MSIAC
Munitions Safety Information Analysis Center

Supporting Munitions Safety

An International Review of Gun Launch Explosive Setback

IMEMTS 2019

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Outline

- Background
- Process / Questionnaire
- Analysis
- Summary of recommendations
- Discussion/Next steps

Background

- MSIAC has conducted a number of surveys initiated to review or develop STANAGs. This normally that leads to a list of recommendations.
- NATO AC/326 SG/A tasked MSIAC to initiate this same type of review in support of the Gun Launch Setback Ignition Study Working Group .

Setback Working Group

- NATO AC/326 Subgroup A (Energetic Materials) approved the creation of the Setback Ignition Working Group (SIWG) in 2017.
  - USA lead: Sean Swaszek, US Army ARDEC
- 1st SIWG Meeting - Friday April 27th 2018, Portland Oregon USA
- 2nd SIWG Meeting - Tuesday October 9, NATO HQ, Brussels Belgium
- 3rd SIWG Meeting - Tuesday March 12, NSWC, Indian Head, MD, USA
- 4th SIWG Meeting - Tuesday September 17, WTD-91, Meppen, Germany

The goal of the working group is to develop a new AOP (Allied Ordnance Publication) document for standardizing the approach to test and evaluate the safety of energetic materials & munitions to setback loading

Procedure

- MSIAC has written a survey related to the Gun Launch Explosive Setback
- The survey was reviewed by the Setback Working Group lead and several SMEs
- The on-line survey was published on the MSIAC web site. Notices were sent to the MSIAC national focal point officers, participants of the Setback Working Group and a list of SMEs.
- After reception & analysis of the answers and other related documents, MSIAC has summarized the results in a report.

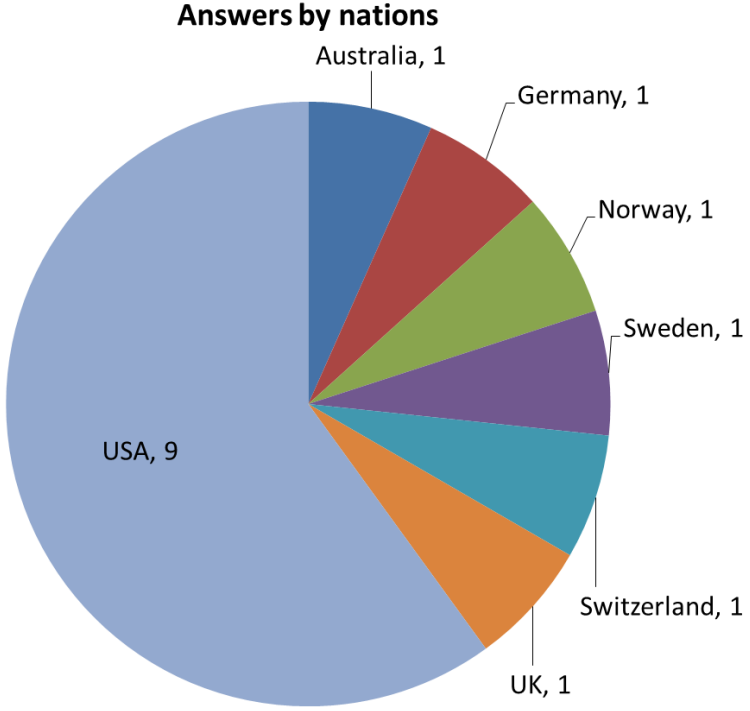
O-194: An International Review of Gun Launch Explosive Setback

