

NASA NDE WORKING GROUP NEWSLETTER

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Quarterly Newsletter

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NASA HQ CODE QW MESSAGE

(J. Siedlecki, 202-358-0205)

Thank you to everyone for your prompt inputs to the presentation of the NASA NDE program at the OSTP MatTech NDE communications Group Meeting. This meeting was hosted this month, at Washington, D.C., by Dr. George Matzkanin of NTIAC and Mr. Jerome Persh of DoD. This Group is the successor group to the former OSTP/COMAT NDE Committee. The presentation went very well thanks to your contributions in providing current status reports on your Centers' NDE programs. In my presentation, I reviewed the Centers' programs, changes in NASA orientation, short range programs, methods development and applications vs. new methods, multi-center programs, clearly defined milestones, life cycle programs, costs and technology transitions.

There is no news to report about the pending reorganization within NASA HQ, Code QW. It is still in the planning stage and no official announcement has been made yet. There is also no new information from HQ, Code Q, regarding the RTOP planning status. However, we should have a telecon soon to discuss the submission of RTOPs to the Code Q Standing Committee of the Working Group, and to make a decision regarding the criteria by which future RTOPs should be reviewed. It is also important for all the NDE Working Group members to assist the Chairperson, Marie Havican, in finishing as soon as possible the draft of the NDE Strategic Plan.

NNWG HIGHLIGHTS

(M. Havican, 713-483-7134 and Dr. Y. Bar-Cohen, 818-354-2610)

GENERAL INTEREST ITEMS FROM THE LAST NNWG TELECON - During our August 30, 1994 Telecon, NNWG members were briefed on the benefits of NADCAP, the National Aerospace and Defense Contractor's Accreditation Program. Mr. Wil Harkins of NASA Headquarters Code QW participates in this program, which provides a review and examination of NDE, heat treating, and materials testing service companies for third-party accreditation. NADCAP auditors visit the suppliers and rate them against SAE specifications. NADCAP is also a registrar for ISO 9000. Since NASA is a member of the users accreditation advisory panel, we can look at NADCAP's list of qualified suppliers for NDE, and at the NADCAP audit reports. If you would like to see this information, call Mr. Harkins at (202) 358-0584 or Larry Sikes at JSC, (713) 335-2622.

RTOP REVIEW PROCESS - The Code Q Standing Committee is currently reviewing the procedure, criteria and priorities that will guide future evaluation of RTOP proposals. Efforts are being made to implement the Committee's lessons learned from the FY94 RTOP review process. Two issues were specifically addressed: (a) Individual centers submitting excessively large number of proposals and (b) Total requested funding significantly higher than the available Code QW resources. The committee decided that each center will:

1. Prioritize its own RTOPs prior to submitting the proposals for review.
2. Limit the number of RTOPs to four, with a total requested funding of no more than \$500K per year.

Several issues are still open, including how to count multi-center joint RTOPs. The issue of selection criteria was debated, but no decision was made yet, since NASA HQ is in the process of issuing general guidelines which may affect NASA's NDE objectives and priorities.

NASA NDE STRATEGIC PLANS - The strategic goals and plans for the NASA NDE Working Group are still being debated, a draft document with the first four sections was prepared and submitted to NASA HQ, Code QW, for review, comments and guidance.

NNWG PERSONNEL NEWS AND ACHIEVEMENTS

In May 1994, Alex Vary was awarded the first NASA Abe Silverstein Medal by NASA Deputy Administrator General John Dailey and LeRC Center Director Don Campbell for his "Exceptional engineering achievement in the creation and development of the acousto-ultrasonic NDE method for assessing the integrity and reliability of composite structures." Congratulations Alex!

Joe Halupnik, JSC SR&QA Office's NDE engineer, has recently distinguished himself by earning his sixth ASNT Level III certification, in Neutron Radiography Testing (NRT). This certification is in addition to the ASNT Level III certifications he already holds in RT, PT, MT, ET and UT. Congratulations, Joe!

The Self-Nulling Eddy Current Instrument that was developed jointly by LaRC, Lockheed, Analytical Services and Materials Inc. won the 32th Annual R&D Magazine 100 awards for 1994. Congratulations!

Jan Tormo, ARC, got married this summer and she has a name change to Jan Tormo-Intravai. Congratulations, Jan!

CURRENT EVENTS AND ACTION ITEMS

INDUSTRY NEWS - We added to this Newsletter a new column entitled "Industry News". This column is intended to create a forum for technical information interchange and to enhance the collaboration between NASA and the industry in the area of NDE.

