TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

# Active Self Venting Round (SEVER) Rarefaction Wave Based Projectile Launchers

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# Location & Hierarchy



Picatinny Arsenal
The Joint Center of Excellence for Armaments and Munitions

WSEC

BENÉT LABS

# ARDEC… What We Do

## Our mission:

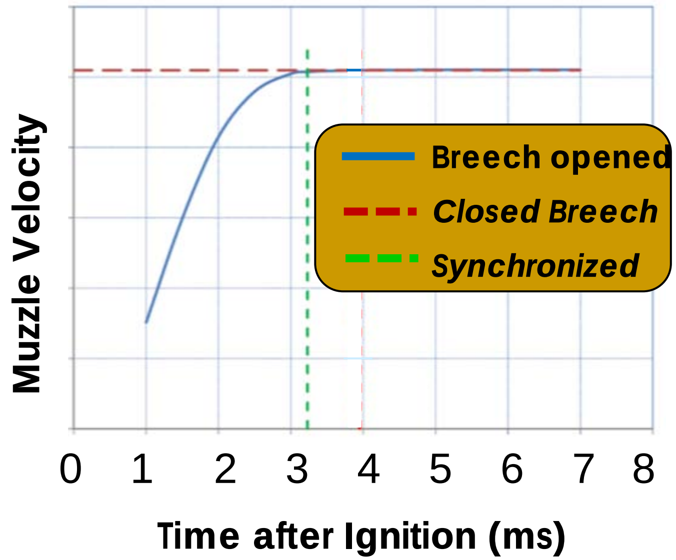
We research, design, develop, engineer and provide field support for armament systems.

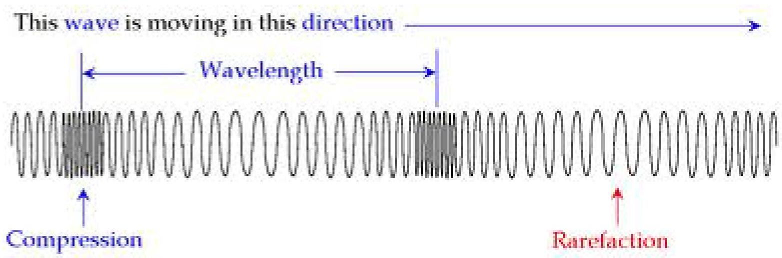
- **Motivation**
- **SEVER Technology**
  - Theory
- **Passive Venting**
  - Implementation
  - Results
- **Active Venting**
  - Implementation
  - Results

- *Weapon system that reduces recoil energy.*
- *Does not reduce muzzle velocity*
- *Reduced weight*

# Rarefaction Wave Gun Technology

- Breech intentionally opened while projectile traveling down barrel.
- Causes a rapid drop in chamber pressure
- Will not cause a decrease in muzzle velocity if the pressure loss wave (rarefaction wave) catches up with the bullet.
- Rarefaction Wave Recoil (RAR) code developed to model technology

