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Nonel (Shock Tube)

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Outline

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  - Reactive Composition
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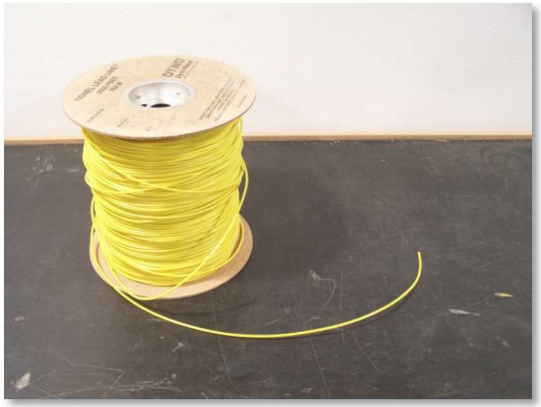
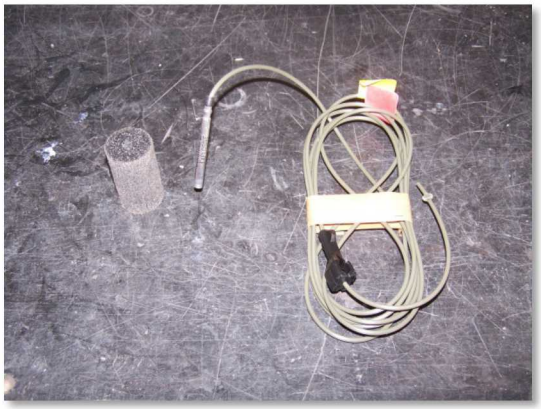
History

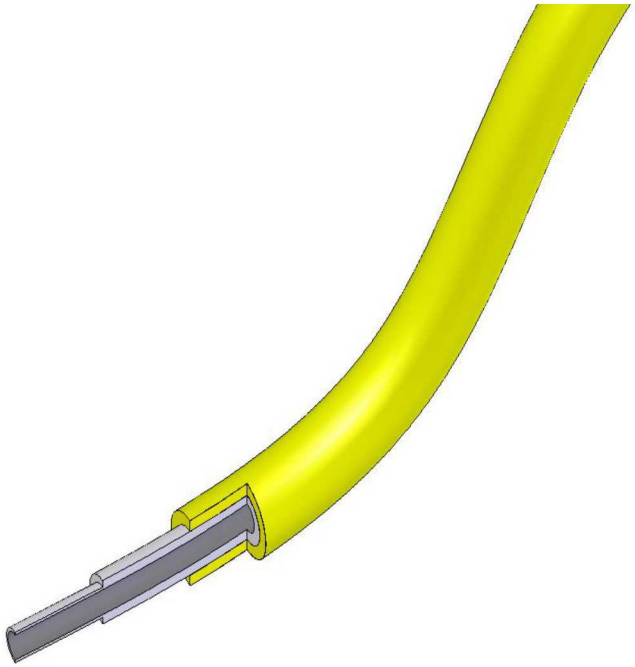
- Prior to 1970 the primary mechanism for initiating explosives was electric detonators that had inherent electrical sensitivity hazards
- 1970 Dr. Per-Anders Persson patents his shock tube delay detonator system called NONEL
- NONEL system has a significant impact in the mining industry by:
  - Reducing electrical sensitivity hazards
  - Reducing the quantity of detonation cord needed and used
  - Increased the efficiency of in-hole explosive operations
- 1980 the US Navy the first in the Department of Defense to certify NONEL for use in explosive operations
- 1990's NONEL becomes the primary mechanism for initiating explosive





Shock Tube Theory

- Construction
  - The plastic shock-tube is typically composed from one or more layers plastic
  - Standard dimension
    - 3 mm outer diameter
    - 1 to 1.3 mm inner diameter
- Deposited on the inner wall surface during extrusion is a reactive composition
- Usually the first layer of plastic is Surlyn:
  - Attractive properties of Surlyn:
    - Adhesive quality
    - Radial strength
    - Compatible with reactive composition
  - Detractive property
    - Stiffness



