Insensitive Munitions: Pyrotechnics Substitution for Explosives at Lake City

or How ATK has paid its PWRFEE

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So why is a Small Caliber Ammunition person here?

1. Small Caliber Ammunition are defined as insensitive munitions.
2. Small Caliber Ammunition is a commodity.
3. To be cost effective, small caliber ammunition must be
    1. very powerful or
    2. very efficient
        a. Most IM/EM solutions are powerful and costly, see statement 2
        b. Cost Effective Improvements therefore must be made in efficiency

ATK has followed a simple engineering design concept in substituting pyrotechnics for explosive in their designs of P_4rimer™ and KICM®. The concept is

“Pay the PWRFEE”

For IM/EM, consider the alternative work paths

Most legacy designs are very powerful and very inefficient. Insensitive munitions should consider alternate paths that incorporate insensitive energetic materials that have more efficient energy usage to perform the desired work.

The PWRFEE Defined

Power evaluation

Work evaluation

Requirements review

Force Evaluation

Energy Assessment

Efficiency Assessment

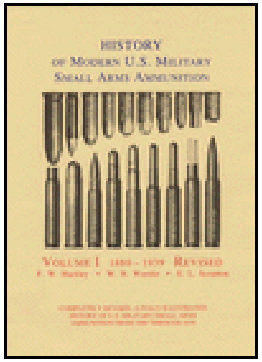
Pyrotechnic Mixtures have been ignored

Whereas, a primary initiating explosive is suitable for ignition of small arms propellant, it does not appear to be necessary.

The percussion cap formulations from the 1910 – 50's have more in common with chemical ignition mixtures than primary initiating explosives. Ignition mixtures appeared to have been under-explored as an alternative methodology in the search for an "environmentally friendly primer". A US patent search reveals several ignition mixtures from the 1900 – 1960s assigned for use in percussion caps. This review suggests red phosphorus as a promising candidate.

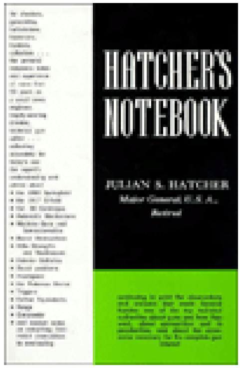
RP was considered as an alternative

History of Modern U.S. Military Small Arms Ammunition by Hackley, Woodin & Scranton, 1978



"Through the 1920s, the U.S. experimented with different primers in an attempt to get away from the corrosive compounds of the time. Some of these tests were identified by special headstamps. Additional tests on primers occurred in the 1930s and again after WWII. Some were plated with tin, nickel or zinc but that alone does not automatically mean a primer is an experimental. In the late 1940s, the U.S. used zinc plating to protect primer cups on the then new **P4** primer. "

"**Hatcher's Handbook" by Maj. Gen. Julian Hatcher, 1956;**



"Meanwhile Frankford Arsenal's search for a perfect non-corrosive primer for other service ammunition had been progressing, and they came up with a non-corrosive primer mixture consisting of barium nitrate and red phosphorous, and started its manufacture.

…

This primer mixture was used for a time (about 1949) with success; but it was finally decided to adopt a lead styphnate primer mixture for all service small arms primers, and such a non-corrosive small arms primer based on lead styphnate was standardized be Ordnance Committee action in August 1949."

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Power Assessment for P$_4$rimer™

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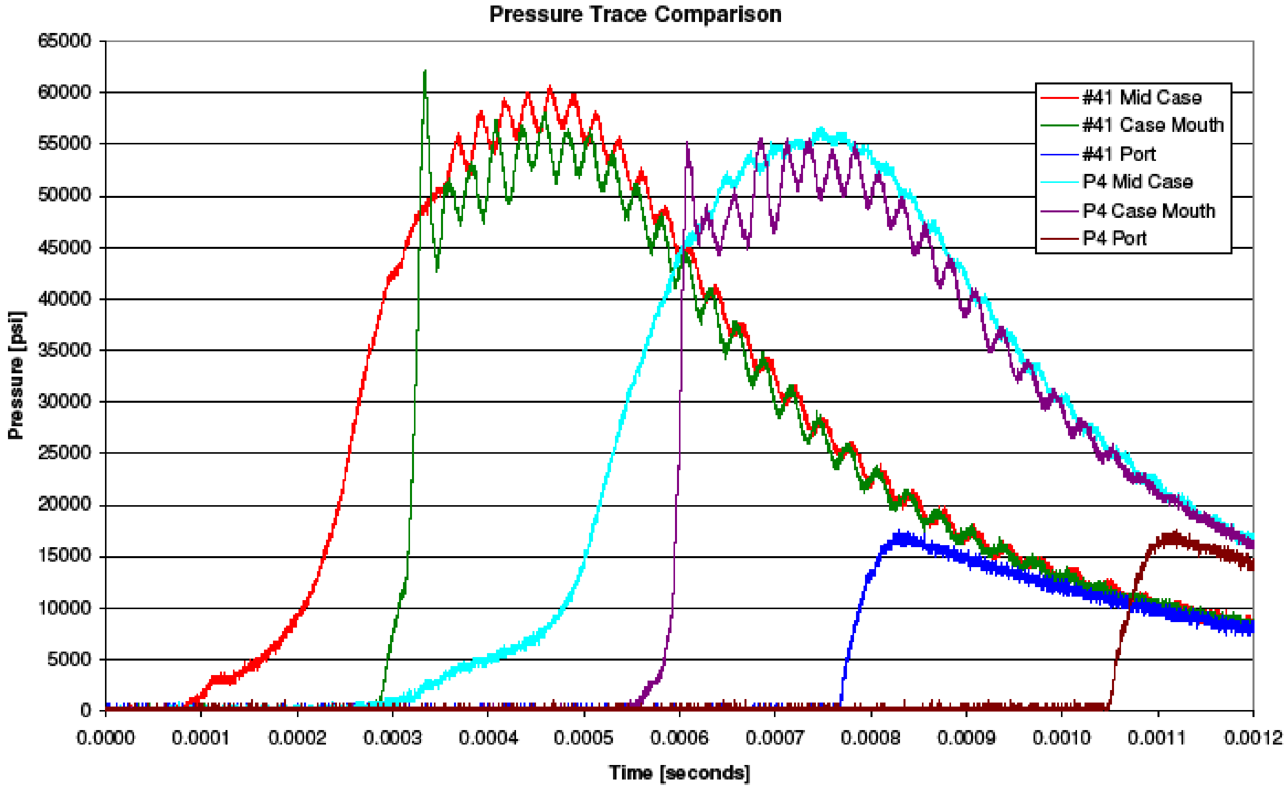

