IM Solutions For Projectiles Crimped to Cartridges for Artillery Application - Phase II, Transition from Cartridge Case Venting to Insensitive Propellant

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Background

- The PGU 44/B cartridge for the AC 130 aircraft consists of a cartridge case and a projectile that are crimped together
- Both components are IM sensitive

Munition	Platform	Propellant	Explosive	FCO	SCO	BI	FI	SD	SCJ
PGU 44/B	105-mm Howitzer	M1	CompB	I	I	I	I	I	I

- Separate effort to replace HE (Comp B → PBXN-109)
- This effort only for propelling charge (M67) and propellant (M1)
  - Vent holes were placed in the cartridge case
    - at the base
    - on the forward end
  - Insensitive propellant

Venting Effort

Venting Holes for SCO & FCO

(Past work – Phase I; Type V reactions)

Cartridge Case with 30 3/8” diameter holes on forward end

Cartridge case with 6 ¾” diameter holes at base

SCO Test Results - Type V

Cartridge case with holes at forward end

Cartridge case with holes at base

FCO with Vent Holes – Type V

Cartridge case with holes at forward end, parts were found near the pit

Cartridge case with holes at base seen on the pit table, after the bonfire test

IM Explosive – PBXN-109

After firing – cartridge case urethane plastic plugs

Comparison of lethality on concrete target

Fuze Cap and Cartridge Case Venting Plugs

- E = Eutectic of bismuth, lead, copper and tin
  - starts to melt at 200° F; fully melted at 240° F
- F = Formion
  - becomes soft at ~ 250° F and started to melt when T > 300° F
- K = Polyamide Polymer
  - starts to melt at 160° F; fully melted at 200° F.
  - improved plug later developed – starts to melt at 200° F; fully melted at 250° F
- Formion fuze cap
  - starts to melt at ~275° F then wax (the explosive stimulant) begins to exit through the nose cap.

Fuze cap, E, F and K Plugs

SCO, with PBXN-109 Inert Propelling Charge with Plugs

Charred remains of container

Formion plugs consumed

Type V reaction; event took place at 425ºF

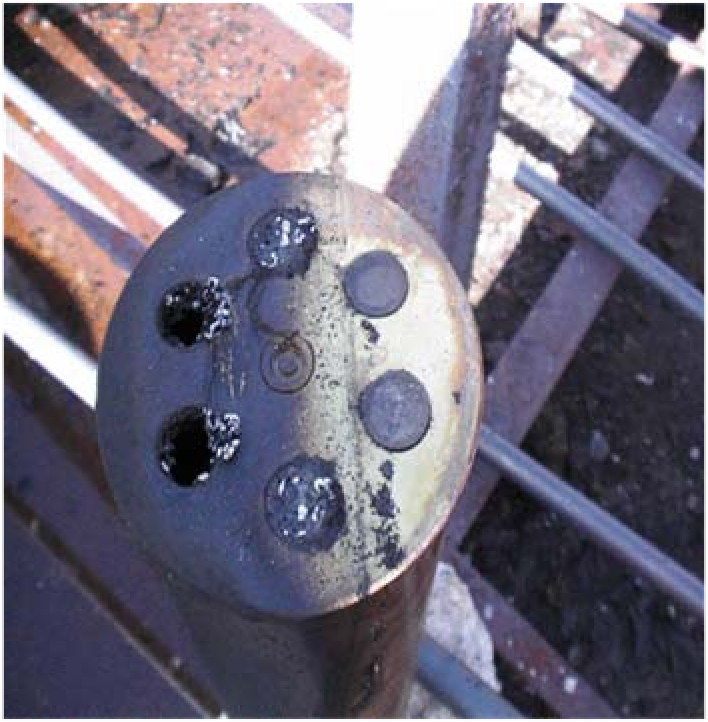
FCO of Cartridge with M67 Propelling Charge, Inert Explosive, Plugs – E, F and K

Test Items – Post Test

Base with E plugs

Type IV reaction

FCO, AUR
Formion Plugs and Fuze Cap



Formion plugs – carbonized instead of melting

Projectile with nose plug consumed

Projectile ejected 20 ft outside pit

Propellant Effort

Propellant

- Leverage propellant development programs for Navy's 5-inch and 155-mm gun systems
- NILE propellant –
  - Improved IM over Navy's single base BS-NACO propellant
  - Similar properties to M1 used in 105-mm M67 round

