Ultra-High Pressure Waterjets in Demilitarization

Steve J. Schmit
Gradient Technology
October 9, 2013

Abstract 16298

Outline

- Background Information
  - High-pressure waterjet
- Process Parameters
  - Waterjet
  - Abrasive
  - Target interface
- Explosive-D Projectile Demilitarization
- Composition A3 Projectile Demilitarization
- UXO Demilitarization
- MLRS Rocket Motor Demilitarization
- PBX Demilitarization

High-Pressure Waterjets

- Converts pressure to velocity

  $V = (2P/\rho)^{1/2}$

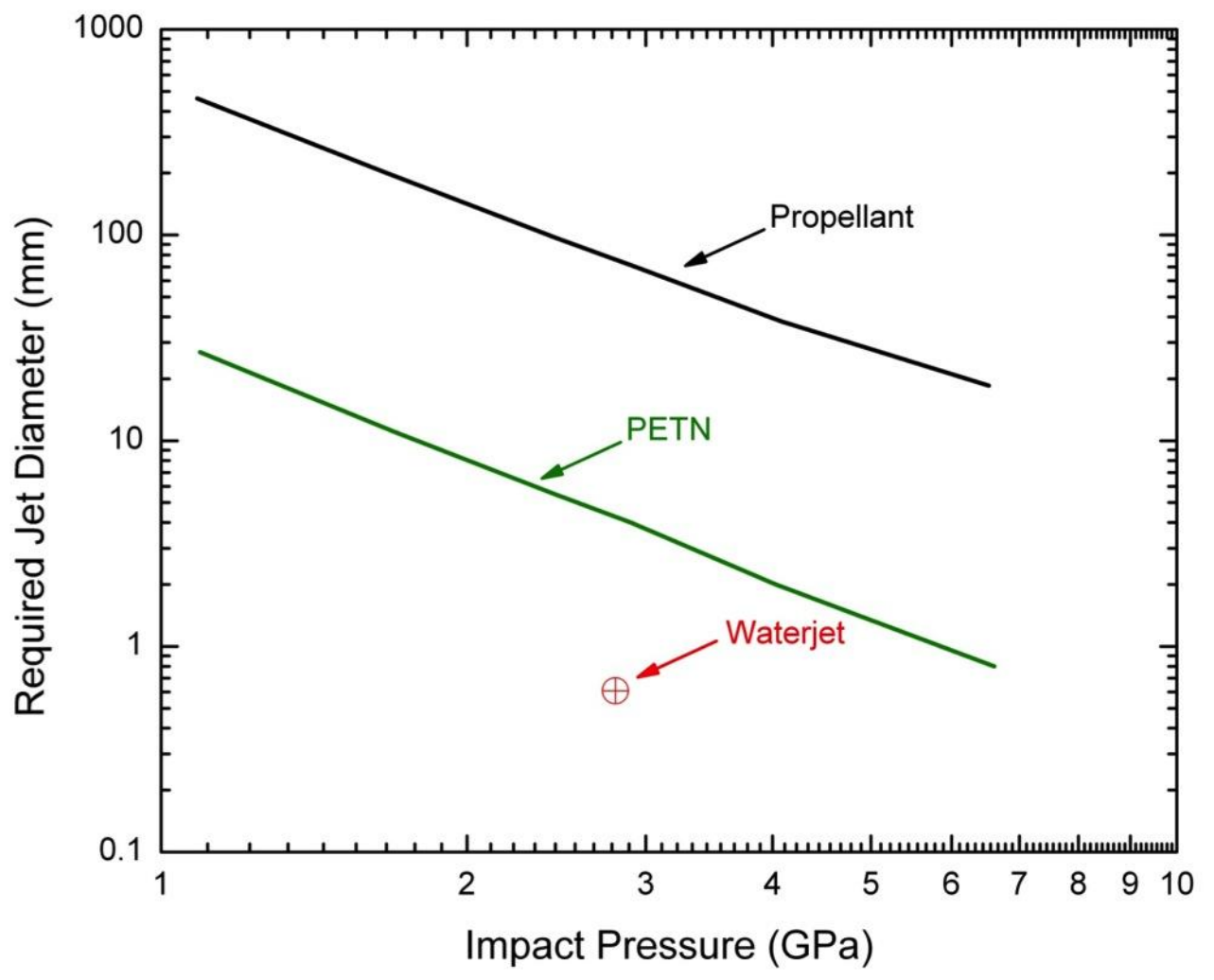
  $M_{water} = A_{orifice} V \rho$

- Abrasive commonly added to increase cutting speed
- Demilitarization use of waterjets
  - Low pressure (90 psi) used in the 1920s to demil HE projectiles
  - Medium pressure (5,000 psi) used in 1960s to demil solid fuel rocket motors
  - High pressure (55,000 psi) currently used to demil 40,000 Explosive D projectiles per year

