COE CST Fourth Annual Technical Meeting

Task 299: Nitrous Oxide Composite Case Testing

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Center of Excellence for
Commercial Space Transportation

Agenda

- Team Members
- Task Description
- Schedule
- Goals
- Results
- Conclusions and Future Work

Team Members

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Task Description

- Develop an understanding of fragmentation hazards from composite tanks used for fuel/oxidizer storage

- Objectives:
    - Test composite panels to understand fragmentation hazards
    - Develop methods to predict fragmentation conditions
    - Develop standard test procedures for composite materials under shock and high-rate loading
    - Develop analytical and computational models to compare to experiments

Schedule

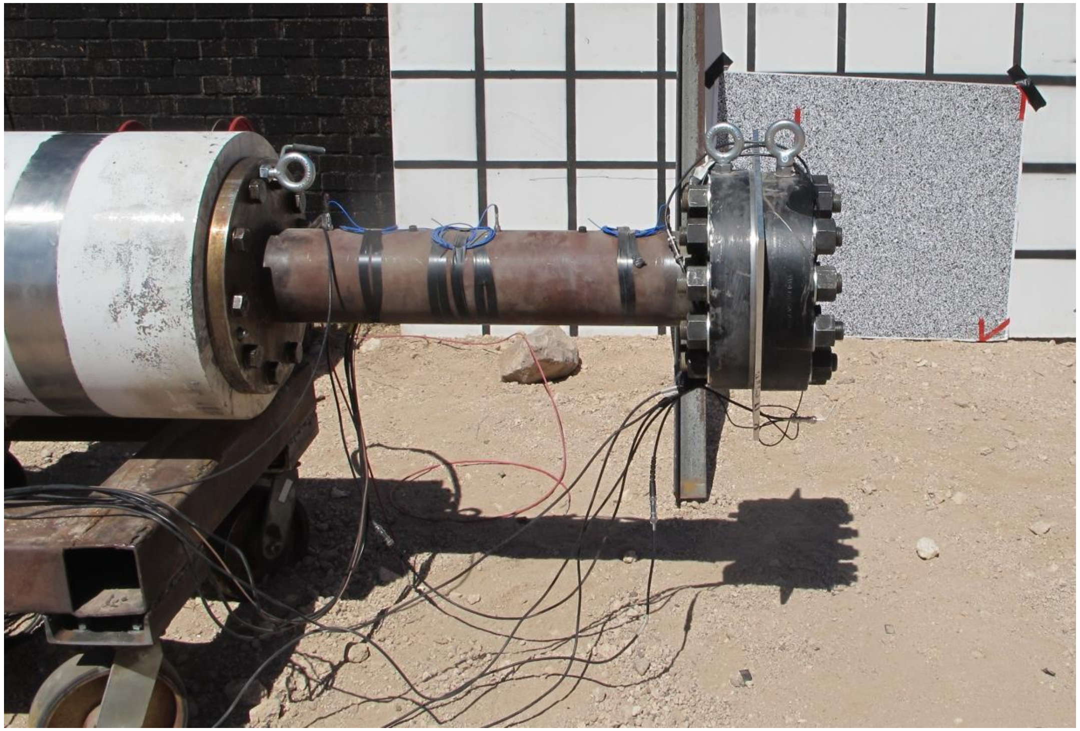
- Fixture construction: October 2013-May 2014
- First successful aluminum test: May 29, 2014
- Second aluminum test: June 29, 2014
- Initial simulations complete: July 2014
- First composite test: October 3, 2014
- Second composite test: November 2014

Goals

- Provide data to help set guidelines for safe distances during launch of commercial vehicles
- Establish standard test procedures for high-rate loading of composites

