RDECOM

Development and Characterization of IM Gun Propellant for the 120mm Tank System

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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OUTLINE

- Objectives
- Approach
- Results
- Summary and Conclusions
- Acknowledgments

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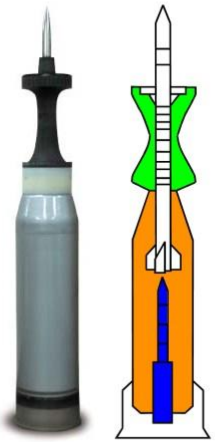
OBJECTIVES

- Goal

Develop high energy and less sensitive propellants to minimize soldier and weapon platform vulnerability from unplanned stimuli

- Technical Objectives:
  - Maintain High Performance:
    - Performance Baseline → JA2 propellant in M829A2
  - Lower the sensitivity of propellants against:
    - Shape charge jet (SCJ):
    - Spall:
  - No anomalies in gun environment:
    - Test fire in a sub-scaled gun → 30 mm gun firing



APPROACH

- Formulation
  - Use less sensitive ingredients
  - Use less of energetic solid fills
- Conduct various characterization tests
  - To observe any trends
  - To discriminate and downselect formulations
  - Tests/Calculations conducted:
    - Closed bomb
    - Interior ballistic (IB) calculation
    - Erosivity Calculation
    - Critical diameter
    - Shock initiation sensitivity→ predictor against shock stimulus
    - Uniaxial Compression (Mechanical Properties)
    - Hot fragment conductive ignition → predictor against spall threat
    - Small scale (1.77 lbs) and 5 lb SCJ ballistic pendulum → predictor against SCJ threat
    - 30mm gun firing (to be completed)

Most of the work was performed during 2005-2008

RESULTS: Muzzle Velocity and Erosion

Theoretical Muzzle Velocity and Erosion Prediction

Formulation	Solid Load (wt%)	Relative Muzzle Velocity (%JA2)	Tflame (K)	Relative Erosivity (%JA2)
JA2	**0**	**100**	**3450**	**100**
A	40	**103**	3454	72
C	50	**103**	3558	92
D	30	**102**	3348	57
E	40	**102**	3486	80
F	40	**102**	3432	70
G	40	**102**	3362	58
H	25	**101**	3299	52
I	25	**101**	3290	51
J	0	**99**	3043	32
K	20	**100**	3246	46
L	10	**99**	3138	38
M	0	**98**	3149	41
B	40	**102**	3454	72

