UNREACTED HUGONIOTS AND DETONATION
SENSITIVITY OF HNS I

L. D. Hanes
C. E. Canada

DEVELOPMENT DIVISION

APRIL -, JUNE 1975
(P.O. NO. 02-9779)
FINAL REPORT

For
Sandia Laboratories
Albuquerque, New Mexico

Mason & Hanger-Silas Mason Co., Inc.

Pantex Plant

P. O. BOX 647
AMARILLO, TEXAS 79177
806-335-1581

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

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Energy Research and Development Administration, nor their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately-owned rights.

UNREACTED HUGONIOTS AND DETONATION
SENSITIVITY OF HNS I

L. D. Hanes
C. E. Canada

DEVELOPMENT DIVISION

April - June 1975
P.O. No. 02 9779

NOTICE
This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Energy Research and Development Administration, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

ABSTRACT

An attempt was made to determine the unreacted Hugoniot and distances to initiation of HNS I at densities of 1.40 and 1.60 Mg/m³ for pressures between 3 and 12 GPa. The effort was unsuccessful since the distance to initiation was less than anticipated. For a pressure near 4 GPa detonation was achieved within a distance of 0.635 mm; for higher pressures the distance was less than experimental resolution.

DISCUSSION

The purpose of this project was to determine unreacted Hugoniot and distances to detonation for HNS I at two densities and over a pressure range extending upward as close as experimentally feasible to C-J conditions. Once determined the data would be used, along with critical energy concepts, for design and evaluation of explosive systems(1,2).

Discrete pressures near 3, 6, 9 and 12 GPa were selected for initial evaluations at the two densities of 1.40 and 1.60 Mg/m³. One test for each density was planned for these four pressures. Dependent upon the results, four additional tests for each density were then to be conducted. HNS pellet thicknesses of 0.635, 1.27, 1.905 and 2.54 mm were selected for the initial series so as to encompass the expected thickness at which detonation would occur(3). Unfortunately, neither the temporal nor spatial experimental resolution was adequate to successfully complete the investigation.

EXPERIMENTAL TECHNIQUE AND RESULTS

A quasi-planar shock wave produced by a P-080 PWL was boosted by a 25.4 mm thick explosive pad and then tailored by passing through inert attenuation plates before being transmitted into HNS pellets. The booster explosive and attenuator materials were varied to achieve desired pressures. Pellets of 0.635, 1.27, 1.905 and 2.54 mm thickness were used on each shot so that chemical reactivity could be detected. The 0.635 mm was the least acceptable thickness primarily because of the shock wave non-planarity. The particle velocity and shock velocity in the final attenuator plate and the shock velocity in the HNS pellets were measured indirectly. Only three shots were actually fired because detonation occurred at about 4 GPa in the 0.635 mm, 1.60 Mg/m³ pellets.

Table I is a compilation of the booster-attenuator systems used to transmit the desired pressures into the Chemtronics Lot 66-48 HNS I pellets. Fig. 1 is a photograph of a shot showing the final attenuator plate. The three copper wires are used to monitor the free surface motion of the polished surface by the reflected wire technique. The vertical row of five pellets includes the four thicknesses of HNS and a metal disk of 2.54 mm thickness made from the same material as the polished plate. Aluminized Mylar strips of 12.7 μ m thickness are on the output surface of each HNS pellet; the output surface of the metal disk is polished. The transit times of the shock waves moving through the

pellets are recorded by a streaking camera by observing the light from an explosive argon candle which is reflected off of the polished plate and the aluminized Mylar. When the shock wave arrives at each surface the reflectivity is considerably reduced. The transit times for another set of pellets are measured by use of piezoelectric pins, which are supported by PMMA brackets and located on top of and beside each pellet. Good contact between the face of each pin and the surface on which it was placed was insured by careful visual inspection.

The pellets were pressed to shape with a maximum density variation of $\pm 0.5\%$. The pellets of each thickness were made the minimum diameter which would insure that no rarefactions would arrive at a 2.5 mm diameter circle in the center of the output face before the main shock front. Minimizing the pellet diameters allowed the measurement of shock wave arrival nearer to the center of the pellet input surface, thus reducing the error due to shock wave non-planarity. Minimizing the diameter-to-thickness ratio of each pellet type also produced a more uniform density in the pellet. The pellets were held in intimate contact with the final attenuator plate by glue spots around the edges of each pellet; there was no glue bond between the attenuator plate and the pellets. Each aluminized Mylar strip was placed with the aluminized surface in contact with the pellet and spray coated with a transparent acrylic. Thus there was no glue bond between the pellet and Mylar strip.

