THE EFFECTS OF IGNITER DESIGN ON THE INTERIOR BALLISTIC PERFORMANCE OF DETERRENT COATED PROPELLANTS

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- Steven Ritchie, ATK, Propellant Development Manager, Radford Army Ammunition Plant
- Steve Lightsey and Matt Brian, National Technical Systems (NTS), Camden, Arkansas, Insensitive Munitions Testing, steve.lightsey@ntscorp.com

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Briefing Outline

- Overview
- System Description
- Performance Test
- IM Test
- Conclusions

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Purpose of the Program

- Develop an environmentally friendly propellant for medium caliber applications
  - Elimination of ether and alcohol processing solvents
  - No ingredients from the EPA watch list
  - Step improvement of IM performance

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Snapshot of Program

- Solventless PAP8386 tailored for medium caliber
- M793/PGU-23 selected as test vehicle
  - Ignition system optimized for propellant
  - Ballistics demonstrated across temperatures
  - Insensitive Munitions Testing of M793 Vented Cartridge Cases and PA125 Container with Developmental PAP-8386 Propellant
- IM testing completed

Vented Case and Container

- Despite the improved IM properties of PAP-8386 propellant a system level approach is needed for all of the IM tests
- A separate ARDEC program has developed a vented case and container
  - Designed to relieve undesired pressure
  - This case and container are expected to provide improved IM response of the loaded round to the Slow Cook-Off test in particular
- Vented cases and containers were used for the IM test

Technical Approach

- Propellant Manufacturing at RFAAP
- Propellant Testing
  - Reproducibity (RFAAP)
    - PVAT (-46C, +21C, +63C)
    - Chemical and physical
  - Characterization
    - Insensitive Munitions Testing (Mil Std 2105C) (NTS)

SMALL SCALE SENSITIVITY SCREENING TEST

Propellant	ERL Type 12 Impact 50% point (cm)	Electrostatic Discharge Test (ESD) NR (NO REACTION)	BAM Friction (N) N (NEWTON)
RDX Lot # 21-18	24.8± 1.2 25.1± 1.7	-	212N reacted 188N 10/10 no go
RPD380 Lot # ARV01A002001	27.1± 2.1	NR 20 trials @ 0.25 Joules	192N reacted 168N 10/10 no go
L1M Lot # NC-00J2890	27.6 ± 1.5	NR 20 trials @ 0.25 Joules	212N reacted 188N 10/10 no go
JA2 Lot # PD-065-5	32.0 ± 1.4	NR 20 trials @ 0.25 Joules	212N reacted 188N 10/10 no go
M14	48.4 ±1.3	NR 20 trials @ 0.25 Joules	252N reacted 240N 10/10 no go
PAP-8386 (RPD-469)	75.4 ± 1.2	NR 20 trials @0.25 Joules	252N reacted 240N 10/10 no go

PAP-8386 is less impact sensitive than M14 and JA2 propellant

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Solventless Propellant Process

Press and Cut

Propellant Paste

Carpet Roll

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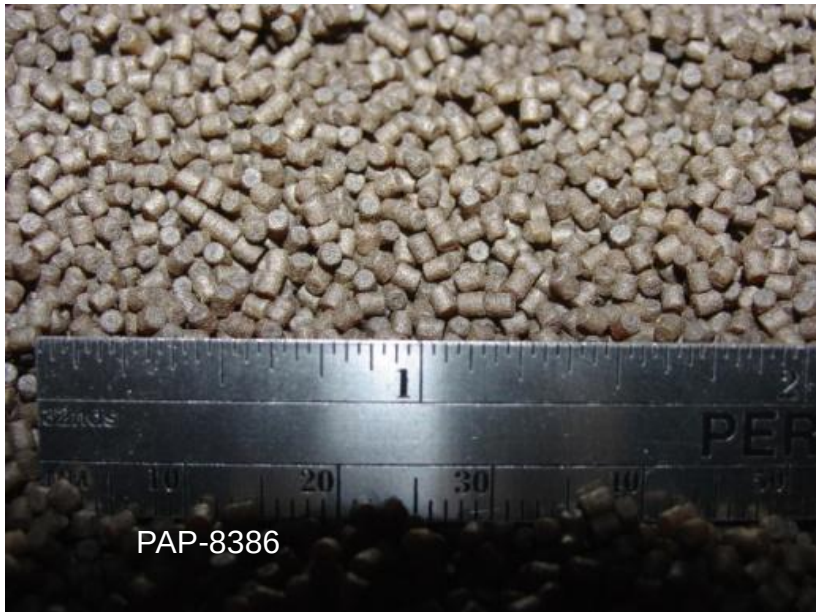
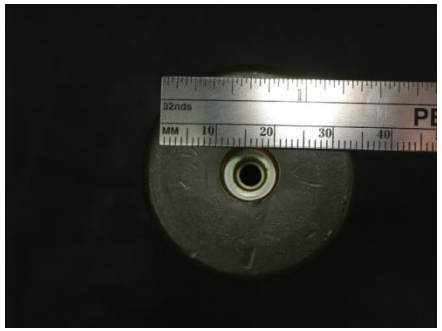
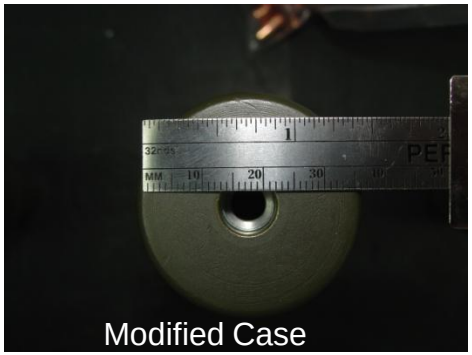
Technical Progress
Ignition Study Using Flash Tube Igniter

Blend Study Results (w/Flashtube)







Loaded Round

Flash Tube

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Pressure Velocity Action Time (PVAT at +63C, +21C and -46C)