Test Data
Date: 02/21/08
Barrel: VPSAWS-444, modified for MCP testing
Samples: #41 Primer RunOrder 1 Shot 5 vs. P4 Primer RunOrder 2 Shot 15
Filter: 180 kHz
Action Time: #41 = 870 micro sec, P4 = 1170 micro sec

Load Data
Bullet: M855, BAM production
Propellant: WC844 Lot 81560 26.50 gr.
Velocity: 3000 fps

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Work Assessment for P_4rimer™

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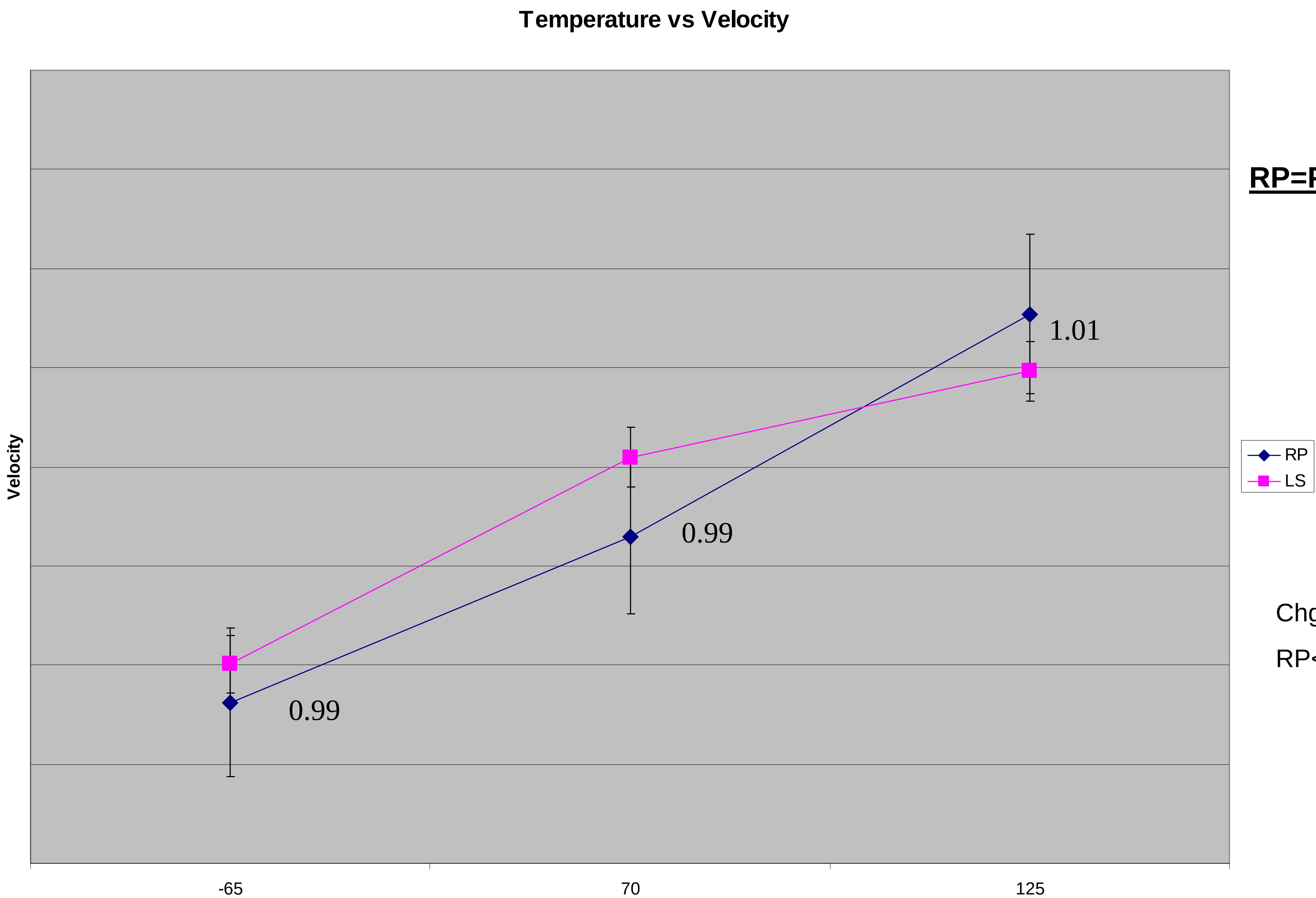

RP=PbSty

Chg. Wt.