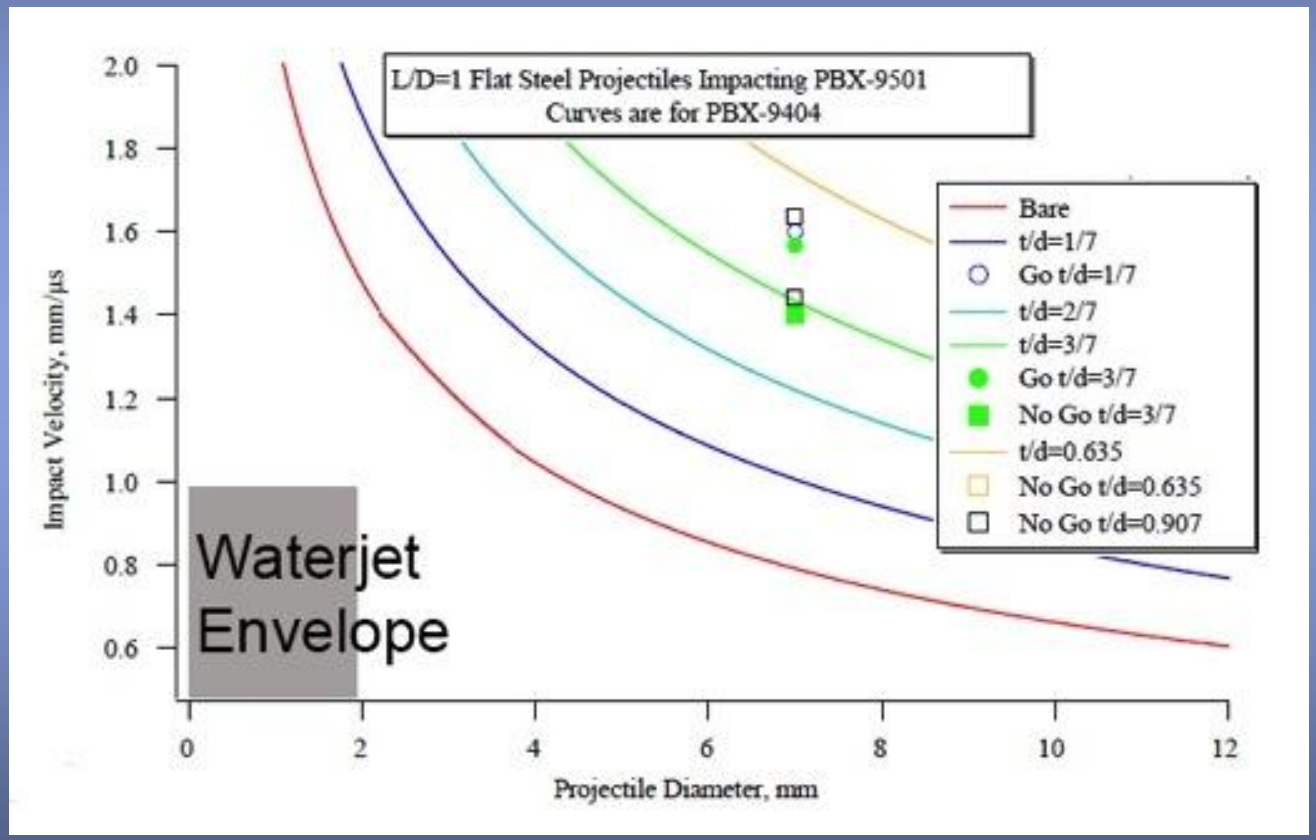
High-Pressure Waterjets Cont'd…

- Numerous safety concerns have been raised about using waterjets on PEP
  - Impact
  - Friction
  - Mechanical Sparks
  - ESD
- Commercial waterjets are safe ($P < 1x10^{-6}$) to use on PEP
  - Impact energy for pumped waterjets remains less than 0.1% of most sensitive secondary HE
  - Friction is not an issue since localized temperature rise is limited by fluid heat sink
  - Safe for use in flammable/combustible atmospheres
  - Proper bonding and grounding MUST be used to prevent ESD

