An Initial Evaluation of Several Promising High Blast Explosives

Authored by:

Paul Braithwaite
ATK Aerospace Group
Paul.Braithwaite@ATK.com

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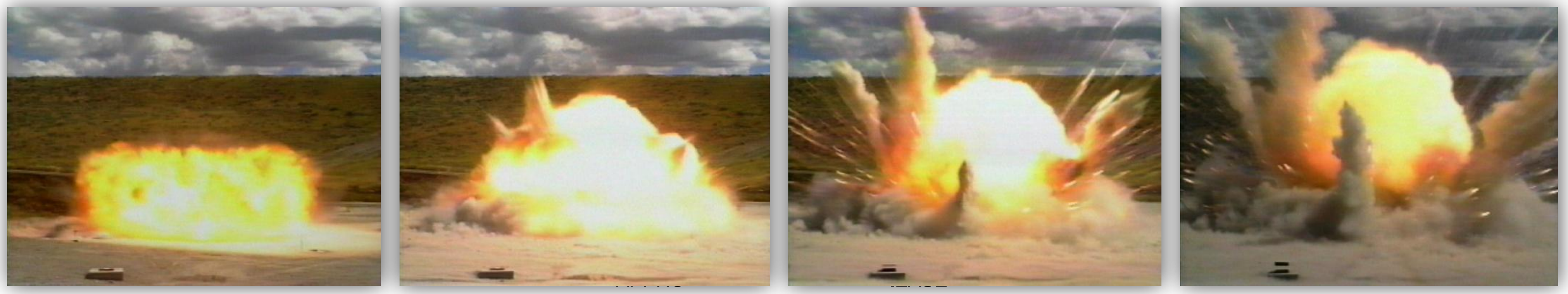


Outline

- **Overview and introduction**
- **Theoretical studies**
- **Safety and handling properties**
- **Test methodology**
- **Test results**
- **Summary and conclusions**

Overview and Introduction

- **Blast explosives are used in many commercial and military applications**
  - Building demolition, runway cratering, quarrying, etc.
- **Blast explosives often utilize aluminum to increase temperature, blast, and impulse**
- **A challenge associated with aluminized blast explosives is to formulate them in such a manner that the aluminum reacts during the early stages of the explosive event**
  - This is a particularly challenging problem for small and medium sized articles
- **This paper presents results of an interesting study that examines the role of specific formulation changes on blast explosive performance**

Formulation Approach

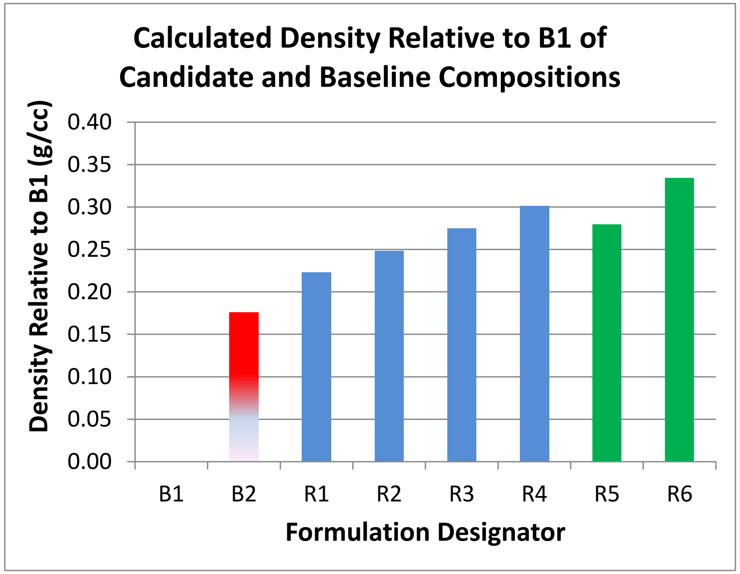
- **A single formulation family was evaluated during this study**
  - Binder system, explosive content, and total solids were held constant
  - A single grade of aluminum was used in all formulations
  - All research compositions utilized a solid oxidizer
  - Oxygen balance was varied by changing the ratio of aluminum to oxidizer
  - Several different solid explosives were evaluated in the formulation family
- **Theoretical results were compared with two baseline aluminized explosives to ensure the new formulations had predicted properties in a reasonable range**
  - Six representative research explosives were selected from a larger group for discussion in this paper