Shock Tube Theory

- Construction
  - Blending of other plastics with Surlyn in the outer layers that improves the flexibility of the tube, its robustness, and makes it easier to handle
  - Overall, the tube construction properties must provide:
    - Resistant to chemicals, water, and abrasions
    - The ability to operate in hot and cold environment
    - Good tensile and radial strength
    - The ability to contain propagation of the detonation

Shock Tube Theory

- Reactive Composition
  - The standard reactive composition used in NONEL shock-tube is a HMX/Aluminum mixture
    - HMX
      - Beta-HMX
      - 20 micron particle size
  - Aluminum
    - Stearic acid coated flake
    - Thin coating of Aluminum Oxide
  - Reactive composition load
    - 20 mg/m

Shock Tube Theory

- Initiation and Reaction Process
  - Initiation of the shock tube requires a hot, high intense shock impulse produced by:
    - Percussion primer
    - Percussive electric match
    - Electrical spark gap
    - Detonation cord or detonator

Shock Tube Theory

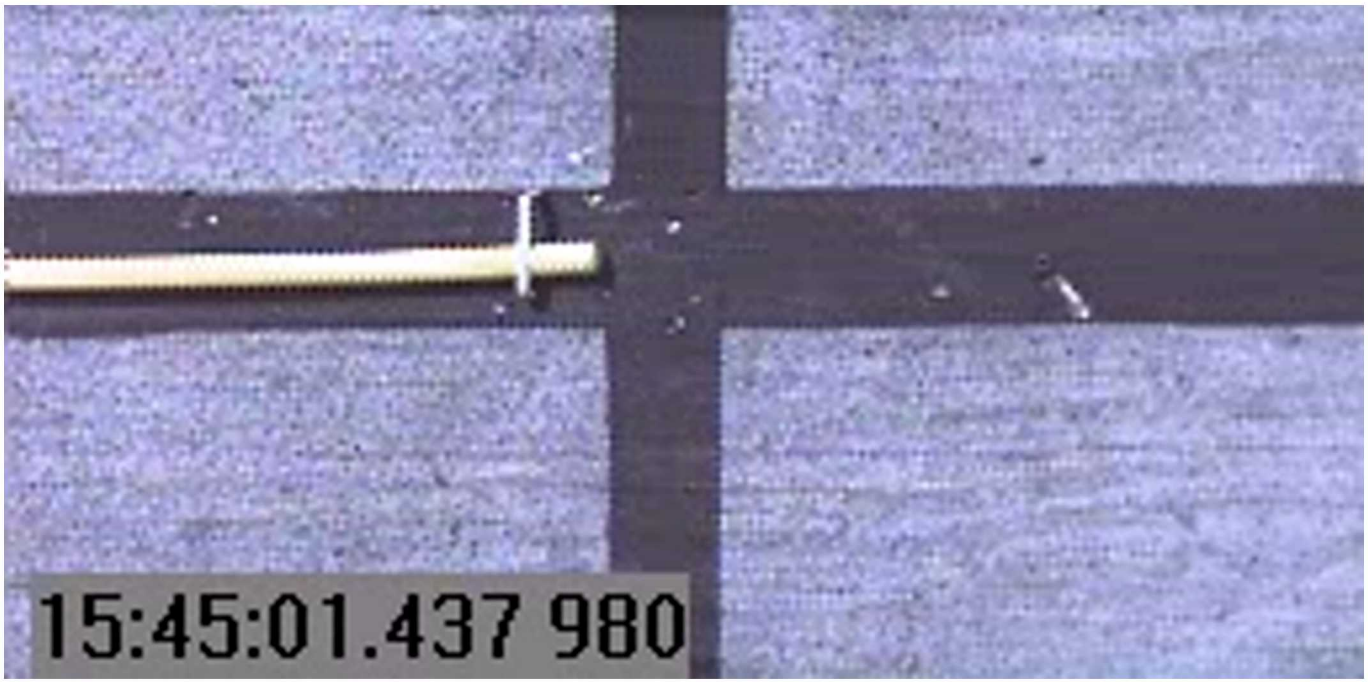
- Initiation and Reaction Process
  - Reaction process starts by:
    - The intense shock from the initiation mechanism turbulently disperses the reactive composition into the center of the tube and also heats the reactive composition to produce a detonation wave

