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A MINIATURIZED GAP TEST

by

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for the

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ABSTRACT: A test arrangement and procedure has been devised for a miniaturized gap test in which the donor is essentially a length of hypodermic needle tubing loaded with an explosive. The particular size used in the work reported herein had an explosive column charge diameter of 33 mils. The procedure was used to determine gap sensitivities of several explosives, including tetryl, RDX, PETN, HED, and HMX-5. Several of the explosives were tested of more than one particle size and loaded at more than one density. Within the group of explosives tested, both particle size and loading density had more affect upon sensitivity, as measured in these tests, than did composition. The coarser materials were found to be both less sensitive and more variable than the fine explosives. The fine explosives were found to become less sensitive as the loading density increased. This trend was apparently reversed for the one coarse explosive (RDX, Class A) for which data was obtained. The test arrangement and procedure is a promising tool for the acquisition of data for the design of fuzes of minimum dimensions.

Respectfully submitted,

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TABLE OF CONTENTS

I.	INTRODUCTION	Page 1
II.	EXPERIMENTAL ARRANGEMENTS AND PROCEDURES . . .	Page 2
	A. General.	Page 2
	B. The Donor.	Page 3
	C. The Barrier.	Page 4
	D. The Acceptor	Page 6
	E. Experimental Procedure (Each Trial) . . .	Page 7
	F. Determination of Criterion of Detonation	Page 8
	G. The Bruceton Procedure	Page 8
	H. Miscellaneous Notes.	Page 10
III.	EXPLOSIVES TESTED.	Page 10
IV.	RESULTS AND DISCUSSION	Page 13
V.	CONCLUSIONS AND RECOMMENDATIONS.	Page 19
VI.	REFERENCES	Page 20

RS1K 69-6-1

A MINIAUTORIZED GAP TEST

I. INTRODUCTION

In Reference 1 this laboratory proposed a program for the development of design criteria components and evaluation techniques for explosive systems with minimum dimensions to the Sandia Corporation. The effort proposed in Reference 1 was subdivided into 15 tasks for each of which a separate cost and time estimate was made to simplify the selection by Sandia Corporation of tasks to be performed and ordering thereof. Reference 2 is a contract for the performance of Task 1 as outlined in Reference 1, the description of which is as follows:

Task 1. Standardization of one or more tests similar to the Micro Scale Gap Test, which has been described in Reference 4, whereby the sensitivity of explosives (in terms of peak threshold firing pressure) can be determined for one or more small source sizes.

The purpose of tests such as those described herein and in Reference 4 is to provide a means of selecting explosives for consideration as lead and booster explosives in fuzes of minimum dimensions and of calibrating "Varicomp" explosives for use in assessing the reliability and safety of such fuzes.

Based on the results reported therein, the series of tests described in Reference 4 seems to be a very well controlled experiment. However, subsequent efforts to reproduce

RSLR 69-6-1

these resulted in data so scattered as to be nearly meaningless. A review revealed that the MDF used in the tests reported in References 3 and 4 was very highly reproducible (less than one mil variation in dent in the soft steel block) while material which was available for the later tests (in which the large scatter was observed) varied greatly in output (dents ranging from 3 to 7 mils). For this reason, it was decided to hand load the donors for use in these tests. The donors used were quite similar to miniaturized detonators which have been made by this laboratory, with base charges elongated in an effort to stabilize the detonators "head." In addition to allowing for more control of donor characteristics, this type of donor seems much more similar to miniaturized fuze components which may be developed.

This report includes a description of the experimental arrangement and procedure and results obtained with a number of explosives which might be considered for use in leads or boosters of miniaturized fuzes.

II. EXPERIMENTAL ARRANGEMENTS AND PROCEDURES

General

The experimental arrangement used in these experiments is shown in Figure 1. The donors used were detached electrode electric detonators of the special configuration and loadings shown in Figure 2. For each explosive, an estimated

RSLR 69-6-1

was obtained (using a so-called Bruceton procedure) of the mean threshold value (the 50% point) of the thickness of the aluminum barrier for detonation transfer between the donor and acceptor. The depth of the dent produced in the witness block was used as the criterion of detonation transfer.

