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U.S. Army Research, Development and Engineering Command



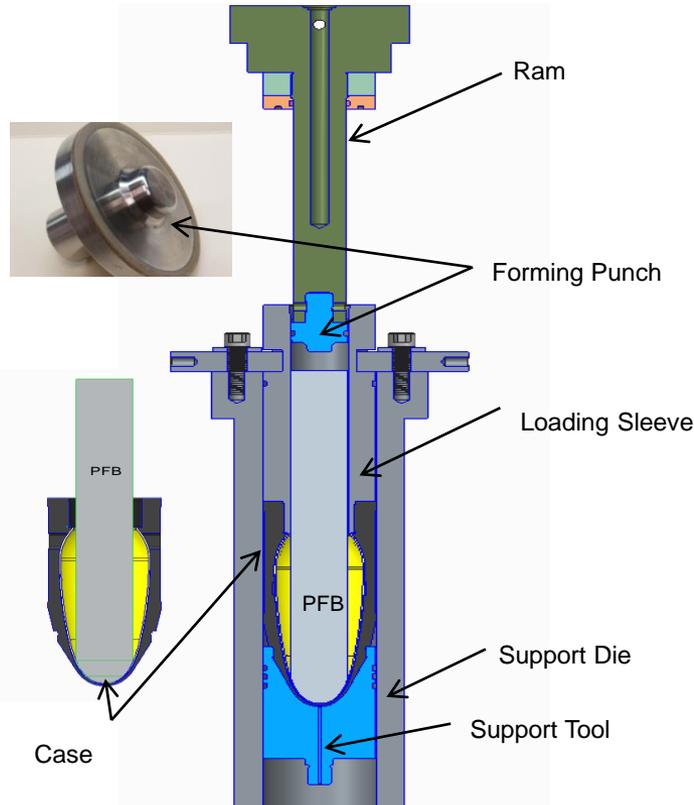
***TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.***

## **Single-Increment Press Loading Process**

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- ARDEC has developed a new compaction press process pressing high explosive charges into long projectiles.
- Pressed compositions have shown better performance than cast compositions for some of these projectiles, however there is no reliable manufacturing base for them.
- This presentation seeks to introduce this process to industry.

