

Shaped Charge Analysis

Diagnostic Measurements

Tom Halliday

Background and Goal

- ❖ DTRA and NNSA need to understand certain energetic products for analysis purposes that help define requirements for ongoing Nuclear Weapon Enterprise programs
- ❖ The products under examination during this test series are demolition type Shaped Charges
 - ❖ M3/A1 40lb
 - ❖ M2/A4 15lb
- ❖ The goal of the analysis is to determine the velocity of the jet and the pressure created (near-field) around the jet as it travels down range

Objectives

- ❖ Characterize Shaped Charges
 - ❖ Static
 - ❖ Dynamic (this is the blow stuff up part) Diagnostics
 - ❖ Flash X-ray
 - ❖ High Speed Video
 - ❖ Still Photography
 - ❖ Pressure Measurement techniques
- ❖ Post Shot Results
 - ❖ Pressure
 - ❖ Velocity

Shaped Charges Overview

- ❖ Basic format

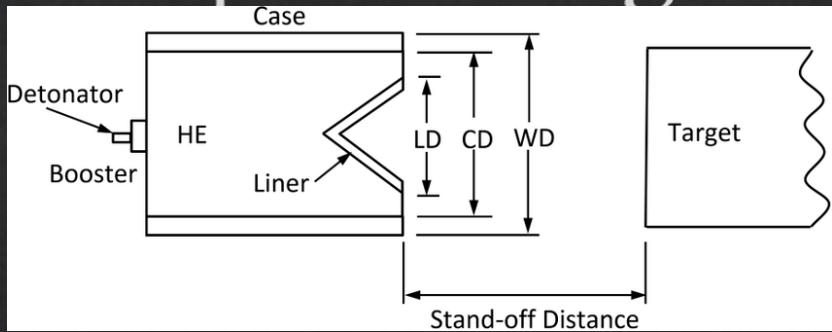


Image courtesy of https://www.researchgate.net/figure/Shaped-Charge-Walters-et-Zukas_fig1_310826065

- ❖ Can penetrate far more material than conventional explosives of similar size.
- ❖ Creates a jet of material that bores through the target.

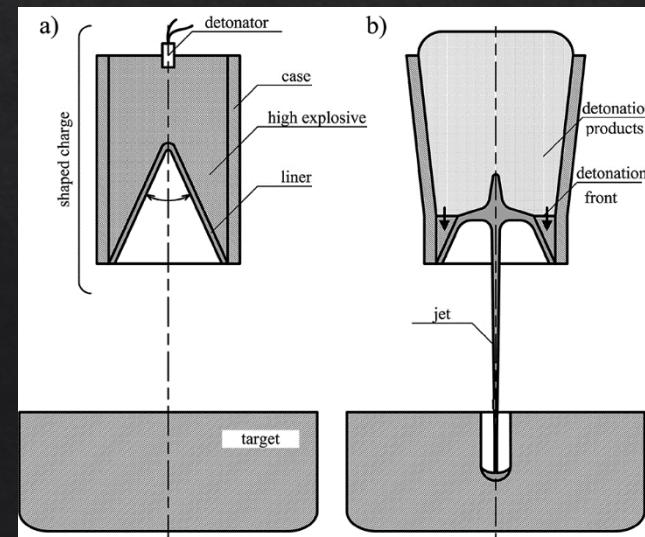
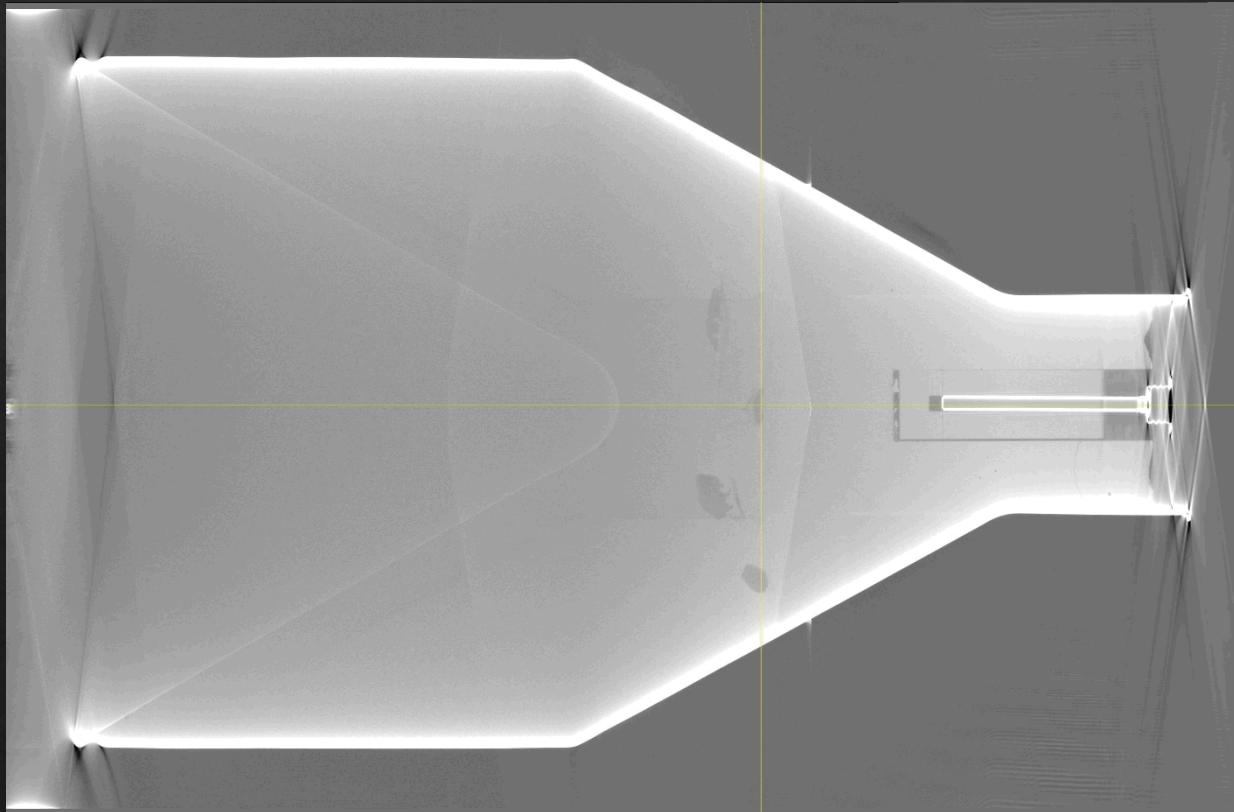