The Donor

The donor, as stated above, is a special detached electrode detonator. The details of construction and loading are given in Figure 2. All of the donors used in experiments described herein were loaded from one lot of RDX, Class E, and it was assumed that the density attained with a loading pressure of 30,000 pounds per square inch was reproducible from one to another. It is suggested that, to obtain comparable results, loading pressures used with other lots of Class E RDX should be adjusted to attain the same loading density as that attained by the RDX used in these experiments (1.65 gm/cc). The output, as measured by steel dent tests, ranged from 5 mils to 7 mils with

mild steel witness blocks (Rockwell B80-84) and from 2.7 mils to 3.6 mils with hard witness blocks (Rockwell C48-51).

This variation is somewhat larger than had been hoped for and had there been time, an effort would have been made to reduce it. However, the Naval Ordnance Laboratory⁵ reports a gradual drift in Small Scale Gap Test donor

RSLR 69-6-1

output (corrected to account for hardness variations of witness blocks) from 62 mils when the tests were first standardized to 69 mils recently, and, in addition, standard deviations within some lots of donors of nearly 5 mils. Since this variation has not been accompanied by any significant change in apparent sensitivity of explosive materials nor in standard deviations as large as would be expected, and since the present experiments were subject to stringent time limitations, it was decided to proceed with the tests.

Donors were initiated by means of a condenser discharge between the electrode and the thin stainless strip end closure. The condenser used was a composite of eight 200 microfarad electrolytic condensers and two 1 microfarad paper condensers all in parallel. The discharge was from a voltage of 165 to 170 volts. This discharge supplied many times more energy than necessary for threshold firing.

The Barrier

The barrier used in each trial consisted of four layers of aluminum (alloy 1100-O, soft). In each case the thicknesses of the four layers were selected to give a sum as close as possible to the thickness given for the "decibang" value indicated by the test procedure and the results of previous tests. Table 1 is a list of decibang values in

RSLR 69-6-1

the range used in these tests with the assortments of thicknesses actually used for each decibang value. Based on the transformation function $X = -10 \log G$ where X is the initiation intensity in decibangs and G is the gap in inches. This function and the "decibang" was proposed by Ayres.⁶ Ayres has used the term "gap decibang" (DBg) as the unit of sensitivity as determined by the Small Scale Gap Test.⁶ It is important in order to avoid confusion, to use designations of decibangs which differ depending upon size and other characteristics of the donor, the material of the barrier, and the confinement afforded the acceptor explosive in the particular test used. For this reason, the designation of the decibang as determined by the Micro Scale Gap Test reported in Reference 4 was referred to as pdBg and for sensitivities as determined by the procedure described herein they will be referred to as DBgn. The gap decibang as determined by the Small Scale Gap Test described in Reference 6 has been calibrated and the relationship between the gap decibang (DBg) and the peak shock pressure in kilobars has been determined and reported in Reference 7. This calibration, of course, is not applicable to the gap decibangs (pdBg) determined by the Micro Scale Gap Test⁴ or those (DBgn) determined by the tests described herein. However, the general relationship should be qualitatively similar and a quantitative determination of the relationship would be of value.

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make an interesting project.

For each trial, the laminations were stacked in order of their thicknesses, with the thinnest closest to the acceptor.

The Acceptor

Acceptors were loaded into the Delrin bushing as shown in Figure 3. Delrin was chosen because, since its shock impedance is less than that of any of the explosives which would be expected to be tested, the confinement it would afford the reaction nucleus would be less than that afforded by the surrounding explosive in a larger acceptor specimen. For the experiments discussed herein, each explosive material was loaded at 10,000 pounds per square inch. A few of the materials were also loaded at higher pressures. The use of charges loaded directly into Delrin at pressures of 10,000 and higher resulted in some misgivings regarding the accuracy of density determinations based on the dimensions of the hole and the weight of explosive. To allay such doubts, each explosive was loaded at each pressure used with it in hypodermic needle tubing containers of similar internal dimensions. The hypodermic needle tubing did not expand measurably even when loaded at 40,000 pounds per square inch. Densities given in Table 1 (except those with asterisks) are those determined in the hypodermic needle tubing. Densities of explosives loaded in the Delrin acceptor bodies,

BSIA 69-6-1

determined from weights and preloading cavity volumes, averaged 4% higher for explosives loaded at 10,000 pounds per square inch and 10% higher for those loaded at 40,000 pounds per square inch than the same explosives loaded at the same pressure in hypodermic needle tubing. The density values given in Table 1 with asterisks* were based on values obtained in the Delrin acceptor charge holders with a correction based on the expansion ratios mentioned above.

