NONDESTRUCTIVE INSPECTION OF ENERGETIC MATERIALS DURING MANUFACTURE

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NDIA Insensitive Munitions & Energetic Materials Technology Symposium
Munich, Germany, October 2010

Program Objectives

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Objective:

- To develop real-time measurement capabilities and then transition technology for cost effective and reliable energetics manufacturing process

Benefits:

- Provide explosive production base with science of manufacturing by establishing a real-time measurement
- Drastically reduces learning curve and production start-up costs of new explosives formulations
- Determine critical parameter values and product quality at any moment during the production process

Two Analyzer Applications

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Explosives Slurry Probe

- Multi-use probe to measure characteristics of explosive mixtures
- Sensor Technology
- Pilot Testing on Inert Slurries
- Next Steps

Explosives Press Analyzer

- Ultrasonic analyzer for quality of pressed explosive warheads
- Sensor Concept
- Live PAX-2A Explosive Test Results
- Conclusions and Future Work

Ultrasound Slurry Probes

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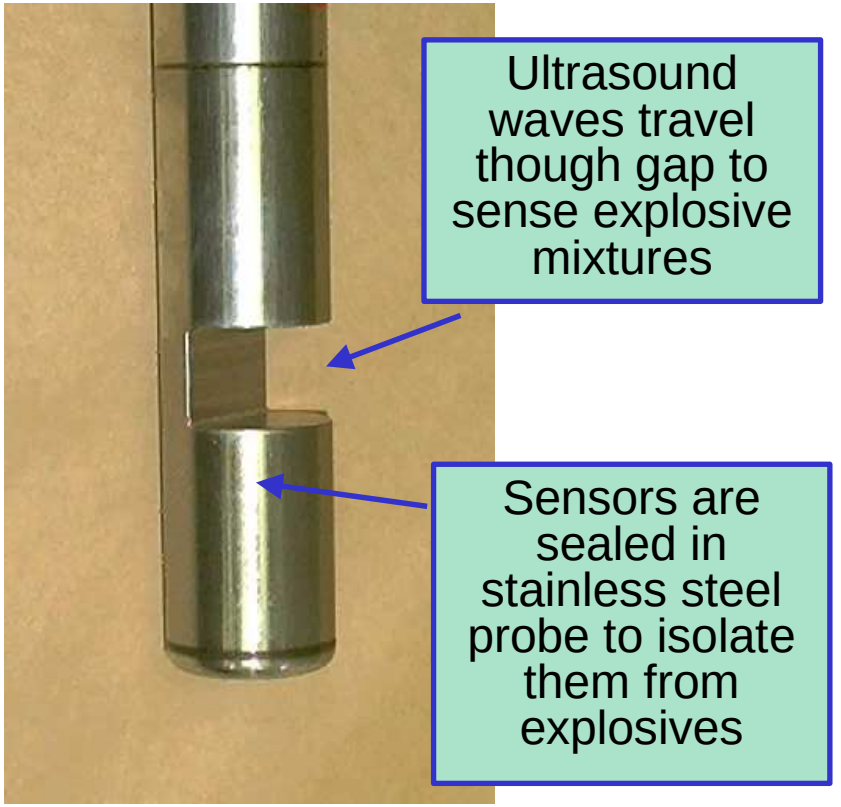
- Explosives manufacturing companies requested a probe capable of many types of characterization
  - Particle size,
  - Settling stability
  - Water content
- One ultrasound probe could provide all types of this characterization safely for explosives
- Funded through Army SBIR program