Results: Fixture construction

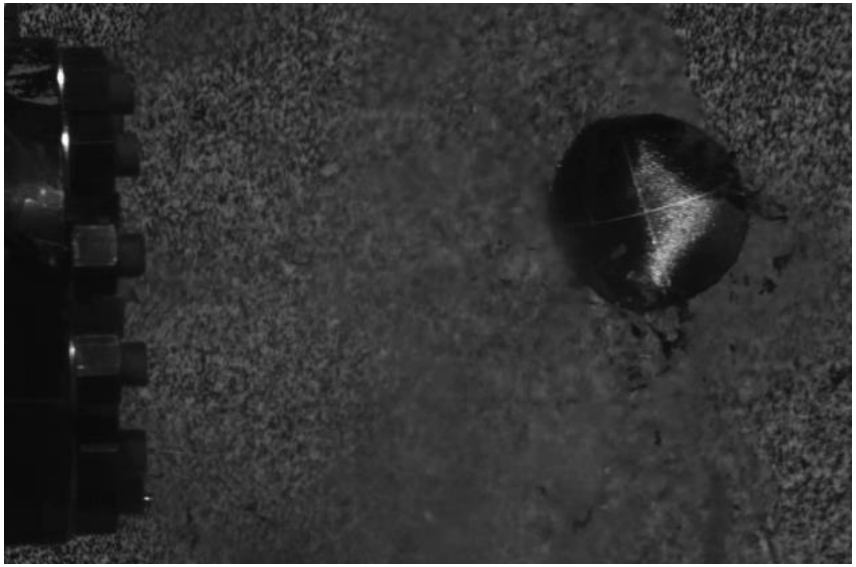
- High-pressure driver up to 3000psi
- Low-pressure driven section to 700psi
  - Models the N2O storage container
  - Test plate fixed to end of tube
- Burst disk fails and produces shock wave



Results: Instrumentation

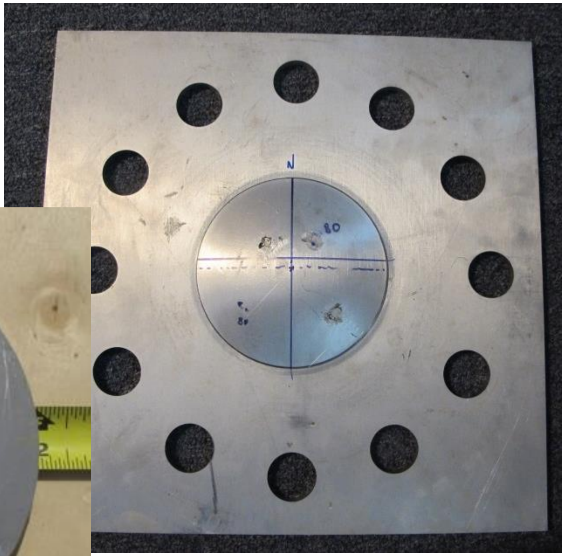
- Pressure gages along low-pressure section
- Thermocouple in low-pressure section
- High-speed imaging of plate failure
- Low-speed imaging of overall test
- Acoustic emission measurements

