Investigation into the 20mm PGU-27 Bullet Crimp

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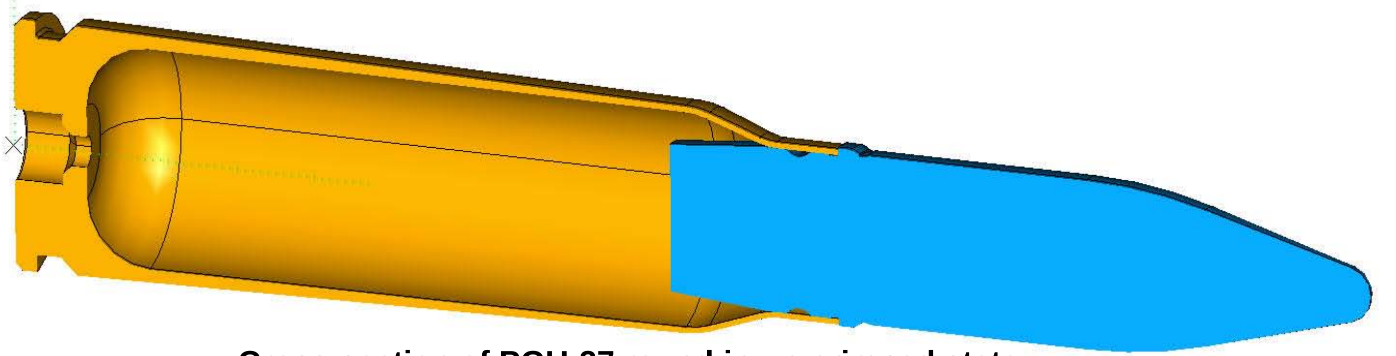
Background

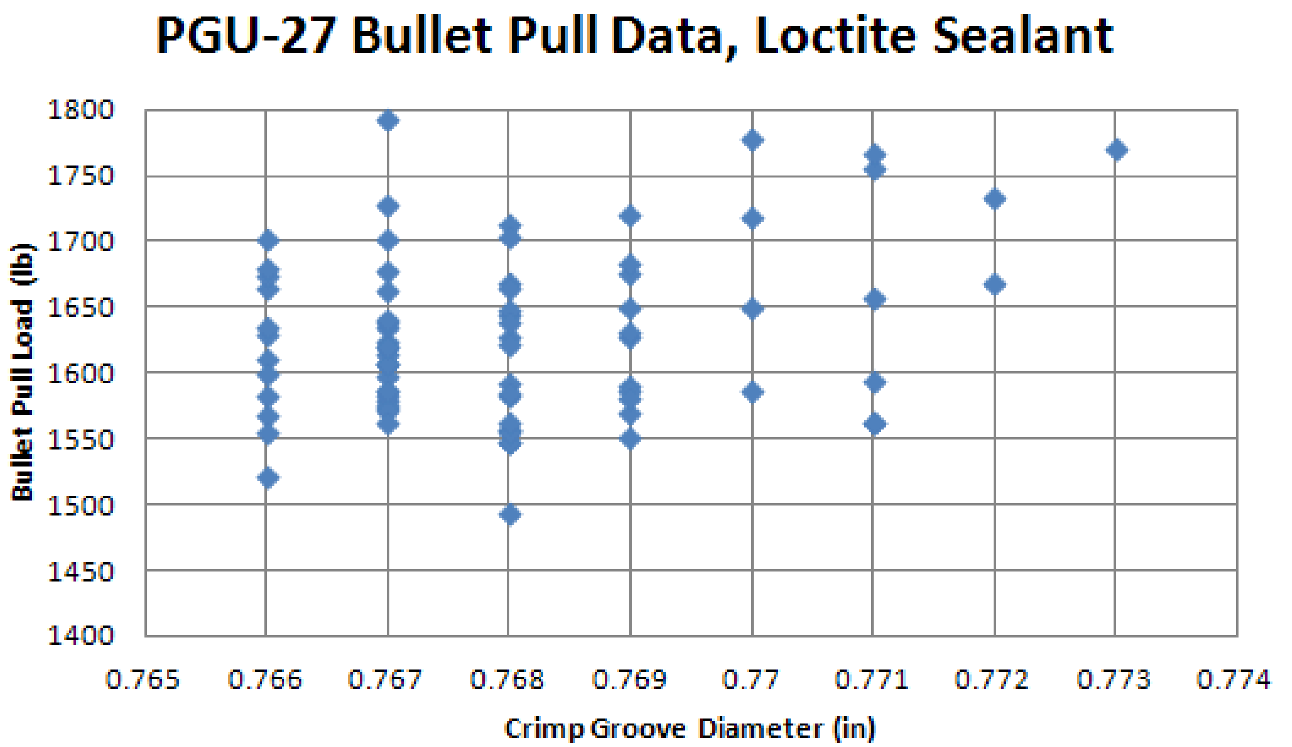
- 20mm cases have experienced case neck separation (CNS)
- Hypothesis: A lower bullet pull requirement may reduce the occurrence of CNS
- Current requirement: 1100 to 2800 pounds
- Our challenge: Evaluate reducing the minimum bullet pull to 990 pounds (-10%)



