Innovation ... Delivered.

Mr. Chris Still
Principle Investigator
ATK Small Caliber Systems
Lake City Army Ammunition Plant

Mr. Mark Leng
Project Manager
US Army ARDEC
Picatinny Arsenal

OSR Approval #: 10-S-1445

Research And Development Effort: Fabricate A 5.56mm Aluminum Cartridge Case

- Latest In Aluminum Alloys
- Advanced Coating Technologies
- Advanced Lubrication Technologies
- Use Both New And Existing Metal Forming Capability

- Reduce Ammunition Weight
- Develop An Alternate Material For Cartridge Cases
- Reduce Sole Dependence On Brass

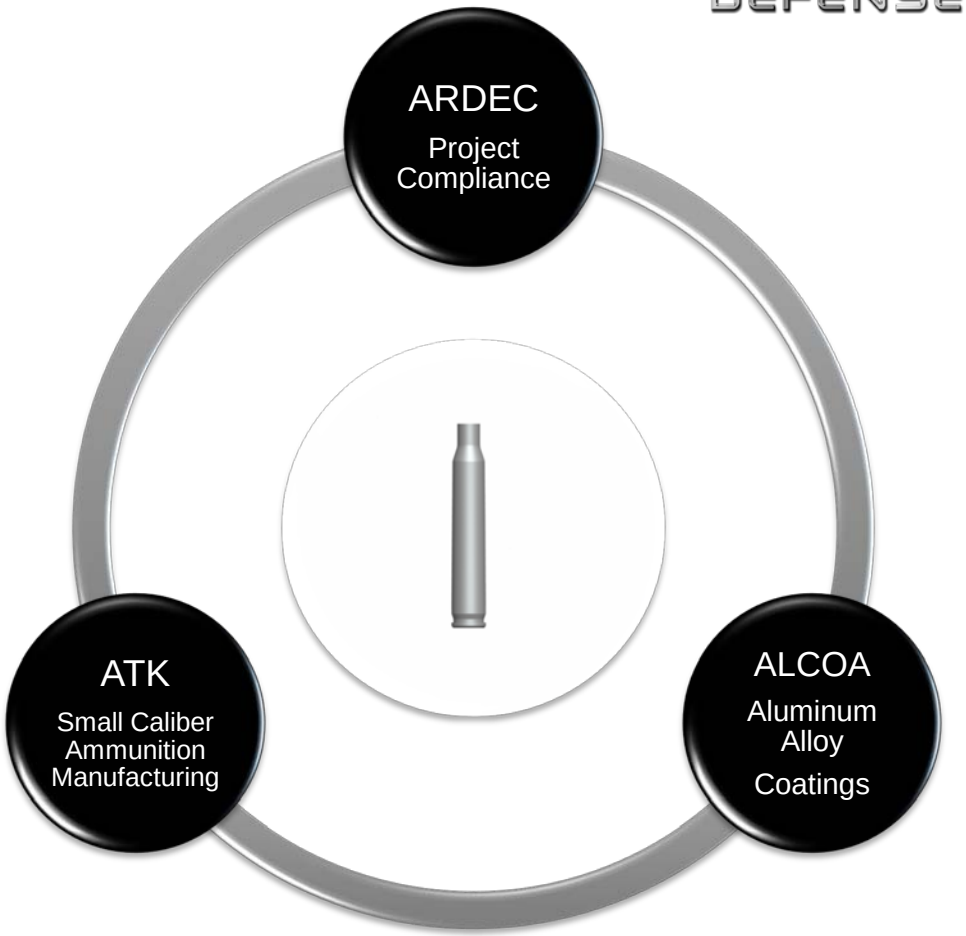
Lighter Ammunition For Today's Warfighter