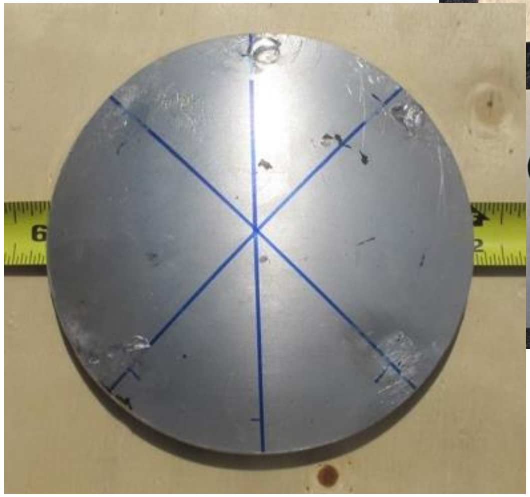
Results: Videos of testing

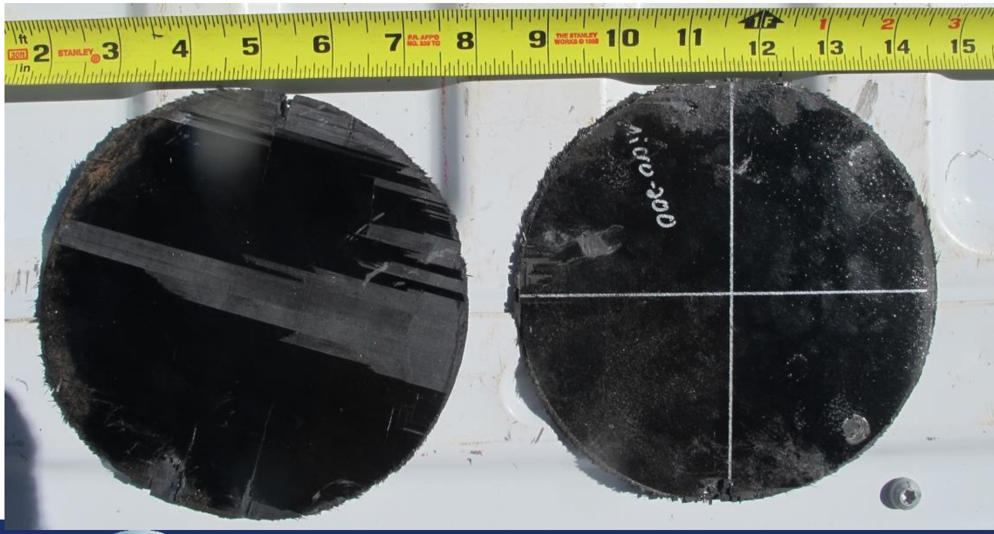


Results: Failure of plates

- 0.375” thick Aluminum test 1
- 0.25” thick Aluminum test 2
- Composite test 1
  - Composite material had thickness and glass transition temperature similar to sample of composite tank from a manufacturer

