FMU-139B/B to AFX-795 and Tritonal Explosive Interface Comparison

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Overview

- Interface
- LSGT
  - Tritonal
  - AFX-795
- Explosive interface comparison

Background

- Joint Air Force/Navy program
  - Mitigate response of GP bombs to unplanned stimuli
- Air Force created AFX-795 for IM mitigation
  - Melt cast
  - RDX based
  - Drains out thermally opened vents in aft end of bomb during slow cookoff
  - Unknown explosive interface margin

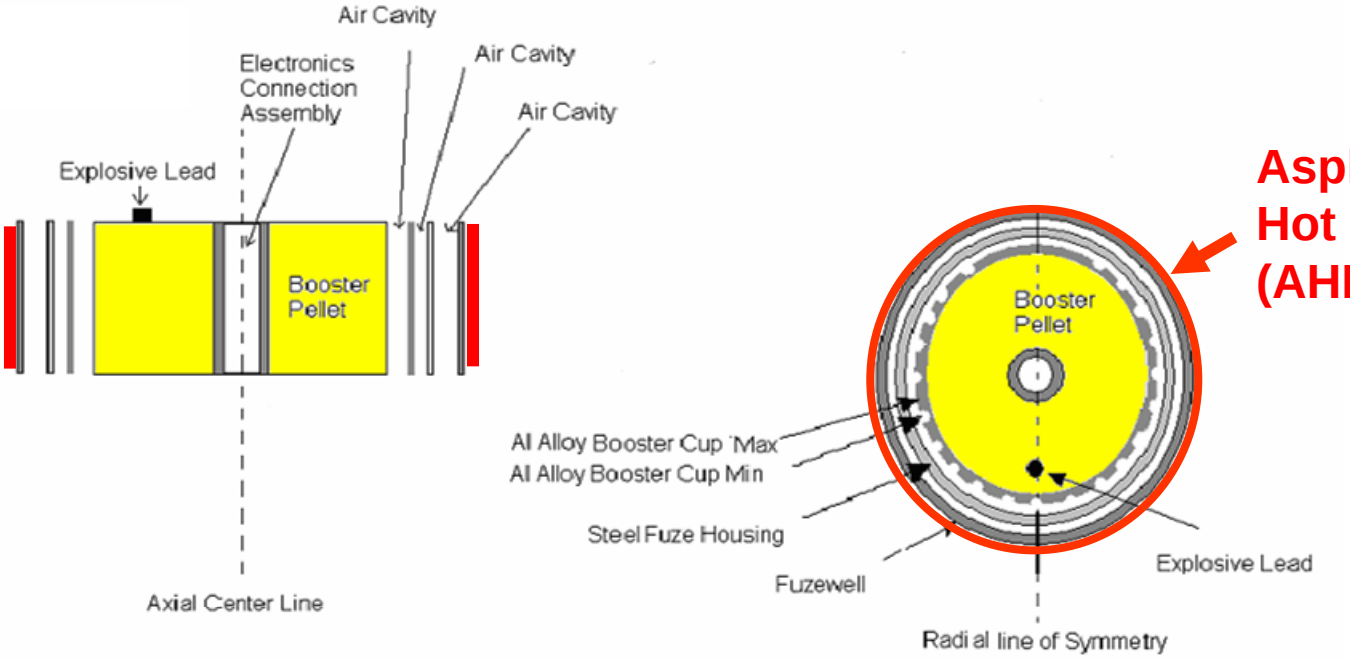
Current Interface

Air Force

CH-6 booster
GP bomb fuze liner
0.110 in max asphaltic hot melt
Tritonal mainfill

Navy

PBXN-7 booster
GP bomb fuze liner
0.110 in max asphaltic hot melt
PBXN-109 mainfill

