TBX Evaluation Testing in the M151 Warhead as Risk Reduction for the APKWS

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Proposed APKWS "Block II" Objectives

Integrate Technologies to Replace the Current M151 and M423

- Insensitive Munition Compliance Is Main Focus
- Improved Warhead and Fuze Lethality
- Improved MIL-STD 1316 Fuze
- Program Ends in FY05 with TRL 6 Prototype Designs and Supporting Test Data
- Low Risk Transition to APKWS Block II SDD

APKWS Warhead / Fuze Program Overview

- Design for IM
- Enhanced Fragmentation
- Enhanced Blast
- Dual Safe Fuze





Next Step: **APKWS Block II Warhead and Fuze Program Will Provide the Capability to Defeat the Current and Evolving Threat**

AMMPGM STO-Funded Warhead Risk Reduction Activities

Objective: To Investigate High-Risk Areas and Critical Technologies of 2.75" Warhead Development as a Parallel Effort to APKWS

Fragmentation Tests

- M151 Modified With Preformed Tungsten Cubes
- Embedded Fragmentation Warhead

Water Tank Tests

- Complete Fragment Mass Distribution Data
- Easier Data Reduction

Tandem Blast Frag / SC

- Shaped Charge and Blast Fragmentation Tandem Warhead
- Various Configurations

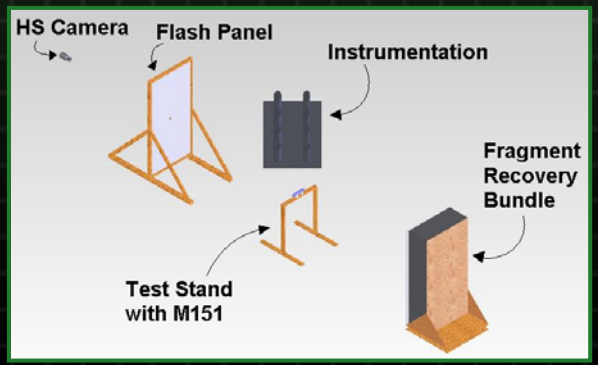
TBX / Enhanced Blast Tests

- Evaluation of Several TBX Fills From Industry
- Pressure, Temperature, and Fragmentation Data
- M151 Warhead Bodies

Thermobarics (TBX) / Enhanced Blast Tests

Objective: Conduct an Evaluation of Candidate TBX Fills from Industry and Other Gov't Agencies for APKWS Warhead

- "Mini" Arena Test Setup
  - One Velocity Panel, One Celetex Bundle
- Evaluation of 14 Different Explosive Fills
- Data Acquisition:
  - Pressure & Temperature
  - Fragment Velocity
  - Fragment Mass and Spatial Distribution
  - Number of Fragments
- Data Will Be Available to Industry
- Evaluate TBX Fragment Driving Capability
- Comp B, PBXN-109, and PBXN-110 Tested as Baselines



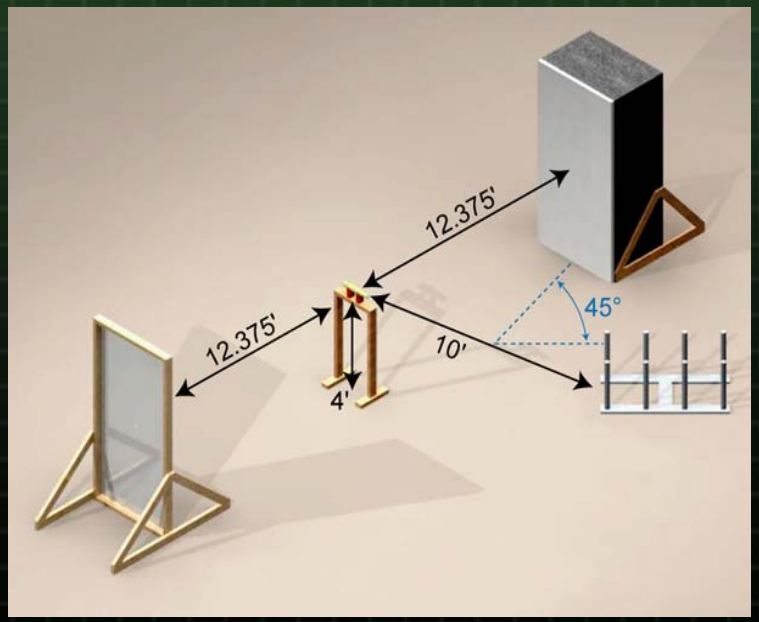
AMRDEC	Comp B
AMRDEC	PBXN-109
AMRDEC	PBXN-110
AMRDEC	RAX-16
Picatinny	PAX-28
Picatinny	PAX-3
EBA&D	YJ-05
ATK	NIX-G
ATK	TEPX-D
Talley	3 fills
Navy	CLAP 1
Navy	C133