RP<PbSty

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Requirements Review for P_4rimer™

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All data at 70 F unless noted	Frankford Arsenal's P4 Primer Formula FA 675 (1947)	Frankford Arsenal's .30-06 Primer Formulation Western (WN) 768 (1947)	Frankford Arsenal's .30-06 Primer Formula FA 70 (1947)	ATK's Federal® 195 P_4rimer™ Composition (2004)	US Army's #41 Primer P_4rimer™ Composition (2007)	US Army's #41 Primer FA 956 (2007)
Peak Pressure	-3.0%	0	0	-4.6%	-11.2%	0
TTPP	NA	NA	NA	+7.7%	0	0
PP at +120 degrees F	-2.0%	0	0	-4.4%	0	0
PP at -65 degrees F	-4.1%	+2.0%	0	-5.2%	0	0
Velocity	-1.3%	-2.3%	0	0	0	0
Velocity Std Dev	+2.0%	+1.9%	0	+2.1%	+2.0%	0
Action Time	0	-14%	0	+10%	+27%	0
Misfires per 1000	9.7	0	0	2.3	6.5	0

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Design vs. Specification as Requirements

Don't confuse a descriptive specification with a design requirement.

Design Rule:
"Primer Must Ignite Propellant at all temperatures"
Thermodynamic requirement

Specification Rule:
"Zero misfires in XXX cartridges at cold temperature"
Systems requirement describing function

P_4rimer™ has the same mechanical activation energy

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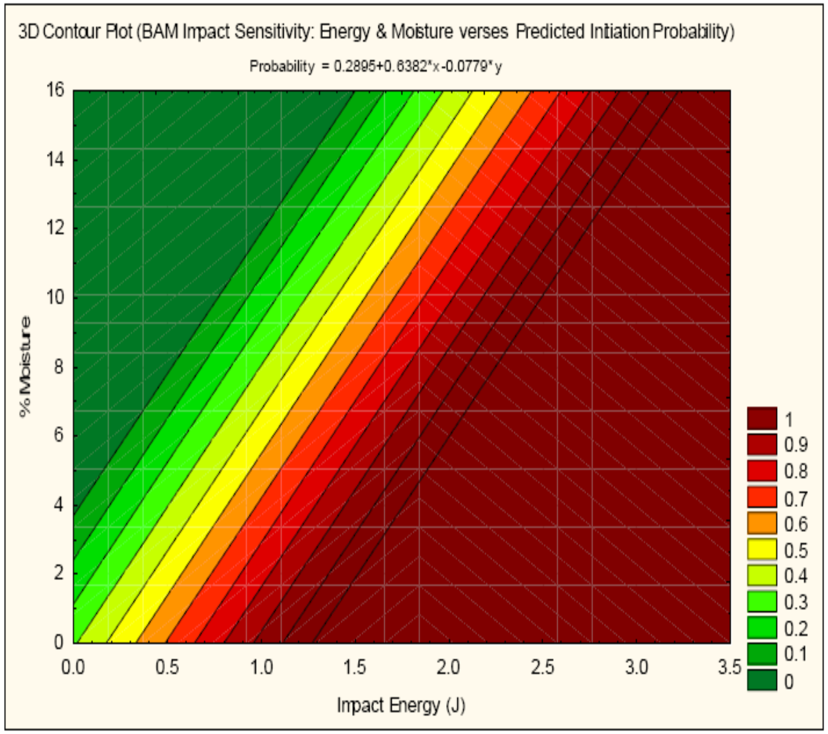
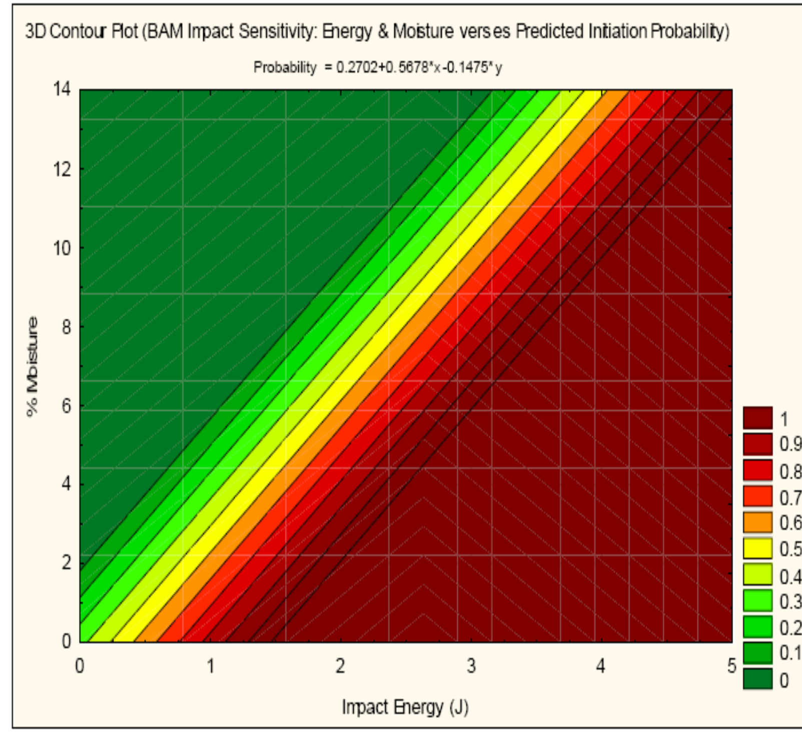
BAM Impact Ignition Probability for ATK P4



BAM Impact Ignition Probability for FA 956



as functions of Energy and Moisture

Impact ignition for P_4rimer™ and FA 956 are very similar.