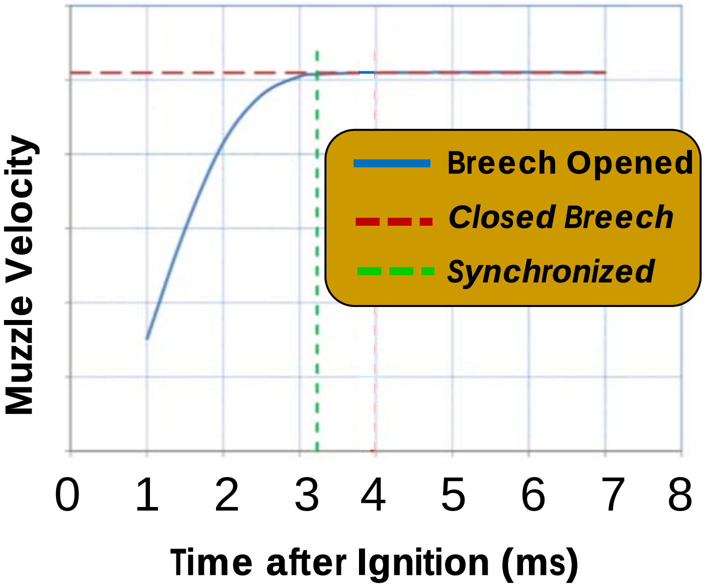


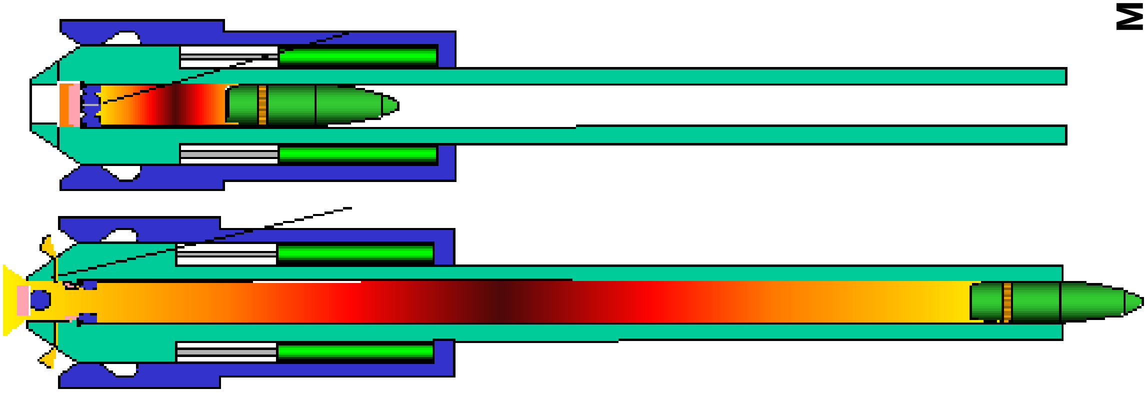




- ***Shock Wave***: increased pressure from gas behind wave front results in adiabatic heating of the gas increasing it's sound speed.
- ***Rarefaction Wave:*** reduces the pressure and density behind wave front , cooling the gas and reducing the sound speed

## Self Venting Round (SEVER) Technology

- Method used to implement rarefaction wave gun technology
- Utilizes the round as the venting medium.
- Base of breech is open.
- Base of round severed off during firing, thus opening breech.
- Offers the potential for a less complex, lighter design.
- Concept allows improved recoil mitigation performance over the current closed breech variants.