M151 Enhanced Blast Test Matrix

Test #	Company/Organization	Explosive Fill	Test Date
1	AMRDEC Baseline (Current M151 Fill)	Comp B	3/17/2004
2	AMRDEC Baseline	PBXN-109	4/6/2004
3	AMRDEC Baseline	PBXN-110	6/2/2004
4	American Ordnance Iowa \ Picatinny	PAX-3	4/20/2004
5	Alliant Techsystems \ Picatinny	NIX-G	4/19/2004
6	Alliant Techsystems	TEPX-D	4/22/2004
7	Talley Defense Systems	7164	5/11/2004
8	Talley Defense Systems	7172	5/12/2004
9	Talley Defense Systems	7174	5/27/2004
10	NAVY (NAVAIR, China Lake)	CLAP	4/28/2004
11	NAVY (NAVAIR, China Lake)	CL133	5/25/2004
12	Ensign-Bickford Aerospace & Defense	YJ-05	4/7/2004
13	ARDEC Picatinny	PAX-28	4/27/2004
14	AMRDEC	RAX-16	4/5/2004

Mini-Arena Test Setup

- Standard M151 2.75” Warhead Body
  - Approx 6.4 lbs (empty)
  - Naturally Fragmenting Cast Iron
- Filled and Returned to Redstone for Testing
- Initiated with RP-80 & Booster at Front
- Comp-B tested as Baseline



- “Mini Arena” Setup
  - 1 Celetex Bundle
  - 1 Alum Velocity Panel
    - Phantom Video
- 4 Pressure Transducers
- 4 Calorimeters
- 4 Thermocouples
  - 45º from WHD Axis

