# Review of Progress in QUANTITATIVE NONDESTRUCTIVE EVALUATION 3A

Edited by Donald O. Thompson
and Dale E. Chimenti

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## Volume 3A

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Volume 3A

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PREFACE

This Proceedings contains the edited papers presented at the annual Review of Progress in Quantitative NDE held at the University of California, Santa Cruz, Aug. 7-12, 1983. In it, papers have been arranged topically by chapters and subsections rather than by order of presentation at the Review. The editors believe that this format is preferable as a reference volume. Thus, the Proceedings contains nine chapters and subsections which provide broad coverage of topics of current interest in NDE research and development. The Review was sponsored by the Center for Advanced NDE, Ames Laboratory of the U.S. Department of Energy, in cooperation with the Office of Basic Energy Sciences, USDOE, the Defense Advanced Research Projects Agency, the Materials Laboratory of the Air Force Wright Aeronautical Laboratories, and the Naval Sea Systems Command. Approximately 275 attendees representing various government agencies, industry, and academia participated in the technical presentations, poster sessions, and discussions. This Review, possibly the most comprehensive annual symposium in NDE, emphasizes both basic research and early engineering applications; it provides a valuable forum for the transfer of technical information. Paragraphs given below provide a brief summary of the contents of the Proceedings.

Chapter 1 consists of four papers that discuss elements of NDE Reliability and contains the keynote paper given by Dr. J. M. Coffey of the NDT Applications Centre, Central Electricity Generating Board, Manchester, England. In his paper, Dr. Coffey highlights the new and important role that NDE modeling is playing in the current Defect Detection Trials as a part of a Public Inquiry in England, an Inquiry that has been undertaken to reaffirm the reliability of ultrasonic flaw detection before proceeding to the construction of the Pressurized Water Reactor. He notes that modeling is now viewed as an important part of the proof of ultrasonic detection reliability. Although the utilization of modeling in this case is focussed primarily upon safety, modeling also offers the potential of substantial cost benefits. This aspect, as well as other advantages of modeling that use scientifically based field-flaw interaction theories, is discussed in another

paper in this chapter. This paper provides a summary of three different approaches for the utilization of the new modeling tools together with a scenario for application to the Retirement for Cause program. The chapter concludes with discussion of other elements of reliability including statistical considerations and human factors.

Chapter 2 is devoted to Ultrasonics. It is separated into sections that deal with essentially all aspects of quantitative ultrasonic technology. The first section includes papers that deal with the Probability of Detection of a flaw. It thus continues the modeling discussion of Chapter 1, but deals with specific research advances that have been made in the AF/DARPA research program in quantitative NDE. The four papers in the section represent science-based topics that have been pursued in parallel; they represent the base from which engineering design models enhancing the Probability of Detection can be constructed and demonstrate the necessity of interdisciplinary involvement and freedom to interact in NDE research. A particular point of interest in this set is the signal-noise improvement provided through the development and limited application of a decision theoretic optimal algorithm. Other sections in this chapter include papers on scattering, sizing, transducers, signal processing, and imaging and reconstruction. The section on signal processing is new this year. Results shown in various papers in this section that deal with both time domain and frequency domain signal processing suggest that time domain processing may be better in yielding accurate sizing information and in reducing the effects of transducer variabilities.

Chapter 3, Eddy Currents, is arranged in a manner similar to Chapter 2. The first section, Probability of Detection, includes four papers which deal with the basics of eddy current modeling. These efforts represent the first significant modeling effort in eddy current technology. They note advances in field-flaw interaction modeling and note the necessity of quantifying probe fields in order to predict the probability of detection. Work given in this section has been provided by an interdisciplinary team effort and includes both theory and experiment. Additional sections in this chapter include further papers on modeling, sizing, and probe design and characterization. The last section contains a description of a novel probe which utilizes a magnetic tape-head.

In Chapter 4, papers are assembled that deal with acoustic emission, thermal wave imaging, and optical techniques. The acoustic emission work is both theoretical and experimental, and shows that theoretical interpretations of acoustic emission events are also now making significant strides. Possible relations of acoustic emission and thermal wave imaging are pointed out. Significant advances are also demonstrated in thermal wave imaging in which

images of fatigue cracks in complex bolt hole geometries have been obtained. An optical technique is also reported for the examination of bolt hole geometries.

Chapter 5 is a relatively short chapter that contains papers on several new techniques. One of them reports on new approaches being investigated for the rapid scanning of large structures; others report on new acoustic and magnetic techniques.

General topics in inverse methods are collected in Chapter 6. These are important and difficult subjects that are key to the development of flaw characterization and sizing algorithms. The edited workshop discussion that follows the formal papers may be of particular interest to the reader in getting a better view of the many aspects of inversion related to NDE.

Chapter 7 is composed of papers dealing with composite materials and include those of both a basic and an applied nature. On the basic side, acoustic phenomena that are similar to Bragg diffraction and to acoustical and optical branches are reported. Models for the characterization of multilayered media by acoustic techniques are also given. Results are also reported for the microwave detection of moisture in composite materials, a technique that is quite mature and may be ready for application. The chapter concludes with discussion of a technique to monitor composite curing and a discussion of damage assessment by ultrasonic means.

Chapter 8 is a fairly large chapter dealing with the NDE of material properties and acoustoelasticity and residual stress. Several papers in the section on material properties discuss advances that are being made in understanding the effects of microstructure on wave propagation. Advances are also reported in the development of material signatures using leaky wave methods. Although evident in preceding years, the interest and progress in acoustoelastic and residual stress techniques for NDE remains high. New techniques are reported for separating the effects of texture from the stress measurements and for the determination of interfacial clamping stresses.

The final chapter, Chapter 9, provides descriptions of new NDE systems that are in development. Some of these are beginning to use advances in quantitative NDE science that have been made in the past several years. The first section of this chapter provides a collection of papers that report on progress that is being made in NDE for the Retirement for Cause program. In one of them an air bearing support for eddy current probes has been designed and tested. The stability achieved is excellent and demonstrates that eddy current lift off problems may be reduced significantly by its utilization. The development of an active ferromagnetic resonance eddy current probe which utilizes a minia-

ture YIG sphere also demonstrates new capability. In this application, the traditional passive eddy current technique is replaced with an active oscillator technique. Results shown indicate that good flaw/lift-off separation is achieved. Section B of this chapter presents papers on other new systems that are in process of development for monitoring rotating components, underwater supports, and weldments.

The organizers of the Review wish to acknowledge the encouragement provided by the management of the Ames Laboratory and the cooperation of the various governmental agencies recognized in the beginning of the Preface. They especially wish to thank Dr. John Coffey of CEGB for his presentation of the keynote address. They are grateful to Dr. H. Sabbagh of Analytics, Inc. who served as organizer and moderator of the workshop discussion on inversion and to all attendees who participated in providing a stimulating technical exchange. They also wish to express their appreciation and thanks to Mrs. Diane Harris who managed the logistics of the Review, to Ms. Margaret Pickett who has handled the preparation of the manuscript, and Ms. Linda Martin who has contributed to all aspects of the Review preparation and conduct.

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