P_4rimer™ is a cost effective substitute

- Cost effective
  - 33% reduction in cost Legacy Formulations
  - 40% reduction for mass in primer

P_4rimer™ meets new "Green" Primer" Requirements

- **P_4rimer™ is a Non-corrosive, "Green", Nutrient Mineral Containing, Non-Toxic, Heavy Metal Free Ignition Mix**

  - Non-corrosive as tested in "Frankford Arsenal's Report Number R-265 Caliber .30 Red Phosphorus Primers Research Item Number 204.0"
  - Meets requirements for Section 5 of the US Federal Trade Commission Act; Federal Trade Commission Guides for the Use of Environmental Marketing Claims, Part 260 and US Environmental Protection Agency in publication EPA 260-B-01-001 as applied to the terms; "green", "heavy metal free" and "non-toxic"
  - Mix Chemicals and Combustion Products are chemical pre-cursors for agricultural fertilizer as nutrient minerals
  - Uses Biologically tolerant and recyclable chemicals

Force Assessment for P4rimerTM

TABLE 2 CHEETAH© Detonation Comparison Summary

Characteristic	FA 956	P4rimer™
Shock Velocity (m/s)	6601	3693
Particle Velocity (m/s)	1411	673
Mechanical Energy of Detonation (kJ/cc)	9.142	4.097
Thermal Energy of Detonation (kJ/cc)	0.976	4.731
Total Energy of Detonation (kJ/cc)	10.118	8.828
Heat of Combustion (cal/g)	1092	1560

F = M*v^2

At equal mass

$v_{FA\ 956} \sim= 2v_{P4}$ therefore

$F_{FA\ 956} = 4F_{P4}$

Energy Assessment for P_4rimer^{TM}

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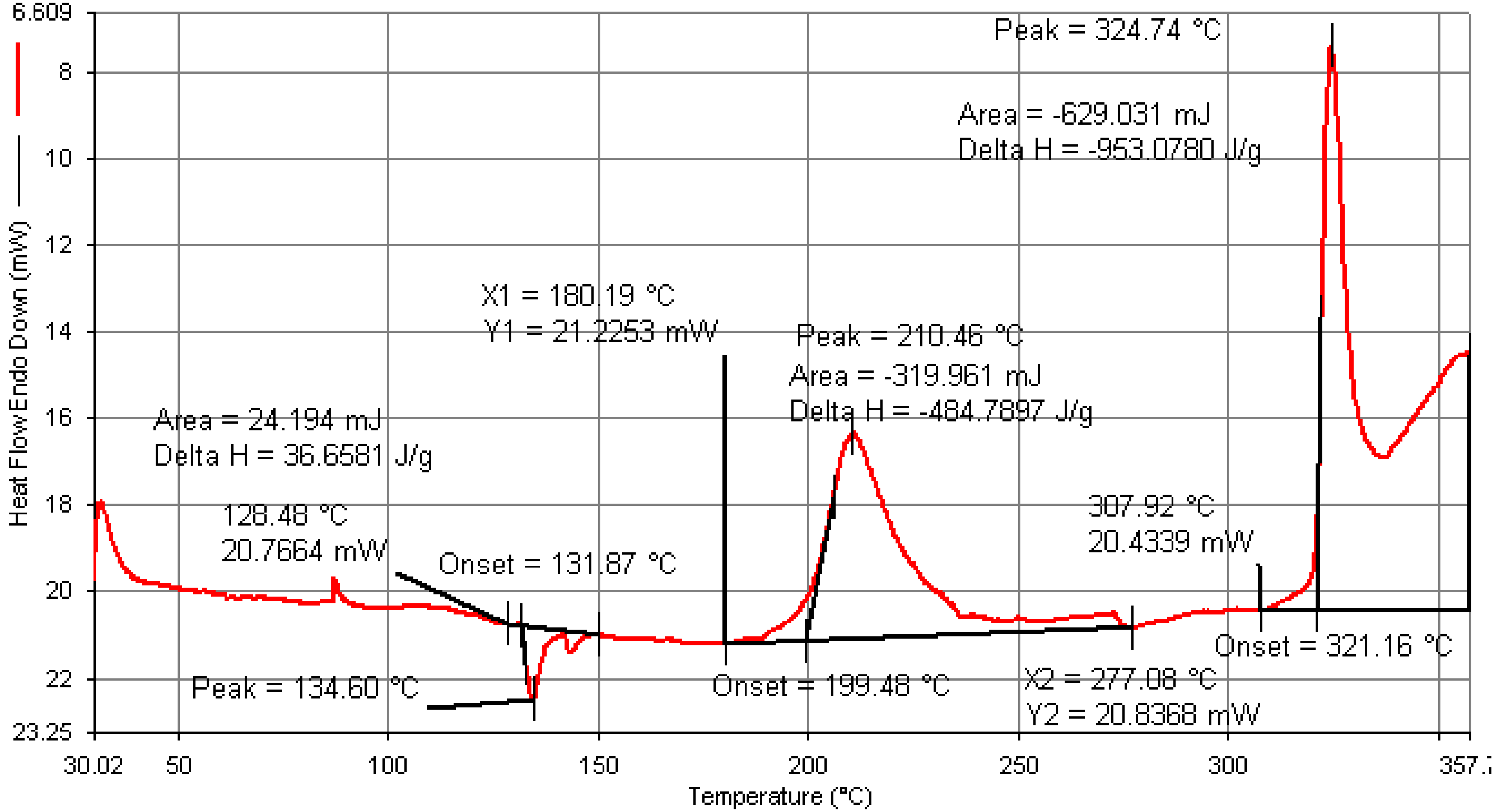

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Efficiency Assessment for P_4rimer™

