MHSMP-72-28 L

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STUDY OF EXPLOSIVES IN THE MDF FORM

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DEVELOPMENT DIVISION

OCTOBER - DECEMBER 1971

Normal Process Development
Endeavor No. 210

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operated for the
ATOMIC ENERGY COMMISSION
under
U. S. GOVERNMENT Contract DA-11-173-AMC-487 (A)

NOTICE

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The purpose of this project is to reliably characterize explosives in long, small diameter supported columns.

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Endeavor No. 210
Acct. No. 22-2-44-01-210

Section L

STUDY OF EXPLOSIVES IN THE MDF FORM

ABSTRACT

Polycarbonate tubes/HNAB were drawn to 85 grain/foot (gr/ft) and test fired.[a] Aluminum tubes/PETN were drawn to 0.8 gr/ft and test fired. Aluminum tubes/HNAB were drawn to 2 gr/ft and test fired to qualify HNAB Lot 1281-11-01 made at Pantex.[b]

INTRODUCTION

Mild detonating fuse (MDF) is capable of consistent detonation velocity and thus provides an accurate timing device when precisely fabricated. Explosives that have been synthesized and designated for use in MDF should be qualified in the end use configuration. An advantage is that the MDF drawing technique provides a means to produce a long consistent density column, which allows an appreciable length for elapsed time measurement, and the build-up zone can be excluded from the measurement interval. Small quantities of HE are sufficient (< 2.0 grams).

The laboratory procedure is to load a plugged tube with HE powder at bulk density seal with another plug, point one plugged end with a swager, and then draw the filled tube to a specific outside diameter. The complete tube is then cut into specific lengths for ease of handling and possible compaction in an isostatic press to increase density. Powders that do not flow well have been pelletized and the pellets inserted into the hollow tube—the pellets at ∿ 30% greater than bulk density. Radiographs are made where necessary to insure HE integrity. Density measurements are taken to correlate HE column diameter and detonation velocity. Test fire of an 11-inch long piece of MDF yields a detonation velocity between two switches placed precisely at 10 inches.

DISCUSSION

POLYCARBONATE/HNAB

Polycarbonate tubes (Lexan)[c] were loaded with hexanitroazobenzene (HNAB). The 3/8-inch OD x 1/4-inch ID polycarbonate tubes were selected first because of prior experience with the same size in aluminum and lead tubes. Initially the tubes were loaded with mock HE of several types and plugs of polycarbonate.

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[a] *Part of this work funded by Sandia P.O. 58-0016*

[b] *Part of this work funded by Sandia P. O. 58-0034*

[c] *General Electric Trade name*

These plugs were discarded because of the inability to swage or draw without cracking. Kimwipes[d] or polyurethane soft foam were substituted for the mock HE because of their ability to flow. A trial swage/draw sequence was made using each of five mock HE powders—sodium chloride, barium nitrate, 90010 mix, pentaerythritol, and diphenylsilanediol. While there were small differences in the way the mock powder flowed, it was decided that the 90010 mix was adequate to use for this project. Parallel to this, fluorocarbon (Teflon TFE)[e] tubes did not swage or draw well because of softening temperature, elongation, rebound, and memory properties. The fluorocarbon tube bent and twisted severely in the swaging machine. When reducing a fluorocarbon 0.354-inch OD tube through a 0.322-inch draw die, the tube would recover to 0.351-inch OD. Respectively, the polycarbonate tube would reduce to 0.336-inch OD and a pure aluminum tube reduced to 0.324-inch OD.

The HE loaded polycarbonate tubes with foam rubber plugs can be drawn to 0.244-inch OD x 0.135-inch ID. The unfilled tube (prior to loading) annealed in air at 250 F (40 minutes) or in silicone oil at 250 F (60 minutes) had lower internal stresses. As an example of the results, one tube of polycarbonate was powder loaded with HNAB at a density ρ = 1.0 g/cc, plugged with urethane foam, swaged and drawn. The column of HNAB (PX Lot 1281-11-01) was 0.135-inch OD at a density of 1.487 g/cc (equivalent to 85 gr/ft). Holes were drilled through the tube and coaxial pin switches seated in contact with the HE. The test fire indicated, from the elapsed time between switches, a detonation velocity of 7.193 millimeters per microsecond (mm/μsec) at 30 F through a 10-inch interval.

