5.56mm High Pressure Test Cartridge Development

How to ruin a perfectly good weapon

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What is a Proof Cartridge?

- Proof cartridges are used to stress test barrels and bolts for weapon acceptance.

- …develop pressures substantially exceeding those developed by normal service loads.
  - ANSI/SAAMI Z299.4-1992, SAAMI Voluntary Performance Standards, Section IV Definitive Proof Loads Center Fire Rifle

- …(shall) produce pressures substantially in excess of the service round.
  - TM 43-0001027, Technical Manual Army Ammunition Data Sheets, Small Caliber Ammunition
• Depleted Proof Load Is Obsolete
  – Not Produced In 35+ Years
  – Material Unavailable
  – Design Not Optimized
  – Obsolete Test Methods

• Current Proof Load Is Inadequate
  – Different Pressure Standard
  – Pressure Too Low
  – Not Representative Of Army Service Ammo

The Problem

5.56mm Case Mouth Pressure (ksi)

<table>
<thead>
<tr>
<th></th>
<th>Max Service @ Hot</th>
<th>SAAMI Rem 223 Proof</th>
<th>M197</th>
<th>M197A1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current  Proof Load</td>
<td>▼ Gray</td>
<td>▼ Red</td>
<td>▼ Yellow</td>
<td>▼ Green</td>
</tr>
<tr>
<td>Depleted Proof Load</td>
<td>▼ Yellow</td>
<td>▼ Orange</td>
<td>▼ Green</td>
<td>▼ Green</td>
</tr>
<tr>
<td>New Proof Load</td>
<td>▼ Green</td>
<td>▼ Green</td>
<td>▼ Green</td>
<td>▼ Green</td>
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How much pressure is too much?

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What Should the New Pressure Be?

Pressure To Destroy Good Weapons

Service Pressure @ Extreme Hot

Supplier Safety Margin

M197A1 Design Pressure

User Safety Margin

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**Analysis Approach**

**Charge Weight Establishment**

- **Linear Regression** used to establish relationship between Charge Weight & Pressure.

- **Ordinal Logistic Regression** used to determine a variety of defect probabilities given pressure.

- **Binary Logistic Regression** used to determine a severe defect probability given pressure.

**Binary Logistic Regression Model**

- Identify Pressure That Corresponds to < ~ 1 in 1 Million Defects

- Include Pressure Limits Constrained By:
  - Service Pressure @ Extreme Hot
  - Manufacturing Process Capability

**Monte-Carlo Simulation**
## M197A1

<table>
<thead>
<tr>
<th>Case &amp; Primer</th>
<th>Same As Service Cartridge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case Stannic Stain</td>
<td>Low Cost Unique Identifier</td>
</tr>
<tr>
<td>SMP 842 Propellant</td>
<td>Same As Service Cartridge</td>
</tr>
<tr>
<td>77 Grain Projectile</td>
<td>Heavier Projectile:</td>
</tr>
<tr>
<td></td>
<td>• Increases Pressure</td>
</tr>
<tr>
<td></td>
<td>• Reduces Powder</td>
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<tr>
<td></td>
<td>Placement Variability</td>
</tr>
<tr>
<td></td>
<td>• Allows Use Of Service</td>
</tr>
<tr>
<td></td>
<td>Cartridge Propellant</td>
</tr>
</tbody>
</table>

**77 Gr Bullet**

**Cannelure**

**SMP 842 Propellant**

**Stained Case**
Product Refinements

- **Design**
  - Add bullet cannelure
  - Eliminate stain masking
- **Specification**
  - Add profile requirement
  - Eliminate:
    - Waterproof test
    - Dropped primer limits
    - Post-stain cartridge dims
  - Relax cartridge OAL tolerance

Process Development

- Measured pressure using Piezo sensors not crusher gages
- Inserted bullet pushing on ogive not tip
- Established loading procedures to manage variability
- Developed plate process
- Sorted cartridges to achieve profile requirement

**Enabled Path For Successful Product Transition Into Production At LCAAP**
Results

- Outstanding collaborative effort
- Rapid evolution from requirements development to production validation
  - Provided pressure assessment consistent with Army small caliber ammunition test procedures
  - Utilized abundant materials
  - Sorted product to achieve optimized results
  - Ensured producible, cost-effective solution

M197A1 Drawings & Specifications Are Producible

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