Performance Evaluation of Reduced Sensitivity Explosives with Novel Applications

2018 IM & EM Technology Symposium

Elizabeth Francois, Bryce Tappan, Patrick Bowden, Rose Burritt, Rajesh Patel

Elizabeth Francois

4/25/2018

High Explosive Pellet Pressing Incident

Elizabeth Francois

Insensitive Munitions and Energetic Materials
Technology Symposium 4/25/2018
LA-UR-23440

Overview

- The details of the Event
- Possible causes
- Lessons learned and the path forward

A routine day of pressing explosives

- At 9am Monday 4/2/18 an operator was preparing to press 1” x 1” PBX 9501 pellets
- 930ish metal fatigue sound heard
- Event occurs

25 Ton Carver press (not the Event press)

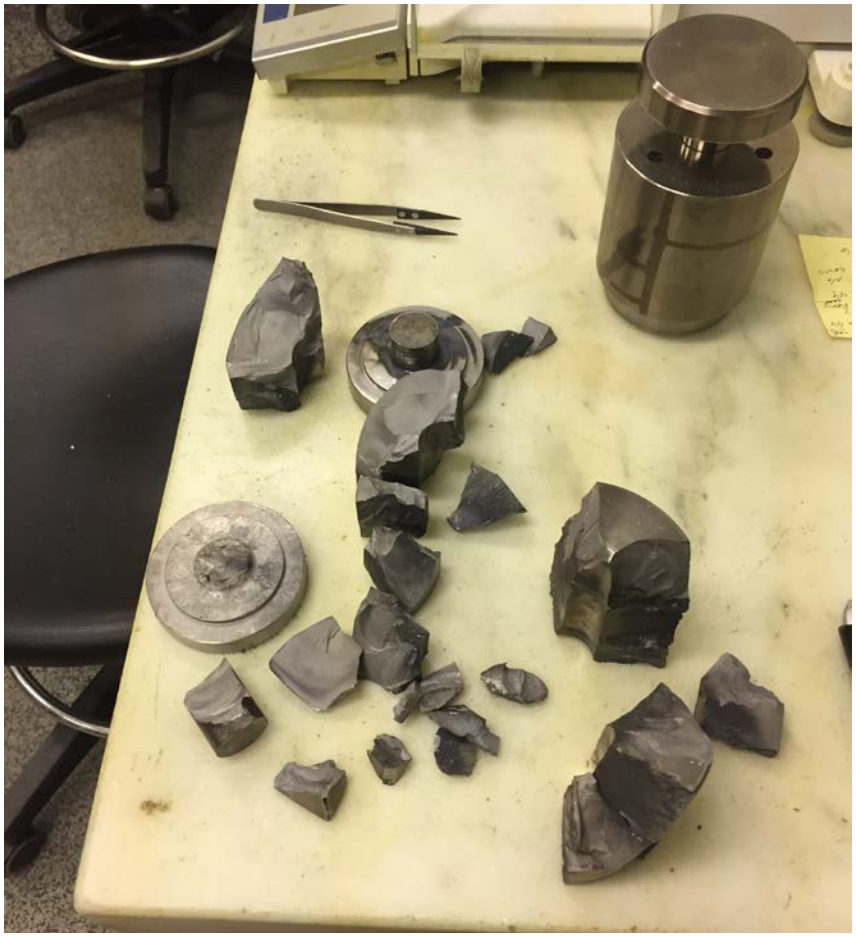
- The press has heated platens
- There is a secondary controller for the heat
- Shielding consists of ½” Lexan, ¼” air gap and another ½” Lexan plate/
- 30g of HE can be pressed with the operator in the room.

The Press involved in the Event

The personnel present for the Event

- One worker and one escort were present.
- Both were 10-12 feet from the press.
- Both were OK!
- Both sustained hearing loss, possibly not permanent.
- Shielding worked. No frag escaped.