"Mini Arena" Test Video

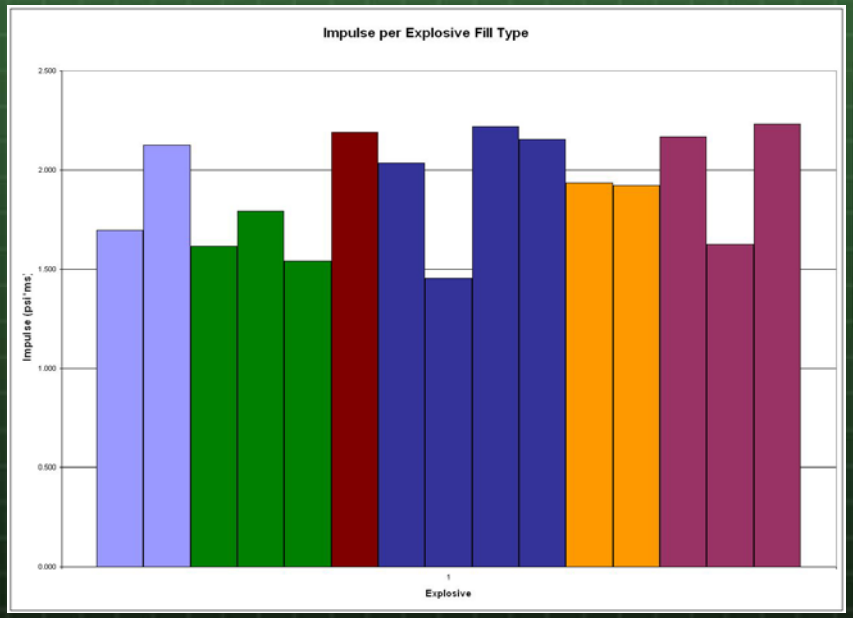
Peak Pressure Measurement

Explosive	Peak Pressure (psi) at 10 feet
A	23.33
B	20.50
C	20.21
D	20.20
E	18.21
F	17.38
G	16.92
H	15.86
I	14.87
PBXN-110	13.88
J	13.34
K	11.44
Comp B	9.91
PBXN-109	9.45

- Peak Pressure Recorded at Closest Pressure Transducer
- 10 Feet from Warhead
- Explosives 'named' A-L Based upon Peak Pressure Data Rank
- Same Nomenclature used for Remaining Comparisons
- Fielded M151 Explosive is Comp B

Pressure Impulse at 10 Feet

Explosive	Impulse at 10' (psi-ms)
A	2.230
B	2.219
K	2.190
D	2.168
F	2.154
C	2.125
E	2.035
J	1.930
PBXN-109	1.793
G	1.697
H	1.627
Comp B	1.617
PBXN-110	1.540
I	1.455

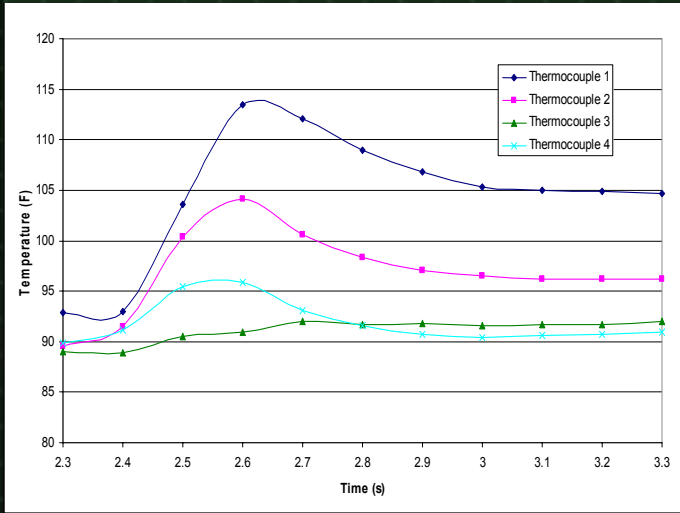


Baselines

Temperature Data

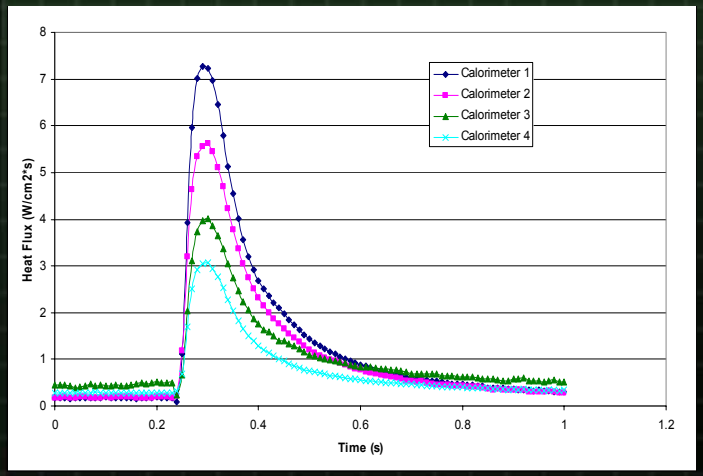
- Temperature Increase Recorded at Closest Sensor
- Pressure and Temperature Effects not on same Trend

