Lead Azide Replacement Program
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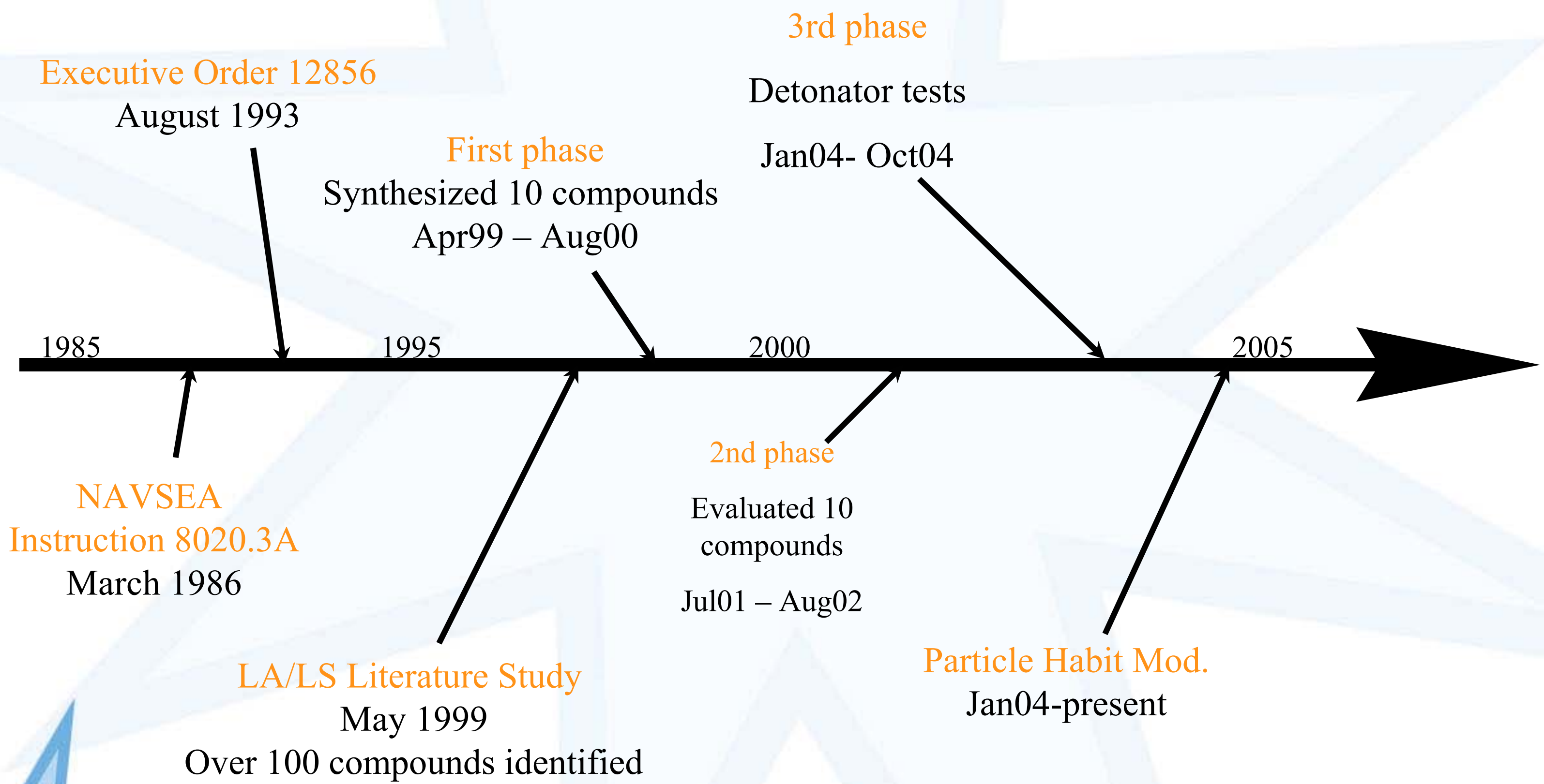
BACKGROUND

