Advancing the Propane Fast Cookoff Burner and Testing

Ephraim Washburn, Ross Falen, and Jeff Prevost
NAWCWD, China Lake, CA

David Hubble and Jon Yagla
NSWCDD, Dahlgren, VA

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Background

- Fast cookoff is an international standard safety test required for all explosive ordnance
- Environmental concerns
  - Tests use large pools of hydrocarbon fuel such as JP5, JP8, kerosene, etc.
  - Emissions from one test: 200 kg CO, 35 kg NOx, 30 kg SOx, 225 kg soot, 125 kg unburned HC, and 20,000 kg CO_2
  - Ground water concerns
  - Public relations
- Propane viable substitute fuel
  - Gas at atmospheric conditions
  - Cleaner burning
  - Readily available
  - Sufficient heat content

Outline

- Calibration of burner at China Lake, CA
- Testing of ordnance items in burner at Dahlgren, VA and China Lake, CA
- Technical drawing package of 3.7 m by 3.7 m propane burner

6.1 m by 4.6 m Propane Burner

- Constructed a 6.1 m by 4.6 m burner: Hoped for better engulfment on sides compared to previous 6.1m by 3.0 m burner
- Tested burner November 2016
  - Flame not as high as previous testing
  - Not enough fuel to burner
  - Reduced burner to 4.6 m by 4.6 m
- Heat fluxes sufficient but not consistent
  - Lower than desired
  - Flame not as high as before
- Reduced pressure drop from propane tank increased propane flow, but still not sufficient
- Added heating blanket to propane tank
  - Temperature in tank determines pressure
  - Winter testing creates low pressures and variable flows
  - Installed Model GCW1KS Rev C from Powerblanket®
  - Maintained temperature in propane tank at 32 ^{o}C

Modified 6.1 m by 4.6 m Burner

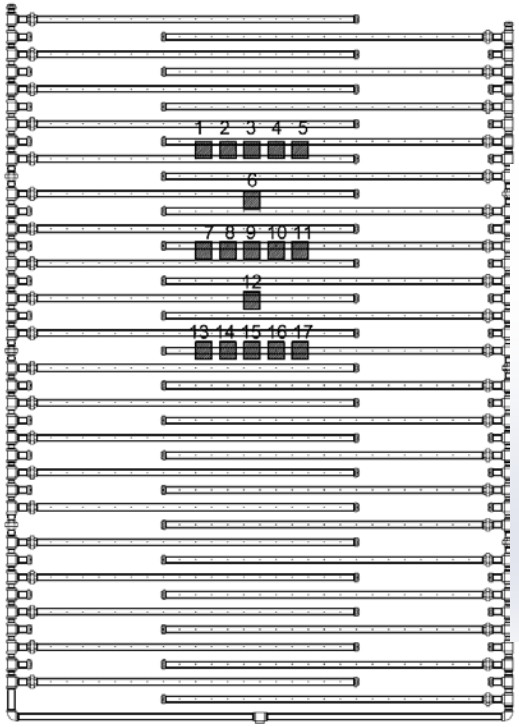
- Burner changes
  - 6.1 m by 4.6 m burner with 3.0 m pipes
  - Alternating side of entrance
  - Overlap in center 1.5 m
  - 3.0 m pipes provide for ease of hole drilling with water drilling facility
  - Fuel directed to center

