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# HIGH EXPLOSIVE EQUIVALENCY TESTS OF ROCKET MOTORS

by

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ABSTRACT. From November 1964 to 19 March 1965 seven solid propellant motor hazard tests and two high explosive calibration tests were conducted at the U. S. Naval Ordnance Test Station, China Lake, California. The primary purpose of the tests was to assess the blast yield of two classes of solid propellant material, when subjected to severe explosive shock, and to compare the propellant blast yields to those produced by a standard explosive. The following yields, in percent of TNT equivalency by weight, were determined from overpressure and impulse data from a blast gage array: The highest yield of class 2 propellants tested alone approximated 40%; class 7 propellants tested alone produced well over 100%; and a combination of equal amounts of each class produced approximately 100%. The quantity and dispersion of fragments varied widely with the propellants used and with the test configuration.

Additional tests are planned using different motor configurations, different propellants, and varying explosive stimuli.

U.S. NAVAL ORDNANCE TEST STATION

China Lake, California

November 1965

U. S. NAVAL ORDNANCE TEST STATION

AN ACTIVITY OF THE BUREAU OF NAVAL WEAPONS

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## FOREWORD

This report documents results from the initial seven tests in a continuing series of experiments planned to investigate the blast yield of solid propellant motors. Blast yields from the seven motor tests are related to those produced by common explosives, TNT, and Composition B, to arrive at high explosive equivalency values for the propellants investigated.

The tests were conducted during the period November 1964 to March 1965 for the Armed Services Explosives Safety Board (ASESB). The primary funding was provided by the National Aeronautics and Space Administration (NASA) under Work Request W-11543B-Am. 1 and Local Project Number 965.

Supplemental funding was provided through the Dividing Wall program, which is supported by funds from the three Military Departments and from the Defense Atomic Support Agency (DASA). The Dividing Wall program is currently identified as Task Assignment RMMO-62061/216-1/F008-11-05 and Local Project No. 556.

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# SECURITY MARKING

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ACKNOWLEDGMENT

Constructive comments in test planning and report preparation have been received from members of the staff of ASESB. Will Filler of the Naval Ordnance Laboratory, White Oak, has provided valuable suggestions relating to the technical aspects of the report.

## INTRODUCTION

This report presents an interim summary of data presently available from a continuing series of solid propellant motor hazard tests. The tests are being conducted at the U. S. Naval Ordnance Test Station (NOTS), China Lake, California, under the auspices of the Armed Services Explosives Safety Board (ASESB), with funds provided primarily by the National Aeronautics and Space Administration (NASA). The motors tested were provided by the Bureau of Naval Weapons, Special Projects Office.

The seven motor tests and two calibration high-explosive tests described in this report were conducted from 5 November 1964 through 19 March 1965. The purpose of the tests was to assess the blast yield of two classes of solid propellant material, when subjected to severe explosive shock, and to compare the propellant blast yields to those produced by standard explosives.

## DESCRIPTION OF TESTS

### MOTOR TESTS

One class 2 motor was used in Test No. 1, and one class 7 motor was used in Test No. 2. A primary objective of the two tests was to determine the blast yield of large solid propellant motors when subjected to the severe stimulus of the detonation of a high explosive primer in intimate contact with the propellant grain. The priming explosive consisted of 96 lb of Composition C-4 placed in the grain perforation, with an electric detonator embedded in each end of the priming charge.

Two motors (one class 2 and one class 7) were used in each of the next three tests. Only the motor containing class 7 propellant was primed; the stimulus to the class 2 motor was provided by the explosion of the class 7 donor motor. Tests 3 and 4 were identical, with the motors placed side-by-side in a horizontal attitude; in Test 5, the class 7 motor was placed on top of the class 2 motor, with both motors in a vertical position.

The test setup for Test No. 6 was the same as for Tests 3 and 4, except that two class 2 motors (each primed with 96 lb of C-4) were used. The seventh test configuration was like that of Test 5; i.e., a class 7 motor was placed on top of the class 2 motor; however, the priming agent used in this test was a 100-lb spherical charge of cyclotol placed on top of the class 7 motor.

Figure 1 shows the test configurations used in each of the seven motor tests.

## CALIBRATION FIRINGS WITH HIGH EXPLOSIVE

### Calibration Test A

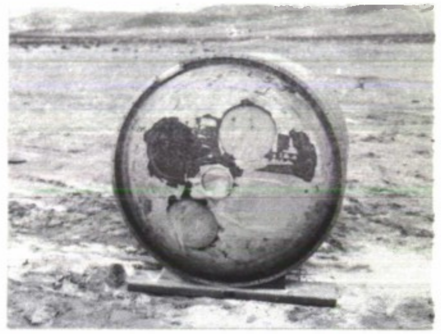
The common explosive, Composition B, was employed for this test. The Comp B was in cast form and contained in cubical metal cans. Each container and its contents weighed $47\frac{1}{2}$ pounds. The cans were arranged in a configuration approximating that of two test motors, side-by-side, as in Tests 3 and 4. The explosive configuration measured 81 inches by 56 inches in plan form and was 36 inches high. Two cans were removed from the main group and stacked on top to make room for the two 40-lb booster charges that were inserted, one in either side of the stack. Each booster charge was equipped with two electric blasting caps, all four of which were fired simultaneously.