Propellant	Impetus (J/g)	Covolume (cm^3/kg)	Gamma	Flame Temp (K)
M1	942	0.1076	1.271	2537
NILE	895	0.1190	1.279	2175

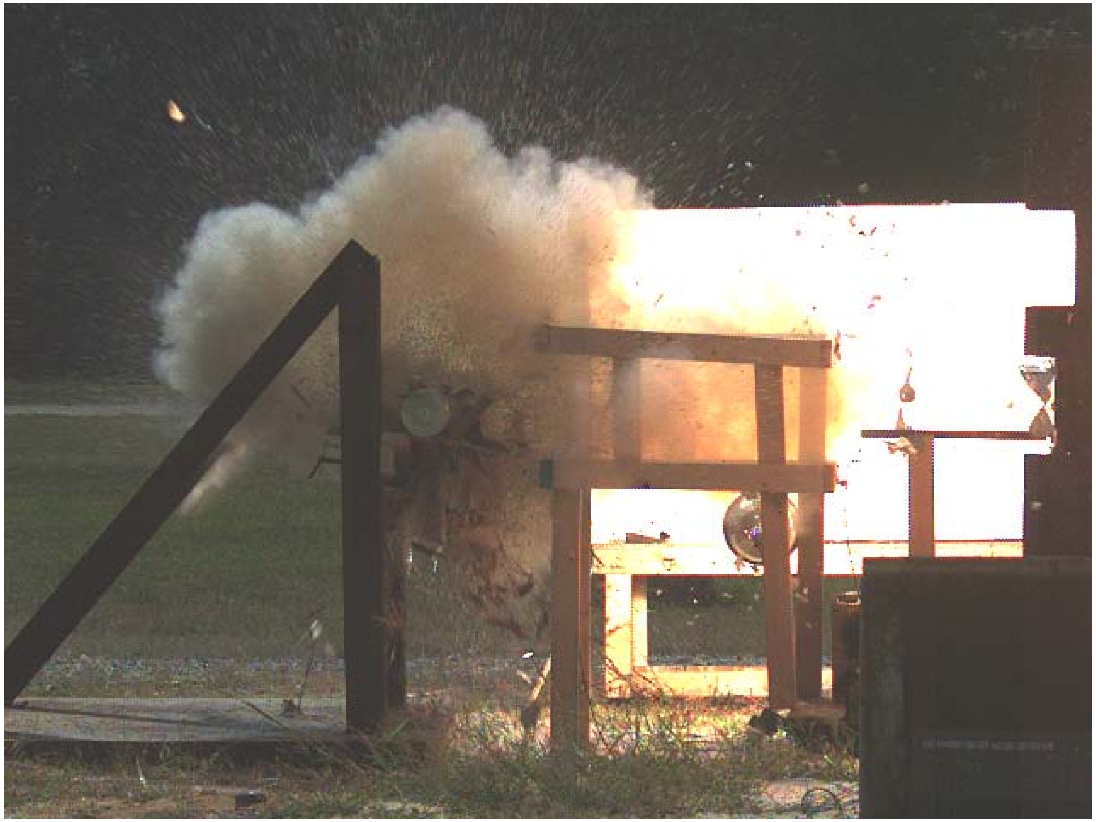
IM Testing of NILE Propellant

Slow cook-off – Type V reaction – pass!!

Current Mk 67 Mod 3 charge (BS-NACO) gives explosive reaction (Type III)