Cross-section of PGU-27 round in un-crimped state

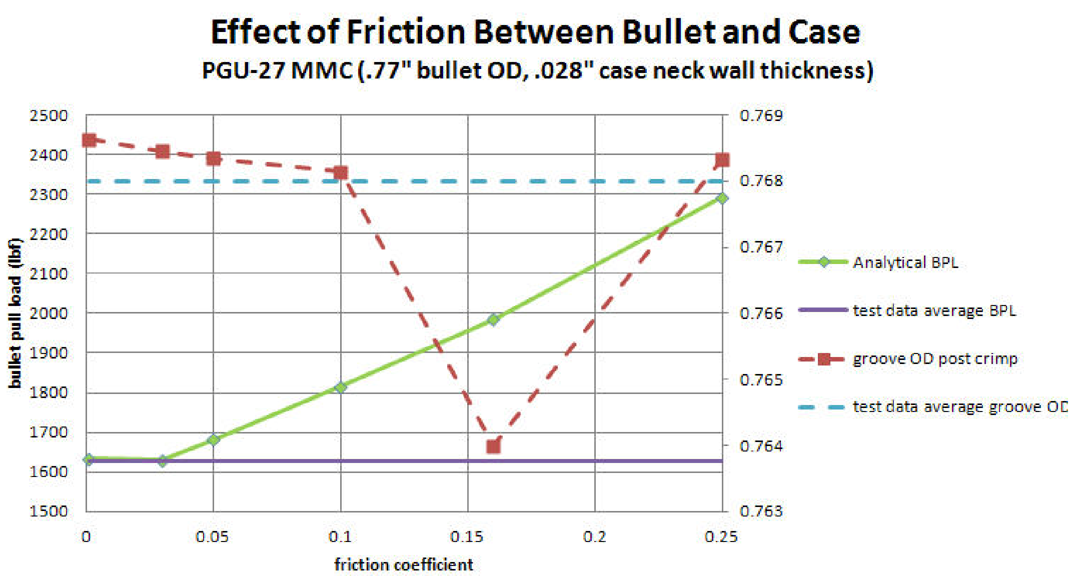
Empirical Bullet Pull Data

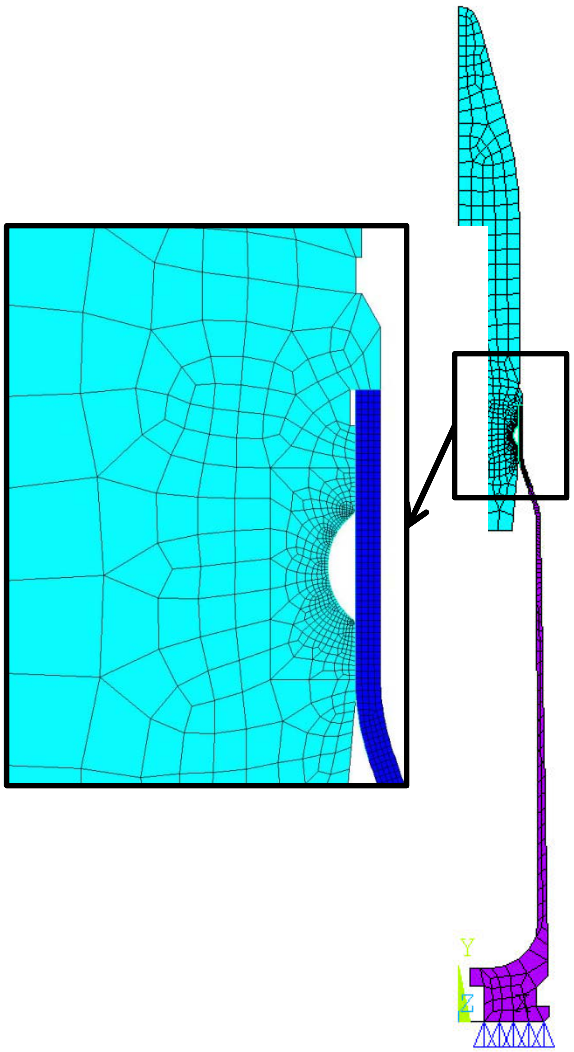
- Empirical bullet pull data with Loctite sealant
  - Average bullet pull load (BPL) of 1628 lb
  - Average bullet groove crimp diameter of 0.768”