### Calibration Test B

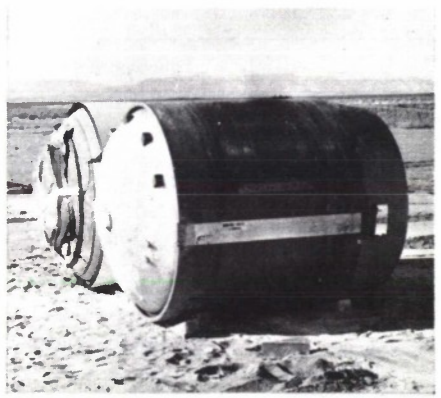
In this test, flaked TNT was placed in a braced wooden structure of octagonal cross section. The length-to-diameter ratio of the explosive charge approximated that of a single motor of the types employed in the motor tests. The main axis of the charge was horizontal, and the bottom of the charge was separated from the ground plane by the thickness of the container floor--about four inches. Priming was accomplished with 96 lb of C-4 contained in a 6x6-inch wooden box that extended from one end to the other at the main axis of the TNT package. The C-4 explosive was detonated by two electric detonators, one at each end of the priming charge. Because the flaked TNT was considerably less dense than were the propellants in the motors tested, and also because of the weight difference, the volume of the TNT charge was substantially greater than that of a single motor.

Test configurations used for the two calibration tests are shown in Fig. 2.

Test Motor in Place for Test 1.

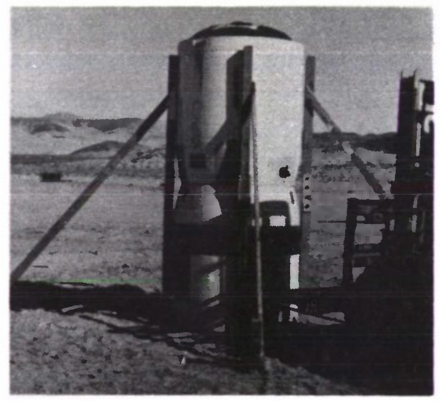


Aft End of Motor Before Installation of Priming Charge, Test 2.

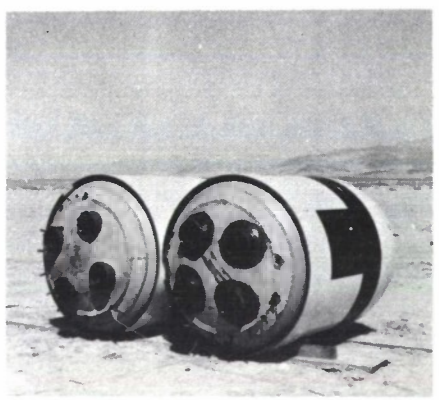


Configuration for Test 3 (Class 7 Donor Motor in Foreground).

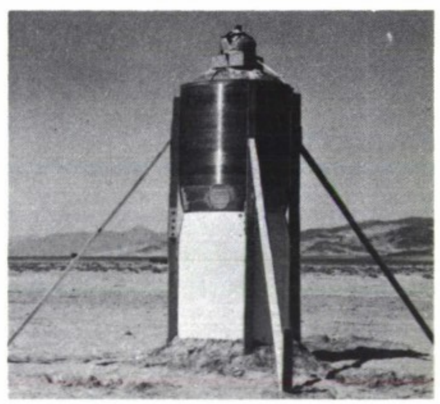
Motors in Place for Test 4. Note absense of aft bulkhead on acceptor motor.



Motors Being Prepared for Test 5. Class 7 donor motor on top.

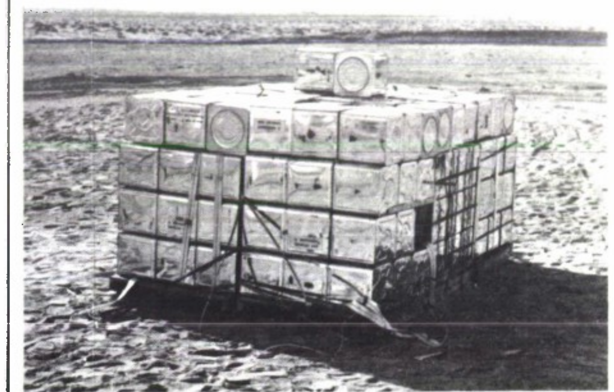


Two Class 2 Motors in Place for Test 6.