Experimental Procedure (Each Trial)

To determine the sensitivity of a given explosive, a series of trials was run, each of which was set up with the arrangement shown in Figure 1. The barrier thickness used was determined from previous results in accordance with the Bruceton procedure. The arrangement as shown was assembled as per Figure 1, placed in the firing chamber, the firing chamber closed, electrical connections made, and the donor fired by means of an electrical discharge as described in an earlier paragraph. After firing the donor the remaining components were withdrawn from the test chamber and a measurement made of the depth of the dent produced in the witness block using a dial indicator height gauge. The results of the trial were recorded as either fire or misfire in accordance with the criterion determined for a particular explosive as outlined

RSLR 69-6-1

below. A record was also kept of the depth of each dent produced.

Determination of Criterion of Detonation

For each explosive (loaded at each pressure at which it was to be tested) two trials were performed with the arrangement shown in Figure 1 except that no barrier was used. The depths of the dents produced in these two trials were averaged and the "criterion of fire" used for this combination of explosive and loading pressure was taken as 30% of this average (the "zero gap dent").

The Bruceton Procedure

The so-called "Bruceton" test procedure was used in all tests reported herein. In this procedure, the first trial of a test is performed at one of a series of pre-established sets of conditions or "stops". If a detonation results, the next trial is performed at the adjacent condition or stop in the direction less conducive to detonation. If it misfires, the next trial is performed at the adjacent step in the direction of increasing detonation transfer probability. The test is continued in this manner, the conditions of each trial being determined by the results of the previous trial. Figure 1C is a typical Bruceton data sheet.

Data obtained in a Bruceton test may be analyzed¹² to obtain estimates of the mean (the condition at which 50% will detonate) and standard deviation of the test variable.

and of the errors of these estimates. The validity of these estimates rests on the assumption that the probability of detonation is normally distributed with respect to the test variable or the function thereof used in establishing the series of "steps". Experience⁶ indicates that, for gap tests, as for many other sensitivity tests, steps so chosen that the logarithms of the gap lengths form an arithmetic progression lend as much validity as practically possible to this assumption. The "gap Decibang" (DBg) series proposed by Ayres⁶ and used in the SSGT is such a series for which the transformation function is

$$X = -10 \log G$$

where X is the initiation intensity in Decibangs (DBg) and G is the gap in inches. For the MGT, the same series of gap lengths was adopted, but, to avoid ambiguities resulting from its differences in detailed test conditions from the SSGT, the sensitivity Gap Decibang unit is abbreviated DBgm rather than DBg. An actual test of an explosive for which no previous gap tests on this scale have been performed, it was the usual practice to use larger steps. In a few preliminary ("zeroing in" trials) the results of these trials were not included as part of the Bruceton test for calculation purposes. As is usual in Bruceton analyses, only data obtained after the first reversal between adjacent steps of the actual

Bruceton series were included in the data used in calculations.

Miscellaneous Notes

Preliminary tests of those explosives regarding which there was some doubt as to the applicability of a miniaturized gap test were performed using the arrangement as shown in Figure 1 with a 25 dBgm barrier. Explosives which misfired in these tests were considered to be too insensitive to initiation by a source of these dimensions (Figure 2) to warrant further testing.

In the series of tests described herein, all of the tests of explosives loaded at 10,000 pounds per square inch were performed concurrently, (one trial from one Bruceton test, the next from another) in rotation. This procedure is used to eliminate the effects of any time dependent systematic variables. A similar procedure was used with acceptors loaded at higher pressures.

III. EXPLOSIVES TESTED

Explosives tested included RDX, tetryl, PETN, HMX, PBXN-5, and HNS. Several particle size distributions of some of the explosives were used. The specific lots tested are described below:

RDX (X-178) received from NOL White Oak in 1962 or 1963,

RDX made by the Woolwich nitric acid process (at the Wabash River Ordnance Plant), referred to in MIL-R-398C.

Specification for RDX as RDX Type A, Class A. Particle

ROLR 69-6-1

size analysis at this laboratory indicates that it is Class A, RDX.

RDX (PC-03) received from Picatinny Arsenal in 1967, made at Holston (Lot HOL 821, batch 3043) by Bachman acetic anhydride process, is referred to in MIL-R-398C as RDX, Type B Class C. Particle size analysis indicates that it is Class C, RDX.

