Always a Step Ahead

ARDEC

ARMAMENTS

DBX-1 "Green" Primary Explosive use in M55 & M100 Detonators

Presented to:

Fuze Conference

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UNPARALLELED

COMMITMENT

& SOLUTIONS

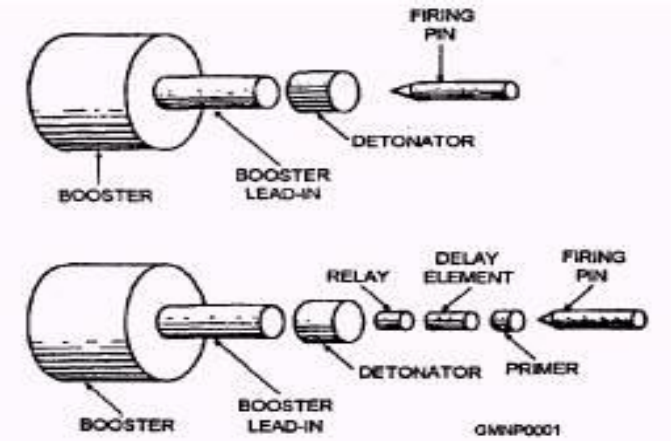
Act like someone's life depends on what we do.

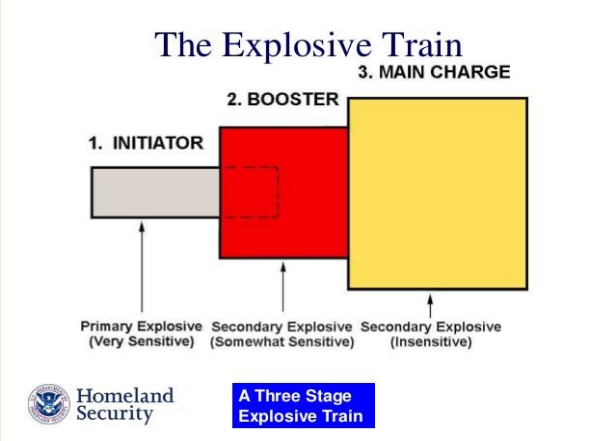
U.S. ARMY RDECOM®

U.S. ARMY ARMAMENT RESEARCH, DEVELOPMENT & ENGINEERING CENTER

WHAT IS PRIMARY EXPLOSIVE?

- Generates a detonation wave when subjected to heat, flame, impact, friction or an electric spark
- Initiates secondary or booster explosive, which will initiate the main charge explosive or propellant
- Most widely used is lead azide or lead styphnate
- Primary explosive and its formulations are incorporated in detonators, primers, blasting caps, igniters, etc.





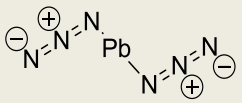
Lead Azide & Lead Styphnate

Lead azide (LA):

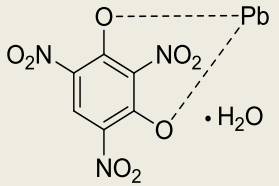
- Most commonly used as the main component in detonators and blasting caps dating back to World War II era
- Several common varieties:
  - **Dextrinated** – "commercial grade", less output, safer production/handling
  - **RD-1333** – "military grade", higher performance/reliability in small size applications
  - **Special Purpose (SPLA)** – very similar composition & performance to RD-1333; often used interchangeably
- Only 3 current sources of military-qualified RD-1333/SPLA:
  - Iowa stockpile
  - TechOrd/Chemring, South Dakota
  - Dyna Nobel, Germany
- Reacts with moisture and copper

Lead Styphnate (LS):

- Less powerful than LA, but easier to initiate by impact (e.g., firing pin); high thermal output
- Typically employed in primers or as the initiating element in detonators and blasting caps
- Most ammunition manufacturers produce their own
- Two common types:
  - Basic
  - Normal