INFORMATION SUPERHIGHWAY - E-mail is increasingly becoming a leading form of information exchange. The capability to simultaneously send detailed paperless messages and documents at high speed to many addressees is making this technology very attractive. Several E-mail software programs (e.g., CC-mail) can send faxes to those who don't have E-mail addresses. This capability has allowed us to form an NNWG E-mail directory. Currently, out of the 26 members of NNWG, only 5 individuals don't have E-mail address and they can be communicated with the E-mail/fax option. The following is the E-Mail directory:

Joseph Siedlecki	NASA HQ	jsiedlec@cc.hq.nasa.gov
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NASA CENTERS NEWS AND ANNOUNCEMENTS

ARC (J. Segreto, 415-604-4112)

UPDATE ON AE APPLICATION TO WIND TUNNEL - Acoustic emission (AE) examination was performed on a 100-ft. x 30-ft. diameter section of the NASA ARC 9x7 ft. unitary plan wind tunnel, which was successfully pressurized to 27-psia. AE data was acquired by Physical Acoustic Corp. and the data is currently being analyzed using MONPAC and source location analytical methods. When this phase is completed the results will be compared with the radiographs that were made of all the weld seams prior to the AE test. The AE report is scheduled to be released by Nov. 1, 1994. Point of Contact: Roy Hampton@(415) 604-6223.

GSFC, Dr. E. J. Chern (301-286-5836)

UPPER MANAGEMENT CHANGE IN OFFICE OF FLIGHT ASSURANCE - Mr. W. Brian Keegan, Deputy Director of Code 300, Office of Flight Assurance (OFA) has assumed the position as the Deputy Director of Engineering Directorate (Code 700) effective August 7, 1994. The position of Deputy Director of OFA was opened for qualified applicants from late August to early September. No decision on the selection of Mr. Keegan's replacement has been announced. OFA has the broad responsibility and general authority to review the technical and flight safety aspects of all GSFC projects, spacecraft systems, launch vehicle systems, operational ground systems and scientific instruments, for both conventional satellites and Shuttle payloads, to assure that the systems meet the Center's goals for mission success and reliability. NDE is a function of the Materials Branch, which reports to OFA through the Assurance Technologies Division.

JPL (Dr. Y. Bar-Cohen, 818-354-2610)

ULTRASONIC OBLIQUE INSONIFICATION USED TO EVALUATE THERMAL DAMAGE TO COMPOSITES - Recent experiments by Dr. Bar-Cohen, jointly with Prof. Ajit Mal and Dr. Shyh-Shiuh Lih from UCLA, have shown that ultrasonic oblique insonification can potentially be used to characterize thermal damage to composites. Past difficulties with detecting and characterizing thermal damage with conventional NDE methods is attributed to the fact that the damage is involved initially with degradation of the material stiffness constants prior to formation of delamination or other critical defects. The capability to determine the elastic constants using the oblique ultrasonic insonification method makes this method a potential NDE tool for thermal damage characterization. Using an inversion technique, based on a micromechanical model, the reflected ultrasonic signals from a pitch-catch set-up are analyzed to determine the laminate overall stiffness constants before and after heating. The dependence of the stiffness degradation data on the temperature and the duration of exposure is currently being investigated.

NDE GATEWAY TO THE INFORMATION SUPERHIGHWAY - JPL is continuing to expand the M&P Homepage system that is accessible via the World Wide Web and the public domain software Mosaic. This system, which is under the responsibility of Dick Weinstein from NASA HQ, is taking advantage of the information superhighway. At present, the Homepage system was setup for NASA-only access and there are no current plans to expand its accessibility. As we reported in the last issue of the Newsletter, we reserved a link to an NDE Gateway that will become active once an equivalent NDE effort is sponsored.

VISIT TO McCLELLAN AIR FORCE BASE TO REVIEW AGING AIRCRAFT PROBLEMS - Dr. Bar-Cohen and Prof. Mal, UCLA, visited at McClellan AFB to review aging aircraft problems

and potential technology transfer. The visit was hosted by Mr. Al Rogel and the visitors were given a tour of the facility and an overview of the scope of the problems of corrosion and cracking on aging aircraft.

JSC (M. Havican, 713-483-7134)

SIXTH ASNT LEVEL III CERTIFICATION - The SR&QA Office's NDE engineer, Mr. Joe Halupnik, has recently distinguished himself by earning his sixth ASNT Level III certification, in Neutron Radiography Testing (NRT). This certification is an addition to the ASNT Level III certifications that he already holds in RT, PT, MT, ET and UT.