Test 7 Configuration Showing 100 lb Spherical Primer Charge on Top.

FIG. 1. Montage Showing Motors in Place for Tests 1 Through 7.



Comp B Stacked for Calibration A Test. Two cans were placed on top to make room for C-4 primers, placed one in either end of configuration. (Total explosive weight: 10,260 lb, total primer weight: 80 lb).

Wood Container Being Loaded With 10,650 lb of TNT and 96 lb of C-4 for Calibration B Firing

FIG. 2. Test Configurations Used in Calibration Firings A and B.

Test parameters for both the motor and calibration tests are summarized below:

| Motor test number | Number of motors tested | Class 2 motors | | Class 7 motors | | Test date | NOTS Experiment Specification Number |
|---|---|---|---|---|---|---|---|
| | | Number | Prop. wt. | Number | Prop. wt. | | |
| 1 | 1 | 1 | 7,250 | 0 | 0 | 5 Nov 64 | 4259 |
| 2 | 1 | 0 | 0 | 1 | 7,360 | 16 Nov 64 | 4260 |
| 3 | 2 | 1 | 7,250 | 1 | 7,360 | 18 Nov 64 | 4261-1 |
| 4 | 2 | 1 | 7,250 | 1 | 7,360 | 20 Nov 64 | 4261-2 |
| 5 | 2 | 1 | 7,250 | 1 | 7,360 | 8 Jan 65 | 5001 |
| 6 | 2 | 2 | 14,500 | 0 | 0 | 16 Mar 65 | 5058 |
| 7 | 2 | 1 | 7,250 | 1 | 7,360 | 17 Mar 65 | 5065 |

| Calibration test | Explosives | Test date | NOTS ES number |
|---|---|---|---|
| A | 10,260 lb Comp. B & 80 lb C-4 | 25 Nov 64 | 4262 |
| B | 10,650 lb TNT & 96 lb C-4 | 19 Mar 65 | 5064 |

## TEST INSTRUMENTATION

### Blast Gages

Three different types of blast gages were used to measure overpressure-time history: Ballistics Research Laboratory (BRL) mechanical PHS gages, BRL mechanical PNS gages, and Kistler piezoelectric gages. The blast-measuring instruments were deployed on two radial lines at right angles to each other, as shown in the diagram in Fig. 3. Because of the differences in response times, the Kistler gages were placed relatively close in, PNS gages were located at mid-positions, and PHS gages were used in the more distant locations. The table below lists the gages and their positions; however, all gages were not used in all tests.