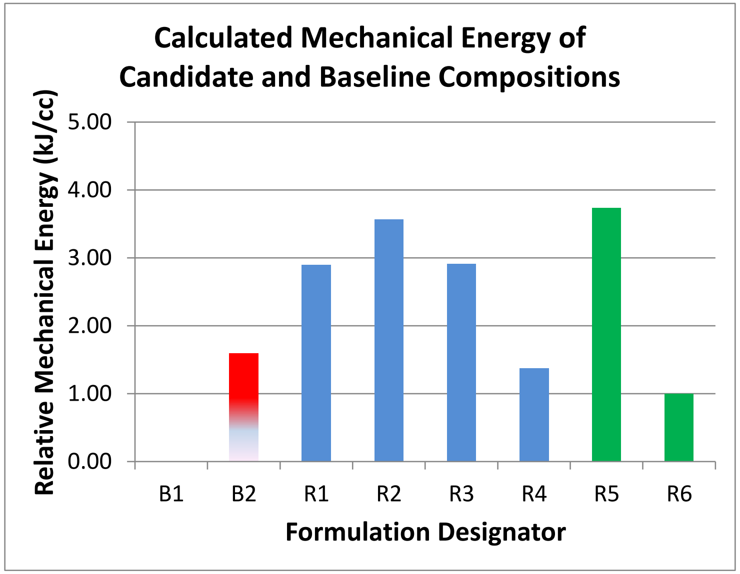
Predicted Density and Mechanical Energy

- **Density of candidate research explosives was universally higher than the baseline compositions**

- **Mechanical energy varied with formulation detail**
  - Research explosives were predicted to have equal to or better mechanical energy than baseline compositions

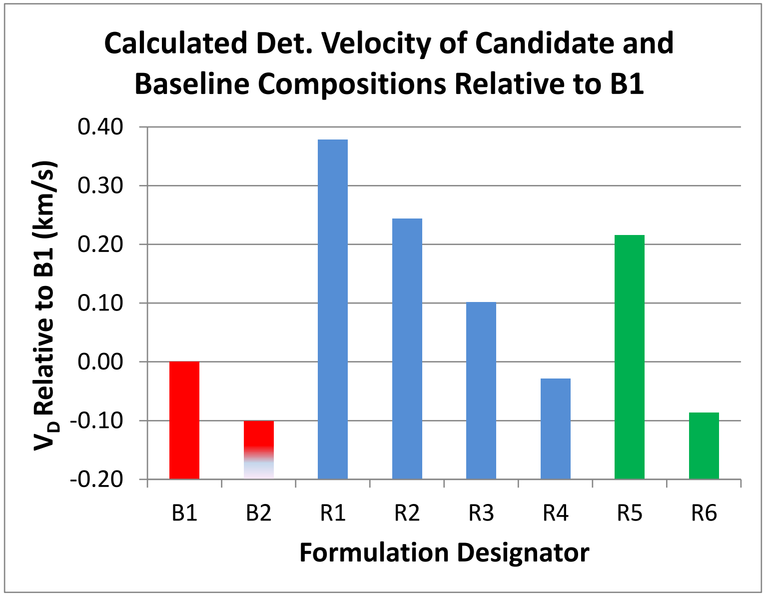
- **Formulation notes**
  - B1 contains Al
  - B2 contains Al and an oxidizer
  - R1 through R4 used explosive 1
  - R5 and R6 used explosive 2