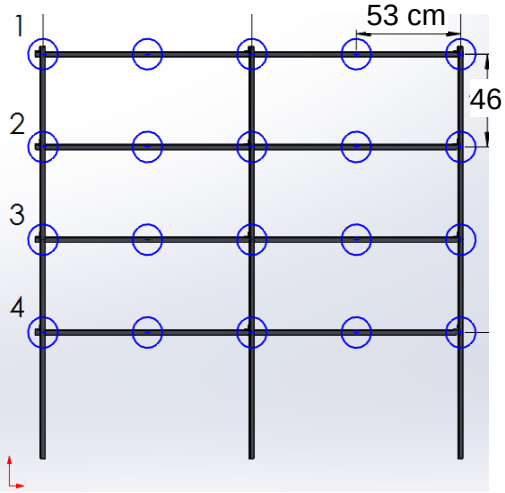
Modified 6.1 m by 4.6 m Burner

Modified 6.1 m by 4.6 m Burner

Qualitative Results

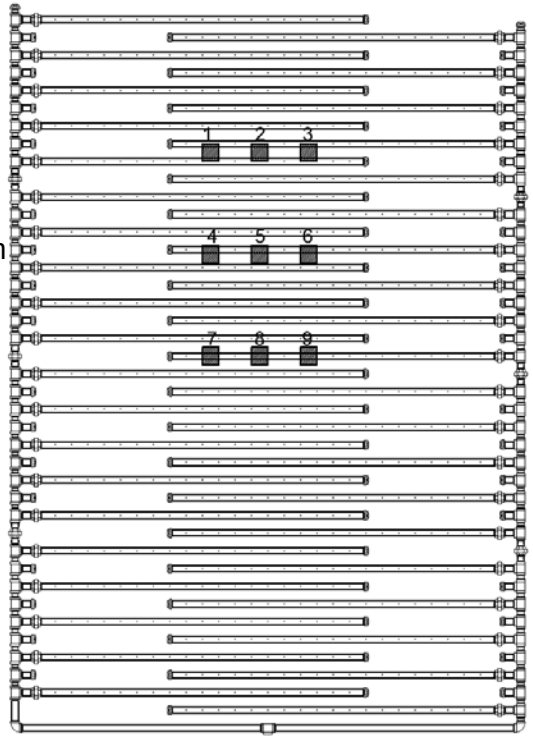
Quantitative Results

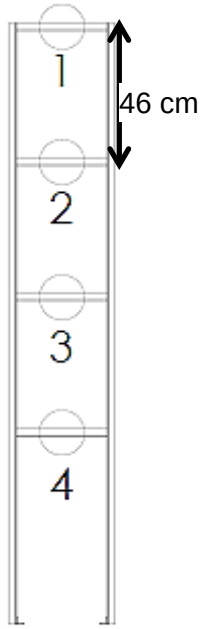




Wall

Temperature Measurement Set Up





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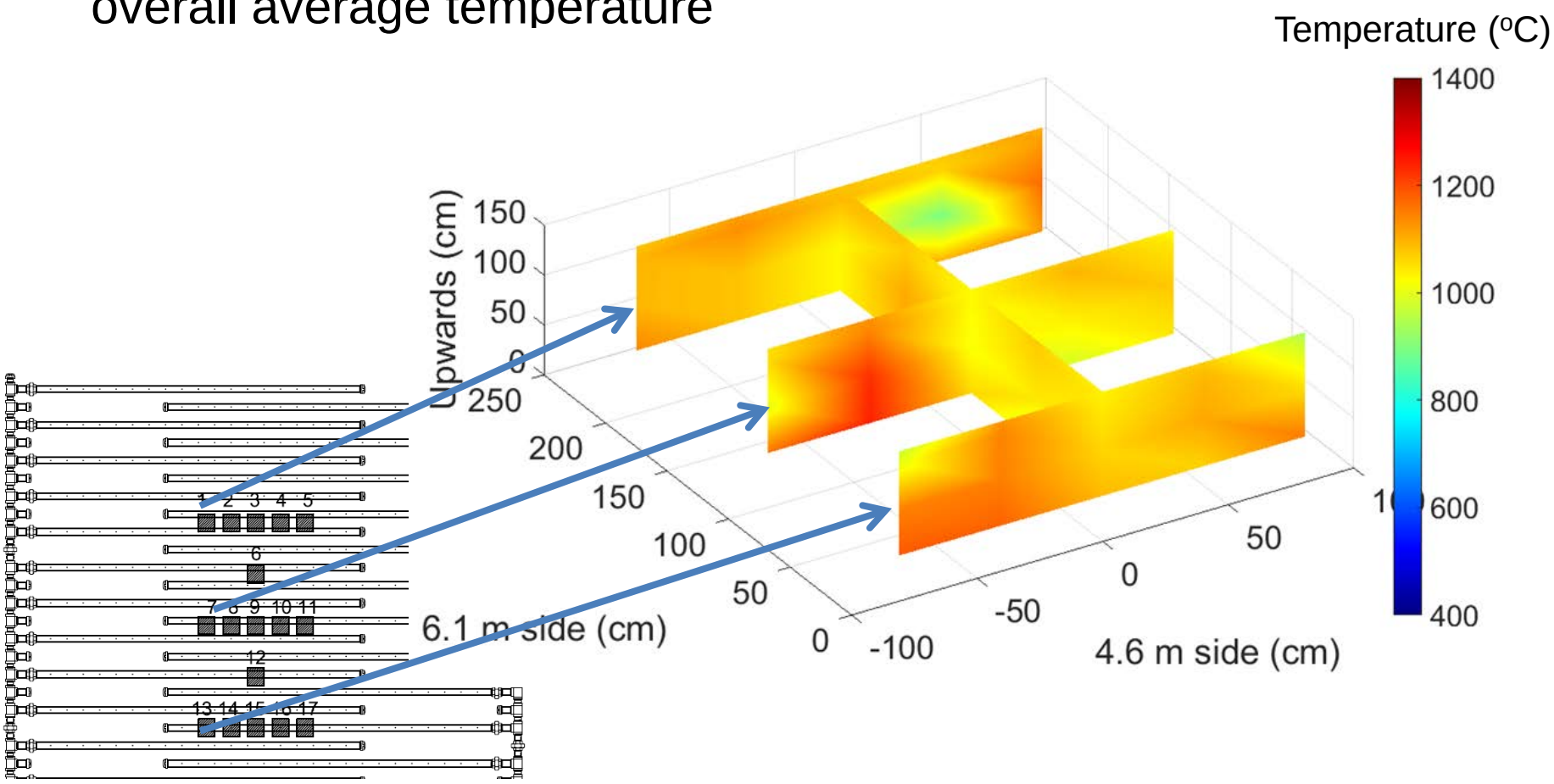
Heat Flux Measurement Set Up

