The Explosive Component Water gap Test - Recent Developments

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A presentation to IMEM Conference 2015

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QinetiQ

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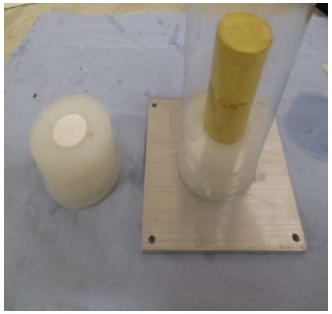


1 Background

Insensitive munitions (IM) improve the survivability of both weapons and their associated platforms from accident or enemy action

In addition to the main charge, each sub-system in the weapon, including the lead, booster and explosive train must be insensitive

STANAG 4187 requires the explosives and/or explosive compositions to be assessed and qualified in their design role in accordance with STANAG 4170 and the explosive train components to be evaluated in accordance with the requirements of STANAG 4363

AOP 21describes the Explosive Component Water Gap Test (ECWGT), which is, is used to evaluate the shock sensitiveness of a filled explosive train component

1 Background

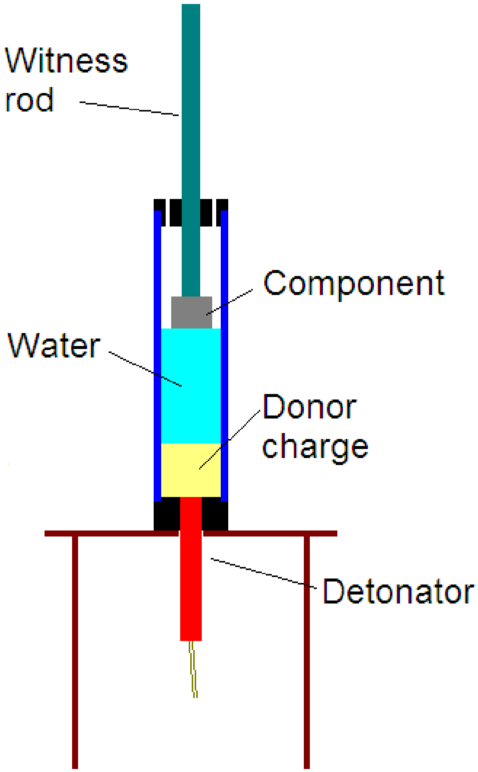
QinetiQ has been working with the UK National Safety Approving Authority to:

- Develop a computer model of the ECWGT with a predictive capability
- Define a regime for testing booster components that are larger than the maximum allowed diameter of 45 mm

- To be used in-line a component must have a water gap of 28 mm or below

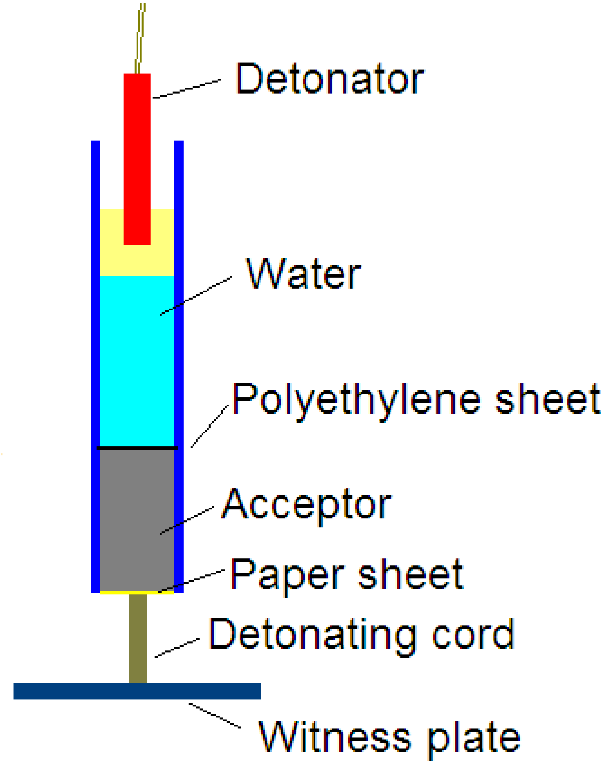
1 Water Gap Tests

Explosive Component Water Gap Test



AOP 21 and STANAG 4363
(Range of experiments)

Small Scale Water Gap Test



STANAG 4488

2 Modelling

The donor charge used in the ECWGT has been modelled using GRIM to give an estimate of the shock pressure at the upper surface with different water gaps

