INITIATION SENSITIVITY OF HNS I PELLETS BY HNS II MDF AS A FUNCTION OF PELLET DENSITY AND MDF LOADING

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DEVELOPMENT DIVISION

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ABSTRACT

Excess transit time of a relatively large diameter HNS I acceptor pellet when ignited by an HNS II MDF donor is being investigated as a function of both pellet density and MDF core loading.

DISCUSSION

The purpose of the project is to establish the excess transit time of a detonation wave for an acceptor pellet which is initiated by MDF. There are two parts: one, to define at a fixed pellet density the relationship between excess transit time and MDF size, and two, to define for a given MDF size the relationship between excess transit time and acceptor pellet density.

Two 15 m lengths of MDF which were manufactured by Ensign-Bickford (E-B) and Explosive Technology (ET) were supplied to Pantex by SLA for use in the excess transit time study. Samples of each MDF were drawn in a pilot operation to determine several pertinent properties, which are shown in Table I. The outside diameters listed include all die sizes available at Pantex in the range of interest. The pellets were pressed from Pantex-synthesized high-purity HNS I(*1*), Lot PX-11.

In part one, the two MDF samples are to be drawn to smaller sizes and tested with acceptor pellets of 1.60 Mg/m^3 density. The smallest size of MDF tested is to be below the critical size necessary for an initiation reliability of 50%. In the second part, the two MDF samples are to be tested in their original form as received from the vendor with acceptor pellet densities of 1.65, 1.60, 1.50 and 1.40 Mg/m^3. No MDF will be hydraulically compacted.

EXPERIMENTAL TECHNIQUE AND RESULTS

The detonation electric effect technique(*2*) is utilized to measure detonation front arrival times at various interfaces in an explosive train. The train consists of an RP-2 detonator, 25 mm of 1 g/m PETN MDF, five segments of HNS II MDF (6.35, 6.35, 12.70, 6.35 and 6.35 mm), and an acceptor pellet stack. The length of the acceptor stack varies from 2.54 to 10.16 mm in order that excess transit time can be measured by the cutback method. The segments of MDF are separated by 13 μm air gaps to create the interfacial signals. There is no air gap, and therefore no interfacial signal between the final MDF segment and the pellet stack. The typical transit time for the final air gap-MDF segment combination is calculated from those measured from all the other gap-segment pairs. This average is then subtracted from the total time measured on each shot for the final air gap-MDF segment-pellet stack combination, giving the transit time for the pellet stack.

Preliminary tests were conducted to determine the minimum size MDF to be used in part one of the sensitivity study. Results, which are given in Table II, indicate that the 1.52 mm OD MDF is probably the critical size for initiation of a 1.60 Mg/m^3 acceptor pellet. It is not known which of the two MDF samples was used in this study.

MDF from each vendor was drawn to the four largest sizes in sufficient quantities for the test series.[a] Samples of each size including the original MDF were submitted for HE core analysis and the results are given in Table III.[b]

Original size MDF from each vendor was tested for its ability to sustain the detonation wave down the MDF train despite the 13 μm air gaps. Results are presented in Table IV. In the first four shots E-B and ET MDF were tested with relatively low density acceptor pellets. Neither of the E-B shots, but both of the ET shots, failed due to the detonation not propagating from one segment to the next. On the following six shots the MDF segment ends were coated with fine PETN powder. In addition the acceptor pellet density was raised to 1.65 Mg/m^3, the highest to be used in the sensitivity study. One ET shot failed because an MDF segment was not initiated. There was no failure due to an acceptor pellet not igniting. The failures for ET MDF are possibly due to the decreased sensitivity to initiation associated with the higher density core loading. Because of the small sample size, no assertion can be made as to the effect the PETN coating has upon the MDF segment transit time.

MDF data were obtained from the shots listed in Table IV. Results for each MDF are shown in Tables V and VI. The excess transit time due to the air gap for the ET MDF is larger by a factor of four than that for the E-B MDF. This agrees with the failures for ET MDF listed in Table IV. The ET material has the higher detonation velocity indicating that the core density is higher, which is in accordance with the densities given in Table III.

The results obtained for the 1.65 Mg/m^3 PX-11 acceptor pellets are given in Table VII. The detonation velocities are higher by about 5% than those obtained in prior work(*3,4*) indicating some error in present work due to the limited number of shots. The excess transit time for acceptor pellets initiated by ET MDF is half that for pellets initiated by E-B MDF. This is probably due to the higher density core material of the ET MDF, which causes the detonation wave to attain a higher peak pressure.

Work on the project was suspended temporarily because of the failures of detonation propagation in the ET MDF train. In addition the failure rate will possibly increase as the MDF size is decreased. Previous work(*4*) has indicated that the shot loss rate is not improved by reducing

[a] *Drawing was done under the direction of H. W. Lichte.*

[b] *Analysis was directed by A. A. Duncan.*

gap size from 25 μm to 5 μm, because the decrease in failures due to non-propagation of the detonation wave is counterbalanced by a loss of some air gap signals.

An optoelectronics technique for measuring detonation wave arrival times at various interfaces in an explosive system is being investigated. Use of this timing method may allow the air gap size to be reduced essentially to zero, thus improving the shot loss rate.

FUTURE WORK

After the optoelectronic technique has been investigated, work upon the project will be commenced using the more promising timing technique.