PVAT RESULTS MET THE PERFORMANCE SPECS

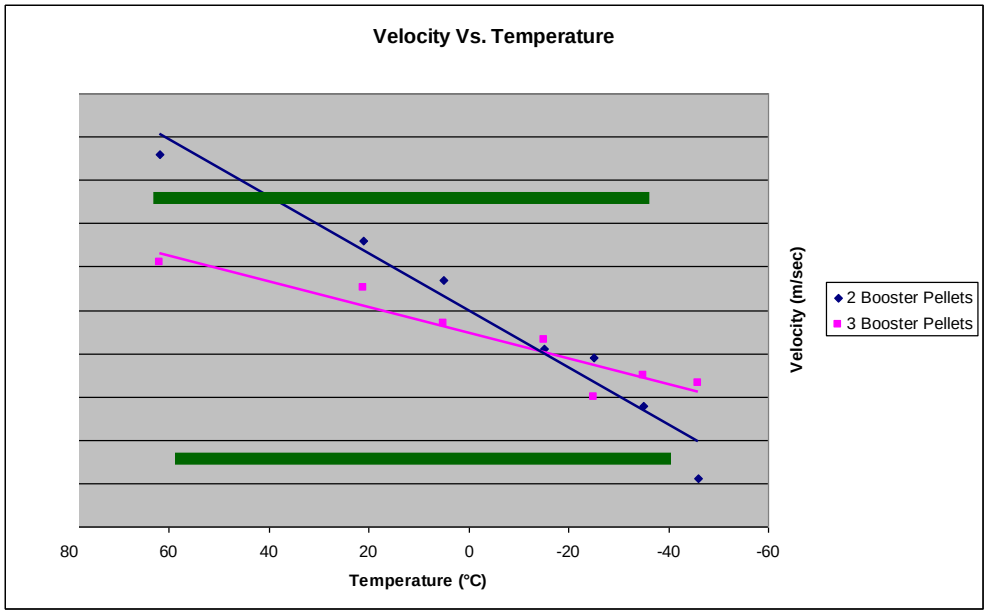

Figure 2: Velocity Vs Temperature results for cold walk-down

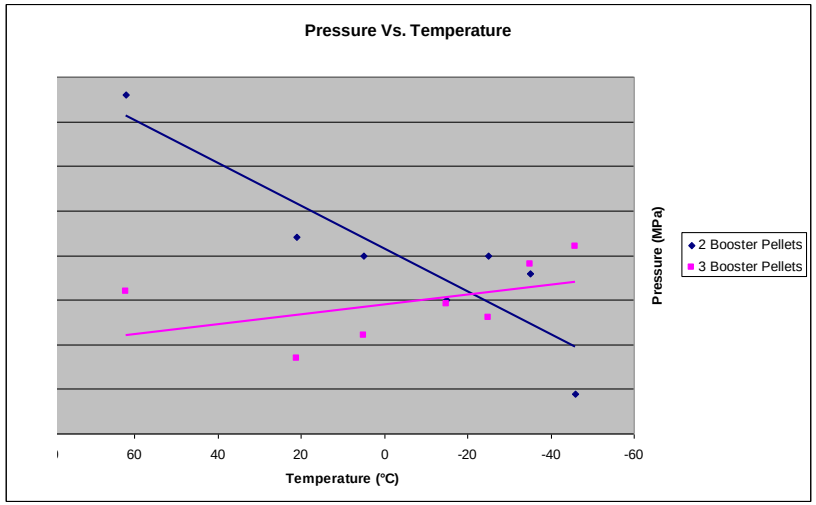

Figure 1: Pressure Vs Temperature results from cold walk-down

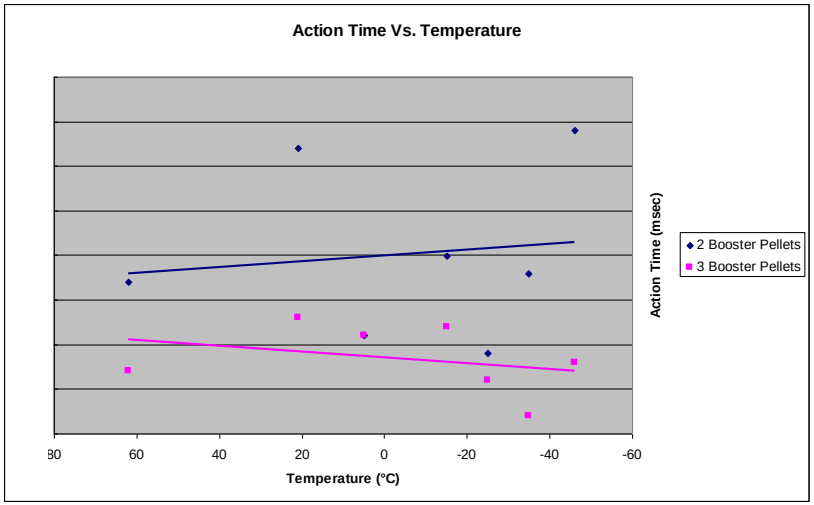

Figure 3: Action Time Vs Temperature results for cold walk-down

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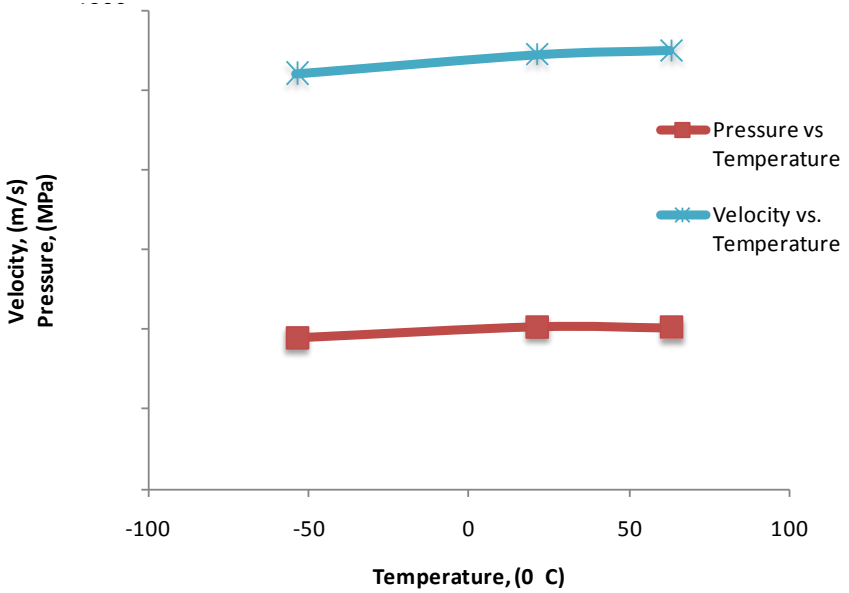
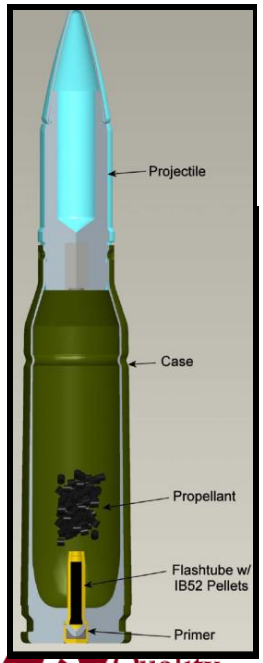
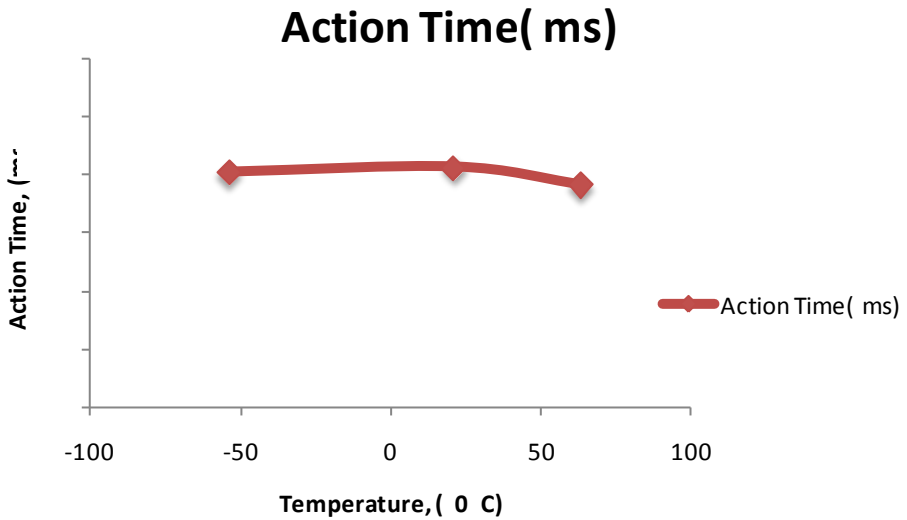
PAP-8386 Pressure Final Performance Across Temps







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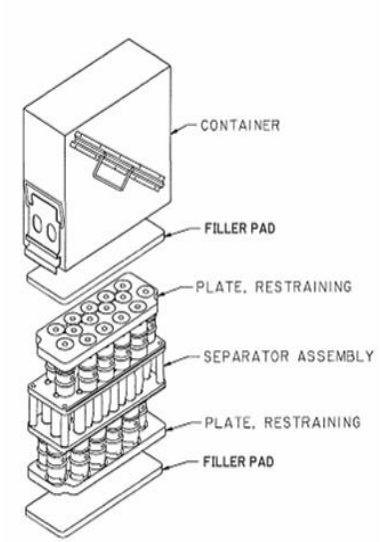
Recommended Testing

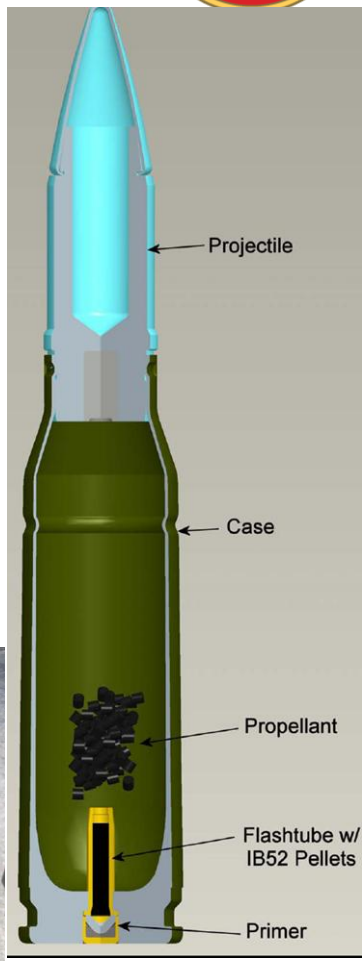
IM Test	MIL-STD-2105C	Test Parameters
Fast Cook-Off (Liquid Fuel/External fire)	V	• Per STANAG 4240 (Edition 2) • Complete engulfment of the test item by the fire for a min of 20 min
Slow Cook-Off (Slow Heating)	V	• Per STANAG 4382 (Edition 2) • Test item to be pre -conditioned at +50°C for 8 hours prior to test or until it reaches equilibrium at +50°C • Oven temperature to be increased +3.3°C per hour from +50°C
Bullet Impact	V	• Per STANAG 4241 (Edition 2). • 0.50 cal Type M2 AP bullet @velocity of 2790±66 ft/sec
Fragment Impact	V	• Per STANAG 4496 (Edition 1). • 0.50 inch mild steel conical fragment@velocity of 8,300±300 ft/sec
Shaped Charge Jet Impact	III,IV,V (PASS)	• Per STANAG 4526 (Edition 1, Ratification Draft 1) • 81mm shaped charge loaded with LX-14 • Impact at the propellant location
Sympathetic Detonation	III,IV,V (PASS)	• Per STANAG 4396 (Edition 2) • Required if SCJI test is a failure • 81mm shaped charge loaded with Comp B

Modified Ammunition Configuration

- General Information
  - All tests to be repeated
  - 1 or 2 Cans per test
  - 2 Groups of 15 linked rounds per can
  - Rounds are modified M793 configuration
  - Energetic components
    - M115 primer
    - IB-52 pellets
    - PAP-8386 propellant
  - Projectiles are inert
    - Not traced



PA125 Ammunition Container



M793

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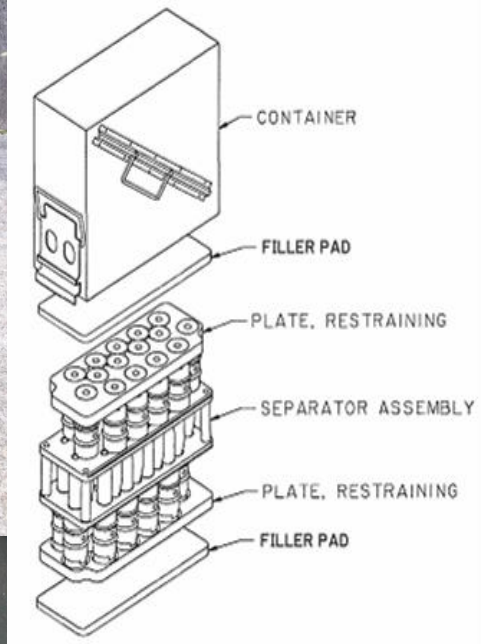
Ammunition Configuration

Vented Cases

Vented PA125 Containers



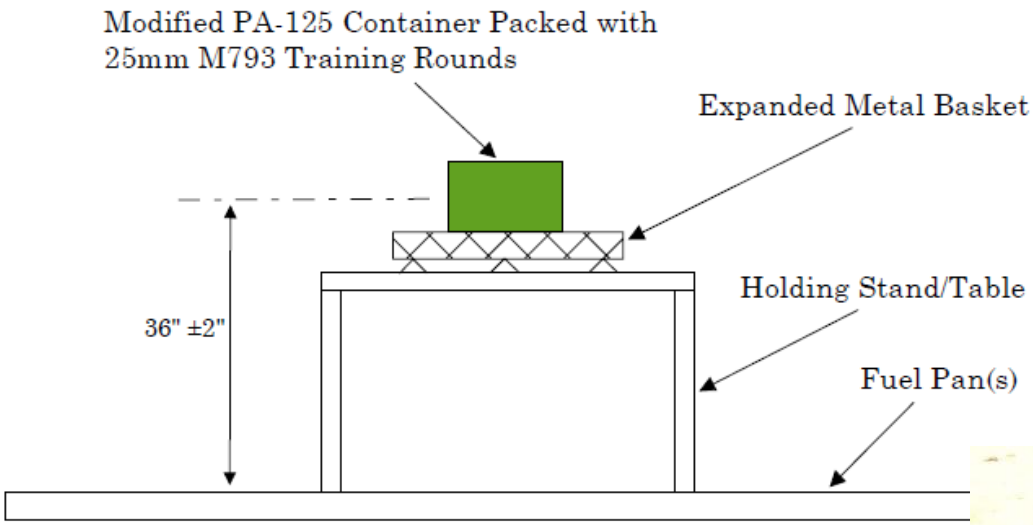
PA125 Ammunition Container

Fast Cook-Off

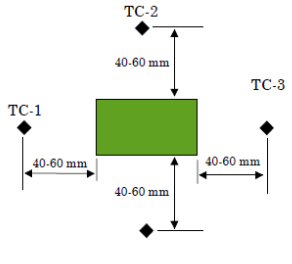
The liquid fuel fire (FCO) tests were conducted IAW MIL-STD-2105C, 14 Jul 2003 and STANAG 4240(Edition 2), 15 Apr 2003 and the test plan to determine and evaluate the response of the test item to a rapid heating in a liquid fire, which completely engulfs the PA125 container packed with 30 rounds of M793 25-mm vented cartridge cases.