- *Regulatory Drivers:*
  - *NAVSEA Ins. 8020.3A (1986)- Limiting use of Lead azide in Navy ordinance for safety purposes – formation of copper azide in situ.*
  - *Executive Order 12856 (1993)- Series of executive orders issued to reduce/eliminate procurement of hazardous substances and chemicals by federal facilities.*
  - *EPA -Strict regulations regarding the use of lead and other heavy metals*
- *Program initiated by NAVAIR PMA 201 to replace hazardous material used in the CAD/PAD procurement*
- *Supplemental effort funded by the SERDP office to synthesize (using existing process) and evaluate de-sensitized silver azide*
- *No U.S. Manufacturer of Lead Azide*

PROGRAM TIME LINE



Synthesis/evaluation process

- Typical process for a replacement compound evaluation
  - Identify Compound as a primary explosive
  - Predict detonation properties and computer modeling
  - Develop Synthesis method
  - Evaluate Compound
    - Phase I Testing – Properties
    - Phase II Testing – Performance
    - Evaluate test results, make recommendations for follow-on development

Synthesis/evaluation process Cont'd

Phase I Testing

- *Impact Sensitivity - Ball Drop Method*
- *Friction Sensitivity – Small BAM – 2075g maximum applied load*
- *Differential Scanning Calorimetry (DSC) - 20°C/min, hermetically sealed Al pans*
- *Solubility in water*
- *Theoretical Maximum Density – Helium Pycnometry*
- *Scanning Electron Microscopy – Particle Habit*

Phase II Testing

- *Strong Ignition – witness plate for explosive output – all viable materials at 10 kpsi loading pressure*
- *Variable Loading Strong Ignition – Best Performer from 10K test*
- *M59 Detonator Testing – Best Performer from Strong Ignition Testing*

Strong Confinement Test Results at 10.0 Kpsi Loading Pressure

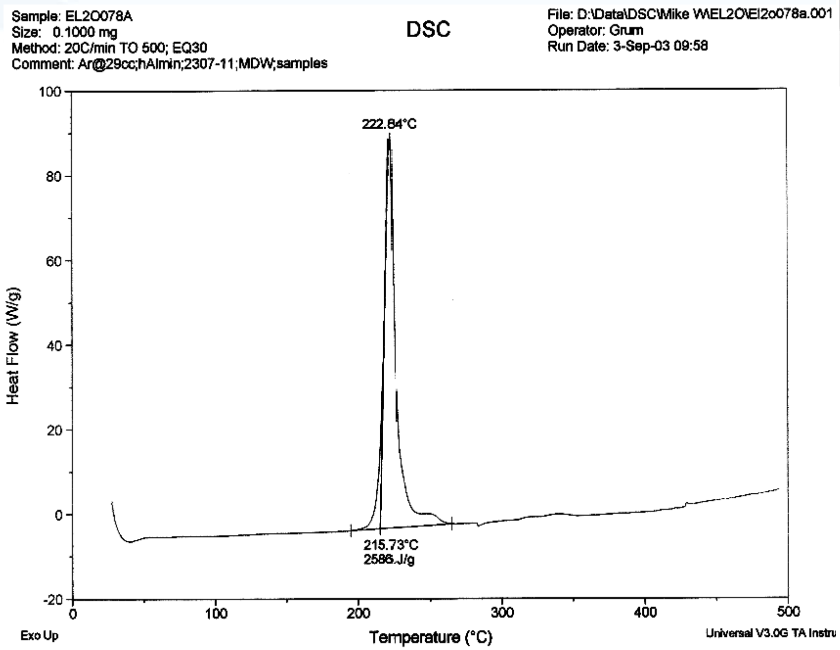
Candidate	Description	Average Charge Density (g/cm^3)	Average Dent (mils)
2A	Trans-tetraamminediazidocobalt(III) perchlorate	1.510	19.1
13A	Copper(II) 5-nitrotetrazole	1.440	13.2
15A	Bis-furoxano-nitrophenol (KBFNP)	1.626	0.8
17A	3-Azido-5-nitro-[1,2,4]triazole, copper complex (dry)	1.421	2.3
19A	Diazido-nitramino-s-triazine, Rb	1.810	0.8
19A	Diazido-nitramino-s-triazine, Cs	2.026	0.5
28A	1,5 Diaminotetrazole, Fe(II) perchlorate complex	1.465	27.0
28A	1,5 Diaminotetrazole, Cu(II) perchlorate comp	1.412	16.8
29A	DAATO 3.5	1.203	0.0
30A	ENTA	1.756	1.3
LA	Lead Azide, RD1333, LN 40148	3.119	37.3

