# Summary of Nondestructive Testing

The nondestructive testing (NDT) section begins with a paper by Berger, which discusses the attributes of neutron radiography, and, in particular, its advantages over other NDT methods because of the potential for early detection of corrosion before extensive attack and thinning of the material has occurred.

Meredith and Lamping discuss three recently developed ultrasonic test (UT) systems that have proven effective in the detection of thinning, pitting, and methane-type hydrogen damage. The specific techniques used with each system are also discussed, along with a specialized technique for detection of corrosion damage in boiler tubes.

Acoustic emission (AE) is a relatively new although maturing NDT technique. Pollock presents two approaches to detect and monitor corrosion, and reviews the demonstrated capabilities and limitations of the technique. He discusses the basic requirements for successful field applications. Yuyama presents a survey of laboratory studies as well as field applications to describe the utility of AE for the detection and monitoring of corrosion, stress corrosion cracking (SCC), and corrosion fatigue. Both authors clearly present the potential usefulness of AE as a powerful NDT technique, if the capabilities as well as the limitations are recognized. Martin et al present further results for two aluminum alloys which show that AE is particularly well suited for studying SCC in the laboratory. They show that the AE produced by the SCC have recognizable signatures, and discuss the applicability of employing AE to detect or monitor SCC in real structures. They conclude that AE is a viable technique for detecting or monitoring SCC in real structures when the resulting AE signals are of high amplitude, although considerable preliminary testing will be required, especially when the AE signals produced are of low amplitude.

A portable, commercially available, field ready, state-of-the-art system to monitor corrosion is the subject of the paper by Grills and Tsao. The system is described, and examples of where it has been used to monitor corrosion are presented, with actual results from the examples, all in "living color."

Another illustration of state-of-the-art ultrasonic NDT systems in field use monitoring corrosion is the subject of the paper by McGarvey et al. Although not limited to only detecting corrosion damage, the paper describes how the computer based automated system is used for locating and sizing flaws in the near-bore region of steam turbine rotors. A magnetic particle (MT) inspection may also be performed with the system, and the authors note that the system also has application for piping and tubing.

Intergranular stress corrosion cracking (IGSCC) detection and characterization is a problem of particular interest to the nuclear industry. Tests have shown that reliability of manual ultrasonic testing (UT) is strongly operator and technique dependent, thereby adversely affecting and monitoring of flaw growth. Mikesell et al describe an ultrasonic imaging technique, which has been developed over a ten-year period, and an automated search head, in development for the past five years. The design of the search head is described, and the results of the imaging technique using the search head in detecting, interpreting, and characterizing IGSCC are presented.

In monitoring crevice corrosion it is necessary to have good geometric data on pit sizing. The paper by Baron et al presents an eddy current technique developed for an application, which precluded visual or replication methods. The theory together with the tests to validate the theory are presented, and the authors conclude that it is possible to use eddy current to monitor the depth of the most common types of corrosion crevices, which are long with respect to their width.

Carmichael et al point out that most forms of corrosion damage in power plant machinery are believed to involve concentrations of corrosive species in the fluid stream. They describe an on-line, real time sensor capable of detecting the concentration of contaminants that cause corrosion, and the results from both laboratory autoclaves and steam line evaluations as well as a field evaluation of three sensors in an actual power plant.

Hydrogen environments combined with high pressure and high temperatures produce hydrogen embrittlement in steels. At present, hydrogen attack may be detected nondestructively using UT, although quantitative evaluation is questionable. Watanabe et al present a new method to apply ultrasonic techniques to quantitatively evaluate hydrogen attack, thereby overcoming the shortcomings of present methods. They show in laboratory tests that the shear and longitudinal wave velocities both decrease in hydrogen affected steels, and that the ratio of shear wave velocity to longitudinal wave velocity is a promising factor to evaluate intergranular type corrosion attack.

Detection of hydrogen assisted crack growth may be possible with a new technique presented by Carpenter and Heiple. The method involves the precise continuous measurement of changes in the elastic modulus coupled with acoustic emission measurements. Results from laboratory tests of samples exposed to high pressure hydrogen gas as well as results from AE tests of small laboratory pressure vessels of the same materials while pressurized with hydrogen gas are presented.

Since many underwater steel structures are rough and pitted because of corrosion, conventional NDT techniques are of questionable value in accurately monitoring and assessing corrosion. Birring describes a focused ultrasonic transducer integrated with a computer-based system, which was used with the techniques presented to successfully and accurately measure underwater thicknesses of steel piling in a severe harbor environment.

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