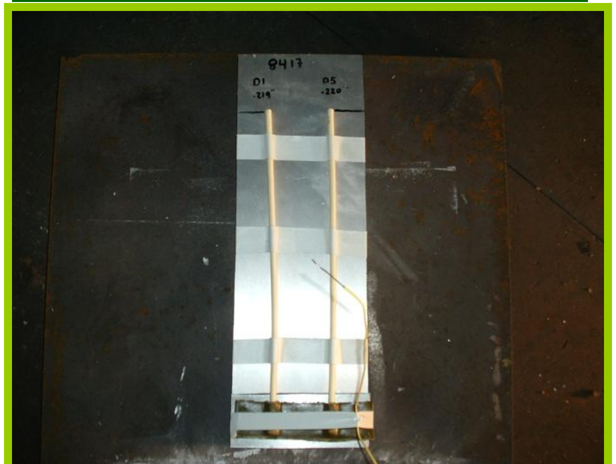
Relative Muzzle Velocity Range: 98-103%

Relative Erosivity Range: 32-92%

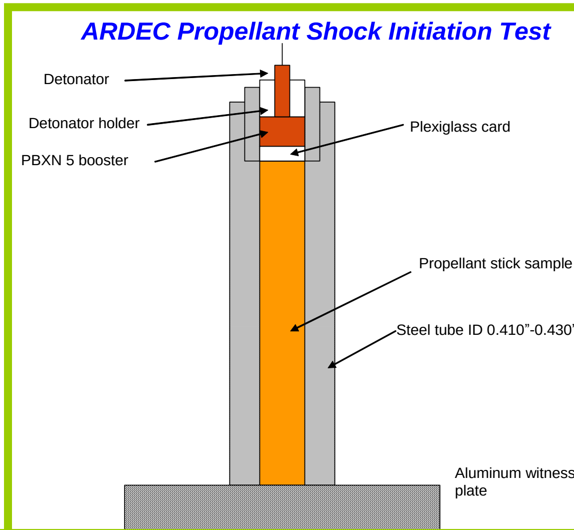
RESULTS: Shock Sensitivity

Critical Diameter and Shock Initiation

Critical Diameter Setup



Shock Initiation Setup

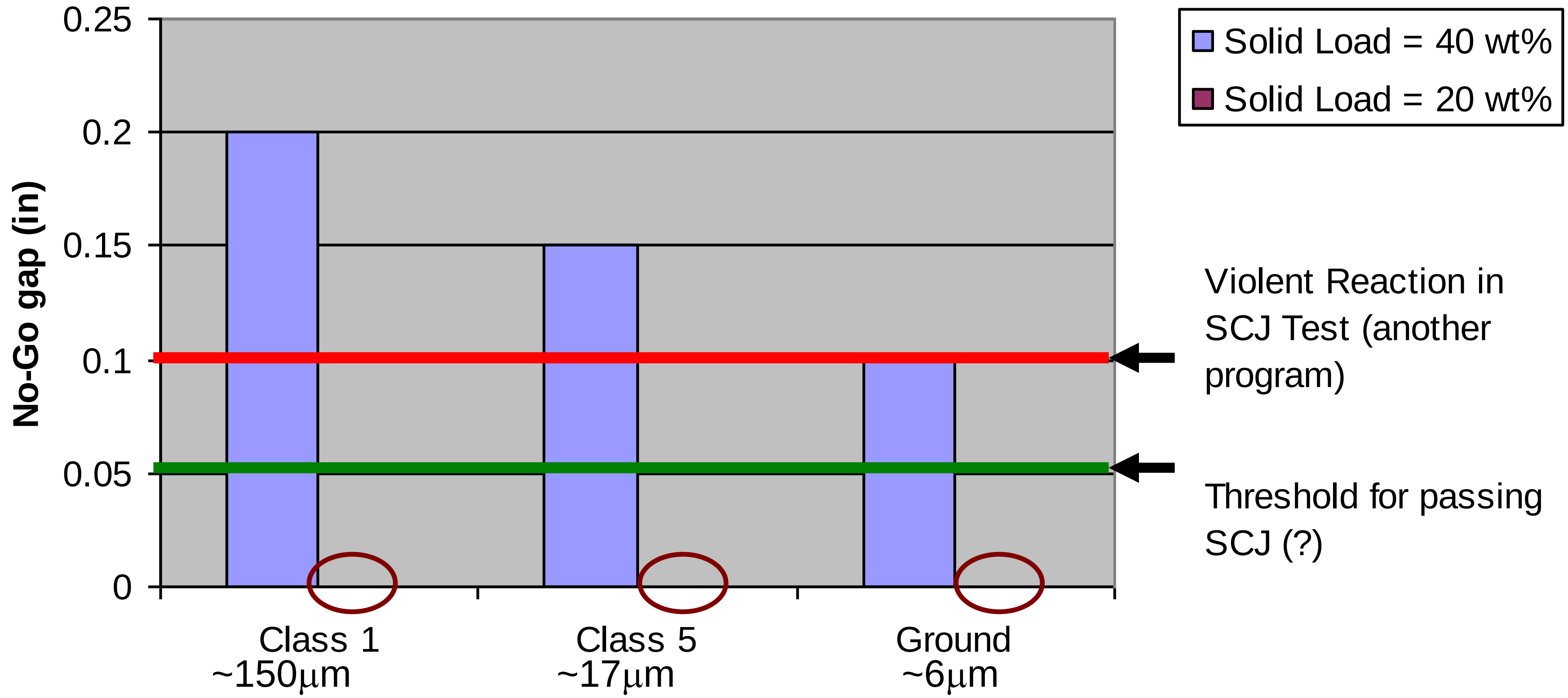


Not detonated

Dent from detonated samples

RESULTS: Shock Sensitivity (Cont.)

