PRESSURE WAVE MITIGTION THROUGH THE USE OF AN ULLAGE MINIMIZATION DEVICE

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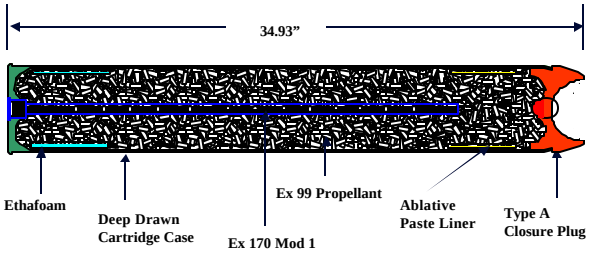
- **Development of the NSFS system has shown that the rear folding fins of the ERGM introduce an excessive amount of initial chamber volume which is leading to unacceptable pressure wave activity during the interior ballistic cycle, that has the potential to damage the ERGM electronic package as well as the gun weapon system.**



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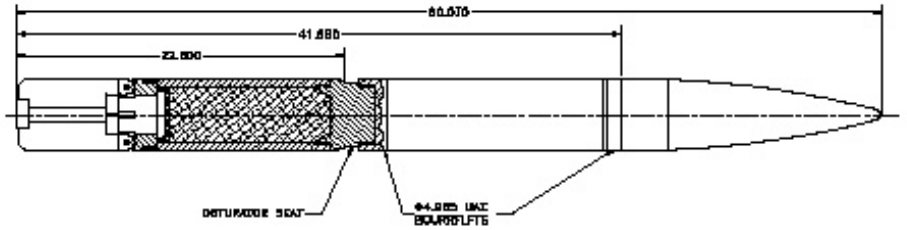