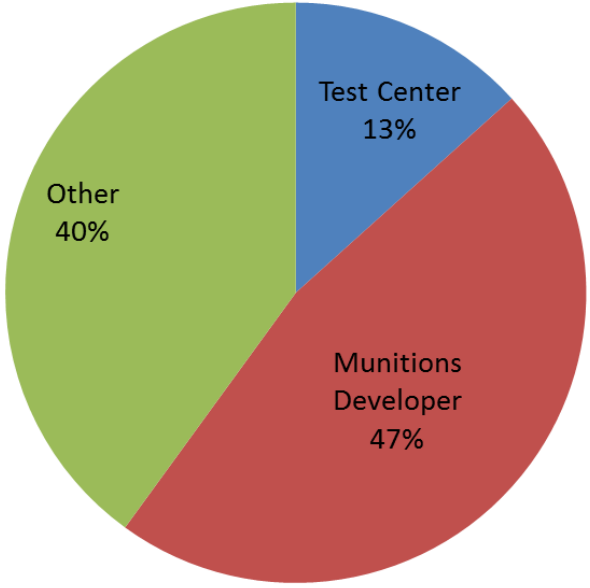
Contents of the survey

- Energetics under gun launch
  - Experimental data
  - Modeling and characterization
- Defects requirements
  - Melt pour
  - Cast cure
  - Pressed
- Defects inspection and identification
- Laboratory testing
- Standardization
- Gaps identification

Origin of the answers

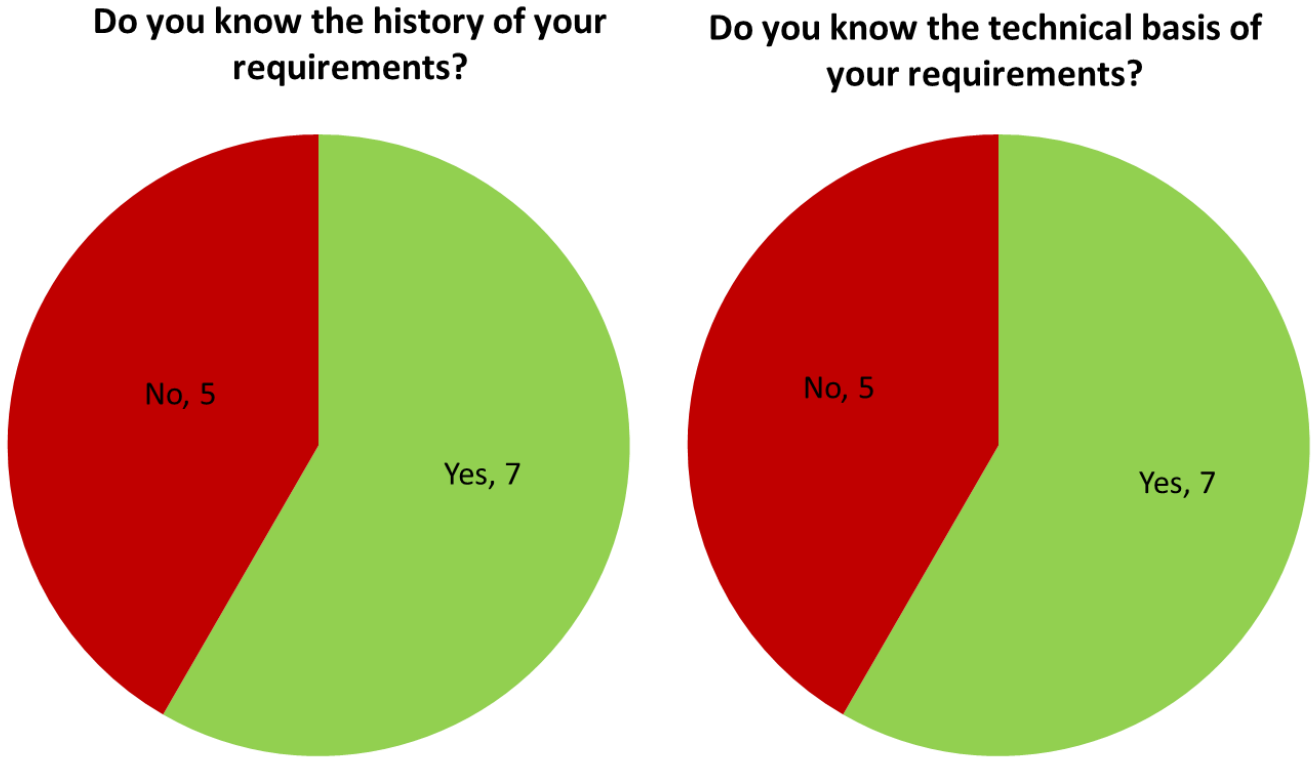
- 15 responses from 7 nations.
- 87%/13% government / private