- Fuel Basin 14' W x 20'L to be filled with 1000 gallons JET A1 Fuel. From the control room, the JET A fuel was ignited underneath the test unit.
- Minimum of 30 minutes complete engulfment
- Average flame Temperature 1733-1754°F minimum
- One (1) ammunition container per test
- Container centered approximately 36 in. above fuel pan
- Four(4) thermocouples to be placed on each container
- One (1) on each side of the container
- Four (4) blast transducers positioned as shown on next page
- Two (2) video cameras positioned as shown on next page
- Temperature profile and reaction history to be recorded.
- After testing visual inspection and mapping was performed after the safety waiting time.

Fast Cook-Off – Test Set-Up



ELEVATION VIEW



PLAN VIEW

Thermocouple Placement
Fast Cook-Off

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Figure 5
Fast Cook-Off Test Setup

Post Test Results
T/S 151-180 / Test 2
Fast Cook-Off Test

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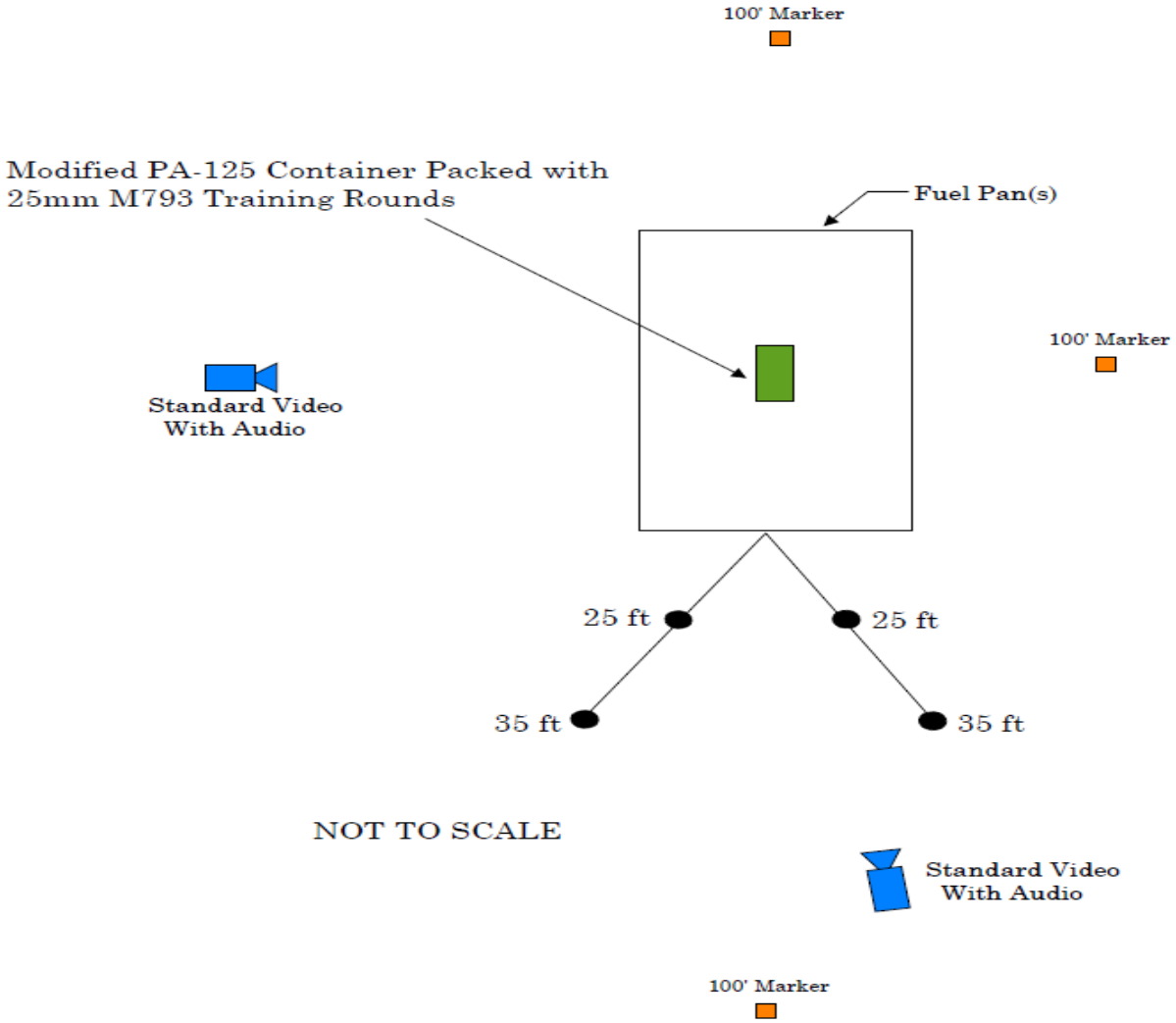
Fast Cook-Off – Test Set-Up



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Fast Cook-Off – Test Set-Up

Test Setup
T/S 121-150 / Test 1
Fast Cook-Off Test

Test Setup
T/S 121-150 / Test 1
Fast Cook-Off Test

Fast Cook-Off – Test Result

S/N: 121-150			
Fuel Type	Jet-A	**Avg. Flame Temp**	1754°F
Fuel Quantity	1000 Gallons	**Time to reach 1022°F**	12 Seconds
Pan Dimensions	14'W x 20'L		
Reaction Type	Type IV Reaction		

Probe Number	Distance	PSI	Probe Number	Distance	PSI
1	25'	0	4	25'	0
2	35'	0	5	35'	0

Results: At 1810 on 3/18/10 the fire was ignited. The first reaction was approximately 2 minutes into the fire and continued for approximately 3 minutes. There was no debris found out past 61'. There was no recordable blast pressure. The fire burned for approximately 30 minutes. All explosives were consumed except for one Live Primer End Cap. The High Vent side of the PA 125 Container was facing 90°.

Post Test Results
T/S 121-150 / Test 1
Fast Cook-Off Test

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Post Test Results
T/S 121-150 / Test 1
Fast Cook-Off Test

Fast Cook-Off Test Result

S/N: 151-180

Fuel Type	Jet-A	**Avg. Flame Temp**	1733°F
Fuel Quantity	1000 Gallons	**Time to reach 1022°F**	32 Seconds
Pan Dimensions	14'W x 20'L		
Reaction Type	Type IV Reaction		

Probe Number	Distance	PSI	Probe Number	Distance	PSI
1	25'	0	4	25'	0
2	35'	0	5	35'	0

Results: At 1922 on 3/19/10 the fire was ignited. The first reaction was approximately 3 minutes into the fire and lasted approximately 1 minute. There was no debris found out past 70'. There was no recordable blast pressure. The fire burned for approximately 30 minutes. All explosives were consumed except for one Live Primer End Cap. The High Vent side was facing 270°.

Post Test Results
T/S 151-180 / Test 2
Fast Cook-Off Test

Post Test Results
T/S 151-180 / Test 2
Fast Cook-Off Test

Slow Cook-Off

The Slow Cook-Off (SCO) tests were conducted IAW MIL-STD-2105C, 14 Jul 2003 and STANAG 4240(Edition 2), 15 Apr 2003 and the test plan to determine and evaluate the response of the PA125 container packed with 30 rounds of M793 25-mm vented cartridge cases when subjected to a gradual increasing heat temperature at a rate of 50 F per hour until reaction occurs.

A 4' X 4' expanded metal grate was placed on top of concrete blocks and covered with 1" high temperature insulation.

One (1) 10" X 20" X ½" thick mild steel witness plate was placed on top of the high temperature insulation. A second witness plate 10" x 18" x ½" thick was placed on the side of the Test Unit.

A calibration Test of the blast transducers was performed by detonating a 1 pound sphere of C-4 explosives.

Test Unit was placed on top of the bottom witness plate.

The Test Unit S/N's 241-270 were instrumented with thermocouples as referenced in Table 3 and Figure 10.

Two (2) standard video cameras, one (1) internal video and four (4) blast transducers were positioned as referenced in Figure 11.