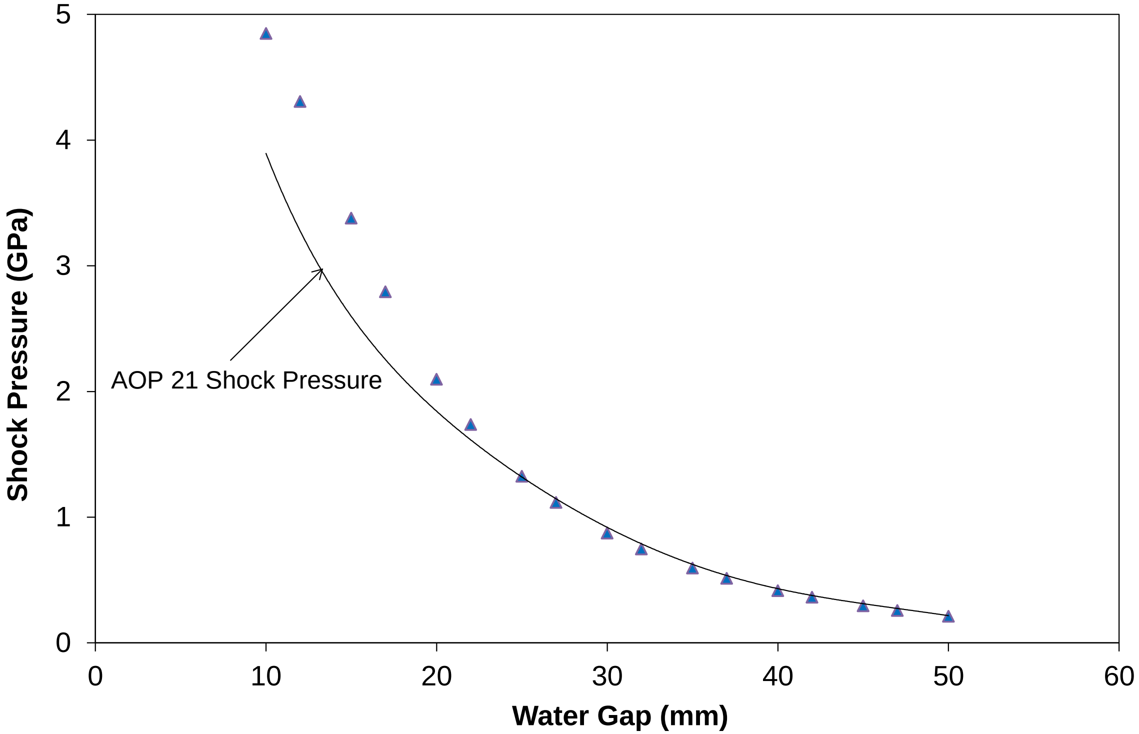
Since the materials used in the ECWGT are not precisely characterised, the Equations of State for the inert materials (water, aluminium, nylon and PMMA) were chosen directly from the GRIM materials library

A Jones-Wilkins-Lee Extended (JWLX) Equation of State for the booster material was based on RDX:wax 97:3 which had been modelled in CHEETAH to provide the input parameters for GRIM

A programmed burn was used for the detonation and it was initiated from a point at the centre of the booster

2 Modelling

At water-gaps of 25 mm or more, a good approximation of the experimentally determined shock pressure at the top surface of the water-gap was found, however, as the water-gap decreased, the model showed increasing divergence from the experimental results given in AOP 21 (Derived by Trimborn)



2 Modelling

Trimborn used two different Hugoniot data sets to calculate the shock pressures from the velocity-time data he determined

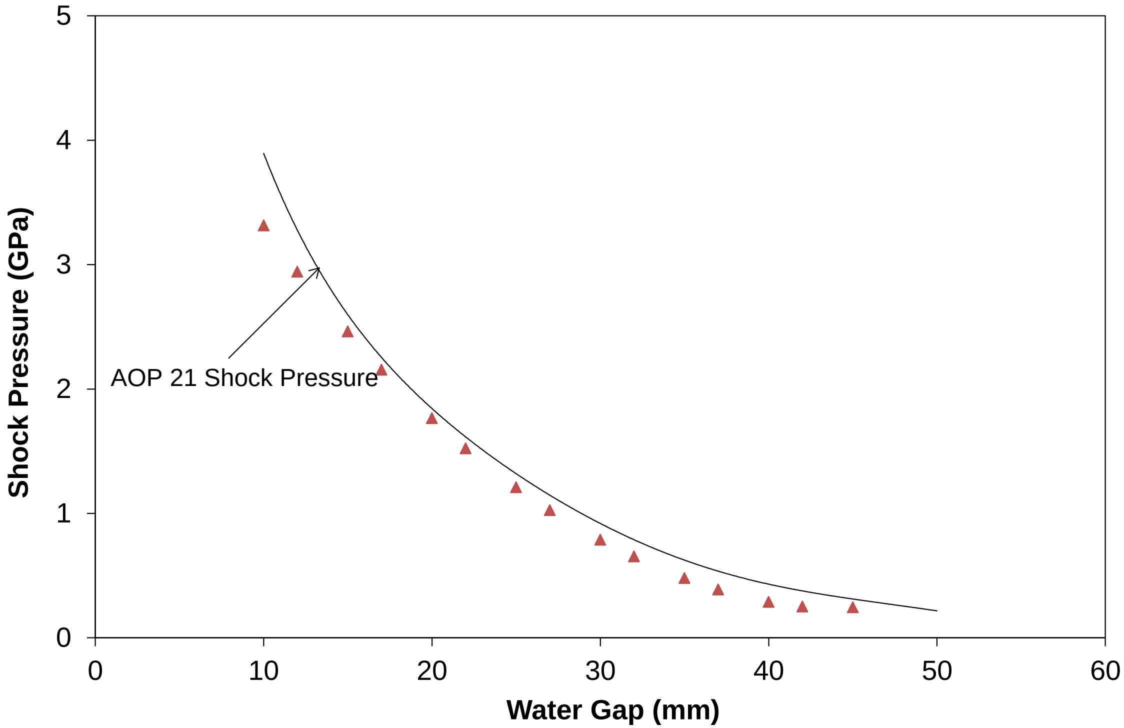
Cook et al – High Pressure (lower water gap)