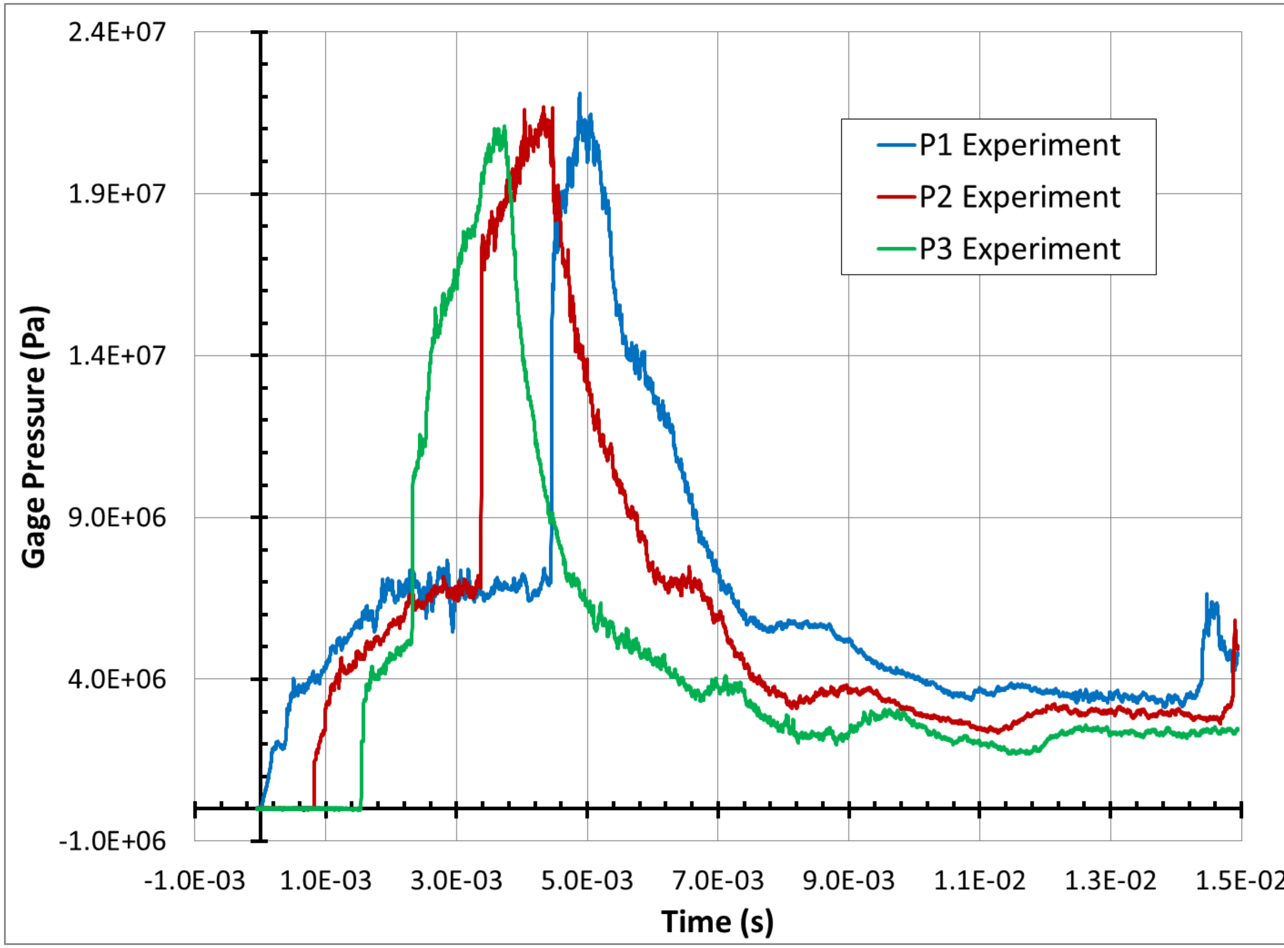






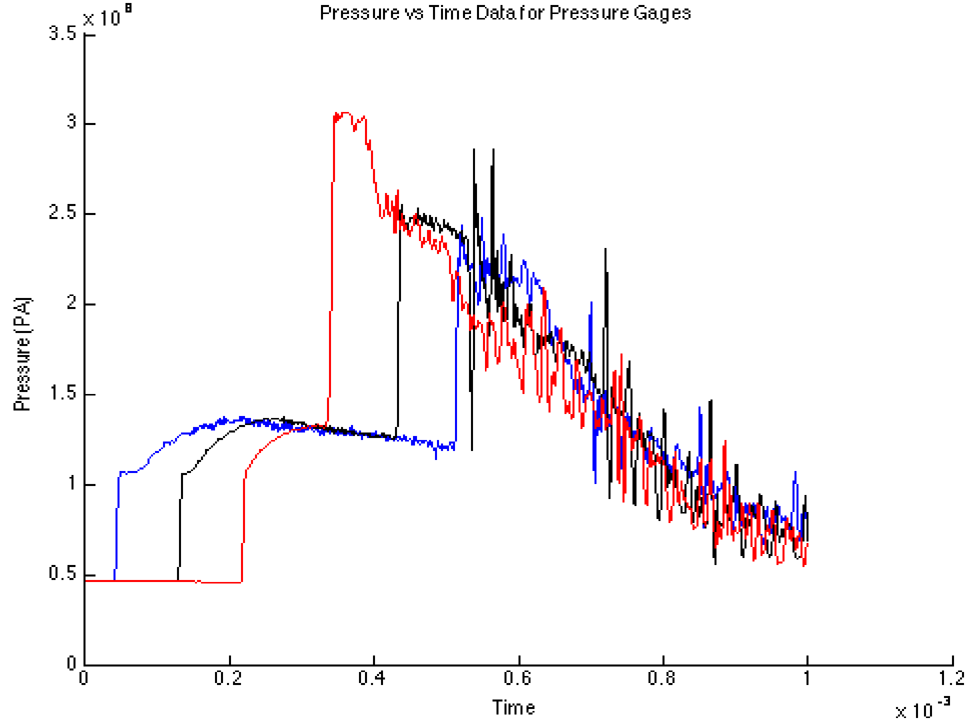
Results: Pressure profiles

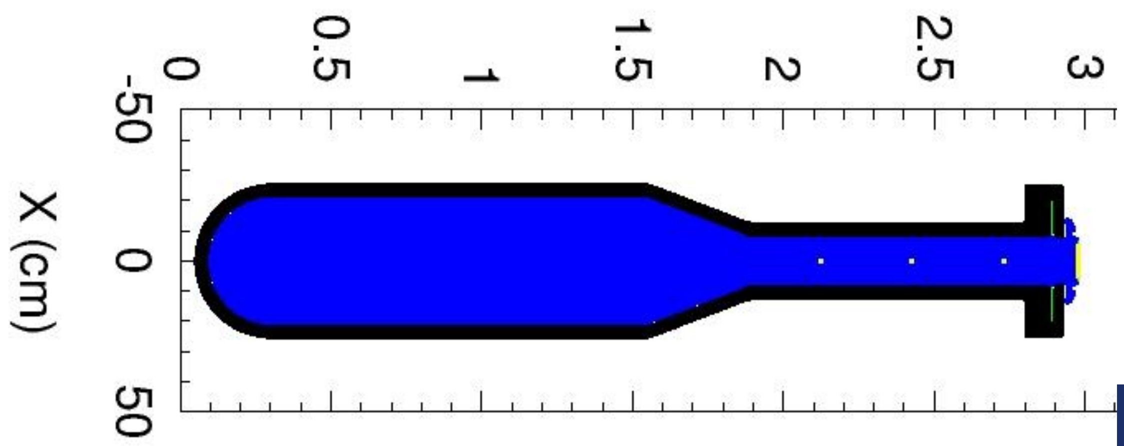
- Shock wave is formed in driver section
- Shock wave reflects from plate
- Plate failure occurs after reflection and results in pressure relief



Results: Simulations

- Simulations using CTH
- Pressure traces are similar to experimental measurements
- Failure of aluminum plate is in the same mode