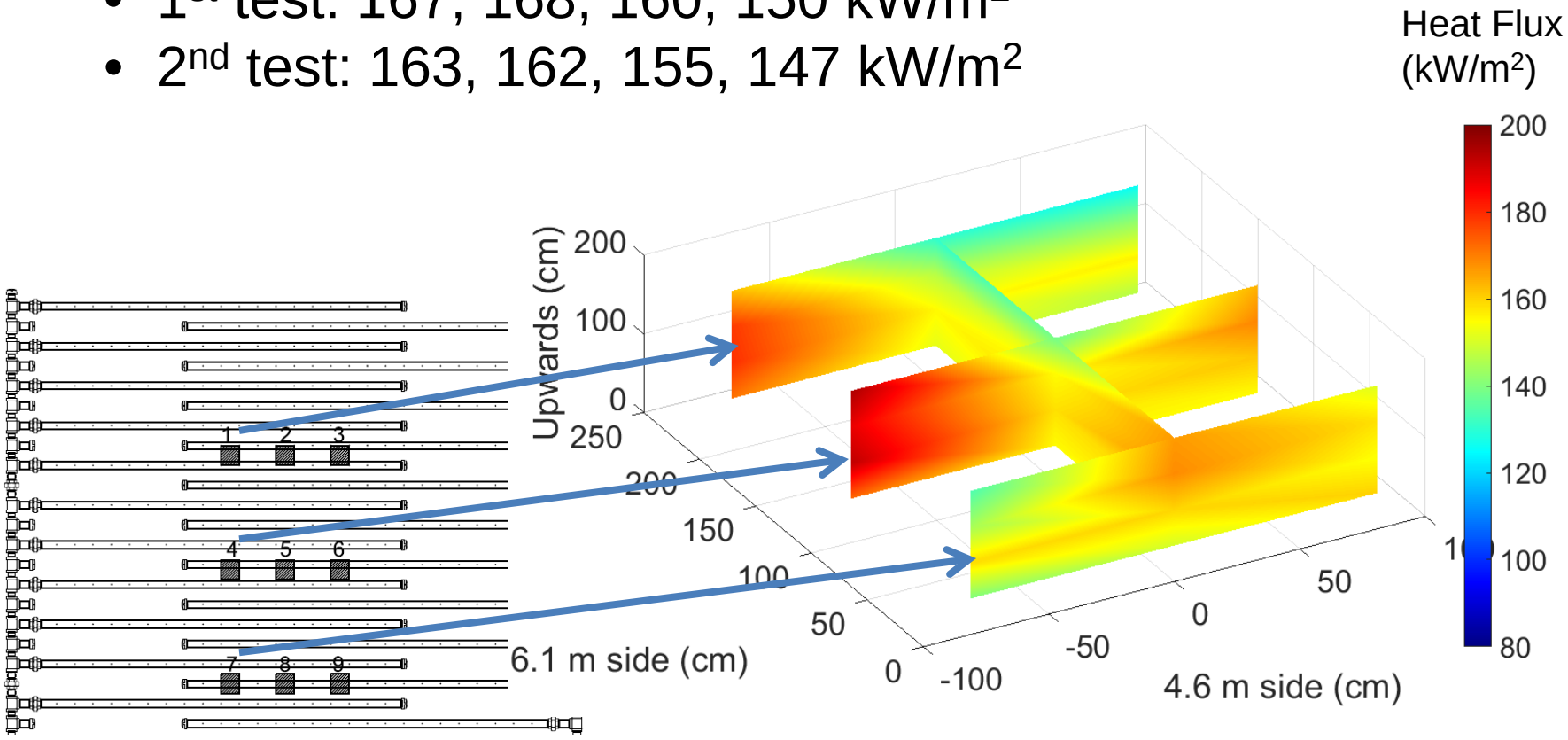
Modified 6.1 m by 4.6 m Burner, Temperature

- All temperatures above 800 °C
- Standard deviation of average local temperatures less than 10% of overall average temperature