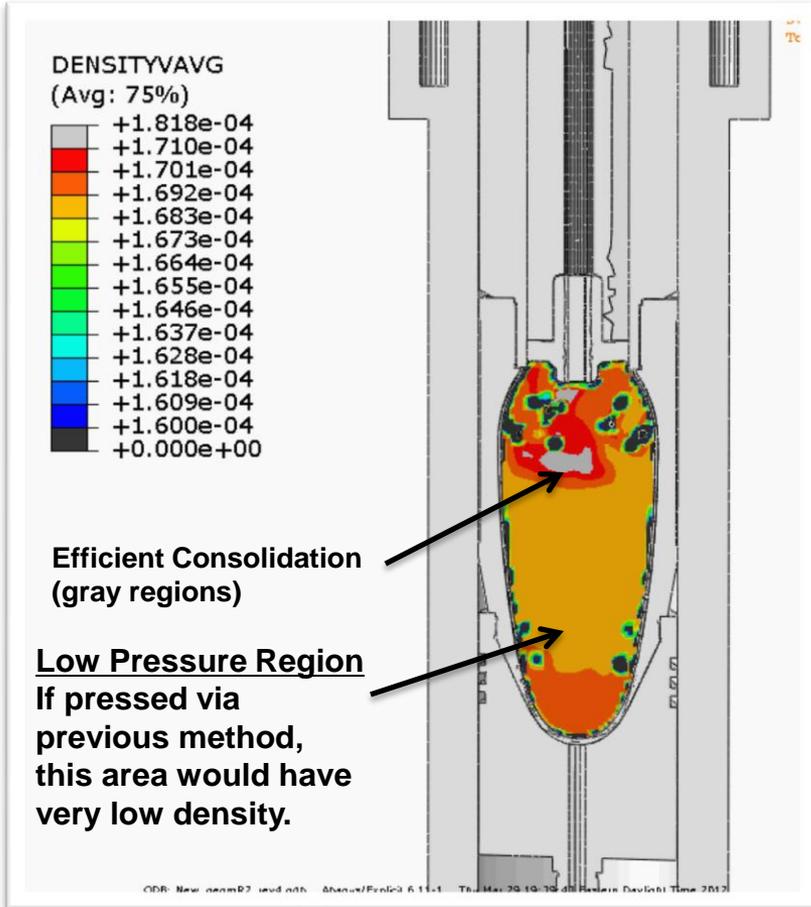


# Problem and Prior Solution



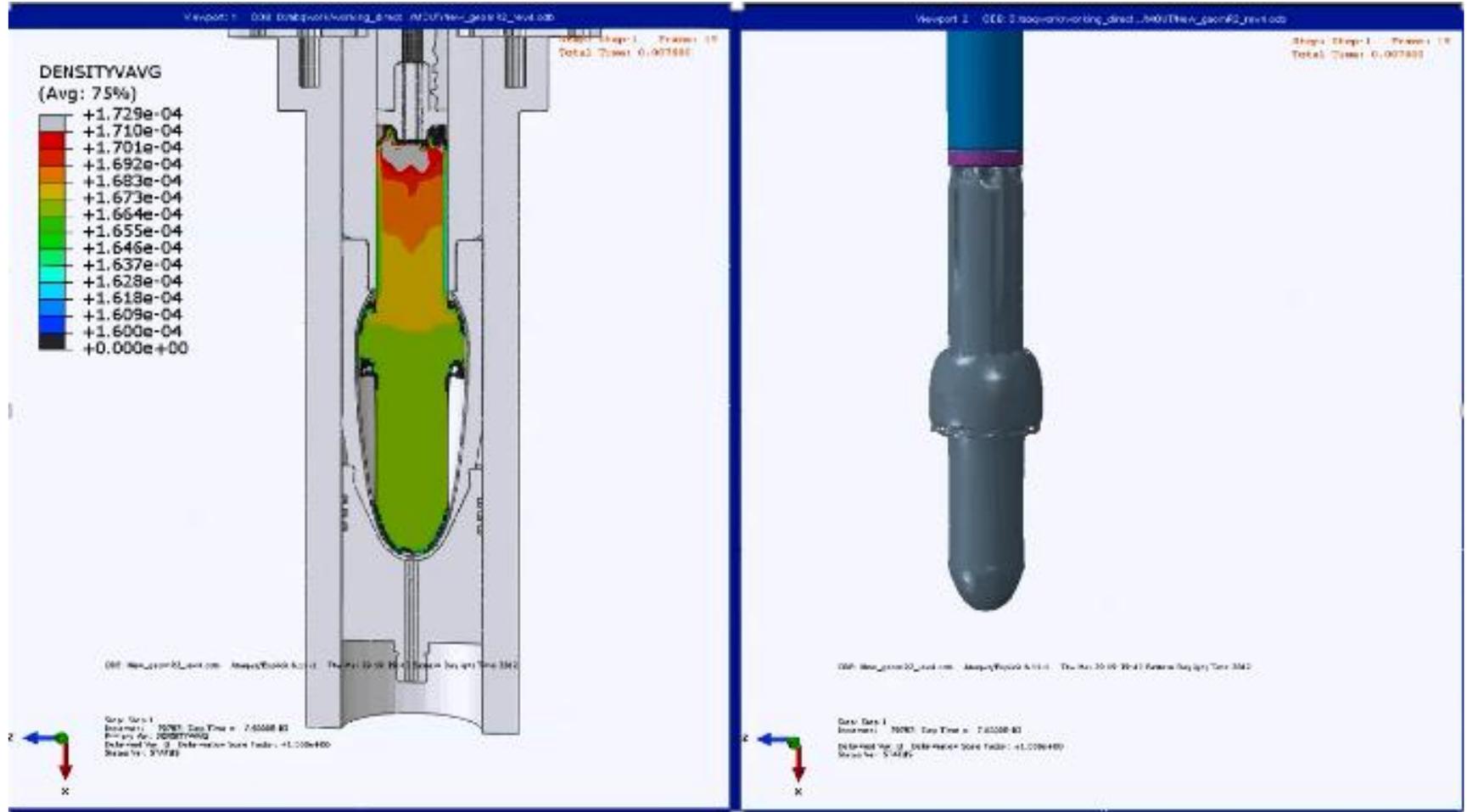
- When attempting to compact powder into long shapes, friction forces along the wall of the container cause insufficient consolidation pressure.

- Efficient consolidation may only be achieved if the punch diameter is equal to or greater than the length of container (length/diameter L/D less than 1).
- ARDEC is attempting to load items with L/D ratios over 3.
- Conventional press techniques require that powder be poured and pressed incrementally.





