Dynamic Shock Pressure Measurement

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Outline

- “Look what I found?”
- Impact
- Shrink Wrapped Detonators - Cause
- Supplier Detonator Specifications
- What is my separation distance?
- How can I measure this myself?
  - Vibration
  - Pressure Sensors
- Proof of Concept (Possibly first experiment)
  - Design
  - Results
  - Next Steps (?)

“Look what I found?”

“Supervisor: What’s this in the in the muckpile?”

“Look what I found?”

Only extract the Detonator gently –
Otherwise dispose of once tested and data collected

Impact

Step	Involved	Cost	Units
Discovery	Digger Circuit	• Time • Lost Material Removal	• 1 Hour • Nil to ‘000s bcm/tonnes
Digging Stops	Digger Circuit	• As above	• 1-60 Hours (pending Rosters and alternative dig areas) • Nil to ‘000s bcm/tonnes
Notifications	Supervisor/ Manager/ DnB	• Time	• 1+ hours per person
Supervised Excavation or Alternative Recovery methods	Digger and Shotfirer	• Time • Lost Material moved • Vacuum Truck	• Hours – Weeks • Nil to ‘000s bcm/tonnes

Impact (Continued)

Step	Involved	Cost	Units
Incident Review - Site	ICAM Team Reporting	• Time • Real work delayed	• Hours
Incident Review - Supplier	Technical Logistics	• Time • Other work delayed	• Transport • Hours
Remedial Actions	Many	• Time • Change of Stock	• Training • Communication • Procedural Change • Transport • Supplier set up
Intangible	***Trust Perception***	***Long time***	***Possibly never recovered***

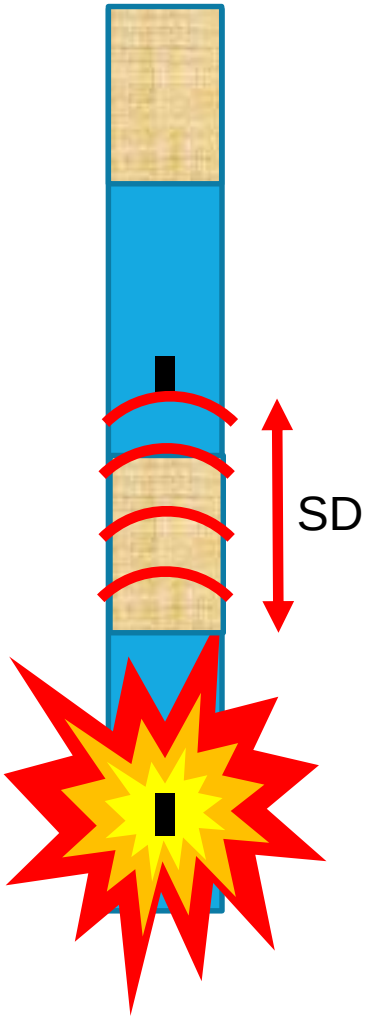
What would the $ be for your current situation?

Thiess MtOwen Shrink Wrap Experience

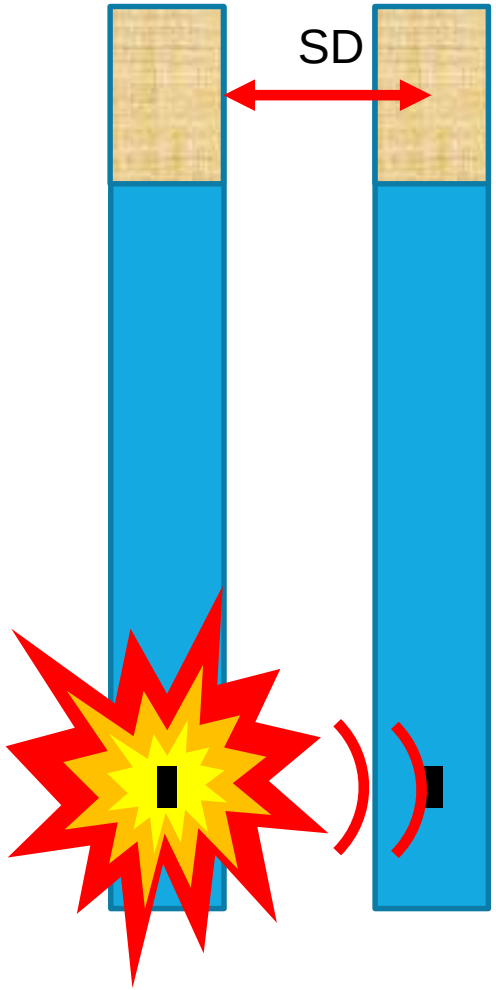
- 23/3/2006 – 25 bottom decks did not fire – 6 dets recovered
  - LTI: Rockfall on Vacuum Truck Operator during recovery
- 1/11/2008 - Single bottom det recovered
- 15/2/2010 – Single bottom det recovered
- 7/11/2010 - Single bottom det recovered
- 23/12/2015 – Two bottom dets recovered from same hole

