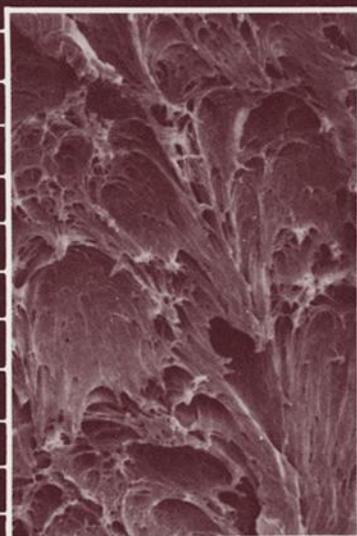


# NONLINEAR FRACTURE MECHANICS

*Time-Dependent Fracture*



**Saxena/Landes/Bassani** *editors*



**VOLUME I**  
**STP 995**

**STP 995**

***Nonlinear Fracture Mechanics:  
Volume I  
Time-Dependent Fracture***

*A. Saxena, J. D. Landes, and J. L. Bassani, editors*



ASTM  
1916 Race Street  
Philadelphia, PA 19103

## Library of Congress Cataloging-in-Publication Data

Nonlinear fracture mechanics/A. Saxena, J. D. Landes, and J. L. Bassani, editors.  
(STP ; 995)

Papers presented at the Third International Symposium on Nonlinear Fracture Mechanics, held 6-8 Oct. 1986 in Knoxville, Tenn., and sponsored by ASTM Committee E-24 on Fracture Testing.

"ASTM publication code number (PCN) 04-995001-30."

Includes bibliographies and indexes.

Contents: v. 1. Time-dependent fracture.

ISBN 0-8031-1174-6

1. Fracture mechanics—Congresses. I. Saxena, A. (Ashok). II. Landes, J. D. (John D.). III. Bassani, J. L. (John L.). IV. International Symposium on Nonlinear Fracture Mechanics (3rd : 1986 : Knoxville, Tenn.). V. ASTM Committee E-24 on Fracture Testing. VI. Series: ASTM special technical publication ; 995.

TA409.N66 1988

620.1'126—dc19

88-38147

CIP

Copyright © by AMERICAN SOCIETY FOR TESTING AND MATERIALS 1988

### NOTE

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

### Peer Review Policy

Each paper published in this volume was evaluated by three peer reviewers. The authors addressed all of the reviewers' comments to the satisfaction of both the technical editor(s) and the ASTM Committee on Publications.

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 of time and effort on behalf of ASTM.

# Foreword

This publication, *Nonlinear Fracture Mechanics: Volume I—Time-Dependent Fracture*, contains papers presented at the Third International Symposium on Nonlinear Fracture Mechanics, which was held 6–8 Oct. 1986 in Knoxville Tennessee. ASTM Committee E-24 on Fracture Testing sponsored the event. The cochairmen for the symposium section on Time-Dependent Fracture were A. Saxena, Georgia Institute of Technology, and J. L. Bassani, University of Pennsylvania. Both men, along with J. D. Landes, University of Tennessee, served as editors of this publication.

# Contents

<b>Overview</b>	1
<b>CREEP CRACK GROWTH</b>	
<b>Evaluation of the <math>C_t</math> Parameter for Characterizing Creep Crack Growth Rate in the Transient Regime—JOHN L. BASSANI, DONALD E. HAWK, AND ASHOK SAXENA</b>	7
<b>A Critical Assessment of Global Mechanical Approaches to Creep Crack Initiation and Creep Crack Growth in 316L Steel—PHILIPPE BENSUSSAN, ROLAND PIQUES, AND ANDRE PINEAU</b>	27
<b>A Numerical Study of Non-Steady-State Creep at Stationary Crack Tips—CHUN-POK LEUNG, DAVID L. MCDOWELL, AND ASHOK SAXENA</b>	55
<b>Crack Growth in Small-Scale Creep—JOHN L. BASSANI, DONALD E. HAWK, AND FWU-HWEI WU</b>	68
<b>Growth of Macroscopic Cracks by Void Coalescence Under Extensive Creeping Conditions—CHUNG-YUEN HUI AND KUANG-CHONG WU</b>	96
<b>Creep Crack Growth of Alloy 800H in Controlled-Impurity Helium—JUDE R. FOULDS</b>	112
<b>Creep Embrittlement Susceptibility and Creep Crack Growth Behavior in Low-Alloy Steels: An Assessment of the Effects of Residual Impurity Elements and Postweld Heat Treatment Condition on Creep Ductility and Crack Growth—SHINJI KONOSU AND KEIKICHI MAEDA</b>	127
<b>Influence of Aging on High-Temperature Creep Crack Growth in Type 304H Stainless Steel—G. M. BUCHHEIM, C. BECHT, K. M. NIKBIN, V. DIMOPOLOS, G. A. WEBSTER, AND D. J. SMITH</b>	153
<b>An Anisotropic, Damage-Coupled Viscoplastic Model for Creep-Dominated Cyclic Loading—DAVID L. MCDOWELL, KWANG-IL HO, AND JAMES STALLEY</b>	173
<b>Experimental Determination of the High-Temperature Crack Growth Behavior of Incoloy 800H—THOMAS HOLLSTEIN AND BERT VOSS</b>	195

## DYNAMIC FRACTURE

- Three-Dimensional Transient Analysis of a Dynamically Loaded Three-Point-Bend Ductile Fracture Specimen**—T. NAKAMURA, C. F. SHIH, AND L. B. FREUND 217
- Influence of Loading Rate on the Deformation and Ductile Fracture of A533B Steel at 70°C**—DAVID J. SMITH AND STEPHEN J. GARWOOD 242
- Measurement of Dynamic Fracture Toughness of Ductile Materials**—EDWIN M. HACKETT, JAMES A. JOYCE, AND CHOON FONG SHIH 274
- An Advanced Procedure for *J-R* Curve Testing Using a Drop Tower**—JAMES A. JOYCE AND EDWIN M. HACKETT 298
- Measurement of the *J*-Integral with Caustics: An Experimental and Numerical Investigation**—ALAN T. ZEHNDER, ARES J. ROSAKIS, AND RAMARATNAM NARASIMHAN 318
- Correlation of Optical Caustics with Fracture Behavior of High-Strength Steels**—RALPH W. JUDY, JR., AND ROBERT J. SANFORD 340

## CYCLIC LOADING

- An Experimental Study of the Validity of a Delta *J* Criterion for Fatigue Crack Growth**—DAVID A. JABLONSKI 361
- Combined-Mode Low-Cycle Fatigue Crack Growth Under Torsional Loading**—ROY A. WILLIAMS AND WELDON W. WILKENING 388
- Fatigue Crack-Tip Mechanics in 7075-T6 Aluminum Alloy from High-Sensitivity Displacement Field Measurements**—GIANNI NICOLETTO 415
- Dislocation-Free Zone Model of Fracture Under Reverse Loading**—SHIH-JUNG CHANG AND S. MICHAEL OHR 433

## FRACTURE OF NONMETALS

- Fracture Toughness Testing of Polyethylene Pipe Materials**—ROBERT E. JONES, JR., AND WALTER L. BRADLEY 447
- Nonlinear Fracture of Concrete and Ceramics**—ALBERT S. KOBAYASHI, JIA-JI DU, NIEL M. HAWKINS, AND RICHARD C. BRADT 457

INDEXES

**Author Index**

475

**Subject Index**

477

ISBN 0-8031-1174-6