Friction Study, PGU-27

- Determine relationship between BPL and friction for PGU-27
  - maximum case neck thickness
  - nominal bullet groove depth
- Friction coefficient of 0.05 results in:
  - BPL of 1675 lb
  - Post crimp groove OD of 0.7684”



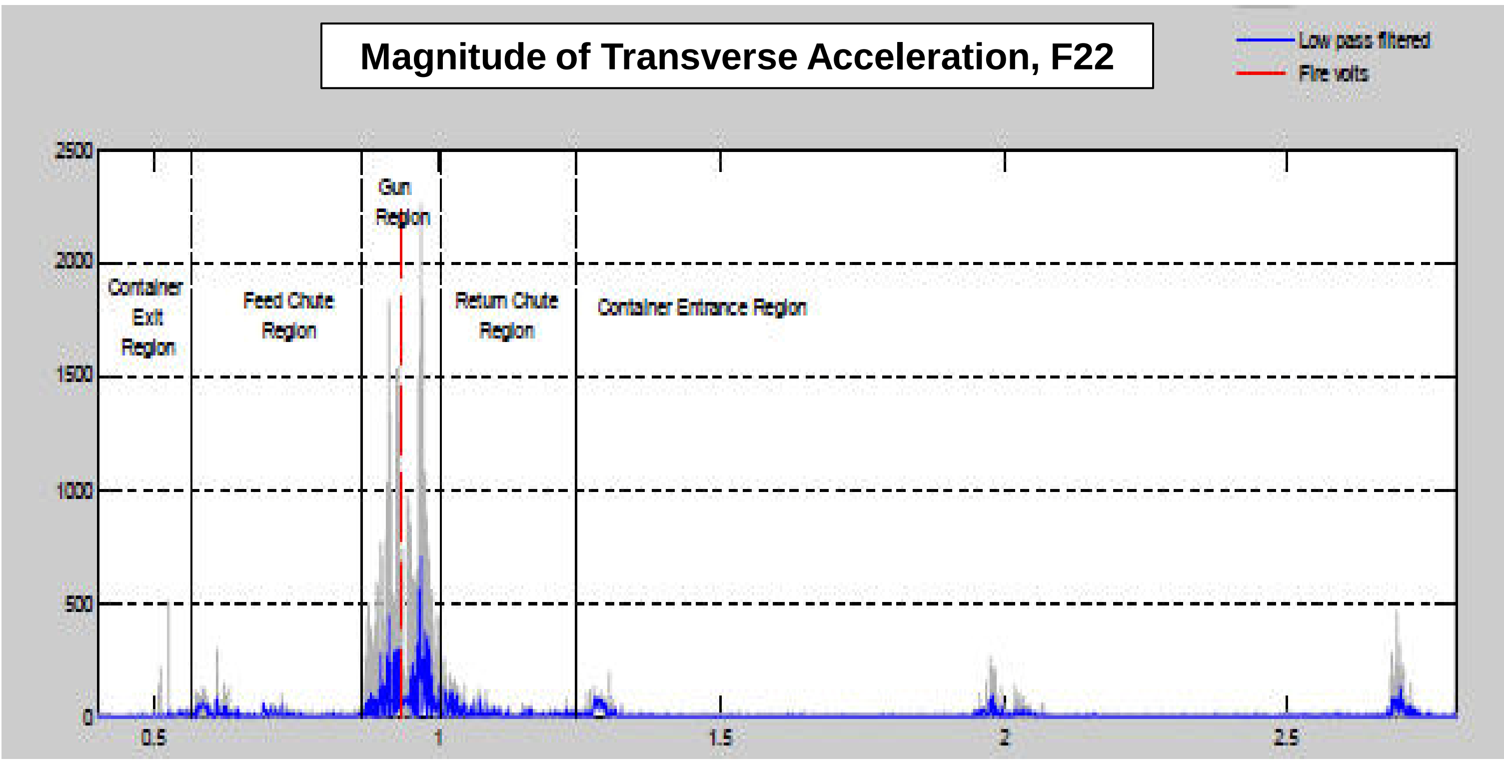


Analysis Process Overview

- Data Collection Dummy Round (DCDR) measured round acceleration within gun and feed systems (see Presentation 14019)
- Reverse engineered loads which produce measured acceleration were computed based on:
  - Transfer functions from correlated finite element model (FEM) of DCDR
  - Support conditions of round during peak measured acceleration
- Nonlinear transient analysis performed using derived loads, key output is:
  - Bullet displacement relative to case
  - Case plastic strain