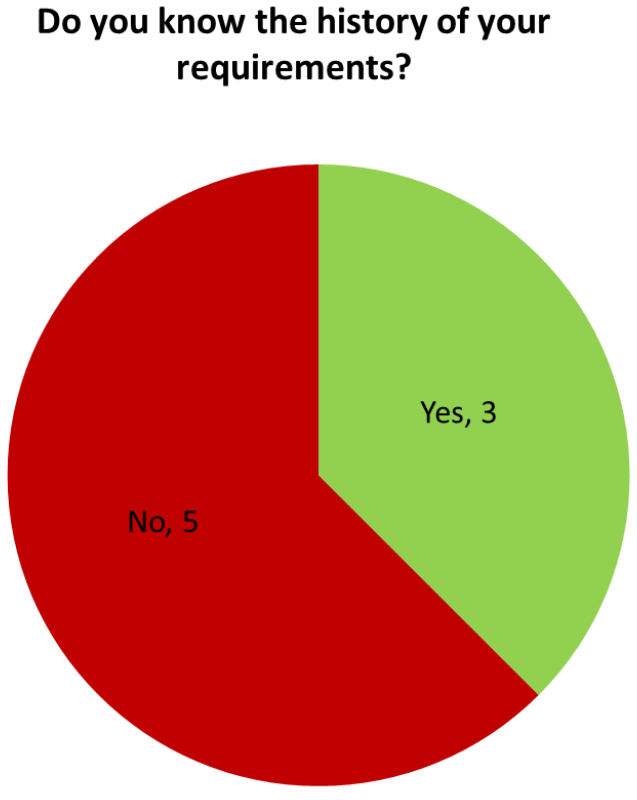
THANK YOU
for your responses!

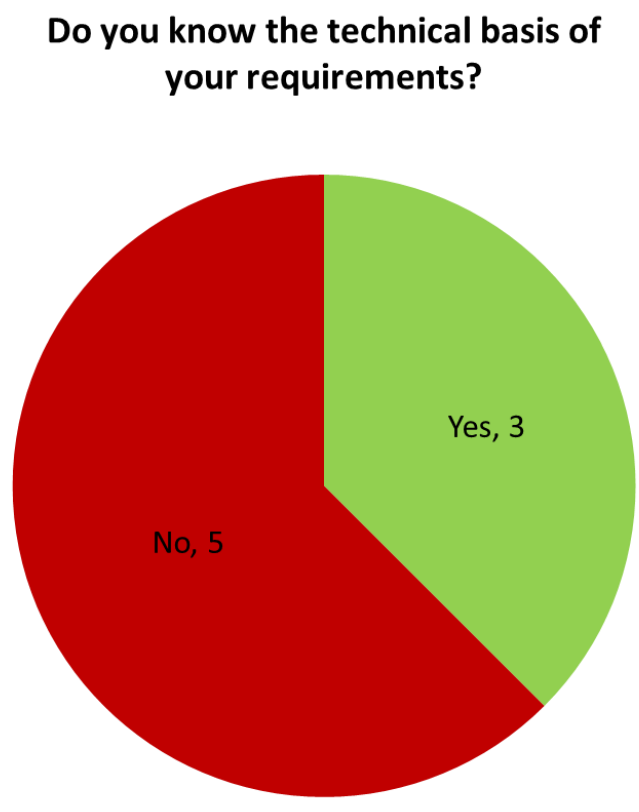
Melt Pour Formulations Filling Requirements



