Cost of Propane Fast Cook-Off Testing

Jon Yagla and David Hubble
NSWCDD, Dahlgren, VA

Ephraim Washburn
NAWCWD, China Lake, CA

2018 Insensitive Munitions and Energetic Materials Technology Symposium
Portland, Oregon

ID# 20258, DISTRIBUTION A. Approved for public release: distribution unlimited.
Background

- Fast cookoff (FCO) 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
Cost Assessment

• Compare cost of propane burner FCO test to jet fuel pool fire FCO test

• 3.7 m by 3.7 m propane burner built at Dahlgren, VA used for comparison

• Three categories
  – Non recurring costs
  – Per-test costs
  – Annualized recurring costs
Nonrecurring Costs

- Engineering design
  - Initial design cost high (>\$500K)
    - Tried multiple design iterations
    - Developed and designed to be made from inexpensive readily available supplies
  - Adaption of 3.7 m by 3.7 m propane burner at Dahlgren, VA to 6.1 m by 4.6 m propane burner at China Lake, CA <$100K
  - Considerable work done, future adaptation costs even less
Nonrecurring Costs

- Engineering design
  - 3.7 m by 3.7 m propane burner technical drawing package available upon request
Nonrecurring Costs

- Material and labor for construction of burner

<table>
<thead>
<tr>
<th>Location</th>
<th>Category</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical Panels</td>
<td>Material</td>
<td>$2633</td>
</tr>
<tr>
<td></td>
<td>Labor</td>
<td>$14900</td>
</tr>
<tr>
<td>Burner</td>
<td>Material</td>
<td>$4317</td>
</tr>
<tr>
<td></td>
<td>Labor</td>
<td>$11920</td>
</tr>
<tr>
<td>Pipe System from tank to burner</td>
<td>Material</td>
<td>$12882</td>
</tr>
<tr>
<td></td>
<td>Labor</td>
<td>$17880</td>
</tr>
<tr>
<td>Total</td>
<td>Material</td>
<td>$19832</td>
</tr>
<tr>
<td></td>
<td>Labor</td>
<td>$44700</td>
</tr>
</tbody>
</table>
Nonrecurring Costs

• Material and labor costs
  – Only $16237 is susceptible to damage
  – Multiple test possible on one burner
Nonrecurring Costs

• Calibration costs
  – Directed by STANAG 4240
  – Costs dependent on skill of operators
  – NSWCD Personnel costs for testing
    • Preparation, testing, clean-up, analysis, and reporting - $27000
    • Materials - $1000
  – Calibration setup shown below
Per-Test Costs

• Different types of tests
• Tests to officially “score” item

• Engineering tests
Per-Test Costs

• Comparison of costs of official FCO tests with jet fuel pool fire and propane burner

• Requirements and documentation
  – Meet with customer and determine requirement
  – Safety research and test stand design
  – Same cost for both types, $4321
Per-Test Costs

• Pre-test preparations
  – Fabrication of test fixtures
  – Preparation of area
  – Instrumentation installation

• Savings of $1192 with propane burner
  – No lengthy pit inspection
  – No fuel delivery cost
Per-Test Costs

• Test execution
  – Follow STANAG 4240
  – Savings of $2384 with propane burner
    • Fewer test cancellations from weather
    • No need to wait for fuel pouring

• Post-test activities
  – Fragment and debris mapping
  – Clean up
  – Compiling, editing, and delivering data
  – Little costs difference between tests
  – Big difference in comfort of personnel (no fumes)
Per-Test Costs

• Material and surcharges
  – Biggest cost difference between tests
  – Fuel savings is $6500

• Total costs
  – Jet fuel pool fire FCO test: $36791
  – Propane burner FCO test: $25886
  – Savings of $10905 per test
Annualized recurring costs

- Significant savings compared to the jet fuel fire FCO tests
  - Liquid fuel hauling and maintenance costs
  - Environmental costs
  - Thermite grenade costs