Modified 6.1 m by 4.6 m Burner, Heat Flux

- All heat fluxes above 80 kW/m^2
- Higher heat fluxes representative of large jet fuel pool fire
- Repeatable: two tests at location 8
  - 1st test: 167, 168, 160, 150 kW/m^2
  - 2nd test: 163, 162, 155, 147 kW/m^2



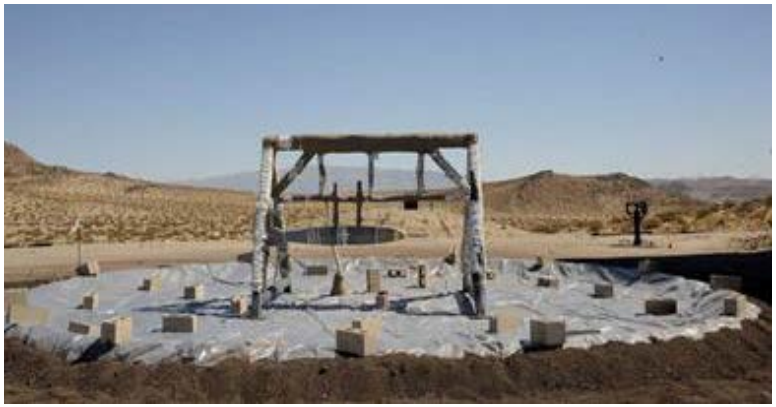
Modified 6.1 m by 4.6 m Burner

- Large test volume where thermal requirements are met: 4.3 m by 1.8 m by 1.5 m
- Replaced 3790 liter tank with 14760 liter tank
  - US regulations on propane tank greater than 15140 liters
  - Increased burn time from ~13 minutes to ~ 50 minutes
- Performed FCO test with 227 kg (500 lb) class bomb

Modified 6.1 m by 4.6 m Burner

- FCO tested 227 kg (500 lb) class bomb in both pool fuel fire and propane burner

Pool Fuel Fire FCO Pretest



Post-test

Propane FCO Pretest

Post-test

Modified 6.1 m by 4.6 m Burner

- FCO tested 227 kg (500 lb) class bomb in both pool fuel fire and propane burner
- Largest item tested in propane burner to date
- Propane burner was able to produce a flame that was large enough to engulf both A-frame and ordnance item
- Learned the importance of propane valve electrical system
  - A corroded relay led to a test stoppage and retest of item
  - Contingency plan needed for stoppage of burner during test before reaction
- No need to plan for same day fuel delivery
  - Provided flexibility in testing
  - Aided dealing with wind variability
- Initial results show similar reaction of bomb in pool fuel fire and propane burner

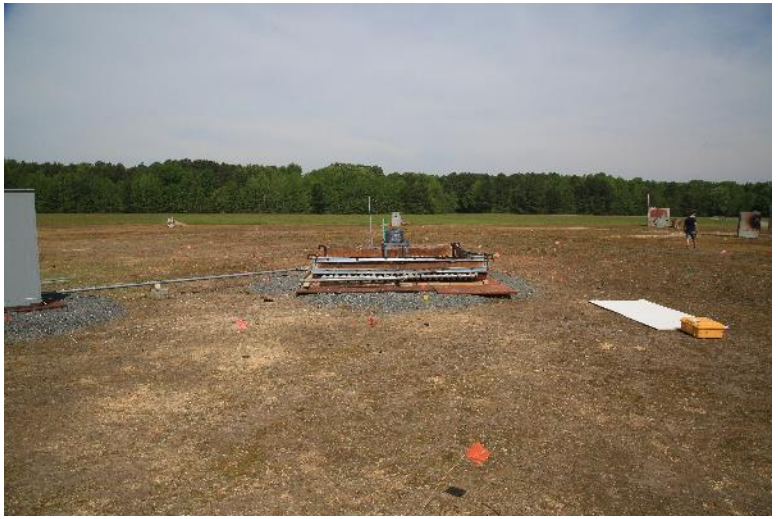
Medium Ammunition Cartridge Test

- Propane FCO test was performed on an ammo can of medium ammunition cartridges
- Ammo can contained 110 training and practice (TP) cartridges (live propellant, inert projectile)
- This was the first test in the propane FCO burner that contained multiple energetic items
- Concern that items cooking off while in contact with the burner tubes would cause damage