DETECTED FLAW DATABASE FOR FRACTURE MECHANICS RELIABILITY - The final report has just been issued for the JSC RTOP, "Detected Flaw Data Base for Fracture Mechanics Reliability". This RTOP, sponsored by Dick Weinstein's office in Code QW, may be of interest to NDE personnel. This database stores information on failures caused by manufacturing and material flaws. The data are limited to aerospace structures and materials that benefit most from the use of fracture mechanics analyses to minimize weight. The data were collected from various NASA contractors and organizations. If you would like a copy of the diskettes and the users manual in order to access the database, call Mr. Mike Pendergast, Space Station Safety and Mission Assurance Division, at (713) 244-5164. The access to this database requires Windows 3.1 operating system, a 386 or higher microprocessor and a harddisk.

KSC (J. Larson, 407-867-3423 or 861-5715)

NNWG NETWORKING RESULTS IN RE-UTILIZATION OF \$1.3M WORTH OF NDE EQUIPMENT - Kennedy Space Center is discontinuing High Energy Radiography (9 MEV) support due to reduced workloads and budget restrictions. In an effort to maximize NASA's return on investment, KSC utilized the technical contacts established through NNWG to inform other centers of the potential availability of equipment. This networking initiated interest from two centers and resulted in an agreement to transfer approximately \$1.3M worth of High Energy Radiography test and support equipment to MSFC. This interaction through the NNWG not only resulted in re-utilization of expensive test equipment, but should result in lower hidden costs to MSFC due to the technical interchange between personnel at both centers. The equipment is in the process of being transferred.

LaRC (Dr. E. I. Madaras, 804-864-4670)

LaRC/STRESSTEL DEMONSTRATE LaRC BOLT MONITOR ADVANTAGES AT KSC - In Sept. 94, LaRC's NDE Sciences Branch jointly with JSC and StressTel have demonstrated their touch-screen prototype at Kennedy. StressTel Corporation is currently in the marketing phase of the NASA P2L2 Ultrasonic Bolt Tension Monitor (BTM) technology. Sid Allison is leading this project for LaRC and he is currently testing the performance of the BTM by applying it to critical fastener. Measurements were made on shuttle vertical tail bolts, external tank (ET) umbilical studs and orbiter-747 attach bolts and the results were compared to current KSC ultrasonic technology. Results showed several advantages of the BTM, including the potential to measure load on certain ET studs that could not be measured using KSC's current ultrasonic equipment due to signal distortion. Personnel at JSC had indicated that signal distortion is preventing tests of about half of the ET studs and BTM could provide good alternative. KSC has suggested user interface improvements by tailoring the BTM to automatically measure ET studs. This suggestion was

accepted by StressTel, KSC, JSC and LaRC, and a follow-up demonstration is planned in the near future. (Allison, x4-4792, Froggatt, x4-4794, and Perey, x4-4796)

INVENTION DISCLOSURE WAS FILED ON ELECTRONIC SHEAROGRAPHY FOR NDE - Recently, an invention disclosure was filed entitled "Operation of an Electronic Speckle Pattern Shearing Interferometer at Zero or Very-Nearly Zero Image Shear for Maximum Optical Stability". This invention provides a more efficient method for the NDE of bonded or laminated engineering structures with the increased interferometric stability. This is important for use in an industrial environment where problems such as room vibrations caused by nearby machinery or air currents caused by elevated temperatures may be present and unavoidable. Such problems often are the limiting factor(s) in the performance of many laser-based optical inspection instruments. Examples of the use of this invention might include the inspection of aluminum or graphite-epoxy honeycomb components to detect disbonds between the outer skins and the honeycomb core. (J. B. Deaton, x4-4789, R. S. Rogowski, x4-4990)

LeRC (A. Vary, 216-433-6019 or Dr. G. Baaklini, 216-433-6016)

ALEX VARY HONORED IN RECOGNITION OF HIS PIONEERING AND NUMEROUS CONTRIBUTIONS TO THE ACOUSTO-ULTRASONIC METHOD - In May 1994, Alex Vary was awarded the first NASA Abe Silverstein Medal by NASA Deputy Administrator General John Dailey and LeRC Center Director Don Campbell for his "Exceptional engineering achievement in the creation and development of the acousto-ultrasonic NDE method for assessing the integrity and reliability of composite structures."