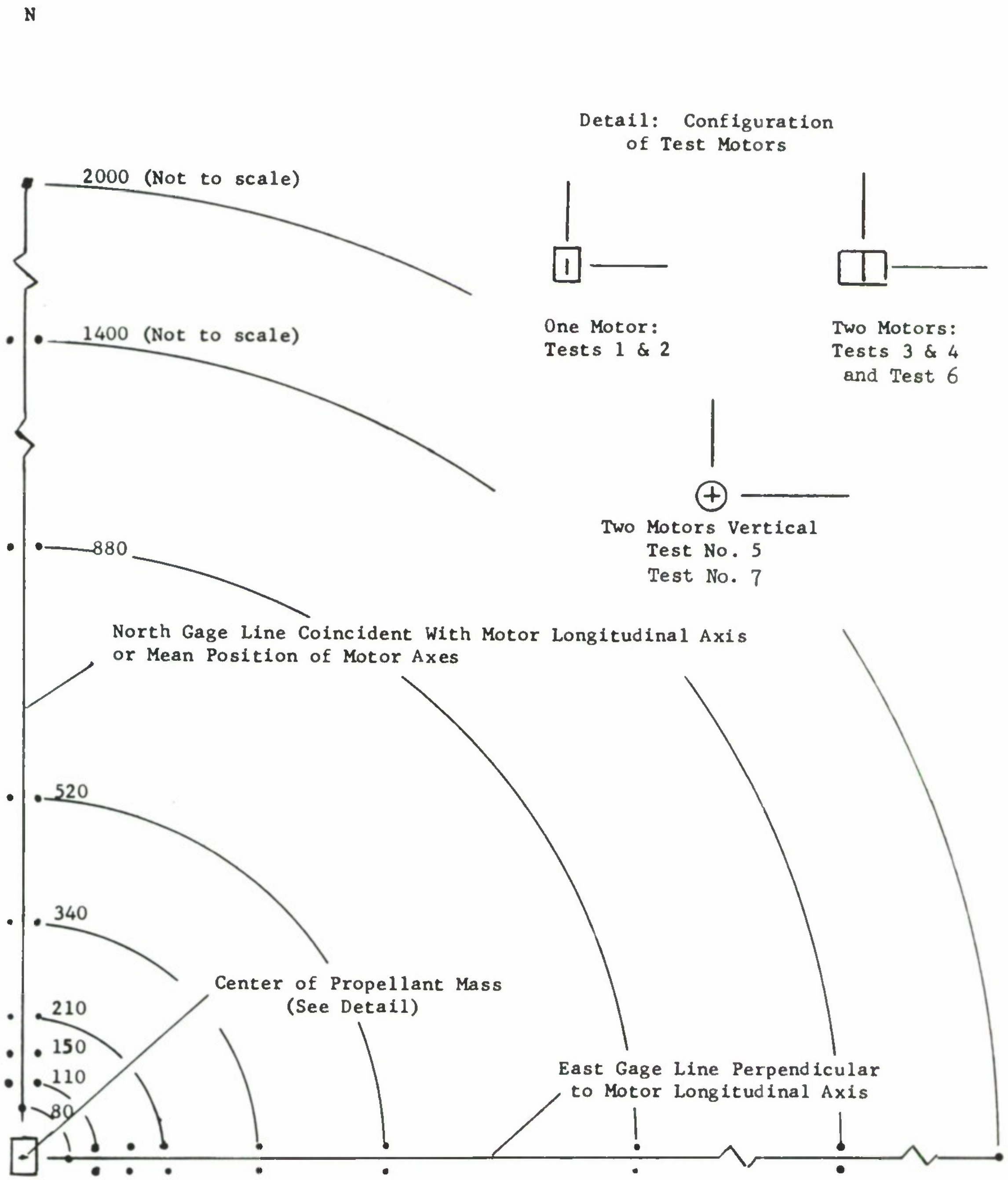



FIG. 3. Overpressure Gage Layout for Motor Hazard Tests Using 1 or 2 Motors Per Test.

| Nominal pressure region (psi) | R gage distance from center of mass (ft) | Gage type (1) and nominal pressure rating (2) for each gage line | | | |
|---|---|---|---|---|---|
| | | Line North | | Line East | |
| | | Gage A | Gage B | Gage C | Gage D |
| 64 | 80 | K | None | K | None |
| 32 | 110 | K | P-50 | K | None |
| 16 | 150 | K | P-25 | K | None |
| 8 | 210 | P-10 | B-15 | P-10 | B-15 |
| 4 | 340 | B-5 | B-5 | P-5 | B-15 |
| 2 | 520 | B-5 | B-5 | B-5 | B-5 |
| 1 | 880 | B-1 | B-5 | P-2 | B-5 |
| 0.5 | 1,400 | B-0.5 | B-1 | B-0.5 | B-1 |
| 0.3 | 2,000 | B-0.5 | None | B-0.5 | None |

NOTE: (1) B = Ballistics Research Lab, PHS type gage
P = Ballistics Research Lab, PNS type gage
K = Kistler piezoelectric gage

(2) Ballistics Research Lab gages yield reliable data to double their nominal pressure rating.

## Optical Instrumentation

Both motion-picture and still cameras (ranging in size from 16mm to 4x5-inch and operating at various frame rates) were used to record fire-ball growth and fragment travel. The 4x5 cameras all used infrared film and long exposure times--from 15 to 20 seconds. The frame rates employed with the motion picture cameras ranged from 30 to 8000 frames per second. In general, photographic coverage was from two directions: one along a continuation of the test motor centerline and the other at right angles to the first.

## Fragment Search Procedures

Prior to the first test, the test site was divided into search areas as shown in Fig. 4, and as propellant fragments were collected, they were identified with the area in which they were found. After the first three tests, however, it became apparent that an attempt to recover all fragments from a large area was extremely time-consuming and expen-sive. Therefore, for the remaining tests, small plots, considered to be representative of larger areas in the same sector at the same distance from ground zero, were selected and marked off (Figs. 5 and 6) for detailed fragment search. (For detailed description of plots, see page 16.)

The data shown in Figs. 4, 5, and 6 are further discussed under Test 1, 4, and 5 results, pages 10 and 16.