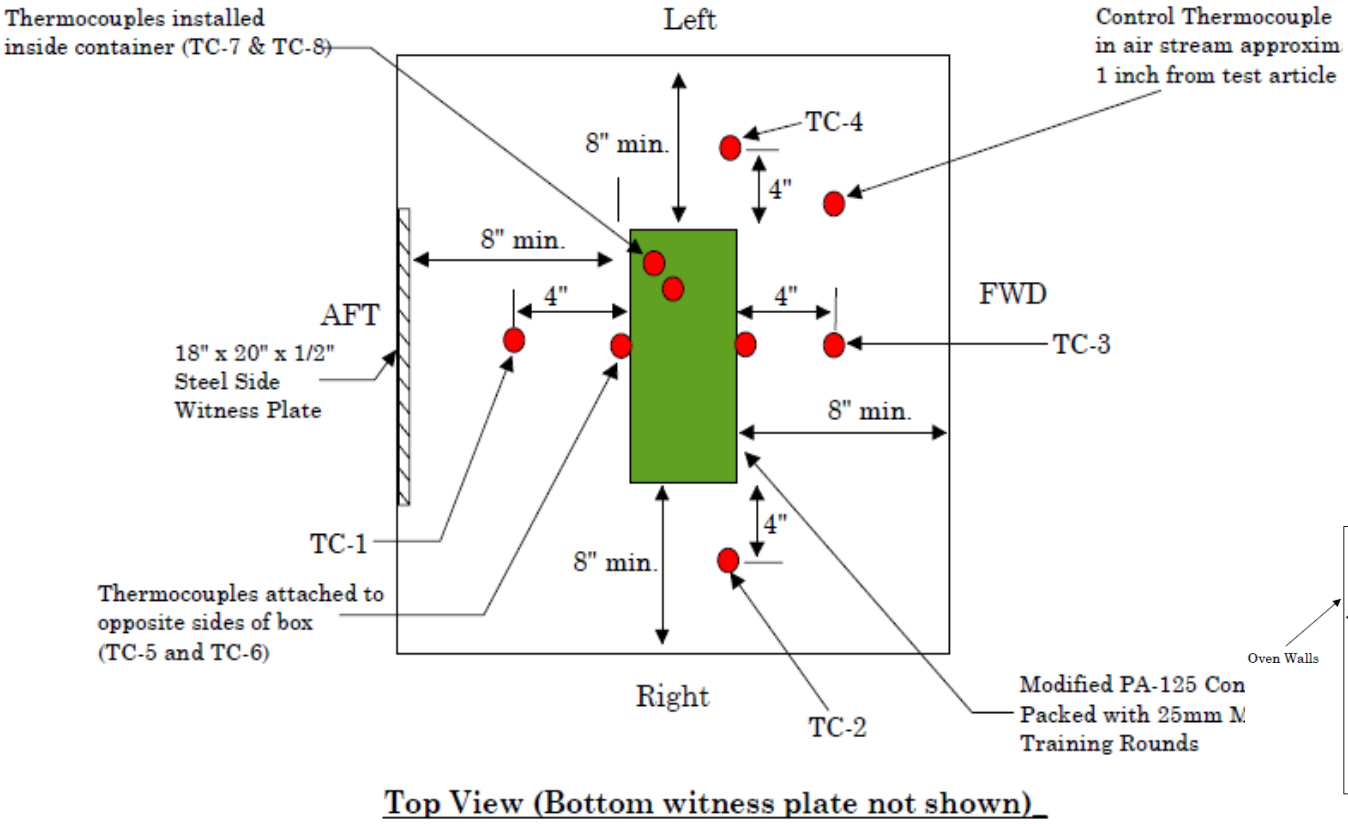
The oven (40" tall x 36" wide x 46" long) was placed over the Test Unit.

The internal temperature of the oven was ramped to +122°F over a period of one (1) hour.

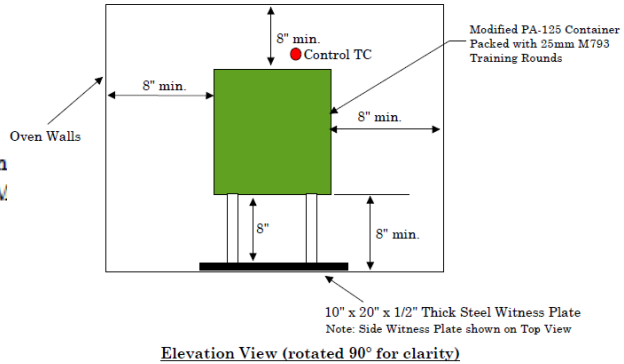
Once at a temperature of +122°F, the eight (8) hour minimum soak was performed.

Upon completion of the eight (8) hour minimum soak at +122°F, the internal temperature of the chamber was ramped at a rate of +6°F per hour until reaction occurs.

Slow Cook-Off Test Set-Up



Top View (Bottom witness plate not shown)



Elevation View (rotated 90° for clarity)

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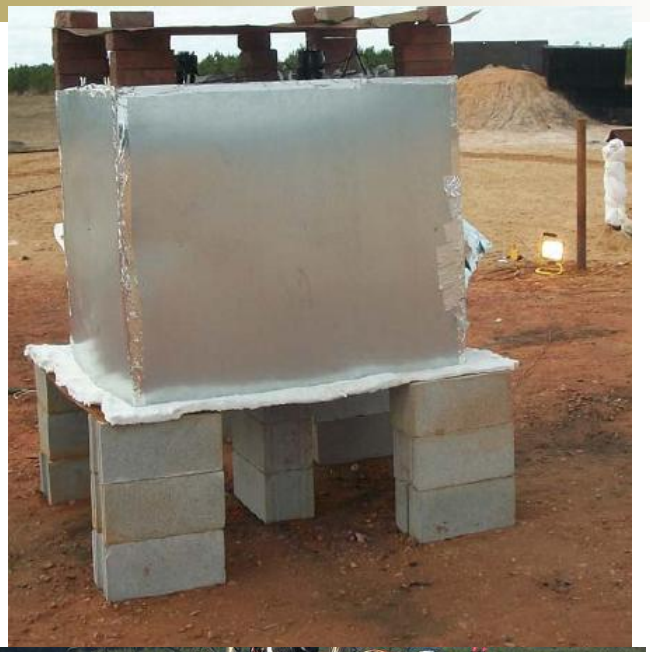
Slow Cook-Off Test Result



S/N: T/S 241-270			
Bottom Witness Plate	10” x 20” x 0.5”	**Witness Plate Damage**	No Damage
Side Witness Plate	10” x 18” x 0.5”	**Witness Plate Damage**	No Damage
Oven Size:	40” Tall x 36” Wide x 46” Long		
Reaction Type	Type V reaction		

Probe Number	Distance	PSI	Probe Number	Distance	PSI
1	25’	0	3	25’	0
2	35’	0	4	35’	0

Test Results: On 3/26/10 at 0210 the first reaction occurred at approximately 276.5°F. There was a small pop and then a fire started all of the rounds went but did not breach the oven. The oven would not continue to heat so the test was ended. All pieces remained inside the oven at ground zero. There was no damage to either witness plate. All debris mapped and pictures taken. The test article was oriented with the handles pointing to 0° and 180°, and the blowout ports to 90° and 270°.

T/C	Location	Reaction Temperature (°F)
1	Air Temperature – Aft end high vent side 90°	266.0
2	Air Temperature – Right side 0°	267.3
3	Air Temperature – Forward end low vent side 270°	267.4
4	Air Temperature – Left side 90°	265.8
5	Skin Temperature – Aft end high vent side 9	
6	Skin Temperature – Forward end low vent s	
7	Internal Temperature – Right side 0°	
8	Internal Temperature – Left side 180°	

Post Test Results
T/S 241-270 / Test 1
Slow Cook-Off Test

Post Test Results
T/S 241-270 / Test 1
Slow Cook-Off Test

Post Test Results
T/S 241-270 / Test 1
Slow Cook-Off Test

Slow Cook-Off – Test Set-Up

Test Setup
T/S 271-300 / Test 2
Slow Cook-Off Test

Test Setup
T/S 271-300 / Test 2
Slow Cook-Off Test

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Slow Cook-Off – Test Result

S/N: T/S 271-300			
Bottom Witness Plate	10” x 20” x 0.5”	**Witness Plate Damage**	No Damage
Side Witness Plate	10” x 18” x 0.5”	**Witness Plate Damage**	No Damage
Oven Size:	40” Tall x 36” Wide x 46” Long		
Reaction Type	Type IV reaction		

Probe Number	Distance	PSI	Probe Number	Distance	PSI
1	25’	0	3	25’	0
2	35’	0	4	35’	0

Test Results: At 2305 on 3/30/10 the container was breached by a round going off. The container caught on fire and all rounds proceeded to go off but remained inside the oven. The lid was blown off of the container and a few rounds came out of the container. There was no visual damage to the witness plates. The oven was not breached and remained in tact. The temperature at time of reaction was 270.0°F. The container was oriented with the handles to 0° and 180°, and the blow out ports to 90° and 270°.

T/C	Location	Reaction Temperature (°F)
1	Air Temperature – Aft end high vent side 90°	269.1
2	Air Temperature – Right side 0°	270.4
3	Air Temperature – Forward end low vent side 270°	267.9
4	Air Temperature – Left side 90°	267.4
5	Skin Temperature – Aft end high vent side 90°	265.6
6	Skin Temperature – Forward end low vent side 90°	266.6
7	Internal Temperature – Right side 0°	270.2
8	Internal Temperature – Left side 180°	268.9

Post Test Results
T/S 271-300 / Test 2
Slow Cook-Off Test

Post Test Results
T/S 271-300 / Test 2
Slow Cook-Off Test

Bullet Impact

The bullet impact tests were conducted IAW MIL-STD-2105C, 14 July 2003 and STANAG 4241 (Edition 2), 15 April 2003 to determine and evaluate the response of the test item to the impact of a .50 caliber Type M2 armor-piercing (AP) bullet traveling at a velocity of 2,790 ± 66 ft/s.

Projectile is .50 caliber type M2 armor-piercing (AP) bullet with a velocity of 2790±66 ft/sec.

Four (4) blast transducers were placed at a 45° angle to the rear of the Test Unit as referenced in Figure 4.

A calibration Test of the blast transducers was performed by detonating a 1 pound sphere of C-4 explosives.

The triple .50 cal guns were positioned, the test stand was constructed, and a piece of 10" x 20" x 1" thick mild steel witness plate placed on top.

Velocity screens were placed along the gun line.

A second 18" x 20" x 1" witness plate was placed on the side of the Test Unit 25" from the center.

One (1) high-speed digital camera and three (2) standard video cameras were positioned to monitor and record testing.

All instrumentation was connected and calibration shots were performed using .50 caliber Armor Piercing ammunition. All data met within the test specification.

Test Unit S/N's 301-330 were placed on top of the witness plate.

Three (3) .50 cal M2 AP rounds were fired at the Test Unit. The first and third bullets were aimed 2 ½" up from the bottom of the round and ¾" the second bullet centered between side walls as referenced in Figure 10.