Particle Size Analysis

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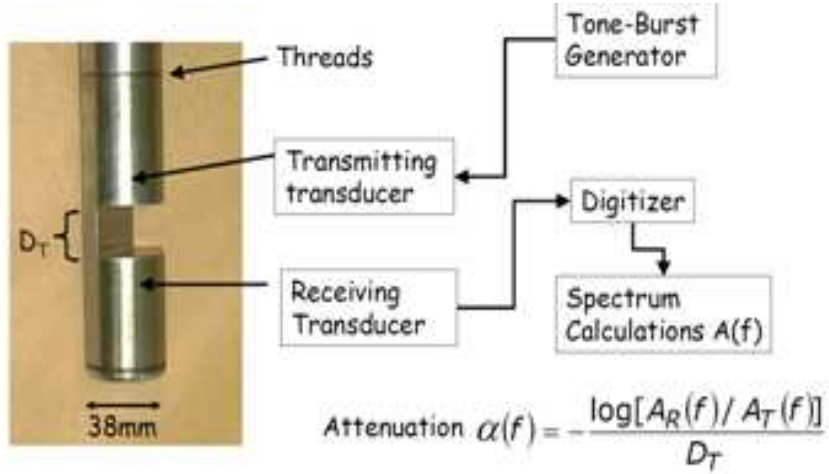
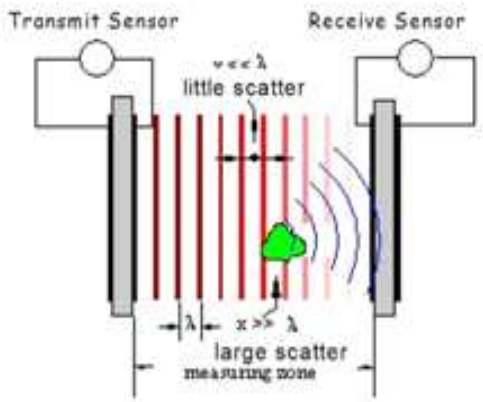
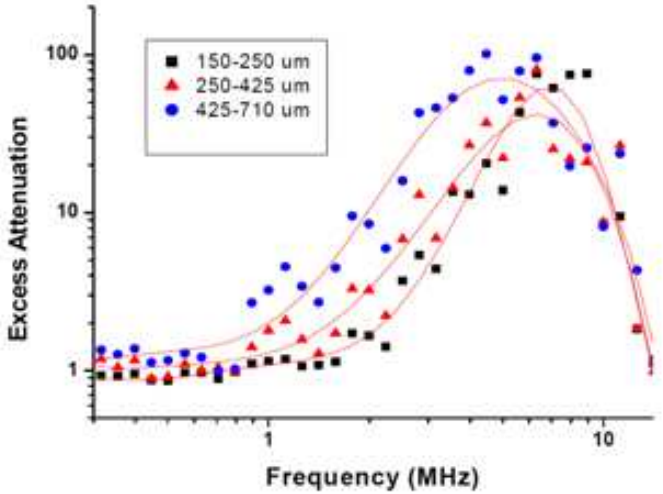
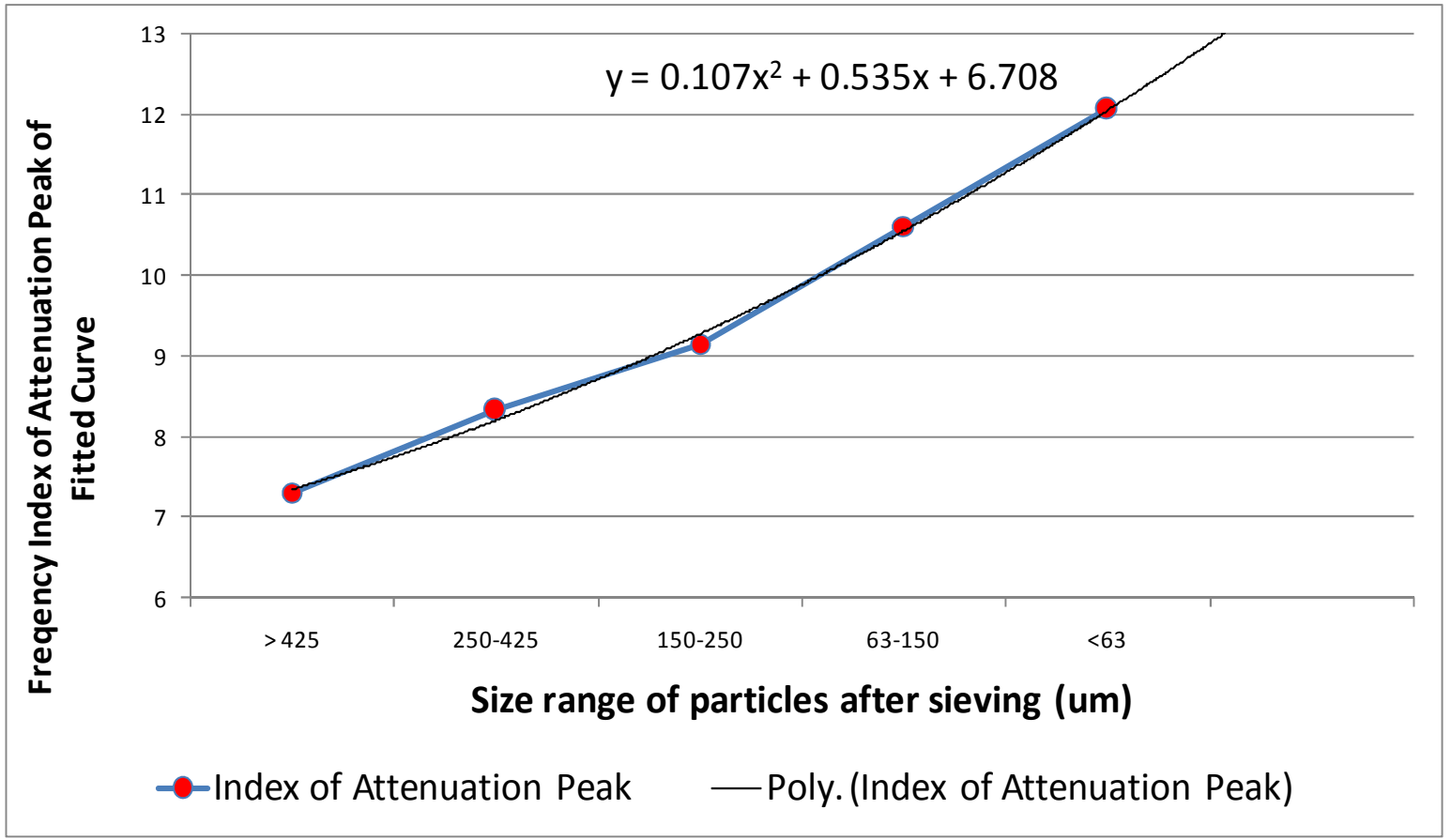
- Uses resonance frequency of particle to measure size
- Successfully used on PAX 2A explosive
- Challenge in bubbles which form during coating process