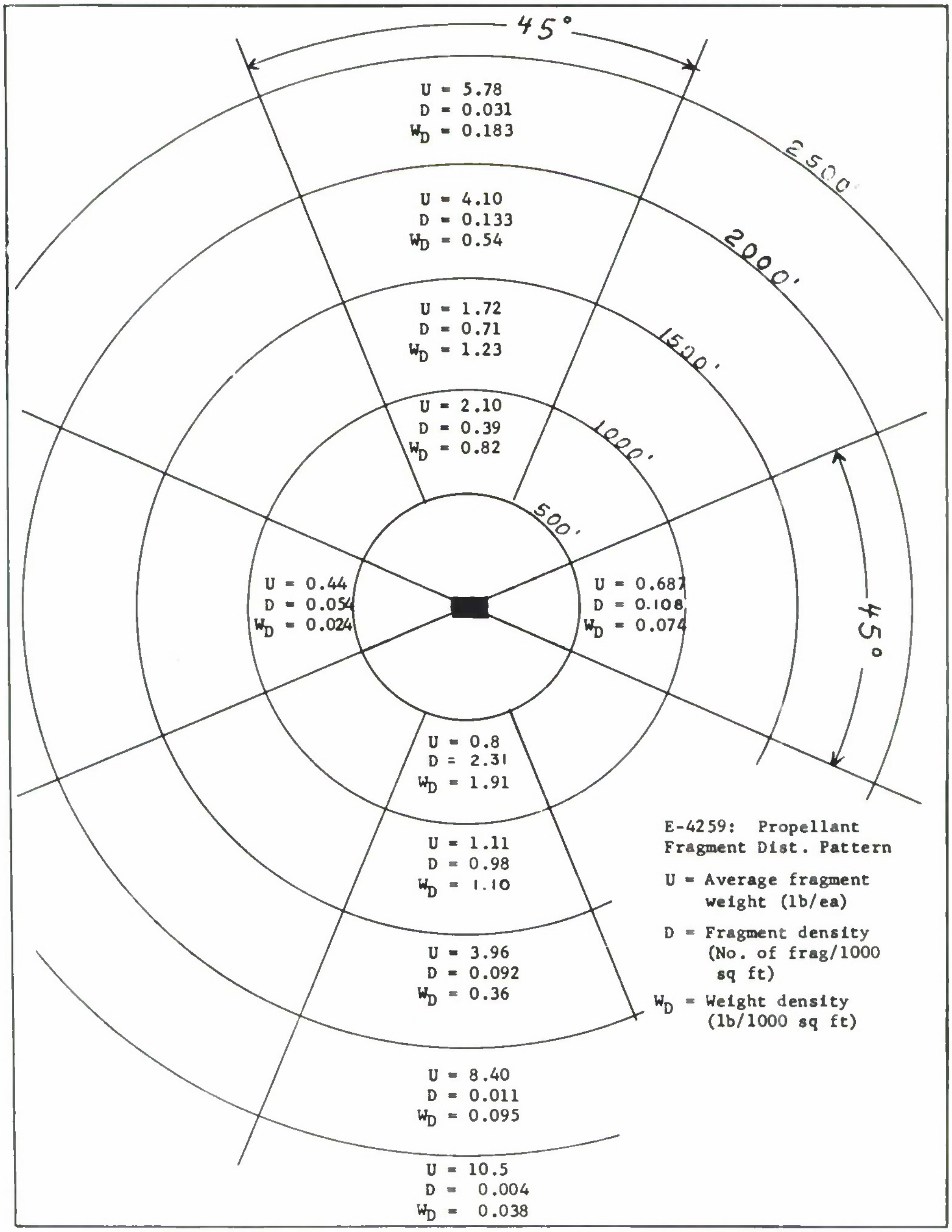



FIG. 4. Fragment Distribution, Test No. 1.

