# Factors That Affect the Precision of Mechanical Tests

Papirno and Weiss, editors

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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.

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# Foreword

This publication, *Factors That Affect the Precision of Mechanical Tests,* contains papers presented at the symposium of the same name held in Bal Harbour, Florida on 12–13 November 1987. The symposium was sponsored by ASTM Committees E-28 on Mechanical Testing, E-24 on Fracture Testing, and E-09 on Fatigue. Symposium chairmen were: Roger M. Lamothe, U.S. Army Materials Technology Laboratory; John L. Shannon, Jr., NASA Lewis Research Center; and H. Carl Weiss, Boeing Commercial Aircraft Co. Coeditors of this publication were Ralph Papirno and H. Carl Weiss.

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GENERAL TESTING

# Overview

The practical value of an experiment and the credibility of the results are dependent on the precision and bias present in the process through which the data are acquired. The purpose of this symposium was to serve as a forum for discussing those factors which individually or in total affect the precision of data obtained by mechanical testing methods. Papers were solicited from members of the materials testing community who have experienced problems or concerns in the generation of test data. We are indebted to those presenters who expended the time and effort to share their experiences at Bal Harbor.

This STP has seventeen papers, approximately half the number presented at the symposium. The papers were originally given under different session headings, though much of the material does not easily lend itself to simple categorization. The papers in this STP were screened for contributory value to the science of material testing, and a sincere effort was made to include those providing informative and innovative subject matter.

**Hardness Testing**

The information in this section deals with several different aspects of hardness testing. A statistical comparison of the results of round-robin Vickers and Knoop hardness testing is offered, showing increased repeatability and reproducibility intervals with increasing specimen hardness and, conversely, improved precision with decreasing hardness and increased test loads. A comparison is given on video image analysis and conventional stage micrometer techniques for microindentation studies, which shows a greater discrepancy with the Knoop over the Vickers' indentation. A discussion of the importance of consistency in test material, test instruments, environmental conditions, and test operator procedures is offered for producing comparable results in hardness test accuracy. Also, a study of gage repeatability and reproducibility is presented, employing the methods of statistical process control (SPC) to interpret equipment, material, and appraiser variables in the results of Rockwell scale test instruments.

**Fatigue and Fracture Procedures**

This section addresses considerations concerning test methods and instrumentation in fatigue and fracture tests. A study of rapid-loading fracture toughness ($J_{Id}$) shows for the unloading compliance method, the multiple specimen method, and the electric potential method that $J_{Id}$ is dependent on loading rate for all methods and that the dynamic conditions may be predicted from the static fracture toughness curve. A comparison of crack-following techniques on high-strength aluminum alloy demonstrates that the compliance method and the potential drop method are appropriate for automated crack growth monitoring and that certain errors may be eliminated with calculated correction factors. A paper describing resolution requirements for automated elastic-plastic fracture toughness ($J_{Ic}$) testing shows that system noise limits the capability of high-resolution analog to digital converters in favor of analog-amplified 12-bit converters. A topic on multiaxial fatigue testing of thin-walled tubular specimens outlines the influencing factors of gage length, specimen geometry, instrumentation, and definition of failure and their affects on the interpretation of test results.

**Alignment Problems**

This section deals with various material test machine alignment considerations and test specimen gripping configurations. A presentation on potential load frame alignment errors gives requirements for eccentricity, angular deflection, and unit alignment. Good corroborative agreement is found between strain-gaged specimen data and dial indicator, alignment telescope, and electronic clineometer data. A very comprehensive method is presented by which the alignment of flat specimen grips may be checked for errors and improved as necessary. A method is provided to aid in mechanical test setup by quantifying specimen bending loads in pinned clevis fixturing, and finite-element analysis is used to show the importance of uniform load distribution. In addition, concern is expressed for axial or torsional forces present in bending tests, and a description of the details of various three- and four-point loading configurations and the attributes which may affect the precision of pure bending data are included.

**General Testing**

This section covers a diverse range of subject matter pertinent to the accuracy of mechanical testing. A comparison is made in test machine type versus strain-rate interaction that shows a lower determination of yield strength from servocontrolled test machines. A presentation is given showing the need for recommended standard procedures and reporting consistency in determining a material's resistance to deformation in hot strip rolling. Information is also provided on the use of yield stress pattern phenomena as a quick-look stress indicator. A detailed presentation of test results is given for the determination of wear factors on orthopedic implants by the method of weight loss determination. In addition, an article describing a study involving eight technical journals shows a low incidence of inclusion of precision in measurement data used in the reporting of materials research.

The topics briefly mentioned in this overview are addressed in considerable detail in the following text. While only a few of the unfortunately abundant areas for concern over factors which affect the precision of mechanical tests have been included in this book, it is hoped that this STP will broaden our base of understanding and provide encouragement for more volumes to follow.

I want to thank the authors, the reviewers, the session chairmen, the editors, and the ASTM staff for their combined efforts in bringing this STP to fruition.

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