Results: Acoustic Emission Testing

- Acoustic emission (AE) is passive sensing technology that allows for monitoring acoustic activity in structural material
- NMT hardware includes state-of-the-art Mistras Micro-II Digital AE System and a variety of conventional (Micro-80) or new (PWAS) acoustic emission sensors

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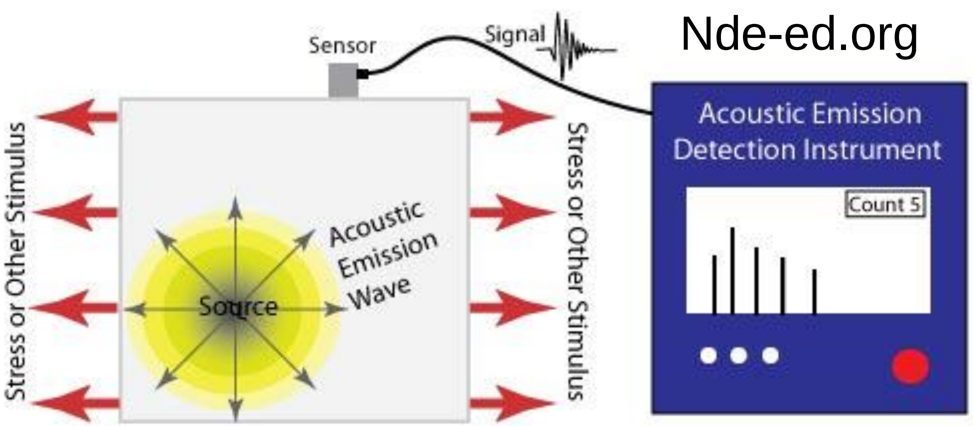
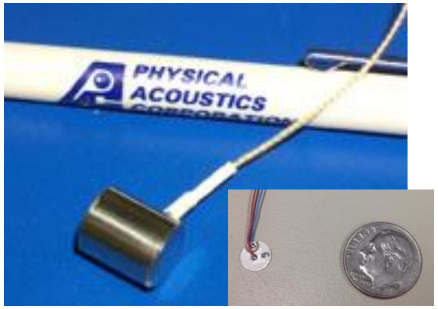
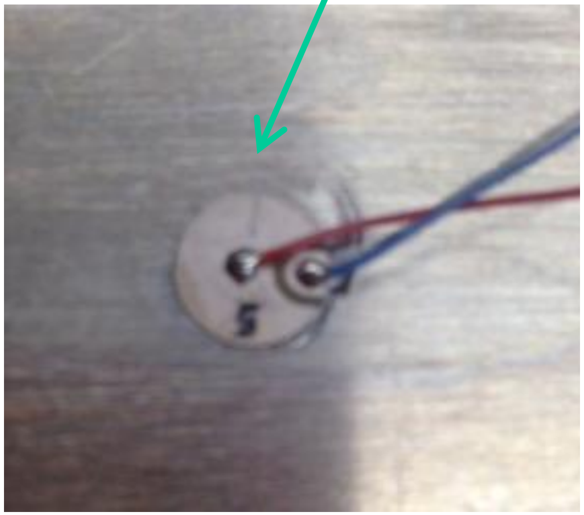




