INITIATION SENSITIVITY OF LX-10 BY A
SMALL DIAMETER CONFINED LX-13

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DEVELOPMENT DIVISION

JANUARY - MARCH 1976

Normal Process Development
Endeavor No. 201

MASTER

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operated for the
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
under
U. S. GOVERNMENT Contract DA-11-173-AMC-487(A)

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ABSTRACT

A sensitivity test, previously developed to study the configuration dependent excess transit time for transfer of detonation from a small diameter confined donor to a larger diameter unconfined acceptor via the detonation electric effect technique has been utilized for evaluation of an LX-13 donor/LX-10 acceptor system.

DISCUSSION

Invar tubes of the types listed in Table I were segmented by grinding into 6.35 and 12.70 mm lengths. After being cleaned they were extrusion loaded with LX-13^a, which was then cured at 68 C for six to eight hours. The segments were N-ray inspected for voids in the LX-13 load. LX-10-0X^b pellets with a diameter of 9.53 mm were pressed at nominal densities of 1.795, 1.825, and 1.855 Mg/m³.^c

The LX-13 loaded tubes and LX-10 pellets were used in a sensitivity test which was developed at Pantex to measure the excess transit time in a relatively large acceptor pellet when initiated by a small confined donor(1,2,3). The testing scheme includes the placement of an accurately controlled air gap between each pair of segments in the donor portion of the explosive train. The test has been successful for donor systems which have repeatable detonation characteristics including the propagation across the air gaps.

EXPERIMENTAL TECHNIQUE AND RESULTS

The detonation electric effect technique(4) was utilized to measure detonation front arrival times at various interfaces in an explosive train. The train consisted of an RP-2 detonator, 25.4 mm of 1.06 g/m PETN MDF, five segments of LX-13 loaded tube (6.35, 6.35, 12.70, 6.35 and 6.35 mm lengths), and an acceptor pellet stack. The pellet stack was made of either 2.03 or 2.54 mm thick pellets; the number of pellets in a shot was varied from one to four in order that excess transit time could be measured by the cutback method. The segments of tube were separated by 25 μ m air gaps to create the interfacial signals. There was no air gap and therefore no interfacial signal between the final tube segment and the pellet stack. The transit time for each final air gap-tube segment combination was calculated from the information obtained for all the other gap-segment pairs; corrections were made for the small variances in tube length. This calculated transit time

^aBatch No. 20-74-0604-158

^bBatch No. 5274-122-01. Standard WR material except granules are smaller in size and identification dye was not added

^cWork reported in this paragraph done under direction of R. J. Slape

for the final air gap-tube segment combination was then subtracted from the total time measured on each shot for the final air gap-tube segment-pellet stack combination, giving the transit time for the pellet stack. The cutback tests were to have been done for each of the four donors listed in Table I with acceptor pellets having densities of 1.795, 1.825, and 1.855 Mg/m³. However, results of initial tests, which are presented in Table II, indicated that only a Type 4 donor would initiate the LX-10 in the density range of interest. Hence, a portion of the planned tests listed in Table II were not conducted.

Data obtained for the Type 4 donor are given in Table III. A linear fit was performed upon all the data by which the excess transit time due to the air gap and the detonation velocity were obtained. The average length of the tube segments and the average transit time of the air gap-tube segment combinations were obtained for both segment lengths. The average transit time of the segments (excluding the excess time due to the air gaps) was computed by subtracting the excess time due to the air gap from the average time for the air gap-tube segment combination. The quotient of the average segment length and the average segment time is another calculation of the detonation velocity. All three calculated detonation velocity values are 7200 m/s. This compares well with the detonation velocity predicted by the equation from reference 5:

$$D = 7260 - 30.2/R = 7240 \text{ m/s for } R = 1.346 \text{ mm}$$

The acceptor pellet stack data for initiation by the Type 4 donor are presented in Table IV. These data were reduced by linear fits to excess transit times and detonation velocities for the LX-10. These data are displayed in Table V. Based upon this information, both excess transit time and detonation velocity appear to be inverse functions of density. However, there is no significant difference between the detonation velocities at each density, and the same is probably also true of the excess transit times. This is not surprising since the density difference is less than 2%, which is stretching the accuracy of the test. The original test series has acceptable donor size and acceptor density ranges, which should have provided meaningful relationships. Therefore, all of the 1.793 and 1.823 Mg/m³ data were combined to give the values for the average density of 1.810 Mg/m³. The detonation velocity of 8750 m/s at 1.81 Mg/m³ is reasonable in comparison to the velocity given in reference 5 of 8820 m/s at a density of 1.86 Mg/m³.