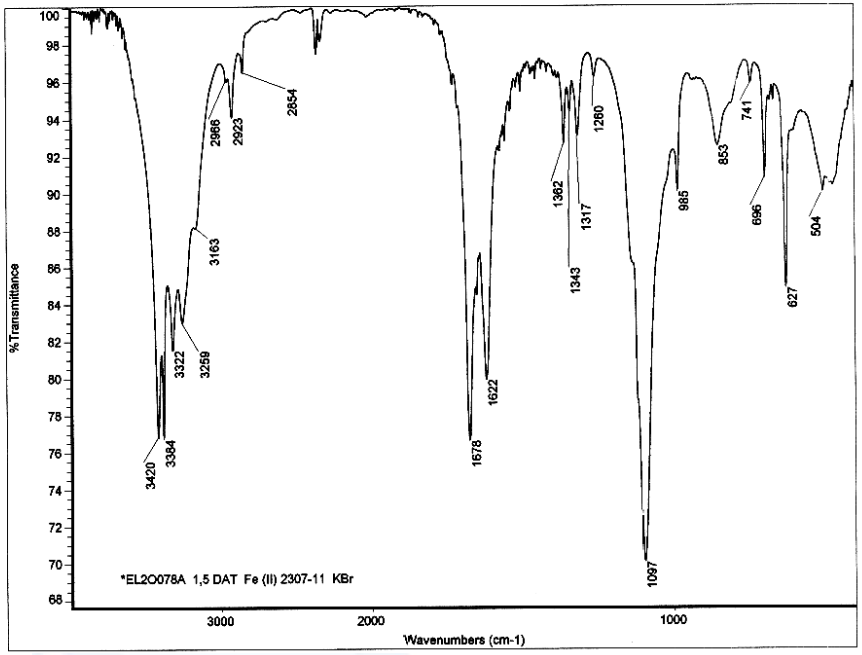
Lead Azide Candidates

- Three Compounds selected for further development/ evaluation
  - 1,5-Diaminotetrazole, Fe complex (28A)
  - Copper(II) 5-nitrotetrazole (13A)
  - Trans-tetraamminediazido-cobalt(III) perchlorate (2 A)

