Always a Step Ahead

ARDEC

ARMAMENTS

The ARDEC Gap Test

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UNPARALLELED

COMMITMENT

& SOLUTIONS

Act like someone's life depends on what we do.

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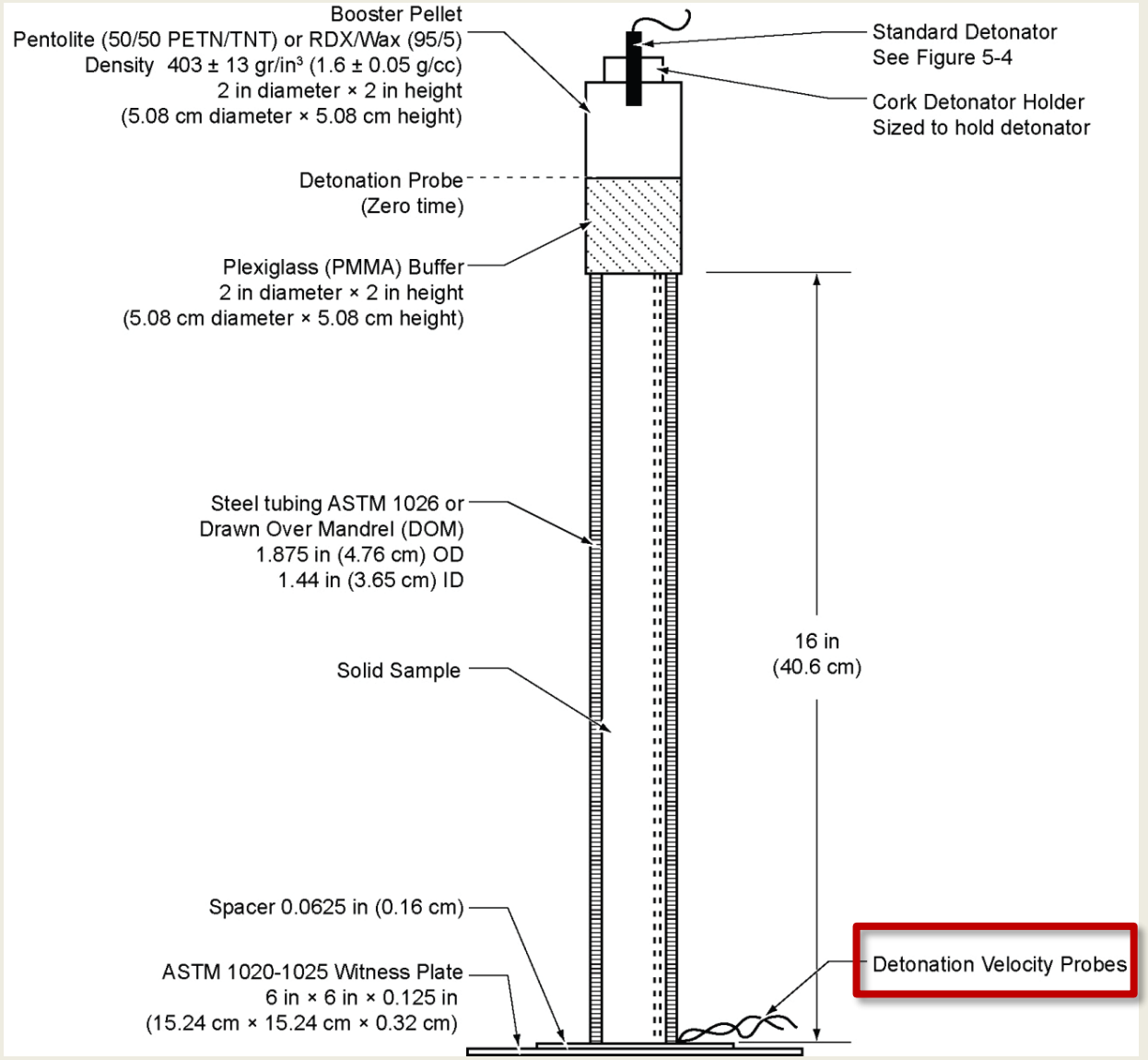
OVERVIEW