Image courtesy of <http://norfolktankmuseum.co.uk/wp-content/uploads/2015/03/Shaped-Charge.bmp>

M2/A4

- ❖ Has 15lbs of explosive.
- ❖ Has a conical glass liner.



M3/A1

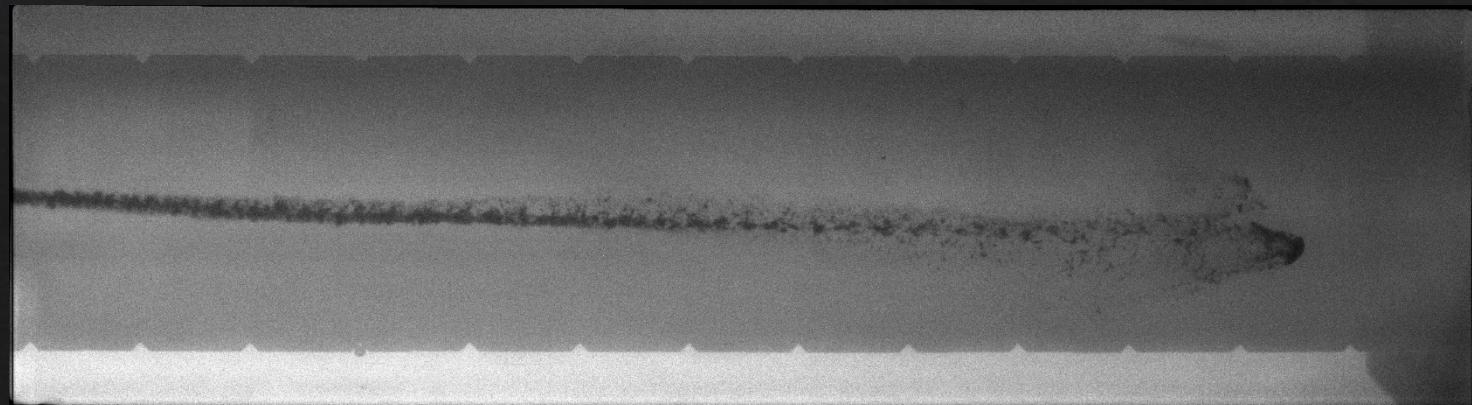
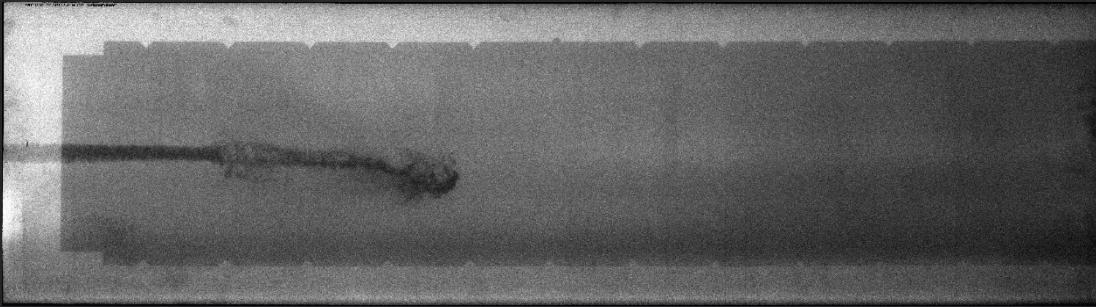
- ❖ Has 40lbs of explosive
- ❖ Has a conical steel liner
- ❖ Was unable to do any testing due to unforeseen circumstances