Requirements

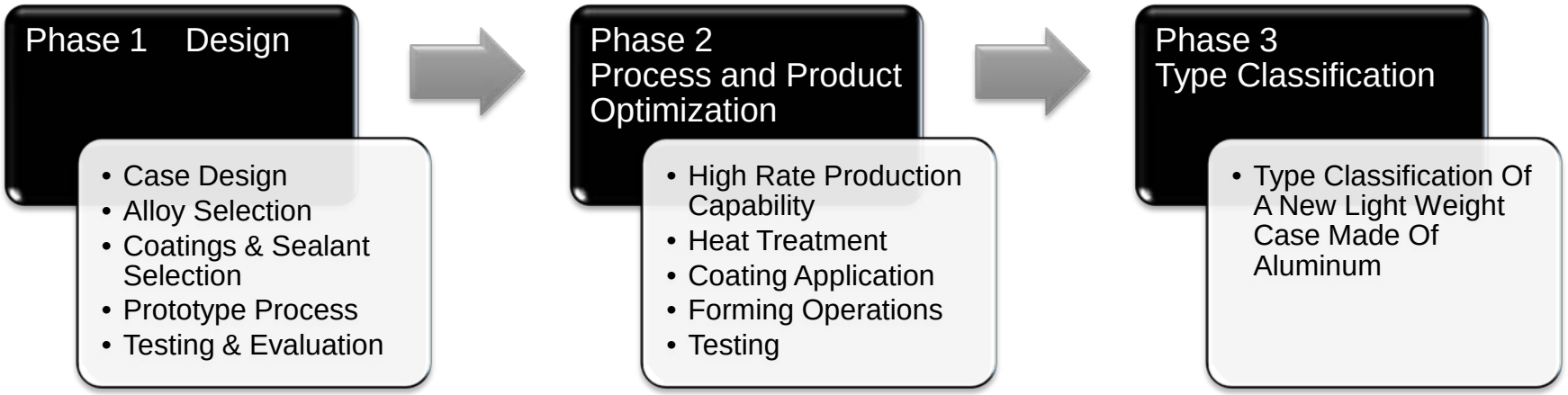
- Review Technical Papers (1956 through 2004)
- Design A 5.56mm Aluminum Alloy Case
- Design & Analyze Tooling And Processes For Case Forming
- Test, Evaluate And Select Coatings And Sealants
- Test And Select The Best Alloy
- Evaluate The Implementation Of Case Production Process
- Report Recommendations Based On Scope Of Work

Research, Design, Build, Test, Report

Project Team



Project Phases

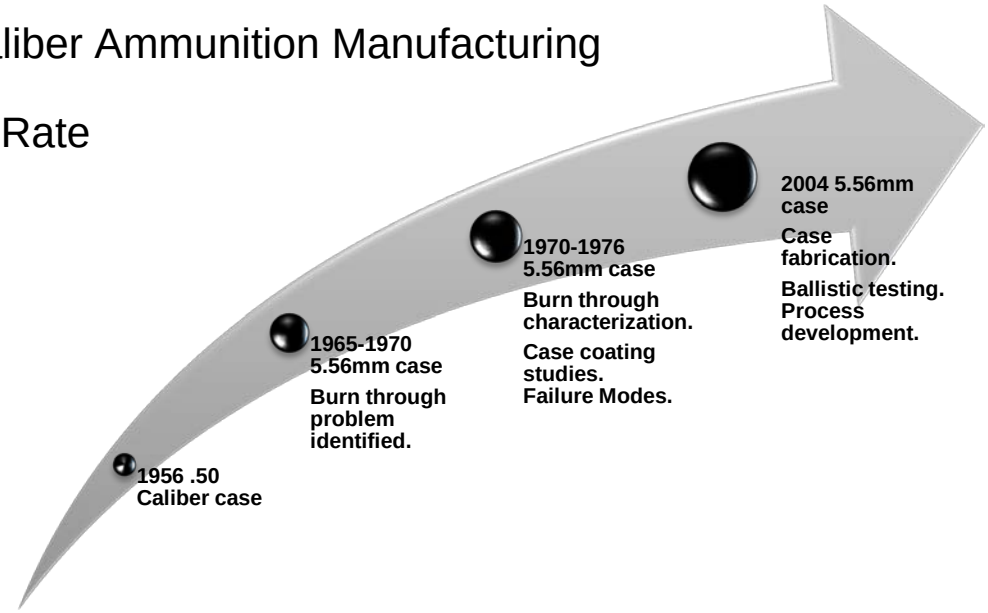


Advancing Technology

A premier aerospace and defense company

Fabrication Of An Aluminum Case Using ATK Small Caliber Systems Capabilities

- Knowledge Of High Rate Small Caliber Ammunition Manufacturing
- Metal Forming At High Production Rate
- Application Of Coating & Sealant
- Forming Tool Design
- Low Rate Lab Production
- Ballistic Test Facilities
- FEA Simulation
- Heat Treatment Process Knowledge



Gradual Advancement of Technology and Knowledge Base For Production Of Aluminum Cased Combat Ammunition