Ultrasonic Attenuation Tracks Particle Size



Water Content and Slurry Stability

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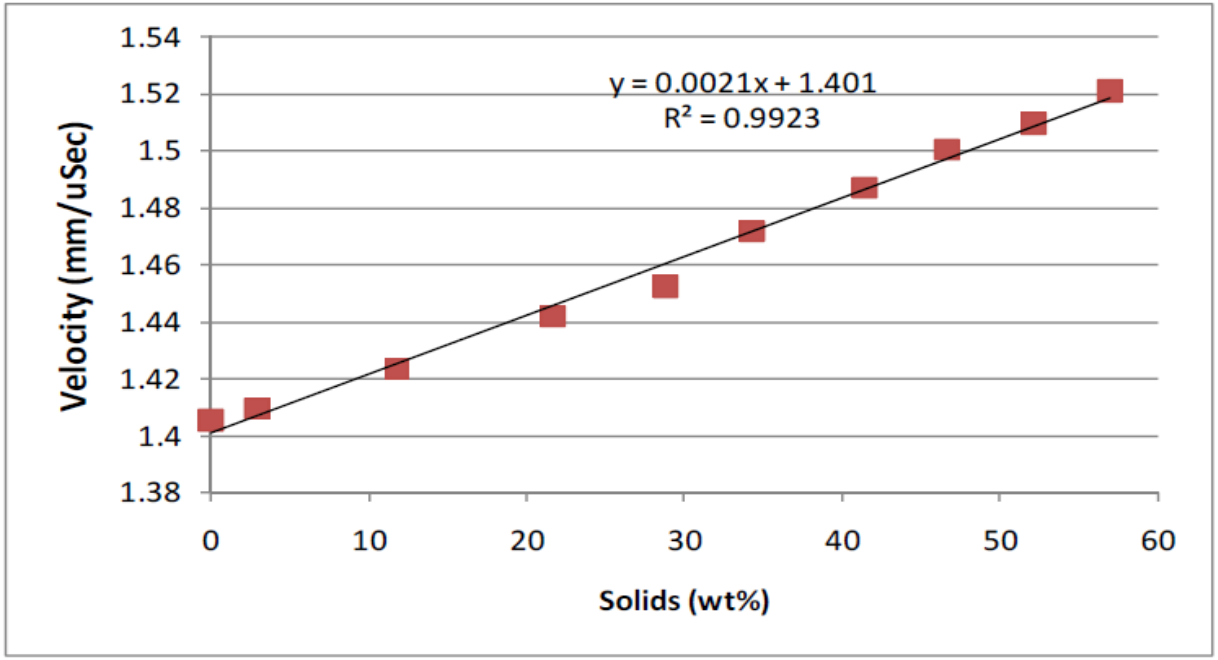
- Use correlation between velocity data and solids loading for viscosity measurement
- Ultrasound velocity measurement during a mixing process shows various changes in viscosity and settling-stability
- Solids content can be measured during a drying process using ultrasound velocity.