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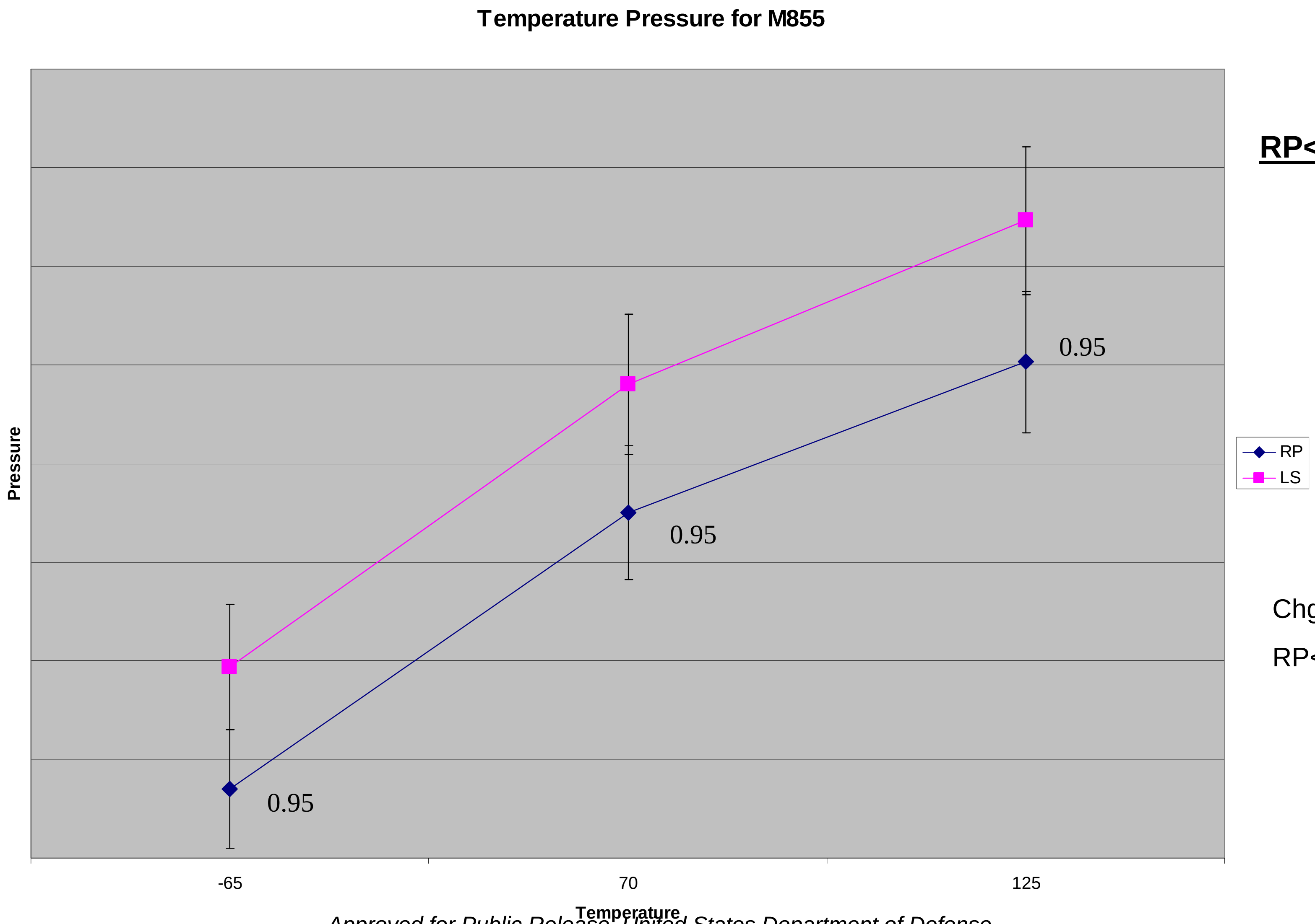

RP<PbSty

Chg. Wt.

RP<PbSty

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US Army has committed to a new primer

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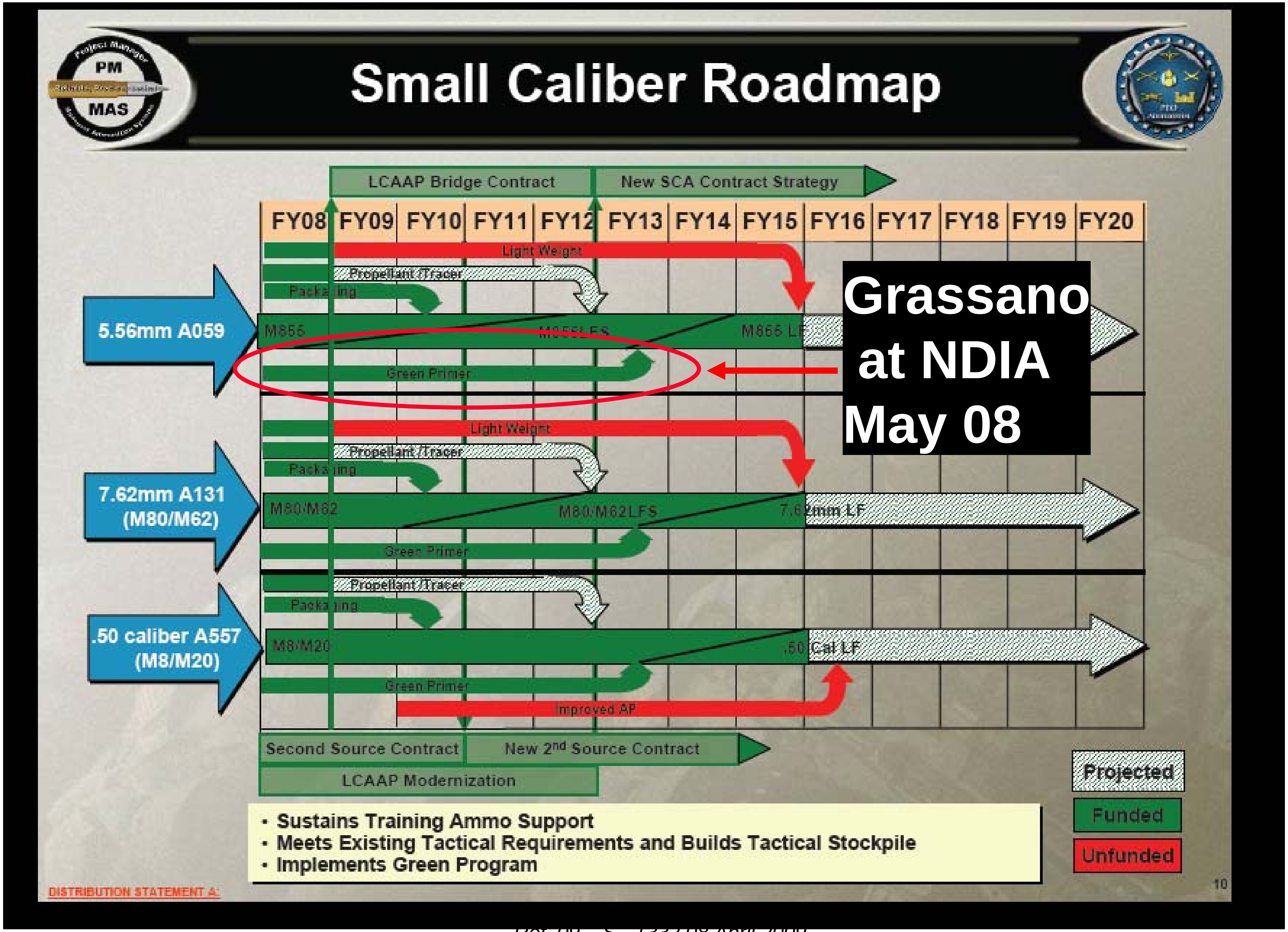