High-Pressure Waterjets Cont'd…



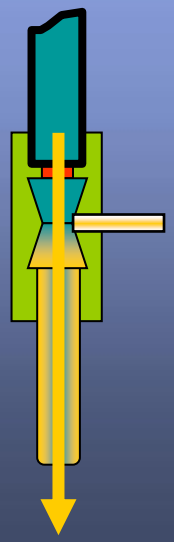
High-Pressure Waterjets Cont'd…



Impact Initiation of PBXN-110 and PBX-9501
Presented by L. M. Hull at 30th Explosives Safety Seminar Atlanta, GA
August 13-15, 2002

Process Parameters

- Waterjet process parameters
  - Hydraulic parameters
    - Motive fluid – density and viscosity
    - Pressure
    - Mass flow rate – orifice size and pump power
  - Abrasive waterjet mixing and acceleration parameters
    - Mixing tube diameter
    - Focusing tube diameter and length



Process Parameters Cont'd…

- Abrasive parameters
  - Mass flow rate
  - Abrasive morphology
    - Size
    - Distribution
    - Shape
  - Abrasive physical properties
- Target interface parameters
  - Tip standoff distance
  - Traverse velocity
  - Impact angle(s)

Explosive-D Projectiles

- Automated system processes 40,000 3”, 5”, 6”, and 8” projectiles per year
- Abrasive waterjet cuts and removes base fuze
- Waterjet (no abrasive) used to remove Explosive D

Explosive-D Projectiles Cont'd…

Mechanical and Chemical Processing

Composition A3 Projectiles

- Pilot plant designed, constructed, and demonstrated to wash out Comp A3-filled projectiles
- Abrasive not needed to access fill since nose fuze can be removed

Composition A3 Projectiles Cont'd…

- Projectiles were prepared (Pull-Apart / Fuze Removal) by CAAA
- 5" / 54 and 5" / 38 projectiles washed out via Nose Fuze Port
- 106mm Cartridge projectiles washed out via Base Port
- 5" / 38 projectiles had Base Fuzes attached during processing
- 77 total items processed and ~600 LBS of Comp A-3 Generated

Composition A3 Projectiles Cont'd…

- Upgraded washout system at HWAD in 2013
- 5" / 38 projectiles washed out via Nose Fuze Port
- 162 total items processed
- LRIP scheduled for spring 2014

UXO Demilitarization

- Gradient Technology utilized a portable high-pressure waterjet system to safely section in excess of 500 UXO items in 2003 at NSWC-White Oak

UXO Demilitarization Cont'd…

- System designed to handle 3000 lbs
- Fabricated of stainless steel
- Utilized remotely operated high-pressure waterjet to cut through steel, concrete and energetics

UXO Demilitarization Cont'd…

- Gradient Technology utilized its portable high-pressure waterjet system to safely section in excess of 500 UXO items in 2006 at Indian Head

