels, providing six papers with improved understanding of irradiation hardening, one paper concerned with ductile fracture mechanisms and finally four important papers on fracture toughness results including new techniques used to understand the fracture process in these steels.

Section five provides a shift in attention to steels with higher chromium levels for use at higher temperatures. Papers include development of Martensitic steels for fusion, effects of radiation on the microstructure of an oxide dispersion strengthened alloy, and four papers on the mechanical properties of this class of steels. Section six is concerned with austenitic ferrous alloys, with four papers covering microstructural response, a paper on the fundamentals of radiation damage in this class of materials, six papers on mechanical properties, and one paper concerned with development of a materials data base. Section seven includes two papers on microstructural evolution in nickel, two papers on mechanical properties of aluminum alloys, two papers on helium effects in vanadium, one on microstructure, the second on mechanical properties, and finally a paper on corrosion of a zirconium alloy. The last section includes four specialized papers on development of structural materials for fusion to avoid long-term radioactivity, and on use of neutron scattering for precipitate characterization, positron measurements, and laser extensometry.

It should also be noted that this proceedings contains a series of excellent papers concerned with the development of small specimen technology and understanding of fractographic information for assessment of fracture toughness response. Papers on these topics are included in sections three, four, and five. Together, they demonstrate that our understanding of the propagation of a crack tip is increasing rapidly.

A photograph of attendees is provided in Fig. 1.

Finally, in order to be fair to those authors at this symposium whose papers could not be



FIG. 1—Symposium attendees.

published in this volume, we have provided the following section that lists authors and titles of papers that have appeared in the companion volume of this proceedings, Volume 225 of the *Journal of Nuclear Materials*.

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