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Bullet Impact –Test Set-Up

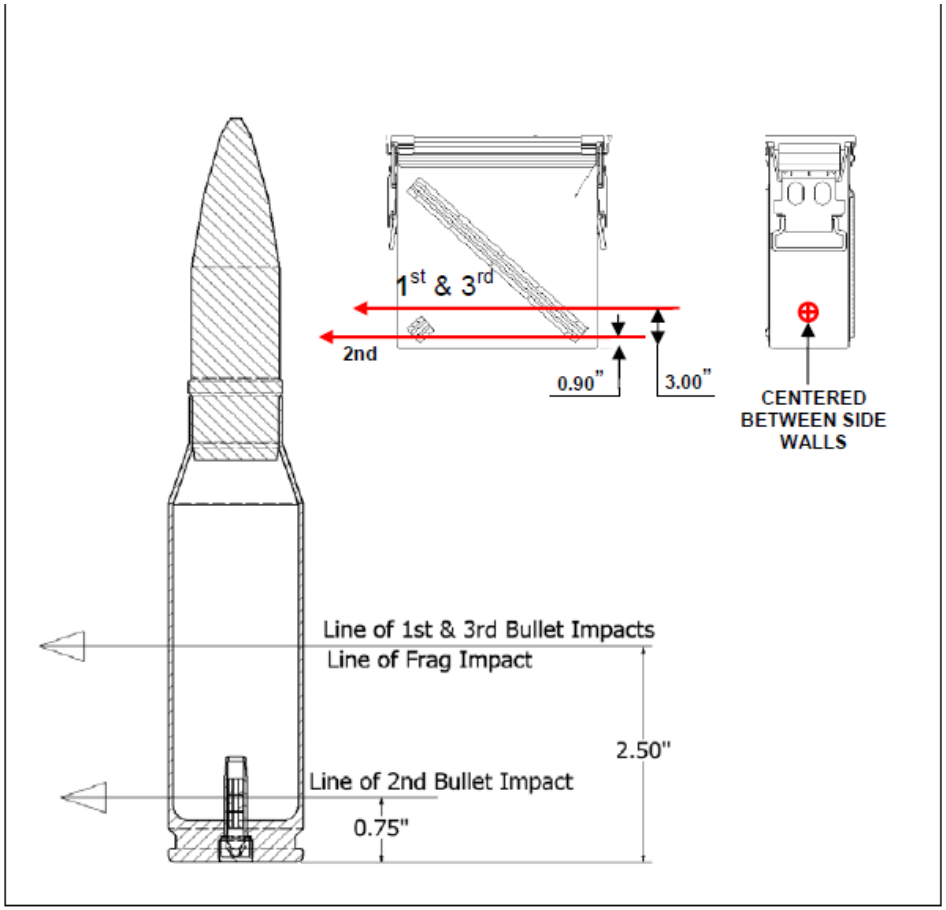

Figure 13
Aim Point and Shot Line for Bullet and Fragment Impact

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Bullet Impact – Test Set-Up

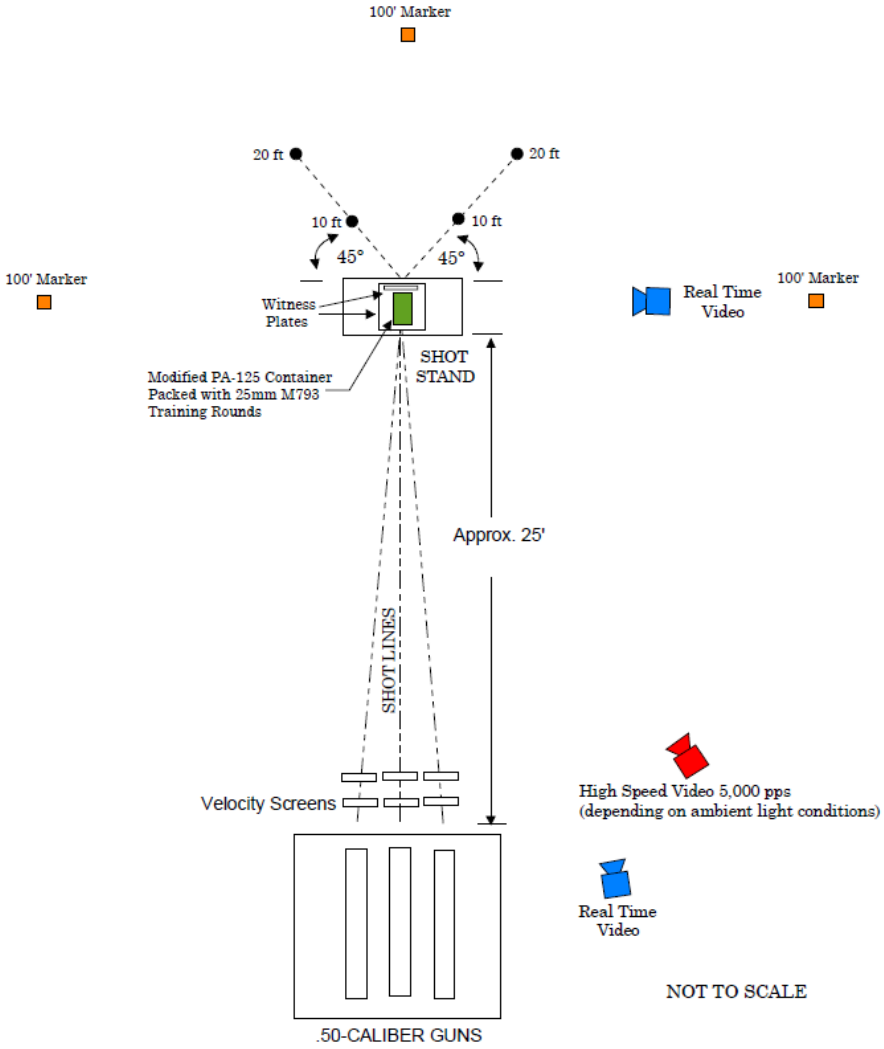
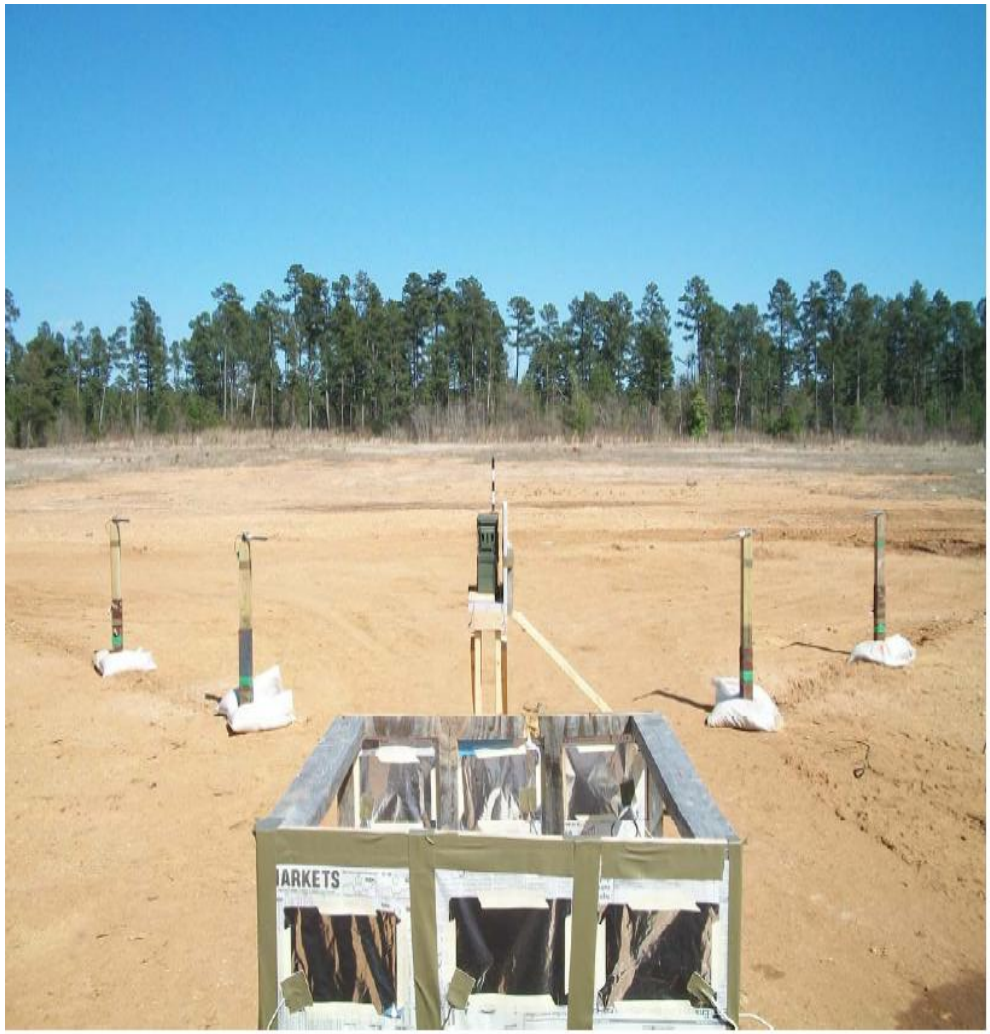


Figure 12
Bullet Impact Test Setup



Test Setup
T/S 331-360 / Test 2
Bullet Impact Test

Bullet Impact – Test Result

S/N: T/S 301-330			
Temperature	76°F	**Relative Humidity**	30%
Barometric Pressure	30.08 inHg	**Wind Speed/Direction**	2.0 mph/SW
Bottom Witness Plate	10”x20”x1” Thick Aluminum Plate	**Witness Plate Damage**	Burn/Gouge
Side Witness Plate	18”x20”x1” Thick Aluminum Plate	**Witness Plate Damage**	No Damage
Reaction Type	Type V Reaction	**Bullet Type**	Three (3) .50 Cal M2 AP

Bullet Velocity		Time	
Gun 1 Velocity	2840.9 Ft/Sec	**Gun 1 to Gun 2**	92.7 ms
Gun 2 Velocity	2854.8 Ft/Sec	**Gun 2 to Gun 3**	107.4 ms
Gun 3 Velocity	2835.5 Ft/Sec		

Probe Number	Distance	PSI	Probe Number	Distance	PSI
1	9’9”	0	3	9’10”	0
2	19’9”	0	4	19’8”	0

Aim Point: 2.50” up from the bottom of the round and .75” for the second bullet centered between the side walls

Test Results: Unit was impacted with all three bullets. The shipping container remained on the shot stand. The units started to catch fire for a brief minute and then started to smoke for about four minutes. There was a few pieces found from 358° to 86° and out to 39' 7". The bottom witness plate had some burnt propellant on top of it and also had a gouge in it that looked like it was from a bullet. The side witness plate had no visual damage. The test article was oriented with the handles on the container to 90° and 270°.

