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QUARTERLY REPORT ON INVESTIGATION OF HIGH AND LOW TEMPERATURE RESISTANT EXPLOSIVE DEVICES [U]

FOR NASA, MANNED SPACEFLIGHT CENTER

NASA REQUEST T-32602 (G)

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⑥ ~~FIFTH QUARTERLY~~ PROGRESS ~~REPORT ON~~

INVESTIGATION OF HIGH AND LOW TEMPERATURE RESISTANT EXPLOSIVE DEVICES [U]

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For NASA, Manned Spacecraft Center
NASA Request T-32602(G)

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BACKGROUND

This is the fifth NOL White Oak quarterly progress report on the "Investigation of High and Low Temperature Resistant Explosive Devices" work being conducted for the NASA Manned Spacecraft Center at Houston. This report covers work from 3 January to 31 March 1966. The work on the investigation of the properties of heat resistant explosives is continuing with some effort on the extremely low temperature performance of these materials.

PROPAGATION OF HEAT RESISTANT EXPLOSIVES

A. Small Scale Gap Test Sensitivity

A-1. General

To insure that new batches of heat resistant explosives are of an acceptable quality, specification testing is performed on them. New batches of NOL prepared HNS-II are the most recent explosives to be subjected to specification tests. These tests were run to determine the reproducibility of the HNS-II product by NOL preparation procedures.

A-2. NOL Preparations of HNS-II

The sensitivity values obtained from the first NOL preparation of HNS-II (X-528) were used as the basis for setting the specification limits (see WS5003C and Fig 1 of this report). The small scale gap test was used to determine the sensitivity to shock. The results of these tests for two new NOL HNS-II preparations (X-538, X-550) are shown in Fig 1. Each point on the sensitivity-density curve represents the statistically determined 50% shock stimulus as obtained from 20 shots. As given by the specification, a sensitivity-density value falling within a given range is acceptable as shown in Fig 1. Additional HNS-II samples are being prepared and will be tested in the same manner. Efforts are now being made to procure HNS-II from commercial sources for testing.

A-3. ABH-II

The new heat resistant explosive azobis (2,2',4,4',6,6'-hexanitrobiphenyl), ABH, m.p.>485°C, has been tested at two loading densities, as shown in Fig 2. ABH with particle size of about 20-100 microns (type II material) appears to have about the same sensitivity as NONA when both are loaded to a density of $\sim$ 1.30 g/cc. Starting at a density of 1.3 g/cc the sensitivity of ABH decreases much more rapidly than that of NONA with increasing density. Investigation of the sensitivity as a function of the density will continue at higher densities. The sub-micron particle size material, ABH-I, will be investigated in the same manner.

A-4. Modified Small Scale Gap Test for High and Low Temperature Testing

There is an increasing demand for the use of explosives in applications up to about 500°F and as low as -200°F. The sensitivity of these explosives to shock has not been determined at these extreme conditions of temperature. In the past most all small scale gap tests have been made at room temperature. Therefore a modified small scale gap test was designed as a means for determining the sensitivity of the heat resistant explosives at various temperatures. The experimental set-up is shown in Fig. 3. Prior to insertion in the test set-up the loaded acceptor is stored in a chamber at the test temperature. The standard RDX donor at room temperature is fitted with a plastic attenuator and then placed into the slotted glass tube to a predetermined position and maintained there by a holder (not in plane shown in the figure). The 20-mil teflon disc is placed in the tube and on the output block. The purpose of this disc is to insulate the acceptor from the large mass of steel on the output block. The acceptor explosive is removed from its environment and placed into this expendable assembly for testing. A time-temperature profile predetermined from thermocouples mounted in the acceptor, the output block, and the attenuator showed that the performance of the explosive must be determined within 30 seconds of removal from its environment. In order to prove-in the experimental procedures, HNS-R was tested by this method at 500°F and -65°F. The tests ran smoothly and the results are shown in Fig. 4. Fig. 4 at extreme densities shows the expected trend in sensitivity, i.e., sensitivity increases with increasing temperature. Work is being conducted to extend the lower temperature to -300°F. DIPAM, HNS-I, HNS-II, NONA, and other explosives will be subjected to these extreme temperature tests and their sensitivities determined.

B. Micro Scale Detonation Velocity Measurement

B-1. Detonation Velocity of ABH-II

Previous work has shown that the detonation velocity of explosives in small column diameters can be determined by using small amounts of explosive in the hypodermic needle-micro scale detonation velocity test. ABH-II was available only in very small quantities, in the order of a few grams, and was loaded into hypodermic needle tubing. Two extreme loading densities were chosen, as is shown in Fig 5. ABH-II appears to have a detonation velocity, comparable to NONA, of about 6.3 mm/μsec at a density of 1.35 g/cc and about 7.3 mm/μsec at a density of 1.63 g/cc. These detonation velocity determinations will be expanded to cover larger column diameters (0.″1, 0.″2, and 0.″3 diameters) and various densities.

B-2. Detonation Velocity of MDF's After High Temperature Exposure

The NOL findings, published in the Third Quarterly Progress Report, shows a definite decrease in the detonation velocity of explosives loaded in MDF's after long exposures at elevated temperatures. In order to determine if the decrease in the velocity is caused by degradation of the explosive or some physical change in the cord, several core loads of various magnitudes must be investigated. Since the preliminary findings were made with 15 gr/ft MDF's, it was decided to repeat this type of experiment with a 2 gr/ft MDF. By reducing the quantity of explosive/unit length the smaller core load should fail to support detonation sooner when exposed to the same temperature environment, if chemical degradation is responsible for the decreased velocity. The results of these preliminary tests are shown in Figs 6, 7, and 8. DIPAM, HNS-II, and NONA MDF's (silver) loaded at 2 gr/ft show more rapid degradation than the MDF's at 15 gr/ft core loads exposed under the same temperature conditions. These experiments will be expanded to include RDX and HMX in MDF's and FLSC's.