CONCLUSIONS

The excess transit time of approximately 80 ns for LX-10 initiated by the Type 4 donor is larger than observed in previous work with HNS systems(1,2,3). It is evident from the test results that the critical donor diameter for initiation of the LX-10 with densities in the range of 1.793 to 1.823 Mg/m³ is between 0.991 and 1.346 mm, and the critical density for initiation of the LX-10 by the Type 4 donor is between 1.823 and 1.853 Mg/m³. Information as to how excess transit time varies as acceptor density is reduced further from the critical value would make possible a more comprehensive understanding of initiation reliability as

a function of acceptor density for each of the four donor types. Likewise, increasing donor size while maintaining acceptor densities in the 1.793 to 1.853 Mg/m³ range would facilitate a better understanding for initiation reliability as a function of donor size for the acceptor density range of interest.

The 14 ns excess transit time for the LX-13, which is due to the insertion of the air gap, is on the same order as the smallest seen in the HNS work(1). Both the relatively low excess transit time and also the fact that the detonation wave did not fail to propagate across the air gaps for any of the four donor types indicate that the detonation wave propagation is stable across an unconfined 25 μ m break for the 1.346 mm diameter.

Table I. Nominal Dimensions of Invar Tubes

<u>Type</u>	<u>ID (mm)</u>	<u>OD (mm)</u>	<u>Wall Thickness (mm)</u>
1	0.749	1.041	0.146
2	0.965	1.549	0.292
3	0.991	1.295	0.152
4	1.346	1.905	0.279

Table II. Results of Initial Tests to Determine Whether Detonation Would Propagate from the LX-13 Loaded Donor Tube to the LX-10 Acceptor Pellet

<u>Number of Shots</u>	<u>Tube Type</u>	<u>Pellet Density (Mg/m³)</u>	<u>Pellet Length (mm)</u>	<u>Results</u>
0	1	1.795	2.54	None Tried
0	1	1.825	2.54	None Tried
0	1	1.855	2.54	None Tried
3	2	1.795	2.54	No Go ^a
0	2	1.825	2.54	None Tried
1	2	1.855	2.54	No Go
2	3	1.795	2.54	No Go
0	3	1.825	2.54	None Tried
2	3	1.855	2.54	No Go
1	4	1.795	2.54	Go
0	4	1.825	2.54	None Tried
1	4	1.855	2.54	No Go

^a"No GO" means that detonation did not propagate from the donor segment to the acceptor pellet

Table III. Results Obtained for 1.346 mm ID, LX-13 Loaded Donor Segments

	<u>6.35 mm</u> <u>Lengths</u>	<u>12.70 mm</u> <u>Lengths</u>	<u>Both</u> <u>Lengths</u>
Number of Points	26	15	41
Length of Segment (mm)	6.328 ^a	12.682 ^a	
Sigma ^f (mm)	0.054	0.035	
Transit Time for Gap and Segment (μ s)	0.893 ^a	1.775 ^a	
Sigma (μ s)	0.020	0.022	
Transit Time for Segment (μ s)	0.879 ^b	1.761 ^b	
Sigma (μ s)	0.022	0.023	
Excess Time Due to Gap (μ s)			0.014 ^d
Sigma (μ s)			0.009
Detonation Velocity (m/s)	7200 ^c	7200 ^c	7200 ^e
Sigma (m/s)	190	100	50

^aValue is the average

^bValue is the difference between the average transit time for one gap-segment pair and the excess transit time due to the air gap

^cValue is the quotient of the average segment length and the average segment transit time

^dValue is the intercept of linear fit to all the data

^eValue is the inverse of the slope of linear fit to all the data

^fOne standard deviation

Table IV. Data Obtained for LX-10 Acceptor Pellet Stacks Initiated with 1.346 mm ID Donor

<u>Number of Pellets</u>	<u>Total Length (mm)</u>	<u>Average Density (Mg/m³)</u>	<u>Transit Time (μs)</u>
1	2.535	1.797	0.372
1	2.543	1.791	0.368
1	2.540	1.794	0.342
2	5.088	1.793	0.716 ^a
3	7.643	1.794	0.930
4	10.208	1.793	1.231
1	2.535	1.825	0.335
1	2.543	1.824	0.351
1	2.550	1.821	0.349
2	5.083	1.821	0.631
3	7.577	1.822	0.931
4	10.130	1.824	1.213
1	2.548	1.854	No Go ^b
1	2.543	1.854	No Go
1	2.040	1.850	No Go
2	4.079	1.853	No Go
3	6.091	1.852	No Go
4	8.164	1.853	No Go

^aThis point was not used in data analysis because it does not fit the trend of the other data

^b"NO GO" means that detonation did not propagate from the donor segment to the acceptor pellet

Table V. Experimental Results for LX-10 Acceptor Pellets
Initiated by 1.346 mm ID Donor

Density (Mg/m ³)	Sigma ^b (Mg/m ³)	Excess Transit Time (ns)	Sigma (ns)	Detonation Velocity (m/s)	Sigma (m/s)
1.793	0.002	90	12	8810	150
1.823	0.002	69	6	8680	80
1.853	0.003	-	-	-	-
1.810 ^a	0.015	79	7	8750	90

^aValues on this row were obtained by using the 1.793 and 1.823 Mg/m³ data

^bOne standard deviation

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