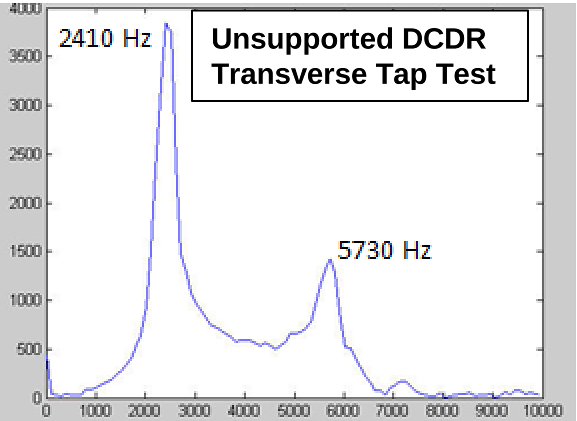
DCDR Accelerations

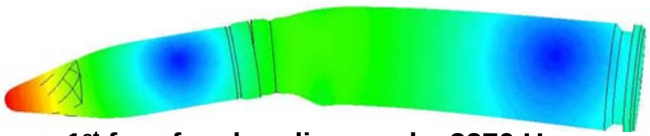
- Peak round acceleration occurs when round within gun housing
- Within gun housing, round restrained by bolt and ID of gun housing – approximates cantilever restraint at base of round



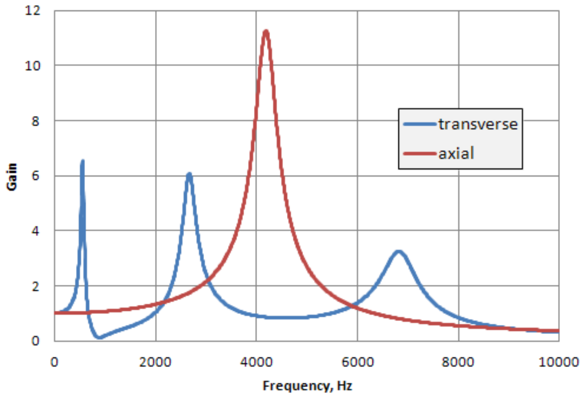
From Response to Load

- DCDR measured acceleration is result of unknown external load applied to round and ***cannot*** be applied as external load
- Must determine unknown external load which produces measured acceleration
- Means to compute load is:
  - Divide Fourier Transform of DCDR accelerations by DCDR transfer functions
    - DCDR transfer functions computed from correlated FEM of DCDR
    - Cantilever support condition included in transfer functions
  - Compute Inverse Fourier Transform of quotient
- Result is “unknown” base acceleration load