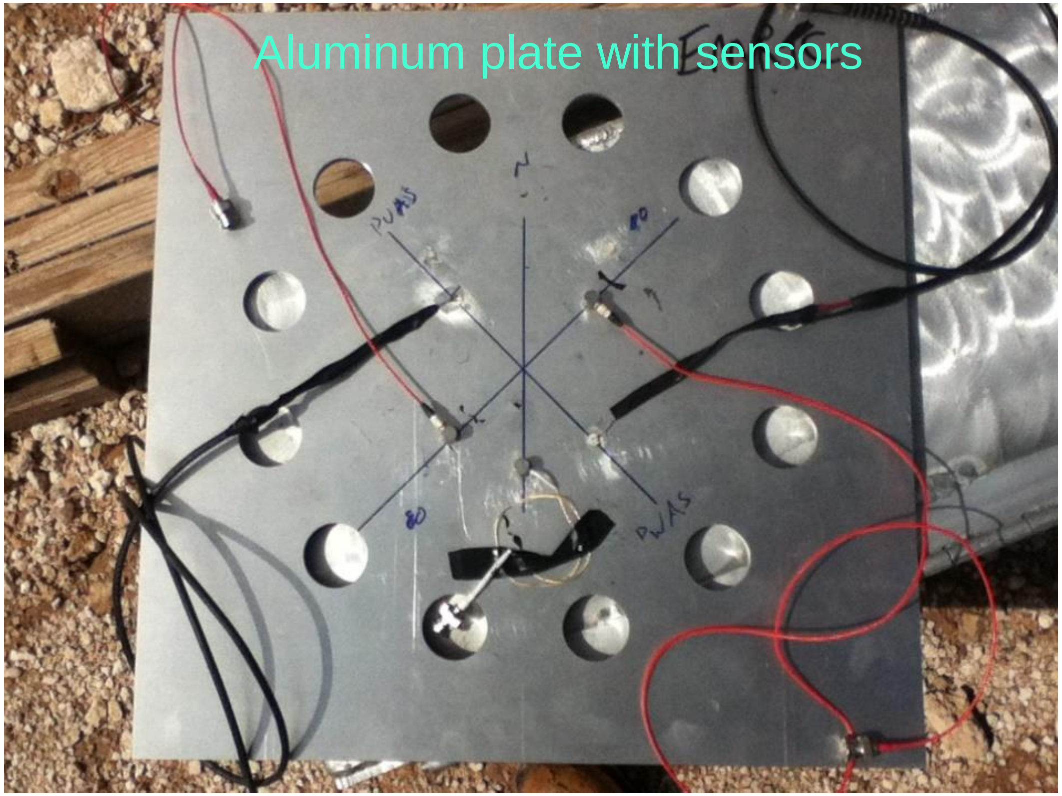
AE Testing of Aluminum Plates

- Goals of the test:
  - Explore feasibility of utilizing AE sensors to record high-strain event.
  - Investigate performance of conventional (Micro-80) and embeddable (PWAS) sensors during high-strain event.

