



BOFORS TEST CENTER



Status of Fast Cook-off Testing using Propane Burners

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Introduction

- Fast Cook-off (FCO) test traditionally use liquid-fuel pool fires
- STANAG AOP-4240 changed in 2018 to allow FCO with propane burners and other alternative fuels
- Propane burners FCO testing
 - Environmentally friendlier
 - Less expensive
 - More convenient
- Report of continued testing using propane burner FCO

Continued FCO testing (1)



- Liquid F-24 fuel pool fire
- Average temperature 840°C
- 13,400 liters of F-24 fuel



- Propane burner
- Average temperature 1100°C
- 4,870 liters of propane fuel



Response Comparison



- Major liquid-fuel pool fire FCO reaction at 3:40
- Major propane burner FCO reaction at 3:15
- Item stayed in one piece, fell off A-frame, and landed in similar place for both
- Some energetic material ejection with propane burner not seen with pool fire



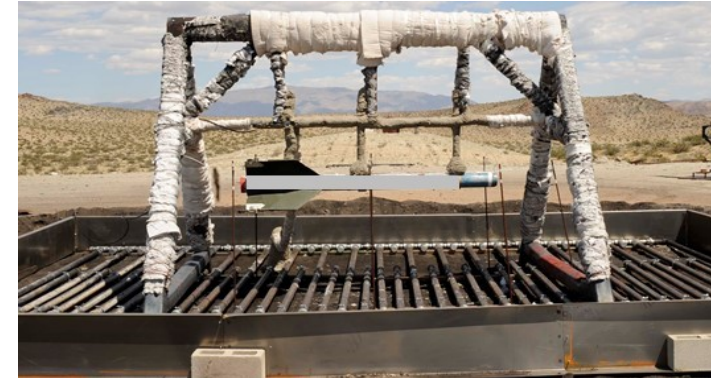
- Damage to pipes from falling item and impinging energetic material flame
- Propane burner still provided encompassing flame with damage

Continued FCO testing (2)

- Rocket motor
- 13 cm diameter and 2.1 m length
- Approximately 25 kg of propellant with total weight of 68 kg



- Liquid F-24 fuel pool fire
- 7,500 liters of F-24 fuel

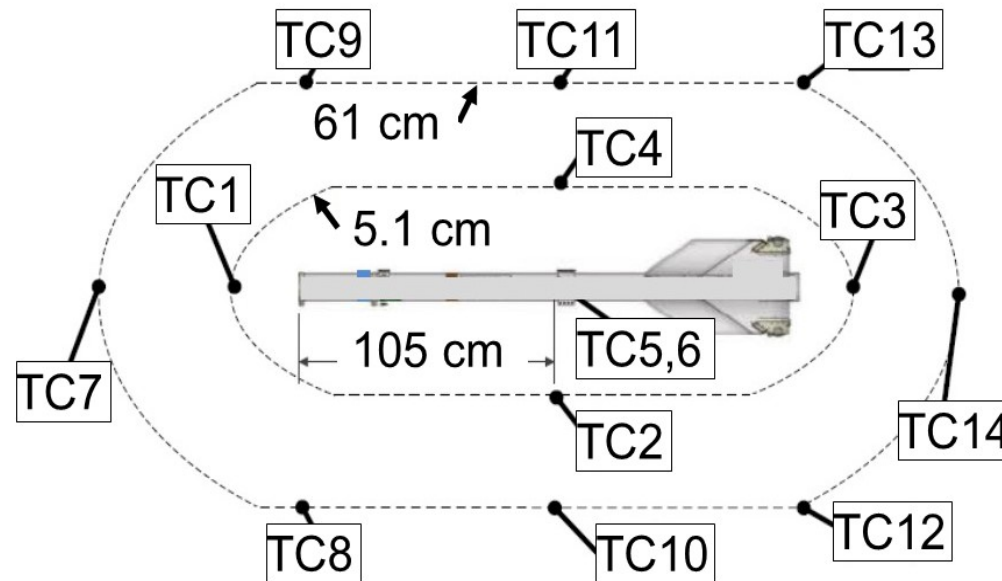


- Propane burner
- 740 liters of propane fuel



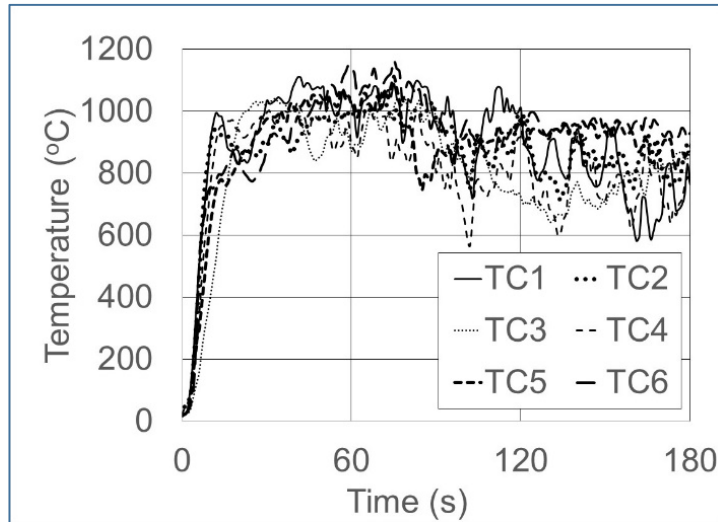
Temperature Comparison

- Two sets of measurement
 - Standard thermocouples 5.1 cm from rocket motor (TC1-TC6)
 - Flame thermocouples 61 cm from rocket motor (TC7-TC14)