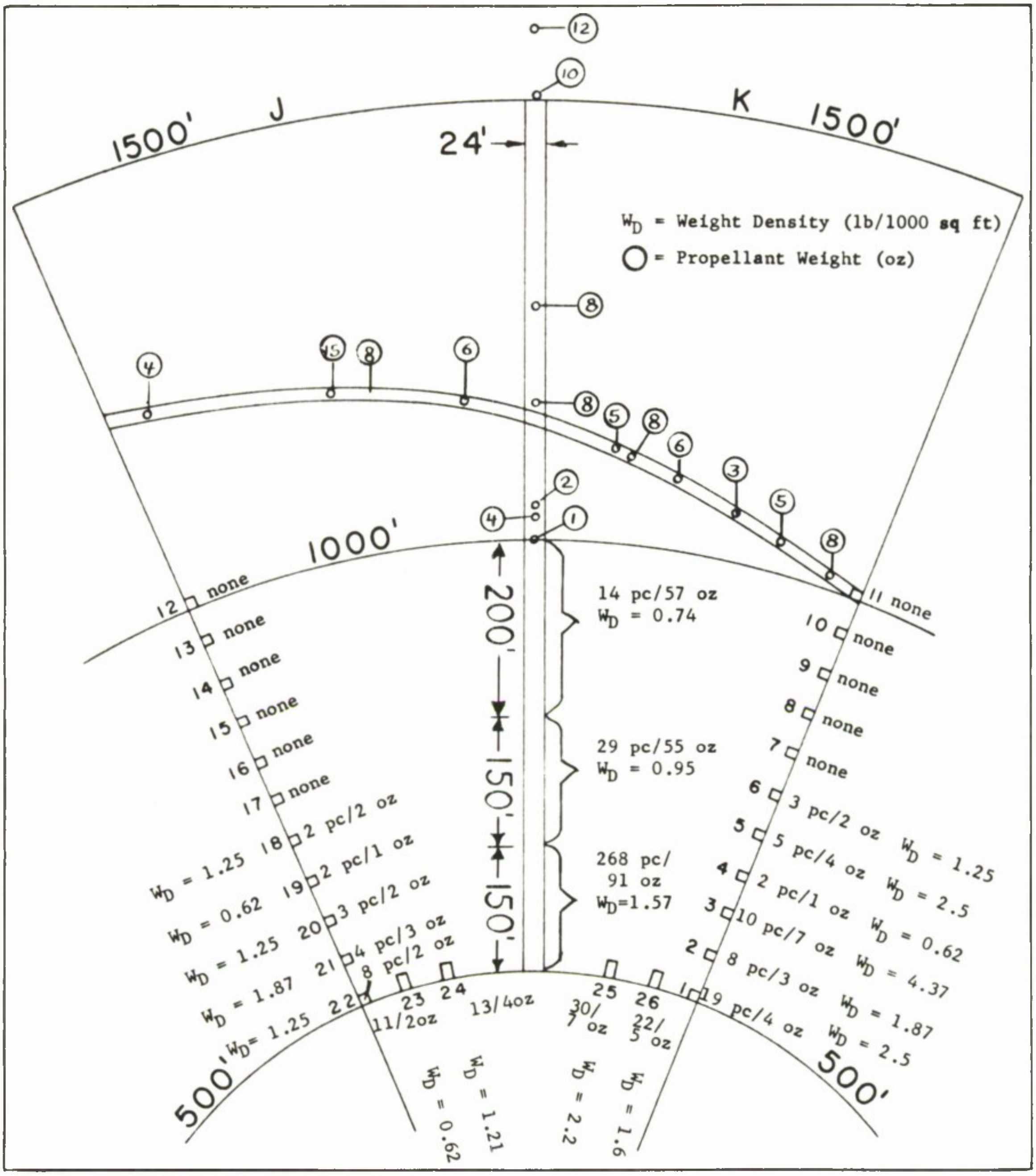



FIG. 5. Propellant Fragment Dispersion on Preselected Plots, Test No. 4.

