

**IRRADIATION EFFECTS
IN
STRUCTURAL ALLOYS
FOR
THERMAL AND FAST
REACTORS**



STP 457

AMERICAN SOCIETY FOR TESTING AND MATERIALS

IRRADIATION EFFECTS IN STRUCTURAL ALLOYS FOR THERMAL AND FAST REACTORS

A symposium
presented at the
Seventy-first Annual Meeting
AMERICAN SOCIETY FOR
TESTING AND MATERIALS
San Francisco, Calif., 23-28 June, 1968

ASTM SPECIAL TECHNICAL PUBLICATION 457

List price \$36.00



AMERICAN SOCIETY FOR TESTING AND MATERIALS
1916 Race Street, Philadelphia, Pa. 19103

© BY AMERICAN SOCIETY FOR TESTING AND MATERIALS 1969
Library of Congress Catalog Card Number: 72-79163
SBN 8031-0018-3

NOTE

The Society is not responsible, as a body,
for the statements and opinions
advanced in this publication.

Printed in York, Pa.
December 1969

Foreword

The Symposium on Irradiation Effects in Structural Alloys for Thermal and Fast Reactors was presented during the Seventy-first Annual Meeting of the Society held in San Francisco, Calif., 23-28 June 1968. The symposium was sponsored by Committee E-10 on Radioisotopes and Radiation Effects. L. E. Steele, Naval Research Laboratory, served as chairman of this symposium committee consisting of A. L. Bement, John Moteff, Edgar Landerman, F. R. Shober, and W. L. R. Rice. The six sessions were presided over by R. W. Nichols, L. R. Weissert, S. Havel, W. P. Chernock, T. T. Claudson, and K. Zwilsky.

Related ASTM Publications

**Nondestructive Testing of Nuclear Graphite, STP
439 (1968), \$8.00**

**Effects of High-Energy Radiation on Inorganic Sub-
stances, STP 400 (1966), \$5.25**

**Radiation Effects in Electronics, STP 384 (1965),
\$5.00**

Contents

Introduction	1
------------------------	---

Materials for Current Nuclear Power Reactor (Cladding and Core Structural)

The Effect of Cold Work, Thermal Treatment, and Neutron Irradiation on the Fracture Toughness of Zircaloy-2—R. G. ROWE AND R. G. HOAGLAND	3
Comparison of In-Reactor Creep and Postirradiation Creep Tests of Structural Materials for Nuclear Applications—E. R. GILBERT AND N. E. HARDING	17
High-Temperature Tensile Properties of Unirradiated and Thermal Reactor Irradiated Nimonic PE16—G. H. BROOMFIELD	38
Irradiation-Induced Embrittlement in Stainless Steel at Elevated Temperature—M. KANGILASKI, J. S. PERRIN, AND R. A. WULLAERT	67
Discussion	87

Materials for Current Power Reactors (Pressure Vessel Steels)

Irradiation Tests of Several Steels for Reactor Pressure Vessels—M. HASEGAWA	92
Initial Assessments of Notch Ductility Behavior of A533 Pressure Vessel Steel with Neutron Irradiation—J. RUSSELL HAWTHORNE AND ULDIS POTAPOVS	113
Discussion	134
Notch Ductility, Tensile and Neutron Spectrum Analyses of PM-2A Reactor Pressure Vessel—C. Z. SERPAN AND H. E. WATSON	135
Irradiation Effects in Pressure Vessel Materials for Steam-Cooled Fast Reactors—M. GROUNES AND P. LINDHAGEN	156

Damage Mechanisms for Pressure Vessel Steels

The Effect of Substructure on the Biaxial Strength and Irradiation Stability of ASTM A 302 Grade B Steel—P. W. FLYNN AND T. A. TROZERA	180
--	-----

CONTENTS

Effects of Interstitial Elements on Radiation Hardening in Mild Steels— E. A. LITTLE AND D. R. HARRIES	215
Radiation Hardening and Embrittlement in a Reactor Pressure Vessel Steel—M. S. WECHSLER, R. G. BERGGREN, N. E. HINKLE, AND W. J. STELZMAN	242

Advances in Reactor Materials

Development of Austenitic Stainless Steels with Improved Resistance to Elevated-Temperature Irradiation Embrittlement—E. E. BLOOM AND J. R. WEIR, JR.	261
Discussion	289
Development of a Titanium-Modified Hastelloy N with Improved Re- sistance to Radiation Damage—H. E. MCCOY AND J. R. WEIR, JR.	290
Effects of Yttrium on the Structure and Post-Irradiation Tensile Prop- erties of an Iron-Chromium-Aluminum Alloy—A. C. ROBERTS, D. R. HARRIES, D. R. ARKELL, M. A. P. DEWEY, AND J. D. H. HUGHES	312

Fast Reactor Materials Technology

Development of Fuel Cladding for Fast Reactors—G. W. CUNNINGHAM	329
Effect of Irradiation on Mechanical Properties of Cobalt-Base Alloys— J. G. W. CHOW	336
Neutron Dosimetry for Fast-Reactor Irradiation and Surveillance Testing —H. H. YOSHIKAWA AND W. N. MCELROY	342
High-Temperature Embrittlement and AISI Type 316 Austenitic Stainless Steels After Irradiation—M. WEISZ, J. MALKIN, J. ERLER, AND J. P. ANDRE	352
Postirradiation Tensile Behavior of 300 Series Stainless Steels—J. J. HOLMES, R. E. ROBBINS, AND A. J. LOVELL	371
Multiaxial In-Reactor Stress-Rupture Strength of Stainless Steels and a Nickel Alloy—H. J. LAUE, H. BOHM, AND H. HAUCK	390
Comparison of Radiation Damage Studies and Fuel Cladding Per- formance for Incoloy-800—F. A. COMPRELLI, H. J. BUSBOOM, AND C. N. SPALARIS	400
Effects of Neutron Irradiation on the Creep-Rupture Properties of Type 316 Stainless Steel Tubes—J. STANDRING, I. P. BELL, H. TICKLE, AND A. GLENDINNING	414