LEAD AZIDE

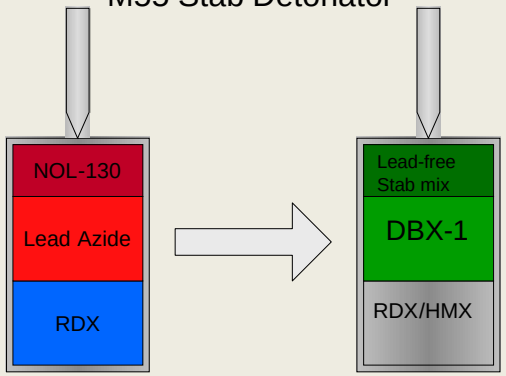


NORMAL LEAD STYPHNATE

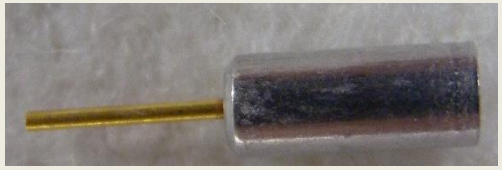
OBJECTIVE

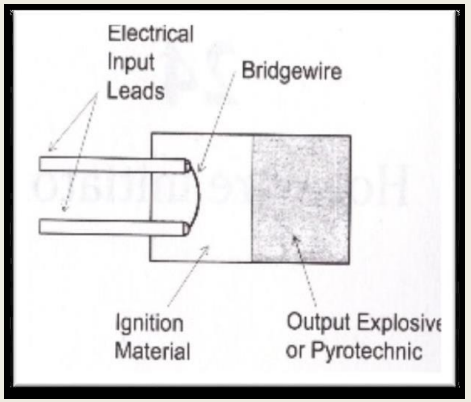
- Replace lead azide as transfer charge and lead styphnate spot charge with DBX-1 in M100 electric detonator
- Replace lead azide as transfer charge AND lead azide/lead styphnate from stab initiation mix with DBX-1 in M55 stab detonator

M55 Stab Detonator



M100 Electric Detonator





DBX-1: BLUF

- Strict new environmental regulations may disrupt supply of the older lead/mercury based explosives as well as restrict training
  - Exposure of personnel to human health hazards must be reduced/eliminated
- DBX-1 is a green primary explosive developed to replace toxic/hazardous lead & mercury based compounds (LA, most of LS, DXN-1)
- Successfully tested in multiple detonator platforms as well as primers
- Material cost will be comparable or cheaper than lead azide

Lead Azide & Lead Styphnate Issues

- ESOH Issues:
  - Lead azide and lead styphnate are the two common primary explosives used in detonators, primers, blasting caps, etc. for military and commercial applications
  - Lead affects health and environment
    - Lead released as air emissions at firing site (training facility, shoot houses, indoor ranges)
    - Soldier/worker exposure in training facility, field, production plant or demil
    - EPA: There are no safe exposure levels for lead
- Changing Regulation:
  - National Academy of Sciences (NAS) Study in 2013: Current lead Operators Exposure Level (OEL) not protective of workers and soldiers
  - Public Health Center (PHC) evaluating reduced OEL for DoD operations
- Current Status:
  - Usage: High (billions of items produced/used per year)
  - Weapon Systems: 1000s of items use lead in primers/detonators

M100 Electric Detonator

- Smallest detonator in mass production
- Hot wire ignition
- Nickel chrome bridgewire
- Lead styphnate spot charge
- Lead azide intermediate charge
- HMX output charge

COLUMN SIZE

- Outer diameter: 0.100”
- Inner explosive diameter: 0.075”
- Total column height: 0.190”

TESTING REQUIREMENT

- Output dent :
  - greater or equal to 0.005”
- Typical dents for standard M100:
  - 0.010” – 0.016”
- All Fire Parameters
  - 1.6V
  - 100µF capacitor

2013: Trial of Various Ignition Charges To Improve Function

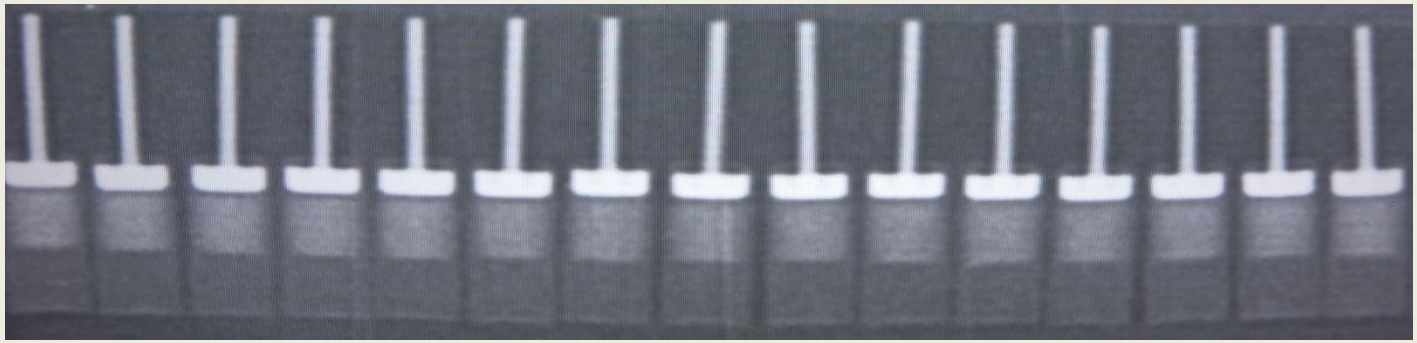
Test results & observations:

- Colloidal Lead Azide spot charge
  - No success with standard bridge wire / firing energy
- Lead Styphnate double spot charge
  - No improvement of high order function
- Milled DBX-1 spot charge
  - Shows great promise for use to replace lead styphnate ignition charge.
  - Equal firing energy and increased output vs. lead styphnate.