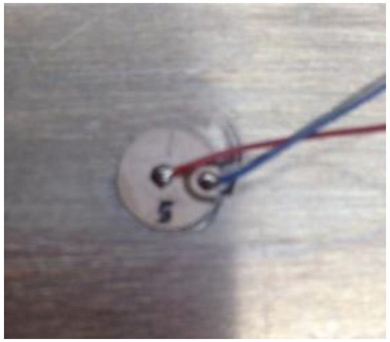


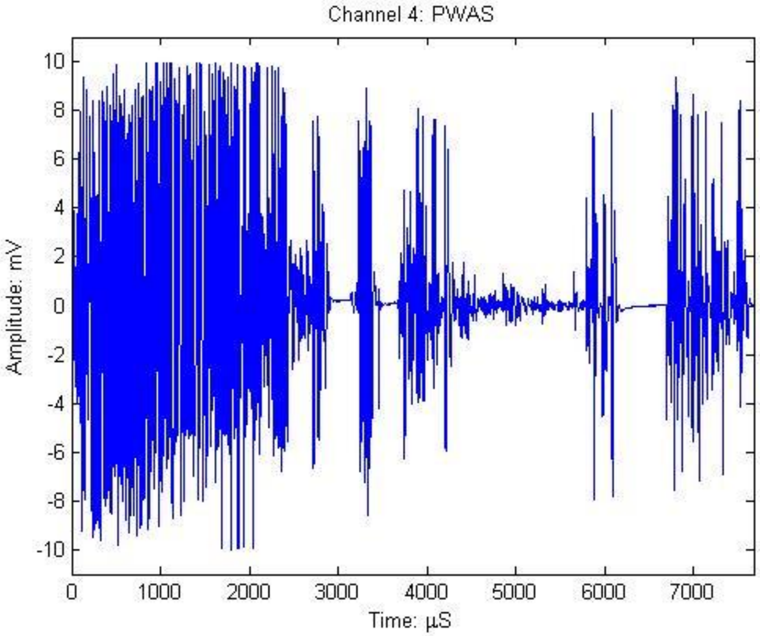
AE Sensor on Aluminum Plates

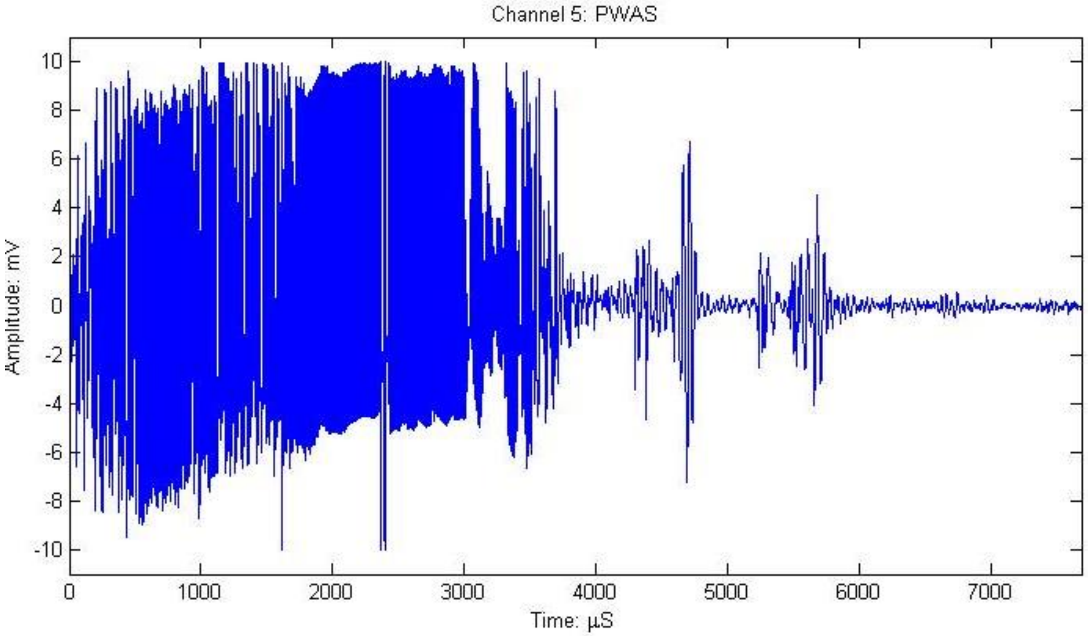
- Sensors were glued to aluminum plate with special epoxy
- Adaptors allow for connecting sensors with very long cables