28A, 1,5 Diaminotetrazole, Fe(II) perchlorate complex

28A, 1,5 Diaminotetrazole, Fe(II) perchlorate complex

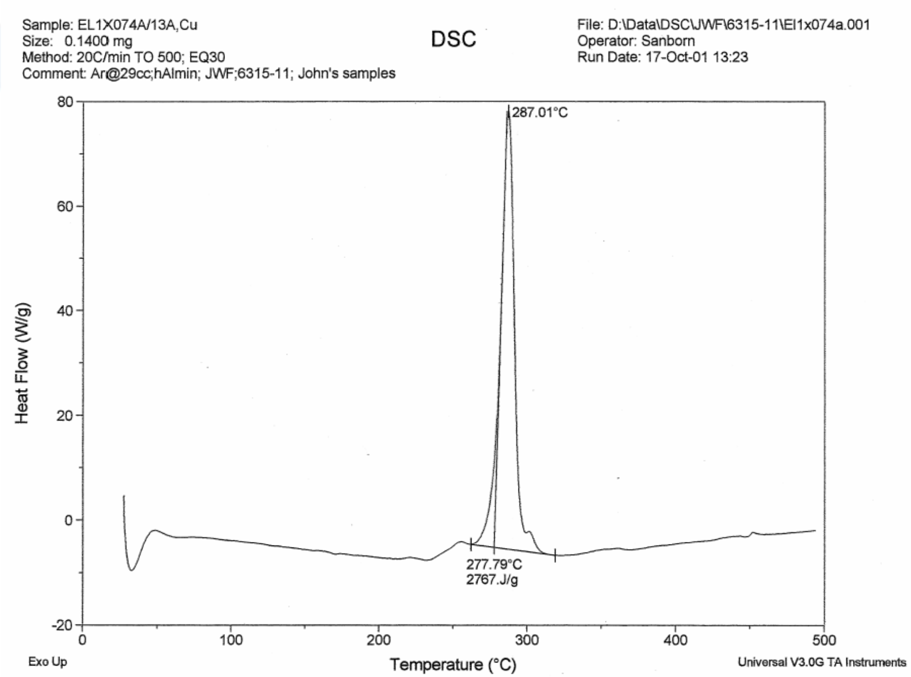


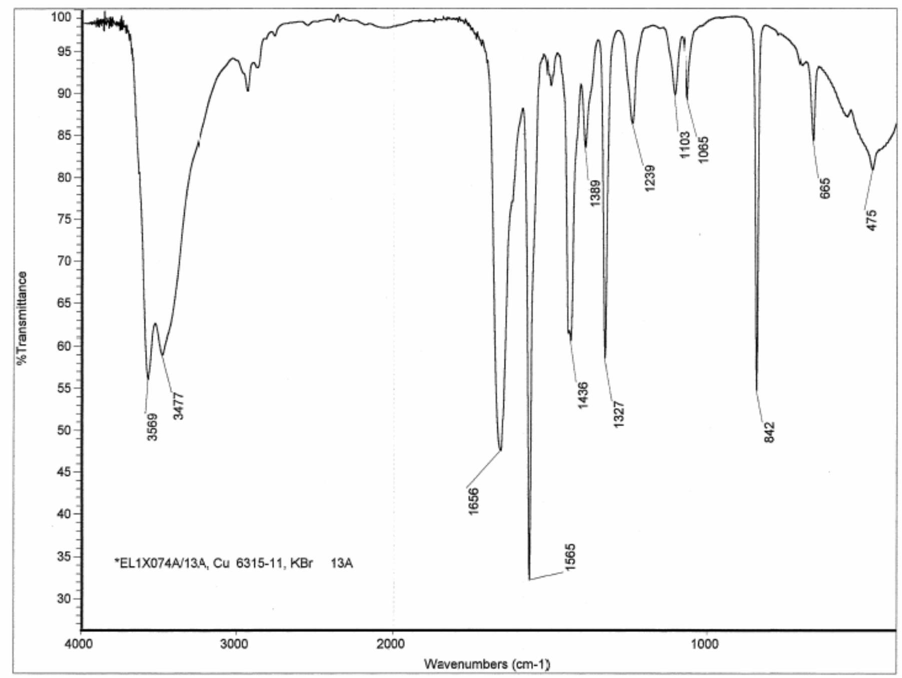


216ºC, 223ºC peak

13A, Copper(II) 5-nitrotetrazole

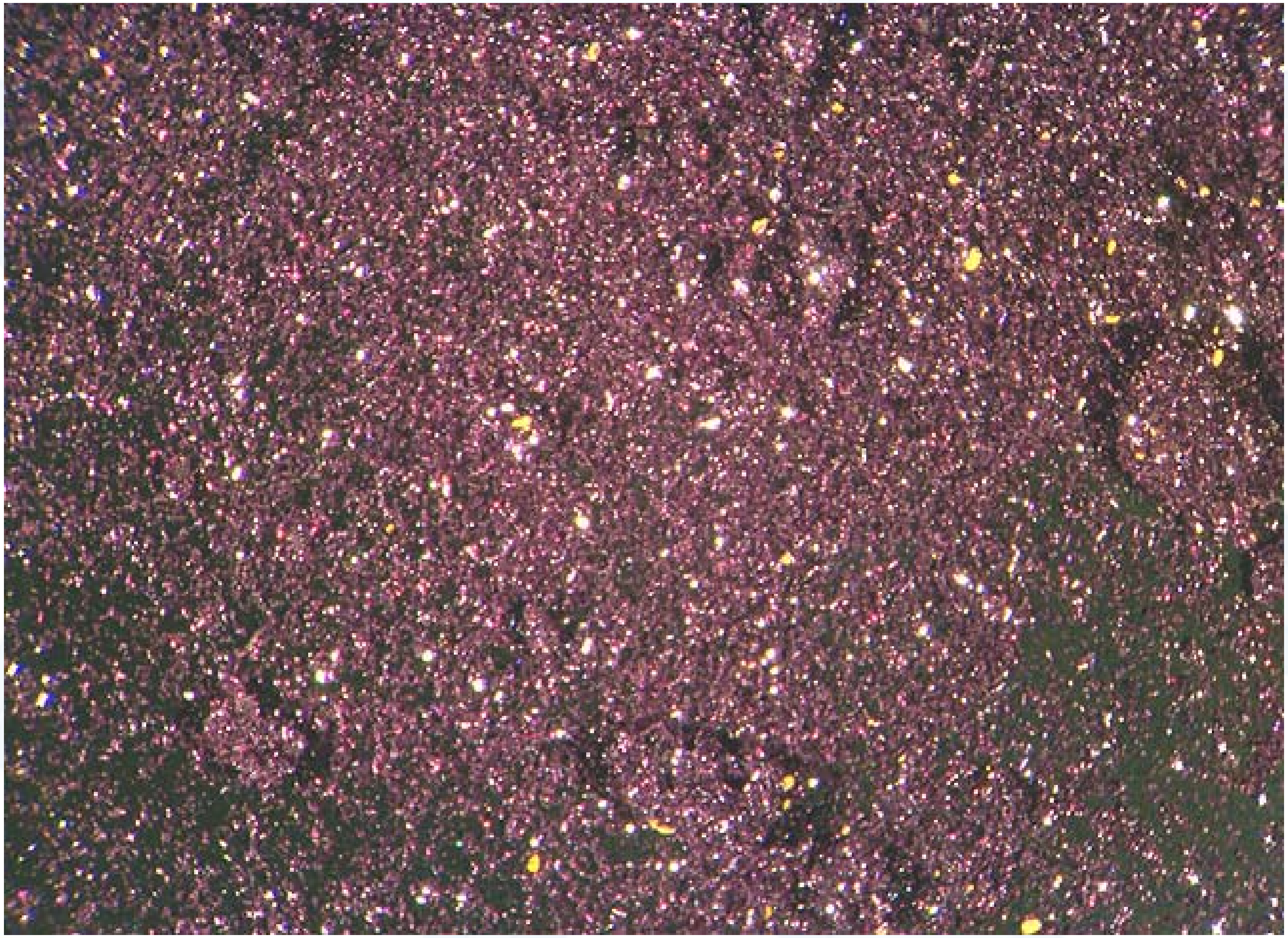
13A, Copper(II) 5-nitrotetrazole