Not all event details available

Shrink Wrapped Detonators - Cause



- Saturated Ground
  - Has anyone seen it in Dry ground?
- Hydraulic Detonation Pressure transfer
- More common in left picture
  - Booster to top of adjacent bulk explosives can be 10-15 diameters
- Right picture: Has it occurred?
  - Hole burdens are 25+ times the diameter
- How to determine and apply the minimum Separation Distance (SD)?



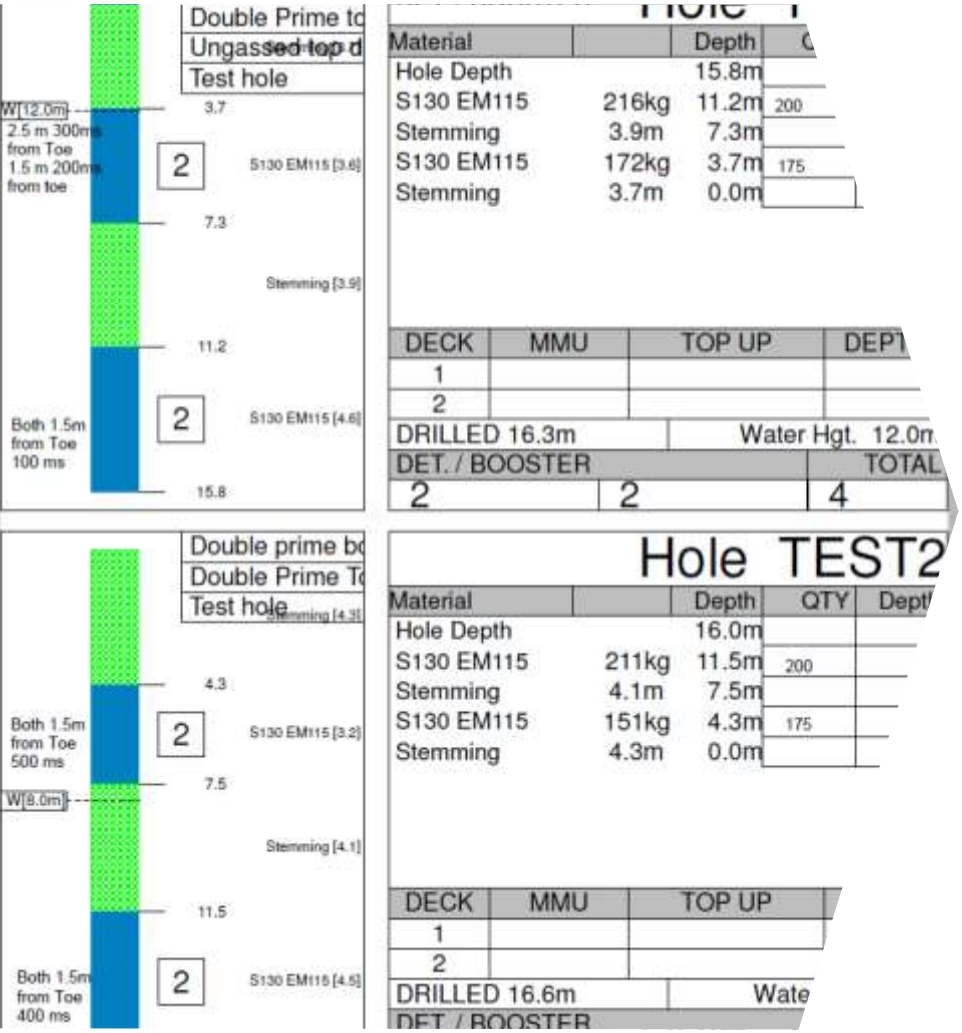
Online Search – Detonator Dynamic Shock Resistance

Supplier	Detonator	Dynamic Shock Resistance	Commentary
Orica	i-konTM RX, i-konTMII, UnitronicTM	None Supplied (190 MPA for X414 dets)	None (Shock waves 5m/ms)
Dyno Nobel	Digishot Plus	None Supplied	None
Dyno Nobel	Smartshot	>12,000 psi 500ns Pulse width	None
BME (AIS)	Axxis	None Supplied	None
DaveyBickford	DBIII	105 Mpa (Training Package)	None
AEL	Digishot Plus	>31,830 psi or 219 MPa	None

What is my separation distance?