M2/A4



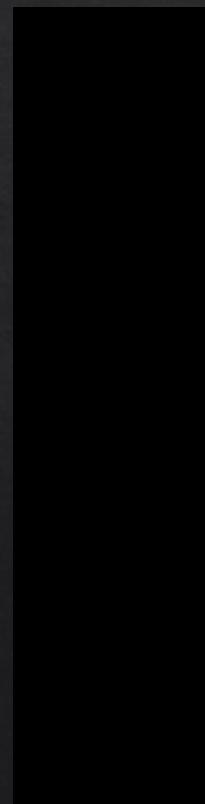
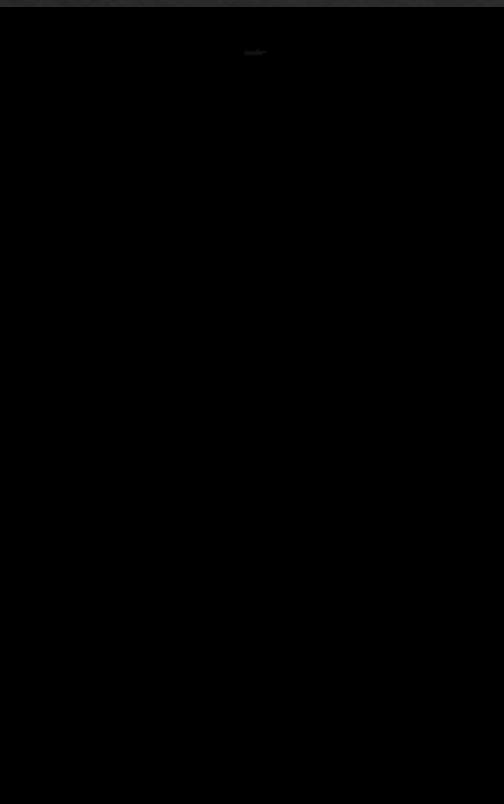
Flash X-Ray

- ❖ Used a cylindrical metal tube to create an image of fixed size on the film.
- ❖ When the charge was detonated several X-rays were taken at fixed time intervals
- ❖ The velocity of the jet could be determined by measuring the distance the jet traveled between X-rays



High Speed Video

- ❖ We used several cameras around the charge to capture videos of the detonations



Still Photography

- ❖ During the shot cameras took photos of the charge before and after detonation.



Pressure Measurement Techniques Failures

- ❖ Pendulum

- ❖ Welded it to ceiling but was knocked off due to explosive force of shot.
- ❖ Hung it in sandbags to dampen force, however the amount of debris raised from shot made it Impossible to view the swing of the pendulum.



- ❖ Water gage

- ❖ Had two water containers connected by tubing.
- ❖ When the pressure hit the water in the first container it would force to down and rise in the second container.
- ❖ Pressure from the initial blast wrapped around and hit the second container before a measurement could be taken.