Post Test Results
T/S 301-330 / Test 1
Bullet Impact Test

Post Test Results
T/S 301-330 / Test 1
Bullet Impact Test

Post Test Results
T/S 301-330 / Test 1
Bullet Impact Test

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Bullet Impact –Test Result

S/N: T/S 331-361

Temperature	78°F	**Relative Humidity**	28%
Barometric Pressure	30.03 inHg	**Wind Speed/Direction**	5.0 mph/SW
Bottom Witness Plate	10”x20”x1” Thick Aluminum Plate	**Witness Plate Damage**	No Damage
Side Witness Plate	18”x20”x1” Thick Aluminum Plate	**Witness Plate Damage**	Gouge
Reaction Type	Type V Reaction	**Bullet Type**	Three (3) .50 Cal M2 AP

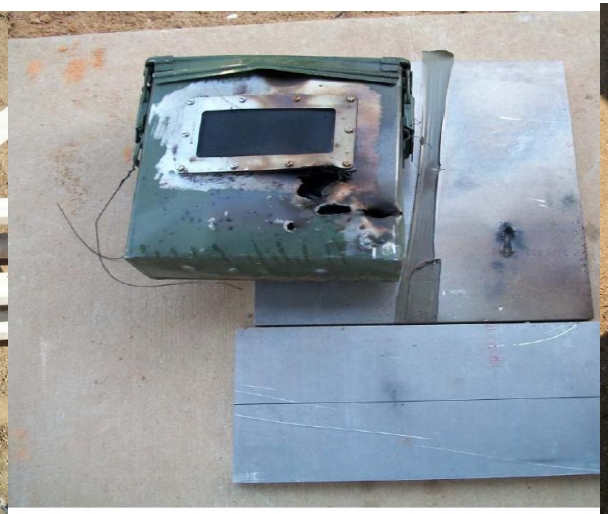
Bullet Velocity		**Time**	
Gun 1 Velocity	2801.1 Ft/Sec	**Gun 1 to Gun 2**	92.8 ms
Gun 2 Velocity	2830.2 Ft/Sec	**Gun 2 to Gun 3**	99.7 ms
Gun 3 Velocity	2846.3 Ft/Sec		

Probe Number	Distance	PSI	Probe Number	Distance	PSI
1	10’2”	0	3	10’2”	0
2	20’2”	0	4	20’	0

Aim Point: 2.50” up from the bottom of the round and .75” for the second bullet centered between the side walls

Test Results: Unit was impacted with all three rounds. The unit and the shot stand both were knocked over from the impact of the rounds. The units started to burn and smoked for about two minuets. The bottom witness plate had no visual damage and the side witness plate had a gouge that looked to be from a bullet coming out of the container. All rounds remained in the container. The test article was oriented with the handles on the container to 90° and 270°.

Post Test Results
T/S 331-360 / Test 2
Bullet Impact Test



Post Test Results
T/S 331-360 / Test 2
Bullet Impact Test

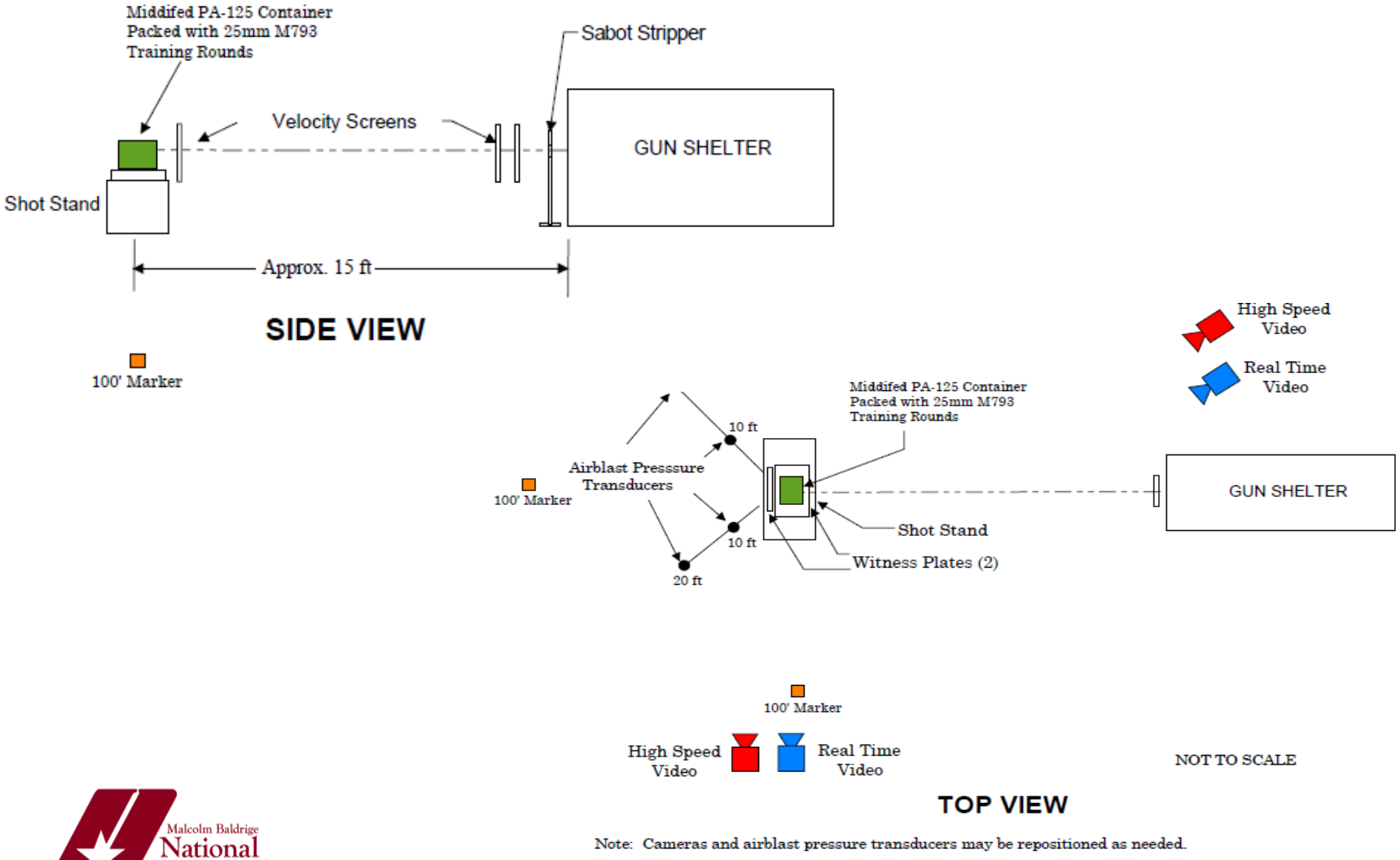
Post Test Results
T/S 331-360 / Test 2
Bullet Impact Test

Fragment Impact

The Fragment Impact (FI) tests were conducted IAW MIL-STD-2105C, 14 Jul 2003 and STANAG 4240(Edition 2), 15 Apr 2003 and the test plan to determine and evaluate the response of the PA125 container packed with 30 rounds of M793 25-mm vented cartridge cases to the impact of a 50-in mild steel conical fragment army fragment travelling at a speed of 8,300 fps.

- ❑ One (1) ammunition container per test
- ❑ Standard projectile is .50” diameter mild steel with a velocity of 8,300±300 ft/sec
- ❑ Gun To Be Located 15’ From Test Article
- ❑ Fragment gun positioned, test stand was constructed, and a 10”x20”x1” thick steel witness plate was placed on top of the shot stand
- ❑ One conical fragment was shot into the Test Unit. The aim point was handle side of the shipping container 3” from the bottom. Line of fragment impact will be the same as the bullet impact test
- ❑ Velocity screens placed along the gun line
- Four (4) blast transducers to the rear of the test units gages positioned as shown on next page
- Second aluminum witness panels located on the side of test unit.
- Two (2) video cameras and two (2) high-speed camera positioned as shown on next page

Fragment Impact Test Set-Up



Note: Cameras and airblast pressure transducers may be repositioned as needed.

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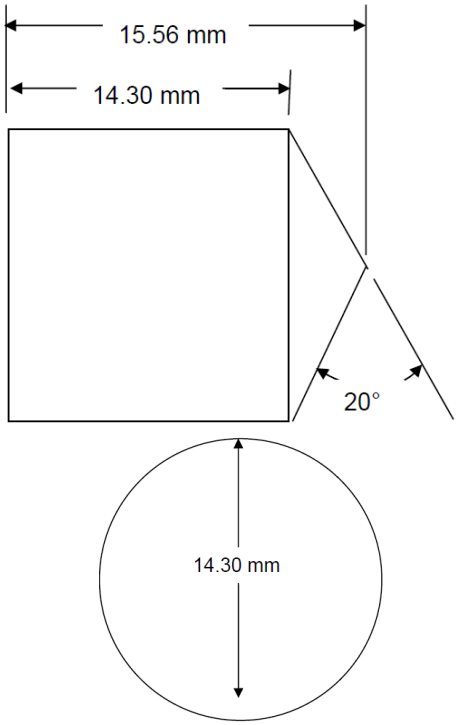
Fragment Impact Test Set-Up