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Another Application for POWERFEE

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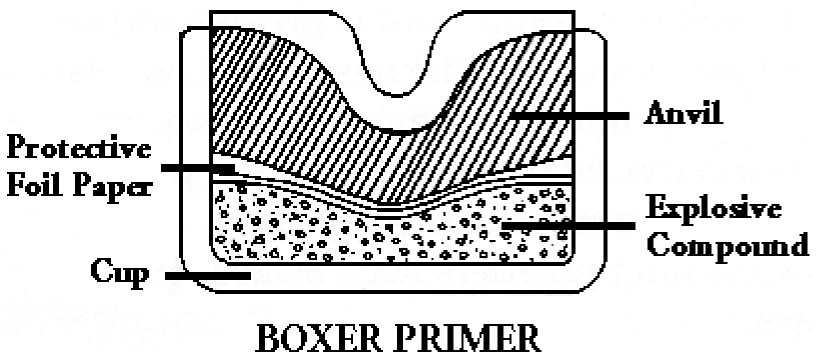

P_4rimer™

Kinetic Initiated Core Munitions
KICM®

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PWRFEE

Power evaluation

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Incendiary Mixtures have been ignored

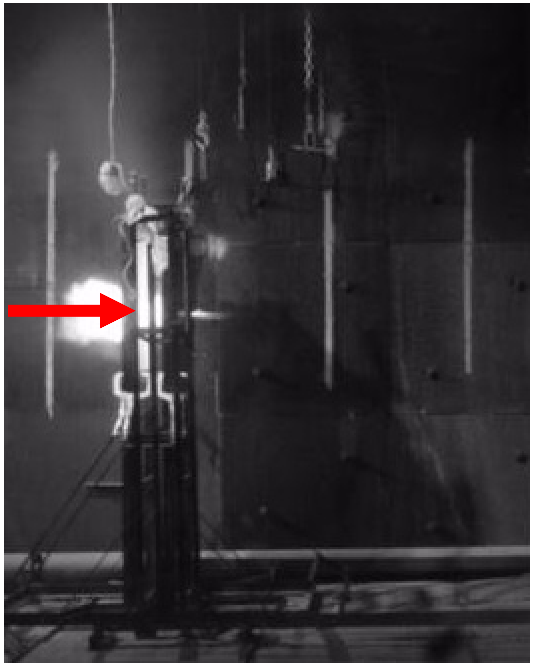
Whereas, a secondary explosives are suitable for use as a incendiary,

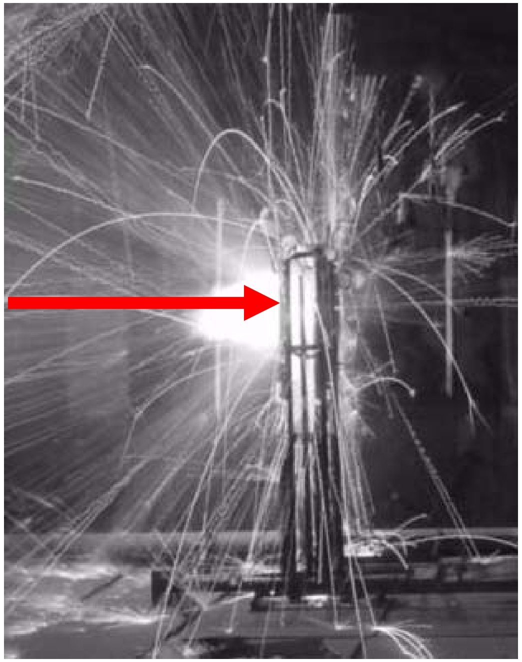
it does not appear to be necessary.

