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Small Specimen Test Techniques: Fourth Volume

Mikhail A. Sokolov, John D. Landes, Glenn E. Lucas, editors

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Foreword

This publication, *Small Specimen Test Techniques: Fourth Volume*, contains papers presented at the symposium of the same name held in Reno, Nevada on 23–25 January, 2000. The symposium was sponsored by the ASTM International Committee E10 on Nuclear Technology and Applications. The symposium chairman was Mikhail A. Sokolov, Oak Ridge National Laboratory, the symposium co-chairmen were John D. Landes, University of Tennessee, and Glenn E. Lucas, University of California at Santa Barbara.

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Overview

The Fourth Symposium on Small Specimen Test Techniques was held January 23–25, 2001 in Reno, Nevada. This is the fourth in a series that commenced in 1983 in Albuquerque, New Mexico. It has served as an important international forum for the exchange of ideas and techniques for extracting mechanical property information from relatively small volume specimens. This effort has largely been driven by the limited volumes of material afforded in irradiation experiments for the development of fusion reactor materials, as well as the need to improve the information obtainable from specimens in existing light water power reactor surveillance programs. Hence, there has been a cross-fertilization of ideas from the fission and fusion communities, and the techniques thus obtained have spawned interest in non-nuclear applications.

The papers presented in this 3-day symposium are collected in a single volume of this ASTM Special Technical Publication. They are divided into sections that correspond to presentation sessions on the following topics: three sessions on *Fracture Toughness*, two sessions on *Subsized Charpy V-notch Specimens*, three sessions on *Mechanical Properties*, two sessions on *Reconstitution* techniques and a session on *Small Punch Tests*.

The papers on *Fracture Toughness* continue to explore the effects of specimen size and geometry on constraint, which affects the ability to extract meaningful fracture toughness from small specimens. Achieving improved constraint from specimen geometry includes work on circumferentially cracked round bars, which provide enhanced constraint by closing the crack front upon itself, and a new technique that employs stress state in a helically cracked torsion bar to achieve this end. The influence of crack ligament, side grooving, and specimen thickness on fracture toughness are explored. A subset of these results are examined with respect to defining censoring limits for data which can be used in the Master Curve approach to determining fracture toughness versus temperature from a relatively small number of relatively small specimens for light water reactor pressure vessel steels. Finally, work on obtaining fracture toughness from polymer films using a stiffening frame to hold the film during testing is described.

A number of papers report continuing efforts to obtain useful data from *Subsized Charpy V-notch (CVN) Specimens*. This includes work aimed at developing correlations between full size specimens and a wide variety of subsized specimen geometries, down to some with cross sections of 1.5 mm × 1.5 mm. A number of materials are examined including reactor pressure vessel steels, high chromium ferritic/martensitic steels, as well as refractory alloys. Finite Element Methods (FEM) are employed to simulate the deformation of notched impact bars, and the results are combined with fracture model to evaluate the absorbed energy in notched bar testing. An IAEA activity to develop a data base for full and subsized CVN testing of reactor pressure vessel steels is described.

A host of papers describe techniques for extracting other kinds of *Mechanical Properties*. These include subsized hourglass fatigue specimens, ring and notched tube tests for nuclear fuel cladding, ion-irradiation creep-fatigue tests, subsized bend bars for measuring fatigue crack growth, thin bend specimens that can be used in high energy proton irradiations, and the application of ultramicrohardness tests to examine irradiation hardening on surfaces exposed to ion irradiation. Again, a wide range of materials are considered, from metals to ceramic-matrix composites. A number of analytical tools are considered for exploring the fundamental flow and fracture behavior of materials from small spec-

imens. These include FEM studies to explore the effect of material constitutive behavior on the macroscopic engineering stress-strain behavior of a tensile specimen, and the use of through-holes, notches and dimples to explore constitutive behavior under multiaxial conditions.

Reconstitution of CVN specimens is a topic of significant interest, especially for utilizing previously tested surveillance specimens in reactor life extension programs. This approach is based on welding end tabs onto inserts obtained from broken CVN specimens, re-notching (or pre-cracking) the reconstituted specimen and testing it. A large multi-lab European effort—RESQUE (Reconstitution Techniques Qualification and Evaluation Study)—is described. It is designed to develop recommended practices for CVN and pre-cracked CVN reconstitution. A number of important variables—including heat input during welding, insert length, and dimensional tolerances—are explored, and their influence on test results are reported.

Finally, several papers report progress in the application of *Small Punch* techniques to obtain mechanical as well as microstructural data. Two general categories of small punch tests are presented: 1) disk bend tests, where a spherical penetrator deforms a circumferentially-supported disc specimen, and 2) shear punch tests, where a flat-ended cylindrical punch blanks a hole in a clamped coupon specimen. Mechanical properties were found to have little dependence on the ratio of specimen thickness to grain size above a threshold for a number of materials tested by shear punch. Moreover, it was demonstrated that transmission electron microscopy of specimens obtained from both disk bend and shear punch specimens provide an opportunity to use these specimens for multiple purposes. FEM techniques were applied to small punch tests in an attempt to extract the constitutive equation, and to shear punch tests to better understand fixture compliance effects and hence improve measurements. Finally, the utility of shear punch techniques to obtaining information from regions in which material property gradients are present was demonstrated in its application to weldments and heat-affected zones of CrMo steels.

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