- ARDEC used the UN 2(a) iii Gap Test as one of the differentiators for HD 1.1 vs. 1.3 IHCs for propellants
- Changes to the TB 700-2 shock sensitivity tests resulted in conflicting IHC/FHC assignments for certain propellants
- Test series developed and executed, briefed the DDESB, and performed additional testing
- Development of the ARDEC Gap Test as a replacement to UN Test 2(a) for small-grain propellants
- Limitations/Future Work

UN Test 2(a) Configuration



200 cards, ~20 kbar input shock

UN Gap Test Revision

- The UN Gap Test revision removed the resistive wire detonation velocity probe
  - Difficult to procure components, dated method of measurement
- Same test fixture, same donor material, same attenuation
- Legacy test had 3 assessment criteria
    - Holed witness plate
    - Fragmented tube
    - Stable shock wave propagation
  - If 2 of 3 criteria were met, material given positive (+) result and was a candidate for a HD 1.1 IHC assignment (ARDEC)
- Current test has 2 assessment criteria
    - Holed witness plate
    - Fragmented tube
  - If either criterion was met, material given positive (+) result and was a candidate for a HD 1.1 IHC assignment (ARDEC)

UN Test 2(a) Legacy vs. Current

Propellant	Legacy Test Result	Current Test Result
Sample 1	Positive TF, HP, No DV	Positive TF, HP
Sample 2	Positive TF, HP, No DV	Positive TF, HP
Sample 3*	Negative TF, No HP, No DV	Positive TF, No HP
Sample 4*	Negative TF, No HP, No DV	Positive TF, No HP
Sample 5	Positive TF, HP, No DV	Positive TF, No HP
Sample 6*	Negative TF, No HP, No DV	Positive TF, No HP
Sample 7	No Data	No Data
Sample 8	No Data	Negative No TF, No HP

TF = Tube Fragmented, HP = Holed Plate, DV = Detonation Velocity

POST-TEST PHOTOGRAPHS

UN Test 2(a) Propellant Fragments (Deflagration)

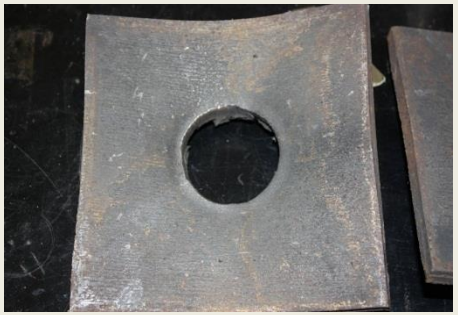
Typical Detonation Fragments

UN Test 2(a) Propellant Witness Plate (holed)