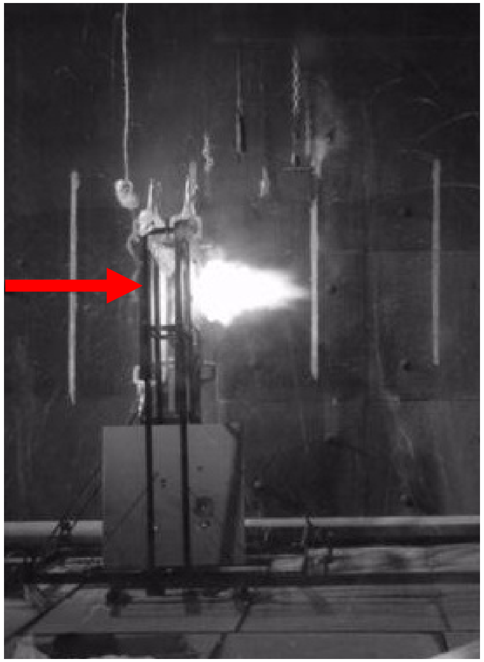
The incendiary formulations from the 1910 – 50's have more in common with chemical ignition mixtures than secondary explosives. Ignition mixtures appeared to have been under-explored as an alternative methodology in the search for an "environmentally friendly incendiary mixture". This review suggests reactive material as a promising candidates.

This product's innovation: KICM differentiates from the legacy cartridges by releasing chemical energy after initial penetration.

Direction of Fire







M8
Armor Piecing Incendiary

MK211
High Explosive Incendiary

KICM®
Semi-Armor Piecing High Explosive Incendiary

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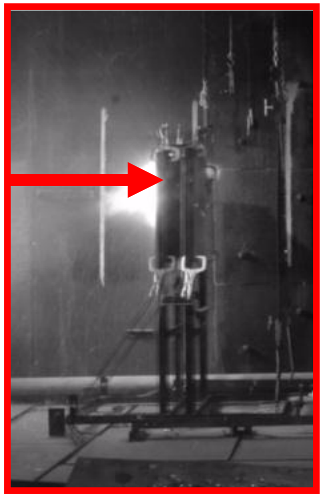
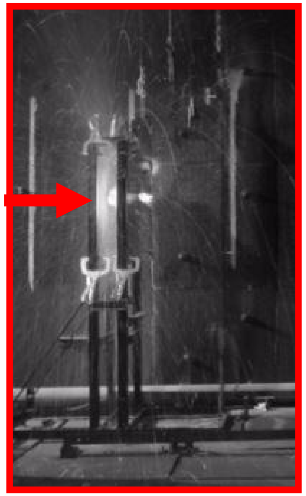
Changes In KICM's™ Modular Design Produces Different Explosive Effects

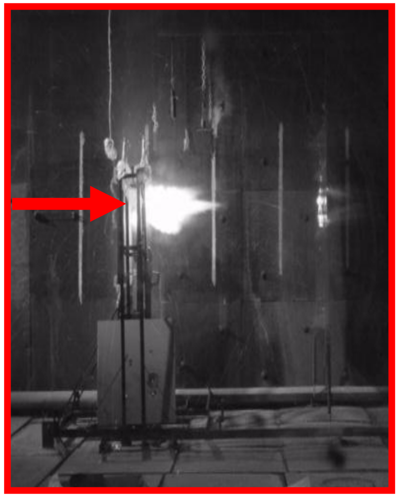
Direction of Fire



Point Ignition



Secondary Impact Ignition



Deep Impact Ignition

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Requirements Assessment for KICM

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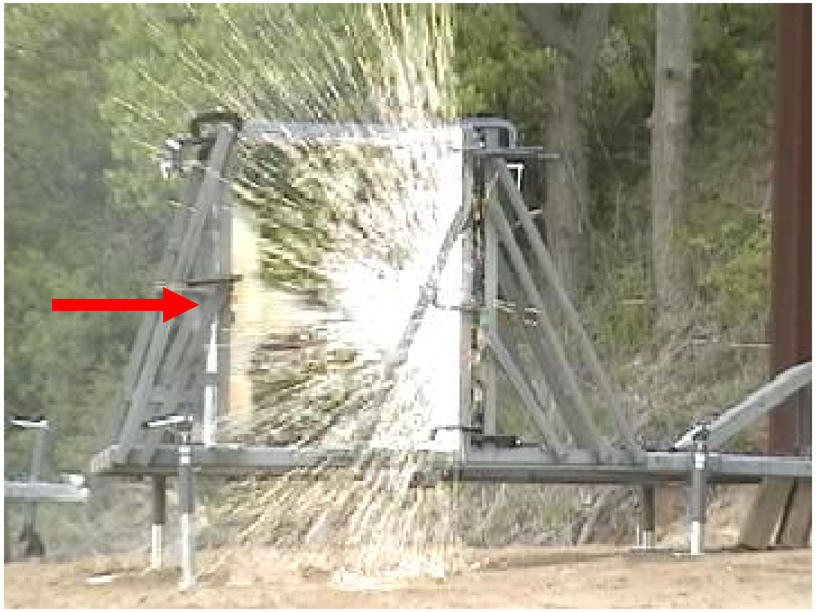
Direction of Fire



KICM®

Mk 211

KICM® ignites deep in the Multi Plate Test Array.
Legacy Projectile detonates earlier in this array.