# Passive Venting

- **Motivation**
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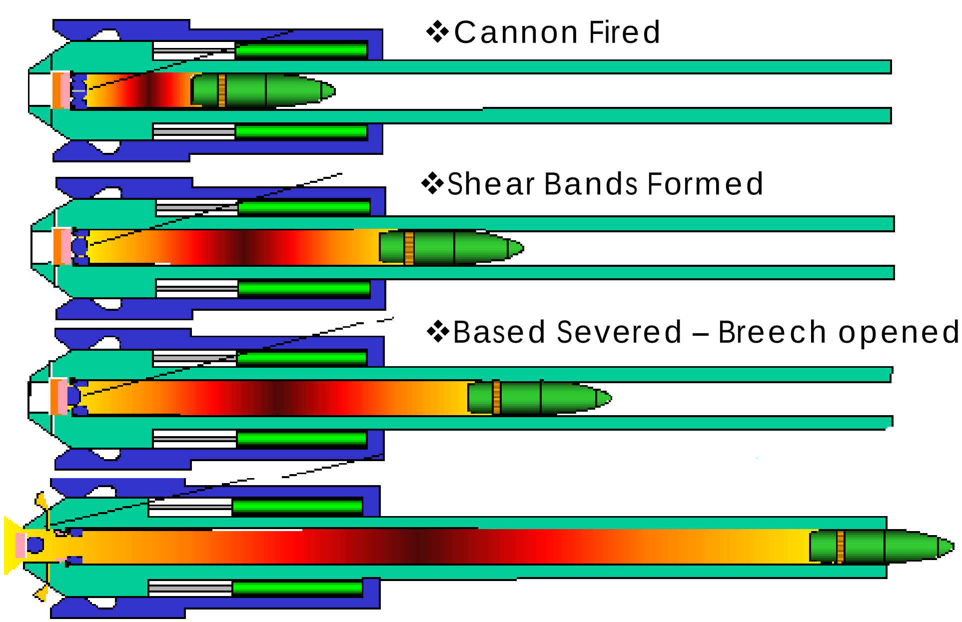
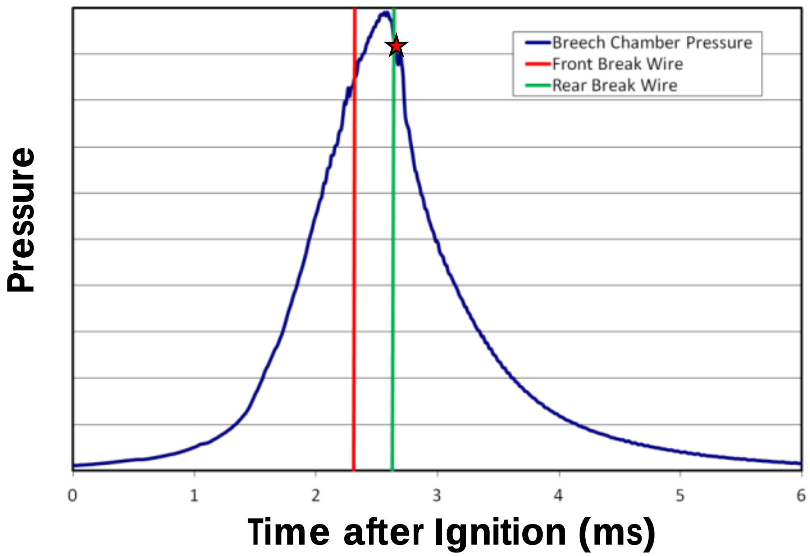
# Passive Venting

- Method uses material and geometrical design to vent
- Concept is based on the formation of shear bands to create a controlled severing of the base of the round.
- Shear bands begin forming just before peak pressure in reached
- Base is severed from cartridge slightly after peak pressure

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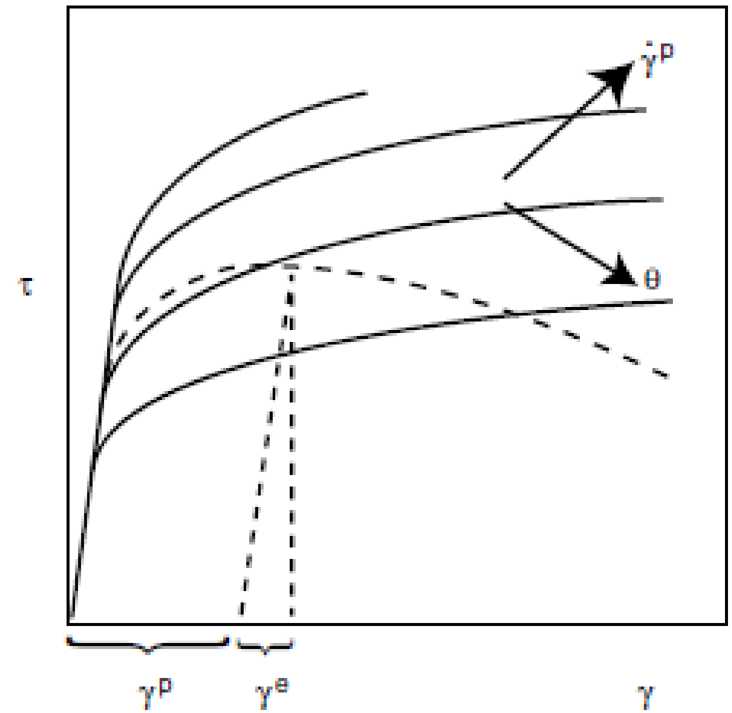
# Passive Venting