C. End Coupler Functioning at Low Temperatures

An end coupler is an explosive component designed to pick-up and intensify the shock produced from the detonation of MDF and to transfer this detonation to a subsequent explosive component. Past experience has shown that superfine explosives are desirable for end coupler explosive loads. Since this type of unit must perform at very low temperatures as well as at elevated temperatures, a preliminary investigation was set-up and will be expanded. The test set-up is shown in Fig 9. The end coupler was placed in a low confinement plastic holder with the output end resting on an aluminum output block. A standard No. 6 detonator was used to initiate the 2 gr/ft MDF. The entire assembly was placed in a test tube and immersed in liquid nitrogen. The assembly was allowed to soak for several minutes after reaching a temperature of -315°F. The performance of the unit was measured by the dent produced in an aluminum output block. The explosive efficiency has not been related to the room temperature performance because the data has not been reduced in terms of strengths of materials at these low temperatures. However, irrespective of immersed strengths of aluminum at low temperature, the propagation of the explosive is of significance. It can be noted in Table 1 that low density loading can give rise to poor reliability in performance. The significant finding in these data is that ABH-I (sub-micron particle size) appears to perform better than HNS-I (superfine). Also, the fact that ABH-II, although large in particle size may be sensitive enough to pick-up detonation from a small impetus shock. This work will continue and should prove valuable in future end coupler designs.

D. Compatibility of Explosives at Elevated Temperatures

Compatibility studies are continuing on DIPAM, HNS-II, and NONA mixed with lead azide (dextrinated) and subjected to elevated temperatures. The latest results are shown in Table 2. The sample consisted of a mixture of heat resistant explosive and primary explosive in a weight ratio of 1.0/0.25 g. It would appear that lead azide is compatible with these explosives at 392°F (200°C). There is no reaction between the high explosives and lead azide at this temperature. However, the lead styphnate sample will not withstand this extreme temperature.

E. Vacuum Thermal Stability of RDX and HMX at Elevated Temperatures

Samples of RDX and HMX have been tested at 300°F for thermal stability with the following results:

HMX Grade II	0.35 ml/g/48 hrs 6.2 ml/g/16 days
RDX Type B Class C Holston Sr-31a-d-65 (74-1680 microns)	1.65 ml/g/48 hrs 7.2 ml/g/16 days
RDX X-494 Type B Class E Holston (44 microns - source, Crane, Ind.)	1.22 ml/g/48 hrs 18.9 ml/g/16 days

From the above data, particle size effect seems to be evident in the RDX samples.

Samples of RDX and HMX were tested at 350°F for thermal stability with the following results:

HMX Grade II	3.6 ml/g/48 hrs 24.8 ml/g/4 days EC* in 5 days
RDX Type B Class C	7.6 ml/g/48 hrs 11.3 ml/g/3 days EC in 4 days
RDX Type B Class E 44 microns	10.5 ml/g/24 hrs EC in 2 days

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* EC = exceeds capacity of measuring equipment.

F. ABH Synthesis

A program aimed at improving the synthesis method for azobis (2,2',4,4',6,6'-hexanitrobiphenyl), ABH, m.p.>485°C, has resulted in a number of refinements such that overall yields in the six step process starting with picryl chloride and m-bromoanisole are now about 50%. It is now possible to prepare 100 g batches using laboratory-scale apparatus and estimates of manufacturing cost have been reduced from $5,000-10,000/lb to $500-1,000/lb. More than two pounds of material have been prepared in the course of this program.

A method of converting the sub-micron particle size material (ABH-I) to a 20-100 micron particle size product (ABH-II) without adversely affecting 260° thermal stability has finally been devised. Both ABH-I and ABH-II evolve 1.0-1.5 cc gas/g/hr in the 260°C vacuum thermal stability test, corresponding to less than 1% decomposition per hour at this temperature.

TABLE 1

END COUPLER FUNCTIONING TEST RESULTS AT -315°F

	ABH-II (Large Crystal)		ABH-I (Superfine Crystal)		HNS-I (Superfine Crystal)	
Loading Pressure (KPSI)	13	32	13	32	13	32
Output	F*	39	F	36	F	31
Dent	F	37	11	33	F	35
(mils)	F	38	16	34	F	36
Aluminum	9	35	10	35	16	38
Block	11	40	17	38	24	33
6061-T6			18			
			21			
			20			

*F - Explosive in ferrule failed to initiate from the shock stimulus produced from the detonation of the MDF.

TABLE 2

COMPATIBILITY OF EXPLOSIVE AT HIGH TEMPERATURE

$Pb(N_3)_2$ Dextrinated Lot 2	cc/gm @ 200°C		
Explosive	2 days	7 days	35 days
DIPAM NOL prep.	3.7	7.8	17.5
HNS-II X-538	3.7	7.9	16.9
NONA 96-7524P.21-1	4.5	9.1	16.0
Control $Pb(N_3)_2$ Dextrinated Lot 2	4.7	29 for 31 days	

PbSty(n) milled	cc/gm @ 200°C	
Explosive	2 days	6 days
DIPAM NOL prep	24.5	27.1
HNS-II X-538	25.5	27.5
NONA 96-7524P.21-1	26.1	26.3
Control PbSty(N)milled	EC* after 26 hours	