Woolfolk et al – Low Pressure region (higher water gaps)

2 Modelling

When the data in the high pressure region given by Cooke et al. were applied to the shock velocities **given by the model** they were found to significantly lower

The shock pressure and the data were found to agreed to within 10% of those given by Trimborn

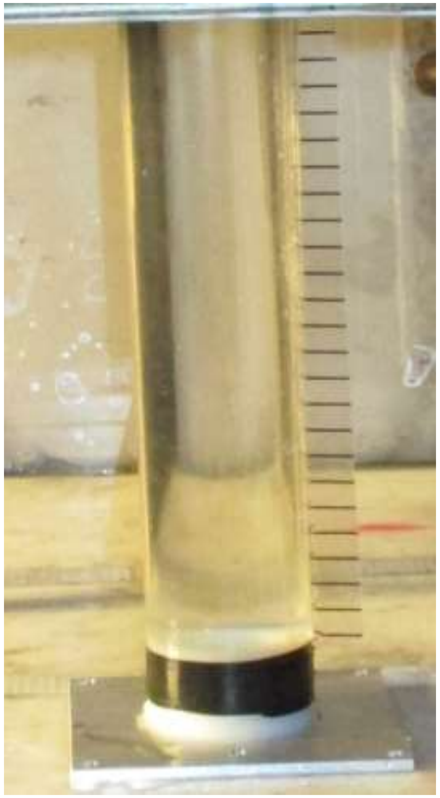


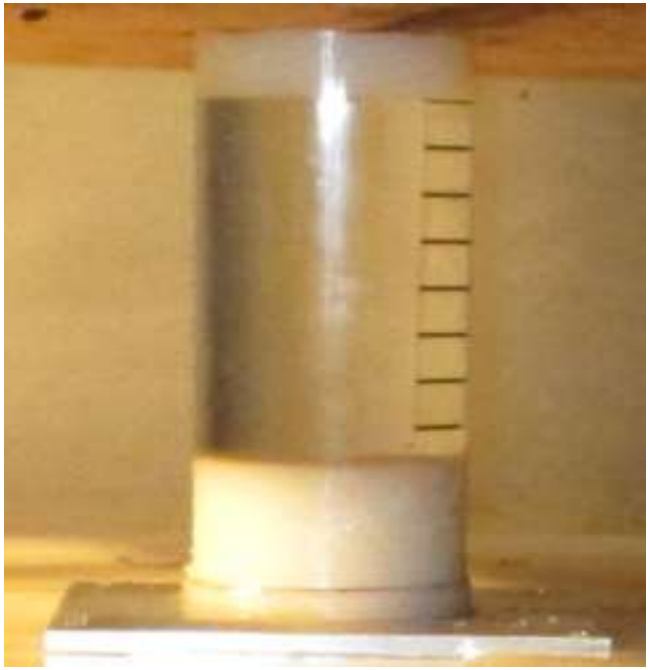
2 Modelling

Application of a Hugoniot for water published by Los Alamos was applied to the Trimborn data changed the calculated shock pressures to within 6% of those originally determined by the model

3 Experimentation

To support the modelling studies, experimental work has been conducted to confirm the distance-time relationship for the shock wave passing through a column of water gap using high speed video