Test Setup
T/S 211-240 / Test 2
Fragment Impact Test



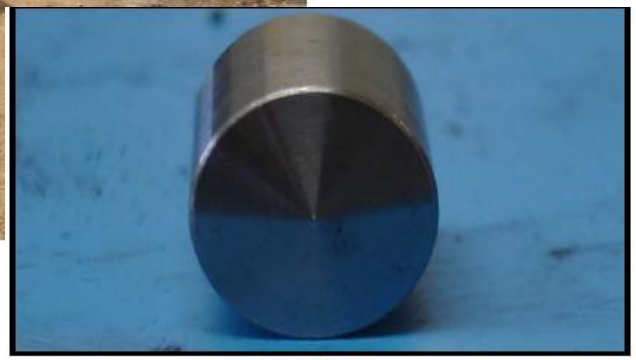


Figure 18
.50-in. mild steel conical army fragment

Fragment Impact Test 1 Result

S/N: T/S 181-210			
Temperature	52°F	**Relative Humidity**	47%
Barometric Pressure	30.09 inHg	**Wind Speed/Direction**	0 MPH
Bottom Witness Plate	10”x20”x1” Thick Mild Steel	**Witness Plate Damage**	Scarring/ Indentions
Side Witness Plate	18”x20”x1” Thick Mild Steel	**Witness Plate Damage**	Scarring/ Indentions
Reaction Type	Type IV Reaction	**Fragment Velocity**	8237.7 Ft/Sec

Probe Number	Distance	PSI	Probe Number	Distance	PSI
1	10’0”	0.96	3	10’0”	0.48
2	20’4”	0.33	4	19’11”	0.22

Aim Point:

Test Results: Test article was impacted on aim point and was knocked off of the test stand. The container split open and the rounds all came out with the packing materials. Both blow out ports were blown out of the container, with the lid staying attached. The furthest piece recovered was located at a distance of 90' 4" on the angle of 345°. There was minimal damage to the witness plates with some scarring and indentations from the test article. The test article was oriented with the handles on the container to 90° and 270°.

Post Test Results
T/S 1-30 / Test 1
Shaped Charge Jet Impact Test

Post Test Results
T/S 211-240 / Test 2
Fragment Impact Test

Fragment Impact Test 2 Result

S/N: T/S 211-240			
Temperature	81.3°F	**Relative Humidity**	27%
Barometric Pressure	30.00 inHg	**Wind Speed/Direction**	7.6mph/WSW
Bottom Witness Plate	10”x20”x1” Thick Mild Steel	**Witness Plate Damage**	Scratching
Side Witness Plate	18”x20”x1” Thick Mild Steel	**Witness Plate Damage**	Scratching
Reaction Type	Type IV Reaction	**Fragment Velocity**	8235.2 Ft/Sec

Probe Number	Distance	PSI	Probe Number	Distance	PSI
1	10’2”	2.03	3	10’3”	0.44
2	20’6”	0.4	4	19’11”	N/A

Aim Point:

Test Results: Test article was impacted on target and knocked off of the test stand. The container was split open with the rounds being strewn out of the container. The lid came off of the container and was recovered at a distance of 11' 1" on the respected degree of 90°. The blow out port frame broke off and landed at a distance of 196' 7" and at 25°. Rounds were found from 3° to 100° and out to 130' 8". The witness plates showed some slight scratching from the test article. Test article was set with the handles on the container to 90° and 270°.

Post Test Results
T/S 211-240 / Test 2
Fragment Impact Test

Post Test Results
T/S 211-240 / Test 2
Fragment Impact Test

Shaped Charge Jet Impact

- The Shaped Charge Jet (SCJ) tests were conducted IAW MIL-STD-2105C, 14 Jul 2003 and STANAG 4240(Edition 2), 15 Apr 2003 and the test plan to determine and evaluate the response of the PA125 container packed with 30 rounds of M793 25-mm vented cartridge cases to the impact of an aluminum cased 81mm shaped charge loaded with LX-14 explosive.

- ❑ One (1) ammunition container per test
- ❑ 81mm shaped charge to be placed 243mm from the test article. Used an LX-14 explosives and a 4 inch conditioning plate between the 81mm SC and Test Article.
- ❑ Test Unit S/N's 1-30 placed on support stand with a 2" standoff. Aim point was 3"from the bottom of the shipping container and centered on the side.
- ❑ Four(4) blast transducers positioned 45^0 angle to the rear of the Test Unit as shown on the next page
- ❑ One (1)18" x 20" x 1" thick aluminum plate placed behind ammunition can
- ❑ Two (2) video cameras and two (2) high-speed camera positioned as shown on the next page
- ❑ One (1) RP detonator was secured to the firing line and placed in contact with the PIC of the 81mm SC and the RP-2 detonator held in place with a tape.

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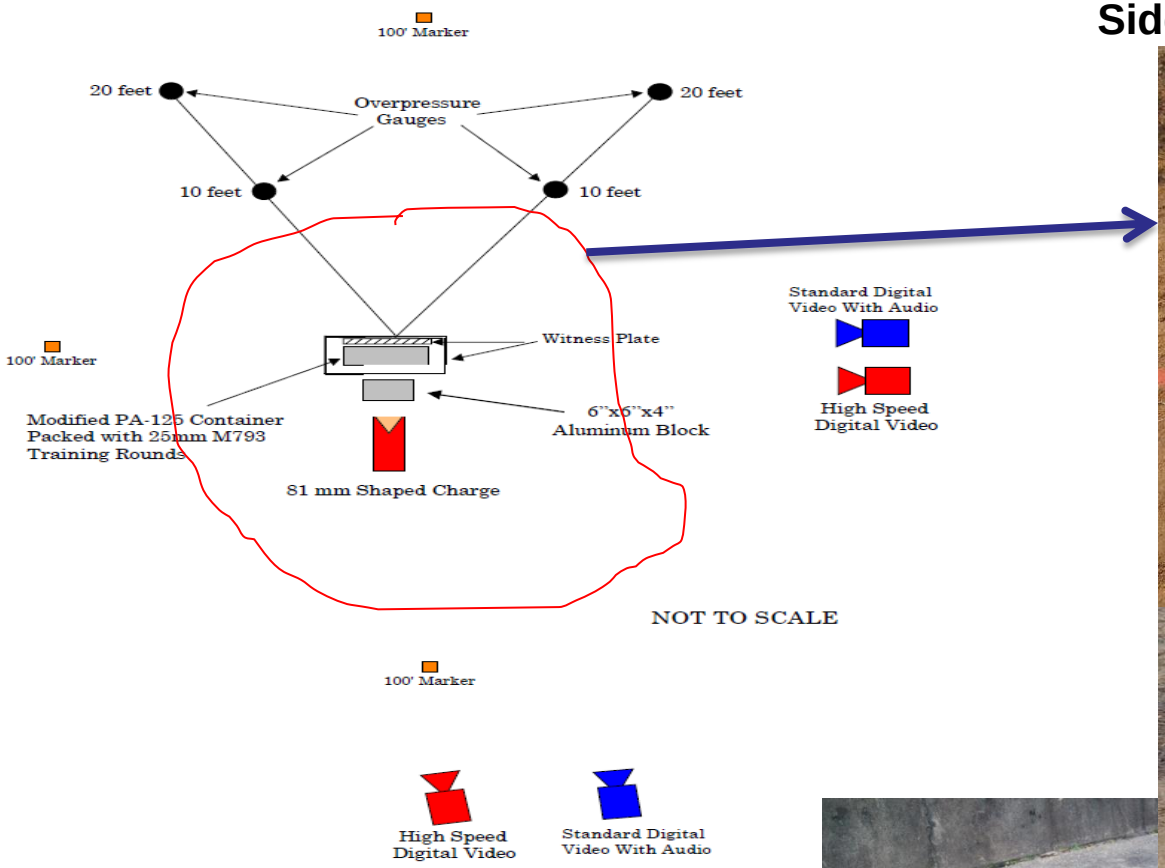
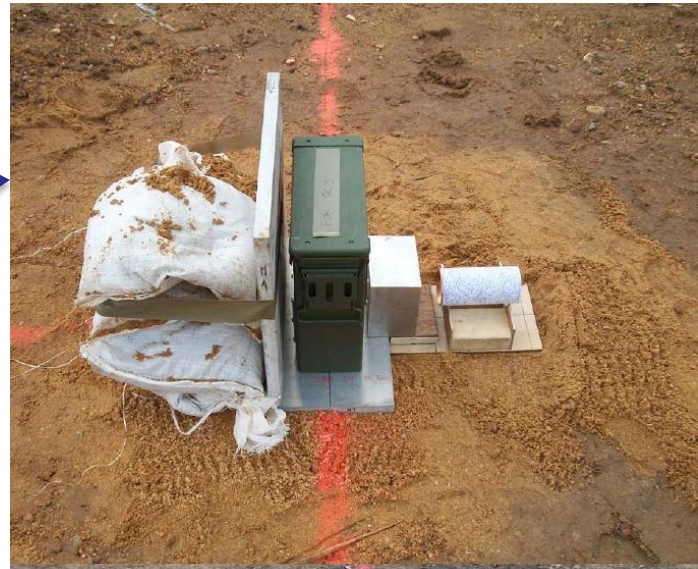
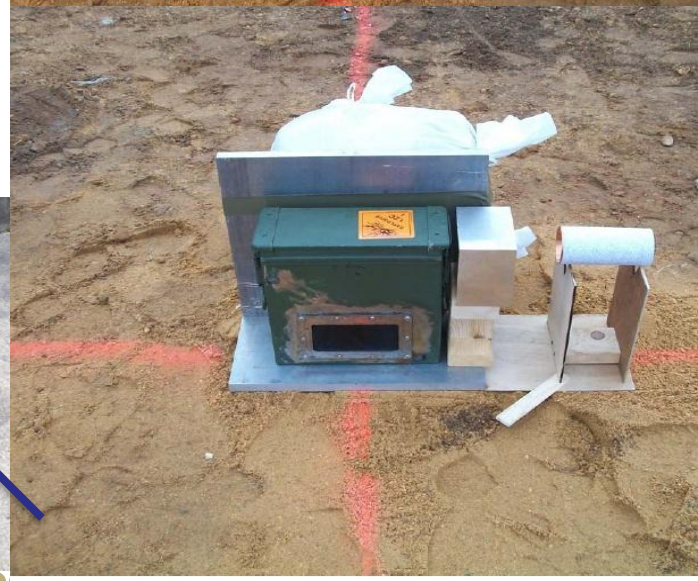
Shaped Charge Jet Impact Test Set-Up



Note: Repositioning of cameras and blast is allowed as needed.