*EC = exceeds capacity of measuring equipment

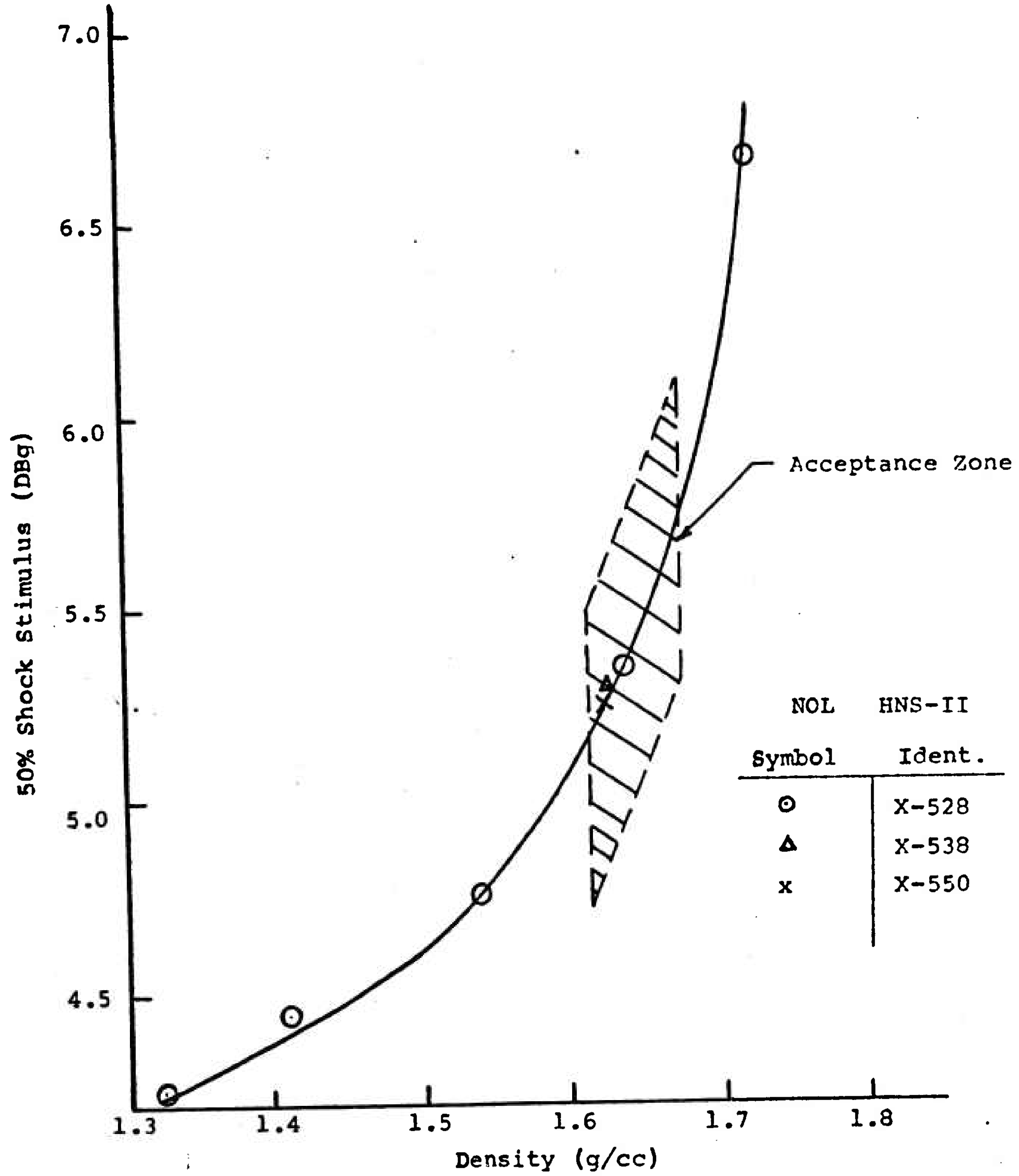


FIG 1 SMALL SCALE GAP TEST SENSITIVITY VS DENSITY OF HNS-II

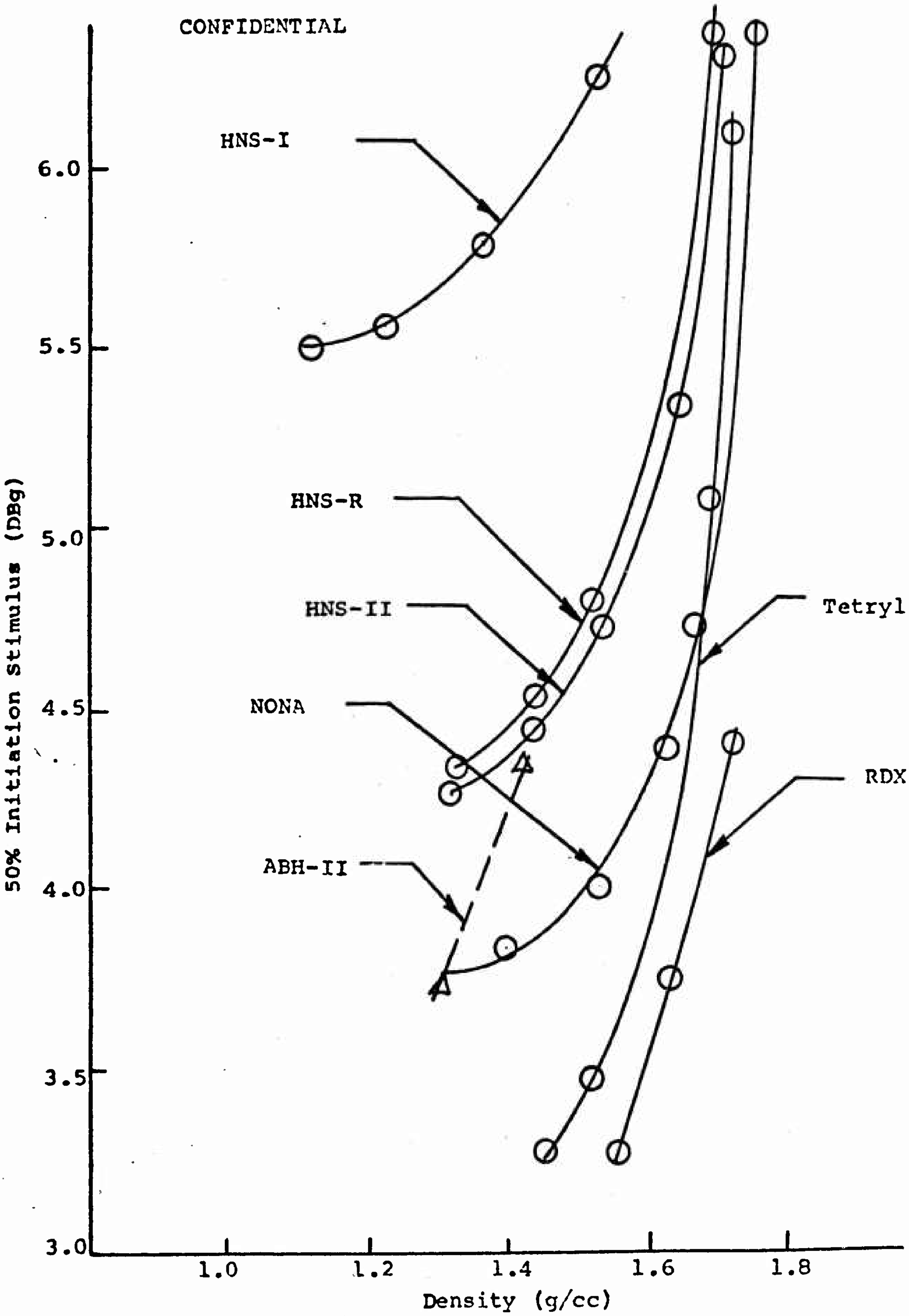