Medium Ammunition Cartridge Test Video

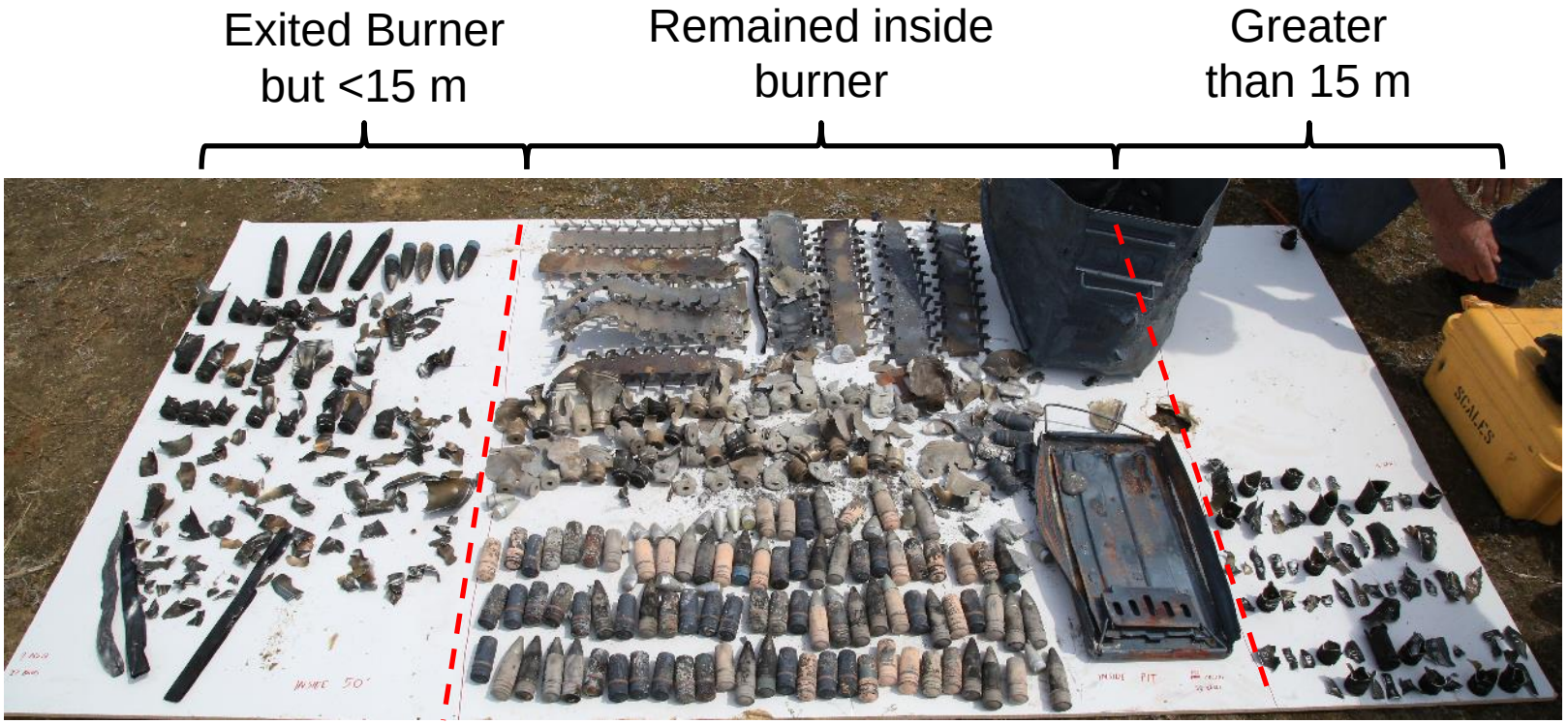
Medium Ammunition Cartridge Test

- Item was engulfed in flame for 14:40
- First reaction occurred 2:30 into test and the last audible reaction occurred 9:10 after ignition
- Burner remained on for 5 minutes after last audible reaction
- Test produced a large number of fragments, 64 of which traveled beyond 15 m (50 ft)
  - Only fragments beyond 15 m were catalogued and weighed