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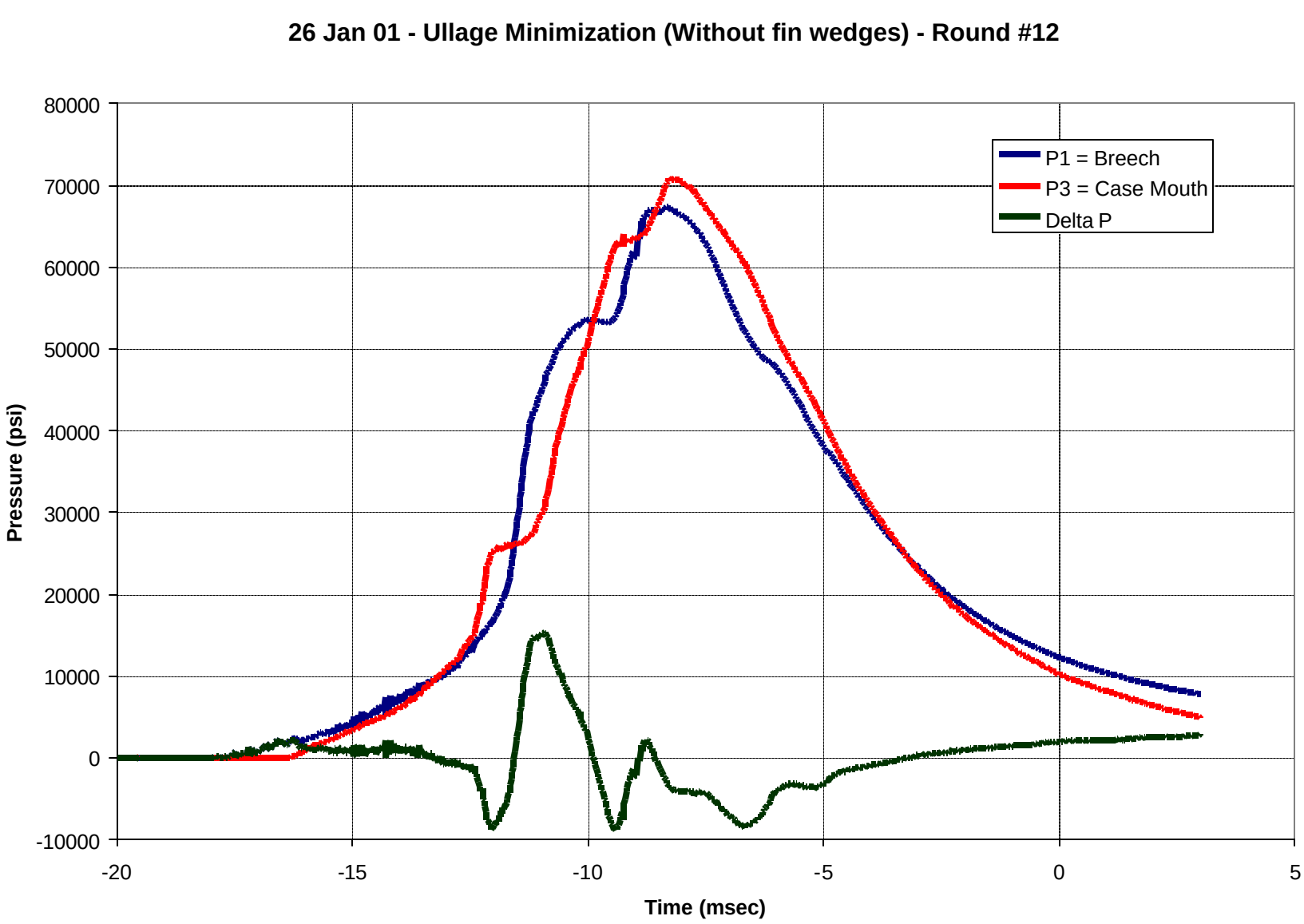
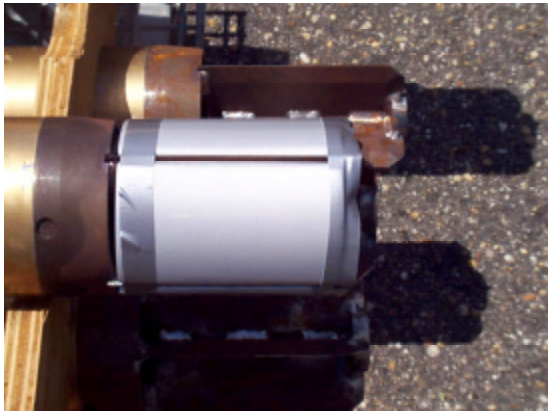

26 Jan 01 - Ullage Minimization (Without fin wedges) - Round #12
Pressure (psi)
80000
70000
60000
50000
40000
30000
20000
10000
0
-10000
-20
-15
-10
-5
0
5
Time (msec)
P1 = Breech
P3 = Case Mouth
Delta P

- **To help combat the chamber volume/pressure wave issue, ARMTEC/NSWCIHD designed and manufactured ullage minimization devices that were positioned between the rear folding fins of the ERGM projectile.**