Ultrasound probe lowered into stirred slurry of inert particles

Explosives Press Analyzer Concept

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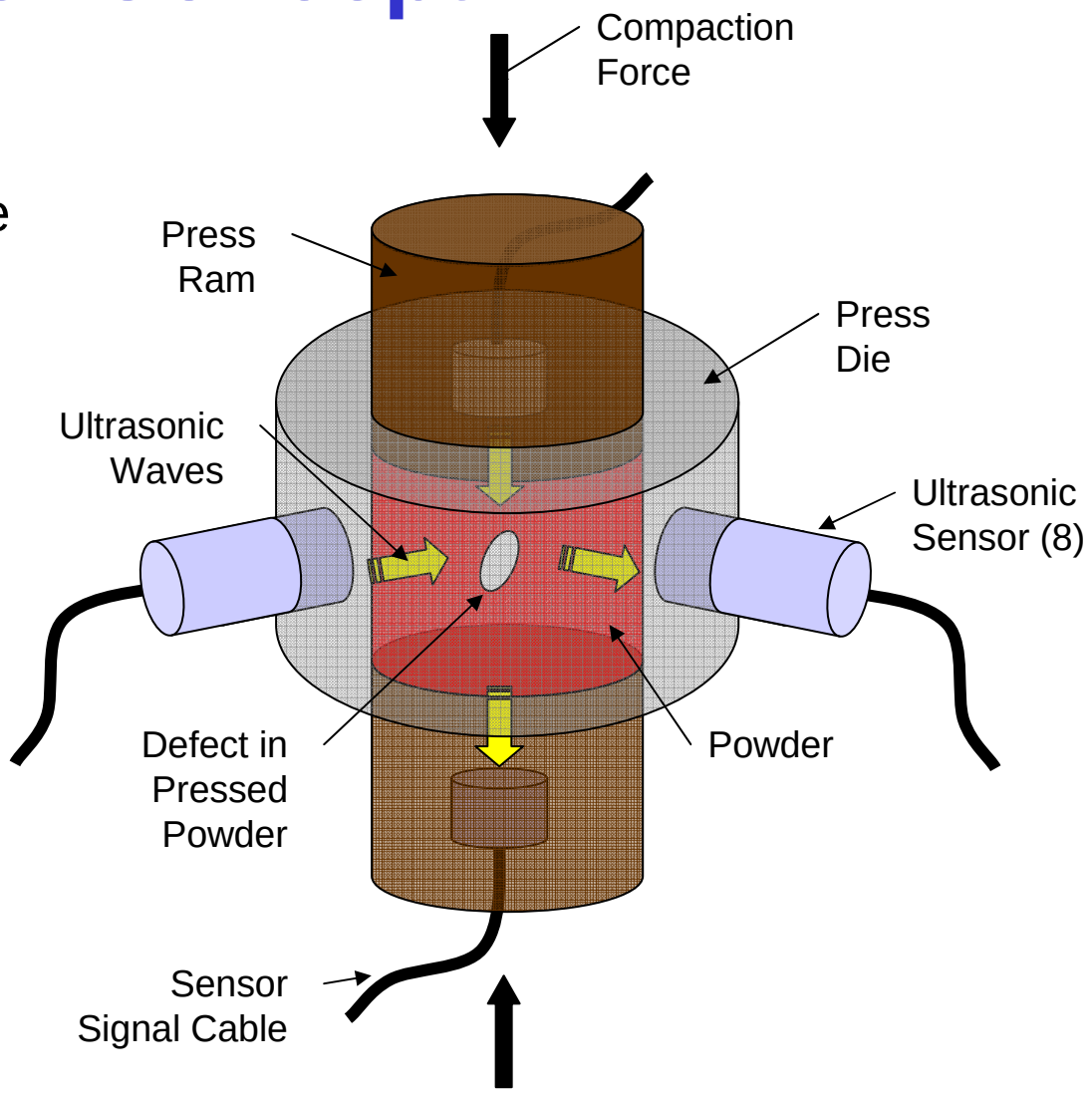
- Cylindrical die instrumented with ultrasonic sensors on the sides (and top/bottom) of the billet
- Ultrasonic waves travel through the die walls and powder to sense changes in density
- Sensors do not contact the explosive powders and allow for an explosion proof design



Inspection Concept

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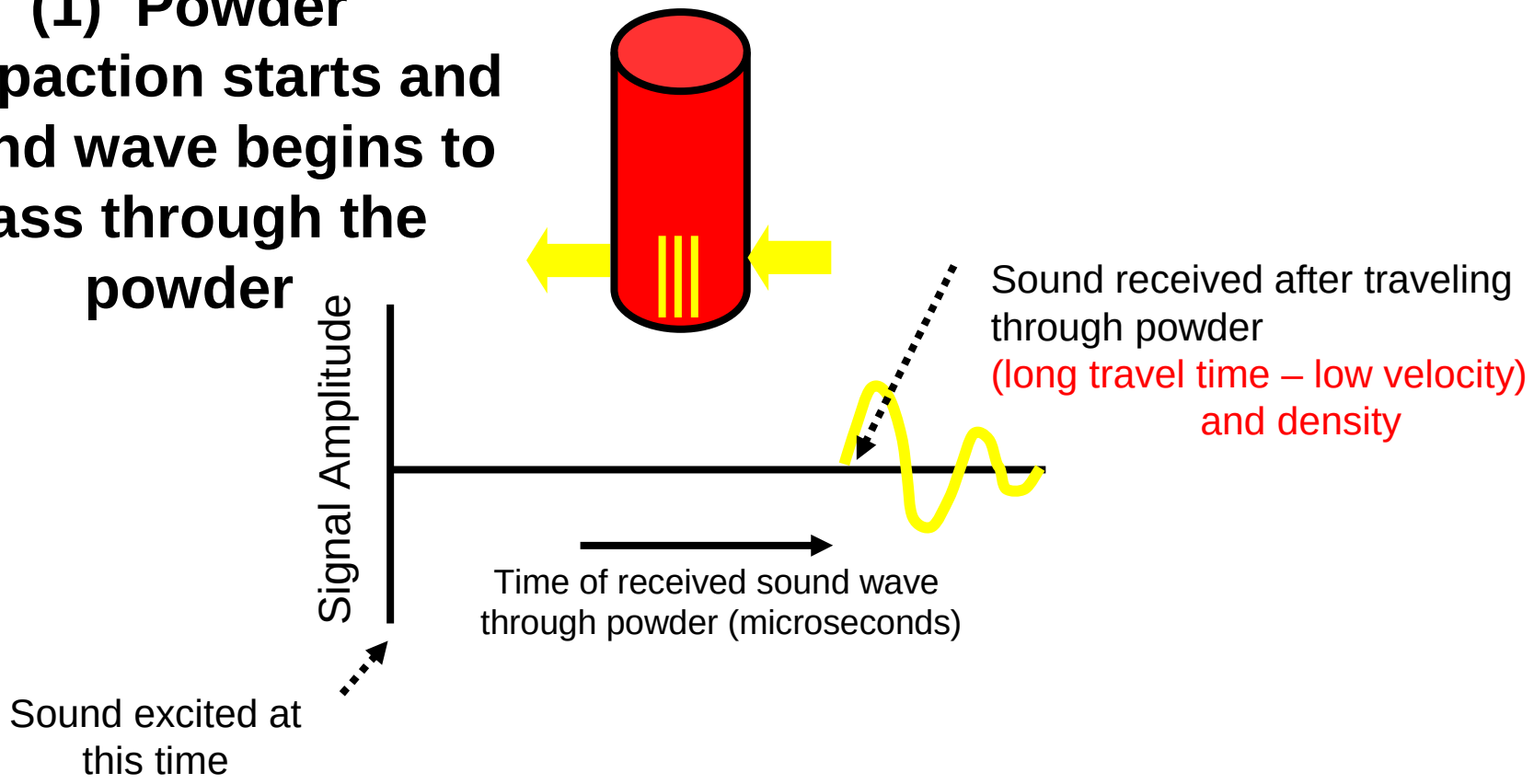
Sound velocity increases directly with the compaction (density) of the billet