We Have a Knowledge Base

Supporting The Design, Development And Production

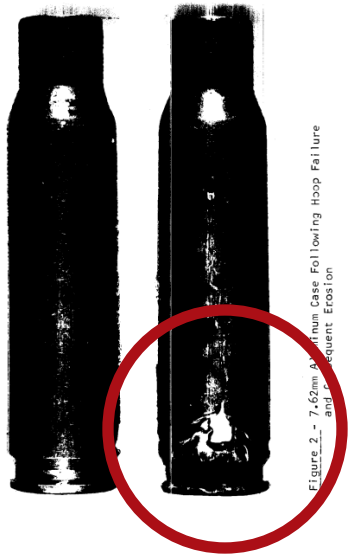
Of A 5.56mm Aluminum Case

Learn From The Past To Move Forward

Burn Through Problem – Frankford Arsenal

Effort

- Early Work Indicated Burn Through As An Obstacle
- Burn Through Is The Erosion Of The Aluminum Caused By Hot Gases Reacting To A Compromised Surface
- Further Work Showed A Reaction To Oxygen And Aluminum



Conclusions

- Proposed a Weapon/Ammunition System Solution To Isolate The Problem

1. Modify The ***Weapon*** Chamber Design To Seal The Chamber
2. Modify The ***Case*** Design to Seal The Chamber

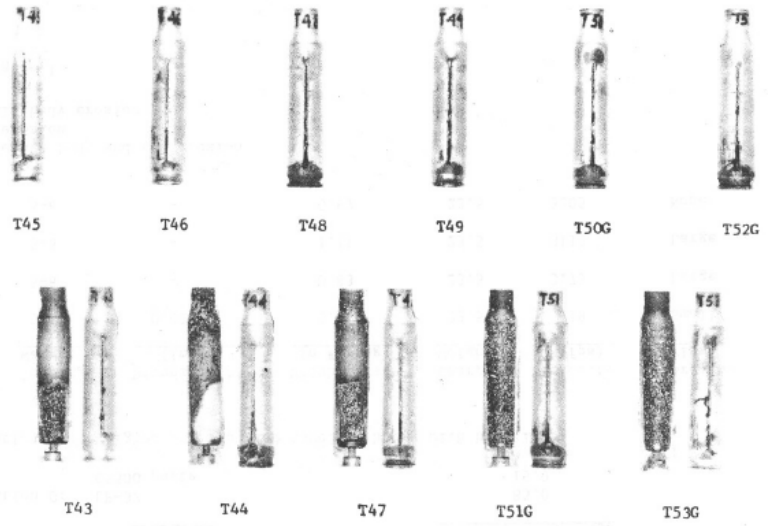
Systematic Approach To Design - Isolation And Means Of Elimination

Effective Inhibitors – Thiokol Chemical Corporation 1972-1973

A premier aerospace and defense company

Effort

- Tests Performed On Six Coatings To Find Inhibitor To Burn Through
  - Toughness
  - Thermal Stability
  - Elasticity
  - Insulation Capability
- Test Samples Damaged To Simulate Field Failures
- Ammunition Was Fired And Results Analyzed



Conclusions

- Identified Proprietary Formulation Composed Of A Polysulfide As Best Coating
- Suggested Polysulfide Pre-Form Cylinder Inserted Into Case Before Loading

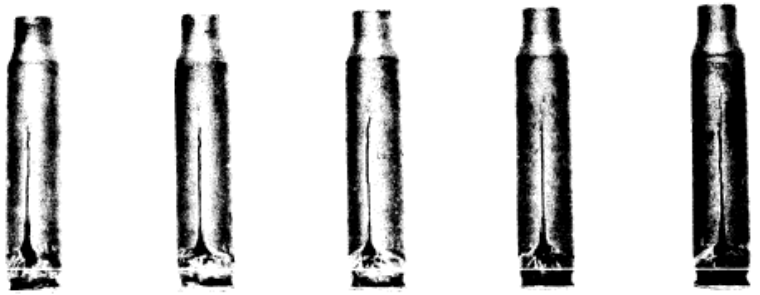
Use Internal Coatings Prevent Burn Through

