Tracer Development in a Non-Conventional Plastic Molded Frangible Projectile

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The main challenge is to develop a tracer in a brittle plastic molded projectile. This projectile contains some plastic, metallic powder, and a blue dye.

Challenges:

- Consolidation in a brittle projectile
  - Method to maintain the projectile during compression
  - Consolidation pressure cannot be very high due to its brittleness
- Projectile with the pyrotechnic composition can cause several failures such as tracer ejection, reduction of the trace distance, etc.
- Since the projectile is brittle, a very small tracer diameter has to be used.
Introduction

In the past:

- Encapsulated tracer (pencil tracer)
  
  - Zirconium and potassium perchlorate composition in a lead sheath
  
  - Lead sheath had to be inserted into the projectile cavity and retained by compressing the projectile wall.
  
  - Due to the brittleness of the projectile and the toxicity of the lead sheath, this technology was abandoned

- Traditional tracer compositions were studied using ignition and tracer compositions such as conventional tracers
  
  - The small diameter of the tracer cavity did not permit an efficient heat transfer from the ignition composition to the tracing composition
Current Design

- Tracer diameter is very small and the tracer length is short.
- As a result, only one composition is used in the SRTA-T ammunition which contains magnesium as a fuel, barium peroxide as an oxidizer, and calcium resinate as a binder.
  - This composition has to both ignite easily and burn slowly enough to achieve the trace distance.
- The lot-to-lot variation in the ingredients appears to be the most important factor affecting the performances of the tracer at both the ignition point and trace distance.
Current Design

- To achieve optimal performance, the Lean Design for Six Sigma method (LDFSS) was used to select the key characteristics. Tools such as process mapping, Cause and Effects matrix (C&E), Process Failure Mode and Effect Analysis (PFMEA) and Design of Experiment (DOE) were used.

- These documents were prepared for each of the following activities to identify important parameters to be tested:
  - Manufacturing process of the composition
  - Ingredient characterization
  - Manufacturing process for the tracer assembly
  - Molding process
Manufacturing process of the composition

- For the composition manufacturing process, the following characteristics were found to be important when tested in DOE for ignition or for distance trace:
  - Mixing time
  - Solid concentration of the binder
  - Drying time
- The removal of solid particles using decantation leads to a composition with a less variable density; consequently, the composition is easier to assemble especially in this small tracer cavity.
- The composition drying time was studied.
Ingredient Characterization

Magnesium

- Characteristics tested on magnesium lots:
  - Shape with SEM (Scanning Electron Microscope)
  - Grain size using Lasentec particulate analyser
  - Purity and melting point

- Conclusions:
  - Magnesium choice is essential to the development of pyrotechnic composition.
  - Purity of the magnesium and melting points were tested but no clear correlations were made with the trace performances.
Ingredient Characterization

- Magnesium shape photos

- Mg from one supplier, two different lots

- Mg from one supplier, two different lots
Barium peroxide

- Following are the characteristics studied for the barium peroxide:
  - Melting point, enthalpy and oxygen content.
  - Particle size

- No significant difference was observed between the three lots tested and trace distance was still different.

- Other tests have to be performed.
Plastic molded frangible projectiles contain
- plastic,
- a powdered metal,
- and a blue dye.

Projectile lots have an effect on the trace performance

Compound formulation, manufacturing process, and ingredient characteristics were studied.
Tracer Manufacturing Process

- Only a small quantity of pyrotechnic composition could be inserted in the small cavity. The pyrotechnic composition is both mechanically difficult to insert and to keep a stable quantity.
  - A variation of only 10 mg of the composition in the projectile has significant impact on the trace distance.

- For a conventional projectile and tracer compositions, the consolidation dead load is in the range of 2000 lbs. The dead load is considerably reduced in the non-conventional frangible projectile process; due to the projectile being too brittle and the pressure can cause a fracture.
  - Consequently, the maximum dead load can not exceed the fracture capacity of the projectile.
Conclusions

- Results presented demonstrate the complexity involved in the development of a tracer in plastic molded frangible projectiles. Several key characteristics were identified:
  - Tracer cavity diameter which is related to the brittleness of the projectile has to be defined at the beginning of the development.
  - Choice of the composition, in this case, only one composition is used. This composition has to both ignite easily and attain the trace distance.
  - Binder has to produce a homogeneous composition and be consistent in density to help in the manufacturing process.
  - Choice of ingredients and their characteristics could affect ignition of the tracer and trace distance.
  - The manufacturing processes of the projectile and the assembly of the tracer have to be consistent. A small change could cause a trace failure.
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