- Rules of Thumb
  - All care no responsibility
    - As demonstrated by online recommendation search of Technical data sheets
    - 10-15 diameters
- Experimentally
  - Vibration: ISEE Paper
    - Inferred distances to avoid sympathetic detonation
    - Top down firing sequence of decks
    - No pressure values for detonator design discussions
  - Pressure Sensors: External Detonator/Booster assembly pressures
    - Bottom up firing sequence of decks to maintain measurement capability
    - Assumes head pressure effects to be negligible Pa when compared to Mpa
- Otherwise fire at same time
  - Doesn’t this negate why to introduce the deck?

Proof of Concept Experiment Design



- Actuals
- Saturated ground
- Bottom up fired for cables
- Fire before main blast
- 100 ms between each booster assembly

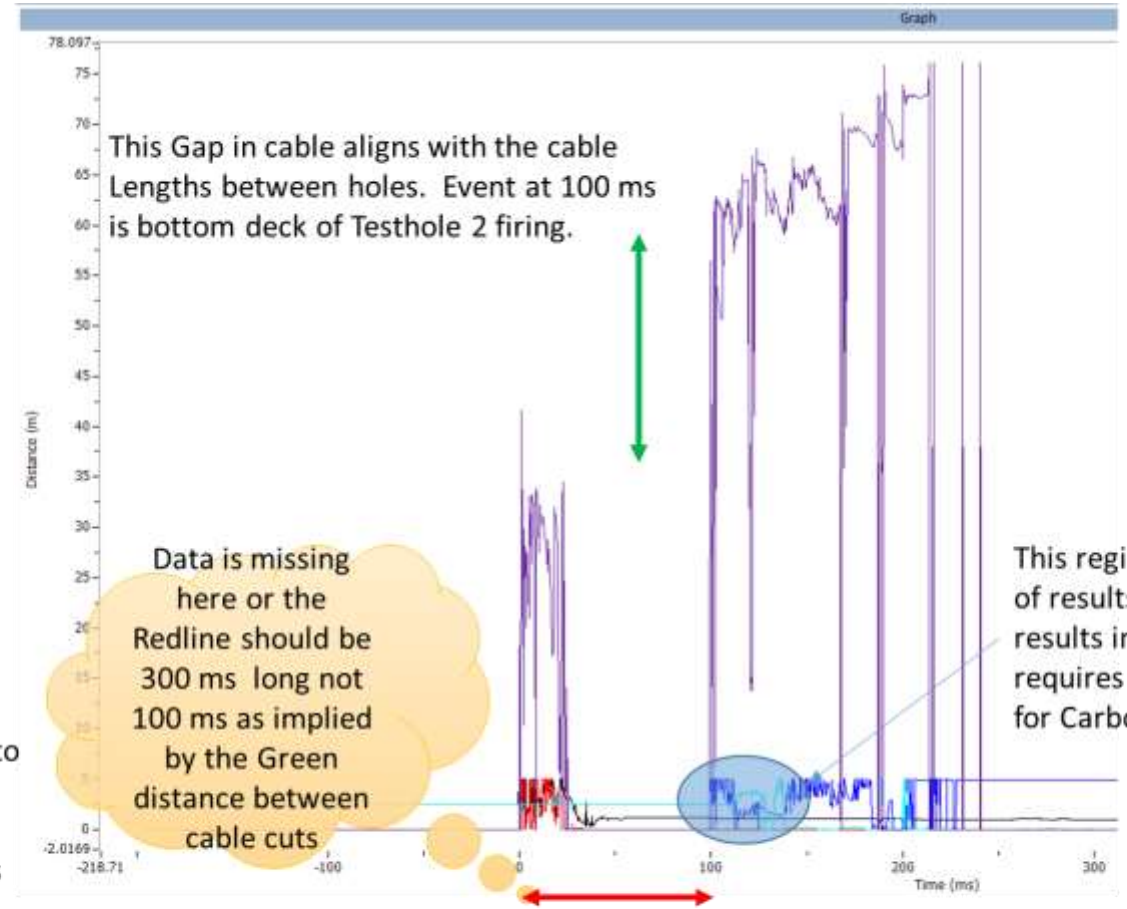
Experiment Measurement Design

- Black Cable – Detonation Pressure Sensor
- Green Probecable for Resistance VOD
- Blue Pneumatic tube for In-Hole Density measurement