Failure Mechanisms – Frankford Arsenal 1976

A premier aerospace and defense company

Effort

- Studied Failure Mechanisms Of Burn Through
  - Not Caused By Interior Surface Burning Through To The Outside Of The Case
  - Burn Through Is A Result Of A Gas Path During Firing
  - Duplicated By Drilling A Hole In The Case Head
  - Duplicated By Creating A Scratch On the Outside Of The Case
  - Initiated By Oxidation Of Aluminum Vapor By CO_2 And H_2O Created By Propellant Burn



Failure Mechanisms of Simulated Burn Through

Conclusion

- Gas Path Caused By A Mechanical Defect Such As A Structural Flaw Or Insufficient Strength Of The Case Material
- Burn Through Inhibited By A Rubber Liner

Burn Through Caused By A Gas Path - Duplicated The Problem

Case Concept – ATK 2004

A premier aerospace and defense company

Effort

- Designed a 5.56mm Aluminum Cartridge Case
- Fabricated Forming Punches And Dies.
- Developed A Cartridge Case Manufacturing Process
- Fabricated Samples For Testing In M249 And M16A2
- Performed Ballistic Tests
- Identified Coatings As A Solution To Burn Through

Identified Areas For Improvement

- Improve Case Design
- Improve Vacuum Test Results
- Improve Bullet Extraction

Process Development – Case Production

Technical Challenges

1. Burn Through
   - Erosion Of Case Caused By Hot Gases Reacting To Compromised Surface
     - Solution Method: Identify Coatings Capable Of Eliminating Burn Through
2. Long Production Cycle Times
   - Aluminum Case Production Requires Additional Heat Treat Requirements
     - Solution Method: Identify Most Effective Method Of Heat Treat To Meet Performance Cost And Ease Of Fabrication
3. Various Advanced Alloys Available
     - Solution Method: Test, Evaluate And Down-Select to Meet Cost, Performance, and Feasibility Criteria

Burn Through, Heat Treat Cycle Time, Alloy Selection

Coatings and Sealants

Use Coating And Sealant To Prevent Burn Through And Meet Specification Requirements

Internal and External Coatings

- Corrosion Resistance
- Wear Resistance
- Heat Resistance

Wicking Grade Sealants

- Improve Bullet Extraction
- Seal Primers
- Seal Case Mouth

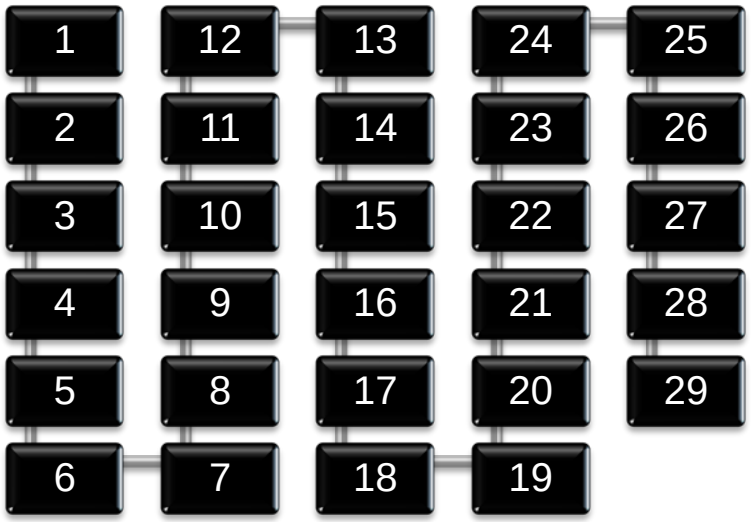
.50 Caliber Externally Applied Case Mouth Waterproofing

Leveraging Experience From Previous Technological Advancements

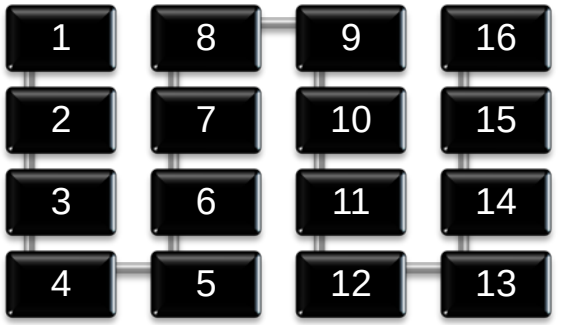
Cycle Time Constraint

- May Require Up To 25 Hours Of Heat Treatment
- Many Process Steps
- Batching Not Desirable In A Continuous Flow Production Environment