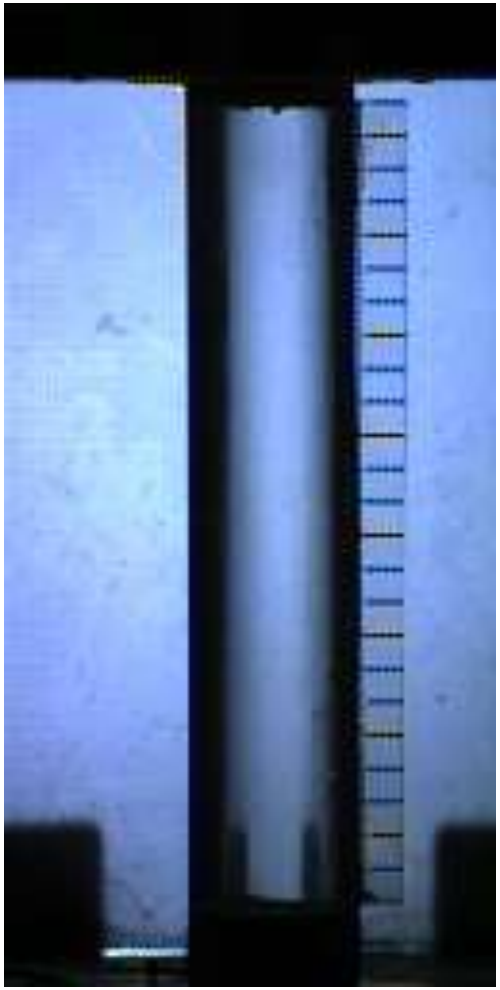
3 Experimentation

240 mm long 50 mm diameter

Camera inter-frame period was 9.09 µsec

Initially concaved shock wave shown by the thin black line

Linear by 70 mm (significantly greater than the 28 mm threshold)



3 Experimentation

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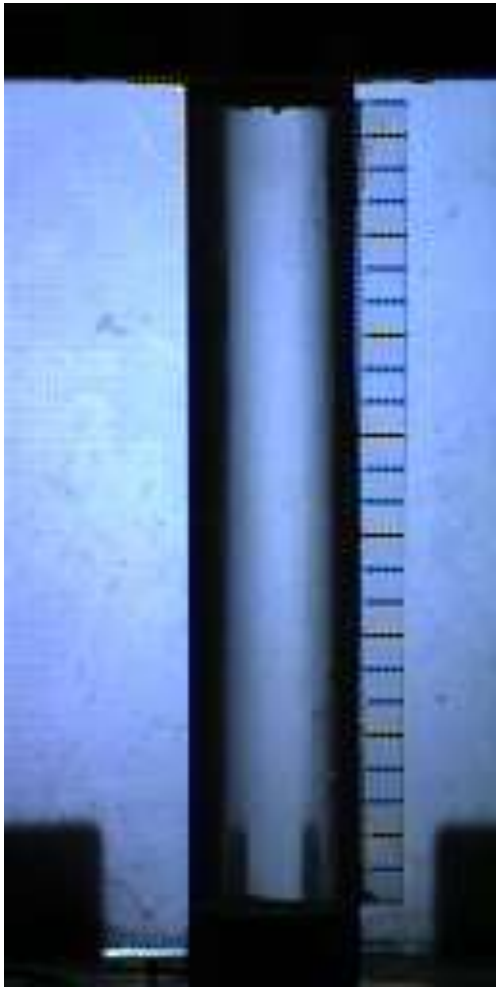
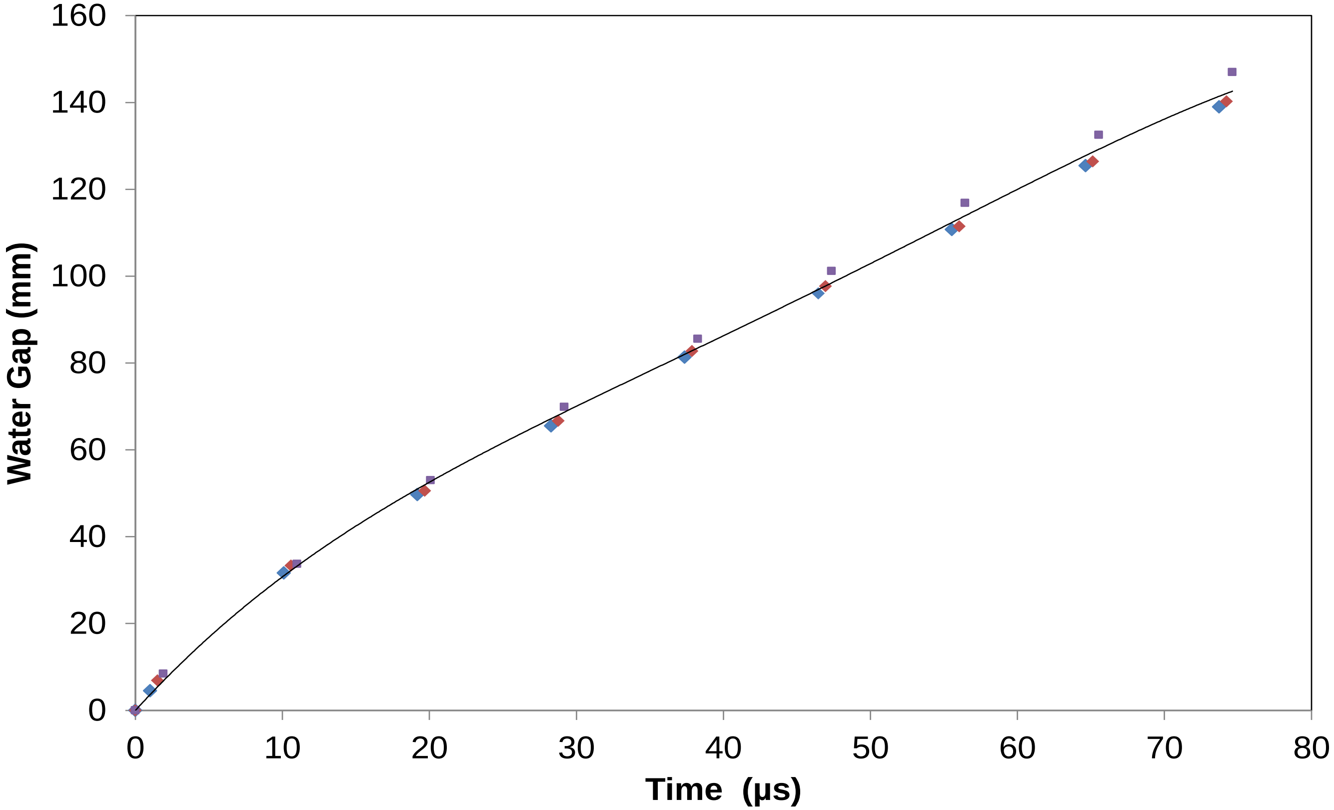


