IM Compliance for Mortar Illumination Cartridges

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Acronym/Abbreviation Description

- IM: Insensitive Munition
- AIMB: Army Insensitive Munitions Board
- SD: Sympathetic Detonation
- SCJI: Shaped Charge Jet Impact
- FCO: Fast Cook off
- SCO: slow Cook off
- BI: Bullet Impact
- FI: Fragment Impact
M930/M983 Internal Configuration

- Item contains very significant amounts of energetics in candle and fuze
- For proper function, the munition pressurizes internally
- Pressurization issue complicates IM mitigation
M930/M983 Current Packaging Configuration

- Individual munition is packed in PA 167 fiber tube
- Two cartridges are packed in PA 154 metal can
Threat Hazards Assessment

<table>
<thead>
<tr>
<th>IM Test</th>
<th>Configuration</th>
<th>Threat Stimuli</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast Cook off</td>
<td>Pallet</td>
<td>Liquid Fuel Fire</td>
<td>1472 Deg F 20 minutes</td>
</tr>
<tr>
<td>Slow Cook off</td>
<td>Pallet</td>
<td>Heat</td>
<td>6 Deg F per hour after preconditioning</td>
</tr>
<tr>
<td>Bullet Impact</td>
<td>Pallet</td>
<td>12.7 mm (50 caliber)</td>
<td>Two tests; three shots per test</td>
</tr>
<tr>
<td>Fragment Impact</td>
<td>Pallet</td>
<td>Army fragment</td>
<td>8300 +/-300 fps</td>
</tr>
<tr>
<td>Sympathetic Detonation</td>
<td>Pallet</td>
<td>M930/M983 donor</td>
<td>Assessed to pass</td>
</tr>
<tr>
<td>Shaped Charge Jet Impact</td>
<td>Pallet</td>
<td>PG-7 series warhead</td>
<td>Assessed to pass</td>
</tr>
</tbody>
</table>

- Army IM Board requested data to confirm assessments
- Most practical way to obtain such data was to perform SCJI
- SCJI was conducted and received a passing score, confirming SD assessment
Test Configuration

<table>
<thead>
<tr>
<th>Munition Configuration</th>
<th>Threat Rationale</th>
<th>Damage Summary</th>
<th>Most Credible Threat Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual Munition (Operational)</td>
<td>Small target opportunity</td>
<td>Limited collateral effects</td>
<td>No</td>
</tr>
<tr>
<td>Palletized Munition (Logistical)</td>
<td>Large target opportunity</td>
<td>Significant collateral effects</td>
<td>Yes</td>
</tr>
</tbody>
</table>

- Joint IM Test Criteria specify testing in logistical and operational configuration
- Joint Criteria allows tailoring of configuration with supporting rationale
- For this munition, logistical is the most credible threat configuration
Baseline Test
Liquid Fuel Fire (Fast Cook off – FCO)

Test Setup

- Reaction was very violent and propulsive in nature
- Fragments of test munition were thrown almost 340 feet

Tail Section at 339 feet

Ignition Cartridge Base at 248 feet
Baseline Tests
Slow Cook off (SCO)

Test Setup

- Reaction was violent and propulsive in nature
- Fragments of test munition were thrown almost 80 feet

Piece of Tail Boom at 79 feet
Baseline Tests

Bullet Impact

- Reaction was violent and propulsive in nature
- Fragments of test munition were thrown 70 feet

Test Setup

Section of Nose at 55 feet

Projectile Remnant at 70 feet
Baseline Tests
Fragment Impact

Test Setup

Test Results

- Reaction was very mild
- Debris was constrained to no greater than 20 feet from target munition
- Adjacent munition was virtually intact (see left side of results)
Baseline Tests
Shaped Charge Jet Impact

• Test items were destroyed by SCJ warhead
• Results obtained by pressure gage readings
• Readings confirmed virtually no contribution of target munition energetics
Baseline Test Results

IPT Scores

<table>
<thead>
<tr>
<th>Test Configuration</th>
<th>FCO</th>
<th>SCO</th>
<th>BI</th>
<th>FI</th>
<th>SD</th>
<th>SCJI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aim point warhead</td>
<td>IV</td>
<td>IV</td>
<td>IV</td>
<td>V</td>
<td>Pass*</td>
<td>Pass</td>
</tr>
<tr>
<td>Aim point expulsion charge</td>
<td>IV</td>
<td>IV</td>
<td>IV</td>
<td>V</td>
<td>Pass*</td>
<td>Pass</td>
</tr>
<tr>
<td>Full-up Round-logistical</td>
<td>IV</td>
<td>IV</td>
<td>IV</td>
<td>V</td>
<td>Pass*</td>
<td>Pass</td>
</tr>
</tbody>
</table>

- SD “Pass” is by assessment made upon analysis of characteristics of main charge fill and was later confirmed when SCJI passed
- Army IMB score is slightly different in presentation
- Difference in score presentation does not affect mitigation plan
M930/M983 IM Mitigation Plan

• Engineered materials (EM) for shear pins
  • Materials weaken under thermal stress
  • Effect allows front and rear bodies to separate and vent

• Blocking foams for thermal threats
  • Prevents or delays ignition from fuze to candle
  • Located in front body cavity
  • Used in conjunction with EM shear pins or vents
  • Foam reacts at a set temperature range

• Vents for thermal threats
  • Fuze well
  • Front body
  • Ignition cartridge

• Barriers for Bullet Impact
Engineered Materials

• Engineered materials (EM) for shear pins
  • Match strength of current pin (mild steel) at operational temperatures
  • Weaken reliably at a specific, elevated temperature range prior to initiation of internal energetics
  • Would allow for orderly separation of front and aft bodies, providing a large vent

• Engineered material may be applied to fuze or body vents if success
• EM shear pins may be used alone, or in combination with other mitigation techniques
Blocking Foams

• Foams are used industrially in rubbers and plastics at large scale for various purposes
• Two basic types-endothermic and exothermic
• Plan is to identify several candidates that reliably expand at a specific, elevated temperature range prior to initiation of internal energetics
• Concept is to delay or prevent ignition from fuze to candle until internal pressure separates front and aft bodies or vents function
• Foam can be molded into almost any shape and is rubbery and flexible until reacted
Vents

- Fuze well vent design leverages prior IM technology developed for 60mm HE cartridge IM effort
- Fuze front body vent allows more flexibility in positioning
- Pressurization issue greatly complicates vent design, requiring sufficient strength to allow normal functioning
- May require an EM solution
Conclusion

• Illumination cartridges provide a challenge for IM compliance
• Such munitions respond poorly under thermal and some impact threats
• Mitigation solutions may require a combination of traditional and novel approaches
  – IPT is in the process of down selecting the technologies/design for future work
    • Expected to have a revised "go forward plan" within few weeks based on all test data already collected or being collected.

• Latest Activities
  – Four types of “Proof of Concept Tests” were performed at Yuma Proving Ground at the end of July, 2011
  – Data being analyzed by the IPT for potential down selection of technologies