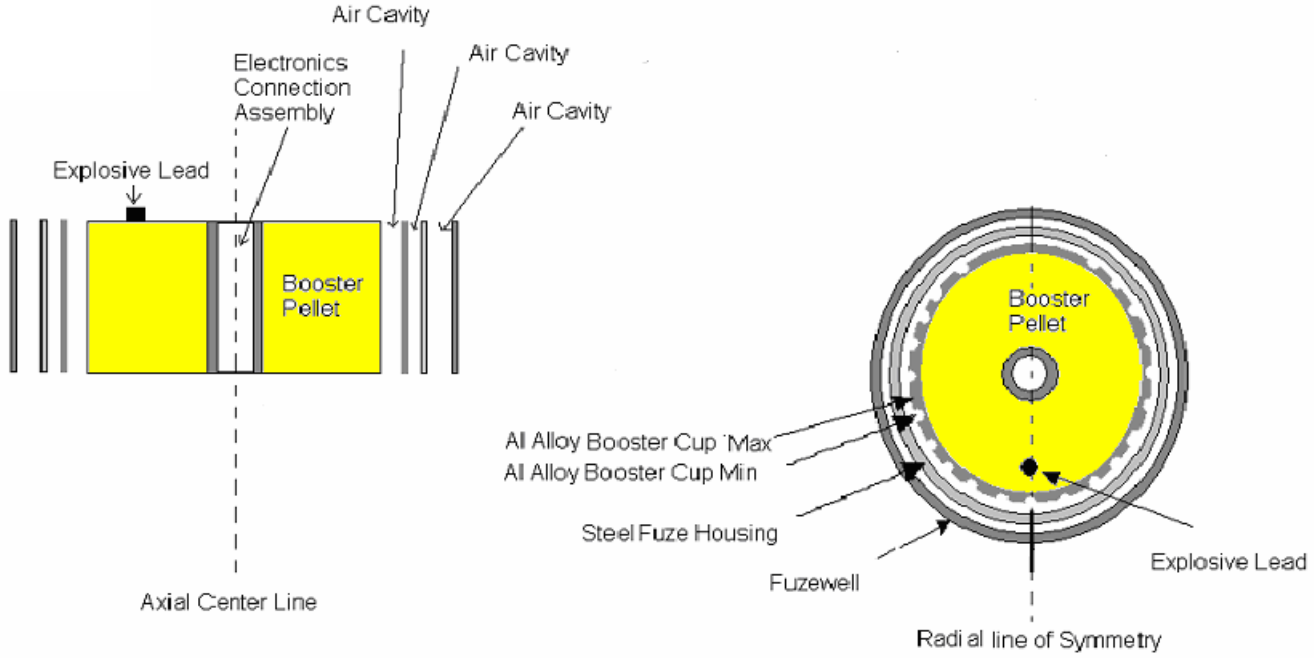


New Interface

Navy/Air Force

- PBXN-7 booster
- GP bomb fuze liner
- No asphaltic hot melt coating
- AFX-795 mainfill