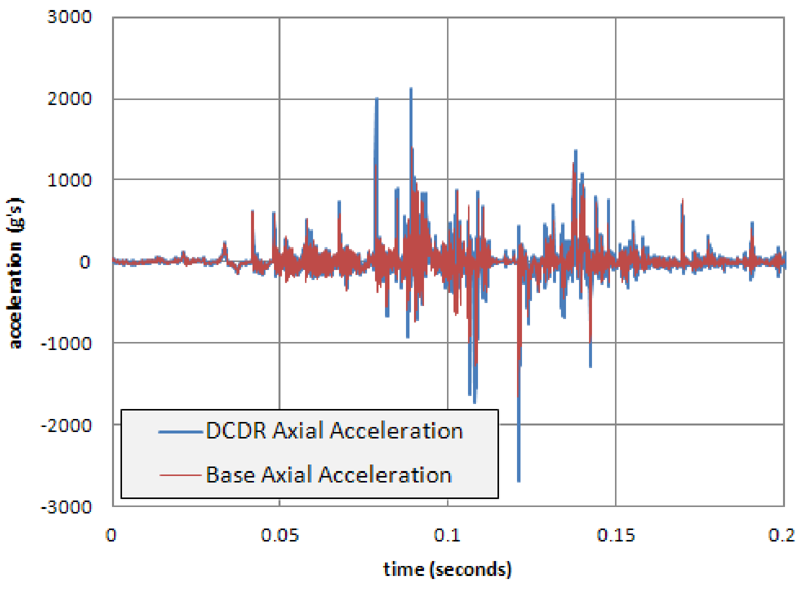
1st free-free bending mode, 2270 Hz

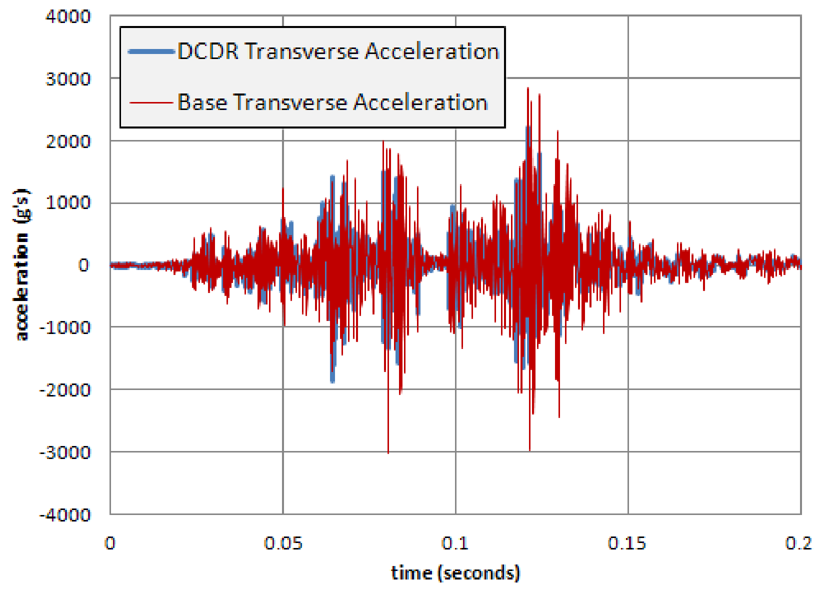


Computed Transfer Functions

DCDR Base Accelerations

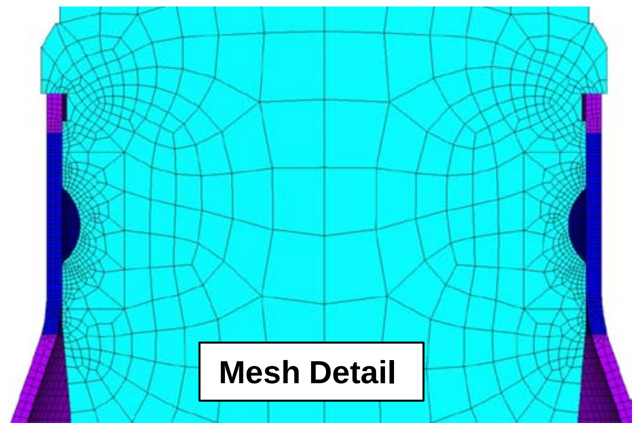
- Axial and transverse derived base acceleration and measured DCDR acceleration