# Problem & Prior Solution (cont.)



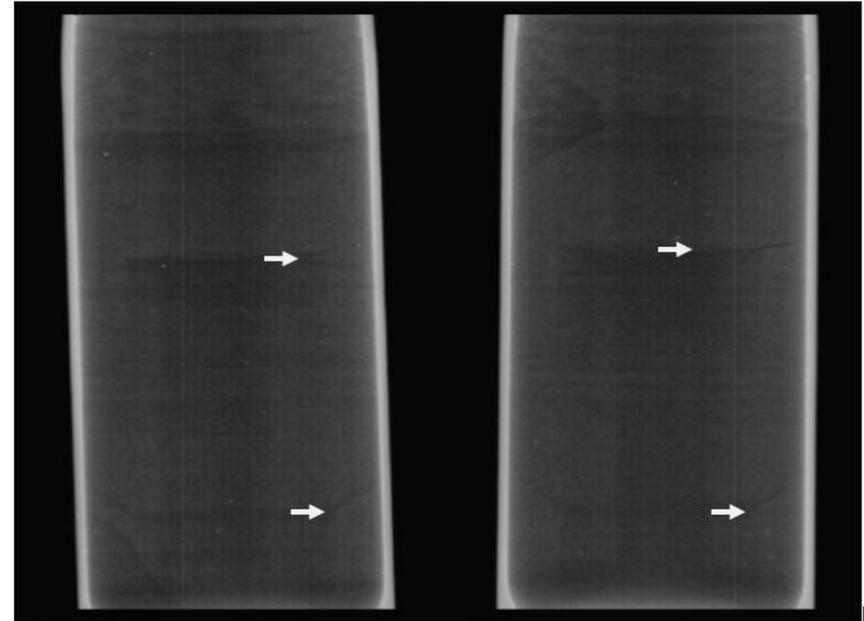


## Multi-Increment Process Disadvantages:

- Successive layers may not bond together.
- If the punch diameter is smaller than the container walls, stress concentrations at the punch corner may form cracks upon retraction.

**The traditional process employs the following solutions at the expense of cost and schedule.**

- Punch designs may be optimized for inter-layer bonding; this requires the punch to be re-tooled before the final increment.
- Longer pressure dwell times.
- More press increments.



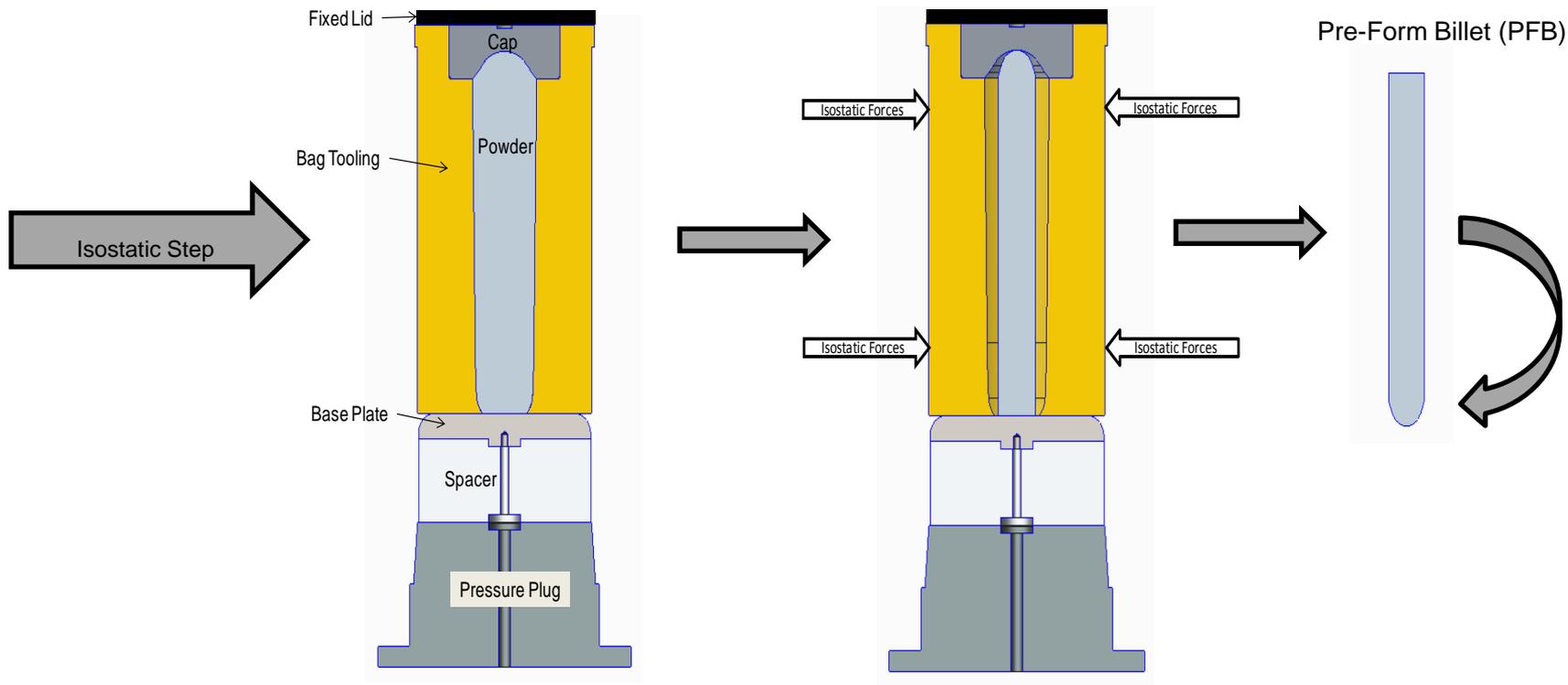
**The pressed Warhead shown here was pressed incrementally. Density gradients and cracks have formed at the boundary of each increment.**