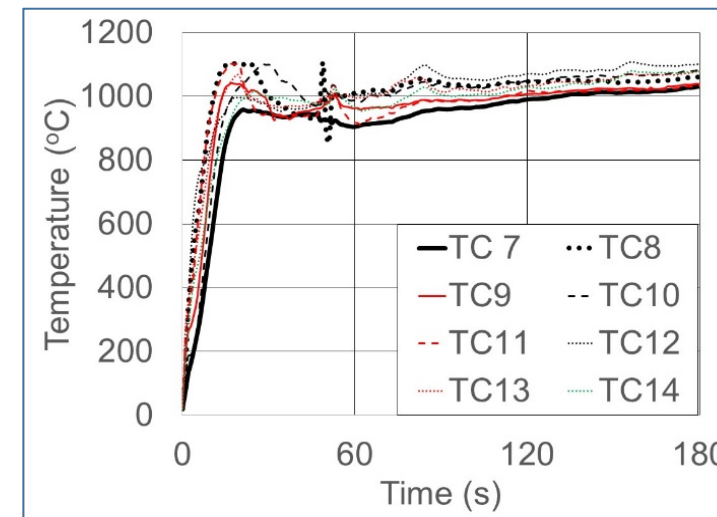
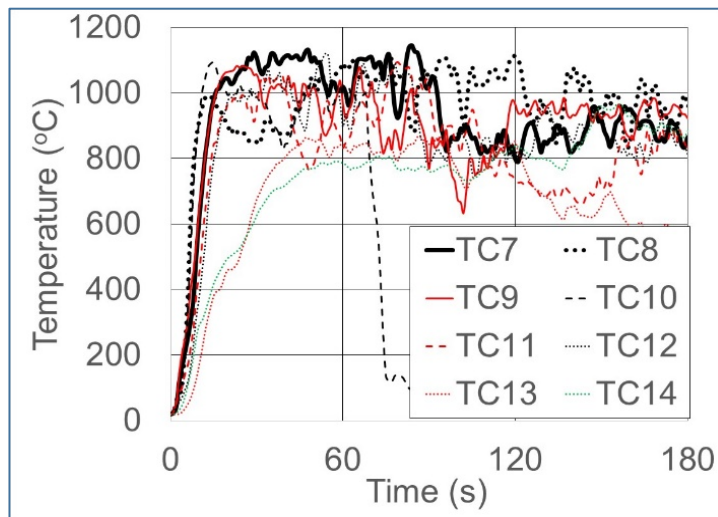
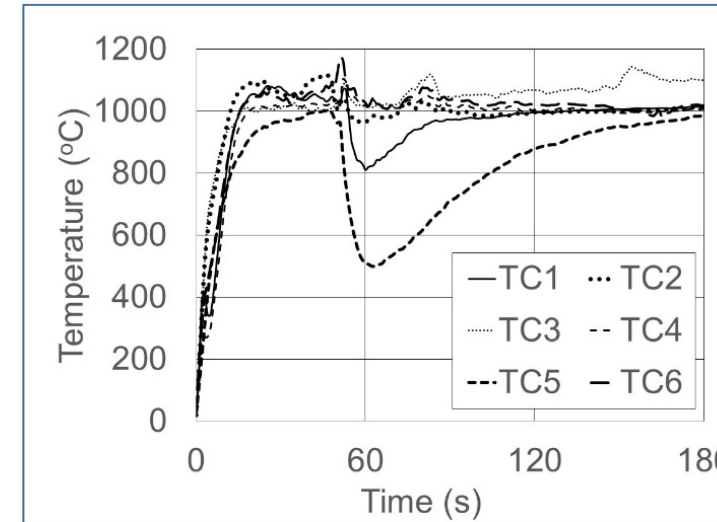


Temperature Comparison

Liquid-fuel pool fire



Propane burner fire





Temperature Comparison

- Similar flame temperatures
 - Average temperatures around 1000°C
 - Steady propane burner temperatures