Side View





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Test Setup
T/S 31-60 / Test 2

Shaped Charge Jet Impact Test Results

S/N: 1-30			
Temperature	63.5°F	**Relative Humidity**	60%
Barometric Pressure	29.76 inHg	**Wind Speed/Direction**	2.1mph/SE
Back Witness Plate	18"x20"x1" Thick Mild Steel	**Witness Plate Damage**	Hole/Scratching/ Pitting
Bottom Witness Plate	10"x20"x1" Thick Mild Steel	**Witness Plate Damage**	Scratching/Pitting
Shaped Charge Size	81mm with copper liner and LX-14 explosive		
Reaction Type	Type IV Reaction		

Probe Number	Distance	PSI	Probe Number	Distance	PSI
1	10'0.5"	16.5	3	10'3"	15.2
2	20'3.5"	5.6	4	20'1"	5.6

Aim Point: 3" from the bottom of the can and centered on the side of the container

Test Results: Container was impacted on target with jet and separated into several pieces. The rounds were scattered from 0° to 360° with the furthest round being recovered at 347.67'. Both witness plates were located at 5' and 90° in tact but did have some scratching and pitting from debris, with the back witness plate having a hole from the jet in it. The orientation of the test was with the shape charge aimed at 90° and the blast pressure probes at 45° and 135°.

Test Setup
T/S 1-30 / Test 1
Shaped Charge Jet Impact Test

Post Test Results
T/S 1-30 / Test 1
Shaped Charge Jet Impact Test

Shaped Charge Jet Impact Test Results

S/N: 31-60			
Temperature	67.8°F	**Relative Humidity**	76%
Barometric Pressure	29.73 inHg	**Wind Speed/Direction**	5.8mph/SE
Back Witness Plate	18”x20”x1” Thick Mild Steel	**Witness Plate Damage**	Scratching/Pitting
Bottom Witness Plate	10”x20”x1” Thick Mild Steel	**Witness Plate Damage**	Scratching/Pitting
Shaped Charge Size	81mm with copper liner and LX-14 explosive		
Reaction Type	Type IV Reaction		

Probe Number	Distance	PSI	Probe Number	Distance	PSI
1	10’1.5”	15.6	3	10’0”	14.0
2	20’4”	5.5	4	19’8”	5.9

Aim Point: 3” down from the top of the can and centered on the latch end of can

Test Results: Test article was impacted on target with the jet and separated into several pieces. The furthest piece that was recovered was found to be at 210.25’ and at the angle of 15°. Rounds were scattered from 0° to 110°, and at a distance up to 127’. The witness plates were in tact and suffered minimal damage with pitting and scratching from debris. The shape charge was aimed at the end of the container 3 inches down from the top and centered. The container was oriented with the blow out ports to 0° and 180°.

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Post Test Results
T/S 31-60 / Test 2
Shaped Charge Jet Impact Test

Unconfined Sympathetic Detonation

- Test Set-Up is Identical to Shaped Charge Jet Impact Test
- Two (2) Ammunition Containers Per Test
- Four(4) blast transducers placed at 45^0 angle of the Test Unit.
- Two(2) high speed camera and two (2)std video camera. All instrumentation were connected and calibration shot performed using 1 pound C-4 explosives.
- One(1) 18”x20”x1” thick aluminum witness plate placed on level ground in the range set up as shown in the figure.
- Test Units placed next to each other
- One (1) blasting cap with a short piece of det cord was secured during firing. Blasting cap inserted into the fuze of th etest Unit and secured in place.
- From the safe area, blasting cap was detonated.

Unconfined Sympathetic Detonation Test Set-Up

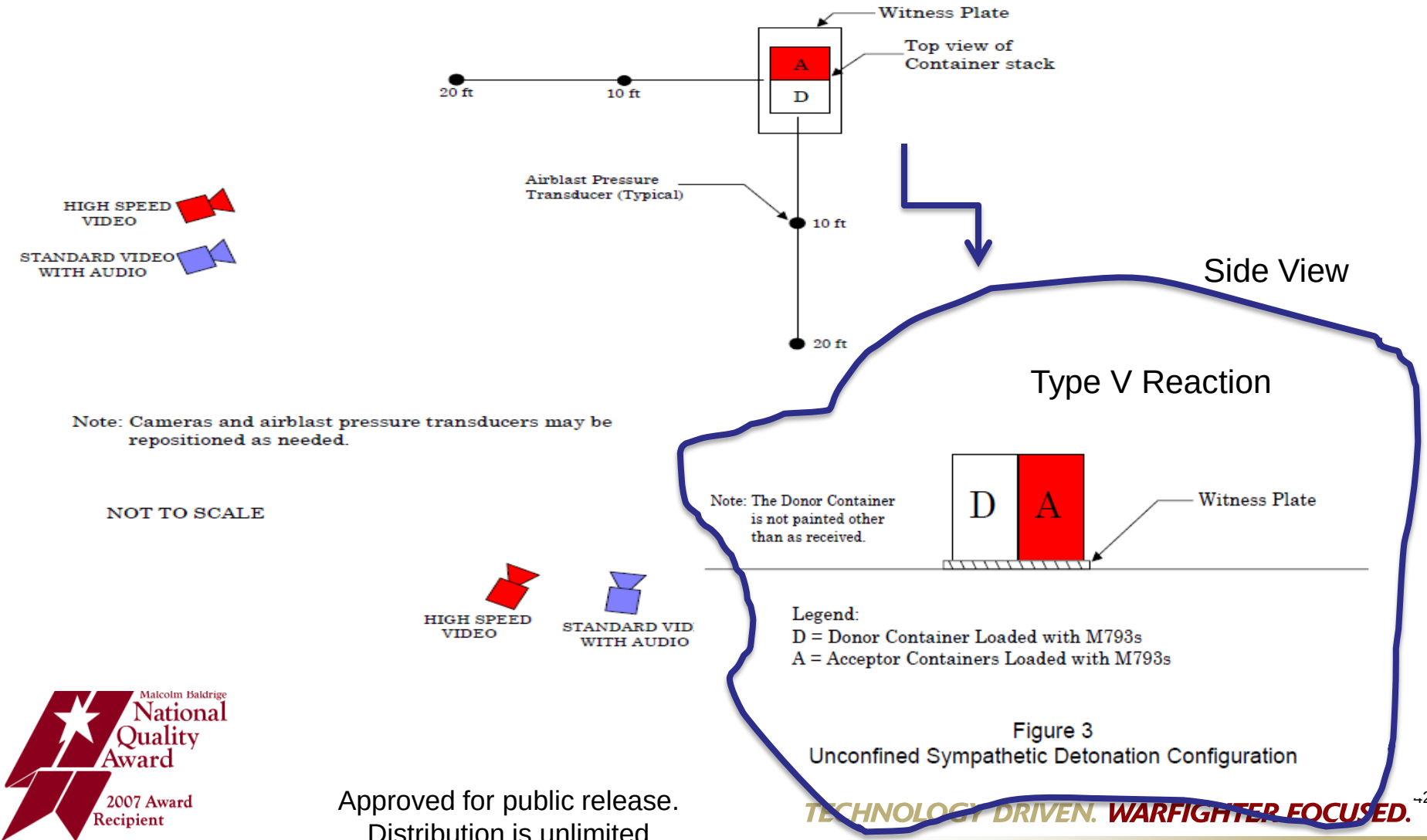

Figure 3
Unconfined Sympathetic Detonation Configuration

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Unconfined Sympathetic Detonation Test Set-Up

Test Setup
T/S 61-120
Unconfined Sympathetic Detonation Test

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Unconfined Sympathetic Detonation Test Set-Up

S/N: 61-90 and 91-120			
Temperature	78.6°F	**Relative Humidity**	45%
Barometric Pressure	29.75 inHg	**Wind Speed/Direction**	0 MPH
Witness Plate	18"x20"x1"	**Witness Plate Damage**	No Damage
Reaction Type	Type V Reaction		

Probe Number	Distance	PSI	Probe Number	Distance	PSI
1	9'10.5"	1.0	3	10'1.5"	0.9
2	20'1.5"	0.4	4	19'11"	0.3

Test Results: The Donor round was detonated and caused one blowout port to blow out, and the other, that was facing the acceptor, to crack around the edge. The bottom of the donor box where round was detonated, was cracked and the primer housing was forced through the bottom of the can. The lid of the donor can remained latched, but was bulged which created a gap. All other rounds inside of the donor box remained inside of the box. The cases of the rounds surrounding the donor round were dented. Both Donor and Acceptor cans were laying on their sides after detonation. There was no damage to the acceptor cans except for small dents on the can from screws of the donor box. Units were oriented with the outer face of the Donor box at 315° and the outer face of the Acceptor box at 135°. There was no visual damage to the witness plate.

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Recommended Testing

IM Test	MIL-STD-2105C	Actual IM Test Results	Test Parameters
Fast Cook-Off (Liquid Fuel/External fire)	V	IV	• Per STANAG 4240 (Edition 2) • Complete engulfment of the test item by the fire for a min of 20 min
Slow Cook-Off (Slow Heating)	V	V	• Per STANAG 4382 (Edition 2) • Test item to be pre -conditioned at +50°C for 8 hours prior to test or until it reaches equilibrium at +50°C (+122°F) • Oven temperature to be increased +6°F per hour from +50°C until reaction occurs
Bullet Impact	V	V	• Per STANAG 4241 (Edition 2). • 0.50 cal Type M2 AP bullet @velocity of 2790±66 ft/sec
Fragment Impact	V	IV	• Per STANAG 4496 (Edition 1). • 0.50 inch mild steel conical fragment@velocity of 8,300±300 ft/sec
Shaped Charge Jet Impact	II,IV,V	PASS	• Per STANAG 4526 (Edition 1, Ratification Draft 1) • 81mm shaped charge loaded with LX-14 and 4”Conditioning Plate bet ween SC and Test Article • Impact at the propellant location
Sympathetic Detonation	II,IV,V	PASS	• Per STANAG 4396 (Edition 2) • Required if SCJI test is a failure • 81mm shaped charge loaded with LX-14

CONCLUSIONS

- Ballistic Performance Test Results met the Mil Spec requirements.
- IM Test completed. Results show great IM improvement

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