IM Testing of NILE Propellant

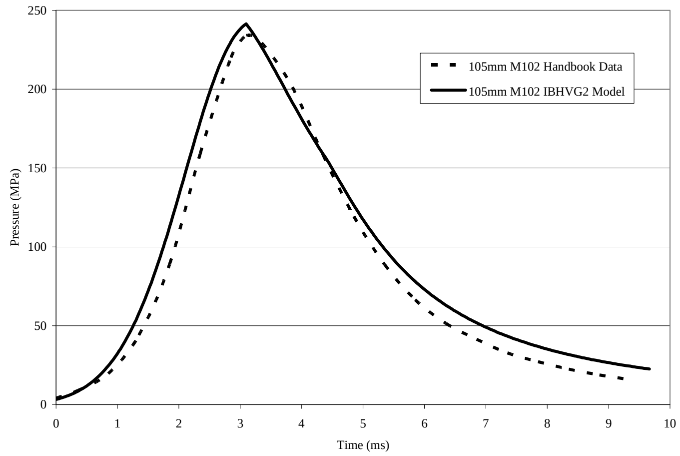
Fragment Impact – Type IV reaction



Current Mk 67 Mod 3 charge (BS-NACO) gives explosive reaction (Type III)

Interior Ballistics Model

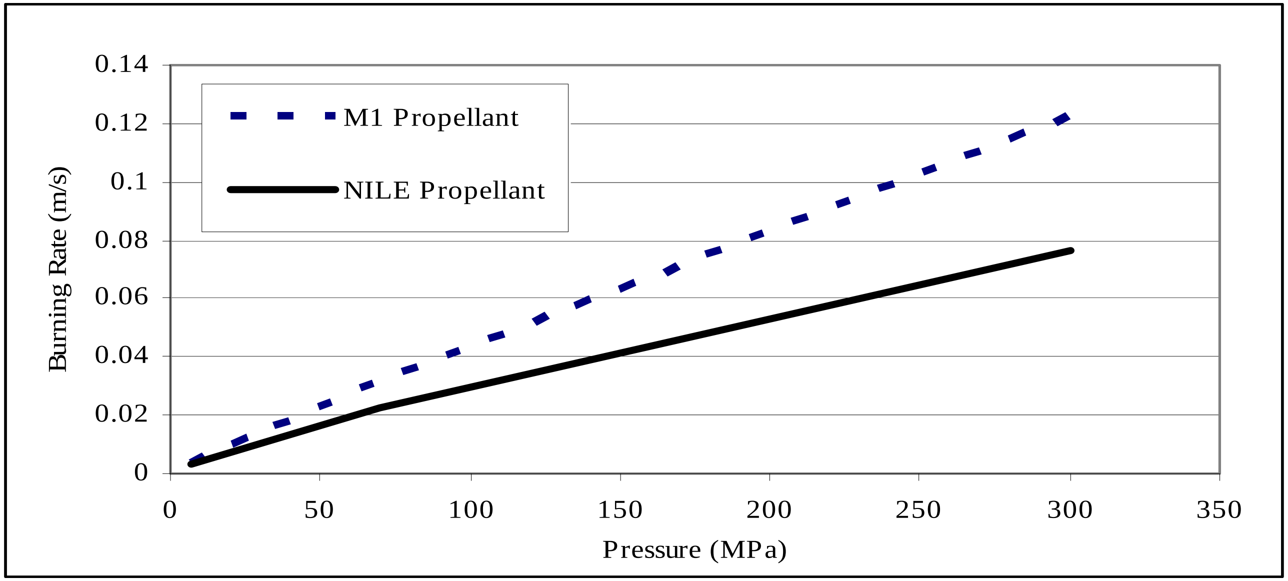
- Developed using IBHVG2 (lumped parameter 0-D code)
- Validated with data for current M1 propellant
  - Minor time offset is due to the lack of primer ignition delay in the IB model
  - Velocity – 490 m/sec (model), 492 m/sec (LAT data)



- IB model use to determine NILE grain geometry that would match M1 ballistic performance

Interior Ballistics Model

- Burning rates of NILE compared to M1
  - Lower burning rate, ok – smaller grains usually = better IM

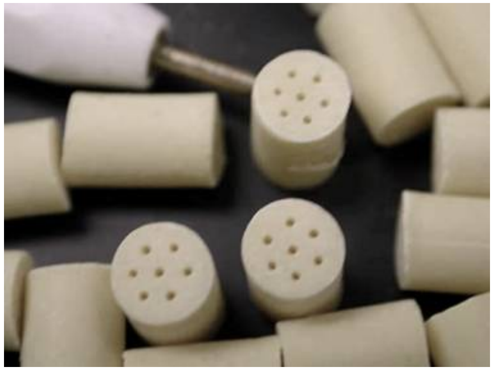


Interior Ballistics Model

- Grain geometry of NILE determined

Grain	Perf #	Length (in)	Outer Diam (in)	Perf Diam (in)	Web (in)	ρ (g/cm^3)	Recommened Charge Weight(lb$_m$)
Optimized	1	0.055	0.06	0.029	0.016	1.616	3.17
Actual	1	0.058	0.062	0.025	0.019	1.588	3.22