# Description of Process

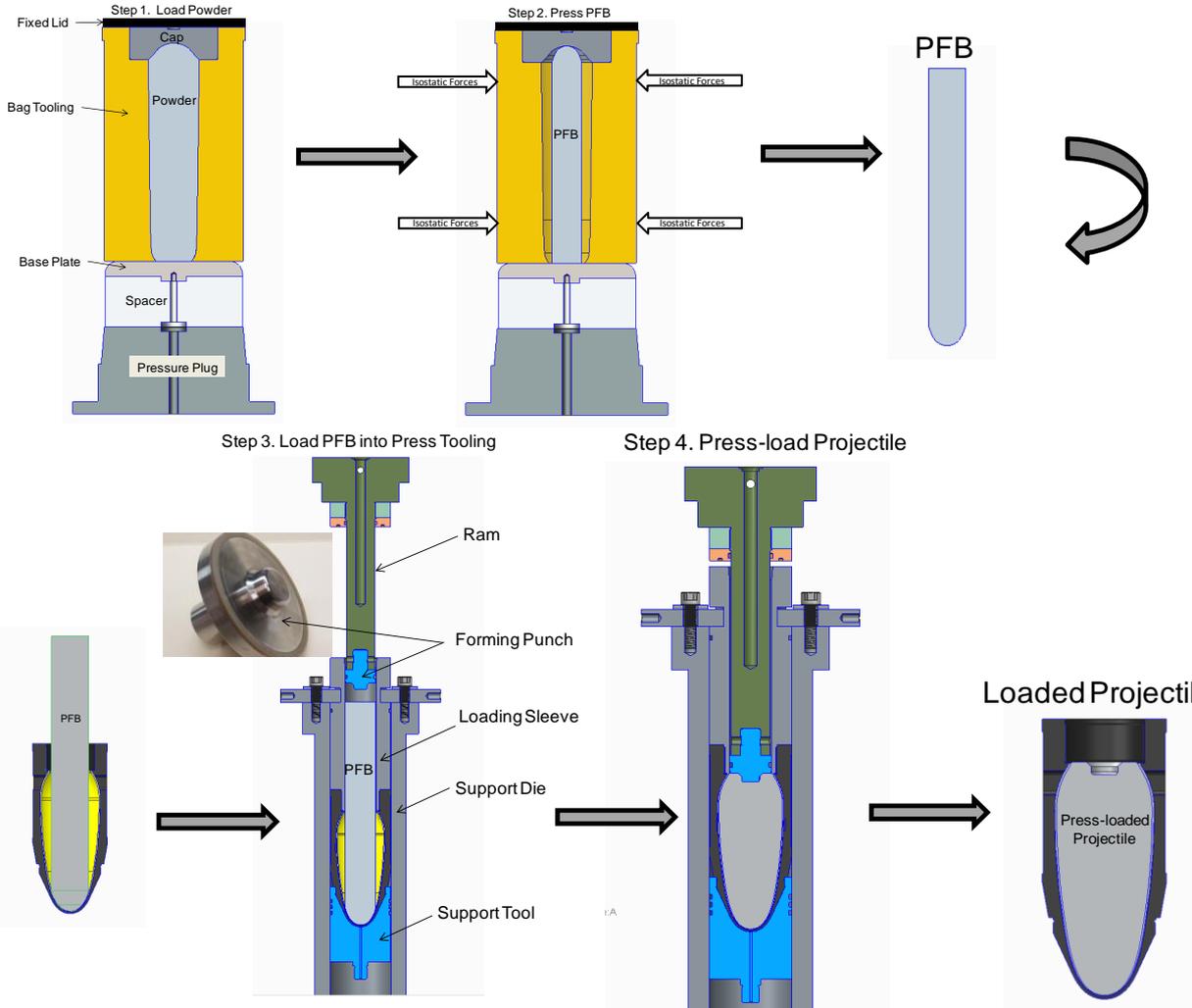


- Isostatic pressing allows for novel shapes, such as a long bare pre-form. Isostatic press technology is now mature enough for use in a high-rate production environment.
- Older presses required a bag to be submerged in hydraulic fluid within a pressure vessel. Now, most of the oil volume is replaced with a low durometer (Shore A 65) polyurethane mold.
- The interior walls of the pressure vessel (not shown) are an oil-filled bladder which applies force without exposing the mold to oil. This simplifies loading/extraction and allows for easy automation.





# Description of Process



**Step 1:**  
Press pre-form under controlled pressure, temperature, vacuum level, and dwell time.