Shock Tube Theory

- Initiation and Reaction Process
  - Steady-state reaction
    - Upon ignition, the reactive composition produces a detonation wave
    - The detonation wave propagates down the tube turbulently dispersing the reactive composition to the center of the tube in the form of a dust cloud
    - The reaction of the dust cloud supports the detonation wave therefore producing a steady-state reaction
    - Because the reactive composition is thin the Detonation wave is weak and propagates at 2 km/s (6500 ft/s) due to large side losses from the reaction

Shock Tube Theory

- Output
  - The shock-tube produces an output that consist of a short duration shock pulse followed by hot gases and particles
  - The output pressure is 7 MPa (1000 psi) to 27 MPa (4000 psi)

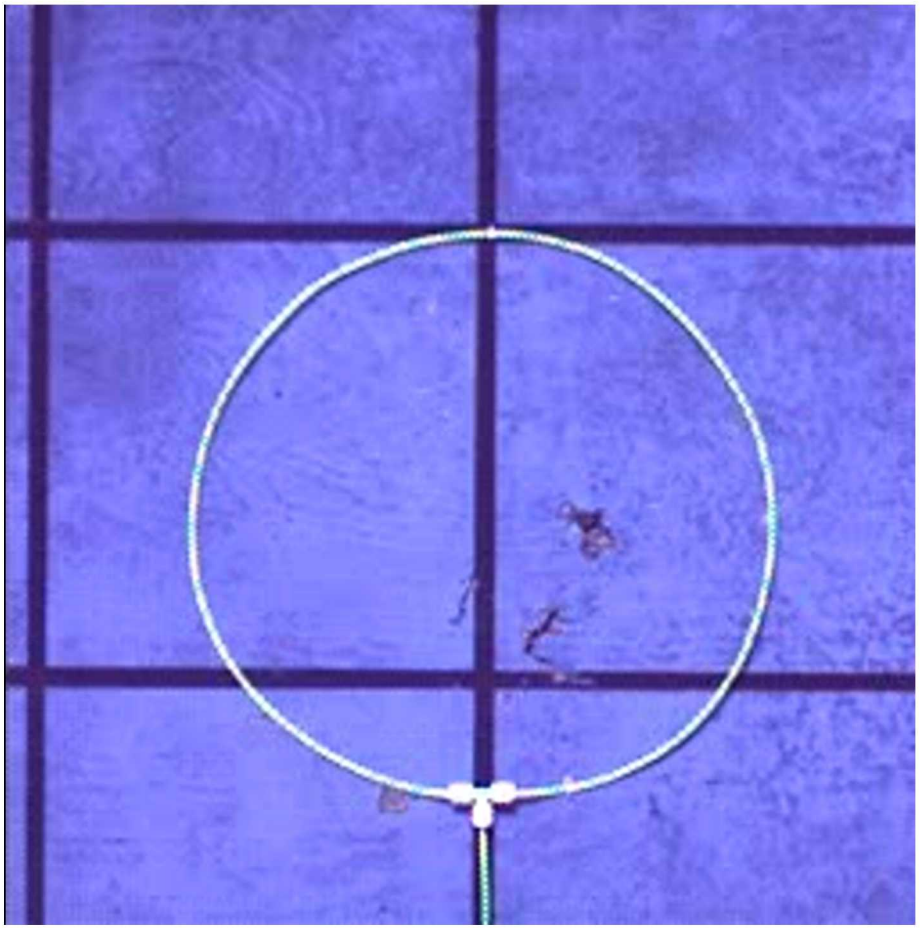


Shock Tube Theory

- Safety Considerations
  - Electrostatic Discharge
    - NONEL shock-tube is insensitive to 30KV, 500 pf capacitive discharge which, exceeds that produced by human (http://www.shocktubesystems.com)
  - Impact resistance
    - The HMX/Al mix is extremely insensitive to impact shock
    - The report “High Velocity Impact & Spark Initiation Experiments on Shock tube” by P. Roberts, P.M. Dickson, and J.E. Field, 1994, PCS, Cavendish Laboratory, UK showed:
      - NONEL with an incision at the impact site would initiate, in one direction, when impacted by a 12.35 mm diameter by 25 mm height cylindrical PMMA projectile with a velocity greater than 720 m/s
  - One can see that NONEL shock tube is a vary safe initiation system in any type of environment