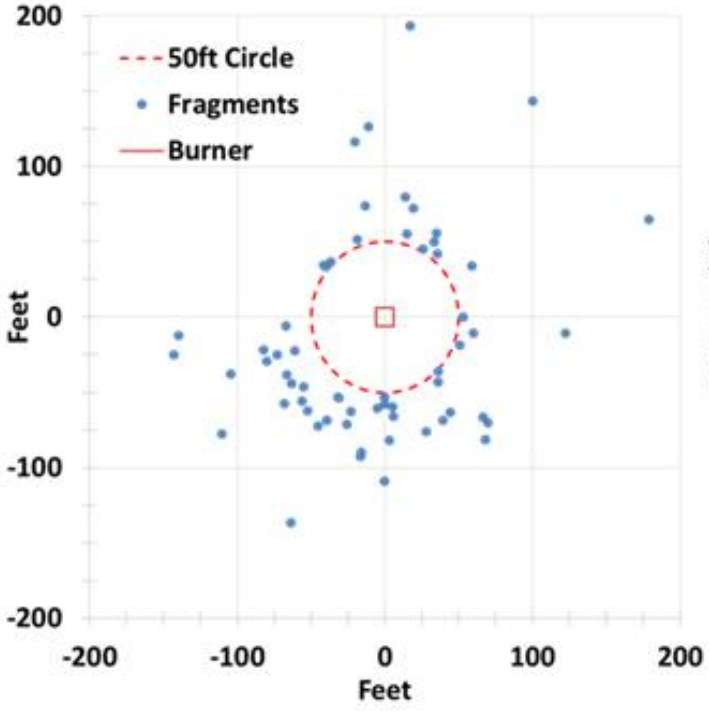
Fragment Collection

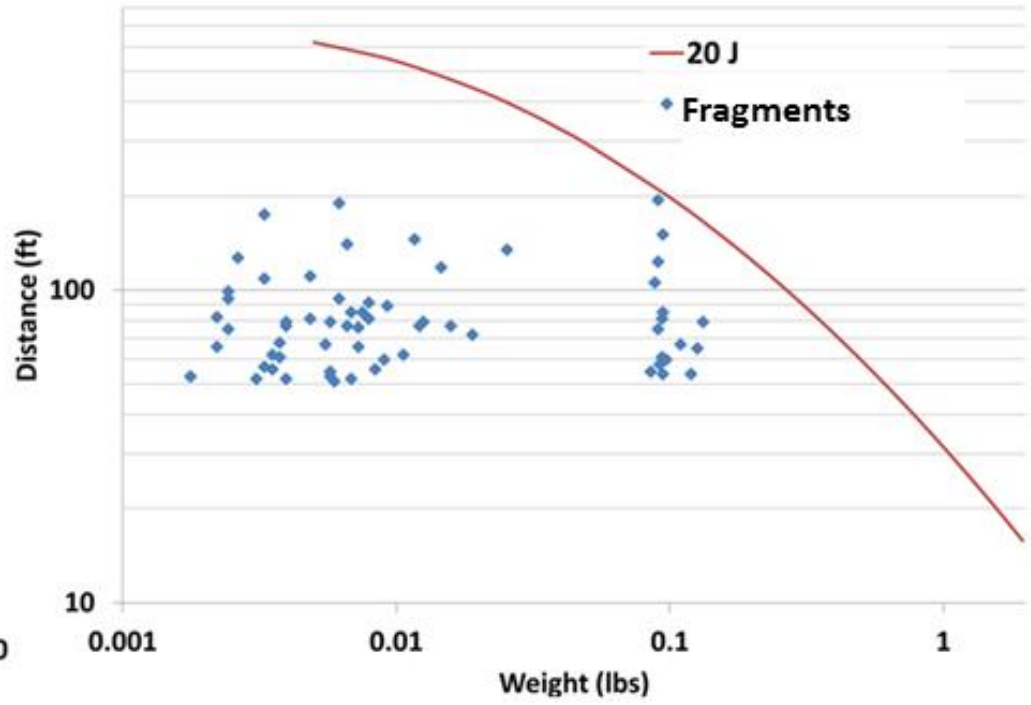
- Fragments were collected and catalogued as if going to MREB
- Majority of fragments remained within the burner and the workers were happy with how easy collection was compared to JP5 test



Medium Ammunition Cartridge Test Results

- Test produced 64 fragments that traveled further than 15 m
- None exceeded the 20 Joule threshold resulting in a type [V] assessment





Comparison to Liquid FCO Test

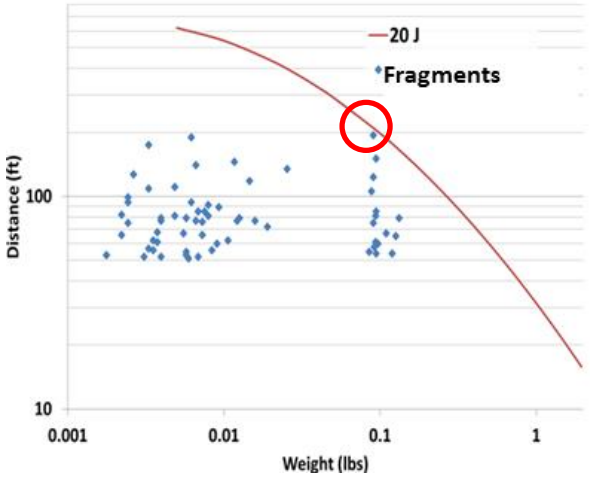
- Test was scored a type IV in the liquid fuel test and a type [V] in the propane test
- Debris map was very similar, barely exceeded 20J in the liquid test, just under 20J in propane test
- No quenching of ordnance items in propane test (shorter duration of reactions)