One inch die, before and after



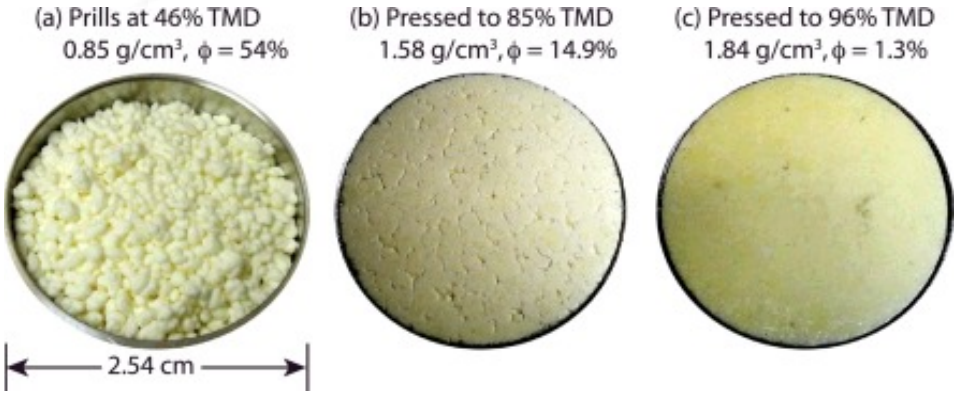
- The die was made of tool steel.
- The steel shattered, and showed no evidence of detonation.
- 23.6g of PBX 9501 was being pressed
- No HE was found after event.

Causes and Hypotheses

- The cause may never be known

- Hypothesis #1
  - The PBX 9501 was at fault in some way
- Hypothesis #2
  - The stemple was cocked in the die, gouging the die polish and creating friction heating.
- Hypothesis #3
  - Metal fatigue sound heard just before Event was the die body or stemple cracking and failing.

Hypothesis #1 PBX 9501



Was there something wrong with the molding powder that caused it to react violently?

- This was a well characterized, ex-WR lot from 1989 that has been extensively studied
- Thousands tests incorporating millions of pellets have been performed.
- No previous accident at LANL with 9501 has been recorded.
- Small scale safety testing (Impact, Friction, DSC, VTS) showed it to be within normal parameters.

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memorandum

Explosive Science and Shock Physics
M-7: High Explosives Science & Technology

To/MS: Distribution
From/MS: Geoffrey W. Brown, M-7
geoffb@lanl.gov
Phone/Fax: 7-6718/Fax 7-0500

Symbol: M-7-AC-18-029 U
Date: April 18, 2018

Material Safety Release: PBX 9501 HOL89C730-010

The material PBX 9501 HOL89C730-010, submitted to M-7 Analytical Chemistry on April 3, 2018 meets the safe handling requirements for explosives as defined in P101-8, rev 4, section 3.2.13.

NOTE: This memo documents the results of M-7 high explosives safe handling and storage testing only and in no way certifies that this material meets all safety, compositional, or material requirements. All IWDs or other work control documents should be reviewed for suitability of this material for specific applications.

Lab Number **52753**
Material Code **PBX 9501 HOL89C730-010**
Manufacturer **Holston**

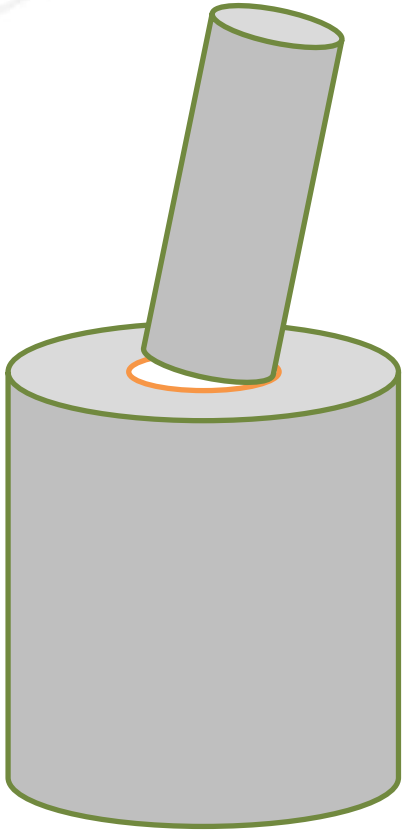
Test	PBX 9501 HOL89C730-010	Reference
Impact (Type 12) H_{50} (cm)[a]	28.6	PETN (0601-02 L-298) 9.6
Friction Load$_{50}$ (N)[b]	244.3	PETN (0601-02 L-298) 66.4
Spark Screen or Til*** (J)[c]	*0.125	PETN (0601-02 L-298) *0.0625
DSC (10°C/min ramp in N_2 atmosphere)		
Onset of Decomposition (°C)	246	PETN (94-01B) 165
Peak Exotherm (°C)	280	PETN (94-01B) 205
Vacuum Stability (ml/g) (Gas evolved after 48hr @ 120°C)	0.16	N/A

a. Drop height resulting in a "go" in 50% of samples obtained through a Neyer D-optimal testing method.
b. Force resulting in a "go" in 50% of samples obtained through a Neyer D-optimal testing method.
c. TIL test: Highest level at which 20 consecutive No-Go results are observed. Screen test: 13 No-Go results at 0.25 J.