Aluminum Case
Multiple Process Steps
Lengthy Heat Treatment Time



Brass Case
Fewer Process Steps
Highly Automated1200 Parts Per Minute



Cycle Time A Constraint To High Rate

Alloy Selection

Alloy A

- Commercially Available
- Has A Balance Of Strength, Toughness And Resistance To Corrosion
- Has A Low Quench Sensitivity

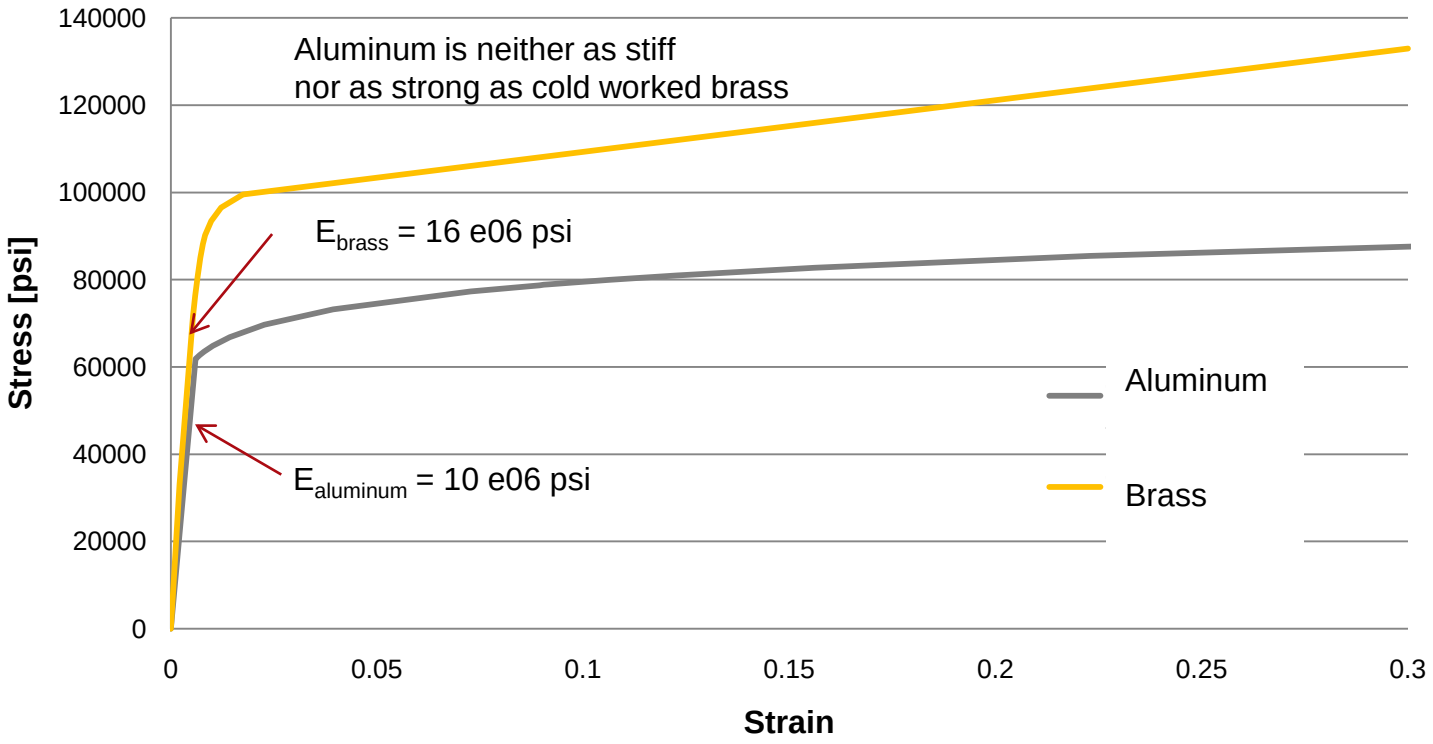
Alloy B

- Commercially Available
- Moderate Strength
- Good Strength After Temperature Exposure