2013: CHARGE CUP EXPERIMENTS

- Loading:
  - Lead styphnate spot charge
  - DBX-1 intermediate charge
  - HMX output charge
- Multiple groups loaded, each time making adjustments to improve results
  - HMX column height adjusted to maximize the increment height of DBX-1
  - Optimized consolidation pressure on DBX-1 increment
- Results:
  - Eliminated low order functions
  - Good output dents

Functioned M100



X-ray of loaded M100's

Low Order: FAILED test pieces

High Order: good dents on witness block

MILLED DBX-1 SPOT CHARGE

- Made small batches of slurry spot charge using DBX-1
- First tried only coating bridge wire with DBX-1 spot charge and functioned
  - Standard M100 headers used
  - Standard Ni Chrome Bridge Wire
  - Standard All Fire Energy
    - 100% Function with Zero Duds
  - All fire sensitivity equal to lead styphnate .999 All fire energy = 1.38 Volts
  - Greater audible report increased output

Various Bridge Wires study with DBX-1 Slurry Spot Charge

Characteristics	M84 Platinum wire	Tungsten Metal wire	Platinum –Iridium Wire
Thickness	0.00023”	0.00012”	0.0005”
Resistance	Lower than standard M100		~0.5 ohms
Fire-Level	100% function: 0.999 all fire level – 1.182V	100% function: 1.25V Not as low as M84	2.37V (much higher than standard M100)
Conclusion	-Viable alternative bridgewire -Good for special applications where lower all fire energy is required	- No further testing was done as all fire level is higher than M84 wire test results	- No further testing was done since this thick wire is not needed

M100 WITH DBX-1 SPOT CHARGE& DBX-1 INTERMEDIATE CHARGE

- Milled DBX-1 spot charge instead of lead styphnate spot charge
- DBX-1 as intermediate charge to replace lead azide
- Standard HMX Output Charge
- Heights of HMX and DBX-1 increments were varied to establish loading parameters
  - ✓ All groups tested successfully
  - ✓ No low Order Functions.
- Results:
  - ✓ Completed and passed full LAT per MIL-D-48120 requirements– sample size of 325 detonators

M55 STAB DETONATOR

- One of the most common stab detonator used for mortar and artillery fuze
- NOL-130 initiation charge
- Lead azide intermediate charge
- RDX output charge

TESTING REQUIREMENT

- Output dent :
  - greater or equal to 0.010”
- Initiated by pin, ball weighs 0.25 oz at a drop height of 3”

M55 (STAB DETONATOR)

- Working with Action manufacturing co. to make "green" M55
  - Load in M55 detonators with DBX-1 as transfer charge to replace lead azide
  - Load in M55 detonators with "green" stab mix to replace lead azide and lead styphnate from NOL-130
  - Function as per Mil-Spec (qty: 500)

RESULTS/PLAN – M55

- Fabricated special milling jar to make “green” NOL-130
- ARDEC/Action working parallel to create green stab mix
- Action is optimizing the loading parameters for stab mix and transfer charge

Stab Initiation Mix

- NOL-130 – stab mix, used in many stab detonators
  - Initiates when impacted by a firing pin
  - Consists of tetracene, barium nitrate, lead azide, lead styphnate and antimony sulfide
  - Replaced lead based compounds with DBX-1 to make NOL-130G (Green)
  - NOL-130G successfully initiated the explosive train – comparable to standard M55
  - Minimum dent depth requirement is 0.01”

Initiating Charge (mg)	Transfer Charge (mg)	Output Charge (mg)	Dent Depth (in)
NOL-130	Lead Azide	RDX	0.0148
NOL-130 “G”	Lead Azide	RDX	0.0140
NOL-130	DBX-1	RDX	0.0153
NOL-130 “G”	DBX-1	RDX	0.0123

SUMMARY

- DBX-1 shows great promise as replacement for lead azide & lead styphnate in M100's
- Loading parameters adjusted significantly from standard M100 loading parameters
  - Column heights
  - Consolidation pressures
- Milled DBX-1 spot charge:
  - Flowed & formed well
  - Greater output than lead styphnate
- Successfully made "green" stab mix replacing lead materials with DBX-1
- Optimizing the loading parameters to meet the test standards
- Coated DBX-1 for better flow properties and safer to handle and load

Acknowledgement

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