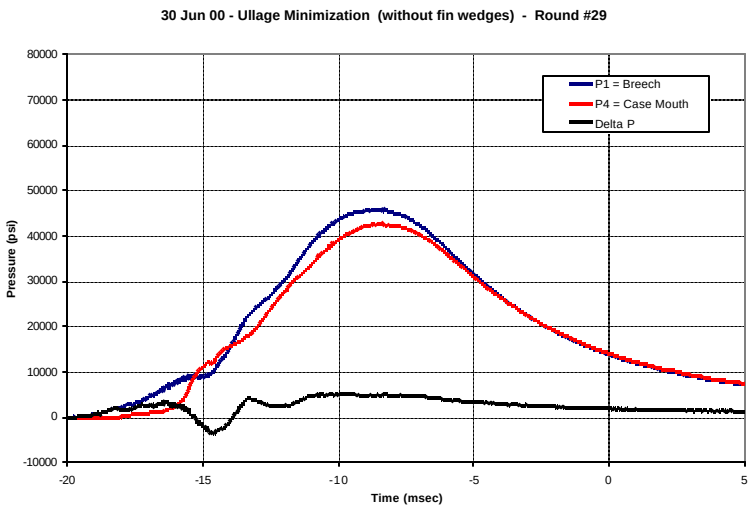
Phase #1

- Phase 1 focused on filling the free volume between the trailing tail fins with a material that would not introduce unnecessary parasitic mass and potentially provide additional energy to the system. With this goal, ARMTEC designed and manufactured light weight, thin walled hollow wedges (ullage minimization device) from a combustible material which contained approximately 64% nitrocellulose (13.35%N).

