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IM Explosive Replacement for Cratering Charge

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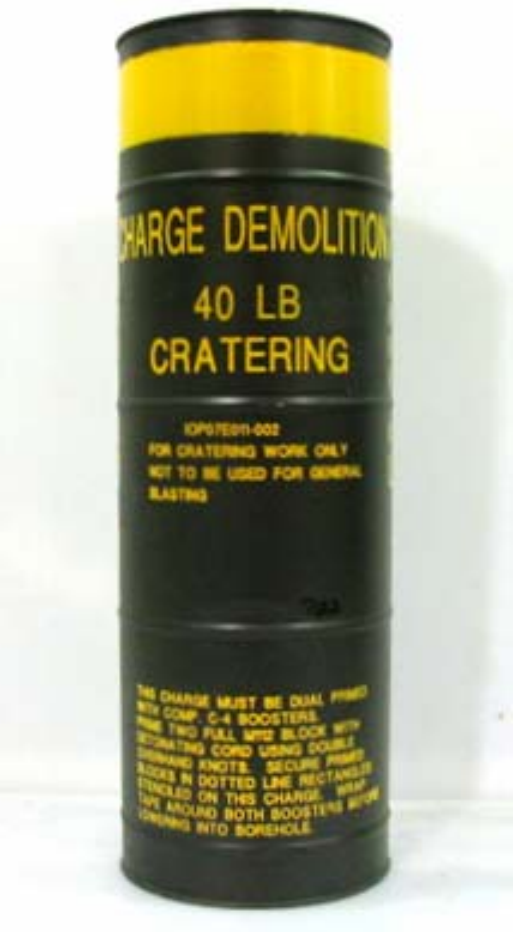
Background

- The 40-lb cratering charge is a tin-plated steel housing loaded with 39 lbs of Comp H6 explosive
- Used in cratering and ditching operations, also as bunker buster
- Not IM-compliant
- Original Type Classification Date: 1958
- Produced By: American Ordnance, Iowa AAP, Middletown, IA



Background (cont'd)

- Baseline IM tests conducted on the charge showed vulnerabilities to FI, SD and SCJI threats in logistical and tactical scenarios

Test	Result	Result Description
Fast Cook-off	**Pass**	Explosive vented/burned after 1 minute
Slow Cook-off	**Pass**	Explosive vented at 90 min & burned 1 hr 15 min after
Bullet Impact	**Pass**	Slow burn Note - Tested with a single 0.50cal AP bullet instead of a triple-round burst
Fragment Impact	**Fail**	High-order detonation
Sympathetic Detonation	**(Fail)**	Assessed to fail – not tested
Shaped Charge Jet Impact	**(Fail)**	Assessed to fail – not tested

40-lb Cratering Charge Baseline IM Tests – Oct 2008

Objective

- To replace the melt-castable explosive fill with a less sensitive fill that maintains current Comp H6 performance and helps the cratering charge pass IM tests.

Test	Expected Result	Result Description
Fast Cook-off	**(Pass)**	Type V – Burning
Slow Cook-off	**(Pass)**	Type V – Burning
Bullet Impact	**(Pass)**	Type V – Burning
Fragment Impact	**(Pass)**	Type V – Burning
Sympathetic Detonation	**(Pass)**	Type III – Explosion
Shaped Charge Jet Impact	**(Pass)**	Type III – Explosion

Desired Outcome from IM Tests

Targets

- **Producible within National Technology & Industrial Base (NTIB)**
  - Maintain current melt-cast processes
  - Maintain Load, Assemble & Pack (LAP) procedures
  - Use common ingredients
  - Use existing infrastructure
- **Affordable**
  - Cost driver: explosive fill
- **Other Consideration**
  - Demilitarization

Development Path

Development of a Comp H6 Explosive Replacement

- *Lower the nitramine content in the formulation*
  - To reduce shock sensitivity
  - Comp H6 sensitivity: Reported at 166 cards, tested 183.5 cards at ARDEC
  - Goal to achieve NOL LSGT 50% card gap value ≤ 100 cards
- *Increase insensitive energetic ingredients*
  - To maintain pressure and energy output of Comp H6
- *Add an additive to aid in cook-off and processing*
  - To achieve melt-processing capability