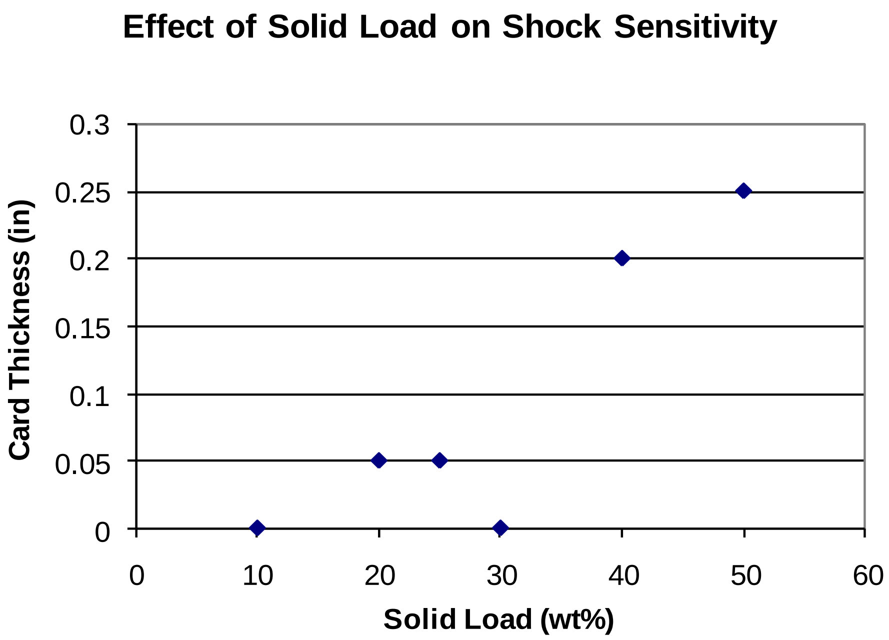
Shock Sensitivity of iRDX Based Propellants



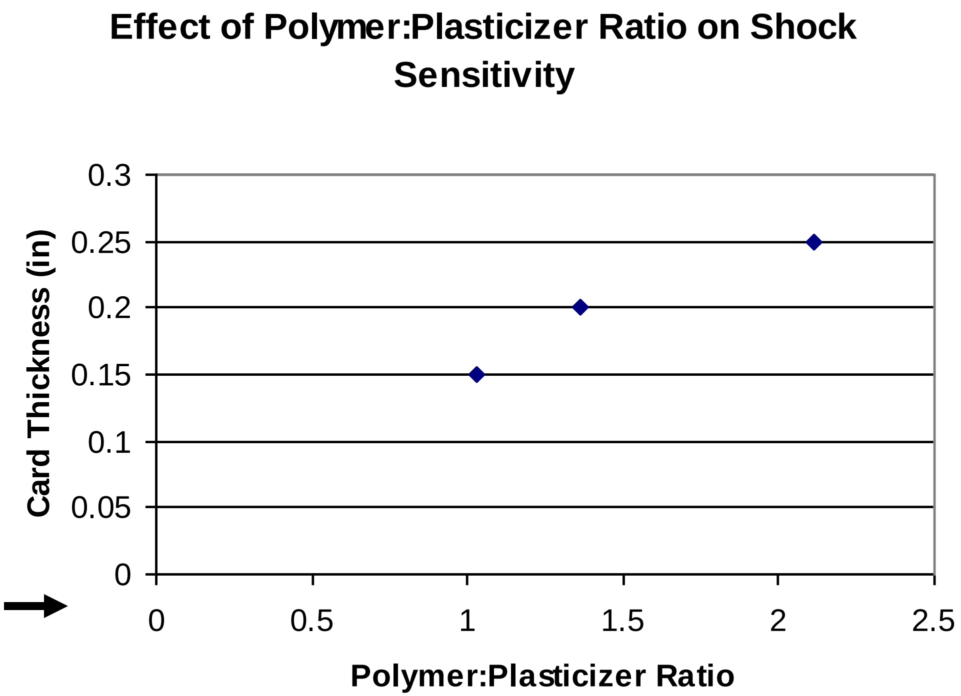
As particle sized decreased the sensitivity decreased

As solid load decreased (total E) the sensitivity decreased

RESULTS: Shock Sensitivity (Cont.)