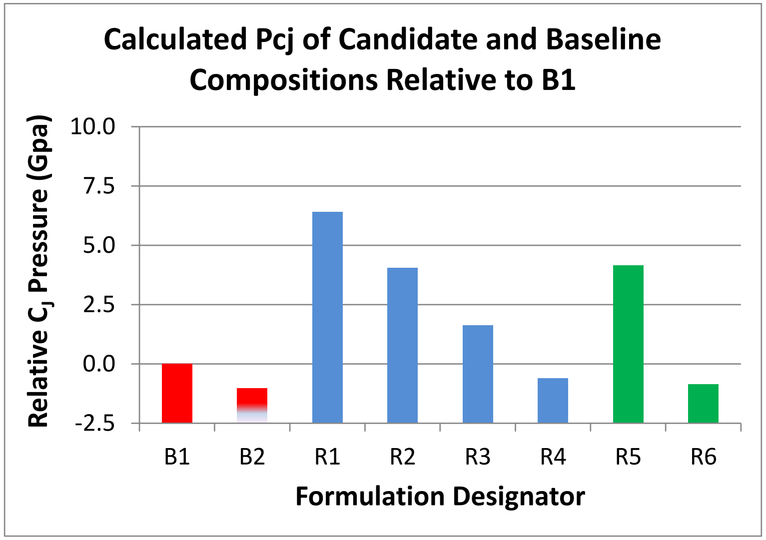




Detonation Velocity and Pressure

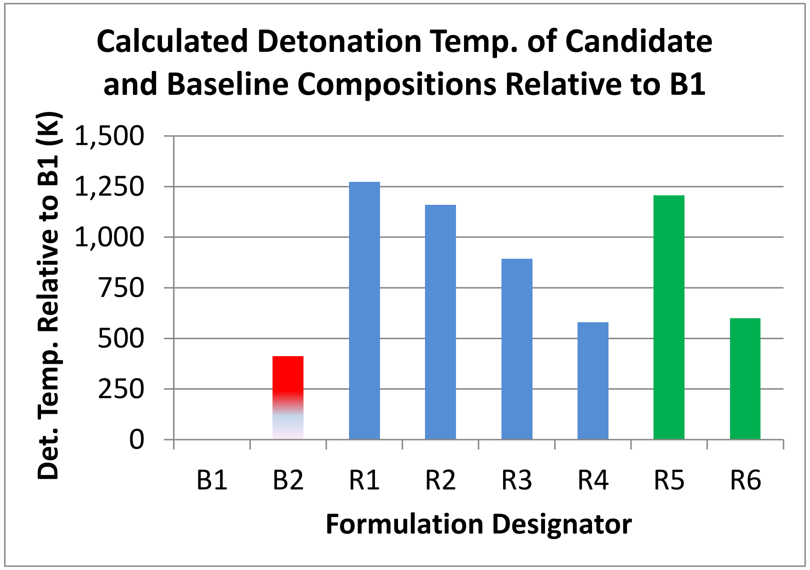
- **Explosives were formulated so the research and baseline compositions had similar calculated detonation velocities**
  - Range was 0.48 km/sec
- **Calculated detonation pressures for research explosives were generally higher than baseline compositions and decreased as aluminum was added**
  - Calculated pressures are in the expected ranges

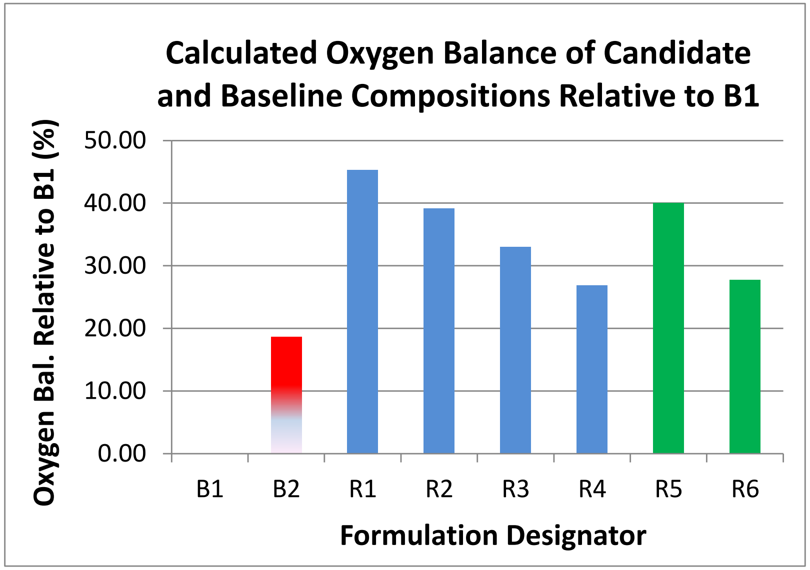




Oxygen Balance and Detonation Temperature

- **Oxygen balance for the research explosives was more favorable than baseline compositions**
  - Reference oxygen balance for well known materials:
    - TNT: -74.0%
    - NG: 3.5%
    - AN: 20.0%
- **Predicted detonation temperatures for research formulations were higher than for baseline compositions**
  - Expected to aid in aluminum combustion