Filling requirements appear to be historically based

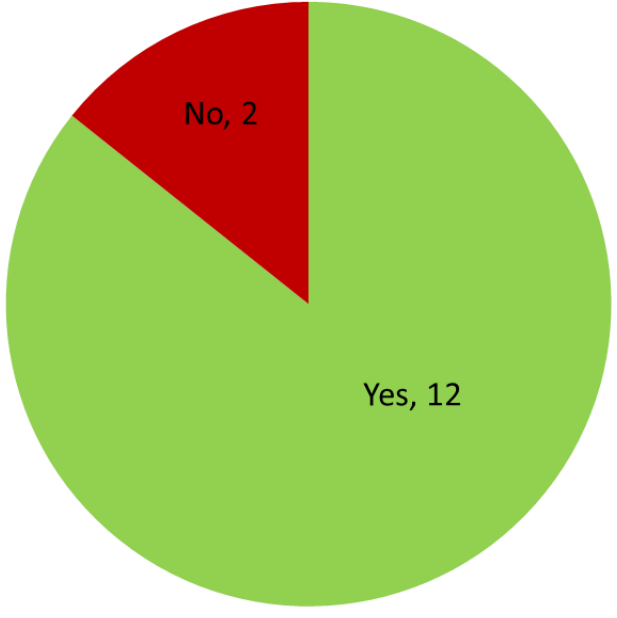
Cast Cure Formulations Filling Requirements



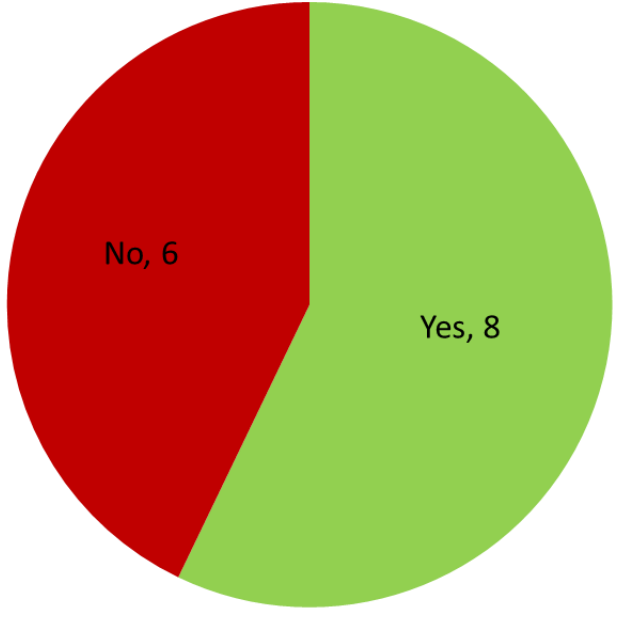


Energetics Under Gun Launch

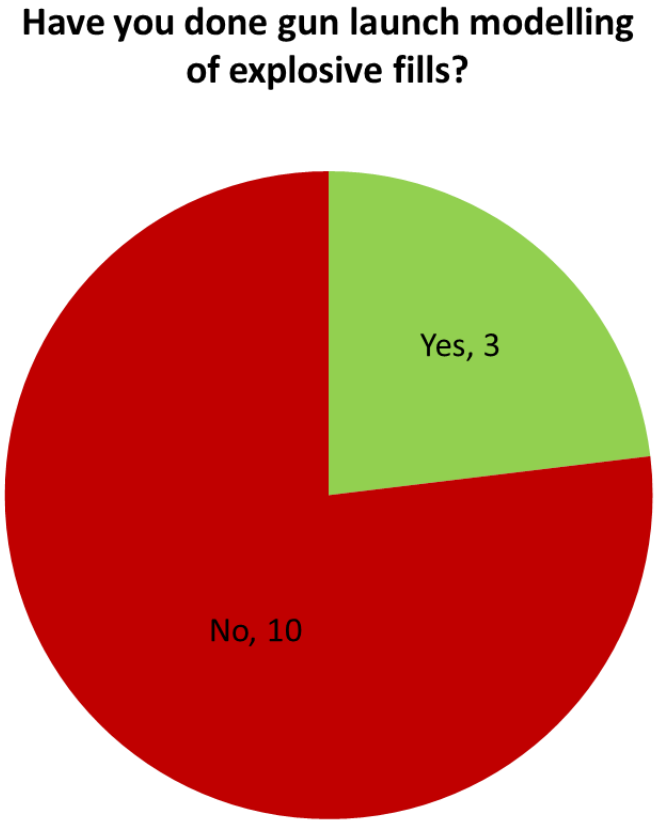
Have you or are you aware of gun launch experiments measuring behaviour of the explosive fill?