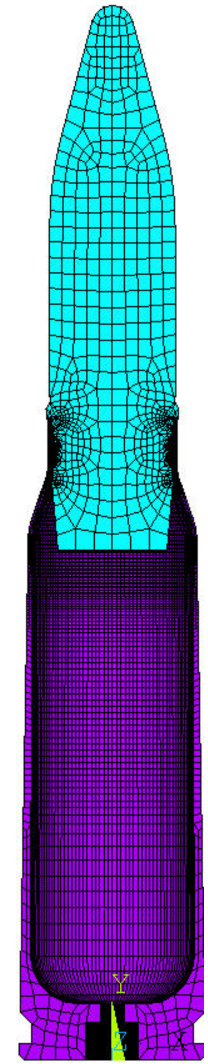




PGU-27 Response to Base Accelerations

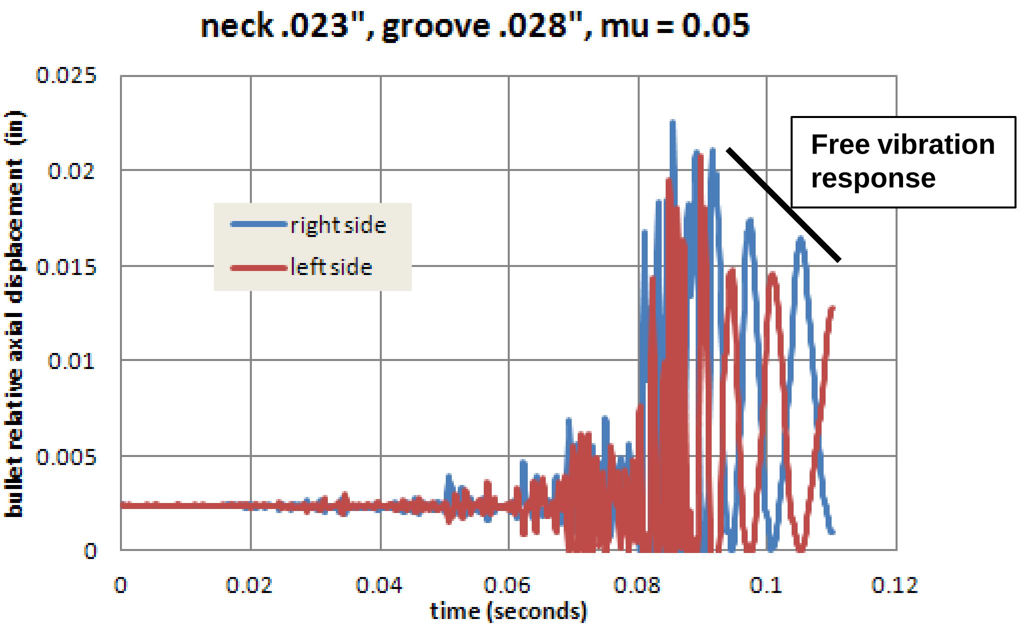
- Transient analysis in ANSYS
  - Nonlinear brass properties
  - 3-D surface contact
  - Plane of symmetry
- 1100 lb BPL FEM
  - Case neck thickness of 0.023”
  - Bullet groove depth of 0.028”
- 990 lb BPL FEM
  - Case neck thickness of 0.022”
  - Bullet groove depth of 0.026”
- First load step applies crimp load
- Second load step removes crimp load
- Subsequent load steps apply derived load

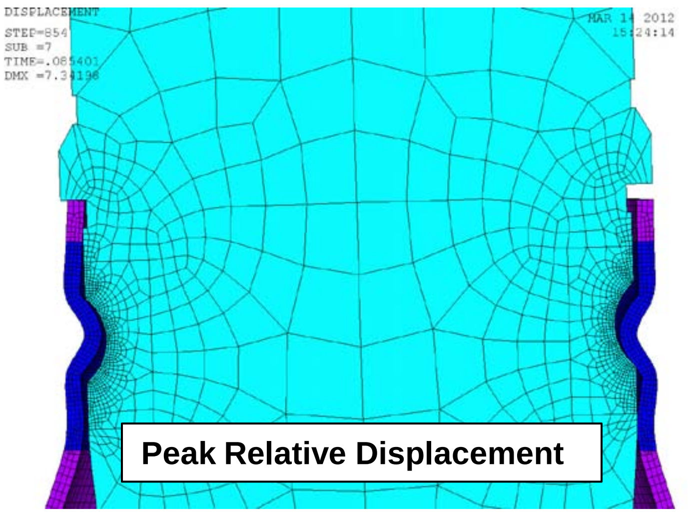




Displacement at Minimum BPL (1100 lb)

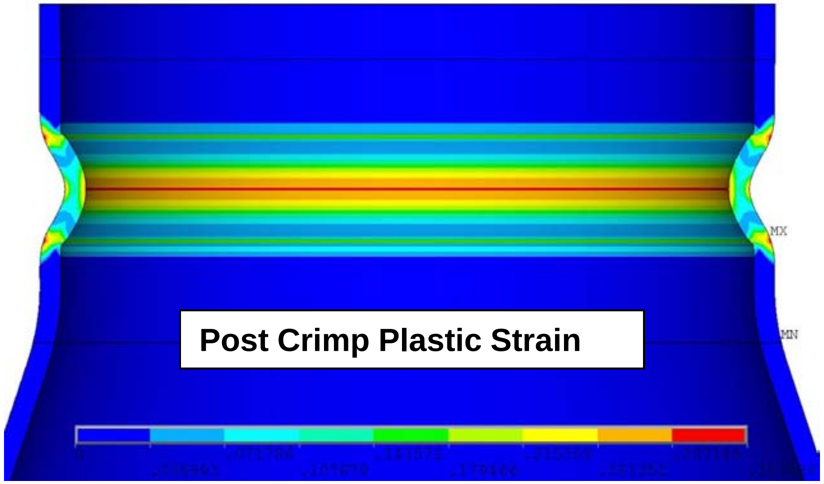
- Peak axial separation is .023" – due to load round sees in gun housing
- Free vibration response at end shows bullet returning to post crimped position – no permanent bullet offset