Safety and Handling

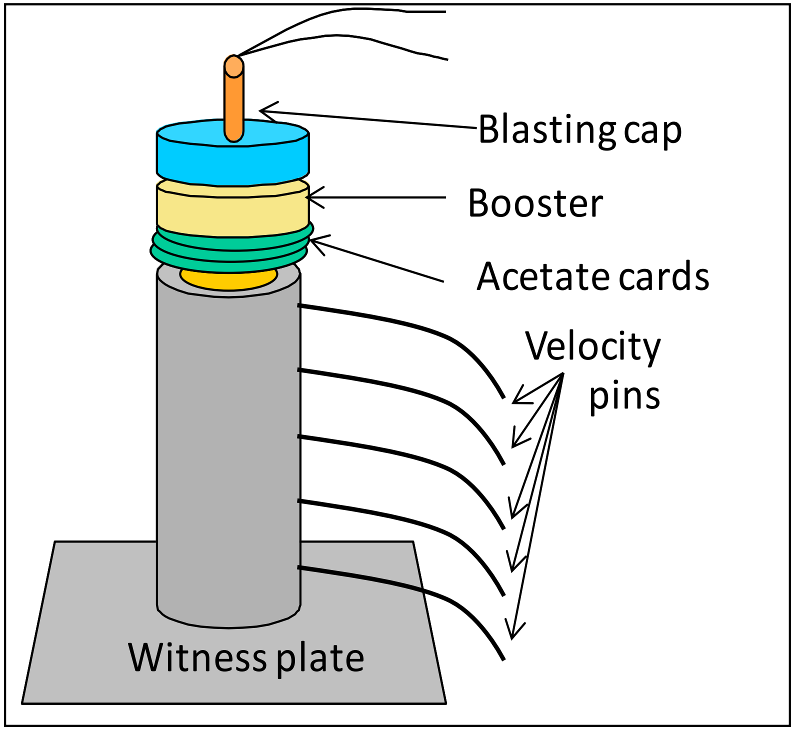
- **Small-scale safety testing was performed on several of the research explosives and the two baseline compositions**

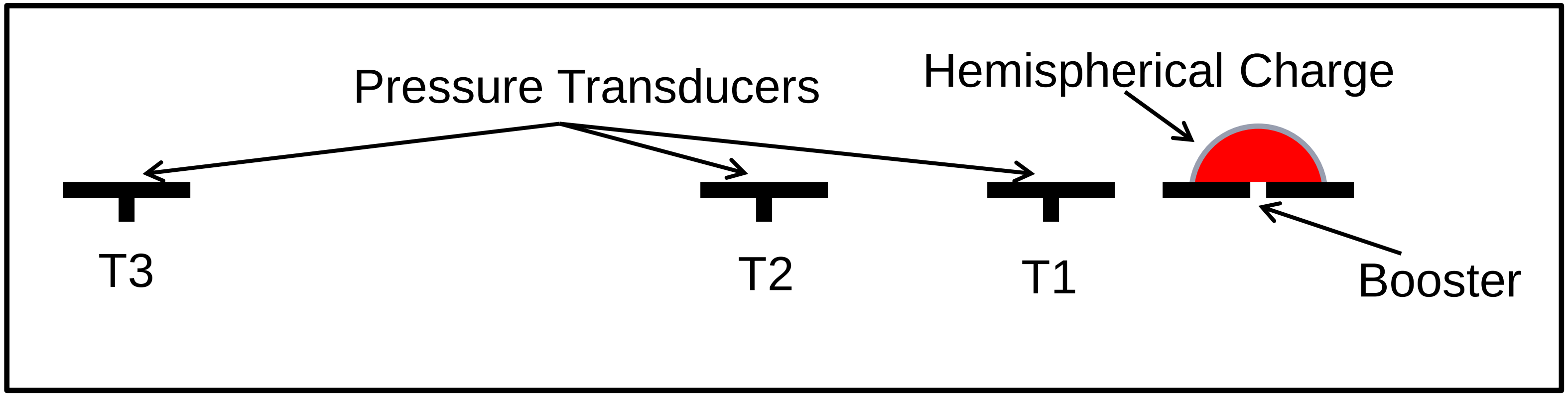
- **Results indicate all compositions are safe to process**
  - Research explosives have lower thermal stability than baseline compositions but all exotherms are in the expected range

Formulation	ABL Impact (cm)	ABL Friction (lb @ ft/s)	ESD (J)	SBAT (°F)
B1	80	800 @ 8	8	322
B2	13	25 @ 8	8	332
R1	17	25 @ 8	8	263
R2	11	50 @ 4	8	272
R3	21	50 @ 6	8	263
R5	11	100 @ 4	8	272
R6	17	25 @ 8	8	268