<table>
<thead>
<tr>
<th>Item</th>
<th>Liquid Fire</th>
<th>Frequency</th>
<th>Cost/year</th>
<th>Propane Fire</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repair and replace expanded metal</td>
<td>2 man days</td>
<td>1/yr</td>
<td>$2,384</td>
<td>n.a.</td>
</tr>
<tr>
<td>grates</td>
<td></td>
<td></td>
<td>$500</td>
<td></td>
</tr>
<tr>
<td>Burner tube replacement</td>
<td>n.a.</td>
<td>1/yr</td>
<td></td>
<td>2 man days $2,384</td>
</tr>
<tr>
<td>Repair wind screens</td>
<td>n.a.</td>
<td>1/yr</td>
<td></td>
<td>2 man days $2,384</td>
</tr>
<tr>
<td>Propane tank rental</td>
<td>n.a.</td>
<td>1/yr</td>
<td></td>
<td>2-500 gallon $100</td>
</tr>
<tr>
<td>Liquid waste pump and haul</td>
<td></td>
<td>5 yrs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collect samples</td>
<td>4 man days</td>
<td></td>
<td>$954</td>
<td></td>
</tr>
<tr>
<td>Laboratory analysis</td>
<td>3 man days</td>
<td></td>
<td>$715</td>
<td></td>
</tr>
<tr>
<td>Vendor contract</td>
<td>2 man days</td>
<td></td>
<td>$477</td>
<td></td>
</tr>
<tr>
<td>Award contact</td>
<td>1 man day</td>
<td></td>
<td>$238</td>
<td></td>
</tr>
<tr>
<td>Schedule range</td>
<td>.2 man day</td>
<td></td>
<td>$48</td>
<td></td>
</tr>
<tr>
<td>Meet vendor, transfer liquid</td>
<td>5 man days</td>
<td></td>
<td>$715</td>
<td></td>
</tr>
<tr>
<td>Fuel Truck with Pump</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parts</td>
<td></td>
<td></td>
<td>$1,500</td>
<td></td>
</tr>
<tr>
<td>Maintenance of SOPs-Inert</td>
<td>2 man days</td>
<td>4 yrs</td>
<td>$596</td>
<td>2 man days $596</td>
</tr>
<tr>
<td>Maintenance of SOPs-Energetic</td>
<td>3 man days</td>
<td>4 yrs</td>
<td>$894</td>
<td>3 man days $894</td>
</tr>
<tr>
<td>Post test clean up w/hazmat</td>
<td>4 man days</td>
<td>1/yr</td>
<td>$4,768</td>
<td>n.a.</td>
</tr>
<tr>
<td>Environmental reporting</td>
<td>2 man days</td>
<td>1/yr</td>
<td>$2,384</td>
<td>n.a.</td>
</tr>
<tr>
<td>Thermite grenades</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>receive shipment</td>
<td>1250</td>
<td>1/yr</td>
<td>$1,250</td>
<td>n.a.</td>
</tr>
<tr>
<td>ammo transfer to EEA</td>
<td>2500</td>
<td>2/yr</td>
<td>$5,000</td>
<td></td>
</tr>
<tr>
<td>grenade unit cost</td>
<td>34</td>
<td>72/yr</td>
<td>$2,448</td>
<td></td>
</tr>
<tr>
<td>squib unit cost</td>
<td>29</td>
<td>72/yr</td>
<td>$2,088</td>
<td></td>
</tr>
<tr>
<td>storage</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>requisitions(atlocate, expend)</td>
<td>.5 man days</td>
<td>1/yr</td>
<td>$745</td>
<td></td>
</tr>
<tr>
<td>expenditure forms</td>
<td>.125 man days</td>
<td>1/yr</td>
<td>$2,682</td>
<td></td>
</tr>
</tbody>
</table>

Total: $45,382
Total: $6,534
Conclusions

• Compared cost of propane burner FCO test to jet fuel pool fire FCO test
• Non recurring costs are significantly reduced
  – Sharing of past engineering design work
  – Protection of expensive components
• Per-test costs reduced by 30% with propane burner
• Annualized recurring costs reduced by 86% with propane burner
Funded by:

The Environmental Security Technology Certification Program (ESTCP)

The Insensitive Munitions Advanced Development (IMAD) Program