New interface required to be as good or better than current



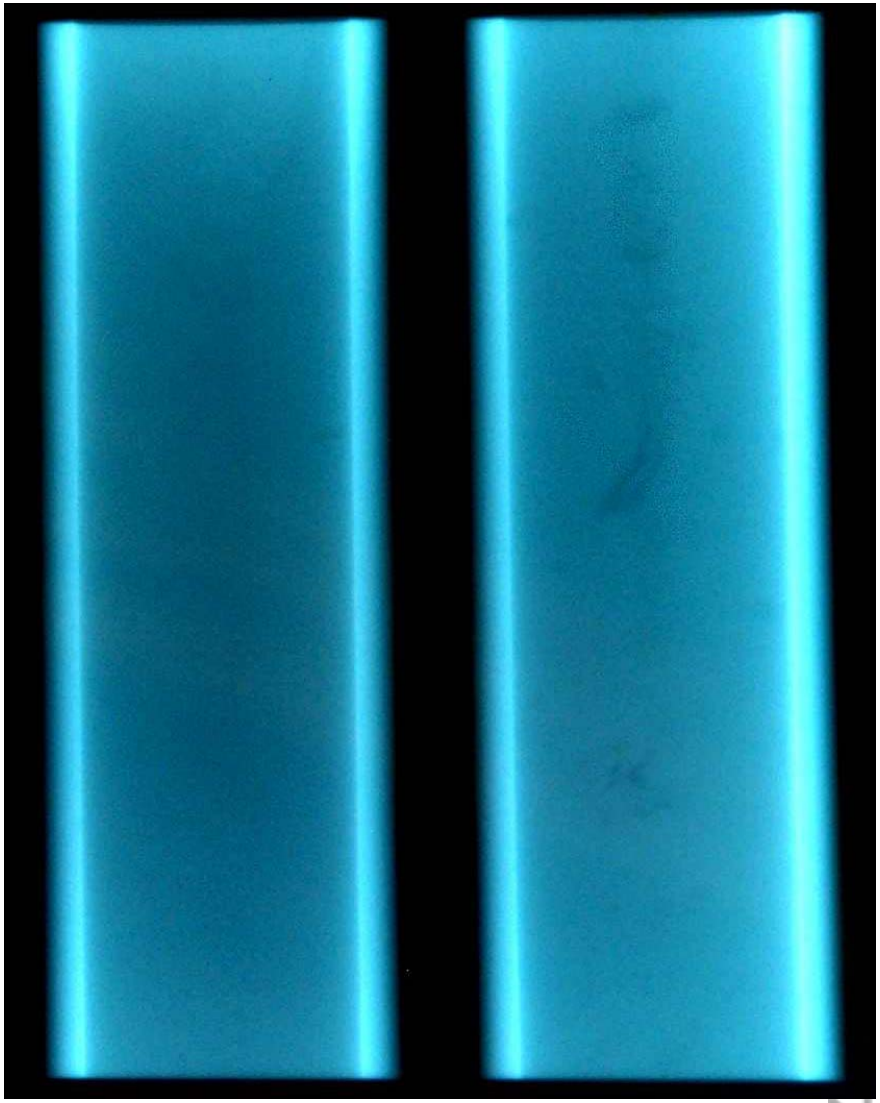
Approach

- Large Scale Gap Test (LSGT) from same batch of explosive in test items
- Varidrive-type comparison
  - 50% go/no-go booster density for AFX-795
  - 50% go/no-go booster density for Tritonal
  - Reduced number of tests

Large Scale Gap Test Results

- AFX-795
  - Density: 1.60 g/cc (96% TMD)
  - Sensitivity: 43.7 kbar (141 cards)
- Tritonal
  - Density: 1.72 g/cc (96% TMD)
  - Very high standard deviation
  - Sensitivity: 31.8-47.5 kbar (165-128 cards)