Force Assessment for KICM

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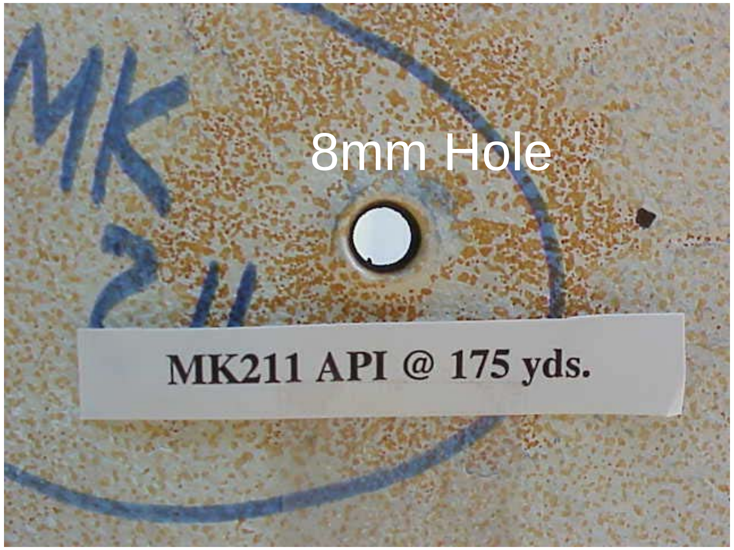


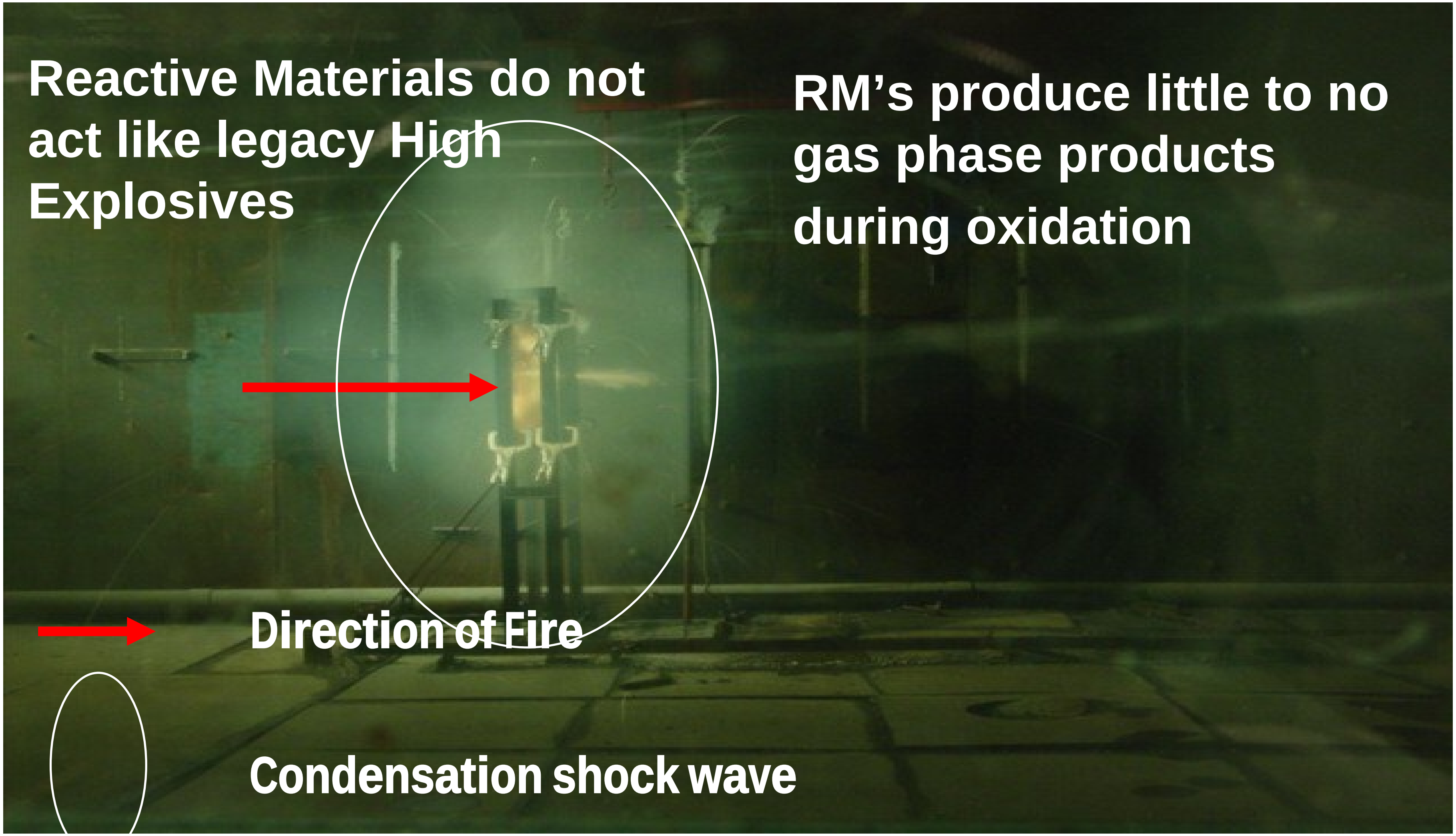
Energy Evaluation for KICM

Penetrated Primary Plate

Ignition on Second Impact Plate

Terminal Ballistics Improvement: Ignition inside or exit of the target has a greater chance of secondary explosions to immobilize target.

Efficiency Assessment for KICM



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The US Navy selected the legacy round

Legacy producer dropped price of projectile

US Navy’s Qualification Costs became prohibitive.

C'est la vie, It’s still a commodity market

For IM/EM, consider the alternative work paths

Most legacy designs are very powerful and very inefficient. Insensitive munitions should consider alternate paths that incorporate insensitive energetic materials that have more efficient energy usage to perform the desired work.

ATK Lake City has been successful with the **PWRFEE** concept in developing lower cost alternatives like P4rimerTM and KICM® while enhancing the IM/EM characteristics of small caliber ammunition.