# Small Specimen Test Techniques

William R. Corwin
Stan T. Rosinski, and
Eric van Walle, editors

STP 1329

STP 1329

# *Small Specimen Test Techniques*

*William R. Corwin, Stan T. Rosinski, and Eric van Walle, editors*

ASTM Stock #: STP1329

ASTM
100 Barr Harbor Drive
West Conshohocken, PA 19428-2959

Printed in the U.S.A.

**Library of Congress Cataloging-in-Publication Data**

Small specimen test techniques/William R. Corwin, Stan T. Rosinski, and Eric van Walle, editors
(STP : 1329)
"ASTM stock #: STP1329."
Papers presented at the symposium of the same name held in New Orleans, Louisiana, on 13-14 January 1997; sponsored by ASTM Committee E-10 on Behavior and Use of Nuclear Structural Materials.
Includes bibliographical references and index.
ISBN 0-8031-2476-7
1. Notched bar testing. 2. Light water reactors—Materials—Testing. 3. Metals—Embrittlement. I. Corwin, W. R. II. Rosinski, Stan T., 1960- . III. Walle, E. van (Eric) IV. ASTM Committee E-10 on Behavior and Use of Nuclear Structural Materials. V. Series: ASTM special technical publication; 1329.
TA418.34.S63 1998
621.48'33—dc21 98-25686
CIP



## Photocopy Rights



## Peer Review Policy

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

To make technical information available as quickly as possible, the peer-reviewed papers in this publication were prepared "camera-ready" as submitted by the authors.

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.

Printed in Philadelphia, PA
July, 1998

# Foreword

This publication, *Small Specimen Test Techniques,* contains papers presented at the symposium of the same name held in New Orleans, Louisiana, on 13-14 January 1997. The symposium was sponsored by ASTM Committee E-10 on Behavior and Use of Nuclear Structural Materials, in cooperation with the European Network on Aging Materials Evaluation and Studies (AMES) and the TC5 Technical Subcommittee on Dynamic Testing at Intermediate Strain Rates of the European Structural Integrity Society (ESIS). The symposium chairman was William R. Corwin, Oak Ridge National Laboratory.

# Contents

FRACTURE TOUGHNESS TECHNIQUES

TENSILE AND PUNCH TECHNIQUES

# Overview

The Symposium on Small Specimen Test Techniques demonstrated the overall interest in ASTM Subcommittee E10.02 activities in radiation embrittlement for nuclear reactors. The symposium, which was held in New Orleans, Louisiana, on January 13-14, 1997, was organized to bring together, in a single meeting, the interests and capabilities of the scientific testing community and the needs of the commerical light-water-cooled power-reactor industry for improved methods to characterize component integrity. Technical interest in this topic was certainly demonstrated through the presentation of over 30 papers and 13 posters by experts representing 15 countries. A wide range of subjects was discussed during the symposium, concentrating on: (1) the use of unique small and miniature specimens, as well as nondestructive, nonintrusive, and in-situ test techniques for measuring mechanical and fracture properties; (2) the application of those test methods to assess irradiation-induced embrittlement; and (3) acutal examples of the use of these test techniques for determining material integrity and to evaluate potential component life extension. The strong interest in the topics results from the desire to improve miniature specimen testing technology and the recognition of the potential benefits in commerical nuclear power plant operation through improved integrity assessment.