FIG 2 SMALL SCALE GAP TEST SENSITIVITY VS DENSITY OF SEVERAL EXPLOSIVES

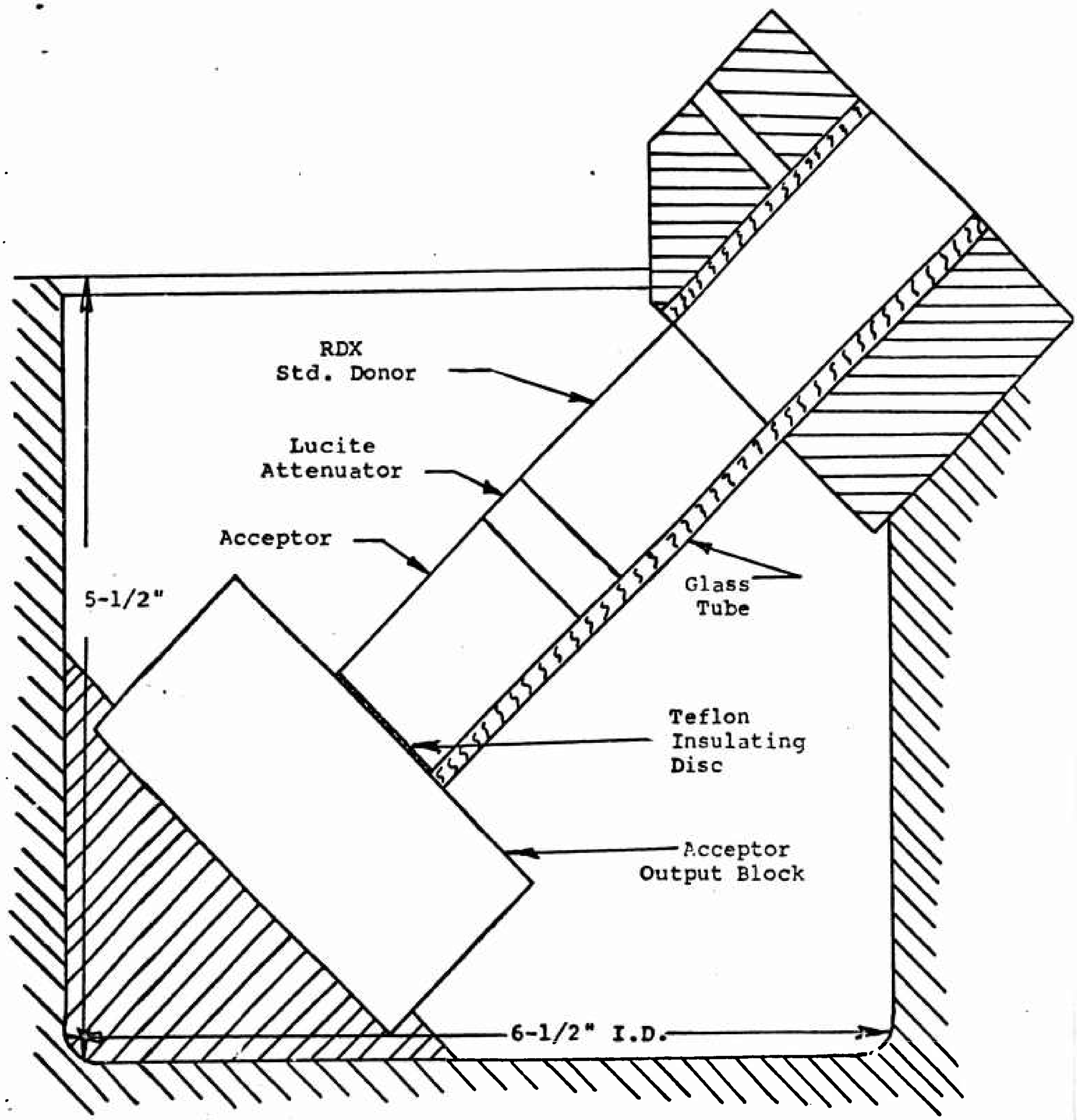


FIG 3 EXPERIMENTAL ARRANGEMENT FOR THE