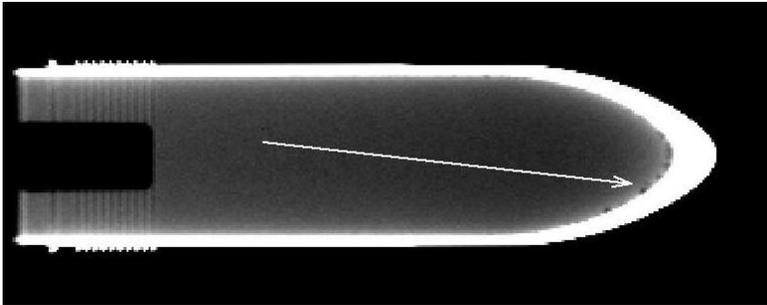
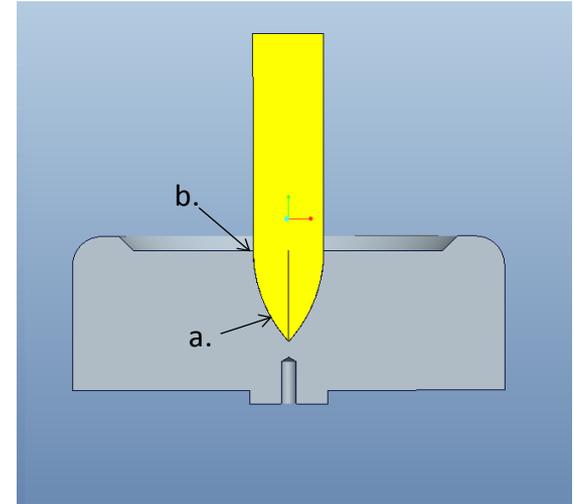
**Step 2:**  
Load PFB into a case. In addition to the parameters in step one, ram position is also controlled.



# Description of Process

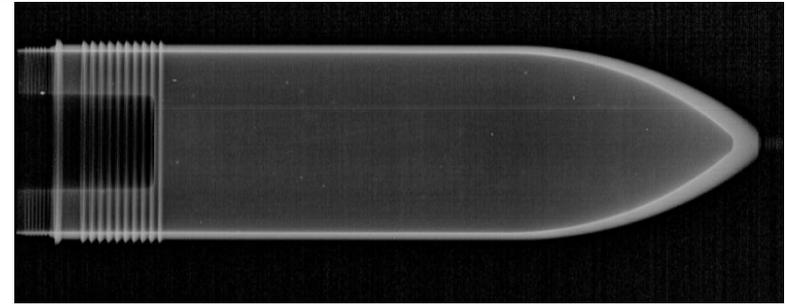


- The only voids were found near at the interface of the case and explosive near the nose. However the entire warhead reached the target density of 1.86g/cc
- Asphalt wall coatings aided cohesion and flowed to fill voids.
- The nose of the explosive was pressed to net-shape during the isostatic compaction, by machining a cavity into the base plate. This effectively reduced the L/D ratio from 4 to 3.