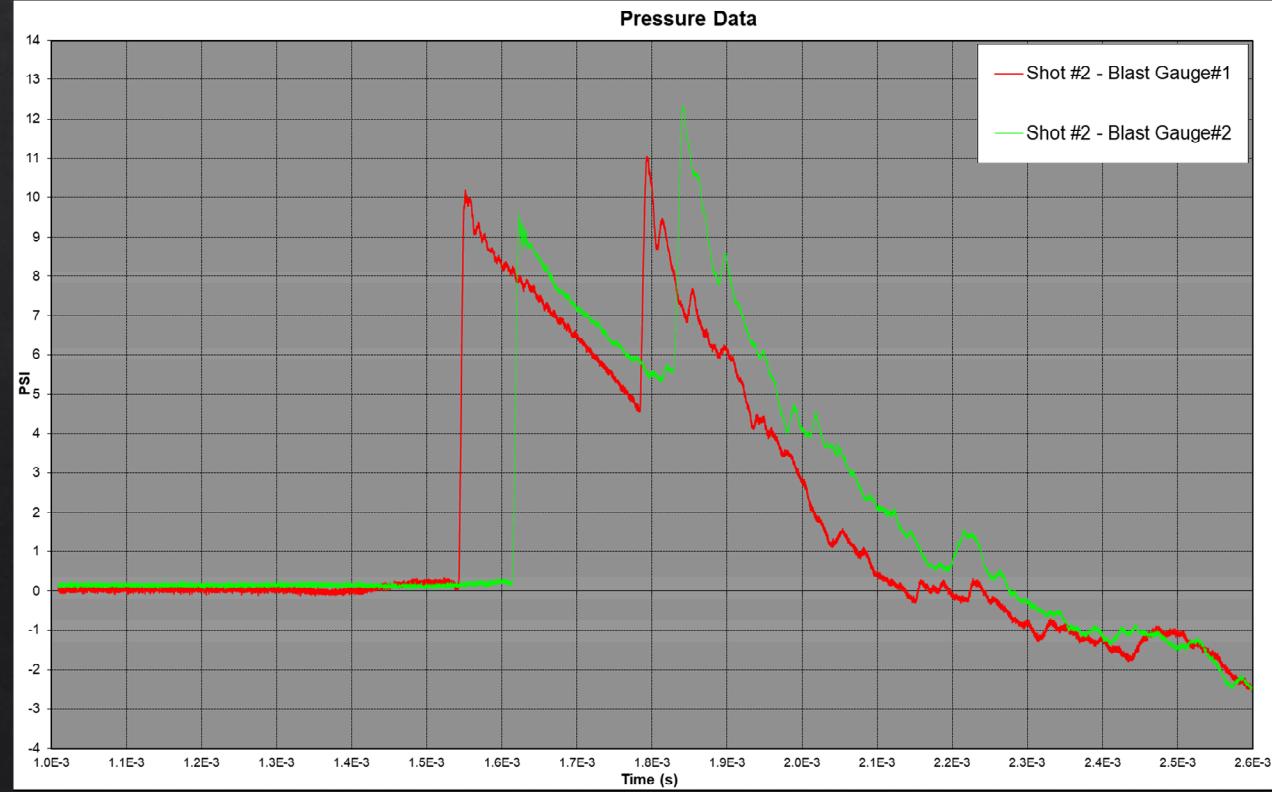
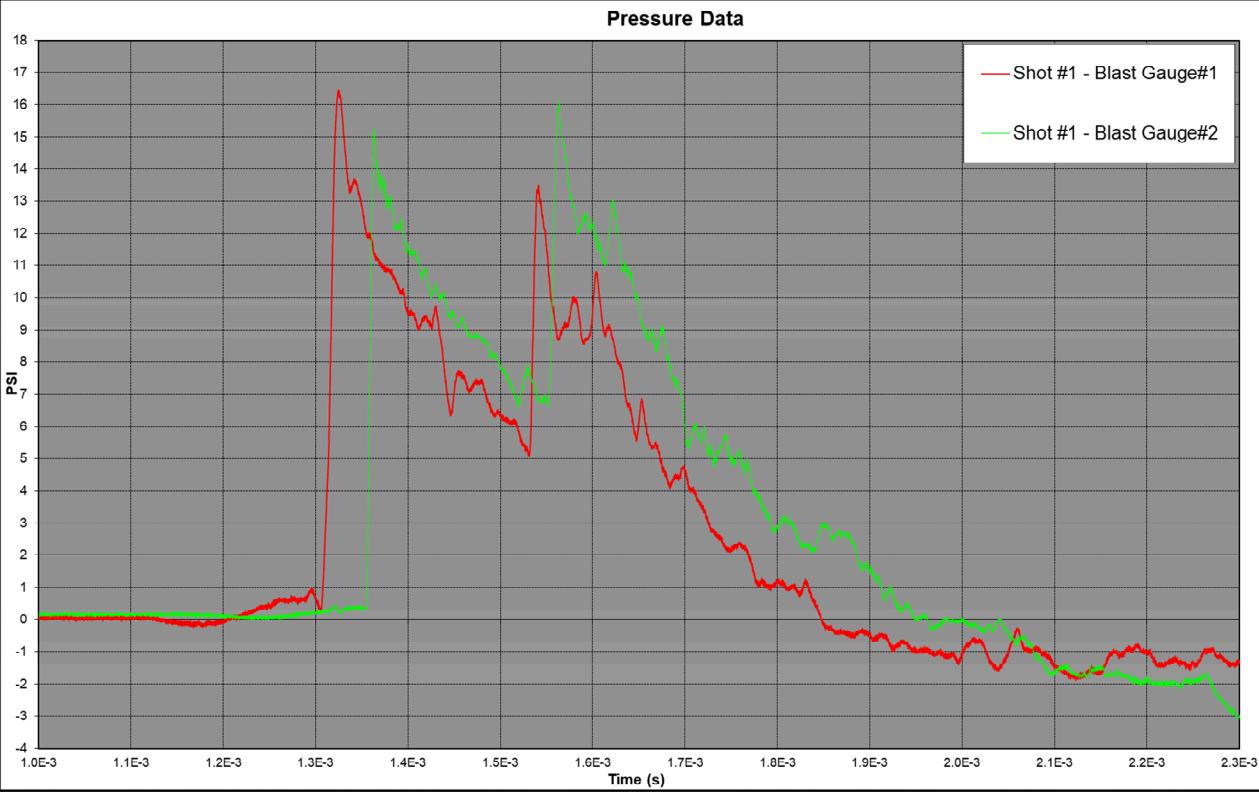
Pressure Measurement Techniques Successes