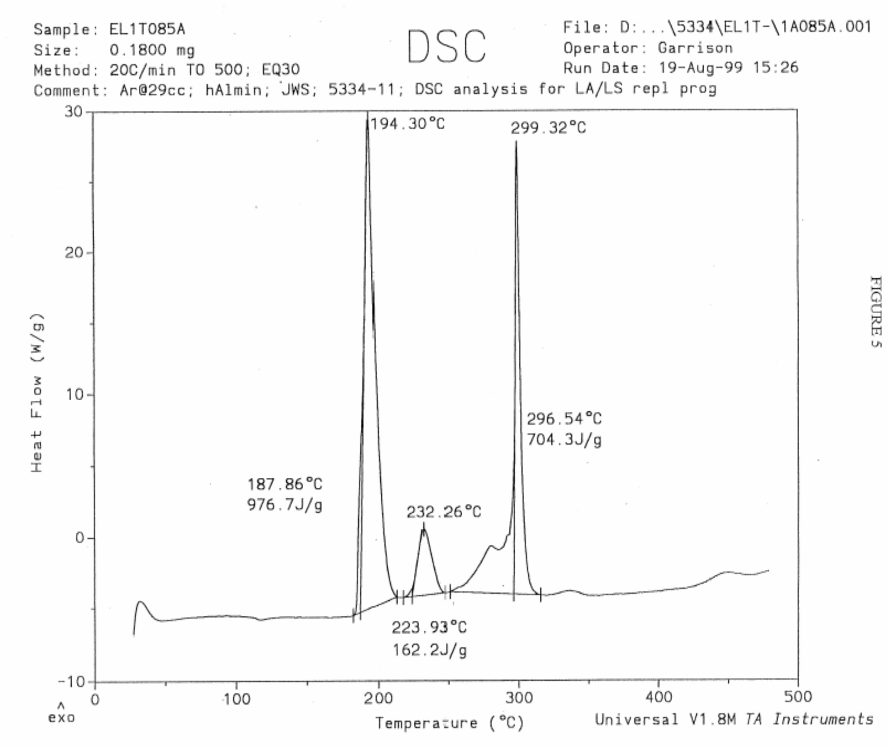


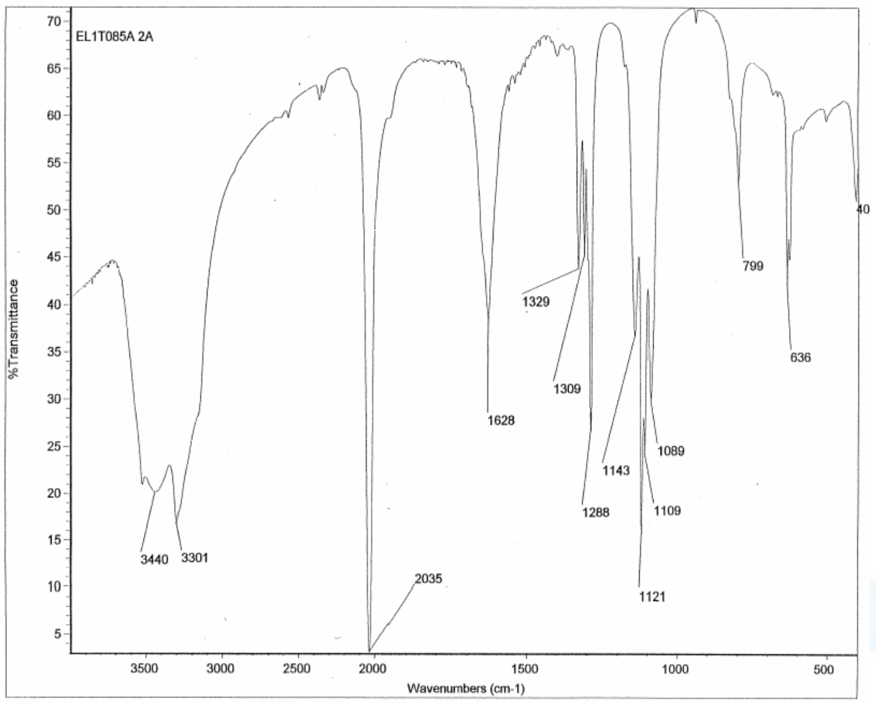
278ºC, 287ºC peak

2A, Trans-tetraamminediazido-cobalt(III) perchlorate



2A, Trans-tetraamminediazido-cobalt(III) perchlorate





Strong Ignition Test Results

CODE	CANDIDATE	LOADING PRESSURE (kpsi)	AVERAGE CHARGE DENSITY (g/cm^3)	AVERAGE DENT IN Al BLOCK (mils)
2A	Trans-tetraamminediazido-cobalt(III) perchlorate	5 10 20 40	1.33 1.44 1.60 1.84	19.6 31.1 29.3 21.7
$13A_1$	Copper(II) 5-nitrotetrazole	5 10 20 40	1.26 1.38 1.53 1.77	9.0 22.6 31.7 29.0
28A	1,5-Diaminotetrazole Fe(II) Perchlorate complex	5 10 20 40	1.18 1.33 1.52 1.62	35.3 40.3 37.7 23.3
	RD1333 LA	5 10 20 40	2.87 3.17 3.60 3.98	30.5 34.0 36.9 39.4