This symposium was the third in a series of ASTM symposia on small specimen testing technology organized by ASTM Subcommittee E10.02 on Behavior and Use of Nuclear Structural Materials. The first symposium was held in Albuquerque, New Mexico in September 1983 and is summarized in *The Use of Small-Scale Specimens for Testing Irradiated Materials, ASTM STP 888*. The primary driving force was the need of the fusion reactor materials research community to assess effects of the very high levels of irradiation expected in the first wall of a fusion reactor. The limited volume of materials which can be irradiated in test reactors to high levels of embrittlement results in the need for small specimen technology. The second symposium, held in New Orleans, Louisiana in January 1992, explicitly included the needs of and applications to commercial nuclear power reactors, with direct application of small specimen test techniques to reactor pressure vessel annealing and life extension and the continued development of testing technology within the fusion reactor research community. The symposium is documented in *Small Specimen Test Techniques Applied to Nuclear Reactor Vessel Thermal Annealing and Plant Life Extension, ASTM STP 1204*. As a result of this keen interest in and obvious applications for the diversity of small specimen testing techniques, ASTM Subcommittee E 10.02 initiated an international testing exercise in 1994 to obtain a cross-comparison of material property measurements obtained from various types of subsize-specimen testing techniques. Sixteen organizations representing 10 countries initially participated. Objectives were: (1) to benchmark various subsize specimen testing techniques by comparing testing results with established material properties for the material tested, and (2) to provide information to participants to improve the correlation of subsize specimen testing results with material properties determined through standard ASTM methods. A variety of miniature testing techniques were utilized by the participants during this exercise on selected pressure vessel steel.

The recent symposium focused on the experimental, analytical, and computational aspects of small (and miniature) specimen test techniques, as well as on application to component integrity assessment. In addition, results of the cross-comparison exercise were presented.

The collection of papers within this special technical publication will provide a resource for both researchers and end users in this field. The symposium was organized into sessions covering the following small specimen test techniques: (1) miniature impact, (2) fracture toughness, (3) precracked round bars, (4) reconstitution, and (5) tensile and punch. In addition, a poster session presented additional information in these areas.

Two separate presentations reviewed international testing programs to compare miniature specimen testing results and investigate the impact of testing variables on the prediction of component behavior. These activities included various types of miniature test techniques and involved different materials and test conditions in order to provide a better understanding of small specimen behavior when compared to results obtained from standard ASTM specimen configurations.

Numerous novel and improved methods for obtaining and applying data from small specimens were described in the various sessions on testing techniques. Improvements in both correlation methods with standard-size specimens and test techniques were described by the authors of papers dealing with impact testing of subsize Charpy V-notch type specimens. The impact of critical parameters in the reconstitution process, including welding technique, insert size, specimen orientation, and even striker tup geometry, were addressed. The potential for utilizing reconstituted Charpy samples on component integrity was discussed in view of future, enhanced surveillance methodologies for plant life management. The portion of the symposium related to fracture toughness provided new insight into both the potential limitations and possible ways to correct and utilize measurements made using very small fracture toughness specimens. Innovative experimental approaches to obtaining fracture toughness data with small amounts of test material included techniques for using very small-sized compact tension specimens as well as those describing new specimen designs. Of particular interest during this symposium was the application of the Master Curve method being standarized under ASTM Committee E 08 on Fatigue and Fracture for the determination of reference temperature in the transition region for ferritic materials. This technique may significantly enhance the assessment of reactor pressure vessel integrity, and several papers demonstrating application of the Master Curve approach were presented. A new addition to this symposium series was the feasibility of using small fatigue-precracked round bars to measure fracture toughness of pressure vessel materials and to refine and validate experiment and analysis procedures. Improvements and innovations in several of the punch and disk testing techniques, discussed in previous meetings in this series, were also reported.

As the level of overall accuracy and the degree of reproducibility of data generated by the small specimen test techniques improves, the techniques can be more fully evaluated among themselves and against other standardized tests. This analysis will ultimately improve the confidence regarding application of these techniques for the evaluation of reactor pressure vessels or any other structures. It is apparent from the papers presented in this symposium, and the technical information presented throughout this symposium series, that these testing techniques continue to mature. They provide a means of obtaining material property information for situations where extraction of samples from vessels or other structural components is not desirable or possible, or when the amount of available materials is too limited to utilize conventional, standardized techniques.

*William R. Corwin*
Oak Ridge National Laboratory, Oak Ridge, TN; symposium chairman and editor

*Stan T. Rosinski*
Electric Power Research Institute, Charlotte, NC; symposium co-chairman and editor

*Eric A. M. van Walle*
SCK CEN, Mol, Belgium; symposium co-chairman and editor

ISBN 0-8031-2476-7