70 CARD LSGT RESULTS

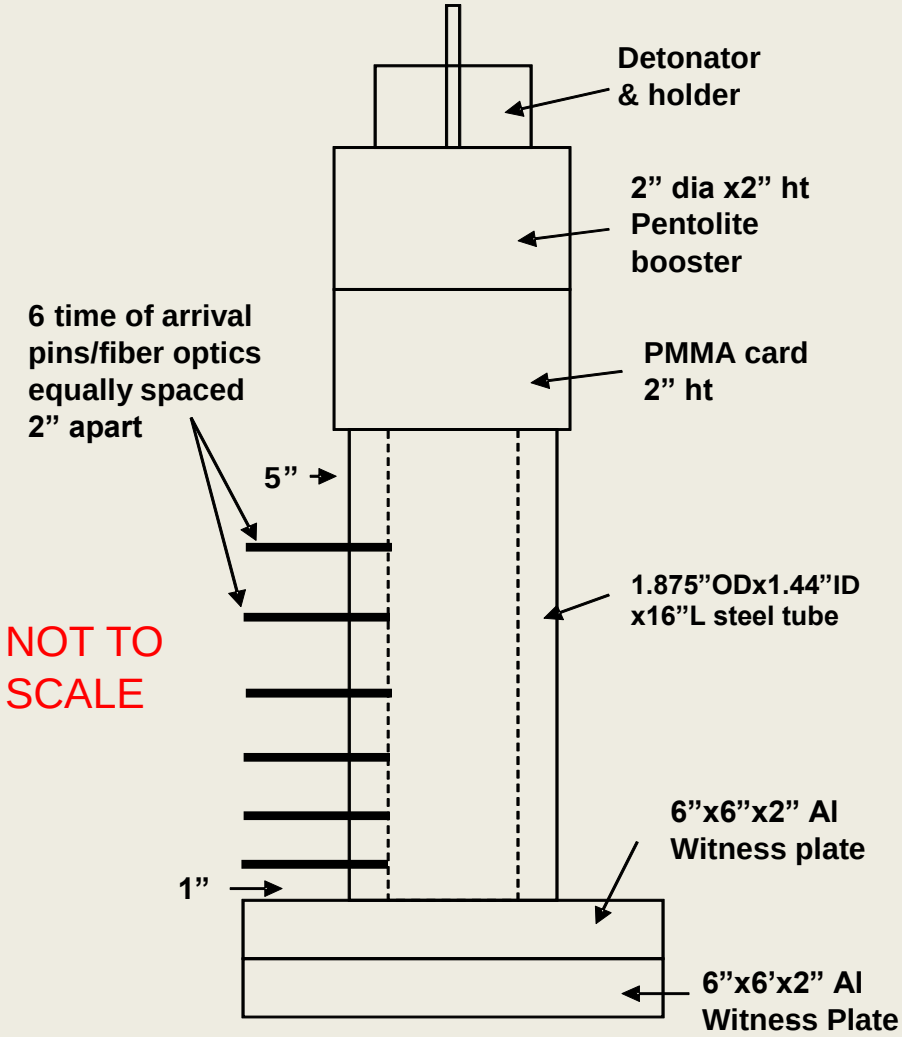
- DDESB briefed with findings and the board recommended conducting 70 card NOL LSGT test series (~70 kbar input)

Propellant	70 Card LSGT Results	NOL LSGT 50% Point (cards)
Sample 1	Go, Go, Go	125
Sample 2	Go, Go, Go	131.5
Sample 3	Go, Go, Go	No Data
Sample 4	Go, Go, Go	141
Sample 5	Go, Go, Go	No Data
Sample 6	Go, Go, Go	139.5
Sample 7	Go, Go, Go	No Data
Sample 8	Go, Go, Go	140.5



All propellants tested would be candidates for HD 1.1

DEVELOPMENT OF THE ARDEC GAP TEST



- Same sample tube, booster, attenuation as UN gap tests
- Optical fibers located down the length of the tube for shock velocity measurements
- Aluminum dent blocks for comparable pressure measurements