DETERMINATION OF THE SENSITIVITY OF EXPLOSIVES AT VARIOUS TEMPERATURES

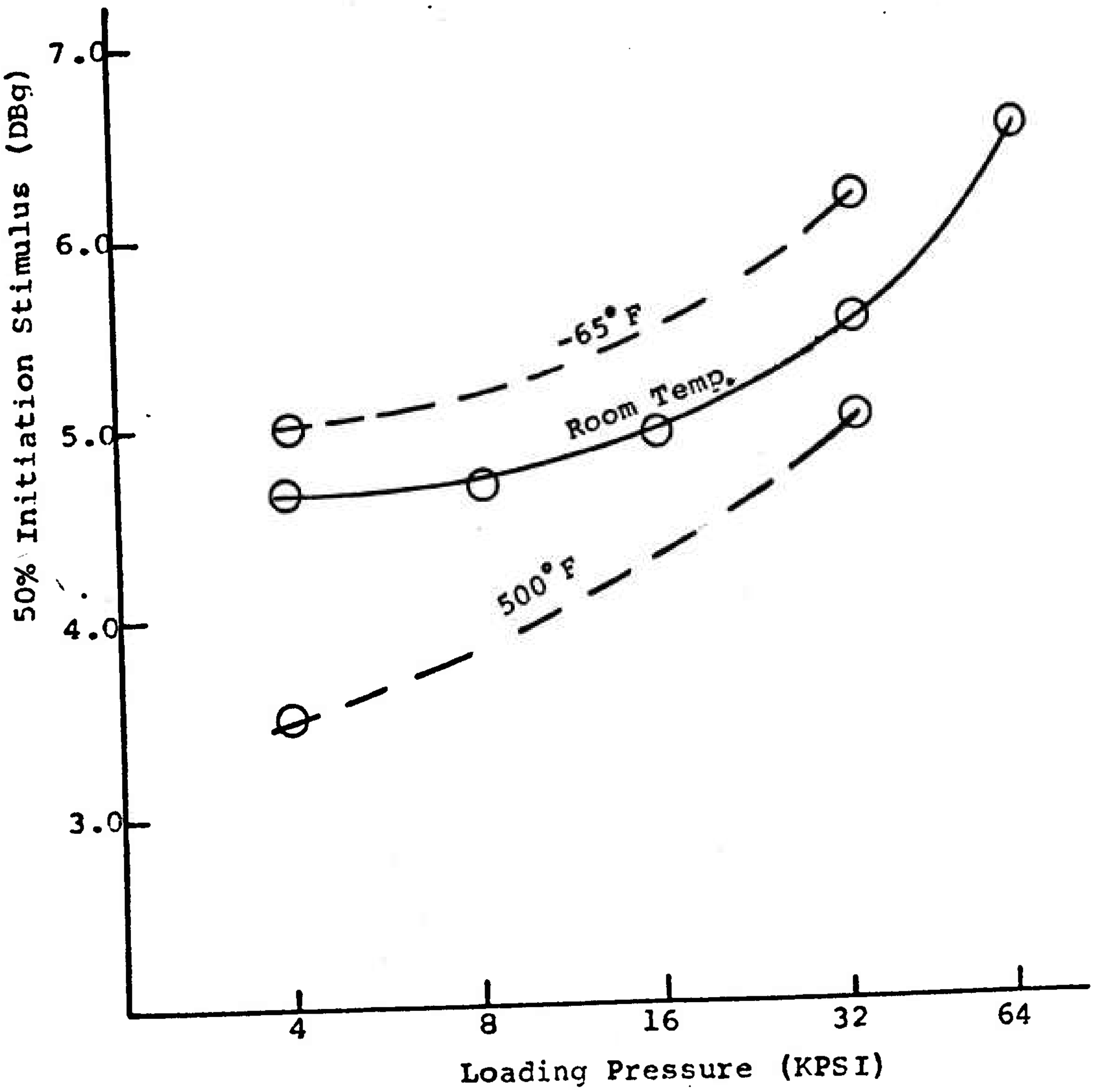


FIG 4 SMALL SCALE GAP TEST SENSITIVITY OF HNS-R AS A FUNCTION OF