

# PENETRATION MECHANICS

## KEYWORDS

Penetration Mechanics

Armor Mechanics

Long-Rod Penetrators

Small Arms

Body Armor

Ballistics Testing

Terminal Ballistics

Ballistic Impact

Fragment-Simulating  
Projectiles

FSP

Shaped Charges

Sabot Development

Concept Evaluation

Homeland Security

**S**outhwest Research Institute® (SwRI) has been involved in penetration mechanics for over 30 years, including experimental, analytical, and computational studies. The staff is internationally recognized for their contributions to fundamental and applied understanding of the mechanics and physics of penetration.

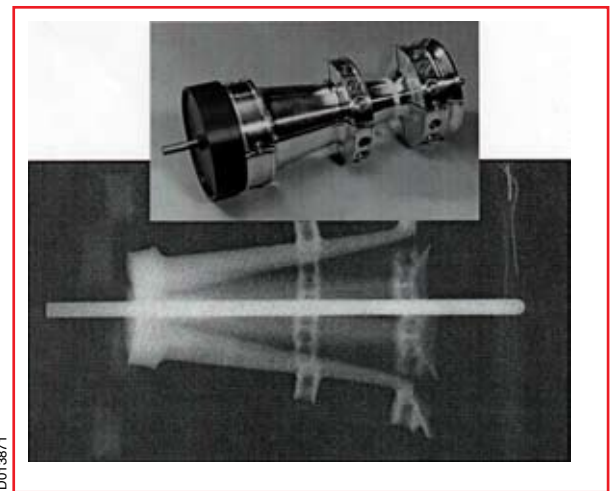
An integrated approach—experimentation, numerical simulation, and analytical modeling—is used to investigate and solve fundamental and applied problems in penetration mechanics. High-speed diagnostics and a wide variety of launchers are used to support experimental studies. Demonstrated capabilities include sabot design and fabrication for a wide range of projectiles from irregular-shaped objects to long rods with high aspect ratios ( $L/D \leq 30$ ). A complementary high-rate materials laboratory allows material characterization and determination of computational constitutive constants.

### Applications and Experience

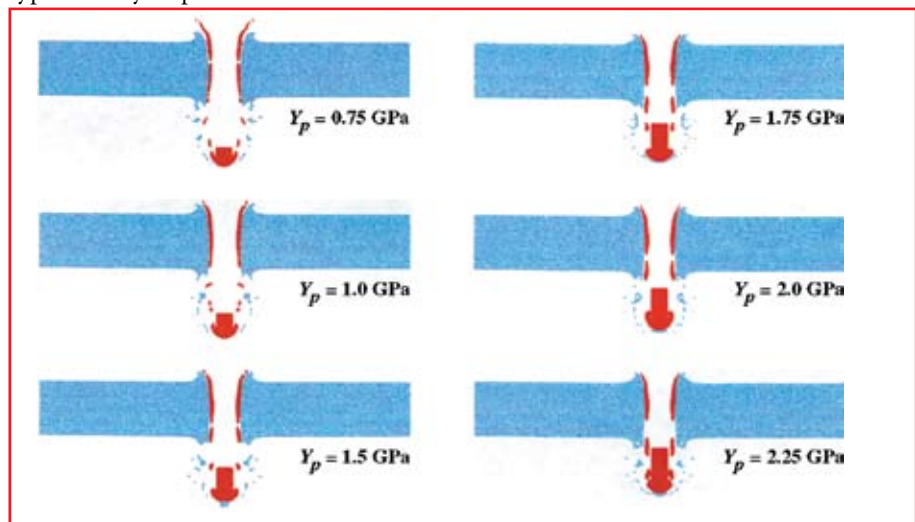
- Low-speed impact
- Small arms
- Anti-tank kinetic energy projectiles
- Advanced penetrator concepts
- Shaped-charge jet formation and penetration
- Penetration efficiency assessment
- Hypervelocity impact

### Facilities

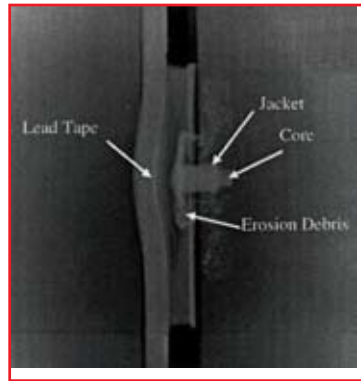
- Indoor ballistics range
- 20/30-mm high-performance gun system
- 50-mm high-performance cannon (impact velocities up to  $\sim 2.0$  km/s)
- Outdoor test areas, up to 1,000 yards
- Fully equipped instrumentation trailer (high-speed data acquisition of pressure, strain, displacement, etc.)
- Flash radiography
- High-speed video (up to 60,000 frames per second)
- Ultra-high-speed digital imaging (up to 100 million frames per second)



Long-rod projectile sabot (top) and a flash radiograph of the sabot opening in flight

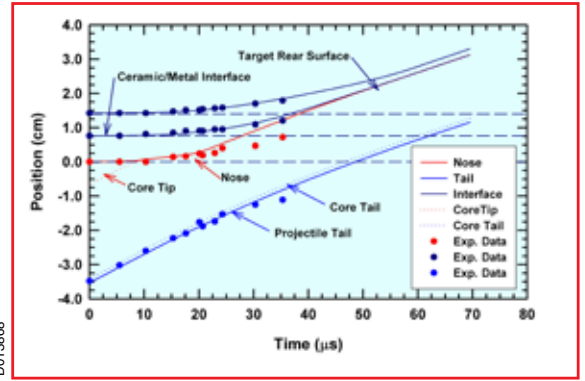


Numerical parametric study of increasing projectile strength: L/D 10 tungsten alloy projectile impacting a hard armor steel target at 1.5 km/s ( $t = 75 \mu\text{s}$ )



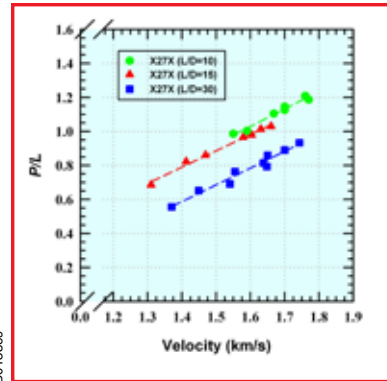
D013872

Flash radiograph of armor-piercing bullet impacting a ceramic/metal substrate target



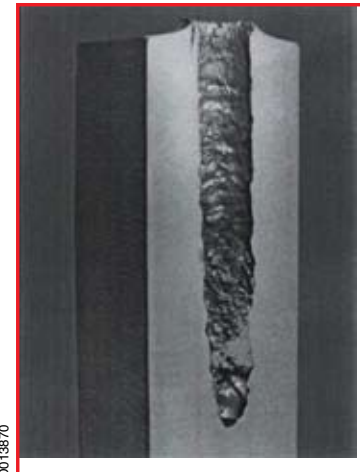
D013868

Comparison of numerical simulations to experiment of a 7.62-mm APM2 bullet impacting (at muzzle velocity) a B<sub>4</sub>C/6061-T6 Al armor



D013869

Normalized penetration efficiency vs. impact velocity for three different L/D ratio projectiles



D013870

Penetration channel for an L/D 30 tungsten-alloy projectile into an armor steel target



Southwest Research Institute is an independent, nonprofit, applied engineering and physical sciences research and development organization using multidisciplinary approaches to problem solving. The Institute occupies 1,200 acres in San Antonio, Texas, and provides more than 2 million square feet of laboratories, test facilities, workshops and offices for more than 3,300 employees who perform contract work for industry and government clients.

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