ALCOA DEFENSE

Two Aluminum Alloys Under Evaluation

FEA Material Models



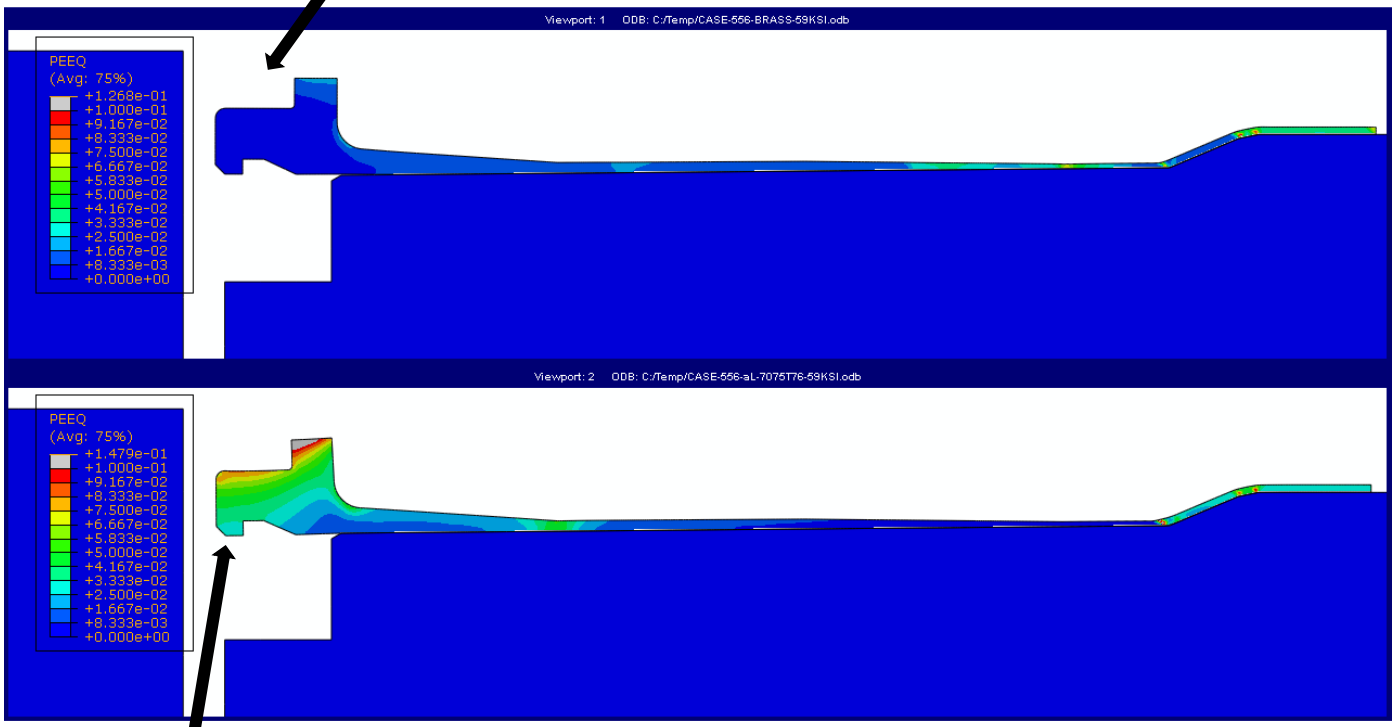
Cold Work Brass Versus Aluminum

FEA Plastic Strain Results

A premier aerospace and defense company

Color Contours Indicate Plastic Strain After Applying Firing Pressure

Brass Case Is The Design Basis For Aluminum Case



Aluminum Case Must Be Thicker To Achieve Performance Of Brass

Firing Pressure Strain

Summary

- Past Efforts Investigated Aluminum Alternatives To Brass For Cartridge Cases
- Design Time Reduced By Lessons Learned From Past Efforts
- Objective - Develop Solutions To Burn Through Problem
- Objective - Design Production Process For LCAAP
- Test And Evaluate Two Aluminum Alloys
- Reduce Cycle Time Constraints To High Rate Production

References

1. *The Aluminum Cartridge Case "Burn-Through" Problem – Characteristics – Isolation and Means of Elimination. Donnard, Grandy, Skochko, Squire. Department of the Army Frankford Arsenal. Philadelphia, PA*

2. *Prevention of 5.56mm Aluminum Cartridge Case Burn-Through. Marziano, Vriesen, Thiokol Chemical Corporation, 1975.*

3. *A Critical Assessment of the Aluminum Cartridge Case Failure Mechanism. Squire, Donnard, Frankford Arsenal, Report no. FA-TR-76011, 1976.*

4. *Aluminum Cartridge Case Concept. Tasson, Alliant Techsystems, 2004.*

Contact Information

Chris Still

ATK Small Caliber Systems

816-796-7371

Chris.Still@atk.com