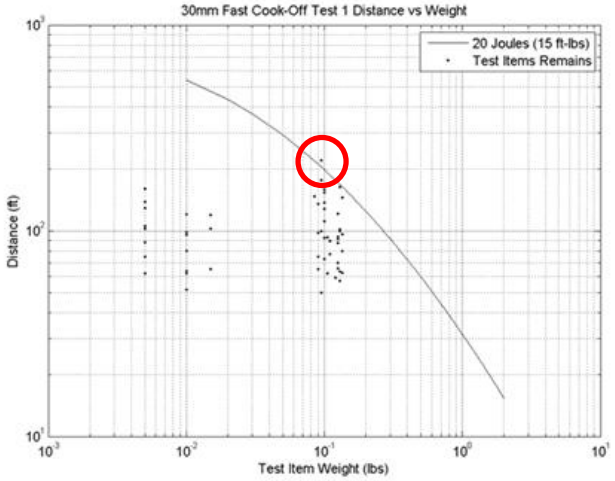
Propane

Average Temp: 1702°F
Time to 1st reaction: 2:30
Duration of reactions: 6min, 40s

Jet Fuel

Average Temp: 1727°F
Time to 1st reaction: 1:40
Duration of reactions: 13min, 30s



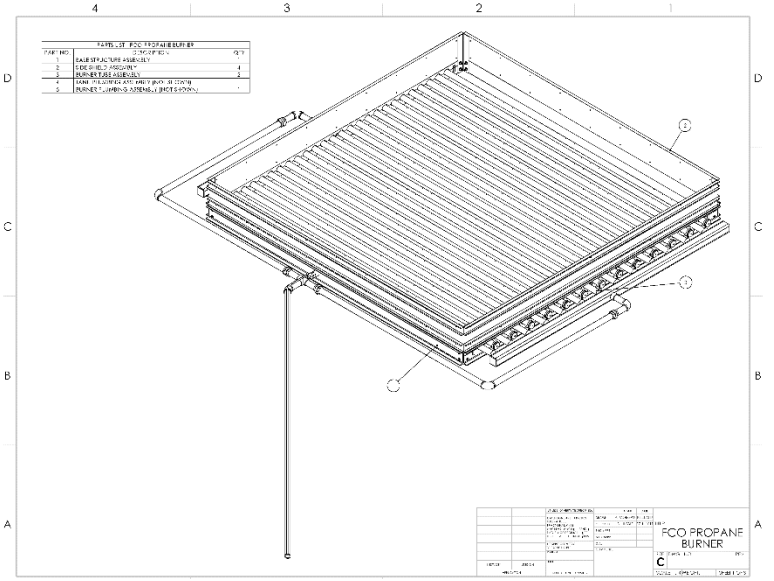


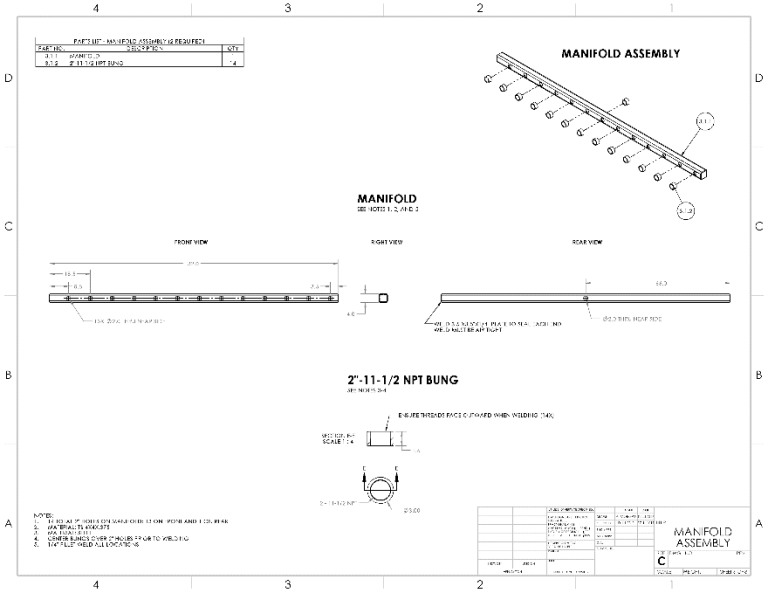
Medium Ammunition Cartridge Test Results