(1) Powder compaction starts and sound wave begins to pass through the powder



Inspection Concept

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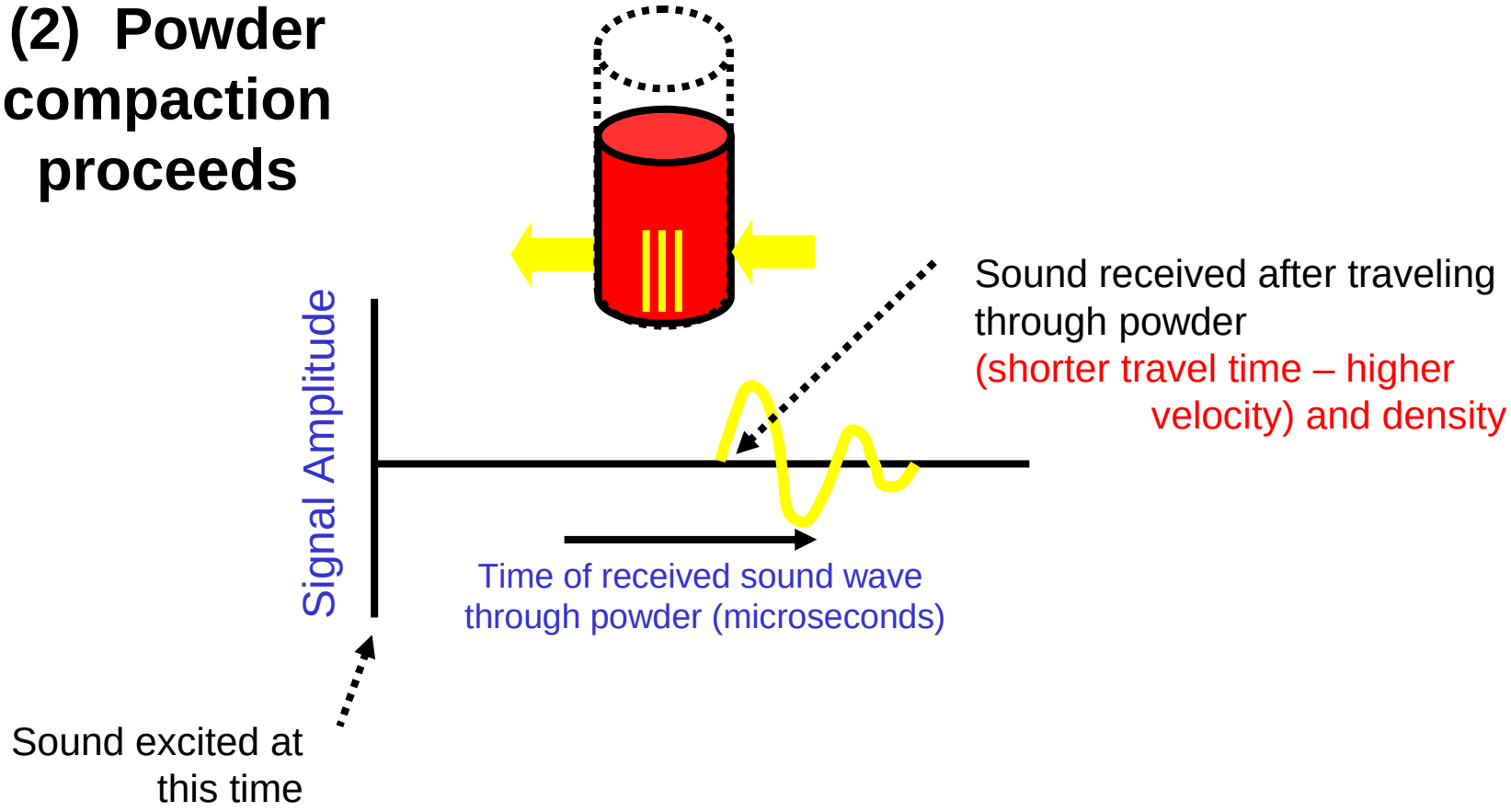
Sound velocity increases directly with the compaction (density) of the billet