Polymer:Pasticizer Ratio = 1.36



Solid Load = 40wt%

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RESULTS: Mechanical Properties

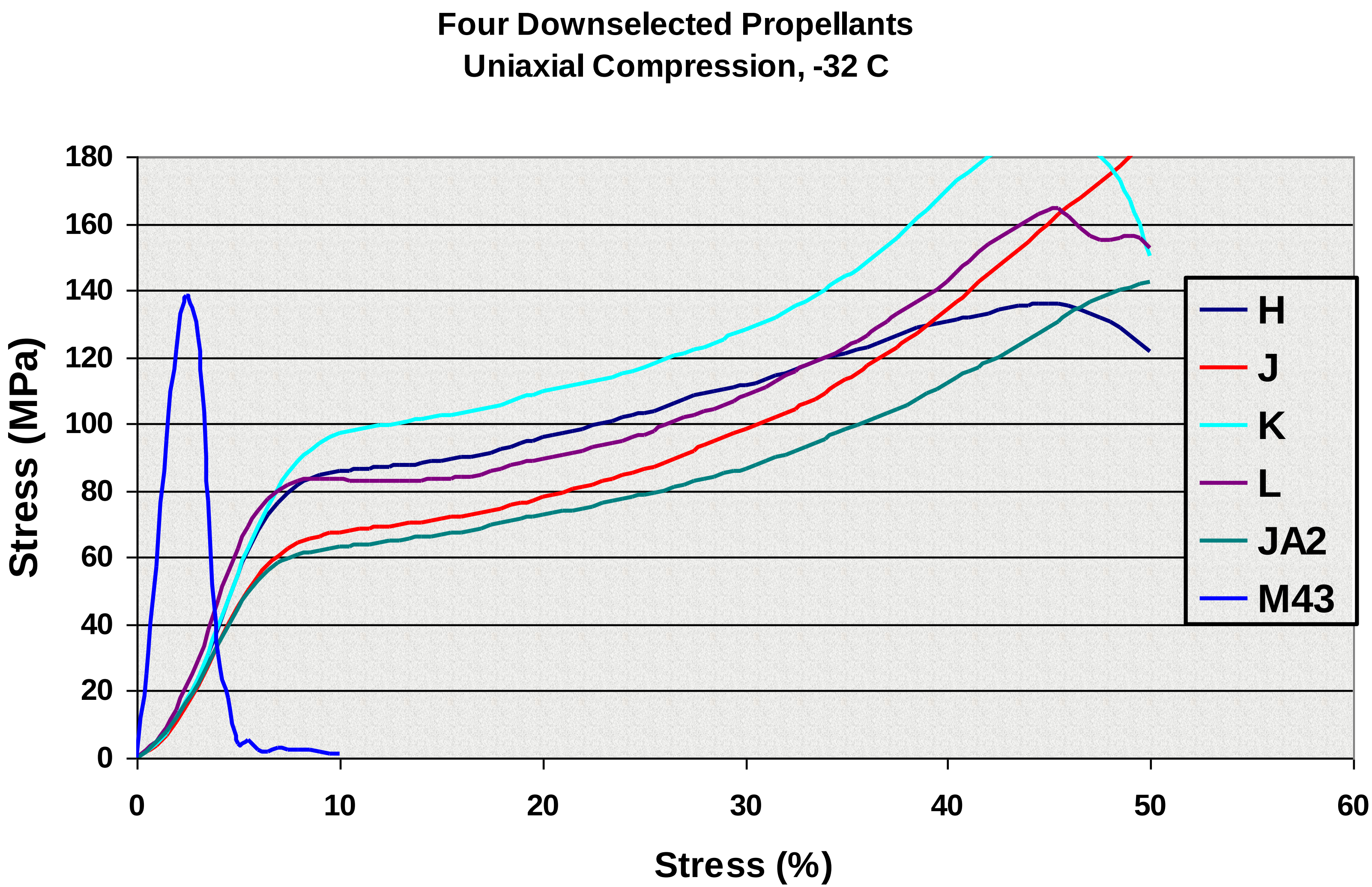
Trends in Mechanical Properties

Polymer: Plasticizer Ratio	Mech. Prop.	Solid Load (wt%)
1.03	Best	40
1.36	Good	40
2.11	Accept.	40
1.5	Best	0
4	Accept.	0