TEMPERATURE AND LOADING PRESSURE

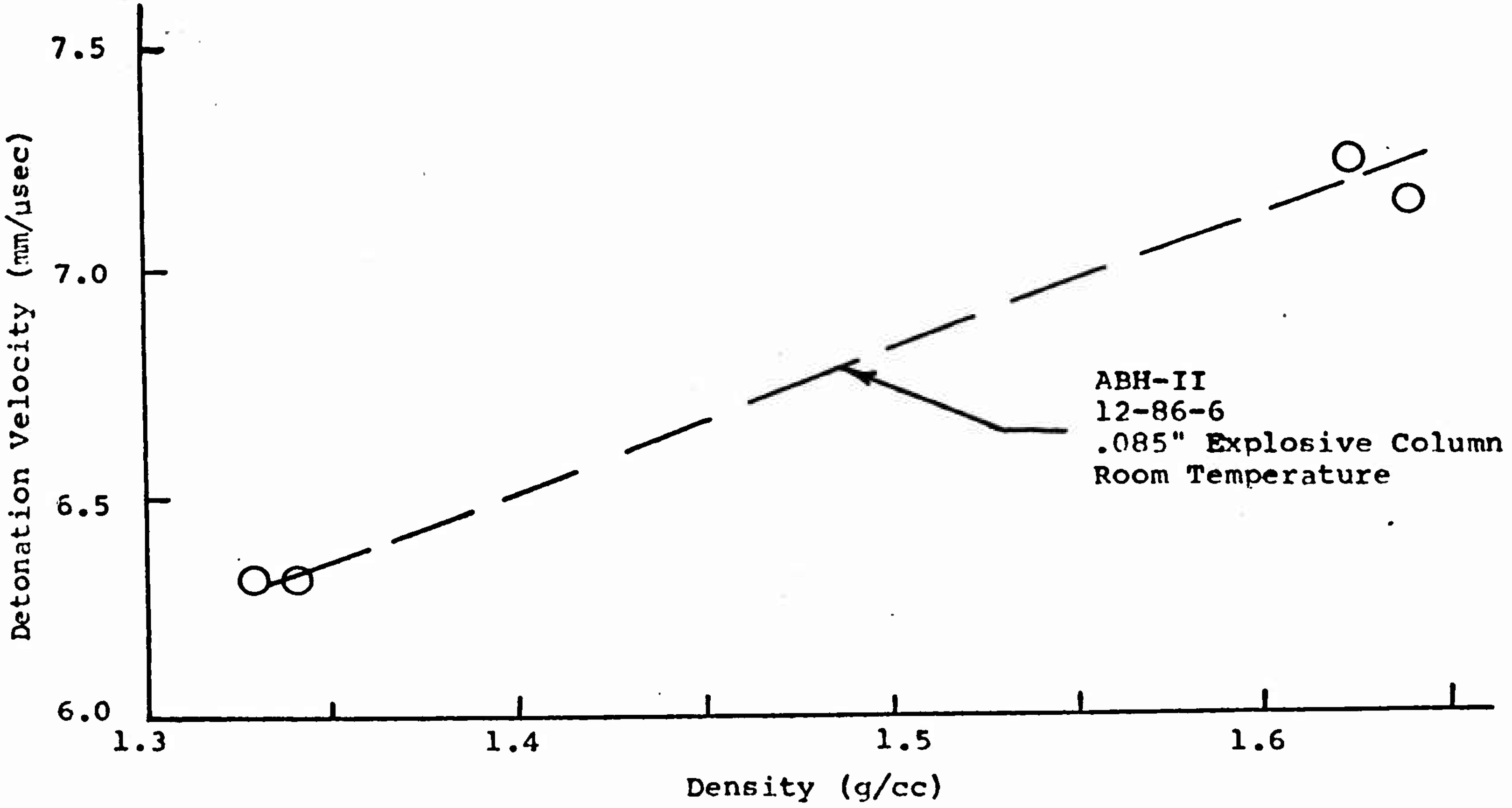


FIG 5 MICRO-SCALE DETONATION VELOCITY OF ABH-II AS A FUNCTION OF DENSITY

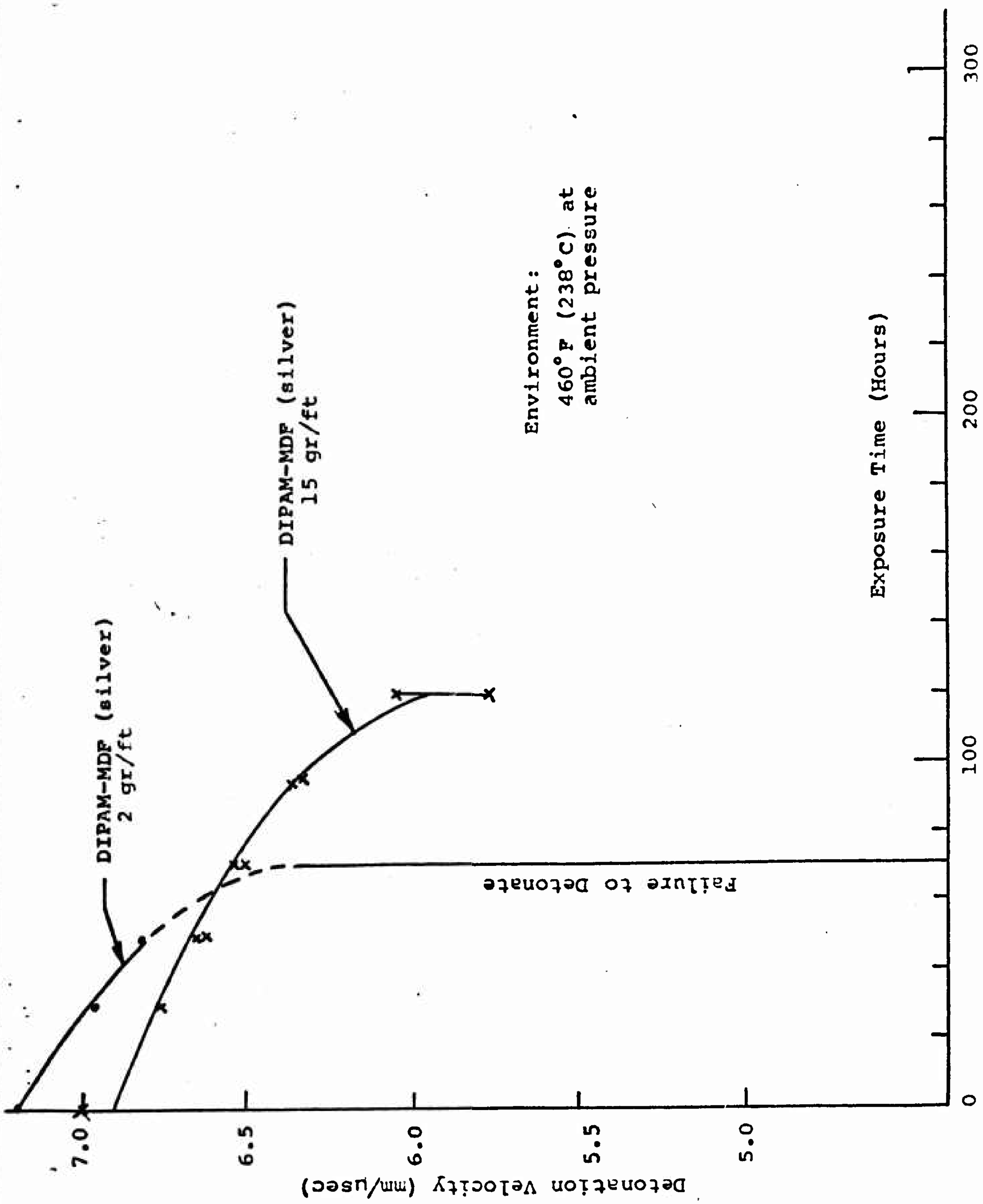