Test 2 Results Ch4/Ch5 PWAS Sensors







Piezoelectric wafer active sensors (PWAS) show comparable, but less stable signal features. This may be due some damage to fragile PWAS.

AE Test Results

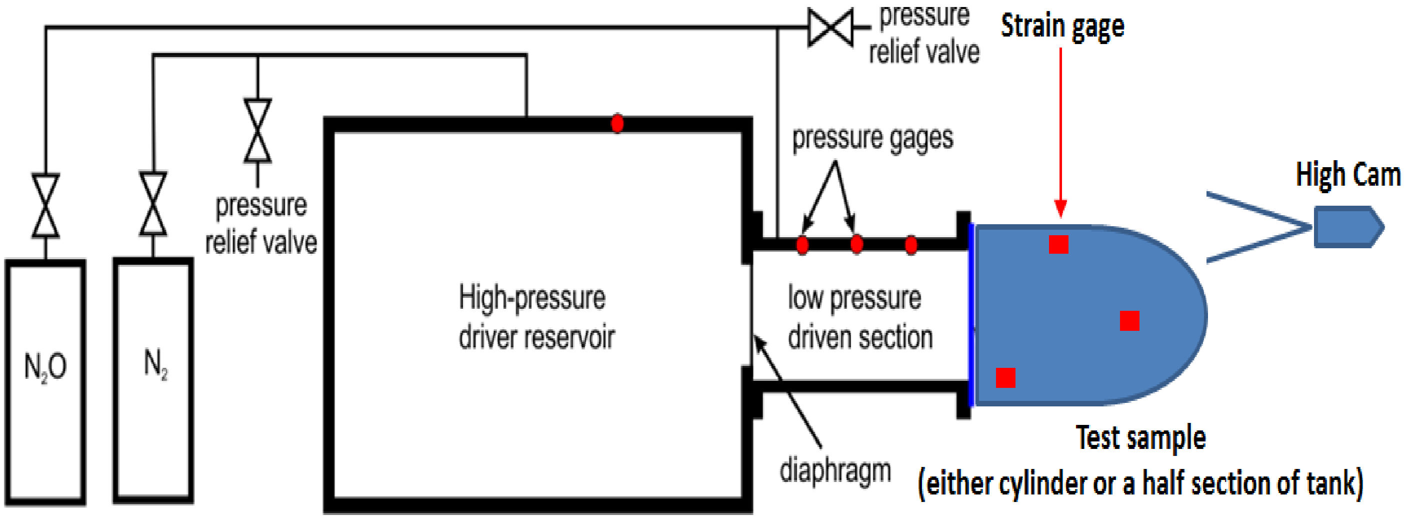
- Acoustic emission sensors are capable of recording high-strain events
- These event produces many signals, which are often indistinguishable from one another
- Signal features are similar when sensors are positioned symmetrically
- Data from conventional Micro 80 sensors is more stable than from PWAS, but PWAS is more economical

Conclusions

- High pressure rapid failure events of composite vessels can be simulated
- Initial evaluation completed on flat plate samples
  - Shear failure of aluminum liner
  - Shear and some fragmentation of composite material
- Test and analysis agree
- Failure mode likely sensitive to type of loading

Next Steps

- Test and analysis of cylindrical sections



- Develop predictive models
- Validate with full composite vessel test