Tabulated Properties of Costain Process Silver Azide

Property	Costain Process Lot 8702	Costain Process Lot 8703	RD1333 Lead Azide
Bulk Density g/cc:	1.6	1.6	1.3
Granulation:			
%On 100	18	17	1
On 140	27	32	5
On 200	33	24	14
On 325	18	22	42
Thru 325	4	5	38
Assay:	99+%	99+%	97-98%
Hygroscopicity:	Nil	Nil	Very Slight
Vacuum Stability:			
1g/40 hrs/150°C	0.49	0.34	0.40
Impact Sensitivity			
P.A. 10% Point:	11 in	7 in	7 in
50% Point	17 in	10 in	8 in
Ball Drop 10%:	11 in	10 in.	10 in.
Electrostatic Sensitivity:	.0094 Joules	.018 Joules	.0005 Joules

T. Costain, “A New Method for Making Silver Azide”, Technical Report 4595, Picatinny Arsenal, Dover, N.J., Feb. 1974; U.S. Patent 3,943,235 (1976)

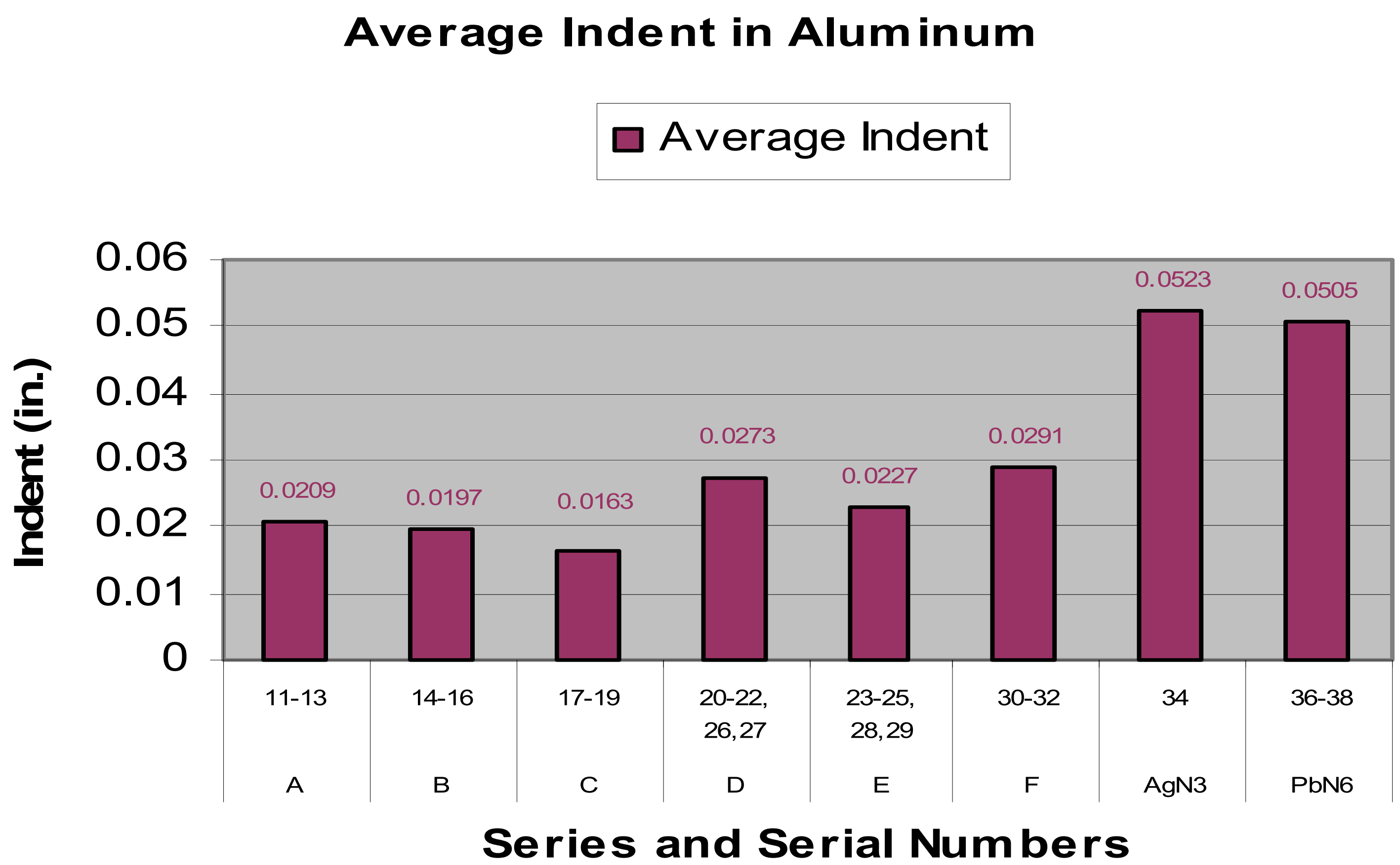
Properties of Costain Silver Azide vs Colloidal Silver Azide

