

Energetic Material Fast Cookoff Testing in a Propane-Fueled Burner



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Background



- Fast cookoff is a standard safety test required for all explosive ordnance
- Environmental concerns
 - Emissions from one test: 200 kg CO, 35 kg NO_x, 30 kg SO_x, 225 kg soot, 125 kg unburned HC, and 20,000 kg CO₂
 - Ground water concerns
 - Public relations
- Propane viable alternative fuel
 - Gas at atmospheric conditions
 - Cleaner burning
 - Readily available
 - Sufficient heat content





Propane Burner Results



A burner to use propane fuel for fast cookoff testing was developed. The following thermal characteristics of the burner were measured

- ✓ *The flame temperature must be at least 800°C – (also has a rise time requirement)*
- ✓ *The heating must be uniform*
- ✓ *The average heat flux over the first 20 seconds after the 800°C temperature is met must be greater than 80 kW/m²*
- ✓ *The heating should be primarily radiative*

The Navy's propane burner has met all of the thermal design requirements



Fast Cookoff Testing with Propane Burner



The propane burner was used to test the reaction of ordnance items in a fast cookoff situation. The desire of the testing was to show the following:

- Reduction of fuel usage*

- Equal scoring of ordnance item tested*

- Ease of test setup and burner repair*



Fast Cookoff Testing with Propane Burner



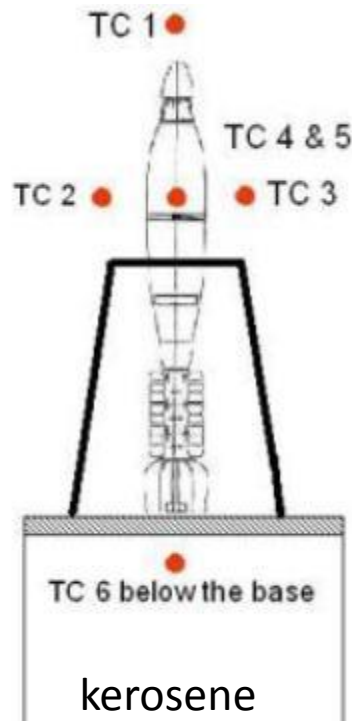
- M821A2 81-mm mortar
 - IMX-104 filled
 - Composition B filled
- 7.0-cm rocket IM-compliant warhead



81 mm Fast Cookoff Testing



- IMX-104 explosive fill
- Kerosene fuel fast cookoff previously performed by ARDEC at Picatinny Arsenal, New Jersey USA
- Fast cookoff with propane burner to replicate kerosene fuel cookoff





81 mm Fast Cookoff Testing



- IMX-104 explosive fill
- Reduction of fuel usage – 3,785 liters kerosene fuel to 568 liters propane
- Equal scoring of ordnance item tested – Officially scored V with kerosene fuel to engineering assessment of [V]
- Ease of test setup and burner repair – No damage to propane burner



kerosene



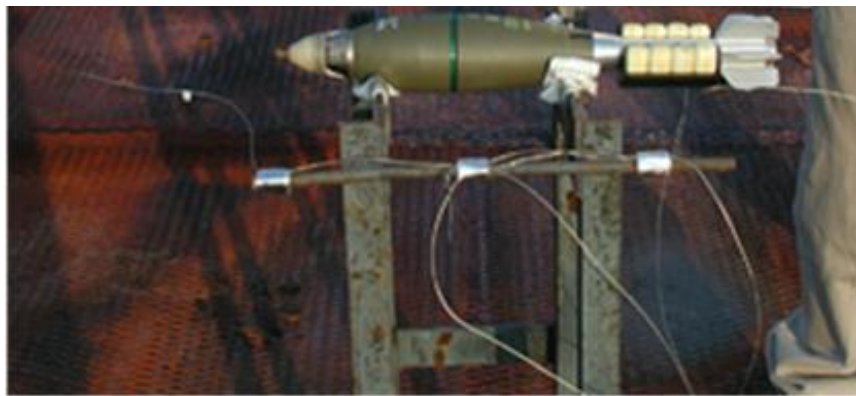
propane



81 mm Fast Cookoff Testing



- Composition B explosive fill (violent reaction expected)
- Kerosene fuel fast cookoff previously performed by NSWCDD at Dahlgren, VA USA
- Fast cookoff with propane burner used same test stand as 81 mm IMX-104 explosive fill mortar (orientation vertical instead of horizontal)



kerosene



propane



M821 81 mm Mortar with Comp B Fill





M821 81 mm Mortar with Comp B Fill



- Photographs of propane fire showing sequence of violent event with 81-mm mortar with Comp B explosive fill
- Sequence is 3 seconds
- Even with 3 damaged pipes, consistent engulfing flame after violent event





81 mm Fast Cookoff Testing



- Composition B explosive fill
- Reduction of fuel usage – 3,180 liters kerosene fuel to 208 liters propane
- Equal scoring of ordnance item tested – Officially scored II with kerosene fuel to engineering assessment of [II]/[III]
- Ease of test setup and burner repair – Damage to three pipes, did not affect test, less than an hour to change out pipes





Additional Benefits to Propane Burner



- 81 mm Comp B explosive fill mortar
- Looking down on item from safety camera
- After ignition of propellant primer
- Test item still supported by test stand, leaning to the right
- Impossible with kerosene fuel cookoff test





7.0-cm Rocket IM-compliant Warheads



- Fast cookoff tests: both propane and kerosene-based fuel pool fire
- Reduction of fuel usage – 7,570 liters kerosene fuel to 833 liters propane
- Equal scoring of ordnance item tested – Officially scored V with kerosene fuel to engineering assessment of [V]
- Ease of test setup and burner repair – No damage to burner



Additional Benefits to Propane Burner



- Photographs after ignition: 2 Seconds, 10 Seconds, 20 Seconds, and 40 Seconds, (a) Pool Fire, (b) Propane Fire
- Consistent and quick ignition process will make more repeatable tests

(a)



(b)





Summary of Results



Test	Fuel type	Fuel quantity	Time to reaction	Average flame temp	IM score
81-mm IMX	Kerosene-based	3,785 liters	43 sec.	950 °C	V
81-mm IMX	Propane	568 liters	44 sec.	830 °C	[V]
81-mm CompB	Kerosene-based	3,180 liters	29/61 sec. (1st/2nd)	996 °C	II
81-mm CompB	Propane	208 liters	43/52 sec. (1st/2nd)	1,020 °C	[II] or [III]
7-cm rocket warhead	Kerosene-based	7,570 liters	118 sec.	900 °C	[V]
7-cm rocket warhead	Propane	833 liters	400 sec.	1,170 °C	[V]



Fast Cookoff Testing with Propane Burner



These results indicate that the propane burner used in the study reported is an acceptable alternative to liquid-hydrocarbon fueled burners for fast cookoff testing.

- Reduction of fuel usage*
- Equal scoring of ordnance item tested*
- Ease of test setup and burner repair*



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