Solid Load (wt%)	Mech. Prop.	Polymer: Plasticizer Ratio
0	Best	1.5
10	Good	1.36
20	Good	1.36
30	Good	1.36
40	Good	1.36
50	Good	1.36

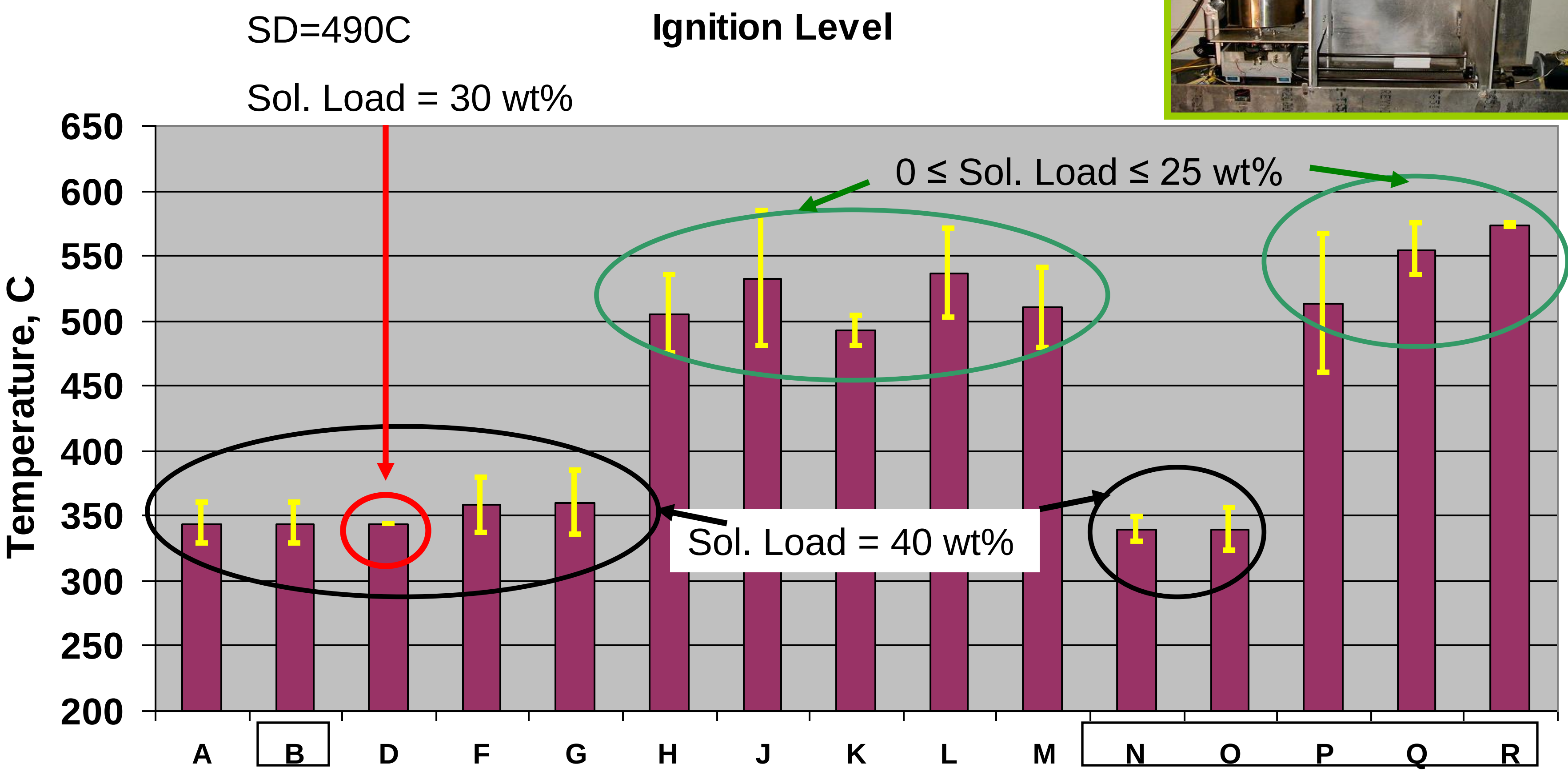
RESULTS: Young's Modulus

Uniaxial Compression (Mechanical Properties)



RESULTS: Thermal Sensitivity

Hot Fragment Conductive Ignition



RESULTS: Downselection