Response Comparison

Liquid-fuel pool fire



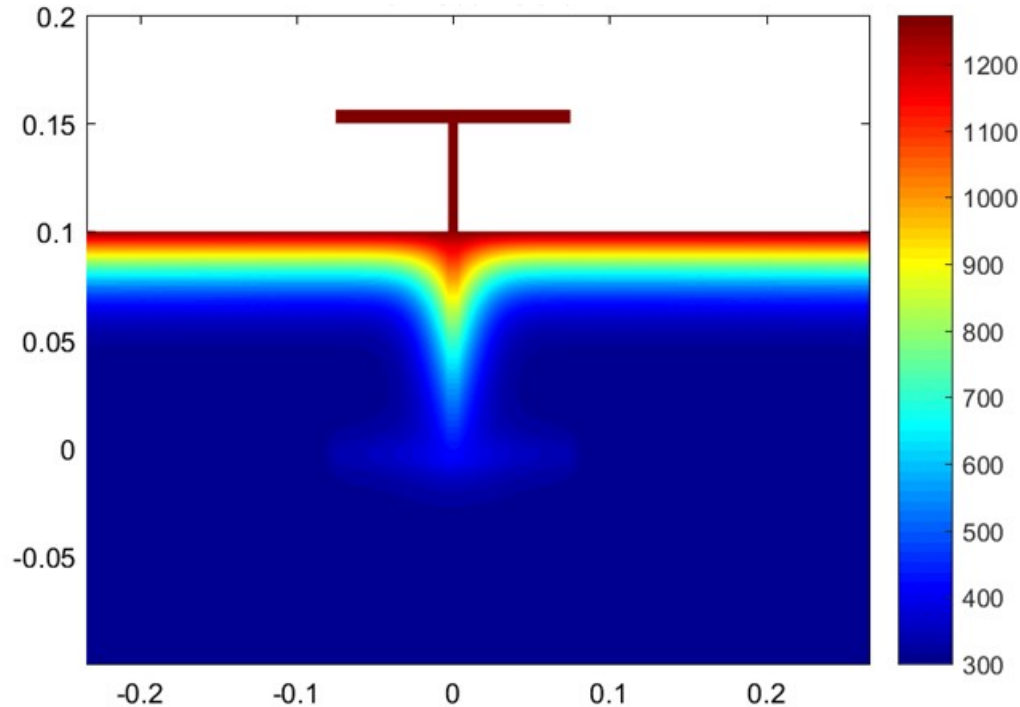
Propane burner fire



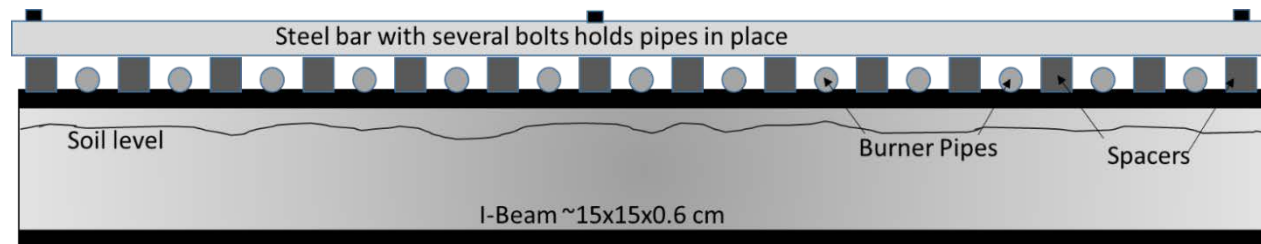
- For liquid-fuel pool fire FCO, small reactions at 21 s, 25 s, and 28 s, main reaction at 49 s and final small reaction at 2:21
- For propane burner FCO, small reactions at 20 s and 22 s, main reaction at 47 s
- Both cases remained attached to A-frame with opening of forward end
- Simulated warhead landed in similar spot and similar fragments

Propane Burner Changes

Thermal model of pipe support design



Pipe support design



- Propane burner is fully functional in current state
- Depending on fire duration and reaction of test item, pipes may warp
- Current effort to use buried steel I-beam for pipe support

Existing solution



- Design for preventing pipe warping
- Implemented in Bofors Test Center's propane burner since 2018



Efficiency of the propane burner

A test campaign performed at Bofors Test Center in March 2019 using propane burner fire

Test Item (in each test): One bare live round

Test No. 1: 4.47 am

Test No. 2: 6.23 am

Test No. 3: 7.21 am

Test No. 4: 8.29 am

Four tests (including assessment work and fragment mapping) in about 4.5 hours

Time and cost comparison

Liquid-fuel pool fire



- Range time: 6 days
- Man hours: 380
- Fuel costs: 40,320 USD

Propane burner



- Range time: 2 days
- Man hours: 125
- Fuel costs: 5,040 USD

Great savings

Range Time

67%

Man hours

67%

Fuel costs

88%

Conclusions

- Further FCO testing of ordnance items completed
- FCO testing with liquid fuel pool fire and propane burner gave similar times to response and response violence
- Propane burners can be adapted for customer and site needs
- Using propane burners continues to be an environmentally friendly, less expensive and more convenient way to perform FCO testing

Acknowledgments

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