Test Methodology

- **Two different tests were selected to generate initial performance data on selected candidate compositions**
  - Detonation velocity in standard LSGT tubing and hemispherical detonation
  - Samples of B1 were also tested at the same time to improve our ability to compare test results





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Detonation Velocity

- **Detonation velocity was checked on three research compositions (R2, R4, and R6) and baseline composition B1**

- **Results for all research explosives were very close to the predicted values**

  - Calculations under predicted Vd for the baseline explosive but were in good agreement (+0.08 mm/μ sec) with literature values for this explosive composition

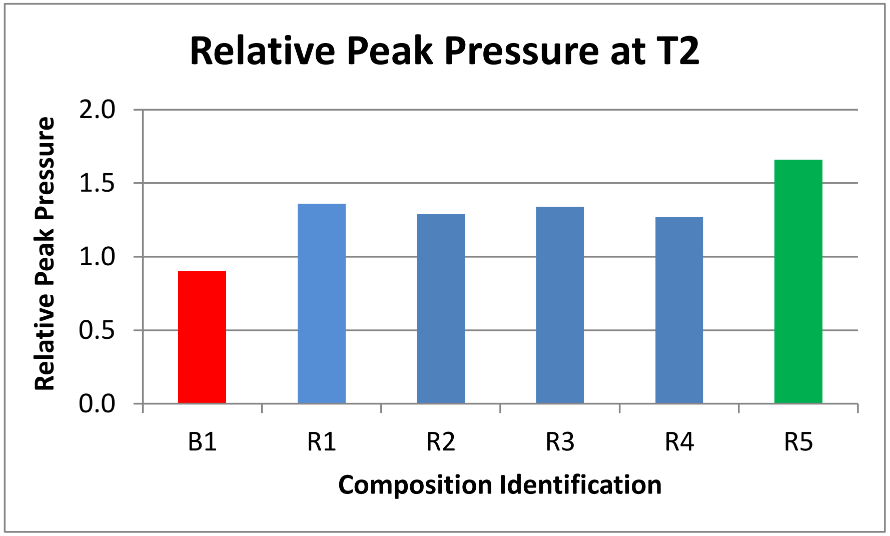
Explosive	Calculated Detonation Velocity Relative to B1 (mm/μ sec)	Measured Detonation Velocity Relative to B1 (%)	Calculated - Experimental Velocity (mm/μ sec).
B1	0.00	100.0	0.66
R2	0.24	94.9	0.03
R4	-0.03	90.1	-0.07
R6	-0.09	89.2	-0.08

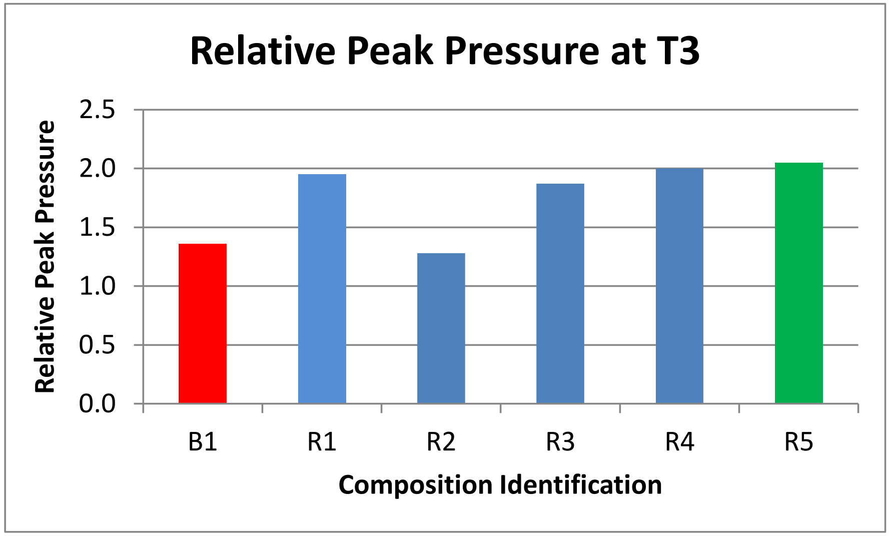
Hemisphere Blast Testing

- **Hemispherical charges of one baseline explosive, B1, and five research compositions, R1 through R5, were prepared**
  - All charges had similar masses & were initiated with a standard charge
  - All explosives processed well and the resulting charges had densities above 99% of their theoretical maximum density
- **Testing was performed at ATK's Northern Utah explosive test facility**