ARDEC GAP TEST METHODOLOGY

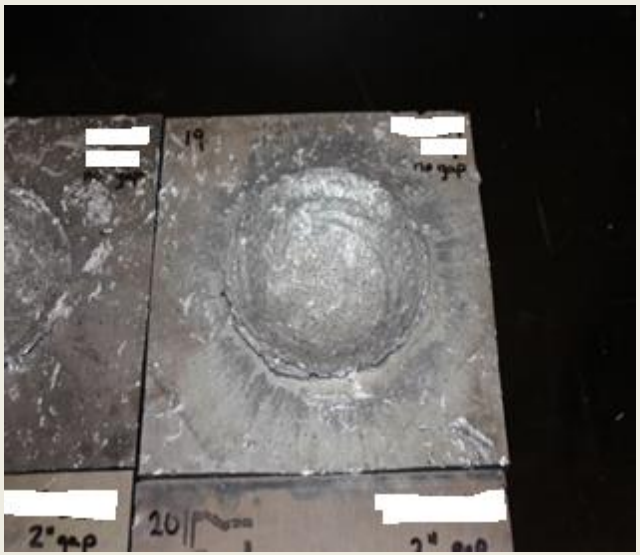
- Three tests were conducted on each sample material
  - Trial 1: Baseline test, no PMMA attenuation
    - Determines detonation velocity and dent with explosive booster in contact with sample
    - Confirms detonability of material at test geometry
      - If material did not detonate, repeat test without attenuation
      - Larger scale test required due to CD, not available in current standards
  - Trial 2: Attenuated test, 2” PMMA gap
    - Determines detonation velocity and dent with the attenuated shock
  - Trial 3: Repeat of trial 2, 2” PMMA gap
- **Evaluation criteria**
  - If the dent depth from either attenuated test is greater than 50% of the baseline dent depth, OR if there is a stable shock velocity in trials 2 or 3, the test sample detonated (positive result).

PROPELLANT RESULTS

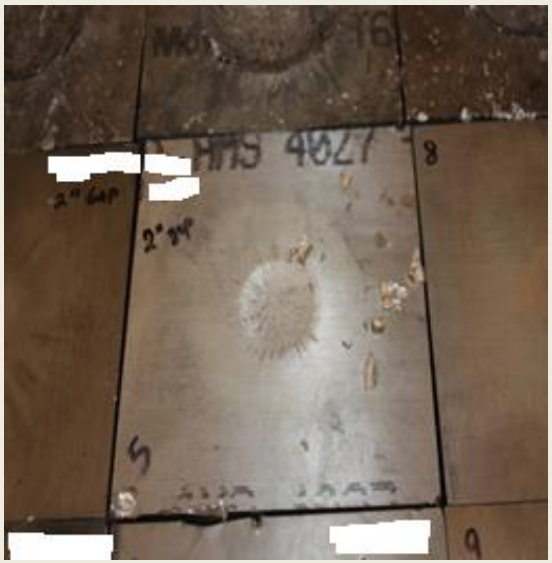
Propellant	Shot #	PMMA gap (In.)	Det. Vel. (km/s)	Dent (in.)
Sample 1	1	None	5.077	0.597
	2	2	Not used	0.043
	3	2	No Velocity	0.039
Sample 2	1	None	5.190	0.595
	2	2	Not used	0.053
	3	2	No Velocity	0.049
Sample 3	1	None	5.322	0.764
	2	2	Not used	0.024
	3	2	No Velocity	0.025
Sample 4	1	None	5.364	0.746
	2	2	Not used	0.037
	3	2	No Velocity	0.035
Sample 5	1	None	5.437	0.697
	2	2	Not used	0.053
	3	2	No Velocity	0.049
Sample 6	1	None	5.435	0.736
	2	2	Not used	0.039
	3	2	No Velocity	0.040
Sample 7	1	None	5.081	0.582
	2	2	Not used	0.002
	3	2	No Velocity	0.002
Sample 8	1	None	4.899	0.581
	2	2	Not used	0.013
	3	2	No Velocity	0.018

PROPELLANT DISCUSSION

- All propellant samples were detonable in the baseline configuration
  - 4.9 to 5.5 km/s detonation velocity
  - 0.581 to 0.746” dent depth in Aluminum (70 to 90% TNT detonation pressure)
- No propellants detonated in the attenuated configuration (2” PMMA)
- No clear correlation with NG% or particle size