(2) Powder compaction proceeds



Inspection Concept

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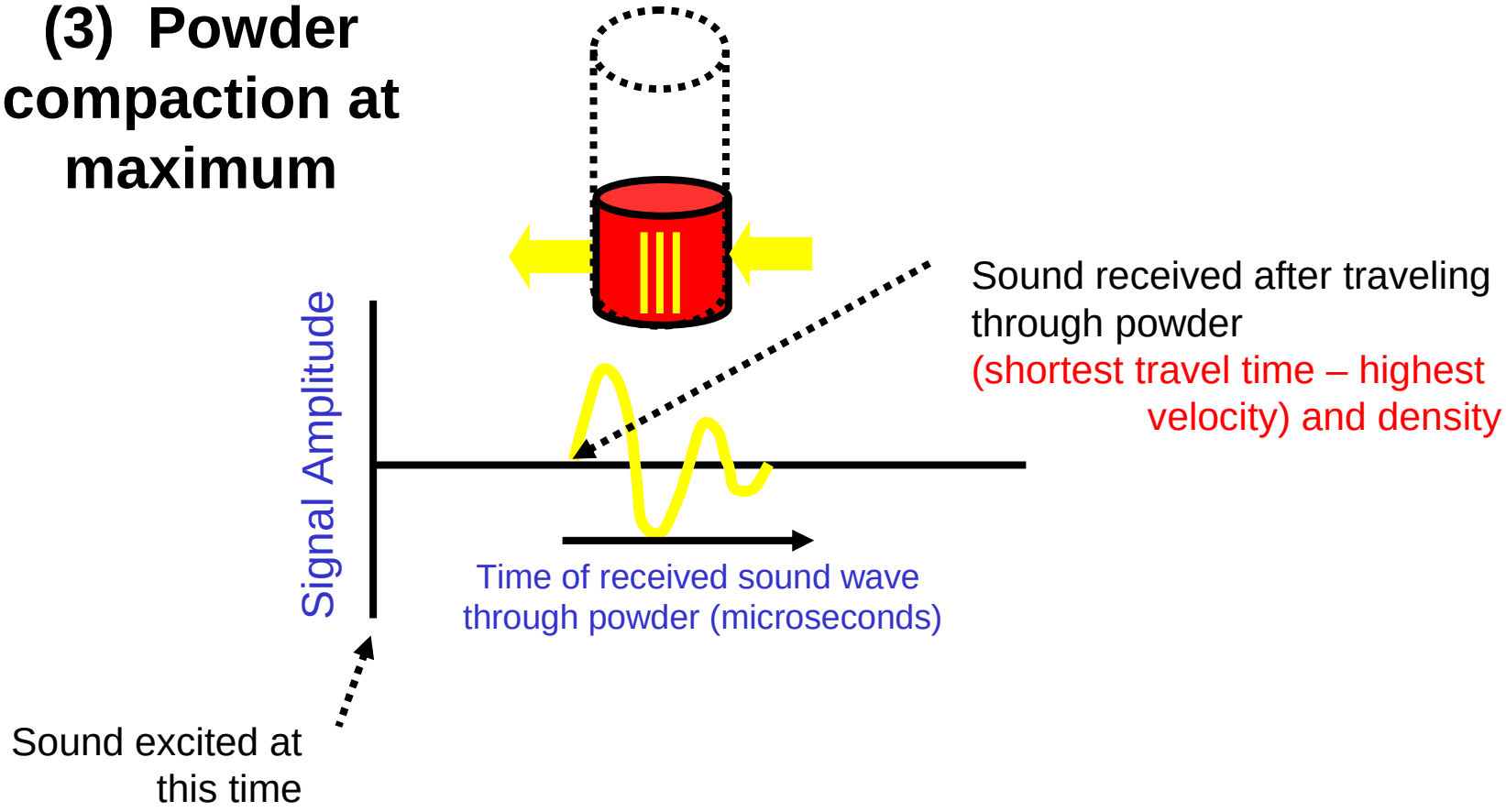
Sound velocity increases directly with the compaction (density) of the billet

(3) Powder compaction at maximum



Technology Application-81mm Die

- 81mm inner diameter die liner used to press warheads at ARDEC, Picatinny Arsenal
- Die produces 3 – 8” long billets using up to 25,000 pounds of ram force
- 7 sensor pairs spaced at seven levels and angles around a cylindrical die
- Holes do not contact powder in die – non-contact sensing
- Outer die container (not shown) encloses sensors for an explosion-proof design

