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EVALUATION OF FOUR HNS II MATERIALS FOR USE IN ALUMINUM LINEAR SHAPED CHARGES

Ted W. Stull

DEVELOPMENT DIVISION

AUGUST 1978
(Final Report)

For
Sandia Laboratories
Albuquerque, New Mexico
(P.O. No. 05-3241)

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INTRODUCTION

This study was undertaken to determine which of four methods for producing HNS II provides optimum material for processing and use in the aluminum linear shaped charge (ALSC).

Four materials were prepared, analyzed, and fabricated into mild detonating fuse (MDF). These were then test fired and the results compared.

Chemical and physical tests of the four materials indicate significant differences. However, there were no significant differences in the way the materials handled during processing into MDF or in final test fire results.

Conclusions outlined in this report are based solely on work done by Mason & Hanger and does not include evaluation of vendor fabricated ALSC.

The major evaluation factors, i.e. data regarding ALSC fabrication, aging tests and test fire results of the actual ALSC, will be evaluated by Sandia Laboratories. The conclusions of this report are therefore preliminary and will be heavily influenced by the Sandia ALSC evaluation.

PRODUCTION DETAILS ON HNS II MATERIALS

LOT 6169-07-010-A

A full scale (45 kg HNS I) cyclic recrystallization was made by the standard Pantex process (cyclic process) in a 100-gallon reactor. These cycles in degrees Celsius are given below.

105-60-100-60-95-60-90-
60-85-60-85-ambient

The product (28 kg) was run for 7 minutes in a Cowles Dissolver at 2400 rpm using 2.6% methanol in water as the working fluid. A portion of the dried product (3 kg) from the Cowles Dissolver was digested in 60 litres of 1:1 DMF/acetone at reflux temperature for 8 hours. The product was filtered and dried yielding 2.50 kg.

LOT 7192-07-010-H

A mixture of HNS I lots was dissolved in DMF, heated to 105 C, filtered through a 5-micron metal filter and then cooled rapidly to ambient temperature. The material was then filtered to yield the recrystallized HNS and dried.

The HNS was dissolved in DMF (ratio of 4.23 kg of HNS to 60.6 litres of DMF) and then thermally cycled at an agitator speed of 50 rpm in the 30-litre reactor. The thermal cycles were identical to those given above for Lot 6169-07-010-A.

When the second temperature of 85 C was attained, the agitator was turned off, cooling removed from the reactor and the material allowed to cool to ambient temperature overnight (26 C). The material was then transferred and filtered in the 4-foot diameter stainless steel filter, washed twice with acetone, dried and then processed in the Cowles Dissolver. Particle alteration was accomplished in a mixture of acetone and water for 4 minutes at 2400 rpm.

LOT 7235-07-010-E

HNS I (3.8 kg) was dissolved in 14.5 litres of filtered DMF in the 30-litre reactor. The reactor agitator speed was 50 rpm and steam heat was applied until the temperature of the solution reached 105 C. At this point, 11.6 litres of acetonitrile was added directly to the hot DMF/HNS solution (addition rate of approximately 5.5 litres per minute). The agitation was stopped, heat removed from the reactor and the solution allowed to cool overnight to ambient temperature (25 C). The product was then trapped on the SS filter, washed twice with 20 litres of acetone, dried in the oven overnight and then altered in the Cowles Dissolver. Particle alteration was accomplished in a mixture of acetone and water for 4 minutes at 2400 rpm.

EB LOT 31

No history is available on this lot. It is assumed that the procedure used by Ensign Bickford was their standard method for producing HNS II.

MDF DETONATION VELOCITY EVALUATION

All four lots of material, when being processed into MDF, handled similarly. The compacted material data on all four lots (Table I) show no significant differences. The uncompacted data (Table I) indicate that Lot 7192-07-010H deviates from the remaining three lots whose results were again quite similar. No significant conclusions can be drawn from these data.

Table I. Detonation Velocity of HNS MDF (mm/μs)

Sample No.	Lot 6169-07-010-A	Lot 7192-07-010-H	Lot 7235-07-010-E	EB Lot 31
		Compacted		
1	6.9466	6.9683	6.9386	7.0173
2	6.9294	6.9396	7.0120	6.9132
3	6.9573	7.0144	7.0181	7.0211
4	6.9772	7.0174	6.9951	7.0219
5	7.0059	6.9375	-	6.9090
6	7.0109	7.0416	7.0066	6.9298
7	6.9368	7.0175	7.0157	6.9601
8	6.9513	6.9510	7.0149	6.9927
9	6.9722	6.9847	6.9524	6.9618
10	7.0057	6.9442	6.9750	6.9504
$\bar{X}$	6.9693	6.9787	6.9920	6.9677
σ	0.0300	0.0350	0.0298	0.0436
		Uncompacted		
11	6.3870	6.2968	6.4896	-
12	6.4037	6.2455	6.4762	6.3666
13	-	6.2988	6.4300	6.3828
14	6.3892	6.2758	6.3913	6.3537
15	6.5092	-	6.4056	6.4726
16	6.4782	6.2511	6.5114	6.4035
17	6.4101	6.3372	6.4535	6.4908
18	6.4920	6.2693	6.5725	6.4001
19	6.4779	6.4770	6.4713	6.4785
20	6.3199	6.2953	6.4208	6.3678
$\bar{X}$	6.4297	6.3052	6.4622	6.4129
σ	0.0627	0.0702	0.0544	0.0534