- ***Adiabatic Shear Bands*** (ASB's) are created when strain hardening, strain rate hardening and thermal softening mechanisms compete in an optimized geometry during the plastic regime
- ***Plastic Softening*** becomes dominant if given sufficient loading and strain rate causing catastrophic stress collapse

- *Isothermal curves* (***solid line***) tend to lie at higher levels with increasing strain rates.
- *Isothermal curves* (***solid line***) tend to lie at lower levels with increasing temperature.
- *Adiabatic loading* (***dashed line***) starts along an isothermal curve along a constant strain rate, but as plastic work and heating build up the stress a maximum and strain softening set in.
- As strain softening continues the material becomes unstable causing a dramatic altering of its ability to transmit shear forces.

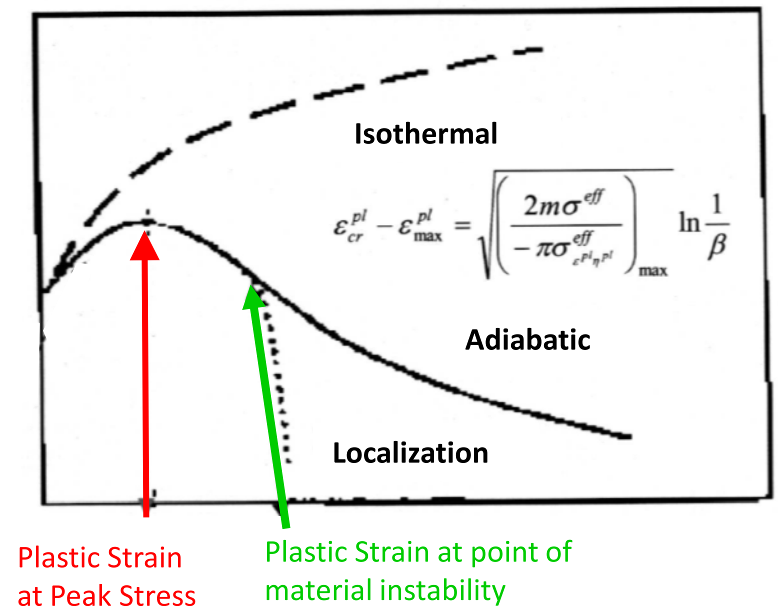