	Costain Silver azide	Colloidal Silver azide	RD1333 Lead Azide
DSC	Endotherm: 310°c Exotherm: 363°c	Endotherm: 310°c Exotherm: 370°c	Exotherm: 323°c
IR (cm^{-1})	3438, 3354, 2036(s), 1630, 648	3451, 3356, 2036(s), 1636, 1382(w), 649	3340, 3331, 2117, 2037(s), 1629, 1329
Friction Sensitivity	No Fire = 10g Low Fire = 15g	No Fire = <10g Low Fire = 10g	No Fire = <10g Low Fire = 10g
Impact Sensitivity	0.047 ± 0.004 joules	0.054 ± 0.001 joules	0.230 ± 0.038 joules
ESD Sensitivity	0.01J (20 TIL)	0.01J (20 TIL)	0.02J (20TIL)

M59 Stab Detonator

- Two compounds selected for evaluation in M59 hardware
  - De-sensitized silver azide
    - Compound Synthesized using Costain method to reduce handling sensitivity
  - 1,5-Diaminotetrazole, Fe complex (28A)

M59 Detonator Testing



M59 Stab Detonator with DFeP

- Series D had second highest indents
  - 15mg @ 70ksi NOL130
  - 60mg @ 15ksi DFeP
  - 10mg @ 15ksi RDX
- Series F had highest indents
  - 15mg @ 70ksi NOL130
  - 60mg @ 10ksi DFeP
  - 10mg @ 10ksi RDX
- Series A had the highest DFeP content but moderate indent
  - 15mg @ 70ksi NOL130
  - 80mg @ 15ksi DFeP
  - No RDX
- Series C had highest RDX content but lowest indent

M59 Stab Detonator with DFeP

- 10ksi loading pressure is preferred
  - PacSci data suggested this w/o output
  - This data shows RDX detonating at 10ksi
- RDX may not be sufficiently driven to strong detonation. Could imply problems transitioning shock to leads or boosters. More work is needed characterizing shock performance rather than random application testing.
- DFeP shots with Brass Confinement can meet .125" min lead disc requirement.
- DFeP has only ½ to 2/3 the indent performance of azides.

Future work

- Enhance crystallization of 13A
- Investigate the use of other oxidizer groups to replace the perchlorate group used in compound 28A.
- Develop a method to further de-sensitize silver azide
- Evaluate the use of Nano material in primary explosives
- Evaluate new compounds as they become available

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