Summary of Activities for Health Monitoring of Composite Overwrapped Pressure Vessels

This three year project (FY12-14) will design and demonstrate the ability of new Magnetic Stress Gages for the measurement of stresses on the inner diameter of a Composite Overwrapped Pressure Vessel overwrap. The sensors are being tested at White Sands Testing Facility where the results will be correlated with a known nondestructive technique acoustic emission. The gages will be produced utilizing Meandering Winding Magnetometer and/or Meandering Winding Magnetometer-array eddy current technology. The ultimate goal is to utilize this technology for the health monitoring of Composite Overwrapped Pressure Vessels for all future flight programs.

Two composite overwrapped pressure vessels were selected from inventory for testing. The bottles were sent to JENTEK Sensors, Inc. where they were scanned for baseline properties. One of the two bottles was then selected for testing.

The first full scale pressurization test was performed at White Sands Testing Facility in June 2012. The goals of this test were to determine adaptations of the magnetic stress gauge instrumentation that would be necessary to allow multiple sensors to monitor the vessel condition simultaneously and to determine how the sensor response changes with sensor selection and orientation. The second full scale pressurization test was performed at White Sands Testing Facility in August 2012. The goals of this test were to monitor the vessel condition with multiple sensors simultaneously, to determine the viability of the multiplexing units (MUX) for the application, and to determine if the sensor responses in different orientations are repeatable. For both sets of test the vessel was pressured up to 6,000 psi to simulate maximum operating pressure. Acoustic events were observed during the first pressurization cycle. This suggested that the extended storage period prior to use of this bottle led to a relaxation of the residual stresses imparted during auto-frettage.

The pressurization tests successfully demonstrated the use of multiplexers with multiple Maundering Winding Magnetometer arrays to monitor a vessel. It was discovered that depending upon the sensor orientation, the frequencies, and the sense element, the Maundering Winding Magnetometer arrays can provide a variety of complementary information about the composite overwrapped pressure vessel load conditions. For example, low frequency measurements can be used to monitor the overwrap thickness and changes associated with pressure level. High frequency data is dominated by the properties of the overwrap, including the fiber orientations and layup of the layers.

Year two of this project will include tests at White Sands Testing Facility on one or two vessels which have been intentionally damaged either through pressurization and/or impact.