Distance between Switches (inches)	Calculated Velocity (mm/μsec)
4	7.206
4	7.186
2	7.181
6	7.186
10	7.193

Further work will include annealing the polycarbonate, and using smaller diameter tubes if practical. Other plastics will be investigated for possible use.

ALUMINUM/PETN

Aluminum tubes were loaded with pentaerythritol tetranitrate (PETN) Lot No. 1195-304-03. The 0.375-inch OD x 0.235-inch ID loaded tube was then drawn to 0.041-inch OD (HE column ∿ 0.020 inch). It should be noted that the 0.041-inch

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[d] *Kimberly-Clark Trademark*

[e] *DuPont Trademark*

Table I. Al/PETN Velocity Data
(mm/μsec) 0.8 grains/foot
(Tube #126)

Uncompacted			Compacted		
Piece	1	7.237	Piece	2	8.041
Piece	3	7.144	Piece	4	7.876
Piece	5	7.111	Piece	6	8.180
Piece	7	7.080	Piece	10	8.029
Piece	9	7.194		$\overline{X}$ =	8.032
Piece	11	7.275			
Piece	13	7.209			
Piece	15	7.242			
	$\overline{X}$ =	7.186			

Table II. MDF Properties

HNAB Lot	Tube No.	Load gr/ft $\overline{X}$	Load σ	Press Lots	Test Temp. F	n	Velocity $\overline{X}$ mm/µsec	Velocity σ[e] mm/µsec
4311B	119	1.737	.116	3 [a,c]	60	13	7.324	.038
				#1		5	7.343	.023
				#2		4	7.311	.031
				#3		4	7.319	.049
1281-11-01	110	1.974	.030	3 [b,c]	45	13	7.357	.046
	111	1.840	.037	#1 [b,c]	54	4	7.357	.033
				#2 [b,d]	54	5	7.369	.030
				#3 [a,c]	54	3	7.283	.046
1281-11-01	121	2.072	.045	3 [a,c]	68	13	7.334	.022

[a] *Pellet Loaded*

[b] *Powder loaded*

[c] *Compacted in surgical tube*

[d] *Compacted with sealed ends*

[e] $\sigma = \left(\frac{1}{n-1} \sum_{i=1}^{n} (X_i - \overline{X})^2\right)^{1/2}$

OD draw will cause a 2.0 gr/ft loading using HNAB but using PETN the average grain loading was 0.8 gr/ft. The PETN has a lower bulk density than HNAB; thus, when drawn to the same outside diameter the loading is less. The compressibility is evident by noting the PETN loaded tube was 0.020-inch ID and the HNAB loaded tubes were 0.022-inch ID.

Sixteen pieces were test fired; records were lost in four because of switch problems. Table I contains velocity data for runs through 10-inch intervals at 65 F. Four of the tubes were compacted at 60 kpsi isostatically. The other eight were not compacted.

ALUMINUM/HNAB

Aluminum tubes were loaded with HNAB (PX Lot 1281-11-01) in an effort to qualify the lot by detonation velocity measurements. The test fire technique is required to produce data such that $100\sigma/\overline{X} < 0.16$ for an acceptable lot of HE. This accuracy has not been obtained as yet. Table II illustrates the progress to date. The lowest value for $100\sigma/\overline{X}$ was 0.15 for a lot of four (after discarding an obviously low value) and in another lot of three (after discarding an obviously low value) was 0.05.

CONCLUSIONS

The MDF form may be used for evaluating HE detonation velocity in long columns (10 inches), small diameters (0.020 inch), with moderate density variations ($\sigma \sim$ 0.030 gr/ft for 0.022-inch columns). Confinement material density can be varied from 1.2 g/cc (polycarbonate) to 2.7 g/cc (aluminum). Lead is another metal that can be used (11.4 g/cc). Velocity data are repeatable. Areas of future investigation include: isostatic pressing techniques, aluminum tube specifications, elapsed time switches and other tubing materials/drawing parameters.