Tritonal LSGT X-rays

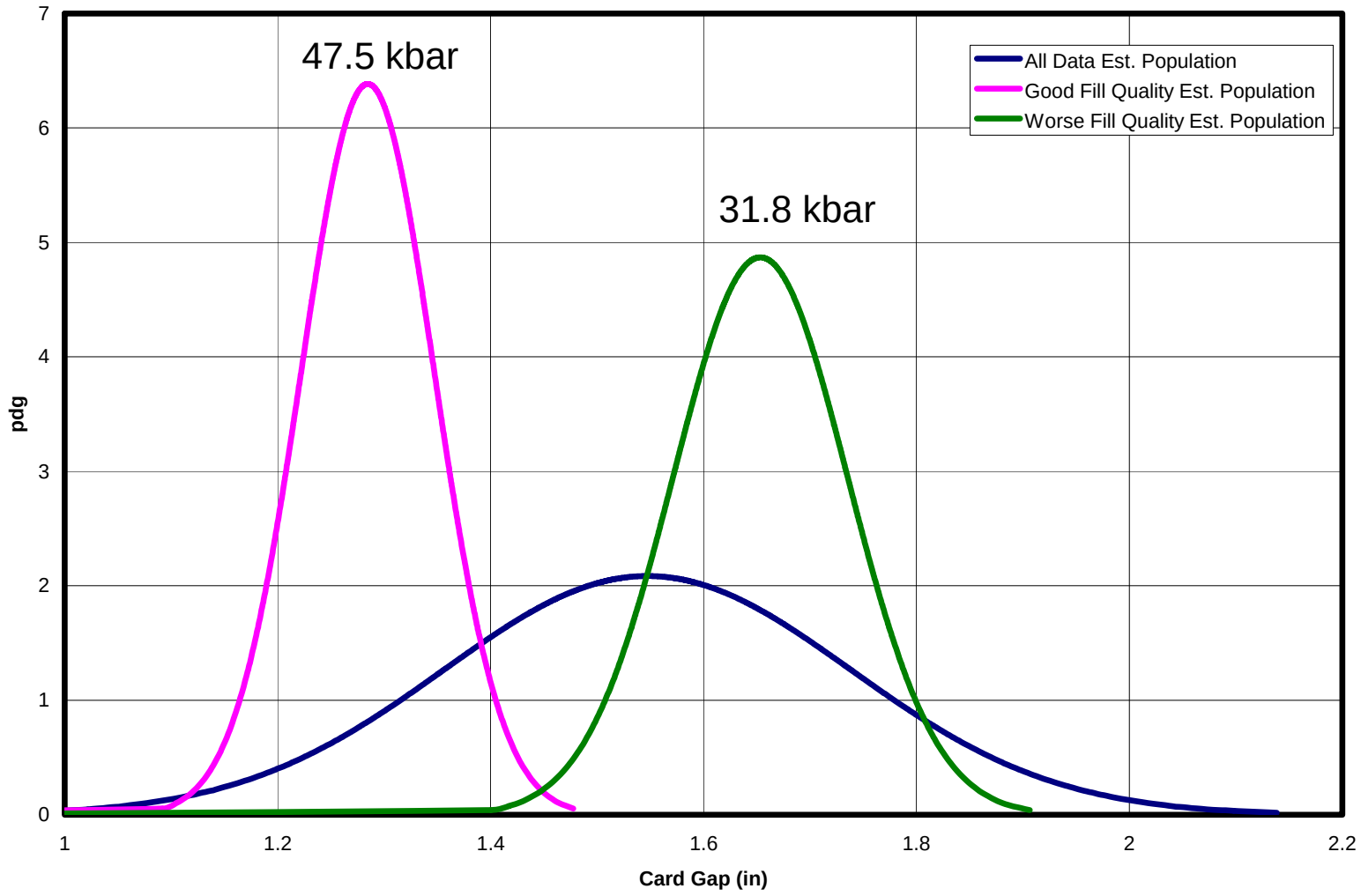


Tritonal LSGT Statistical Analysis

	MU	SIGMA	-2ln(likelihood)
All Data	1.54727773	0.19133345	-13.40190464
Worse	1.65339395	0.08192435	-3.008072684
Good	1.28462571	0.06248429	-2.771213596

- Chi-square distribution with 2 degrees of freedom
- Probability of rejecting H_0, p-value, is P(X >=15.245…) = 0.000489259, where X is distributed chi-square with 2 degrees of freedom.
- Given a p-value of 0.000489259, **the two groups are not from the same population. It can be assumed they come from two different populations.**

Tritonal LSGT Statistical Analysis



Test Setup

- Production representative loads
- Conditioned to -65º F
- 3 foil switches
- 15 piezoelectric pins
- 0.75” witness plate
- Thermocouple

- Go criteria:
  - Hole in witness plate>=item diameter
  - Spall on back of witness plate
  - Terminal detonation velocity>80% known value

Test Data

AFX-795	
Calculated Booster Density [g/cc]	Go (X)/No Go (O)
1.17	**O**
1.3	**O**
1.38	**O**
1.4	**O**
1.41	**O**
1.42	**O**
1.42	**O**
1.44	**O**
1.45	**O**
1.35	**X**
1.39	**X**
1.41	**X**
1.44	**X**
1.45	**X**
1.45	**X**
1.45	**X**
1.48	**X**
1.48	**X**
1.49	**X**
1.6	**X**

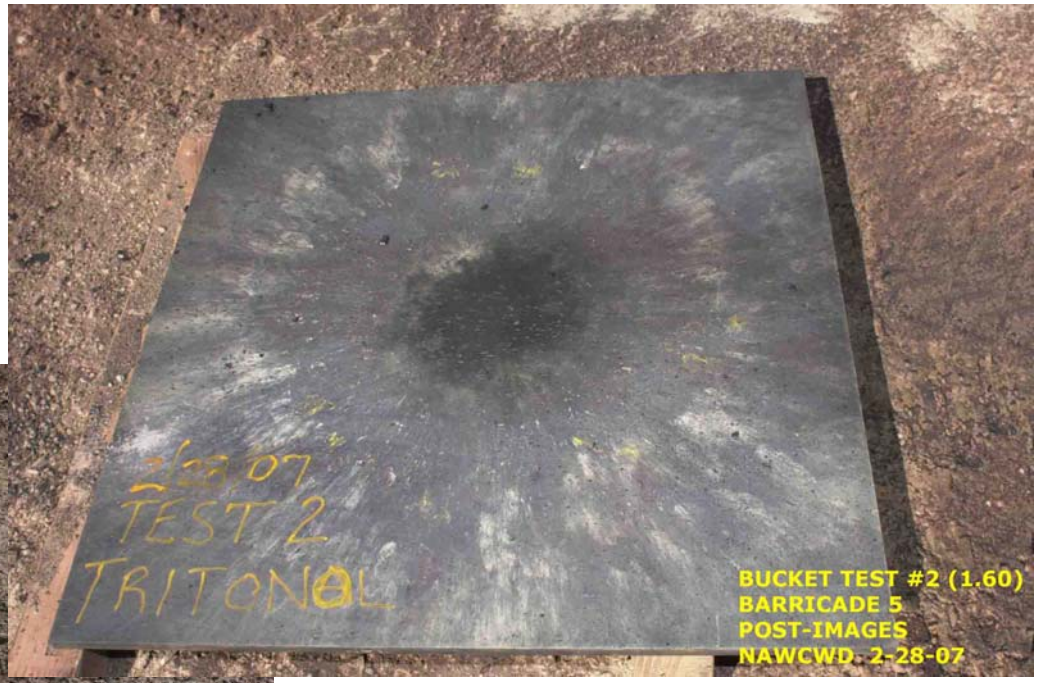
Tritonal	
Calculated Booster Density [g/cc]	Go (X)/No Go (O)
1.5	**O**
1.6	**O**
1.64	**O**
1.67	**O**
1.69	**O**
1.69	**O**
1.68	**X**
1.69	**X**