Ranking for Downselection

Formulation	Vel. Ranking	Erosiv. Ranking	Shock Init. Ranking	HFCI T_{ig} Ranking
JA2	**10**	**13**	**-**	**-**
A	2	10	10	8
C	1	12	11	-
D	6	7	1	9
E	3	11	11	-
F	4	9	9	7
G	5	8	8	6
H	8	6	6	4
I	7	5	1	-
J	12	1	1	2
K	9	4	6	5
L	11	2	1	1
M	13	3	1	3

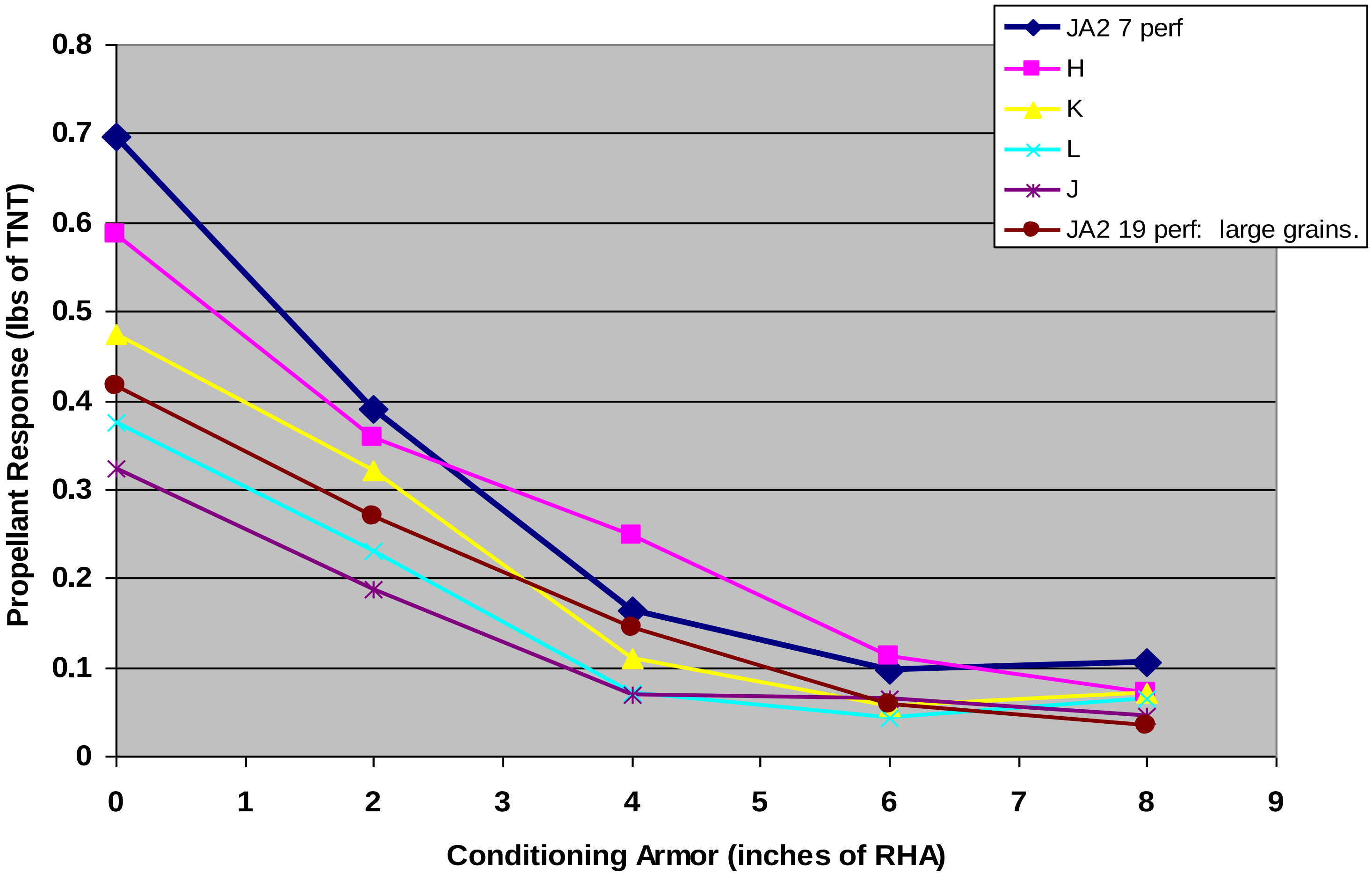
•Formulations H, J, K, and L were downselected