- ❖ Pencil Gages
 - ❖ Electronic pressure gauges
- ❖ Accelerometers
 - ❖ Two types- both used the same principle. When an object of known mass and size was hit by the pressure wave its acceleration and velocity was measured by a PDV which uses light reflection to make the measurements.



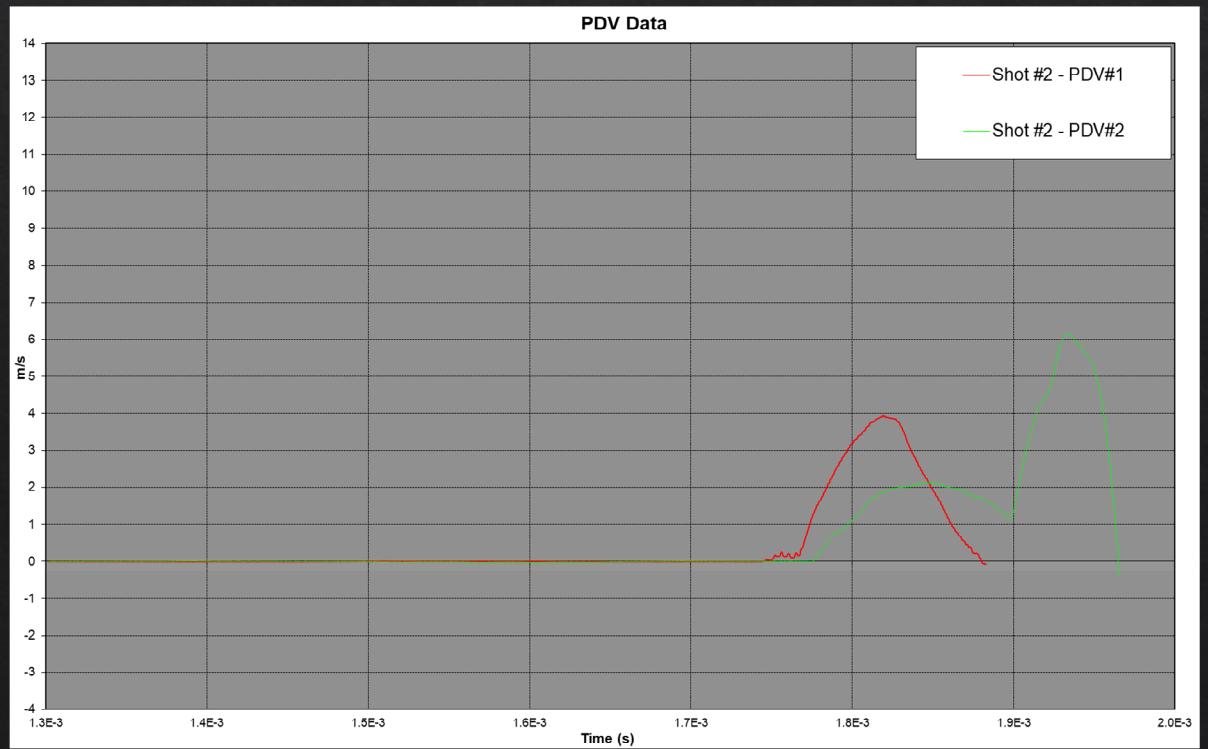
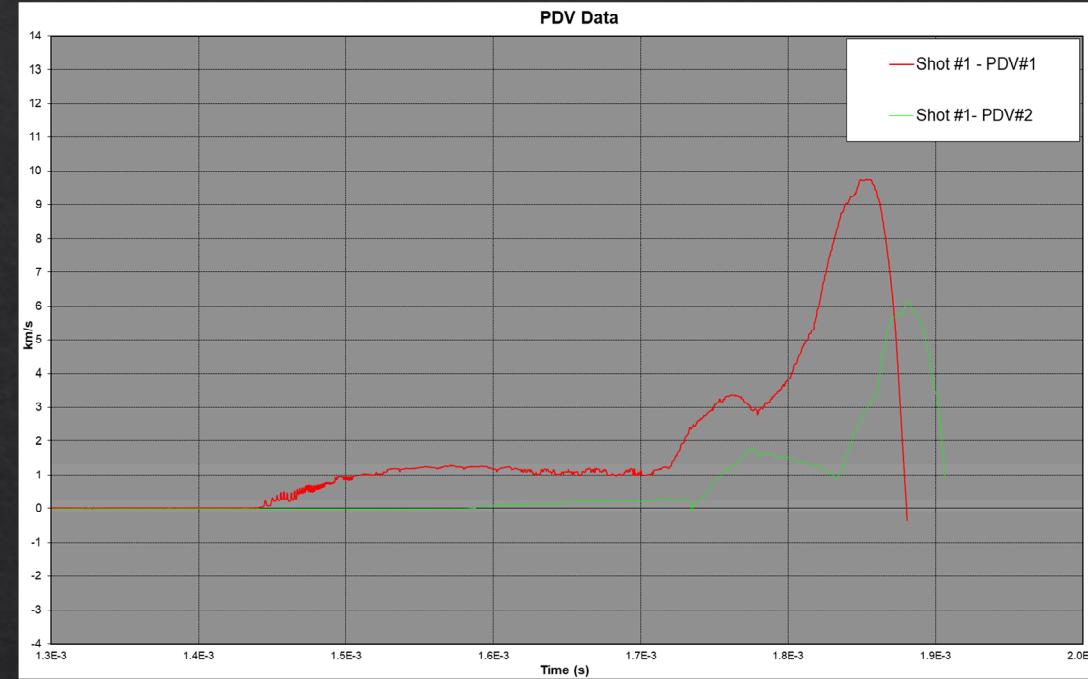
M2/A4 Pressure

- From the data collected a pressure of 15-17 psi was determined for the first shot and 10-12 psi for the second at a standoff distance of 36 inches using the pencil gauges.



M2/A4 Velocity

- ❖ To determine velocity the distance the jet traveled between each X-ray photo was measured, then divided by the time between photos.
- ❖ Based on the collected data the velocity was:
 - ❖ Shot 1~ 3.17 mm/us (There was a timing malfunction for the first shot)
 - ❖ Shot 2~ 6.76 mm/us
 - ❖ Shot 3~ 6.48 mm/us
 - ❖ Shot 4~ 6.35 mm/us
 - ❖ Shot 5~ 6.82 mm/us



Conclusion

- ❖ From the experiments, the range of velocities and pressures obtained was within the expected variance predicted.
- ❖ The charges tested were old commercial grade demolition charges. As such they had high degrees of variation in the density of the explosive and in how it was packed, resulting in multiple voids throughout the charges.
- ❖ Even though these charges are old, they were manufactured in great numbers and they are found all over the world, still able to do the job they were designed for very effectively.
- ❖ The goal of this project was to experimentally measure the charges pressure and velocity which we succeeded in doing.