Experiment Measurement Design Applied

- Use Brick to hold assembly 1.5 m form toe of hole
- Pump bulk explosive

Results



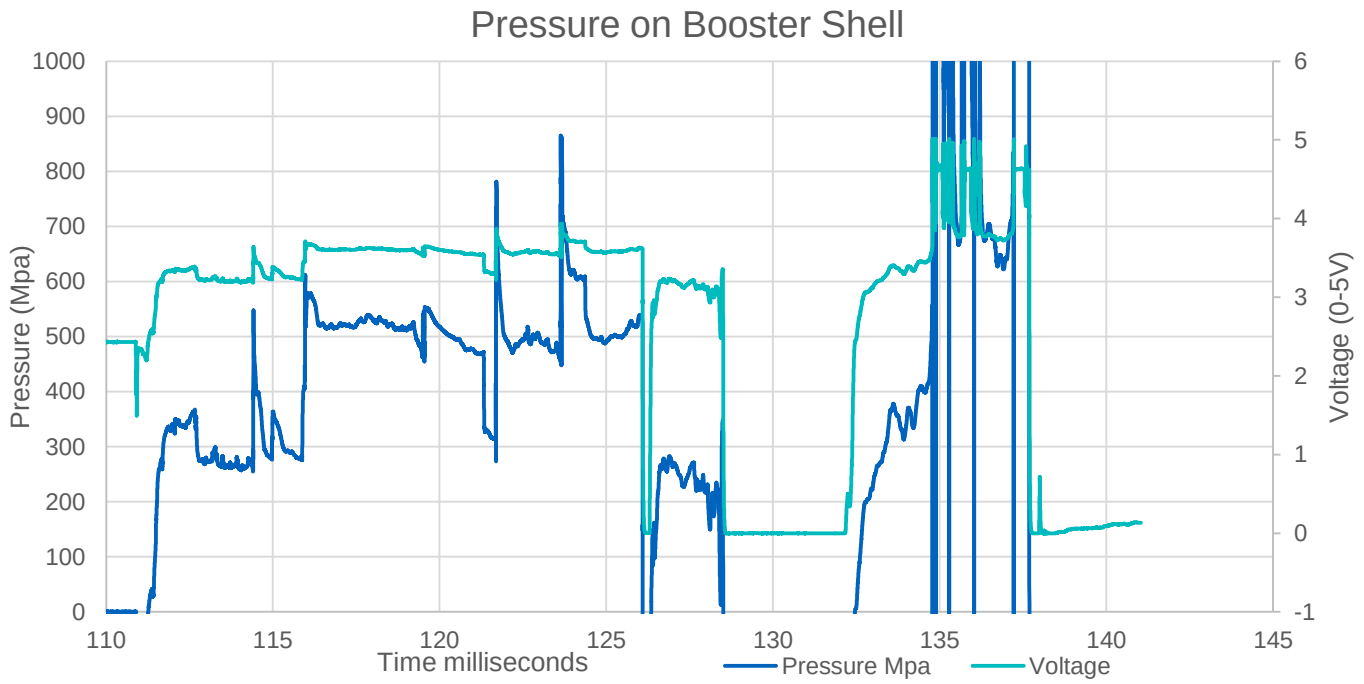
This regions is aligned with expectation of results, except Pressure Sensor gave results in range for which it's calibration requires validating. <1GPa range for Carbon Resistance pressure sensors.

Not enough Pre-trigger to Capture the first event. Given it was under 200 ms only the -100 ms should be captured.

This is too short a gap for Testhole 1 to have been timed incorrectly – top down. If it was the gap should have been 400-100 ms >> 300 ms

Results Zoom

- Good alignment in inputs and outputs – Calibration factor has Pressures too high



Next Steps (?)

- Carbon Wire Resistor as supplied by QMR can be calibrated to two ranges:
  - GPA when calibrated with ideal explosives
  - kPa to 20 Mpa via manual system
    - Range of Interest is missed
- Determine if Resistance VOD measurement via Microtrap is affected by Detonation pressure probe consumption

- Or stick with current rule
  - Costs of next steps and trialing to be cost benefit analysis versus the next Detonator recovery

- Or Fibre Optics……

- Suggestions…