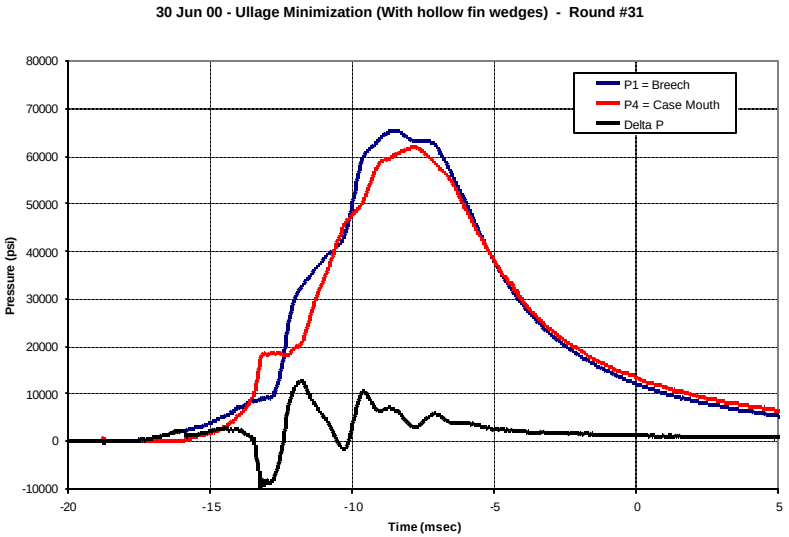




Without Fin Wedges



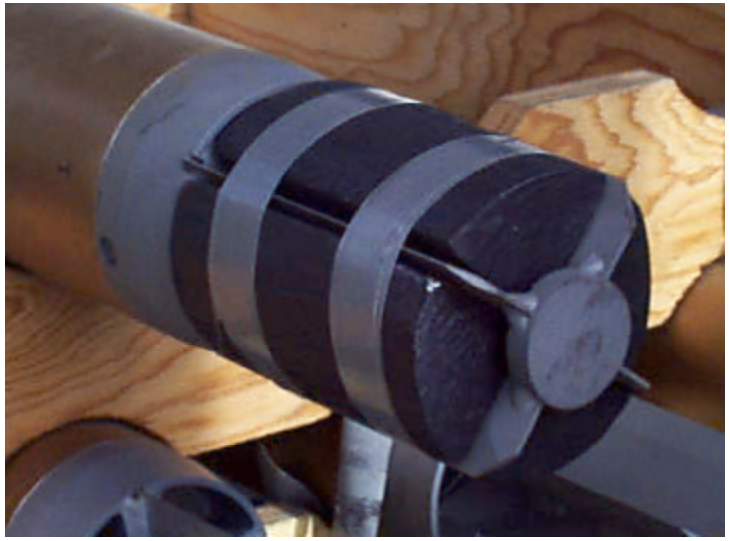
With Fin Wedges



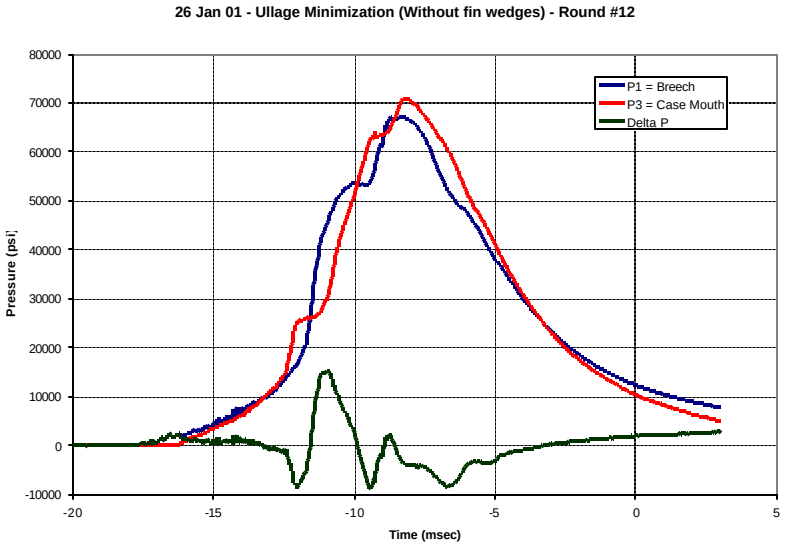
- The increase in pressure wave activity is most likely the result of the fin wedges breaking immediately upon the closure plug making contact with them. This premature failure would negate the purpose of the wedges, which was to occupy the excess chamber volume for a portion of the interior ballistic cycle. Increase in overall pressure can be attributed to the increase in pressure wave activity and energy from the fragmented combustible wedges.

Phase #2

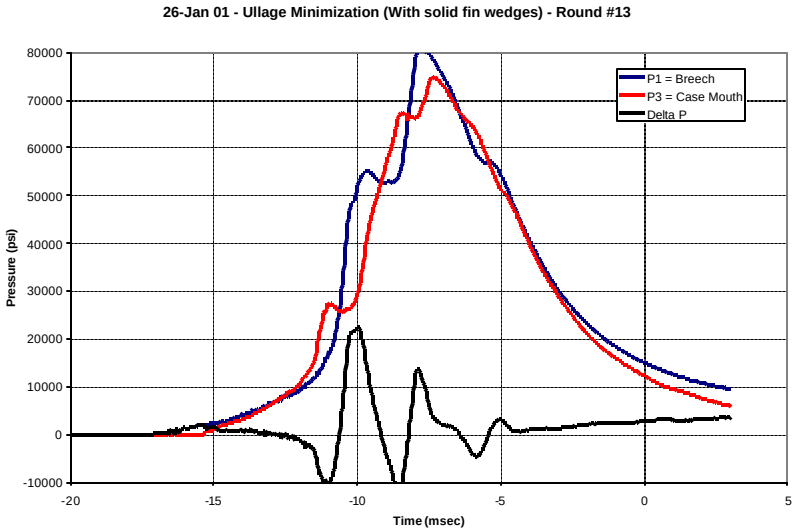
- Phase 2 focused on increasing the strength of the fin wedges so as not to break upon closure plug impact. With the new goal, ARMTEC designed and manufactured solid wedges from the same material as used in phase 1. 120mm cylindrical combustible cartridge case bodies were cut into curved laminations with laminations orientated longitudinally and bonded together to form the wedges.