FIG 6 DETONATION VELOCITY OF DIPAM-MDF AFTER EXPOSURE TO HIGH TEMPERATURE

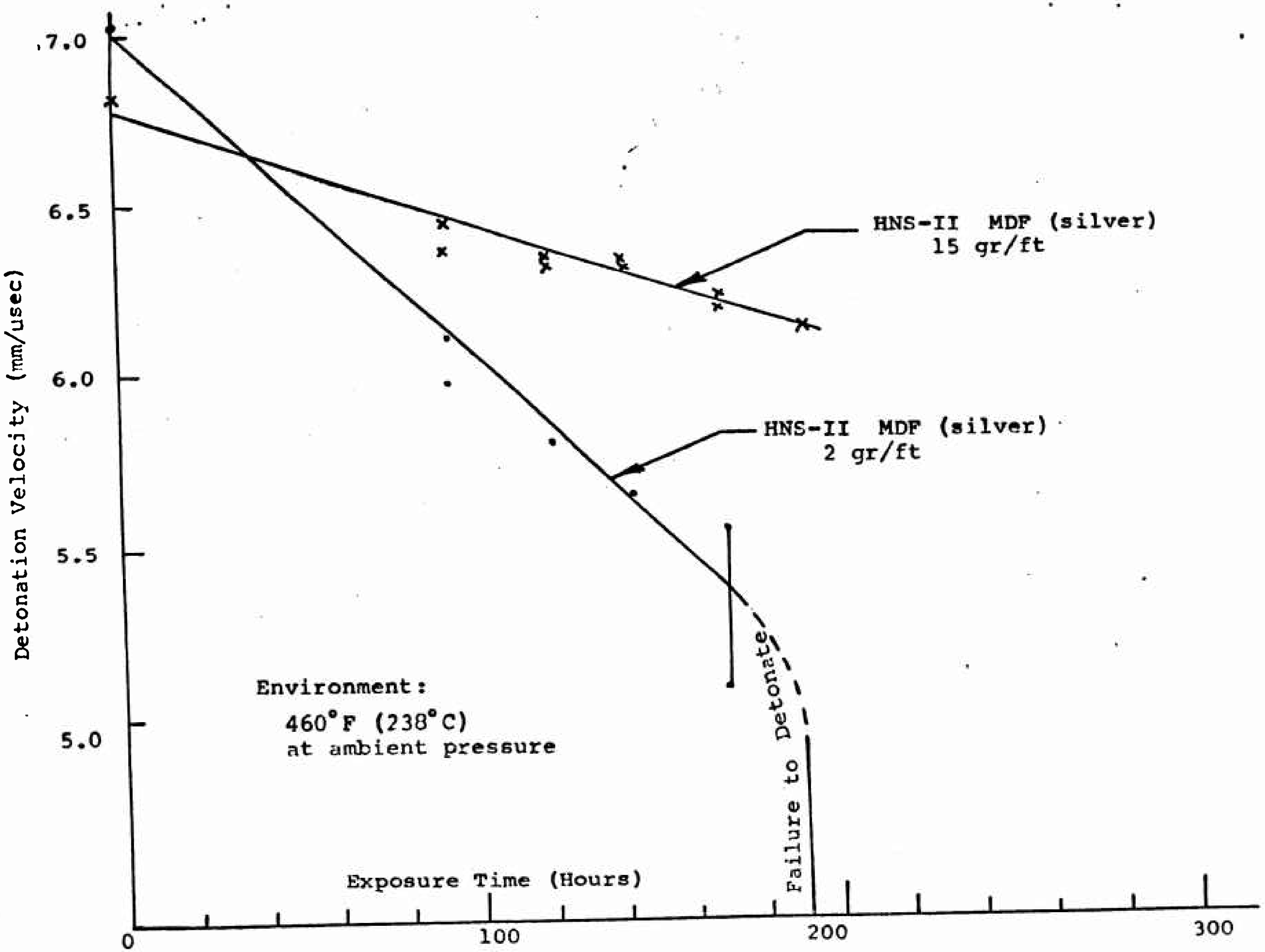
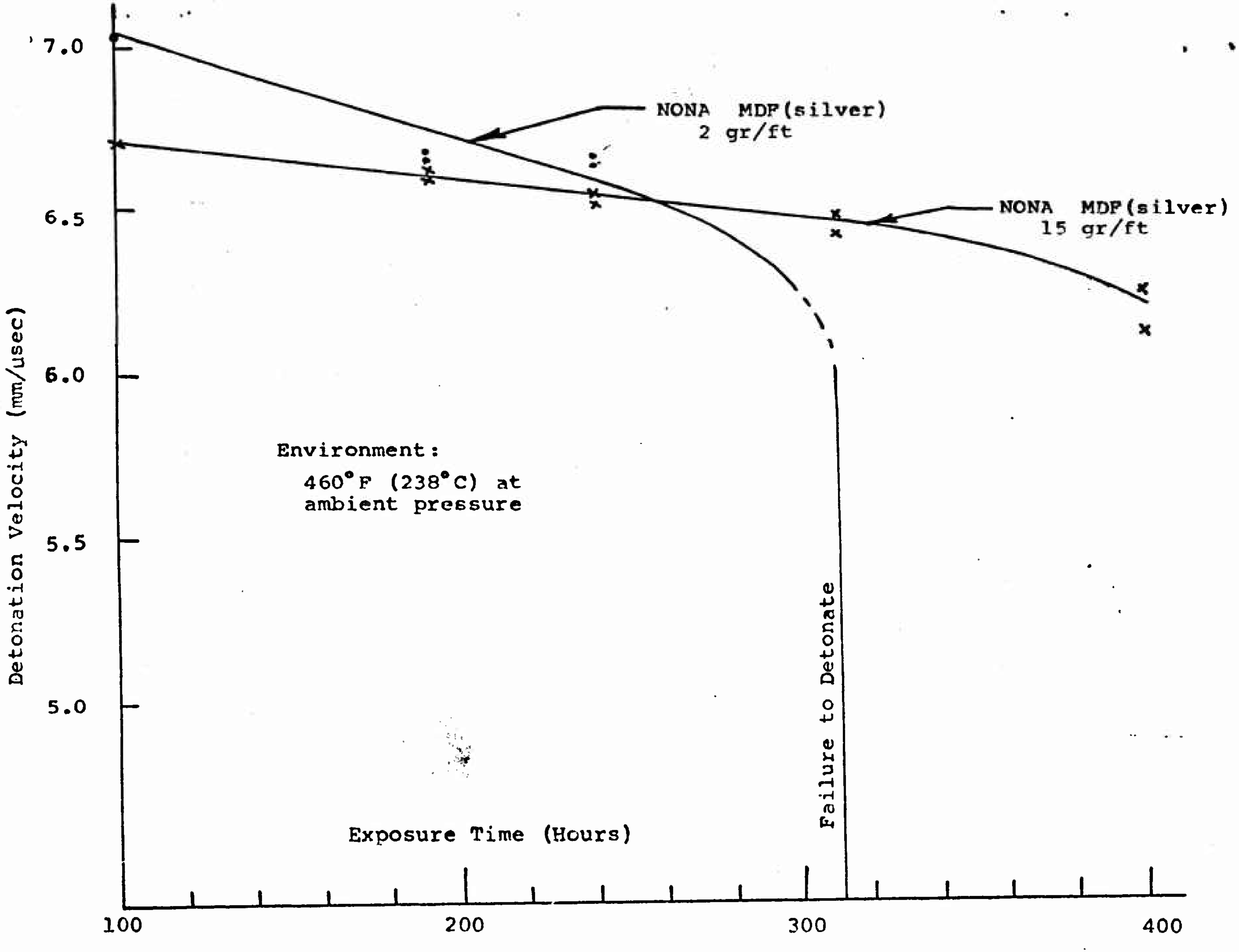