RDX (X-177) furnished by NOL/White Oak for general use in connection with work for NOL/Corona. RDX, Type B, Class B.

RDX (CA-1) purchased from Canadian Arsenals Limited (their batch A-911R) in August of 1964. Type B, Class A.

Tetryl (precipitated) tetryl X-436, furnished by NOL/White Oak, precipitated from acetone at the R. Stresau Laboratory in August 1967.

Tetryl. Presumed to be in accordance with MIL-T-00339A, supplied by NOL/White Oak. Identified on bottle as "yellow tetryl". Although no sieve analysis was made, an appreciable fraction was coarse enough to be held on a No. 30 U. S. Standard Sieve.

PETN, T4-1, Class 4 PETN, (MIL-P-387A) made by Trojan Powder Company. Received from Technical Ordnance 10/22/68.

PETN, T2-1, Class 2 PETN, (MIL-P-387A) made by Trojan Powder Company. Received from Technical Ordnance 10/22/68.

PETN, TP-2, PETN, T2-1, precipitated twice from acetone

ASLR 69-6-1

at the R. Stresau Laboratory in October 1968.

HNS-I, HNS X-498, HNS-I, Grade A, NOL Purchase Description WS 5003 D), received from NOL/White Oak, 1966.

HNS-II X-567, HNS-II, Grade B (WS 5003 D), received from NOL/White Oak, in January 1969.

HMX, HE-1, HMX, Grade II, Class E (MIL-4-4544a) received from Honeywell and made by Holston, lot 705-37.

PDXH-5 H-2, received from China Lake 10/68, made by Holston (Batch 1020-9A, lot 95-23).

The following explosives were used in loading the donors;

RDX CE-2, lead azide, and silver azide, a description of which follows.

RDX CE-2, purchased from Canadian Arsenal Limited (their batch E-40) in August 1964. This material is certified to meet the requirements of Military Specification MIL-R-00398C (Ord.), for RDX, Class E. Microscopic examination shows it to be appreciably finer than RDX (X-177), ranging up to about 25 microns.

Silver Azide H-2, received from Hanley, their lot 3770 to 3772

Lead Azide, RD-1333, purchased from Dupont, Batch #2152.

Note. Lot designations with the prefix X- are NOL, White Oak-designations. Other lot designations are those of this laboratory or, where so identified, manufacturers lot numbers.

MSLR 69-6-1

IV. RESULTS AND DISCUSSION

Results of the experiments are given in Table 2. It may be noted that these results are not only different in magnitude but include a number of inversions as compared with the results of the Micro Scale Gap Test given in Table 3. Also the standard deviations are, in general, appreciably greater than those for the same or similar explosives as determined by the Micro Scale Gap Test.

Although the reasons for these discrepancies cannot be stated with any degree of confidence at this time, a detailed consideration of the data suggests a number of factors one of several which may contribute to these differences. As compared with the MDF used as the donor in the Micro Scale Gap Test, the donors used in these tests have appreciably smaller charge diameters and appreciably higher loading densities, although the loading densities are not high enough to compensate for the reduction of charge cross section area (the linear loading density is about 4 grains per foot, for comparison with 5 grains per foot MDF). The thinner walls of the

hypodermic needle tubing cases (as compared with the lead casing of the MDF) combined with the very much higher shock velocity in the stool than in the lead combine to result in a considerably different pressure time profile in the shock wave induced by these donors. As compared with the output of the MDF, the shocks induced by these

RDR 69-6-1

donors as shown in Figure 2 would be expected to have a higher peak pressure, a somewhat flatter top for a shorter time after which the decay would be appreciably more rapid. This difference could account for at least part of the inversions since the pressure time profile of the induced shock wave would be expected to interact with the reaction kinetics of the explosive in determining threshold initiation values.

Another difference between the experiments discussed herein and the Micro Scale Gap Test discussed in Reference 4 is in the choice of criterion of detonation. In the experiments described herein, the criterion used was 80% of the "zero-gap dent" whereas that used in the tests described in Reference 4 was 50% of the "zero-gap dent". The reason for this choice was that the ultimate intended application of these data was for use in reliability estimates and, for such applications, an output near the maximum was considered to be a more appropriate criterion. An examination of the data obtained in many of the tests shows that substantial numbers of the results recorded, for purposes of the Bruceton test, as "misfires" produced dents between 50% and 80% of the "zero-gap dents". There is no doubt that the mean sensitivity values obtained for some of the explosives would have shifted appreciably if the criterion of detonation had been 50% of the "zero-gap dent" and it is quite possible

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that the standard deviations would have been appreciably smaller. It is, of course, possible that at least some of the standard deviations would have been increased if a 50% criterion had been used.