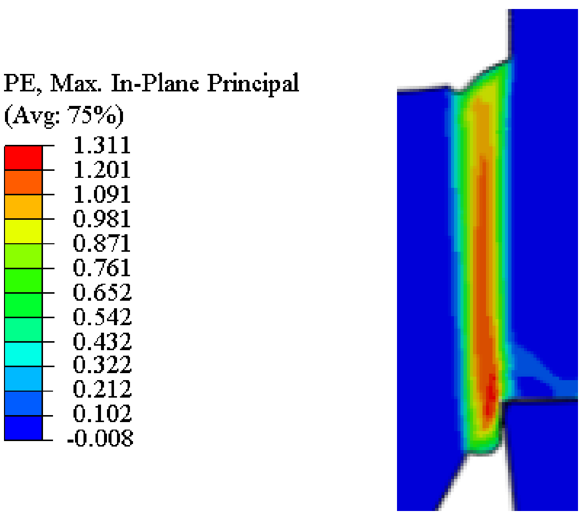

* Image from Wright - 2002

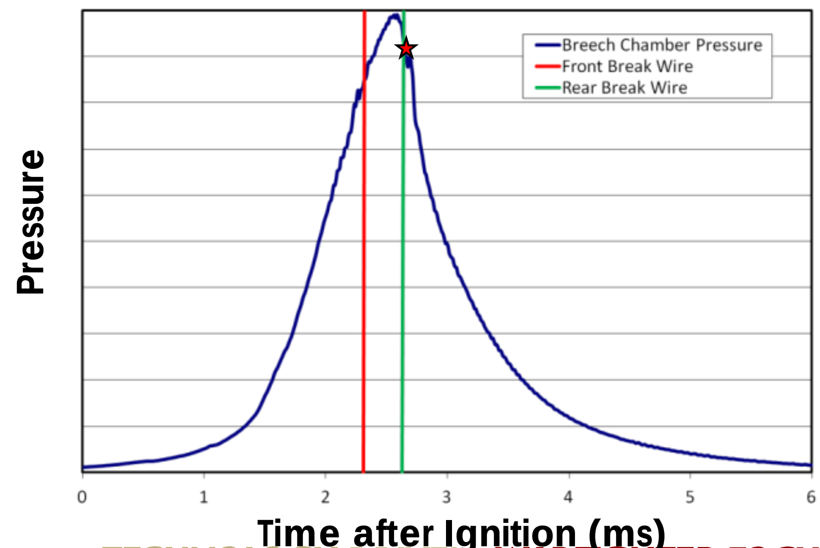
# Passive Venting

***Three Phases:***

1. *Localization:* Where one area begins to heat up from plastic work more than its neighbors ***(Red Line)***
2. *Initiation:* The temperature is this area increases until it becomes close to the materials melting temperature, and less load is supported ***(Red to Green)***
3. *Propagation:* The point where the catastrophic stress collapse occurs ***(Green line)***

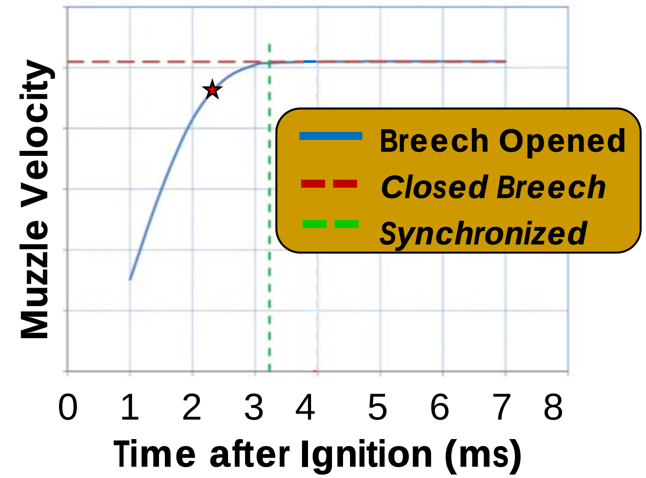


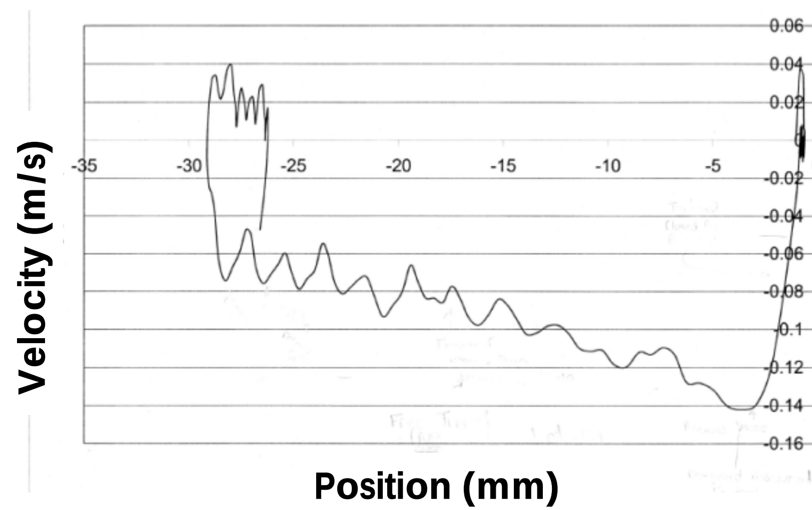



# Passive Venting

- 35mm Demonstrator cannon with modified breech was used
- Testing occurred at ARES proving ground
- 97% recoil energy mitigation
- 80% muzzle velocity
- Similar Results have been reported for the Recoilless Automatic Cannon RMK 30/35