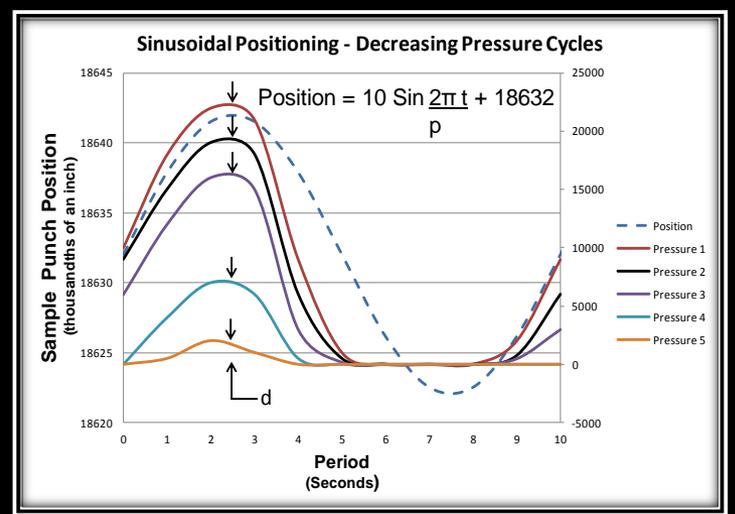
CT-Scan cross-section of the initial case-load attempt.

- Voids are visible along ogive.
- No transverse cracks.
- No interior voids.

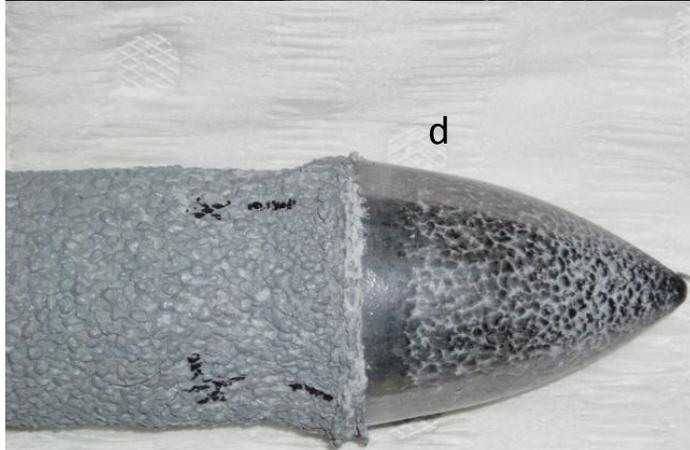
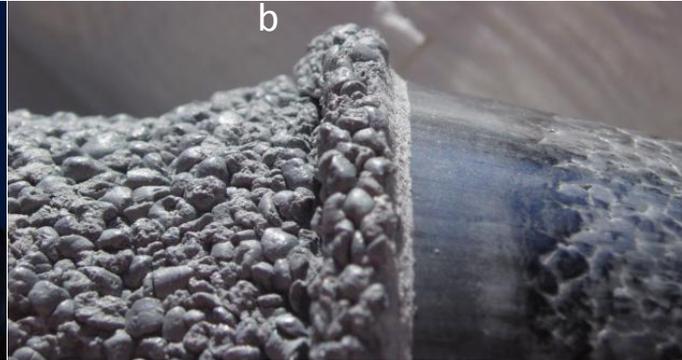


X-ray of latest case loads.

- Large voids have been eliminated.
- No transverse cracks.
- No interior voids.



- Parts were pressed to a punch position rather than pressure. Sub-torr vacuum levels were required, and maximum allowable pressure was 30,000PSI for safety/quality purposes.
- A new machine interface screen was developed, and a sinusoidal step was added to allow the part to stress-relieve and reconsolidate. However, the effects of sinusoidal loading have not been well characterized.



a. Warhead and base plate after isostatic consolidation

b. Edge of PFB. This material chips away to fit within the case. Note surface texture caused by large grains.

c. Warhead on base

d. PFB nose. Dark surface is due to graphite lubricant.

- The explosive used in development of this process was PAX-3, an Aluminized HMX composition. It is known empirically to flow well, but further study is needed to determine exactly what mechanical properties respond best to the single-increment process.



# Conclusion



**The single-increment load process carries several advantages over conventional load methods.**

- The process requires two machines rather than one; however they may be combined into one platform as shown here. Cycle times as low as 6 minutes can be achieved.
- Elimination of transverse voids produces safer, more reliable warheads.
- **US Army press equipment is already capable high throughput**
- **The pressed compositions used in these press trails are expected to be popular in upcoming designs.**
- **The Government seeks to transition this process to production facilities.**