Explosive	Temperature Increase at 10' (°F)
J	20.48
H	19.42
PBXN-109	17.82
A	17.24
E	14.87
I	13.39
C	12.14
K	9.50
B	9.17
D	8.86
F	5.16
PBXN-110	Gage Malfunction
Comp B	Gage Malfunction
G	Gage Malfunction



Heat Flux (Calorimeter) Data

- Peak Heat Flux Recorded at 10 feet from Warhead

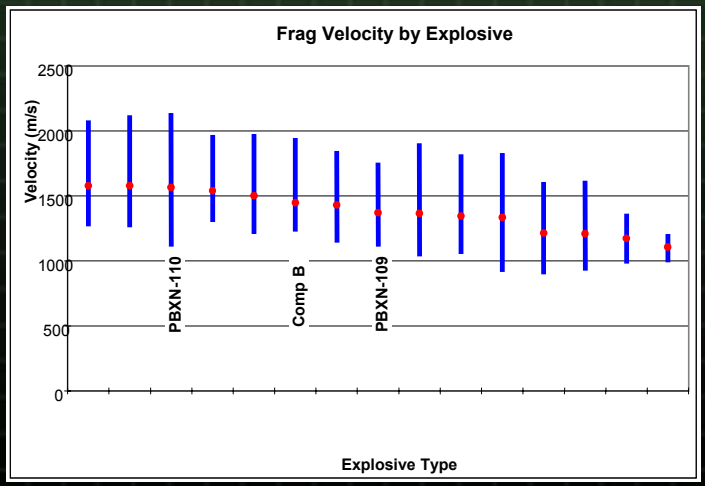


Heat Fluxes	Heat Flux at 10' (W/cm^2-s)
J	7.09
H	5.32
E	4.66
G	4.57
D	3.49
PBXN-109	3.10
F	2.66
K	2.62
A	2.35
B	2.07
C	1.99
I	1.86
Comp B	Gage Malfunction
PBXN-110	Gage Malfunction

Fragment Velocities

Explosive	Average Fragment Velocity (m/s)
A	1580
B	1579
PBXN-110	1566
C	1542
F	1502
Comp B	1449
K	1430
PBXN-109	1372
D	1365
H	1346
G	1336
J	1213
E	1174
I	1109

- Velocities Measured via Phantom High Speed Video
- Min, Max, & Avg Velocities Calculated
- **The Best Performers in Pressure were Also the Best at Driving Fragments**



of Fragment Perforations

Explosive	Number of Perforations
A	564
B	523
PBXN-110	493
C	441
Comp B	396
H	378
F	368
G	347
K	333
J	326
D	324
PBXN-109	315
E	268
I	155

Summary of TBX Evaluation Results

Explosive Fill Rankings	Peak Pressure	Pressure Impulse	Temperature Delta	Fragment Velocity	Fragment Perforations	Heat Flux	Cummalitive Score (Lower=Better)
A	1	1	4	1	1	9	17
B	2	2	9	2	2	10	27
C	3	6	7	4	4	11	35
H	8	11	2	10	6	2	39
F	6	5	11	5	7	7	41
D	4	4	10	9	11	5	43
J	11	8	1	12	10	1	43
E	5	7	5	13	13	3	46
G	7	10	7	11	8	4	47
PBXN-110	10	13	8	3	3	10	47
K	12	3	10	7	9	8	49
PBXN-109	14	9	3	8	12	6	52
COMP B	13	12	10	6	5	10	56
I	9	14	6	14	14	12	69

No Data, (Estimate)

- Each Measured Characteristic Given an even Weighting
- 80% of Candidate Explosive Fills Exceeded Baselines
- Ranking may be different depending on desired application
- This Testing Demonstrated that Many Enhanced Blast (i.e. TBX) Explosives Maintain Adequate Fragment Driving Characteristics