Distribution:
E. Francois, M-7,
elizabethf@lanl.gov
M-7 Group Office

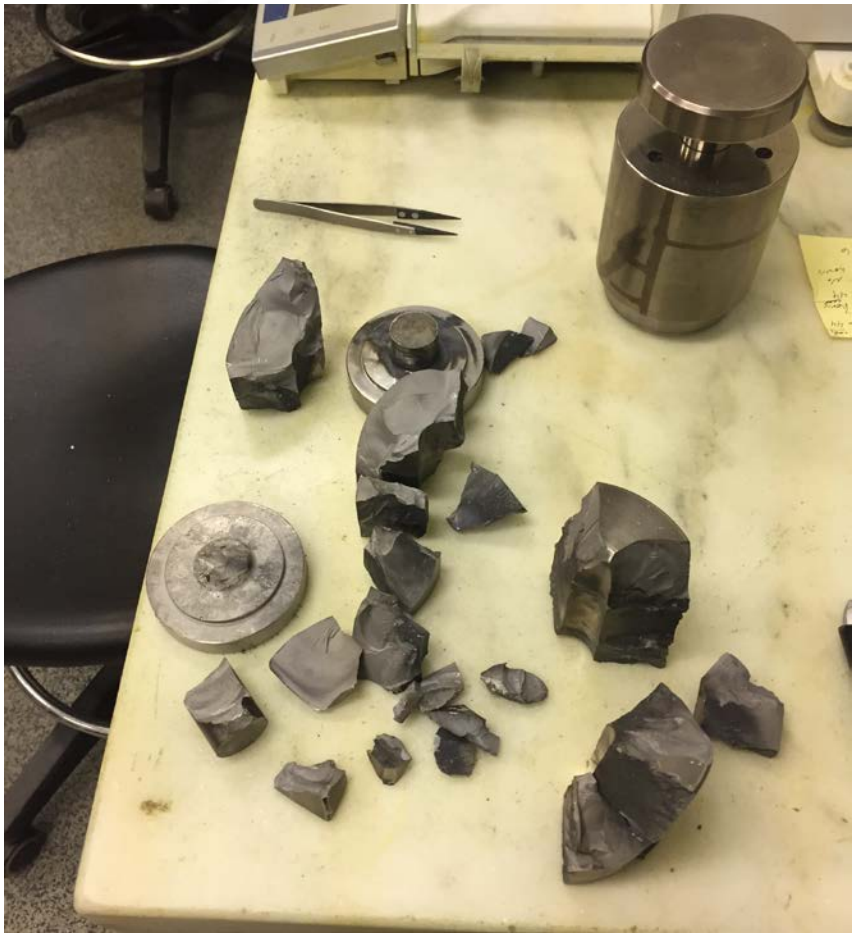
Reviewed:
G. Brown 4/18/18 Date

Hypothesis #2 The stemple was angled



- Pellets are pressed in cycles
- A cycle consists of a pressing phase and a relaxation phase.
- This is done to increate density and pellet quality
- The stemple moves mostly during the first cycle only.
- The event occurred on the fifth cycle.

Hypothesis #3 Metal Fatigue causing a die failure



- The operator heard a metallic sound immediately before the event occurred.
- The sound could have been from some failure of the die.

Lessons learned

- The controls put in place worked.
- Improvements can be made:
  - Shielding Improvements
  - Formalized Non-Destructive Testing
  - Formalized die maintenance
  - Addressing hearing protection
- The path forward
  - Restart

Shielding as defined by the DOE Standard Explosives Safety

Table II-6. Safety Shields for Explosive Laboratory Operations*

Shield	Minimum distance from explosive	Explosives limit
Leather gloves, jackets, or coats, and plastic face shields	----	.77 gr (**50 mg**)
.12 in (**3 mm**) tempered glass	3.15 in (**8 cm**)	.77 gr (**50 mg**)
.2755 in (**7 mm**) Lucite/equivalent material	5.905 in (**15 cm**)	.0882 oz (**2.5 g**)
.8 in (**20 mm**) Lucite/equivalent material	5.905 in (**15 cm**)	.3527 oz (**10 g**)
.6 in (**15 mm**) laminated resistant glass	7.874 in (**20 cm**)	.7054 oz (**20 g**)
.9999 in (**25.4 mm**) Lexan/Lexguard	11.81 in (**30 cm**)	1.764 oz (**50 g**)
2 units each of .9999 in (**25.4 mm**) plate glass laminated with .4882 in (**12.4 mm**) polycarbonate with a .374 in (**9.5 mm**) air gap between units (glass sides facing the explosive)	11.81 in (**30 cm**)	1.764 oz (**50 g**) (steel confined)

Shielding improvements

- Lexan is good at stopping fragments, but what is better?
  - Thicker lexan?
  - Lexan with a tempered glass inner layer
  - Bulletproof glass? Bulletproof fiberglass?