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# Active Venting

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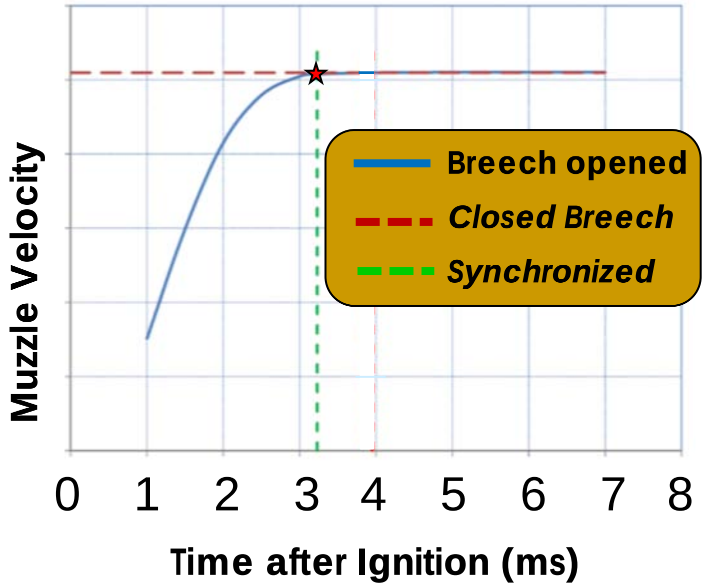
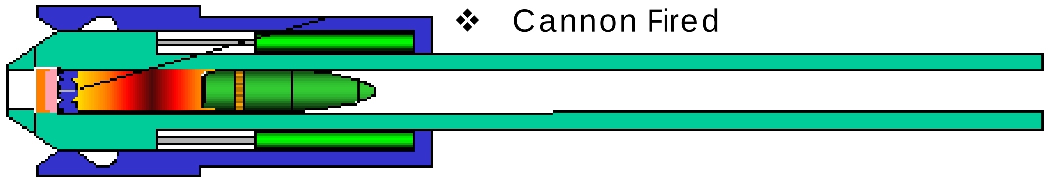
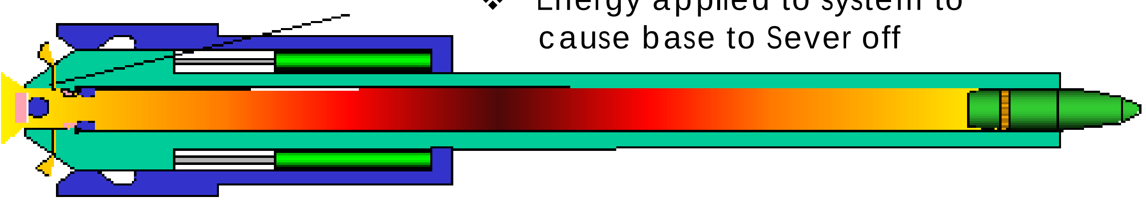
# Active Venting

- Method uses material, geometrical design and additional energy to vent
- Concept uses shear band formation as a guide from catastrophic energy to follow.
- Energy is applied to the system via a triggering mechanism to control when breech is vented
- Base can be severed from cartridge at any point during firing