Although the study of particle size effects is another task (Task 3) of Reference 3 than that with which the work reported herein is primarily concerned, the some of the acceptor explosives used were chosen to yield data regarding such effects. Data for RDX, relating miniaturized gas sensitivity to particle size are given in Table 4.

Table 4. Particle Size Effect on Miniaturized Gas Sensitivity of RDX

Lot No.	Approx. Average* Particle Size (Microns)	Threshold Stimulus for Detonation	
		Mean (DBgm)	Std. Dev. (DBgm)
X-177	40 (a)	18.05	0.343
CA-1	135 (b)	20.97	0.750
X-178	166 (b)	21.79	1.980
PC-03	500 (c)	25	---

* Weight basis

(a) from microscopic examination

(b) from sieve analyses

(c) from specification and sieve check

It is of interest to note that both the threshold stimulus intensity and its standard deviation increase with increasing

RSIR 69-6-1

particle size as would be predicted from the considerations discussed in Reference 8. Tetryl and HNS exhibit the same tendency. Neither of the coarser varieties of these materials (HNS-II and "yellow" tetryl) were initiated at the 25 DBgm level, while the finer variety (HNS-I and precipitated tetryl) of each was among the more sensitive of the materials tested (see Table 2). The coarser variety of PETN (T4-1) was also the least sensitive, but the other two were not significantly different. The writer would have expected the precipitated PETN (TP-2) to be appreciably more sensitive and to have a smaller standard deviation than it did (see Table 2). This material was double precipitated for EBM use, in which application it was quite satisfactory. Possibly there is an optimum particle size for maximum sensitivity in any given system and possibly the particle size of PETN, T4-2 is below this optimum for PETN. With the possible exception of PETN, all of the explosives for which such data are available exhibit the predicted⁸ trend toward decreasing sensitivity with increasing particle size.

The apparent effects of loading density upon miniaturized gap sensitivity are interesting. Each of the finely divided explosives exhibits the same trend for which such data was obtained (RDX, X-177, PBXN-5, and HNS-I) toward increasing sensitivity with increasing density, as is generally observed in the NOL standardized small

RSLR 69-6-1

scale gap test⁶ and most other gap tests. The coarser ADX, CA-1, on the other hand, seems to reverse this trend (although the apparent reversal is of marginal statistical significance). Assuming the reversal to be real, it may be attributable to the crushing of the large particles at high loading pressures, resulting in an increase in sensitivity due to the particle size effect discussed in the paragraph above.

As Hampton⁹ has shown, estimates of standard deviations, obtained by means of small sample Bruceton tests, vary substantially, even when the same sample is used, due to the order in which individual specimens are selected. For this reason, not too much significance should be attached to individual estimates of standard deviations given in Table 2. For example, the extremely small standard deviation obtained with the PETN, T4-1, could very well be the completely fortuitous result of the sampling and order of selection which happened to be used in that particular test. However, the general tendency for the coarser materials to have larger standard deviations than the finer materials, as well as the generally larger standard deviations obtained in these tests as compared with the Micro Scale Gap Tests, appear to be quite real. The large standard deviations of the coarser materials is not surprising in view of the fact,

RSLR 69-6-1

that their particle sizes are of the same order of magnitude as the size of the reaction nucleus induced by a donor of the size used in these experiments.

It is possible that the larger standard deviation obtained in the tests reported herein as compared with those obtained in the Micro Scale Gap Test reported in Reference 4 are the result of the difference in pressure time profiles of the output of the donors used in the two tests. It is also possible that it is the result of the larger variability in output which has been noted in an earlier paragraph. Further experimentation may indicate a means of reducing this variation.