Detonation

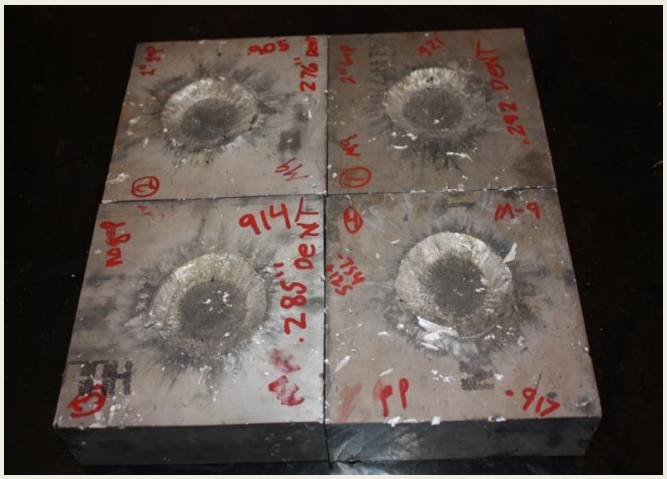


Deflagration

M9 ARDEC Gap Test Results

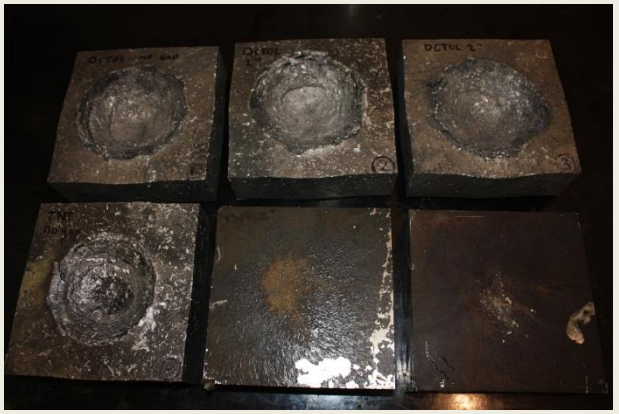
- M9 Flake propellant tested in ARDEC Gap Test configuration
- High NG content, small bed critical diameter
- All shots detonated, positive (+) result. Optical fiber technique did not work for M9.

Propellant	Shot #	PMMA gap (In.)	Det. Vel. (mm/us)	Dent (in.)
M9	1	None	No Trace	0.276
	2	2	No Trace	0.292
	3	2	No Trace	0.275
	4	2	No Trace	0.286



HE ARDEC Gap Test Results

- Two high explosive formulations were tested for comparative purposes
  - Octol 70/30 (cast)
  - TNT (cast)
- Octol 70/30 detonated with the 2” attenuator, positive result
- TNT did not detonate with the 2” attenuator, negative result



Explosive	Shot #	Density (g/cc)	NOL 50% Point (cards)	PMMA gap (In.)	Det. Vel. (mm/us)	Dent (in.)
Octol 70/30 (cast)	1	1.8	>220	None	8.274	1.078
	2	1.8		2	Not used	1.081
	3	1.8		2	8.239	1.119
TNT (cast)	1	1.56	~150	None	6.583	0.826
	2	1.56		2	Not used	0
	3	1.56		2	No Velocity	0

UTILIZATION OF THE ARDEC GAP TEST

- ARDEC hazard classifiers approved the use of the ARDEC Gap Test for assisting in differentiating between HD 1.1C and 1.3C IHCs for small-grain propellants

- The test yields more information and is a better indicator of detonation than the current UN Test Series 2 shock sensitivity test

LIMITATIONS, FUTURE WORK

- 2” attenuator thickness a topic of debate
  - Unsure of origin of this input shock (20.7 kbar)
  - 0.7” attenuator used in legacy modified NOL LSGT test for HD 1.1 vs 1.3 IHC (69.8 kbar)
  - Should 50% initiation points be determined instead of limited testing at specified input shocks? Where should the line be drawn?

- Detonation or “violent reaction”?
  - ARDEC Gap Test determines if the material detonated
  - Is HC testing done to evaluate technical detonation or “violent reaction”?

Questions?