Technical Approach

- **Perform thermochemical CHEETAH calculations on candidate formulations**
  - To predict performance output
- **Perform Differential Scanning Calorimetry (DSC)**
  - To determine melting point & onset of decomposition
- **Conduct Safety & Stability Tests**
- **Conduct Shock Sensitivity**
- **Conduct lab-scale Performance Tests**

Formulations & Processing

	DETAILS	DENSITY	PRESSURE	VoD	GURNEY
Formulation 1	TNT-based	1.85 g/cc	22.44 GPa	7.41 km/s	2.83
Formulation 2	DNAN-based	1.85 g/cc	25.11 GPa	7.69 km/s	2.86
Formulation 3	DNAN-based	1.79 g/cc	23.78 GPa	7.47 km/s	2.80
Comp H6	TNT-based	1.77 g/cc	19.49 GPa	6.83 km/s	2.78

CHEETAH Calculations to Predict Performance

Thermochemical (CHEETAH) Calculations

• The three formulations are predicted to each have higher pressure output, detonation velocity and gurney than Comp H6

Processing

• Differential Scanning Calorimetry (DSC) – melting points are between 75°C & 95°C

• Viscosity – All three have efflux viscosity readings < 15 sec for melt-casting

Technical Results – Safety Tests

Safety Tests

- ERL Impact height may be indicator as to material sensitivity
- The formulations tested for sensitivities to impact, friction & electrostatic discharge are safe for processing, handling and shipment

	ERL Impact 50% impact height	BAM Friction	ESD
Formulation 1	77.9 cm	No reaction in 10 trials at 252N Reacted at 288N	No reaction in 20 trials at 0.25J
Formulation 2	108 cm	No reaction in 10 trials at 288N Reacted at 324N	No reaction in 20 trials at 0.25J
Formulation 3	60.7 cm	No reaction in 10 trials at 360N Did not react >360N	No reaction in 20 trials at 0.25J
Comp H6	37.6 cm	No reaction in 10 trials at 324N Reacted at 360N	No reaction in 20 trials at 0.25J

Safety Test Results

Technical Results – Stability Tests

Stability Tests

- The formulations are stable and safe to process and transport

	Vacuum Thermal Stability Amount of gas generate for 5 g sample	**Small-Scale Burn**	**Thermal Stability**
	Passing Criteria < 2mL of gas evolved	Passing Criteria Reaction less than an explosion	Passing Criteria No visual evidence of ignition, explosion, color change
Formulation 1	0.74 mL **Pass**	Burn **Pass**	0.04% change **Pass**
Formulation 2	0.51 mL **Pass**	Burn **Pass**	0.06% change **Pass**
Formulation 3	0.44 mL **Pass**	Burn **Pass**	0.07% change **Pass**

Stability Test Results

Technical Results – Shock Sensitivity & Performance

Shock Sensitivity

• All three candidates achieved NOL Large Scale Gap Test (LSGT) 50% card gap value ≤ 100 cards

Performance

• Detonation velocities and dent depths are close to those of Comp H6

	NOL LSGT 50% card gap	VoD	Dent Depth	Estimated pressure output
Formulation 1	83.5 ± 5 cards	6.76 km/s 6.52 km/s	0.304 in. 0.309 in.	170.4 kbar
Formulation 2	100 ± 5 cards	7.30 km/s 7.27 km/s	0.362 in. 0.359 in.	226.7 kbar
Formulation 3	94.5 ± 5 cards	7.08 km/s 7.06 km/s	0.331 in. 0.318 in.	189.2 kbar
Comp H6	183.5 ± 5 cards	7.18 km/s 7.21 km/s	0.335 in. 0.337 in.	201.1 kbar

Shock Sensitivity & Performance Test Results

Conclusions

- Three formulations exhibit performance characteristics comparable to Comp H6
- The candidates achieved shock sensitivities much lower than Comp H6
- The new formulations are shown to be stable and safe to handle, process, and transport
- End item can be demil-ed with melt-cast formulations
- IM tests in the end item will be conducted at this point to further evaluate the candidates for 40-lb cratering charge