As may be noted (Figure 2) the donors used in these tests are quite simple electric detonators in which hypodermic needle tubing is used as the case. The particular size used (18 gauge) was chosen because it is the size which has been used for a number of miniaturized detonators by this laboratory. 10, 11 The general test arrangement

and procedure is, of course, readily adaptable for use with other sizes of hypodermic needle tubing which is

available with inside diameters ranging from 0.004 inch

(32 or 33 gauge) to 0.173 inch (6 gauge). Some difficulties

might be anticipated in loading of the smaller sizes

(regarding which practical interest is somewhat doubtful

anyway). In connection with the acquisition of data

RSIR 69-6-1

for the design of miniaturized explosive trains, a series of tests of this kind would be useful in assessing the interaction of such variables as composition, particle size, and loading density with donor diameters upon detonation transfer probabilities. The techniques described herein would be directly applicable to such studies.

V. CONCLUSIONS AND RECOMMENDATIONS

The Miniaturized Gap Test described herein provides a means for evaluating the sensitivity of explosives to initiation by means of sources of small diameters. As compared with the Micro Scale Gap Test described in Reference 4, it has the advantages of closer simulation of miniaturized fuze explosive components and of greater flexibility in the choice of donor charge dimensions, explosives, and loading conditions. Its precision, as indicated by the standard deviations described herein, is somewhat poorer than that which was obtained in the Micro Scale Gap Test described in Reference 4.

The data reported herein indicate that susceptibility to initiation by small sources is reduced with increasing particle size of the explosive as predicted in Reference 8.

It is recommended that the procedure be further defined

and applied to the study of the interaction of donor the inspection of

dimensions with acceptor explosive particle size, explosive particle size

composition, and loading density and that the data so

RCLR 69-6-1

obtained be applied in the development of miniaturized explosive systems.

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RSLR 69-6-1

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Table 1. Barriers Used in Miniaturized Gap Test
(1100-O Aluminum)

Decibang Values (DBgn)	Thicknesses (Mils)	Layer Thicknesses Used (Mils)			
15 1/2	28.0	2.0	2.0	12.0	12.0
15 3/4	26.5	0.7	0.8	10.0	16.0
16	25.0	3.0	6.0	8.0	8.0
16 1/4	23.5	0.7	0.8	10.0	12.0
16 1/2	22.0	3.0	3.0	8.0	8.0
16 3/4	21.0	2.0	3.0	8.0	8.0
17	20.0	2.0	2.0	8.0	8.0
17 1/4	18.5	0.7	0.8	5.0	12.0
17 1/2	17.8	0.8	3.0	6.0	8.0
17 3/4	16.8	0.8	2.0	6.0	8.0
18	15.8	0.8	5.0	5.0	5.0
18 1/4	14.9	0.8	1.1	5.0	8.0
18 1/2	14.0	2.0	2.0	2.0	8.0
18 3/4	13.3	1.1	1.1	3.0	8.0
19	12.6	0.8	0.8	3.0	8.0
19 1/4	11.8	0.8	2.0	3.0	6.0
19 1/2	11.2	1.1	1.1	3.0	6.0
19 3/4	10.6	0.7	1.0	1.0	8.0
20	10.0	1.0	3.0	3.0	3.0
20 1/4	9.4	0.7	0.7	2.0	6.0
20 1/2	8.9	2.0	2.0	2.0	3.0
20 3/4	8.4	1.1	1.1	3.0	3.0
21	7.9	0.8	1.0	3.0	3.0
21 1/4	7.5	0.7	0.7	3.0	3.0
21 1/2	7.1	0.7	0.7	0.7	5.0
21 3/4	6.7	0.7	2.0	2.0	2.0
22	6.3	0.7	0.7	2.0	3.0
22 1/4	5.9	0.8	1.0	2.0	2.0
22 1/2	5.6	0.7	1.0	2.0	2.0
22 3/4	5.3	1.1	1.1	1.1	2.0
23	5.0	1.0	1.0	1.0	2.0
23 1/4	4.7	0.7	1.0	1.0	2.0
23 1/2	4.5	1.1	1.1	1.1	1.1
23 3/4	4.2	1.0	1.0	1.1	1.1
24	4.0	1.0	1.0	1.0	1.0
25	3.2	0.8	0.8	0.8	0.8