Vary pioneered experimental and theoretical foundations for ultrasonic characterization of the strength, toughness, and other properties of structural materials by demonstrating the linkage between material microstructure, ultrasonic waves, and mechanical properties. His work resulted in the acousto-ultrasonic (AU) method for which he established the fundamental approach and then fostered applications. His AU approach has been accepted and applied internationally.

Intended for NDE of composite structures, numerous studies have confirmed that AU is particularly useful for assessing adhesive and interlaminar bond strengths. The method has wide applications to automotive, aerospace, and many industrial composites. The method has been applied to adhesively bonded joints by Canada's National Aeronautical Establishment, to ceramic composites by the Idaho National Engineering Laboratory, to tire inspection by the University of Illinois and Goodyear, and to wood products by the University of California Forest Products Laboratory and the Weyerhaeuser Company.

The American Society for Testing and Materials (ASTM) has adopted and published a "Standard Guide for Acousto-Ultrasonic Assessment of Composites, Laminates, and Bonded Joints" (E-1495-92). Additional ASTM Standard Practices for AU assessment of filament-wound pressure vessels and wood products are in preparation. Three American firms manufacture and market instruments for AU measurements. Several U.S. patents incorporate AU for monitoring adhesive bond quality, polymer composite curing, and bond strength in wood composite panels and wood structures.

Two international conferences on AU have been sponsored by the American Society for Nondestructive Testing (ASNT). During the past 7 years, over 300 technical papers and two books on AU have appeared. The AU method is featured in the ASNT Nondestructive Testing Handbook. The May 1991 issue of the ASNT journal Materials Evaluation was dedicated to acousto-ultrasonics. The June 1994 issue of the Journal of Acoustic Emission is also dedicated entirely to AU.

In 1988 Vary gave the Northeastern University IBM Honor Lecture. In 1990, he was honored by the University of Illinois "in recognition of his pioneering research in the field of acousto-ultrasonics and for his outstanding service to the profession." He has been granted seven US Patents. In 1991, he received the NASA Exceptional Engineering Achievement Medal. He gave the 1989 ASNT Fall Conference Keynote Address and the ASNT 1992 Lester Honor Lecture. In September, he was inducted as an ASNT Fellow during its 1994 Fall Conference.

NDE METHODS SUCCESSFULLY APPLIED TO CERAMIC MATRIX COMPOSITES - As part of the NASA HST (High Speed Research) and LeRC EPM (Enabling Propulsion Materials) teams. The Lewis NDE group is charged with the development and integration of NDE methods for ceramic matrix composites (CMCs). This involves the use of NDE methods for assessing microstructural damage accumulation as well as the detection of overt flaws. It also involves the use of NDE data in durability and life prediction analyses for high temperature aircraft engine structures consisting of CMC components.

Recently completed work applied NDE techniques to CMC samples made of Amercom SiC/SiC 20 weave and Nicalon/UT22. Evaluation of fatigue test samples that exhibited various degrees of accrued damage was done with acousto-ultrasonic and vibration NDE methods. The diffuse field acousto-ultrasonic (DF-AU) method and vibration damping (VD) method were shown to be complementary and sensitive to damage progression in both materials. Conventional NDE methods, such as pulse-echo ultrasonics and photo-microscopic methods, were unsuccessful in revealing the damage when it resulted a subtle degradation of the mechanical properties.

MSFC (R. Neuschaefer 205-544-7382, and Dr. S. Russell, 205-544-4411)

OSEE III DEVELOPMENT - A third generation stimulated electron emission (OSEE III) system is currently being developed by MSFC, Thiokol and LaRC personnel. The system is in two configurations, with 6-inch and 1-inch heads. Both units are compatible with the same controller. The 6-inch unit will be available for evaluation December 1994. The similar 1-inch units will be completed by December 1995.

NDE OF SILICON NITRIDE BALLS FOR BALL BEARINGS - This activity was in support of the Space Shuttle Main Engine Alternate Turbopump Development Program. NITI completed the RTOP-funded Si₃N₄/440C in liquid oxygen tribology investigation. This provided the baseline for the MSFC traction rig regarding slip and sliding friction. Pratt & Whitney selected optimum ultrasonic and fluorescent penetrant techniques to meet requirements for detection of critical flaws initiation in Si₃N₄ balls. These techniques were implemented on schedule to support the certification and flight production pumps. A special thanks to Jonathan Salem, Dr. George Baaklini and Alex Vary of LeRC for preparation and guidance regarding surface crack reference

standards. Thanks also to Dr. Ken Dolan and Dr. Keith Wilfinger of the Lawrence Livermore National Laboratory for the preparation of seeded defect reference standards. The support provided by Dr. Eric Madaras of LaRC in characterizing surface artifacts using SEM and SEAM techniques is also appreciated.