3 Experimentation

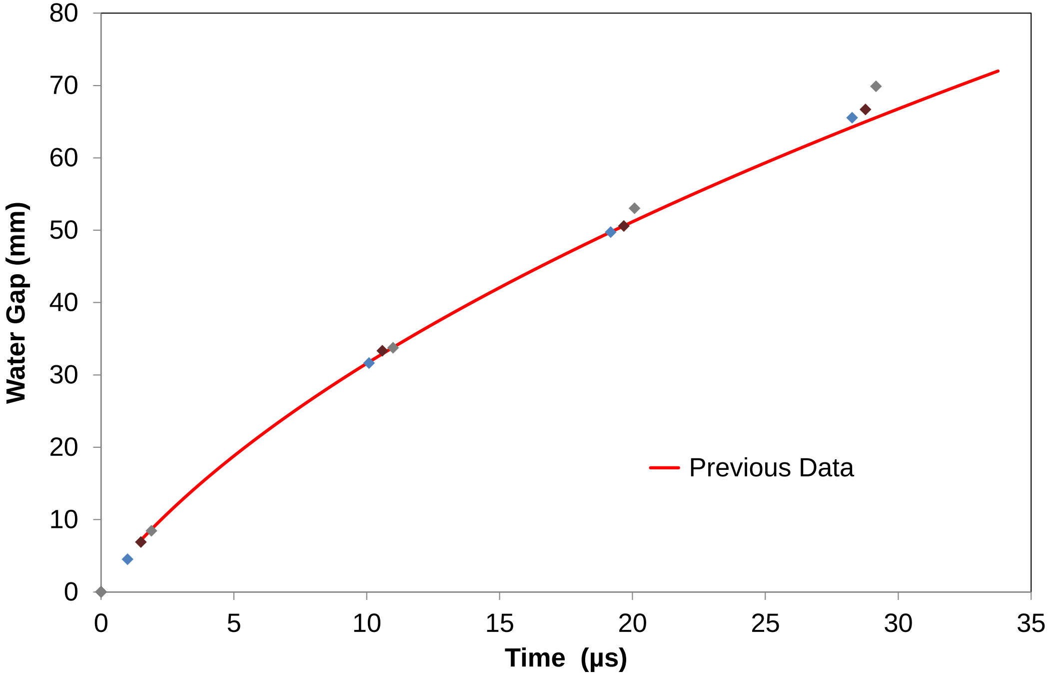
Good agreement was found between the three experiments performed on the 240 mm long tubes over the range 0 to 140 mm of water (9)



3 Experimentation

Good agreement was found between the three experiments performed on the 240 mm long tubes over the range 0 to 140 mm of water (9)