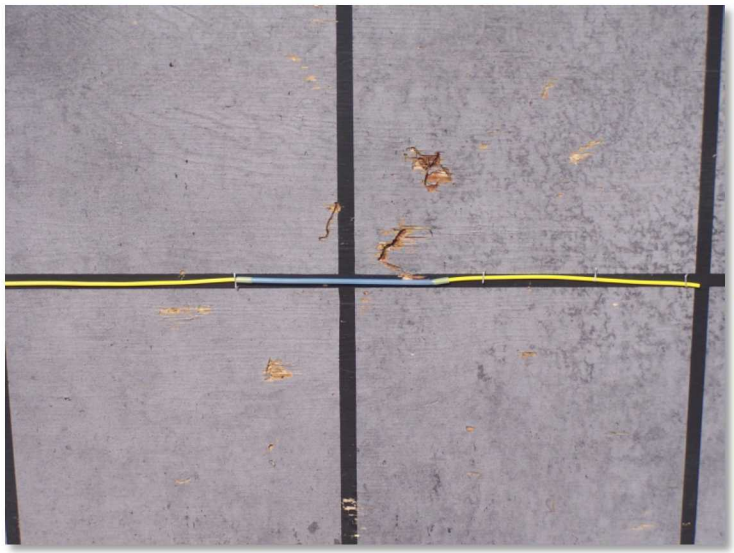
Shock Tube Characterization

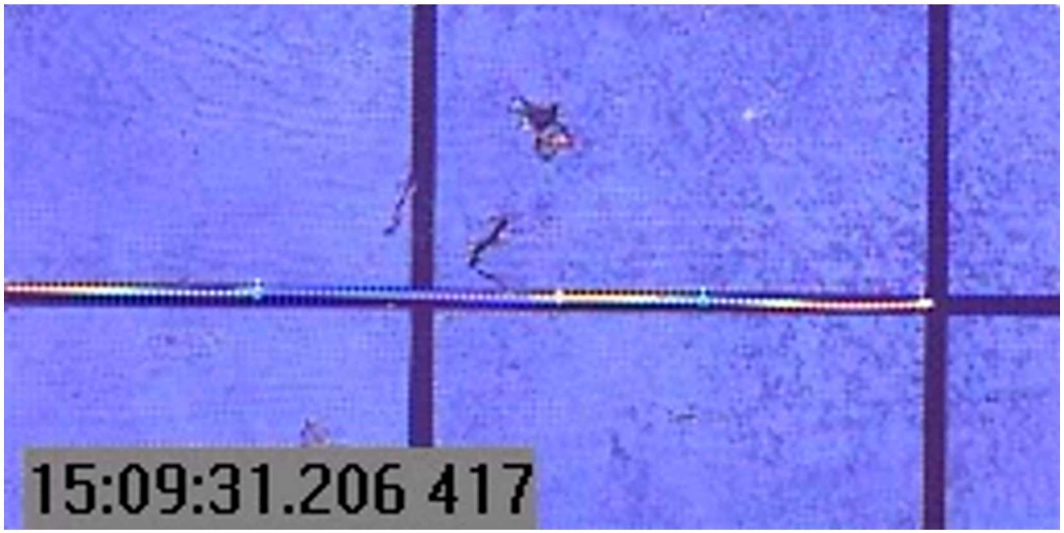
- Timing



Shock Tube Characterization

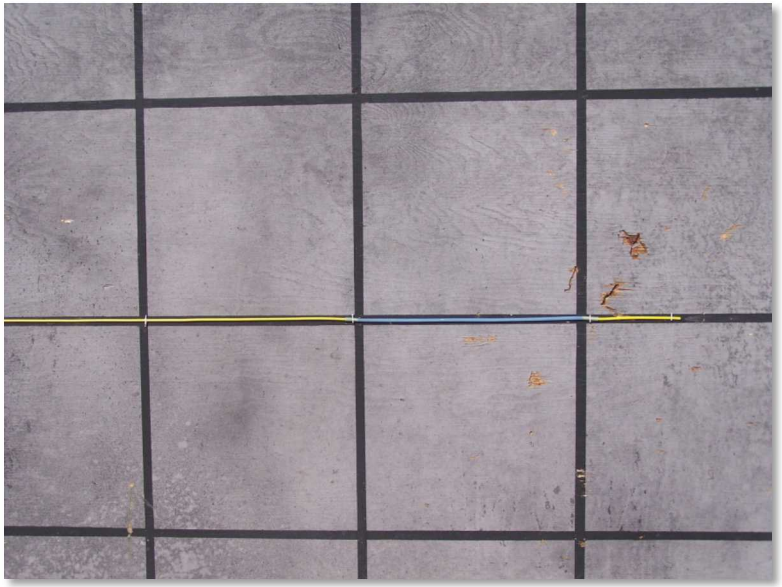
- Coupling (6” Connector)