- Actual grains manufactured – slightly different size – not unusual
  - Swelling during extrusion
  - Contraction during drying



Test Configuration

- Dugway Proving Ground - 105mm M102 Howitzer
- Data collection
  - Projectile muzzle velocity (dual Weibel radar)
  - Maximum breech pressure (M-11 copper crusher gauges)
- Spotter rounds fired first
  - Warm gun
  - Calibrate data collection systems
- Reduced charge NILE rounds
- Full charge NILE rounds

Test Configuration

Test Configuration

Test Matrix										
General						Propelling Charge			Data Collection	
Test #	Test Date	Propelling Charge Designation	QE (mil)	Projectile Type	Fuze Type	Propellant Type	CW (lbm)	Cond Temp (°F)	Weibel Radar Track	M-11 Gages
1	9/11	Spotter-1	10	105H	M564	M1	2.82	AMB	Y	0
2	9/11	Spotter-2	20	105H	M564	M1	2.82	AMB	Y	0
3	9/11	Spotter-3	25	105H	M557	M1	2.82	AMB	Y	0
4	9/11	Spotter-4	25	105H	M557	M1	2.82	AMB	Y	0
5	9/11	M67-1	25	105H	M557	M1	2.82	AMB	Y	2
6	9/11	NILE2	25	105H	M557	NILE	2.27	AMB	Y	2
7	10/30	Spotter-5	27.5	105H	M564	M1	2.82	AMB	Y	0
8	10/30	Spotter-6	27.5	105H	M564	M1	2.82	AMB	Y	0
9	10/30	M67-2	27.5	105H	M564	NILE	2.82	AMB	Y	3
10	10/30	NILE3	27.5	105H	FMU153	NILE	2.75	AMB	Y	3
11	10/30	NILE1	27.5	105H	FMU153	NILE	3.24	AMB	Y	3
12	10/30	M67-3	35	105H	M564	M1	2.82	AMB	Y	3
13	10/30	NILE4	35	105H	M564	NILE	3.39	AMB	Y	3
14	10/30	NILE5	35	105H	M564	NILE	3.49	AMB	Y	3
15	10/30	NILE6	250	105H	FMU153	NILE	3.54	AMB	Y	3
16	10/30	NILE7	250	105H	FMU153	NILE	3.49	AMB	Y	3