UXO Demilitarization Cont'd…

Mk84 bomb

2000 lb sea mine

Missile

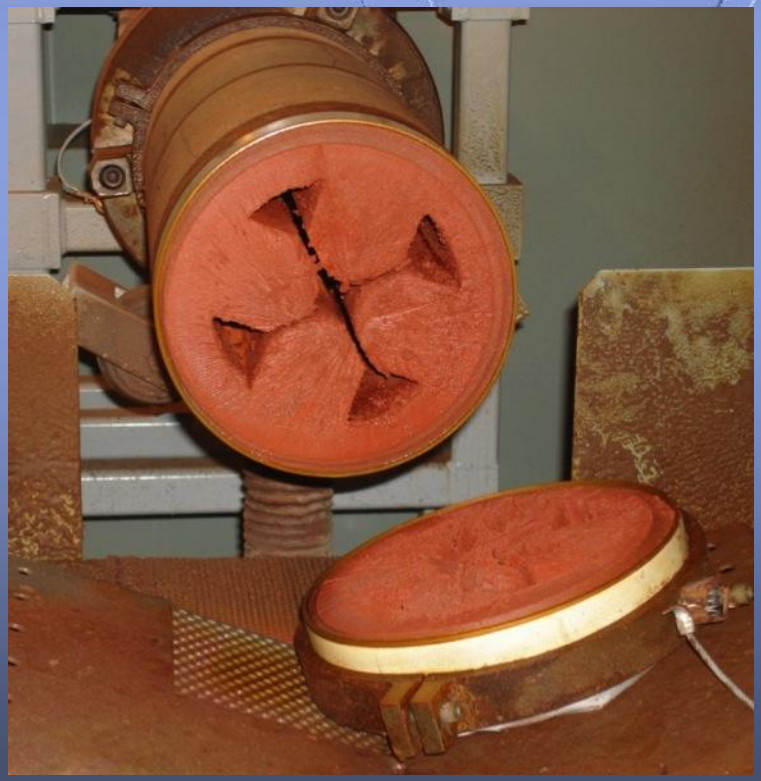
MLRS Rocket Motors

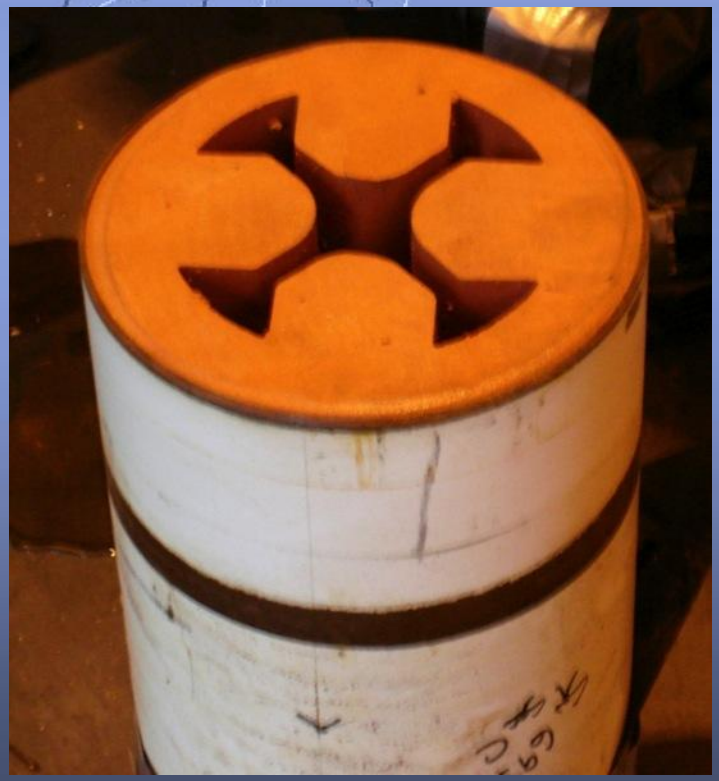
- Tested waterjet system with live rocket motor at Redstone Arsenal Building 7695
- Cut 3 live rocket motors
  - M26 MLRS rocket motor segment without nozzle. Contained 6 mm *Arcadene 360B* propellant rind.
  - M26 MLRS rocket motor 13-inch segment without nozzle. Contained full *Arcadene 360B* propellant cross section.
  - M26 MLRS rocket motor 24-inch segment without nozzle. Contained full *Arcadene 360B* propellant cross section.

Inert Rocket Motor Segmenting Cont'd…

Live Rocket Motor Segmenting Cont'd…

- M26 MLRS rocket motor 13-inch and 24-inch segments without nozzle





PBX Demilitarization

- Pilot plant designed and built to wash out PBXN-109 from warhead and recover high purity RDX and aluminum

PBX Demilitarization Cont'd…

Initial PBXN-109 surrogate round

Slurry collected from high pressure washout

PBXN-109 surrogate round after washout

Conclusions

- Ultra-high pressure waterjets can safely and effectively demilitarize ordnance and allow for the recovery of metals and energetic fills
- Ultra-high pressure waterjets are especially effective for the demilitarization of cast-cured energetic fills that cannot be removed via melting
- Ultra-high pressure waterjets allow for munition body recovery and reloading

Acknowledgements

Defense Ammunition Center
McAlester, Oklahoma