Do you have or are you aware of balloting and axial acceleration gun launch information?



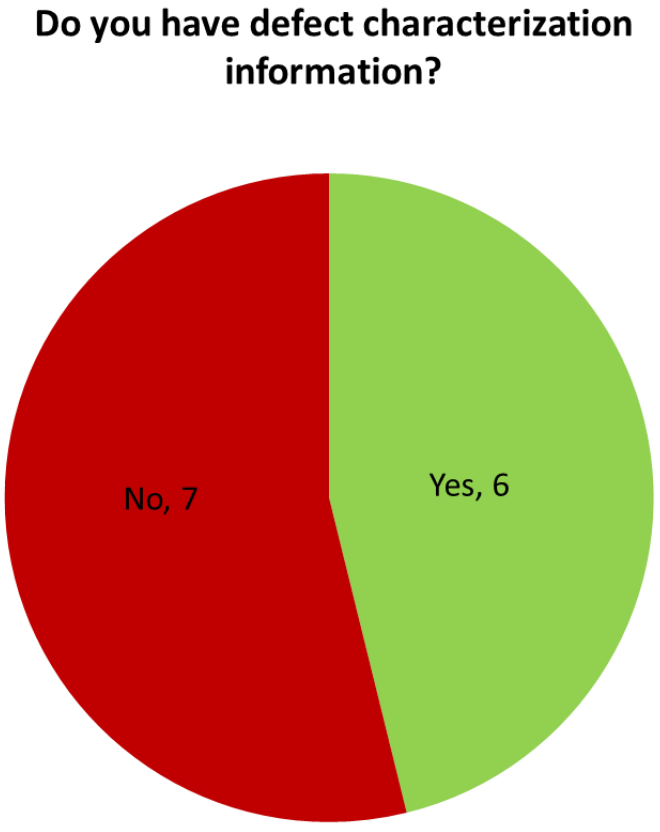
Energetics Under Gun Launch

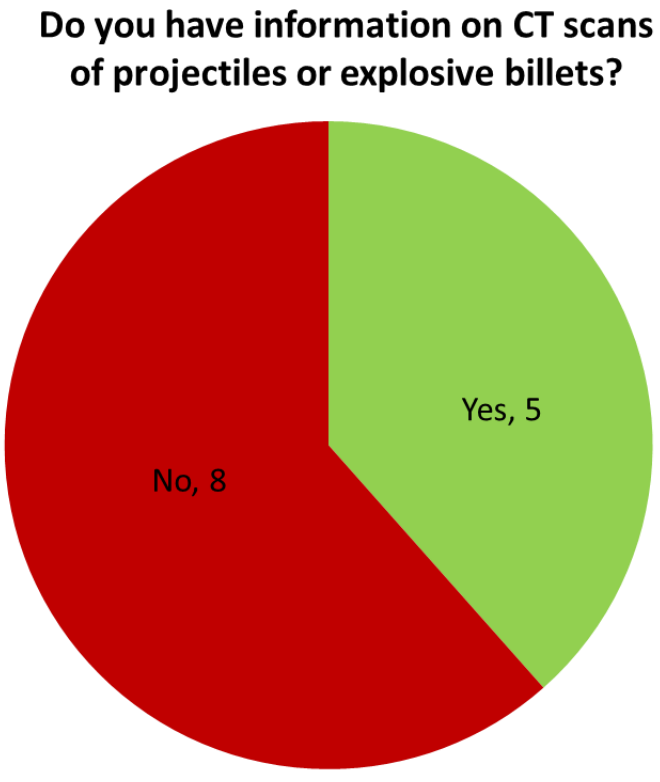


What energetic material models do you use?