- AFX-795 50% density=1.41 g/cc
- Tritonal 50% density=1.69 g/cc
- Production density=1.76 g/cc

Witness Plates

Go Example

No Go Example



Relative Detonation Transfer Margin

$(\rho_{795T})^2 (K_{795H} / K_{795T}) \sim<= (\rho_{TriT})^2 (K_{Tri\ H} / K_{Tri\ T})$, where

ρ_{795T} is the threshold density to initiate AFX-795 determined by these tests (1.41 g/cc)

$\rho_{Tri\ T}$ is the threshold density to initiate Tritonal determined by these tests (1.69 g/cc)

K_{795T} is the threshold sensitivity of the AFX-795 used in these tests (43.7 kbar)

$K_{Tri\ T}$ is the threshold sensitivity of the Tritonal used in these tests (31.8-47.5 kbar)

K_{795H} is the historical worst-case threshold sensitivity of the AFX-795 (43 kbar)

$K_{Tri\ H}$ is the historical worst-case threshold sensitivity of Tritonal (57.1 kbar)

AFX-795: 1.96

Tritonal: 3.43 (assuming 47.5 kbar in test units)

5.13 (assuming 31.8 kbar in test units)

Future Testing

- PBXN-7 to PBXN-109
- CH-6 to PBXN-109
- Tetryl to PBXN-109
- GP bomb configuration
- FMU-139 interface

Summary

- LSGT showed Tritonal has a strong dependence on fill quality
- If bombs are filled with HQ Tritonal, the FMU-139 B/B appears to have insufficient design margin/reliability under worst case conditions based on test results
- Based on conservative analysis principles assuming worst case conditions the FMU-139 B/B has greater detonation transfer margin/reliability initiating AFX-795 than Tritional in the configurations tested

Backup

Estimation of Detonation Velocity

$$\sqrt{(x_i-x_0)^2+(y_i-y_0)^2+(z_i-z_0)^2} - v(t_i-t_0) = E_i$$

where

x_i, y_i, z_i were the Cartesian coordinates of the i^{th} pin,

t_i was the arrival time measured by the i^{th} pin, and

E_i is an error function for the i^{th} pin (ideally $E_i = 0$)

- 15 equations, 5 unknowns
- Microsoft Excel's Solver function
- Solved by minimizing the error function:

$$E = (W_1E_1^2 + W_2E_2^2 + \ldots.W_{15}E_{15}^2)/ (W_1+ W_2+ \ldots.W_{15})$$

- 1) Utilizing all pins (all pins having weight factors of 1)
- 2) Ignoring the two pins closest to the detonator
- 3) Ignoring the 3 pins nearest the detonator
- 4) Ignoring the top two pins of each column
- 5) Ignoring the top and bottom pins of each column

Estimation of Detonation Velocity

Test No.	Booster Density	Calculated Location of Initiation Point				Time of Initiation
		Angle from Detonator	Radius	Height	Detonation Velocity	
	g/cc	deg.	mm	mm	mm/μsec.	μsec.
1						
2	1.48	137 - 139	55 - 65	134 - 163	7.3 - 7.6	14 - 17
3						
4	1.49	164 - 174	61 - 80	138 - 167	7.5 - 7.9	19 - 24
5	1.6	139 - 140	57 - 61	142 - 158	7.4 - 7.6	15 - 16
6						
7	1.48	176 - 183	64 - 79	137 - 174	7.7 - 7.9	19 - 23
8						
9	1.45	144 - 150	72 - 83	155 - 164	7.2 - 7.4	18 - 20
10	1.44	148 - 229	41 - 68	184 - 282	4.0 - 6.6	17 - 28
11						
12						
13						
14	1.45	160 - 164	61 - 69	158 - 168	7.6 - 7.8	19 - 20
15	1.45	184 - 232	41	151 - 184	8.0 - 8.5	30 - 33
16						
17	1.41	162 - 165	70 - 77	144 - 165	7.6 - 7.8	22 - 24
18	1.39	160 - 164	65 - 69	156 - 164	7.5 - 7.7	22 - 23
19	1.35	197 - 203	77 - 87	133 - 161	7.9 - 8.1	24 - 27
20						

- D_v =7.70 mm/μs
  - .8*D_v =6.16 mm/μs
- D_v for Tritonal not convergent
  - Passing based on witness plate only