Figs. 2 and 3 show typical streaking camera and oscilloscope records. Particle and shock velocity, and pressures at the final attenuator output surface are given in Table II. Pellet data are listed in Table III and plotted in Fig. 4. The slope of the lines drawn in the figure is 6890 m/s which is the detonation velocity of Chemtronics Lot 66-48 HNS I at 1.60 Mg/m³ (4). The two shots at the higher pressures each indicate a very short distance to detonation. The low pressure shot has about 0.1 μ s excess transit time.

An offset between optical and electrical data for a given test is apparent in Fig. 4. This offset probably results from that time required for shock and rarefaction interactions to change the reflectivity of the aluminized Mylar. The electrical records are thus considered the more accurate of the two methods. Deviation of data from curves shown in Fig. 4 is largely due to shock front non-planarity.

CONCLUSIONS

For the pressure range of interest, distance- and time-to detonation data for HNS I at 1.60 Mg/m³ could not be quantitatively resolved with the methods used. Although thinner HNS pellets could have been used, systematic errors due to shock front non-planarities would probably be large compared to actual transit times through the pellets. Since shock sensitivity increases as the density decreases, tests at 1.40 Mg/m³ would be even less fruitful.

Methods described here do have potential use for lower pressure ranges or less sensitive explosive materials, but they proved inadequate for HNS I above 3 GPa.

Table I. Booster-Attenuator Systems for Pressure Transmission into HNS I Pellets

P_o of HNS (Mg/m ³)	Booster ^a Pad	Attenuator ^b Plates	Anticipated P in HNS (GPa)
1.60	TNT	Aluminum ^e	11.3
1.60	TNT	Plexiglas, Aluminum	9.8
1.60	76/24 Baratol ^c	Plexiglas, Aluminum	6.2
1.60	85/15 Baratol ^d	Brass ^f	3.4
1.40	Comp. B	Plexiglas, Aluminum	12.4
1.40	TNT	Aluminum	9.3
1.40	76/24 Baratol	Aluminum	6.1
1.40	76/24 Baratol	Brass	3.5

^aAll booster pads were 25.4 mm thick.

^bAll attenuator plates were 12.7 mm thick.

^cStandard mixture of 76% barium nitrate and 24% TNT.

^dModified mixture of 85% barium nitrate and 15% TNT.

^e2024-T351 alloy.

^f856 or 860.

Fig. 1. View of Shot Showing Typical Makeup

Fig. 2. Typical Streaking Camera Records

Fig. 3. Typical Oscilloscope Records

Table II. Measured and Calculated Properties in Final Attenuator Plate

Shot No.	Plate Material	Plate Density (Mg/m ³)	Particle Velocity ^a (m/s)	Shock Velocity ^b (m/s)	Pressure ^c (GPa)
1	Aluminum*	2.785	983	6860	18.8
2	Aluminum*	2.785	904	6730	16.9
3	Brass**	8.450	442	4500	16.8

^aCalculated from measured free surface velocity by reflected wire technique.

^bCalculated from transit time measurement through the metal disk by piezoelectric pins.

^cCalculated by $P = 10^{-6} \rho_0 U_P U_S$.

*2024-T351 alloy.

**856 or 860.

Table III. Comparison of Electrical and Optical Determination of Transit Times for HNS I

Shot No.	Measurement Method	Pellet Density (Mg/m ³)	Pellet Thickness (mm)	Transit Time (μsec)
1	Electrical	1.606	2.535	0.373
		1.596	1.900	-
		1.600	1.257	-
		1.599	0.640	-
	Optical	1.603	2.535	0.380
		1.596	1.913	0.287
		1.596	1.262	0.194
		1.607	0.638	-
2	Electrical	1.603	2.540	0.379
		1.596	1.900	0.264
		1.596	1.270	0.166
		1.603	0.631	-
	Optical	1.601	2.543	0.388
		1.595	1.905	-
		1.601	1.262	-
		1.598	0.638	-
3	Electrical	1.603	2.540	0.464
		1.592	1.910	0.390
		1.606	1.272	0.283
		1.597	0.630	0.190
	Optical	1.603	2.540	0.488
		1.597	1.902	0.400
		1.594	1.267	0.301
		1.592	0.630	0.183

Fig. 4. Time - Distance Data for HNS I

REFERENCES

1. F. Walker and R. Wasley, "Critical Energy for Shock Initiation of Heterogeneous Explosives," Explosivstoffe 17, 9 (1969).
2. J. Kennedy and A. Schwary, "Detonation Transfer by Flyer Plate Impact," Proceedings of the Eighth Symposium on Explosives and Pyrotechnics, The Franklin Institute Research Laboratories, Philadelphia, Pennsylvania, February 1974.
3. J. Roth, "Shock Sensitivity and Shock Hugoniot of High-Density Granular Explosives," pp 219-30 of Fifth Symposium (International) on Detonation (1970).
4. R. J. Slape, "Detonation Pressure of HNS I and II," MHSMP-75-23, June 1975.