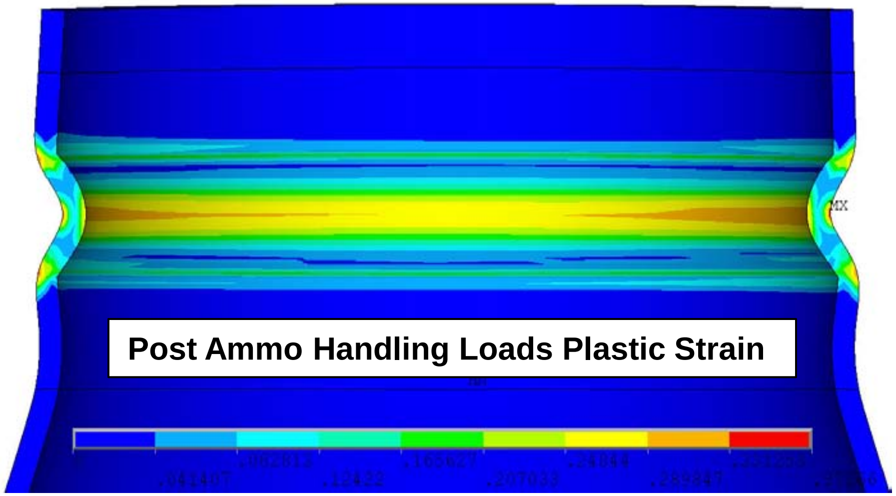




Plastic Strain at Minimum BPL (1100 lb)

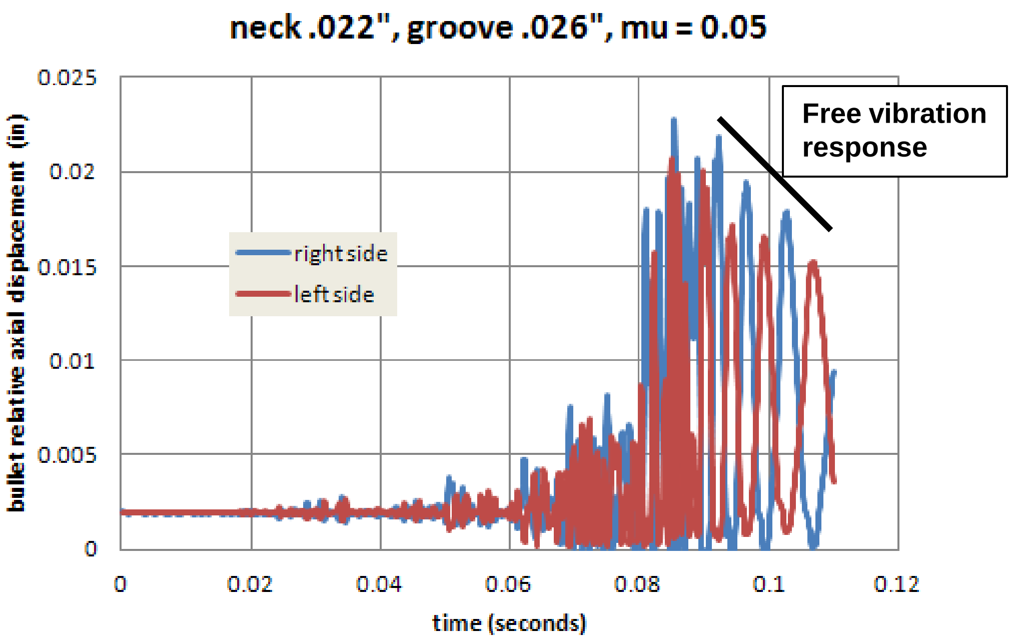
- Plastic strain due to crimping process is 32%
- Plastic strain after exposure to round handling loads is 37%

