Nondestructive Evaluation (NDE)
Annual Technical Plan
323-78

S&MA Annual Technical Plan

Level 2A

Approval: ______________________________
NDE Program Manager

Concurrance: ______________________
Code QT Division Director

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Task Title: Evaluation of Recently Developed Magnetic-Sensor Technologies Applied as a Non-Intrusive, Portable Corrosion Detector

I. Objectives:

Evaluate new magnetic-based technologies as potentially applicable to a portable, non-intrusive detector of magnetochemical noise generated during corrosion processes.

II. Center Point of Contact:

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III. Technical Methodology/ Approach:

The initial approach involved evaluation of recently-developed non-intrusive sensor technologies for a simple portable corrosion detector. Technologies include:

- Spin-dependent tunneling thin-film low-field magnetic sensors
- And Magnetic-field-enhanced microelectromechanical acoustic emission sensors.

The first step was to determine whether simple application of commercial implementations of such technologies were adequately sensitive to monitor corrosion-generated magnetic fields. A preliminary trial of a commercial spin-dependent magnetic flux detector in a simple configuration could not detect such fields, and this test demonstrated that the state-of-development of this technology was not yet as mature as expected.

The next step was to establish the absolute magnitude of the corrosion-generated magnetic field for a simple case. A commercial flux-gate magnetometer, operated inside a small zero-gauss chamber, demonstrated that magnetic fields on the order of a few microgauss are produced by saline solution corroding heavy aluminum foil. There was also an obvious extension of this step involving the measurement of the corrosion magnetic field generated by a standard electrochemical cell and to qualitatively compare the magnetic signature to the electrochemical signature for a particular case.

The next proposed step will be to evaluate the relative attenuation of the flux-gate detected fields in the laboratory as a function of the intervening thickness of wall material between the corrosion and the non-intrusive detector. Two or more typical wall materials will be investigated for their attenuation. This step addresses the potential for field applicability of directly sensing the magnetic signals.

In the final step, the acoustic coupling of the corrosion magnetic signals will be considered as an alternative for thick conducting walls. A simple magnetic corrosion field simulator device will be fabricated to simplify evaluations. The comparative performance of prototype devices implemented with both these technologies will be ranked using the simulator. Subsequently, devices with acceptable performance will also be compared to the equivalent electrochemical noise signals.

Techniques for nullifying ambient field influences on the detected signals will be investigated for some typical environments. In particular, the need for application of shielding to nullify ambient influences will be avoided to facilitate field applications of selected prototype implementations.

IV. Customers:

Sam Jones, JSC, (281) 483-9031 - Shuttle OMS/RCS systems; John Applewhite, JSC, (281) 483-9030 – Shuttle Orbiter Propellant Transfer System (OPTS), Albert Behrend, JSC, 281-483-9241 - Advanced Environmental and Life Support Systems; Dr. Steve Schneider, GRC, (216) 977-7484 – Propulsion Systems Test and Development; Pierce (256) 544-6366 –International Space Station Propulsion Module/OPTS, Claude Smith, NASA HQ, 202-358-1675 - Spacecraft Safety

V. Metrics:

Project schedule/milestones and project data will be reviewed with the customers on a weekly basis. Project success will be indicated by the development of a prototype apparatus to non-intrusively monitor internal corrosion in selected aerospace plumbing structures.

VI. Products:

FY02/FY03 – A comparison of the relative performance of two alternative non-intrusive corrosion sensor technologies. A documented NDE method and prototype apparatus using a choice technology if found suitable. A final report of the findings of the project.

VII. Schedules/Milestones:

<u>**FY00-01** (early start from co-funding)</u>

- Assembled an initial demonstration system utilizing a spin-dependent tunneling magnetic sensor
- Demonstrated the inadequate sensitivity of a simple detector based on the current state of the spin-dependent tunneling technology
- Evaluated the magnitude of corrosion signal from thin aluminum boats using a commercial flux-gate magnetometer.
- Assembled a simple, portable data acquisition system for long time-interval recording.
- Compared the signal from a commercial electrochemical noise apparatus to the corresponding magnetic response measured by the flux-gate magnetometer.

<u>**FY02**</u>

- Determine the attenuation of a typical magnetic corrosion signal as a function of material-wall thickness for two or more typical containment materials using the flux-gate magnetometer.
- Design and fabricate a magnetic-field simulator of corrosion magnetic noise from a small region.
- Compare the sensitivity response for an alternative corrosion detection technology in a magnetically-shielded lab environment using simulated corrosion-equivalent acoustic emission (with and without magnetic enhancement)
  - Measure the relative response of a directly coupled acoustic sensor.
  - Measure the relative response of a commercial implementation of microelectromechanical system (MEMS) ultrasonic sensor technology.
  - Compare to the response measured with the fluxgate magnetometer.
- Select for more detailed characterization a technology choice that has the greatest potential for a practical portable corrosion detector.

<u>**FY03**</u>

- Develop preliminary nulling schemes, such as gradiometer detect, to avoid the need for shielding or other deterrents to simple application in the field.
- Fabricate an initial prototype of a portable corrosion monitor using a selected technology.
- Characterize the performance of the prototype apparatus
- Compare the prototype response to the WSTF electrochemical noise measurement results.
- Write and submit a final report