RESULTS: Small Scale SCJ Test

Small Scale SCJ Ballistic Pendulum Test Setup

RESULTS: Small Scale SCJ Test

Small Scale Ballistic Pendulum Tests



No Detonation Observed

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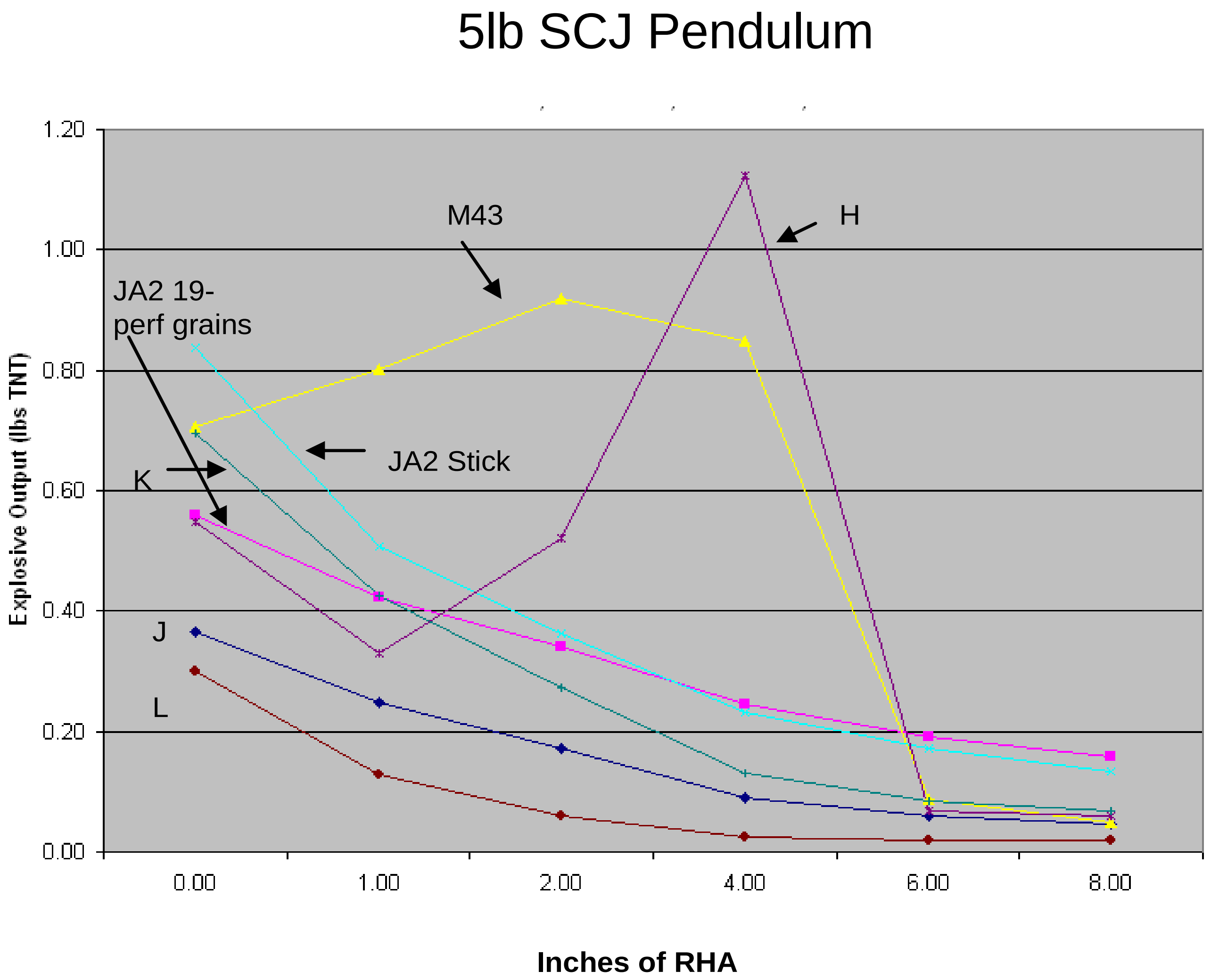
RESULTS:
5lb SCJ Pendulum Test