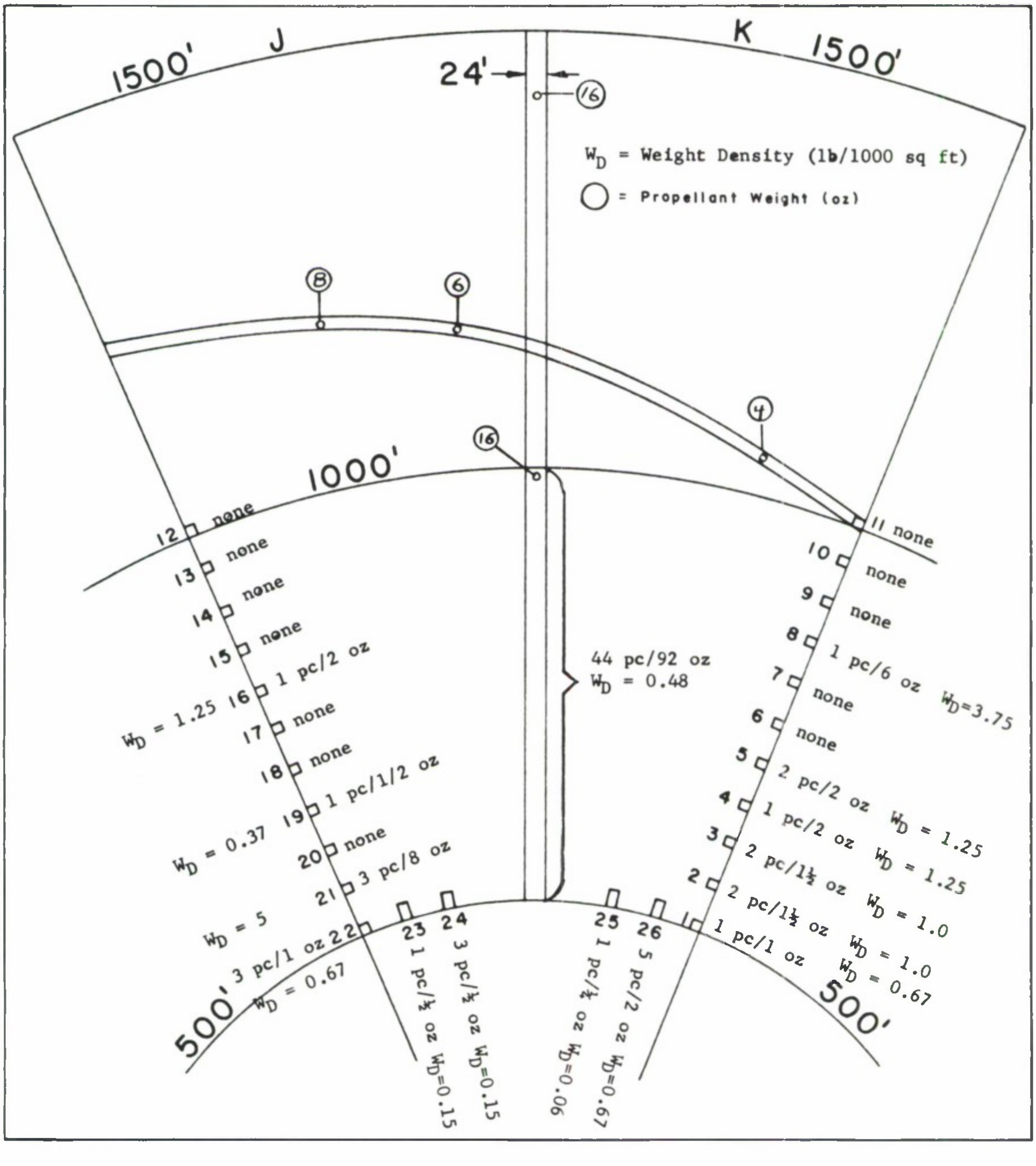



FIG. 6. Propellant Fragment Dispersion on Preselected Plots, Test No. 5.

# TEST RESULTS

## SUMMARY

The largest fragments were produced in the first test, in which one class 2 motor was primed and exploded. In all tests, a small number of fragments (possibly 10% of the total) were burning as they traveled through the air and continued to burn on the ground. In general, larger fragments traveled farther than smaller ones. In Tests 1, 3, and 4, in which the class 2 motors were placed on the ground in a horizontal position, most fragments were thrown out at right angles to the motor axis, while smaller and fewer fragments were thrown out at the ends--in the direction of the motor axis. Since very few inert fragments large enough to be a significant hazard were recovered from any of the tests, they were disregarded.

Summaries of conditions associated with each test are presented in the Appendix to this report.

## Test No. 1

The single class 2 propellant motor, primed with 96 lb of C-4 for this test, exploded without much violence and produced a crater that measured 3 ft deep and 13 ft across. Fragments of motor propellant were thrown out to 3,000 ft on either side of the test motor and, to a lesser degree, into the two sectors at either end of the motor.

The area inside the 500-ft circle shown in Fig. 4 was saturated with numerous small fragments. Since this area was also subjected to severe blast pressure, these fragments were not considered as primary hazards and no attempt was made to plot the fragment densities in this region. Since primary concern was with the larger fragments, and with those that were thrown farthest, many small fragments (less than 1/2 pound) were ignored. As a result, the fragment density values shown in Fig. 4 are lower than the actual densities that were present--especially at close range, where the small fragments were most numerous.

It is reasonably certain that in the four 45-degree sectors searched, no large fragments at distances beyond 500 ft were overlooked, and distance values are considered accurate to ±50 feet. Figures 7-11 are views of the test site taken during and after the explosion.

LHL 108915

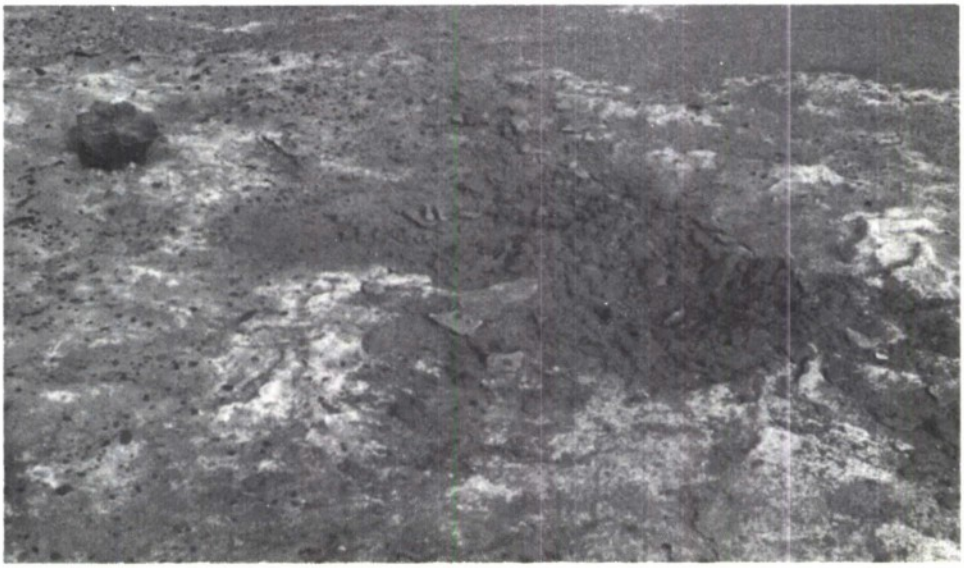
FIG. 7. Aerial View of Test No. 1 at Time of Explosion.