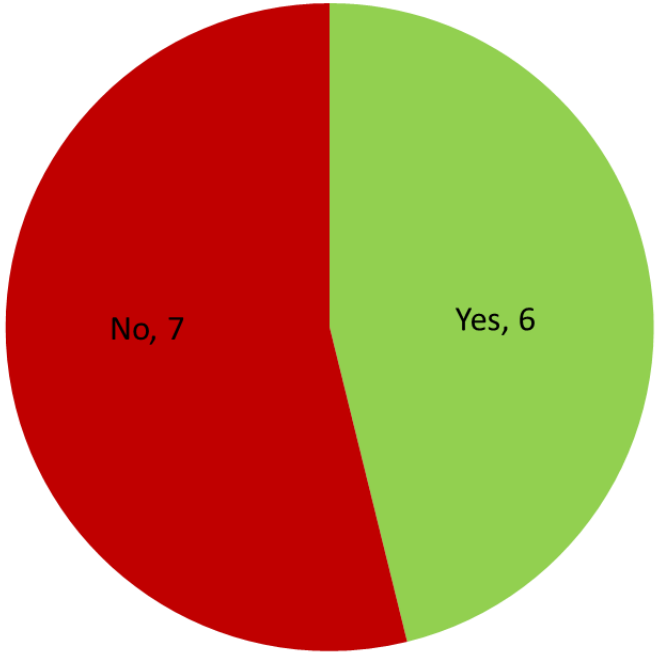
- Models provided by US DOE National Laboratories
- Land UK has limited in-house modelling capability in this area, and have traditionally relied on third parties for more rigorous analysis (e.g. QinetiQ, Fluid Gravity Engineering). We use LS-DYNA for this type of modelling. A standard (i.e. from the software library) elastic-plastic continuum model is used for both PBXs and melt-cast explosives. This approach predicts stress/strain/deformation of the explosive at the continuum level.
- So far only inert material models where we estimate risk of collapse of a certain defect geometry given acceleration.