Results for PAX-2A explosive powder

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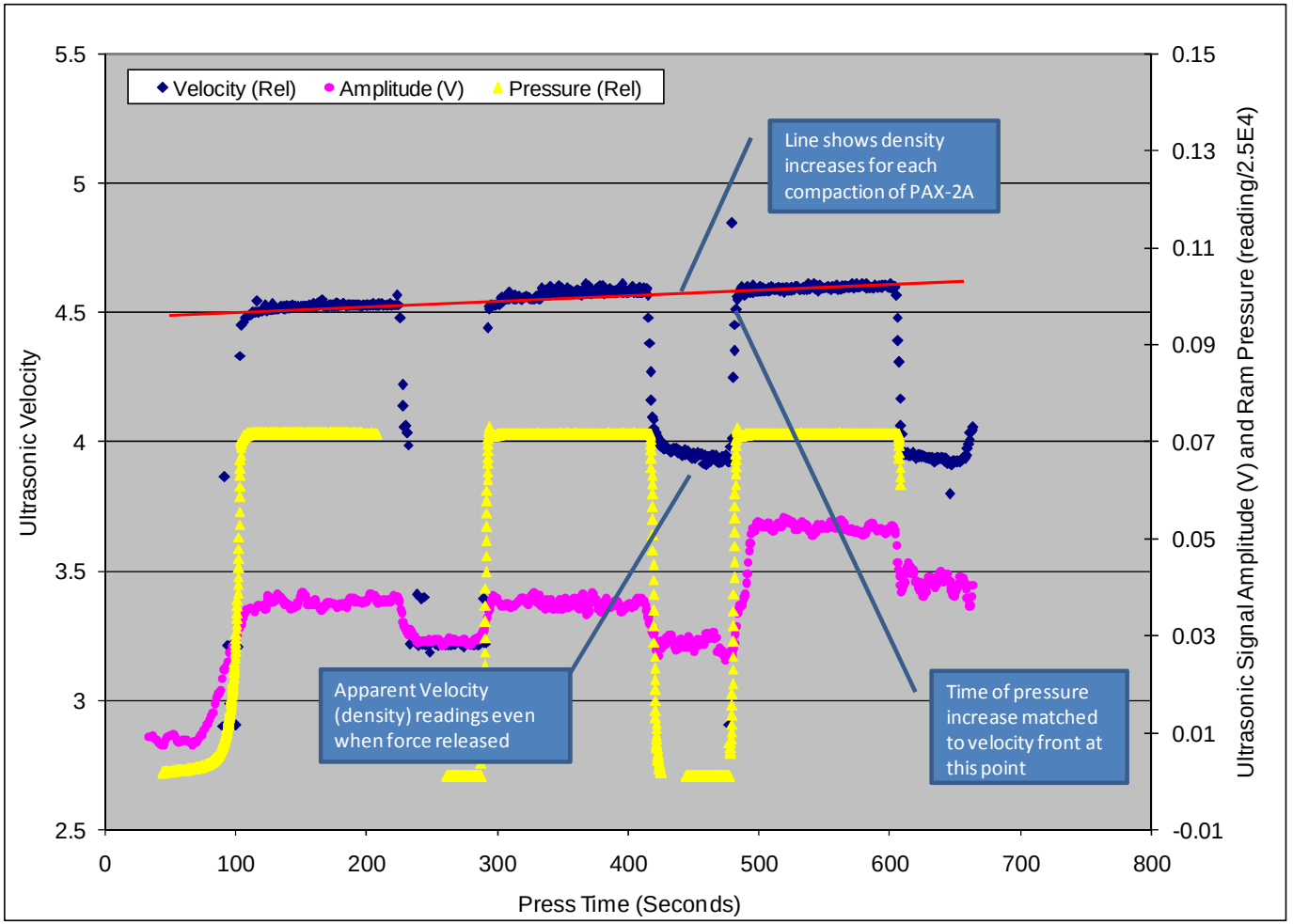
- Increases in the pressure result in increases in the ultrasound velocity and amplitude as expected.
- Final ultrasound velocity (and density) increases with each press cycle, indicating that the additional cycles are a benefit to the compaction. This is not true for all the explosives tested.