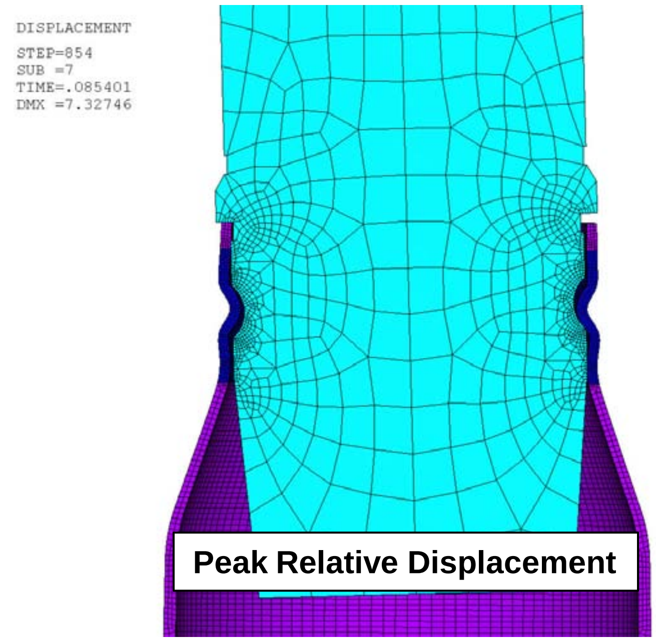




Displacement at 90% of Minimum BPL

- Peak axial separation is .023" – due to load round sees in gun housing
- Free vibration response at end shows bullet returning to post crimped position – no permanent bullet offset

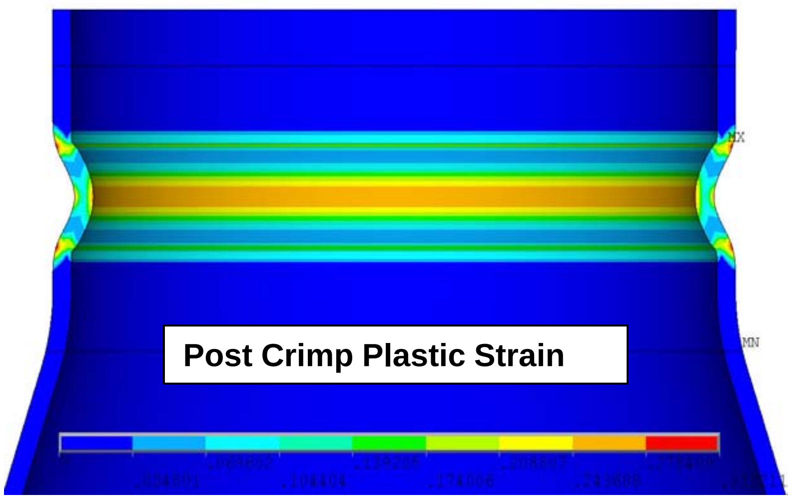


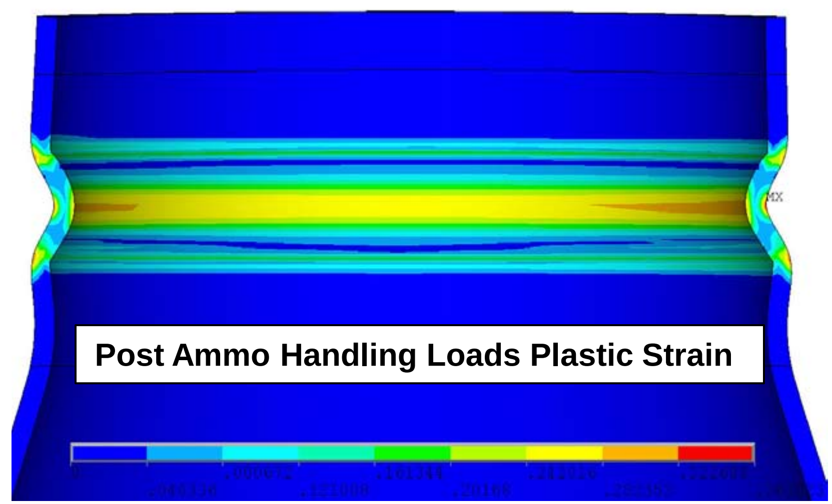


Peak Relative Displacement

Plastic Strain at 90% of Minimum BPL

- Plastic strain due to crimping process is 31%
- Plastic strain after exposure to round handling loads is 36%





GENERAL DYNAMICS
Armament and Technical Products

Summary

- Rigorous analysis performed to evaluate relationship between BPL and capability of case to restrain bullet as PGU-27 round travels through various M61 gun systems
- Correlation study performed to establish friction coefficient of 0.05 between bullet and case with Loctite sealant
- Current bullet pull requirement (1100 lb to 2800 lb) adequately restrains the bullet for measured round accelerations
- Analysis results support a reduction of minimum bullet pull load from 1100 lbs to 990 lbs
  - Bullet control by case not compromised during exposure to round handling load
  - Based on evidence that current minimum BPL results in adequate bullet control in field