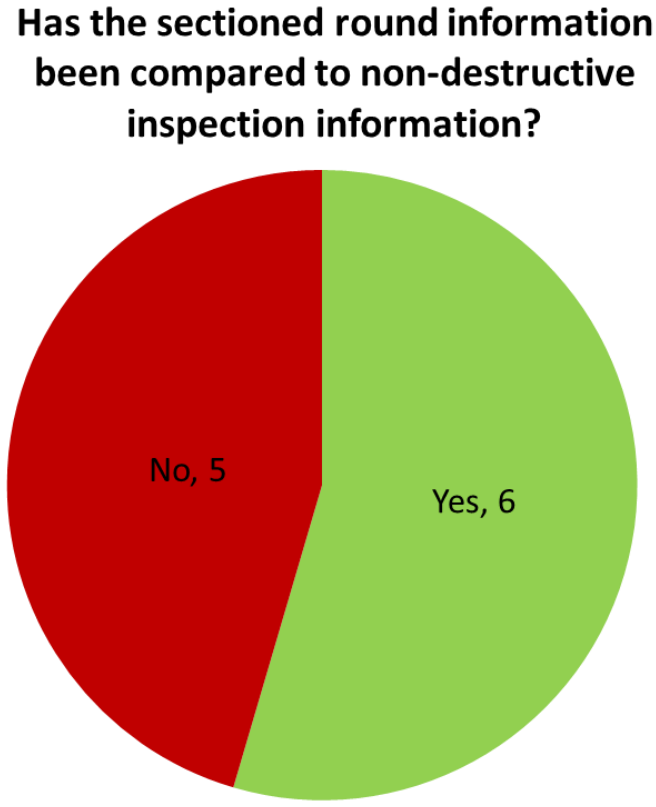
Defects


Do you have defect characterization information?
No, 7
Yes, 6

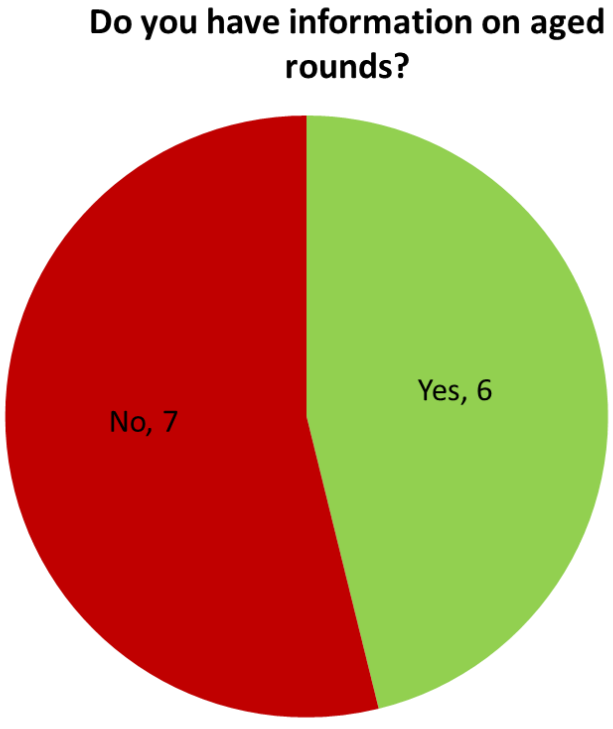

Do you have information on CT scans of projectiles or explosive billets?
Yes, 5
No, 8

Defects


Do you have sectioned round information?
No, 7
Yes, 6


Has the sectioned round information been compared to non-destructive inspection information?
No, 5
Yes, 6

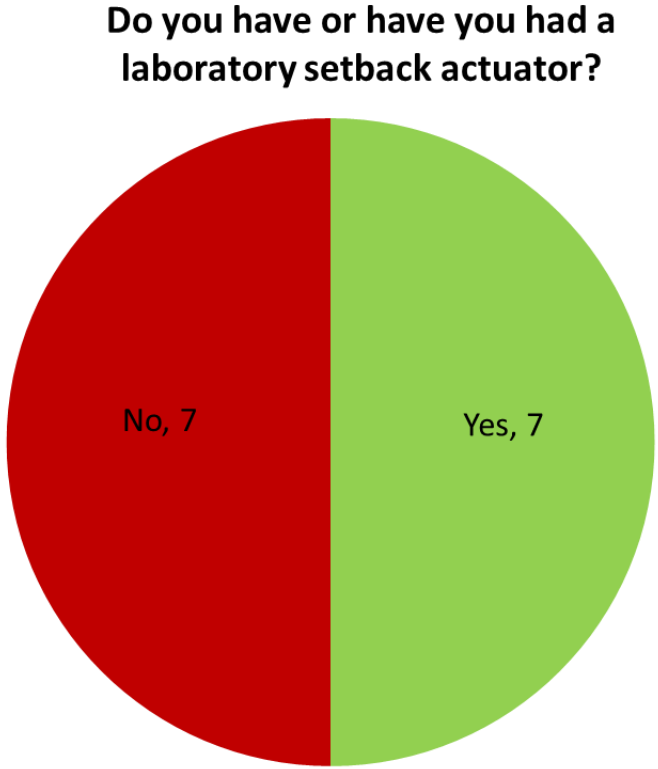
Aged Rounds



What concerns do you have for aged rounds ?

- Cracking, shrinkage, bubble formation and growth
- Exudation, Cracking, and base separation growth (on certain pressed filled projectiles).
- If cracks occur over time with warheads, does setback sensitivity increase? Especially as a function of temperature that would be seen in a hot gun scenario
- I've always had concerns around adiabatic compression upon launch of small gas bubbles and of sheer forces on cracks. However I believe that some formulations are able to avoid some of these issues and further research should not be overlooked for melt cast formulations.
- An unknown, as Ammunition Surveillance Reliability Programs typically x-ray and then fire rounds. As long as they go down range and detonate normally, no other testing is completed. We have seen Comp B exudation in mortars and are currently studying a recent lot of Marine Corps mortars that had exudate coming out of the fuze.