Table I. Properties of MDF Obtained in Pilot Drawing Operation[a]

Manufacturer	Draw No.	OD (mm)	ID (mm)	Load Size (g/m)
E-B	Original	1.83	0.66	0.47
E-B	1	1.78		
E-B	2	1.65		
E-B	3	1.52	0.53	0.30
E-B	4	1.42		
E-B	5	1.35		
E-B	6	1.27		
E-B	7	1.22		
E-B	8	1.17		
E-B	9	1.12	0.33	0.13
ET	Original	1.89	0.64	0.43
ET	1	1.78		
ET	2	1.65		
ET	3	1.52	0.51	0.19
ET	4	1.42		
ET	5	1.35		
ET	6	1.27		
ET	7	1.22		
ET	8	1.17		
ET	9	1.12	0.33	0.13

[a]*Information obtained from H. W. Lichte*

Table II. Results of Preliminary Study for the Initiability of the Pellets as a Function of MDF Size and Pellet Density

Shot No.	MDF OD (mm)	Pellet Density (Mg/m^3)	Results
1	1.52	1.6	NO GO [a]
2	1.52	1.5	GO
3	1.52	1.6	NO GO
4	1.52	1.5	NO GO
5	1.52	1.5	GO
6	1.52	1.5	GO
7	1.12	1.4	BAD DETONATOR
8	1.12	1.4	NO GO
9	1.12	1.4	NO GO

[a] *NO GO means the MDF donor failed to initiate the acceptor pellet*

Table III. Properties of MDF Selected for Use[a]

MDF Type	Sample No.	OD (mm)	HE Density (Mg/m^3)	Load Size (g/m)
E-B	1	1.83	1.56	0.55
E-B	2	1.83	1.57	0.55[b]
E-B	3	1.78	1.68	0.65[b]
E-B	4	1.65	1.57	0.45
E-B	5	1.52	1.54	0.38
E-B	6	1.42	1.55	0.34
ET	7	1.89	-	-[c]
ET	8	1.89	1.64	0.58
ET	9	1.78	1.60	0.55
ET	10	1.65	1.59	0.43
ET	11	1.52	1.59	0.36
ET	12	1.42	1.58	0.33

[a]*Information obtained from A. A. Duncan*

[b]*Results do not fit trend of other data*

[c]*Sample destroyed by attempt to split lengthwise*

Table IV. Results of Initial Cutback Shots

Shot No.	MDF Manufacturer	MDF OD (mm)[a]	PETN Coating[b]	Pellet Density (Mg/m^3)	Result
1	E-B	1.83	NO	1.39	GO
2	E-B	1.83	NO	1.38	GO
3	ET	1.89	NO	1.32	Failed[c]
4	ET	1.89	NO	1.31	Failed
5	E-B	1.83	YES	1.65	GO
6	E-B	1.83	YES	1.65	GO
7	E-B	1.83	YES	1.65	GO
8	ET	1.89	YES	1.65	Failed
9	ET	1.89	YES	1.65	GO
10	ET	1.89	YES	1.65	GO

[a] *MDF was "as received" from the manufacturer*

[b] *The ends of each MDF segment were coated with fine PETN*

[c] *Failed means that the detonation front failed to propagate from one segment to the next*

Table V. Results Obtained for the Original E-B MDF

	6.35 mm Lengths	12.70 mm Lengths	Both Lengths
Number of Points	10	5	15
Length of Segment (mm)	6.342[a]	12.687[a]	
Standard Deviation (mm)	0.014	0.001	
Transit Time for Gap and Segment (μs)	0.989[a]	1.960[a]	
Standard Deviation (μs)	0.013	0.010	
Transit Time for Segment (μs)	0.971[b]	1.942[b]	
Standard Deviation (μs)	0.016	0.013	
Excess Time Due to Gap (μs)			0.018[d]
Standard Deviation (μs)			0.009
Detonation Velocity (m/s)	6540[c]	6540[c]	6540[e]
Standard Deviation (m/s)	110	40	40

[a] *Value is the average*

[b] *Value is the difference between the average transit time for one gap-segment pair and the excess transit time due to the air gap*

[c] *Value is the quotient of the average segment length and the average segment transit time*

[d] *Value is the intercept of the linear fit to all the data*

[e] *Value is the inverse slope of the linear fit to all the data*

Table VI. Results Obtained for the Original ET MDF

	6.35 mm Lengths	12.70 mm Lengths	Both Lengths
Number of Points	6	3	9
Length of Segment (mm)	6.341[a]	12.630[a]	
Standard Deviation (mm)	0.013	0.028	
Transit Time for Gap and Segment (μs)	0.967[a]	1.860[a]	
Standard Deviation (μs)	0.023	0.010	
Transit Time for Segment (μs)	0.894[b]	1.787[b]	
Standard Deviation (μs)	0.030	0.022	
Excess Time Due to Gap (μs)			0.073[d]
Standard Deviation (μs)			0.020
Detonation Velocity (m/s)	7100[c]	7110[c]	7110[e]
Standard Deviation (m/s)	240	90	110

[a] *Value is the average*

[b] *Value is the difference between the average transit time for one gap-segment pair and the excess transit time due to the air gap*

[c] *Value is the quotient of the average segment length and the average segment transit time*

[d] *Value is the intercept of the linear fit to all the data*

[e] *Value is the inverse slope of the linear fit to all the data*

Table VII. Experimental Results for Pellets Initiated by (a) Original E-B MDF, (b) Original ET MDF and (c) Both E-B and ET MDF

	Density (Mg/m^3)	Standard Deviation (Mg/m^3)	Excess Transit Time (ns)	Standard Deviation (ns)	Detonation Velocity (m/s)	Standard Deviation (m/s)
(a)	1.656	0.011	66	24	7350	230
(b)	1.652	0.001	36	0[a]	7290	0[a]
(c)	1.654	0.008	67	24	7451	221

[a] *Zero because the linear fit was done only on two datum points*

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