Non-Destructive Testing

12.2. Pressing

12.2.1 General

(c) Pressing mandrels, punches, and dies used in explosives operations shall be examined regularly during periods of use for evidence of structural failure. Suitable nondestructive test methods shall be used to perform the examination. Site management shall establish intervals between inspections for each tooling design before committing the tooling to use. The inspection interval and updating should be based on experience with similar tooling designs and configurations. All new or modified mandrels, punches, and dies shall be inspected before their first use. At least one pressing cycle should be completed with mock explosives before proceeding to explosives.

NDE continued

AET-6 personnel assisted us with formalizing NDE

- Magnaflux: Ferrous materials, surface defects.
- Dye Penetration: Non-Ferrous materials, surface defects
- Radiography: internal defects, low resolution
- Visual inspection, Micrometry.

Die Maintenance

- Inspect Die set before each use.
- Measure tolerance of body and stemples before each use.
- Reject die if scratches and chips are found on body mirror polished surfaces
- Reject die if tolerance is less than 0.001” or greater than 0.002”.
- Rejected Die sets may be re-machined if possible.

Pantex process comparison

- Pantex small scale pressing managers visited LANL on 4/10 to view and discuss the event. LANL's process was walked down and dissected.
- LANL managers visited Pantex on 4/12 to view and discuss their operations.
- Differences exist but are due largely to the nature of the pressing. The adherence to the DOE safety standard is comparable.

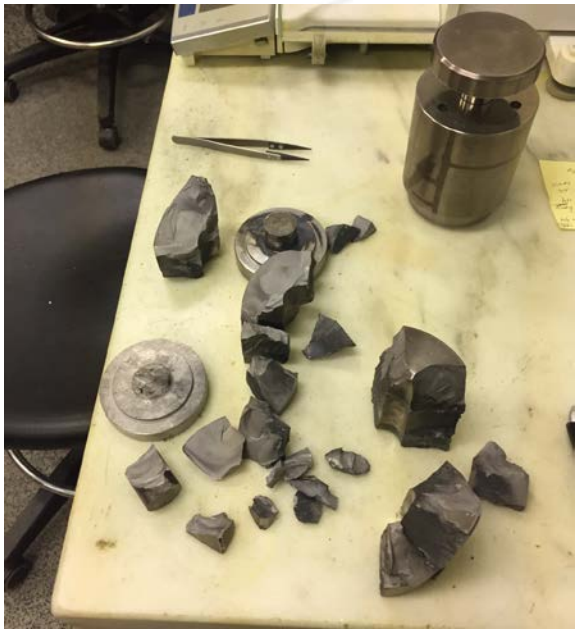
Industrial Hygiene and Hearing protection

- Calculations completed by Bruce Dahlquist (Industrial Hygiene) suggest blast over pressurization NOISE from the event to be 172-169 dB (10 feet and 15 feet respectively).
- This is well above the impulsive noise exposure limit of 140 dB (threshold for hearing loss).
- Hearing protection is recommended.

Restart

- TBD

Acknowledgements



M-7
- Sean Bashaw
- Alice Branch
- Sheldon Larson
- Ken Laintz
- Laida Valdez

Pantex
- Monty Cates
- Lennon Mings
- Ed Patterson
- Tony Dutton
- Tori Gallier

M-DO and WFO
- Eric Brown
- Ellen Cerreta
- Joe Lloyd
- Ken Gillespie
- Brian Watkins
- Doug Tasker

Medical and IH
- Bruce Dahlquist
- Occupational Medicine

AET-6
- Yoshi Coe
- Steve Fresquez
- Dick Bingham
- David Harvey

Forensic Metallurgists
- Robert Hackenberg
- Kevin Bohn
- Jessica Lopez
- Joel Montalvo
- Andrew Richards
- Eric Tegtmeier
- David Alexander

Other
- Steve Malcolm
- Dan Hooks
- Doug Tasker