Peak Pressure

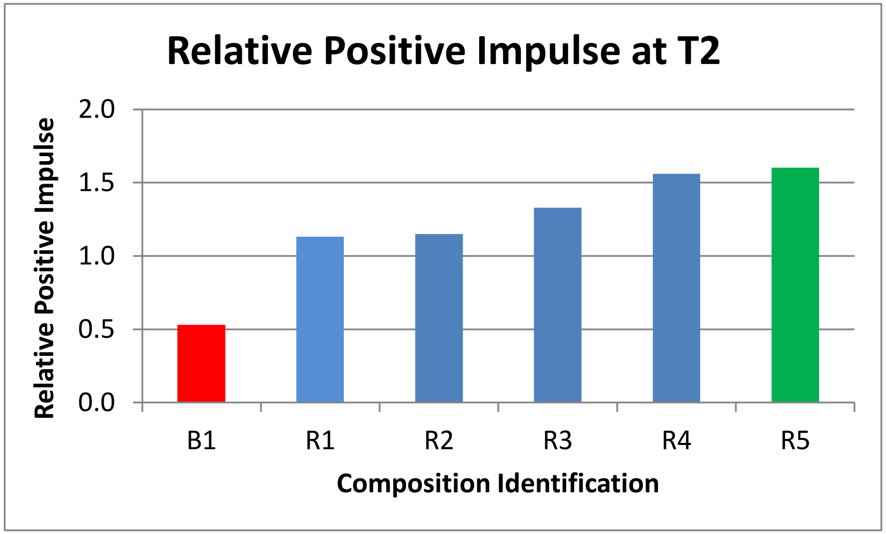
- **Peak pressures at both T2 and T3 transducer locations for the research explosives were nearly all higher than for the baseline composition**
  - R5 had a peak pressure more than 1.5 times that of B1
  - Trend of decreasing P_{CJ} with higher aluminum content was not observed
  - Results at T1 are not reported due to test difficulties

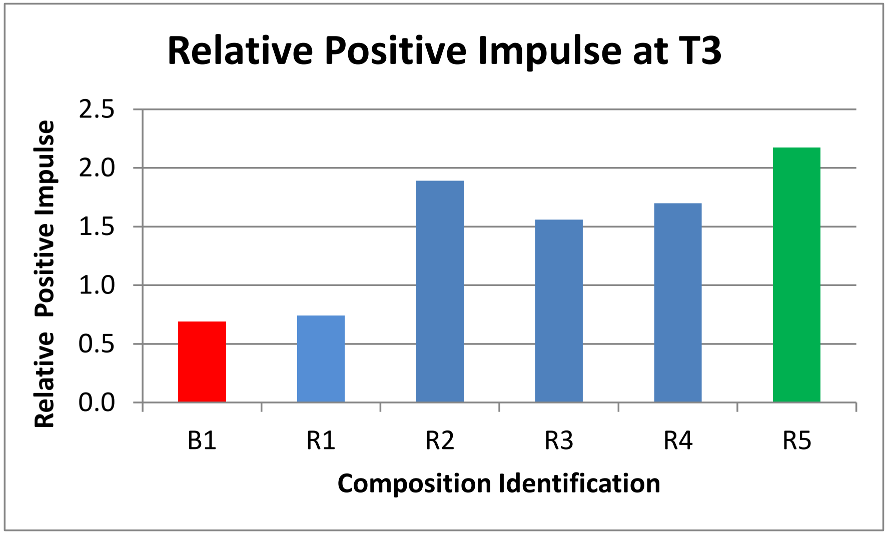




Positive Impulse

- **With the exception of impulse data for R1 at T3, all measured impulse values for the research explosives were substantially greater than for B1**
  - R5 was again the top performer with a relative positive impulse more than three times greater than B1
  - Appears to be a trend of increasing impulse with increasing aluminum level for explosives R1 through R4 close to charge





Application

- Data generated in subscale tests were used to select a composition for a small prototype warhead
- Results were most impressive!

Summary

- **Formulation approach was found to be a very useful tool when developing new high blast compositions**

- **Subscale test results gave promising results that translated well into the selection of an explosive for a small prototype warhead**

  – Results support further development of this formulation line

- **Additional testing is needed to verify that the large improvement in performance is realized in large-scale articles**