FIG 7 DETONATION VELOCITY OF HNS-II MDF AFTER EXPOSURE TO HIGH TEMPERATURE



Environment:
460°F (238°C) at
ambient pressure

FIG 8 DETONATION VELOCITY OF NONA MDF AFTER EXPOSURE TO HIGH TEMPERATURE

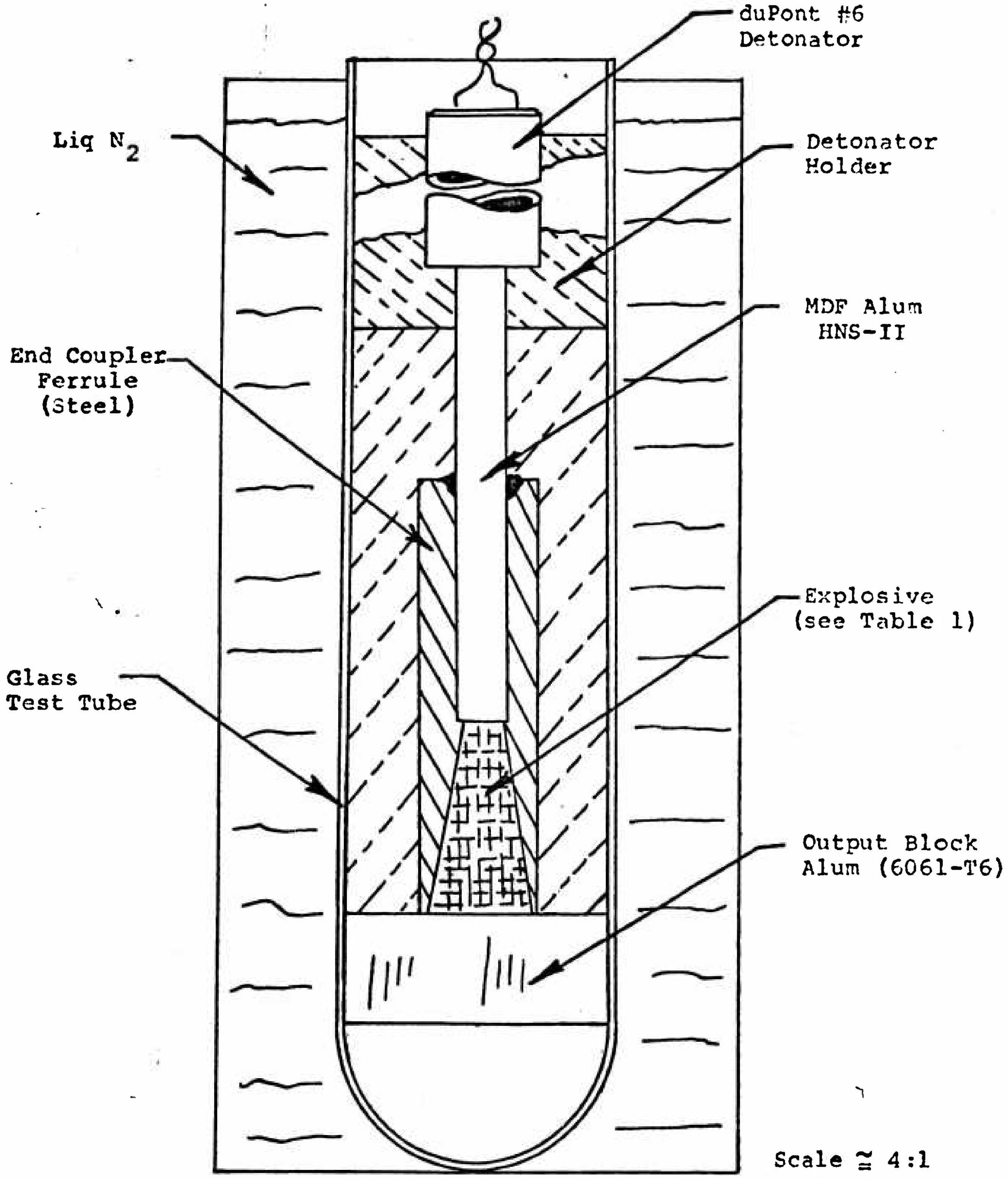


FIG 9 LOW TEMPERATURE END COUPLER TEST ASSEMBLY