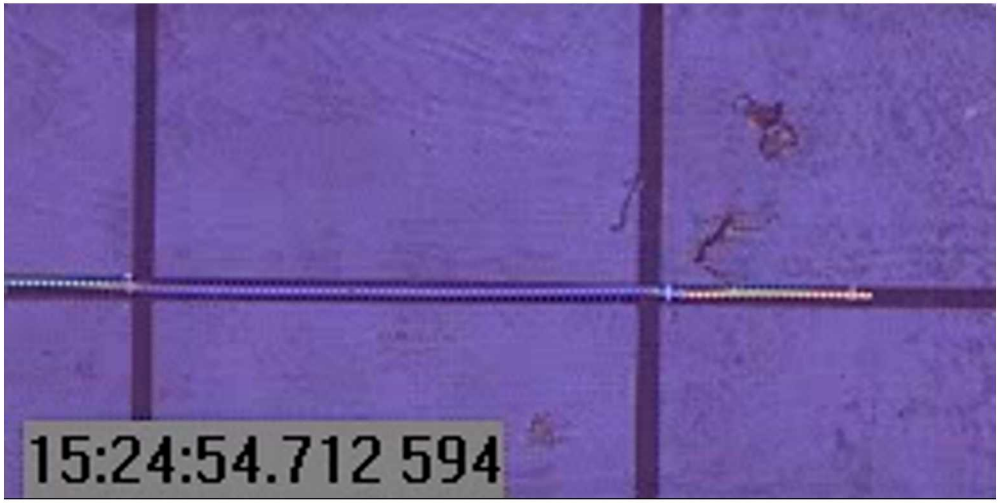




Shock Tube Characterization

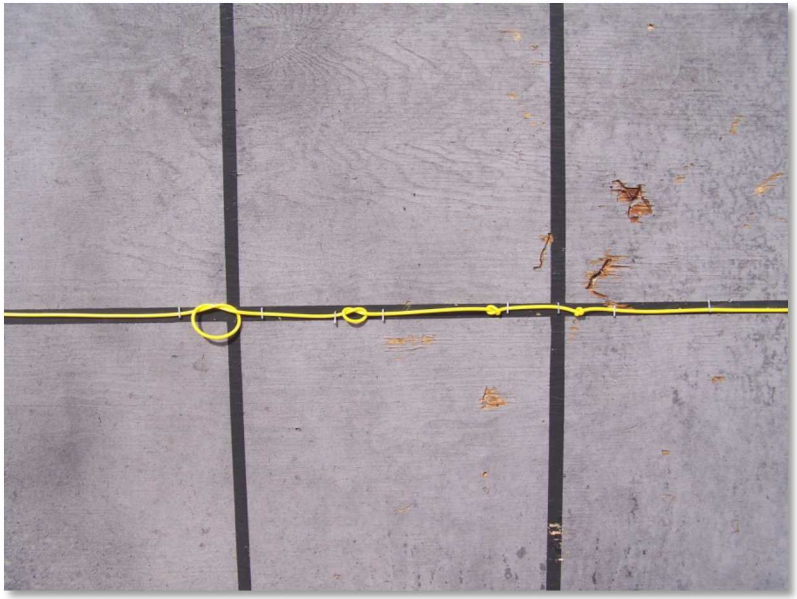
- Coupling (12” Connector)





Shock Tube Characterization

- Ruggedness



Questions