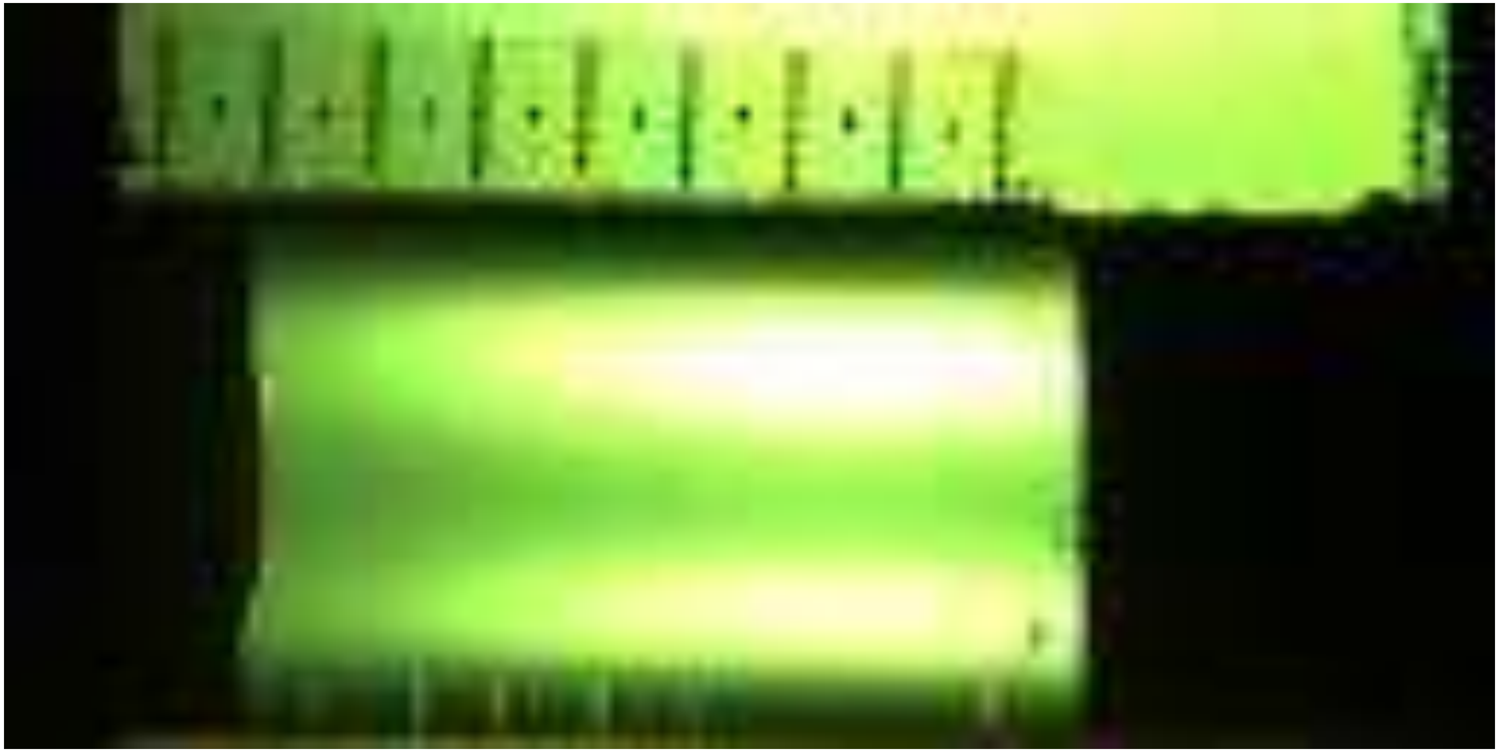
A comparison with the original water gap-time data (Trimborn) shown below (red line) also showed good agreement over the range 7 to 70 mm of water (4)