Without Fin Wedges



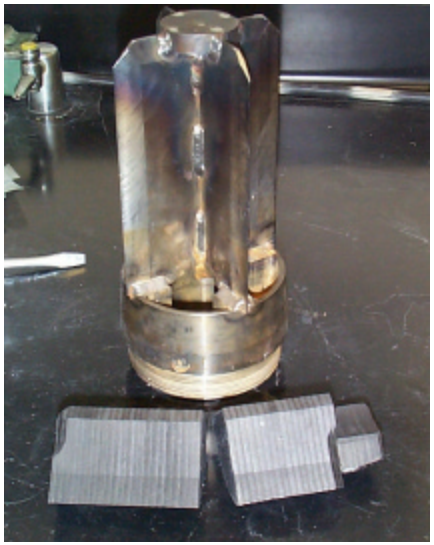
With Fin Wedges



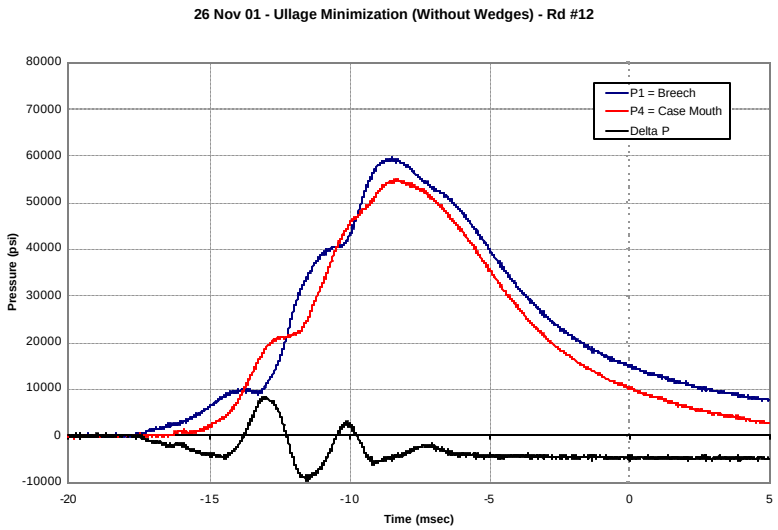
- Review of data to the theory that the wedges sheared along the longitudinal lamination lines as a result of the way in which they were supported by the projectile base. Increase in overall pressure can be attributed to the increase in pressure wave activity and energy from the fragmented combustible wedges.

Phase #3

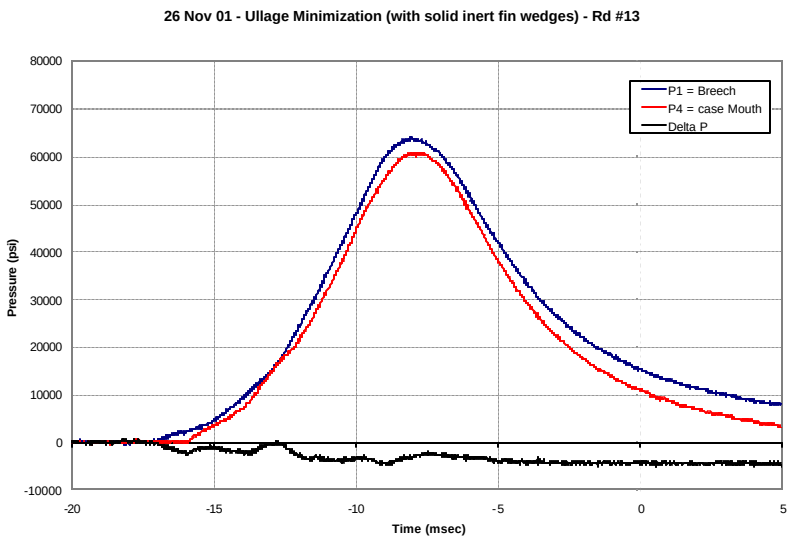
- Phase 3 focused on ensuring that the wedges were precisely manufactured to fit firmly between the trailing tail fins of the ERGM and ensure an efficient load path from which to transmit the propulsive load through the wedges to the aft bulkhead of the ERGM airframe. It was also decided to concentrate on successful ullage mitigation/pressure wave minimization without the introduction of additional energy.



Without Fin Wedges



With Fin Wedges



- **Introduction of the wedges reduced the initial chamber volume and increased overall projectile weight by approximately 3.3 pounds. Despite the additional propelled mass, the muzzle exit velocity increased to the extent that muzzle energy increased by approximately 1 MJ. This illustrates the efficiency improvements which can be realized if empty volume in front of the propelling charge can be reduced.**

Conclusions

- **In this study it was demonstrated that introduction of an ullage minimization device has the potential for significantly reducing pressure wave activity, as well as increasing overall system performance.**

- **In addition to the pressure wave reduction and muzzle energy improvements, the use of an ullage minimization device may yield additional benefits such as performing additional functions.**
  - Ram Brake

- **The ullage minimization devices, if funded and included in the final ERGM configuration could offer many if not all of the benefits described. It is thus the hope that further research in the area of ullage minimization will be funded.**