Real-time density results for PAX-2A

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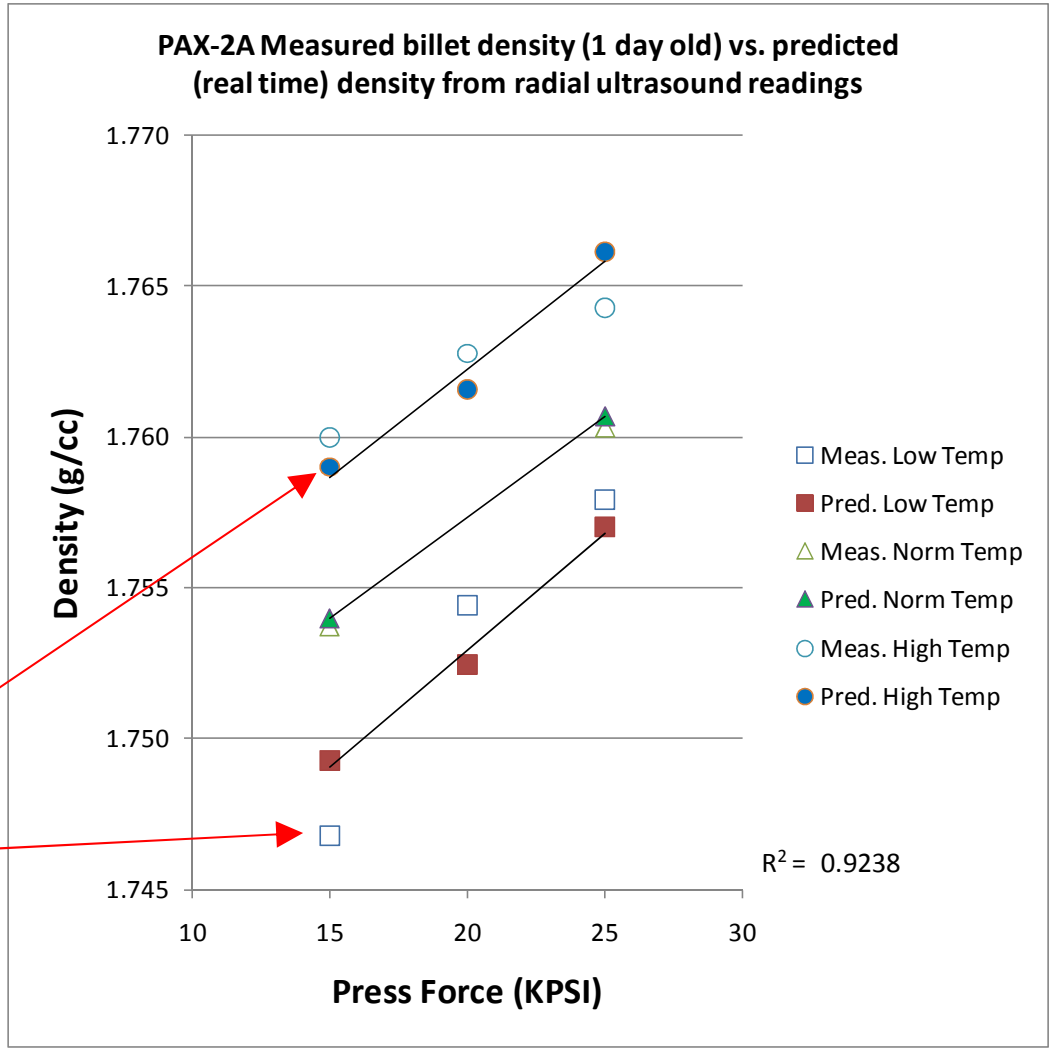
- Calibration relation developed using 8 pressings of PAX-2A at different temperatures and ram pressures.
- All predicted densities were within 0.002 g/cc of the actual wet-density measurements



Ultrasound predicted density shown as solid markers

Actual wet-density measurements shown as open markers

Primer Press Analyzer

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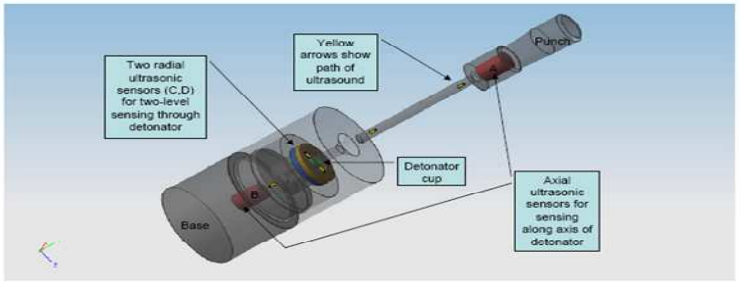
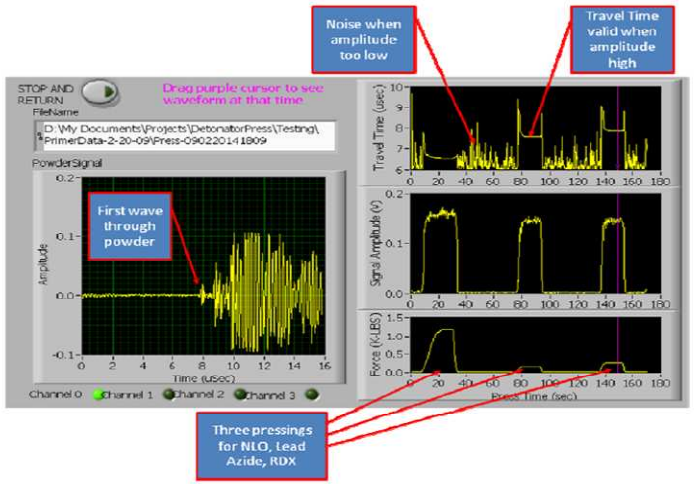
Contributors: Emily Cordaro, Daniel Stec, Gartung Cheng, Joel Rivera

- Primer Detonator Caps
- 4 Sensors, 2 axial, 2 radial
- Correlate measured travel time and density between pressings of material
- Identify current problems with inconsistency in detonator caps



Model of Primer Press Sensor and Die



Primer Press Analyzer screen

Primer Press Setup

Conclusions

- Simply using time of flight and amplitude data, many manufacturing processes can be analyzed in real time
- Ultrasound technology is used in ARDEC in a number of applications
- Ultrasound technology is in the process of transition to the Iowa Manufacturing Plant, BAE systems, and various non-energetic manufacturing plants