Laboratory Testing

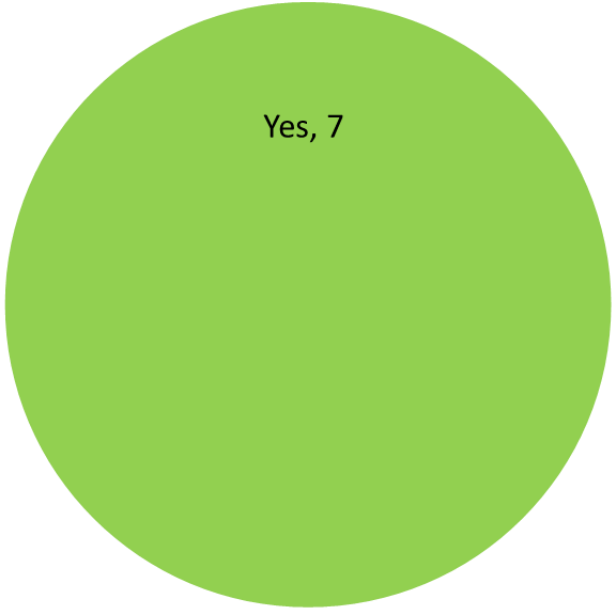


How do you use the results?

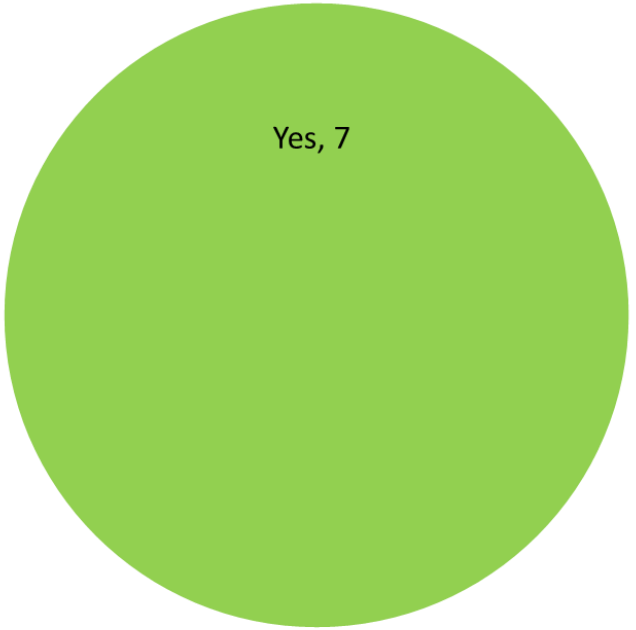
- We simply compare the results to Comp B
- The defect size is varied to find a threshold at which a reaction does not occur for the max loading rate of the projectile. Loading rate may be increased beyond maximum to determine a factor of safety.
- It is used to evaluate the adiabatic compression to compare with the failure of base gaps in munitions in melt pour munitions.

Standardization

Should best practice guidance be developed for an assessment methodology?



Should an assessment methodology for energetics acceptability and defects acceptance criteria be standardized?



Summary of recommendations

- Aim to develop a standard assessment protocols for:
  - Acceptability of explosive for gun launch
  - Acceptable defect types, sizes, distributions
  - Acceptable defect identification methods
- Review and generation of gun launch data
  - Acceleration and spin
  - Acceleration perturbations
  - Fill stress histories
  - Incidents
- Review of explosive mechanical response modeling under gun launch and in setback actuators
  - Current state of the art
  - Energetic mechanical response material models
  - Defects modeling
- Standards development: best practices document (STANREC)
  - Setback actuators
  - Statistical analysis and quantitative risk protocols
  - Defect identification methods
  - Explosive acceptability process
  - Acceptable defect types, sizes and distributions process