3 Experimentation

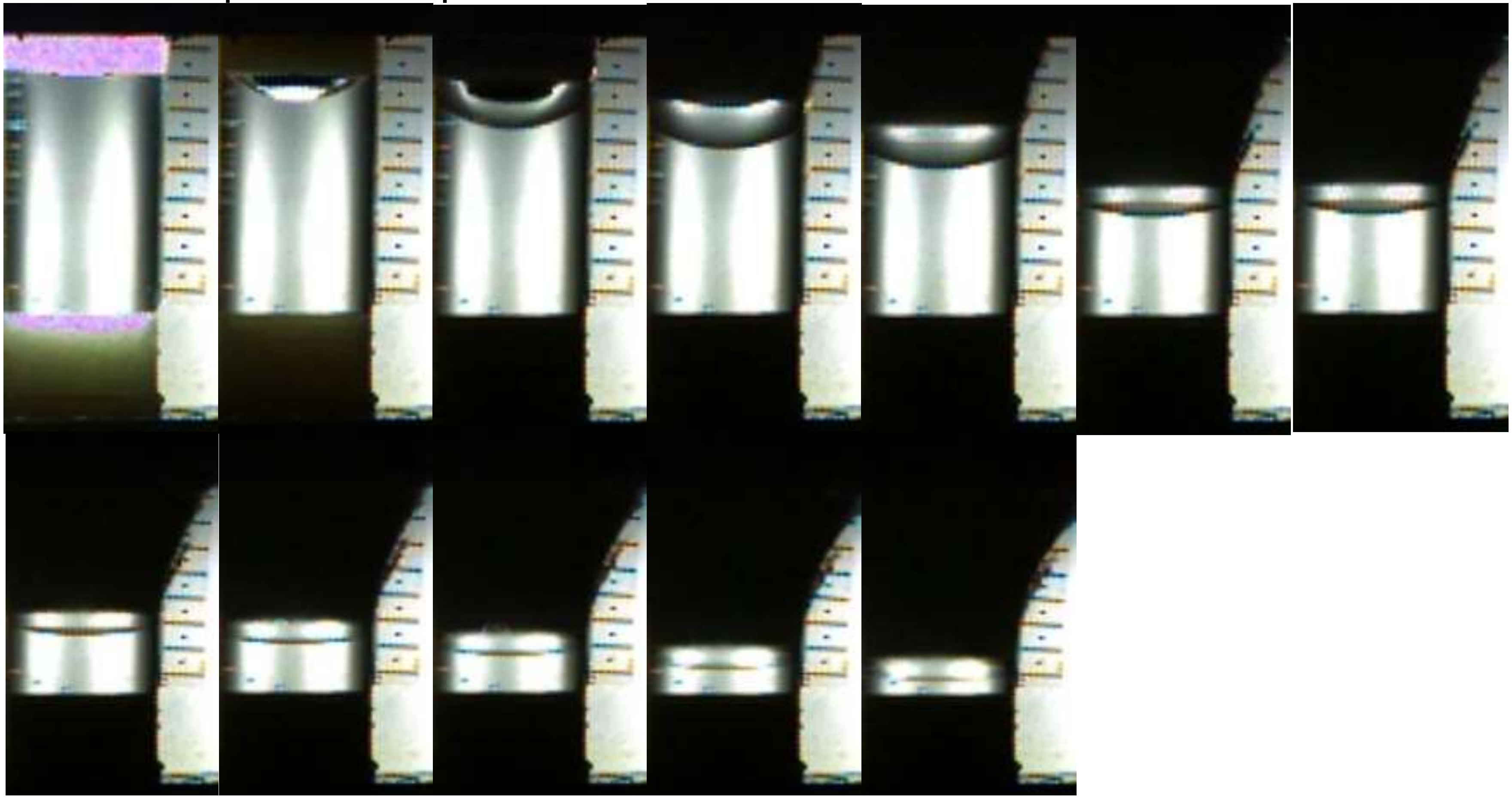
Inter-frame period 2.56 µsec

Shorter water column – 70 mm



3 Experimentation

Inter-frame period 2.56 µsec



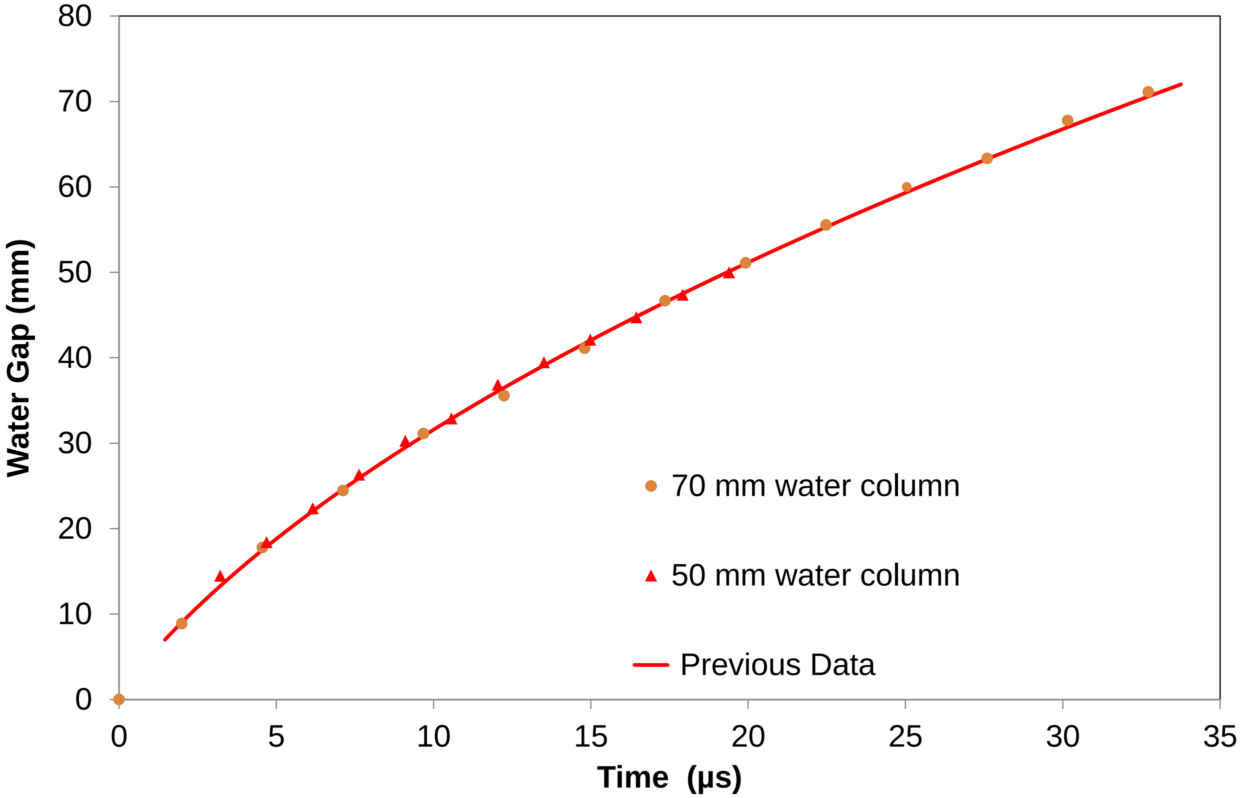
3 Experimentation

Inter-frame period 1.47 µsec

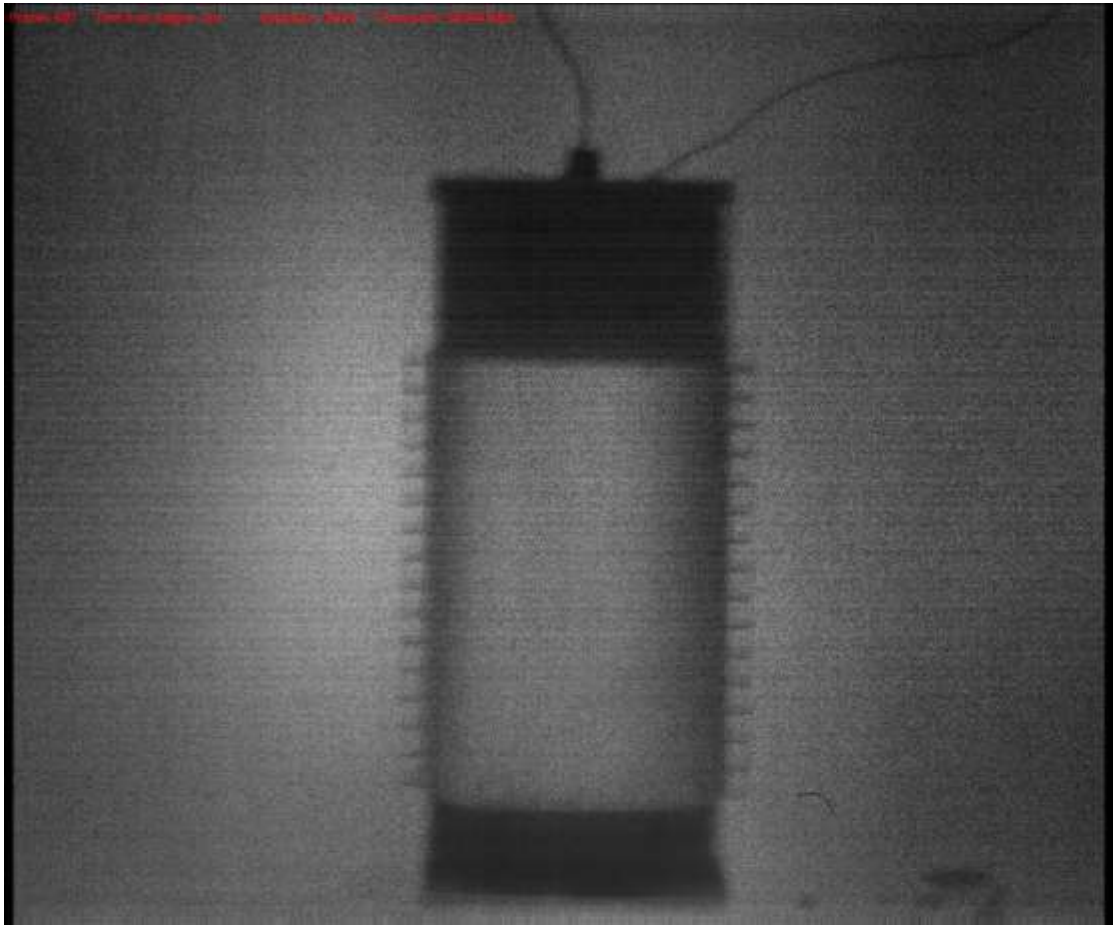
3 Experimentation

Inter-frame periods 2.56 and 1.47 µsec

Good agreement between the data at each framing rate and with the data of Trimborn



Kirana camera



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4 Conclusions

A model that described the donor charge reasonably accurately was established. The positon of the shock stations was found to be critical and the optimum mesh size was established

The choice of Hugoniot for water used in the model was found to significantly affect the predicted shock pressures especially at lower water gaps

The high speed video experiments were found to agree well with the shock wave position-time data determined previously but it was necessary to estimate the time for the shock wave in the first video frame

The ultra-high speed camera allowed significantly more data to be recorded but resolving the shock wave was difficult; however, it is likely this could be improved by making changes to the illumination of the sample

5 Recommendations

Shock gauges should be used to direct measure the shock pressure at different water gaps. This study should also examine perforated pellets

Future high speed video experiments would benefit from the incorporation of a technique to determine when the shock wave first enters the column of water

The application of streak photography to determine the shock wave velocity should be investigated

The work should be extended to model an acceptor which should initially be a pellet of tetryl. Once a successful model has been developed it should be extended to cover new materials and more complex geometries

6 Acknowledgements

The authors would like to acknowledge the contribution of Ashley Jones, Stephen Matthews, and Philip Ottley who designed and conducting the firing trials, and contributed to the data analysis. The work was funded by DE&S Wpns, MoD Abbey Wood, UK.

Initiation of tetryl

Water gap 28 mm