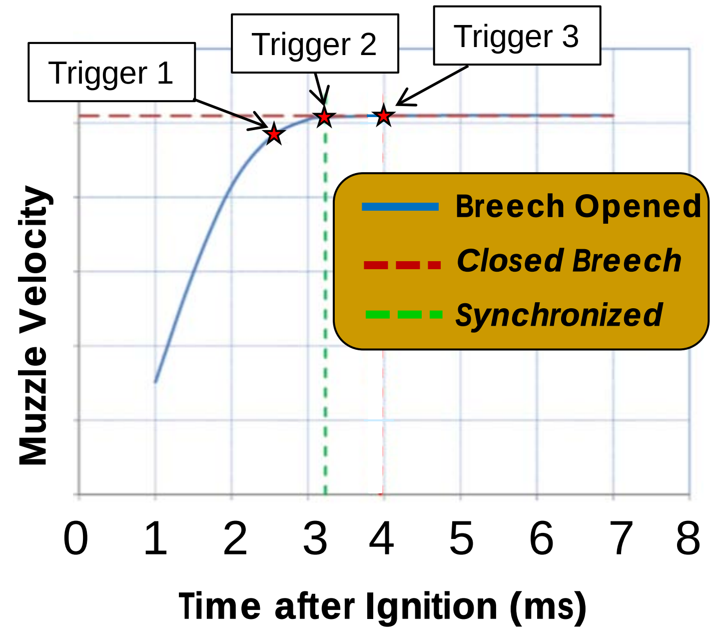
- Cannon Fired

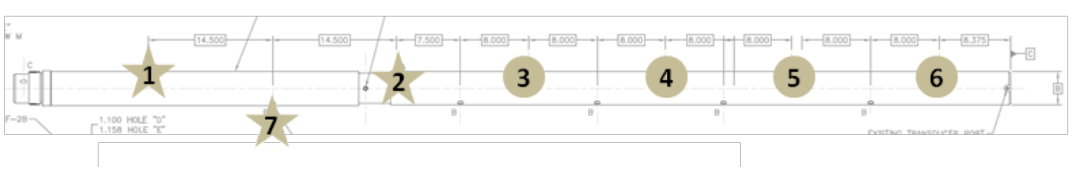


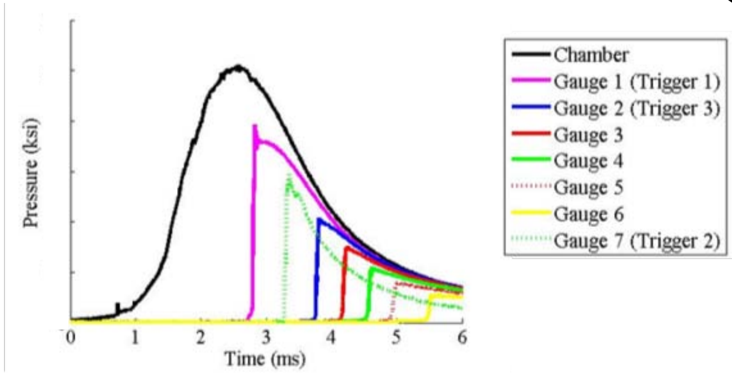
- Energy applied to system to cause base to Sever off

# Active Venting

- 35mm Demonstrator contained Six pressure gauge ports with one additional port added (gauge 7)
- Triggers (1, 2, 3) were set at gauges (1, 7, 2) to signal to additional energy added when bullet passed gauge.
- Bullet location correlated to time after ignition.

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# Active Venting

- 35mm Demonstrator cannon with modified breech was used
- Testing occurred at ARES proving ground
- Trigger 2 demonstrated synchronized rarefaction wave with maximum recoil reduction

| Trigger (1) ~1.8ms | | Trigger (2) ~3.2ms | | Trigger (3), ~3.8ms | |
|---|---|---|---|---|---|
| Muzzle Velocity | Recoil Reduction | Muzzle Velocity | Recoil Reduction | Muzzle Velocity | Recoil Reduction |
| 95% | 44% | 102% | 35% | 101% | 28% |

- ***Future Work:***
  - ***What happens if Breech does not vent?***
  - *Address fail-safe requirements*

# Summary

- ***Passive Venting*** *greatly reduces recoil, however it also significantly reduces muzzle velocity.*
- ***Active Venting*** *enables the capability to produce a synchronized rarefaction wave, thus producing equivalent muzzle velocity when compared to a closed breech system as well as reducing recoil.*