NOTE: No significant differences in handling characteristics or in overall results

ANALYTICAL RESULTS

Analytical results shown in Table II and a comparison of results shown in Table III indicate that Lot 6169 is less pure than the other materials, and Lot 7192 the most pure. In addition, the double recrystallization used to prepare Lot 7192 is an efficient means of removing excess dipicrylethane, a major impurity found in the HNS I used to produce HNS II. Other factors involved are as follows:

1. Lot 7235 was produced from a single recrystallization, using DMF and acetonitrile, and as such, makes it attractive to produce from a labor cost standpoint.

2. Lot EB 31 was made by an established process.

Table II. Analyses of Four HNS II Materials for the ALSC Study

Specific Test	Lot 6169-07-010-A	Lot 7192-07-010-H	Lot 7235-07-010-E	EB Lot 31
Melting Point (°C)	317.6	317.5	318.0	316.2
Melting Point Range (°C)	1.2	0.3	0.7	0.6
Surface Moisture and Volatiles (Wt. %)	0.000	0.001	0.008	0.006
Water Solubles (Wt. %)	0.02	0.001	0.003	0.019
Bulk Density (g/cc)	0.45	0.71	0.86	0.78
Vacuum Stability (mℓ/g)				
1st 20 Minutes	0.54	0.24	0.14	0.36
Additional 2 Hours	0.30	0.13	0.10	0.26
Liquid Chromatography (%)				
Trinitrobenzyl Chloride	0.0	0.0	0.0	0.0
Dipicrylethane	Trace	< 0.05	0.34	0.63
HNS	99.9	99.9	99.7	99.4
DMF Insolubles (wt. %)	0.03	0.006	0.008	0.003
Conductivity (Mhos x 10^{-6})	1.22	0.44	0.51	0.78
DMF Insoluble Particles (Number Retained On)				
40 USS Mesh	6.0	0.5	1.0	0.5
60 USS Mesh	15.0	2.0	4.0	2.5
Pressure/Density (g/cc at)				
3 kpsi	1.278	1.365	1.408	1.359
16 kpsi	1.526	1.592	1.611	1.591
32 kpsi	1.613	1.645	1.660	1.652

Table III. Comparison of Four HNS II Lots for ALSC

Individual Test	Lot 6169	Lot 7192	Lot 7235	Lot EB31
(Rating* on all test data with the exception of Surface Moisture & Volatiles and VOD of MDF)				
Melting Point	2	3	1	4
Melting Point Range	4	1	3	2
Water Solubles	4	1	2	3
Bulk Density	4	3	1	2
Vacuum Stability	4	2	1	3
Liquid Chromatography	1	2	3	4
DMF Insolubles	4	2	3	1
Conductivity	4	1	2	3
DMF Insoluble Particles	4	1	3	2
Pressure Density	4	3	1	2
Total Points	35	19	20	26
(Rating on most significant analyses)				
Water solubles	4	1	2	3
DMF Insolubles	4	2	3	1
Vacuum Stability	4	2	1	3
Liquid Chromatography	1	2	3	4
Total Points	13	7	9	11

**Ratings were in the following order: 1-best, 2-2nd best, 3-3rd best and 4 was the worst. The material with the least total points is rated as the best HNS I. In the second part above, the four tests chosen are those which have the most bearing on material use. They are very good indicators of both physical and chemical impurities.*

CONCLUSION

The following conclusions are drawn.

1. If cost is not a factor, material prepared as in Lot 7192 would be chosen based on product purity.

2. If material is needed quickly, Lot EB 31 would be recommended because of its ready availability.

3. If material use is in the distant future, time is available to complete the scale-up of the DMF/aceto-nitrile process and the scale-up proved successful, Lot 7235 would be the material chosen. The process used to produce this material is the most efficient from a time labor and cost standpoint.

The conclusions drawn are temporary and drawn without the knowledge of the vendors processing of ALSC and its subsequent evaluation by Sandia Laboratories. These conclusions are therefore subject to change and will be heavily influenced by Sandia's ALSC evaluation.

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