Table 2. Miniaturized Gap Test

Explosive Used	Loading Pressure kpsi	Density g/cm ³	Dent in Witness block at 0 Gap	Threshold Stimulus for detonations (DBgm)			
				Mean	Std dev	Max dev of mean (at 95% Conf)	Max dev of dev
RDX X-177	10	1.47	0.0095	18.05	0.3425	0.192	0.310
RDX X-177	20	1.59	0.016	18.55	0.3370	0.190	0.267
RDX X-177	40	1.65	0.011	19.075	0.657	0.3474	0.732
RDX CA-1	10	1.53*	0.011	20.975	0.750	0.401	0.900
RDX CA-1	20	1.64*	0.015	20.375	1.010	0.621	1.59
RDX CA-1	40	1.71	0.013	19.50	2.520	1.862*	6.120*
RDX X-178	10	1.58	0.0095	21.792	1.98	1.105*	3.442*
RDX PG-03	10			>25.00			
PEXN-5 H-2	10		0.0105	17.375	1.21	0.76	2.075
PEXN-5 H-2	30	1.56	0.0135	18.350	0.2125	0.126	0.1647
HMX HE-1	10	1.40	0.009	16.00	0.595	0.320	0.644
HNS-I (X-498)	10	1.39	0.007	17.903	0.406	0.240	0.406
HNS-I (X-498)	30	1.53	0.0076	18.514	0.825	0.471	1.10
HNS-II	10			>25.00			
Tetryl (yellow)	10			>25.00			
Tetryl (PMT)	10	1.57	0.0095	17.84	0.406	0.241	0.406
PETN TP-2	10	1.48*	0.011	18.264	1.181	0.609	1.85
PETN T4-1	10	1.62	0.0115	19.35	0.2125	0.126	0.1647
PETN T2-1	10	1.55*	0.0105	18.0175	3.175	2.08*	7.00*

* Approximations

Table 3. Revised Micro Scale Gap Test Results.
(From Reference 4)

Explosive ^a Used	Mean sensitivity pdBg ^b	Std. dev. pdBg	Max dev of mean at 95% Conf	Max dev of mean at 95% Conf
RDX (Class E) X-177 ^c	17.153	0.073	0.0728	0.0387
RDX (Class B) CE-2 ^d	17.275	0.095	0.0688	0.104
PETN (precipitated)	17.575	0.152	0.0525	0.096
RDX (270-325 mesh)	17.791	0.100	0.077	0.105
SPX-2	17.90	0.075	0.0672	0.0408
HNS-I	19.25	0.197	0.119	0.150
Tetryl (precipitated)	19.575	0.152	0.0963	0.161
SPH ^e	20.30	0.250	0.145	0.199
HNS-II	infinity ^f			

^aAll explosives were dried for two days at 160°F, loaded at 10,000 lb/in.²

^bSee Table 4 for barrier thickness.

^cRDX (X-177) was furnished by NOL, White Oak for general use in connection with work for the Corona Laboratories. RDX, Type B, Class E.

^dRDX (CE-2) was purchased from Canadian Arsenals Limited in August 1964, and meets MIL-R-60398C (Ord.)

^eSPH = SPX-2 with HNS instead of RDX

^fCould not be fired with any barrier

RSLR 69-6-1

Miniaturized Gap Test

RSIR 69-6-1

Figure 2

RSLR 69-6-1

Material - Delrin

Firing Pin Holder

Figure 3

RSLA 69-6-1

Material - Delrin

Donor Support Bushing

Figure 4

RSL 69-6-1

Material - Delrin

Acceptor Holder

Figure 5

Steel Phonograph Needle

Figure 6

RSLR 69-6-1

Steel Witness Block

Figure 7

RSIR 69-6-1

Brass Connector

RSIR 69-6-1

Polyethylene tubing

Figure 9

Typical Bruceton Data Sheet

Date 3 June 1969

BRUCETON DATA SHEET No. 1

Type of Test Miniaturized Cap Test Item Dwg No. 1

Variable Aluminum Barriers Step Size 1/4 DBgm

Criterion of Fire Dent 80% of Dent at C Gap

Bridgewire Material _____ Dia. _____

Explosives

Flash Charge Silver Azide Base Charge ^{Lead}Azide Donor CE-2 acc. PBXN-5

Charge Dia. or Other Size _____ 0.275 0.1 Dia
Flash Charge 0.025 long Base Charge 0.1 long Donor long Acc. 0.250 long

Loading Pressure or Density

Flash Charge 100 k Base Charge 30 k Donor 30 k Acc. 30 k

Dipn	Barricade Thickness in Miles
19	12.6
18 3/4	13.3
18 1/2	14.0
18 1/4	14.9
18	15.8