PROOF TESTS OF FIBER WOUND COMPOSITE PRESSURE VESSELS - The University of Alabama at Huntsville and MSFC NDE personnel are proof testing impact damaged 5.25 inch diameter carbon fiber pressure vessels. Of the 15 carbon-fiber 5.25 inch diameter pressure vessels filled with simulated propellant, 7 were already proof tested. During the proof test the impacted area was monitored by shearography (SH), sub-pixel digital video image correlation (SDVIC), and acoustic emission testings. The pressure test load sequence included several holds that allowed the images to be acquired around the damaged region with SH and SDVIC. The SDVIC images have not been processed into strain field plots yet, but in previous tests on unfilled bottles the degree of damage was clearly indicated in the strain fields (Figures 1 and 2). During shearography inspection using convective heating of the bottles, fiber and delamination damage in the impacted zone have been detected. Impacted Kevlar wound bottles are scheduled for testing upon completion of the carbon fiber bottles. (Sam Russell)

TRANSFER OF HIGH ENERGY RADIOGRAPHIC FACILITY FROM KSC - Due to changes in program requirements and budget restrictions, KSC has closed its High Energy Radiography Facility (HERF). After review by NASA Headquarters, MSFC has been approved to relocate and utilize the HERF. This property is valued at \$1.3 million and MSFC will only be responsible for transportation and disassembly cost. This will eliminate the need for a GSA property sale of the equipment by KSC. This equipment was disassembled by EG&G, a support contractor at KSC. (Sam Russell).

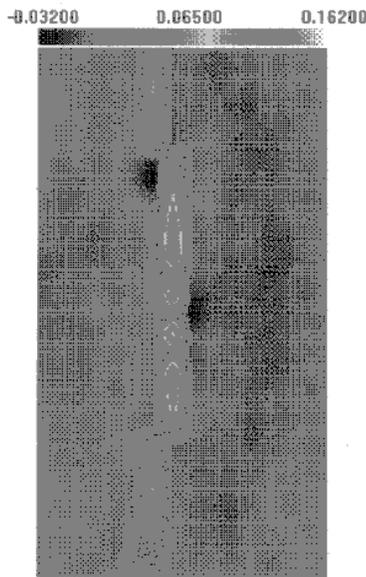


Figure 1. Hoop Strain in Impact Damaged Carbon Fiber 5.25 inch Dia. Bottle at 1000 psig.



Figure 2. Proof Tested Carbon Fiber Bottle

INDUSTRY NEWS

Rockwell International (reported by P. Hodgets, 310-922-0969)

PERALTA TECHNOLOGIES DEVELOPED A SYNTHETIC APERTURE IMAGING SYSTEM - Peralta Technologies, located in Southern California, has developed a new ultrasonic imaging system that uses an array of 256 transducers and a synthetic aperture. The system is operated in the pulse-echo mode using frequencies in the range of 2 to 8 MHz and is employing technology that has been originally used for geological applications. A set of fine wires along one plane with several micron diameter were easily visualized. This reported system is currently being tested for medical applications and it has potential application for NDE of composite materials (J. R. Fort, 714-588-9085)..

Northrop Grumman, Corp. (B. Wray, 310-942-6281)

NORTHROP GRUMMAN SUCCESSFUL USE OF SHEAROGRAPHY - Northrop Grumman Corp. has been using shearography on the B-2 program since 1988. The method was applied for inspection of bonded composites and metallic assemblies. Experience have shown reduction in inspection time by 75% compared to other NDE methods. Further, there are many cases where this method is found to be the only one capable of detecting the specific flaws.

COMING EVENTS (all events are give in EDT format)

ASNT 1994 Spring Conference, Las Vegas, NV, March 23 to 25, 1995

JANNAF NDE Subcommittee meeting, Oct. 24-28, 1994, OO-ALC, Hill Air Force Base, UT

3rd NASA M&P Engineering Meeting - Marshall Space Flight Center, AL, April 1995

NASA NDE Working Group (NNWG) Newsletter

This NNWG Newsletter is published quarterly by the NNWG and NASA HQ, Code QW.

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