Detonation was Observed for H at 4” RHA

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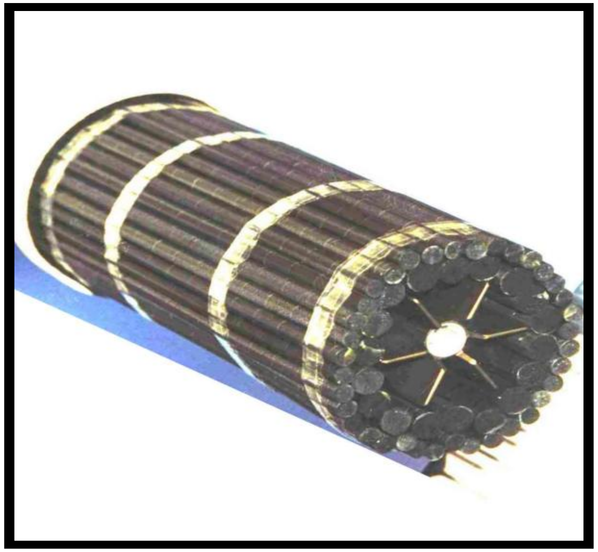
RESULTS: Shock Sensitivity of End Item

5lb SCJ Pendulum Test Sample vs End Item Loading Configuration

Propellant Sticks loaded in 6 in x 6 in Cardboard Tube

Source: Boyd, K. et. al., ARL, MD (Aug 2006)



Tank KE Charge Configuration

Source: ATK, Radford, VA

- Formulation H has lower critical diameter of bed than JA2
- It may not react violently in actual charge configuration due to space made by projectile
- Further testing is needed to confirm this

RESULTS: Gun Firing

60mm Gun Firing

- One slot became available in Novel Energetics Material ATO
- Formulations H was selected to test (before 5lb SCJI pendulum test data was available)
- 60mm Gun:
  - sub-scaled from 120mm
  - Base pad electrothermal-chemical (ETC) igniter
- Formulation H performed better than JA2 as expected
- Formulation K was not test fired but should have similar performance as JA2
- Some shots displayed high negative delta P
  - Data under further evaluation
  - Blocked pressure ports on several shots

SUMMARY and CONCLUSIONS

- Eighteen IM gun propellant formulations were thoroughly characterized in this program
  - One formulation **met performance** requirement and had **better IM** properties than JA2
  - One formulation **exceeded performance** requirement and had **better IM** properties than JA2 **except against SCJ** – critical diameter of the bed is smaller than that of JA2
    - This formulation also had higher ballistic efficiency than JA2 in the 60mm sub-scale gun firing
  - Two formulations had **slightly lower performance** than required but had **much better IM** properties than JA2
  - All Four formulations mentioned above have **much lower erosivity** than JA2

Patent Pending

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