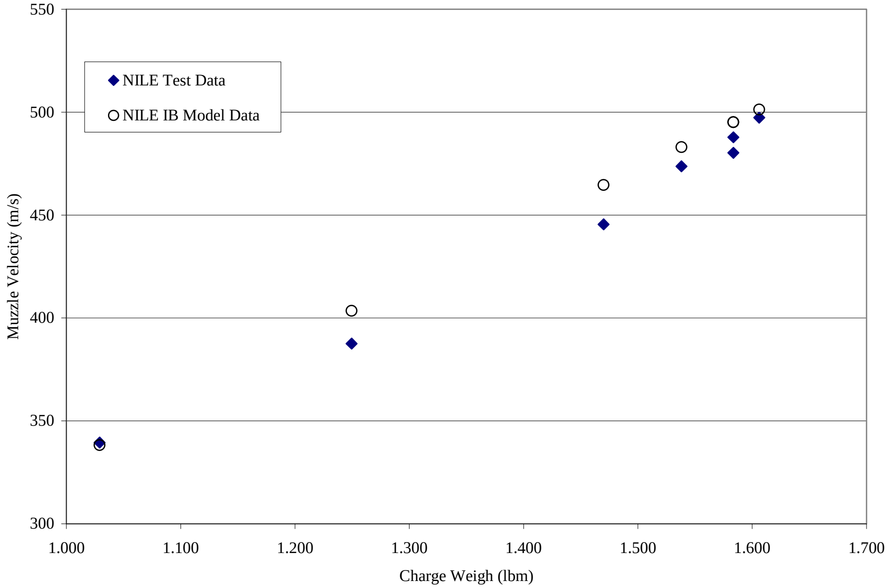
Test Data

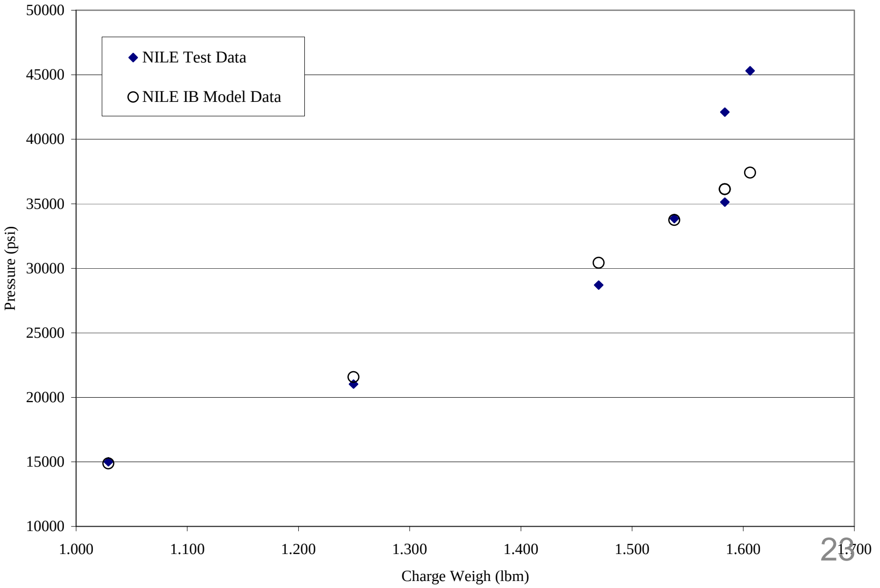
Test Predictions and Performance Results							
General				Predicted		Actual	
Test Number	Test Date	Propelling Charge Designation	CW (kg)	Muzzle Velocity (m/s)	Max. Breech Pressure (psi)	MV_{avg} (m/s)	Avg. Max. Breech Pressure (psi)
1	9/11/2008	Spotter-1	1.281	448	35089	489	ND
2	9/11/2008	Spotter-2	1.281	448	35089	486	ND
3	9/11/2008	Spotter-3	1.281	448	35089	489	ND
4	9/11/2008	Spotter-4	1.281	448	35089	490	ND
5	9/11/2008	M67-0	1.281	448	35089	492	36750
6	9/11/2008	NILE1	1.029	338	14876	340	15000
**	**	**	**	**	**	**	**
7	10/30/2008	Spotter-5	1.281	448	35089	492	ND
8	10/30/2008	Spotter-6	1.281	448	35089	489	ND
9	10/30/2008	M67-1	1.281	448	35089	489	37100
10	10/30/2008	NILE3	1.250	404	21569	388	21025
11	10/30/2008	NILE1	1.470	465	30424	445	28700
12	10/30/2008	M67-2	1.281	448	35089	489	35250
13	10/30/2008	NILE4	1.538	483	33747	474	33850
14	10/30/2008	NILE5	1.583	495	36131	480	35125
15	10/30/2008	NILE6	1.606	501	37413	497	45300
16	10/30/2008	NILE7	1.583	495	36131	488	42100

** Testing was interrupted after test shot number 6 due to gun carriage structural failure. ND: No Data

Test Data

- Good agreement with IB model predictions
- High pressures due to non-ideal ignition – pressure waves
  - especially at higher pressures, but no corresponding increase in projectile velocity
  - Used standard igniter – not optimized for NILE
  - Anticipated – will be addressed in further study





Conclusions and Future Work

- F plugs have been excluded; future designs will have E or K plugs
- First test of NILE in 105-mm howitzer was a success
- Further optimization of the propellant (granulation) necessary
- Optimization of primer necessary
  - Primer propellant – less sensitive than black powder
  - Increase tube length – eliminate non-optimal ignition/pressure waves
- IM testing of propelling charge to demonstrate improvement