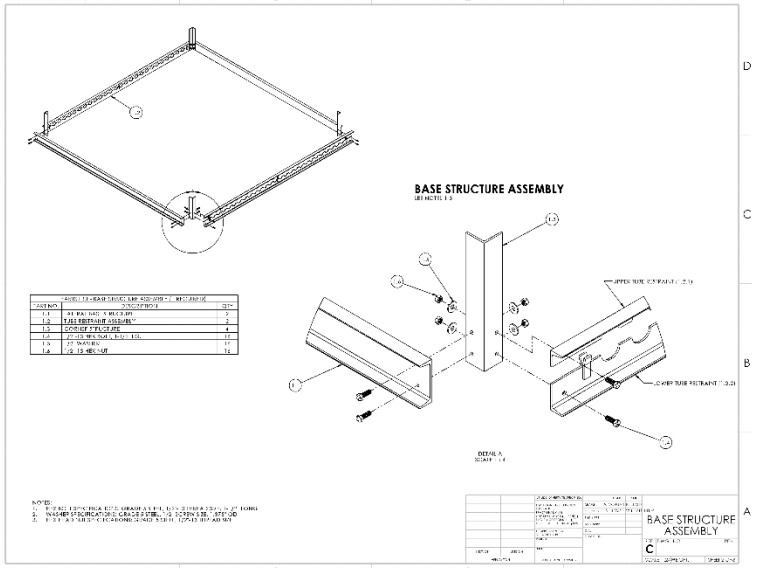
- Fragments produced during the test easily punctured the ammunition can and the side shields
- Reactions of items in contact with the burner tubes did cause some slight denting but no punctures occurred

Technical Drawings

- A technical drawing package was developed to aid in the dissemination of the burner
- Since the propane burner was developed as a series of prototypes with refinements, no official drawings existed

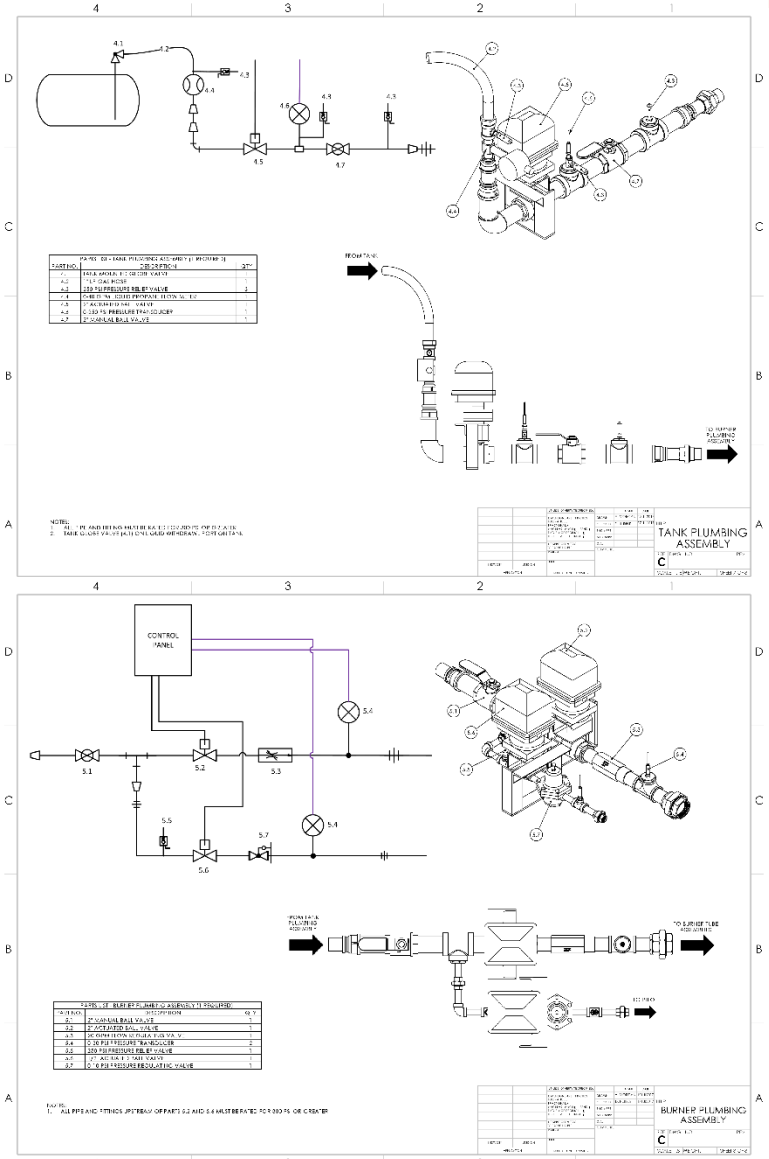






Technical Drawings

- The drawing package also includes detailed plumbing schematics
- These incorporate all the lessons that were learned through trial and error
- The drawing package provides all the information needed to fabricate the 3.7 m by 3.7 m propane burner in use at Dahlgren



Conclusions

- A modified 6.1 m by 4.6 m propane burner was designed, built, and calibrated
  - Large engulfing flame
  - Meets temperature and heat flux requirements
- 227 kg class bomb tested in modified 6.1 m by 4.6 m propane burner
- Ammo can of medium caliber ammunition tested in 3.7 m by 3.7 m propane burner
  - Similar result to liquid fuel fire test
  - Easy clean up
  - Multiple reactions did not damage burner
- Technical drawing package for 3.7 m by 3.7 m propane burner developed and available upon request

Acknowledgments

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