LHL 108916

FIG. 8. Aerial View of Test No. 1 Approximately 5 Seconds After the Explosion Showing Burning Fragments of Propellant in the Air.

LHL 099280

FIG. 9. Crater Formed by Test No. 1.



LHL 108913

FIG. 10. Test Site After Test No. 1. Unburned class 2 propellant is shown at upper left; impact position is shown at left center.

LHL 108914

FIG. 11. Residue of Class 2 Propellant
After Burning on Ground, Test No. 1.

Test No. 2

The second test also involved only one motor--a class 7--which produced a sharp explosion, with attendant high pressure readings, and carved out a crater 7 ft deep and 36 ft across. Essentially, all of the propellant contributed to the explosive effects. No propellant fragments were found, and only a few firebrands can be seen in the test pictures. Figures 12 and 13 show the test site after the explosion.

LHL 099678

FIG. 12. Crater Formed by Test No. 2.

LHL 099680

FIG. 13. Crack in Ground Surface
Near Crater Formed by Test No. 2.

## Tests 3 and 4

These two test setups were identical, and the results were very similar. In each test, one class 7 motor and one class 2 motor were placed side-by-side on the ground. The class 7 (donor) motor, which was primed with 96 lb of C-4, exploded completely leaving no propellant fragments, while the class 2 (acceptor) motor produced both burning fragments and scraps of unburned propellant.

In each test, the fragments were smaller and less numerous than those observed in Test No. 1. Maximum fragment travel was only 1,650 feet. A 3-lb fragment was recovered at this distance after Test No. 3. None of the other fragments recovered after either test weighed over 3/4 pound. Each explosion produced a crater measuring about 10 ft deep and 52 ft across. Two views of the crater produced by Test No. 3 are shown in Figs. 14 and 15.

In Test No. 4, fragments were collected from small discrete plots (see Fig. 5). Each of the square plots encompassed 100 sq ft of area, while the rectangular plots contained 200 square feet. The cleared diagonal path was 12 ft wide, and the radial path on the centerline was 24 ft wide. In those areas where the fragments were larger and less numerous (beyond 1,000 ft), individual fragments were plotted. Fragment densities $W_D$ (weight of recovered propellant per 1,000 sq ft of area) are listed for each individual plot and for several sections of the cleared paths.

The number of fragments recovered and the total weight of propellant recovered are also listed for each plot and for three sections of the cleared radial path.

This fragment collection scheme was used for the two $22\frac{1}{2}$-degree sectors on one side of the test motors only. Photographs taken during the two tests indicated that this region (i.e., on the open side of the class 2 motor) received the heaviest concentration of fragments.

## Test No. 5

The fifth test also involved two motors--one class 7 and one class 2. However, for this test, the motors were in a vertical position, one on top of the other. The top motor was the class 7, which was primed with 96 lb of Comp C-4. Test results were similar to those obtained in Tests 3 and 4, although fewer and smaller fragments were recovered, probably because of the difference in placement of the motors.

Once again, fragments were collected only from the discrete plots shown in Fig. 6. The test configuration favored a symmetrical fragment dispersal and, as expected, the collection plots produced fewer fragments

LHL 099443

FIG. 14. Side View of Crater Formed by Test No. 3.

LHL 099442

FIG. 15. Top View of Crater Formed by Test No. 3.

than were recorded for either of the two previous tests. In general, the fragments were not thrown quite so far. The largest fragment of unburned propellant recovered was one pound, and the maximum distance traveled was 1,500 ft from ground zero.

The motor placement also accounted for the crater configuration--which was much shallower, but had a larger diameter than those produced by Tests 3 and 4. The crater was saucer-shaped with a small conical hole at the center. The deepest point at the bottom of the cone was five feet; average depth, exclusive of the cone, was two feet; and the diameter was 60 feet.

Test No. 6

Two class 2 motors, each primed with 96 lb of C-4, were placed side-by-side for this test. Unburned propellant fragments ranging up to eight pounds were found, and maximum fragment throw was 2,300 feet. The fragment recovered at this distance weighed $2\frac{1}{2}$ pounds. Average crater diameter was 20 feet, rim-to-rim.

Test No. 7

This test setup was identical to that for Test No. 5 except that the primer was a 100-lb spherical charge of cyclotol placed on top of the class 7 motor. Small fragments of propellant were thrown out to 1,500 ft, or more, in all directions. The average rim-to-rim crater diameter was 60 feet.

Calibration Test A

The 10,260 lb of Comp B used in this test was primed with 80 lb of C-4 and produced two distinct shockwaves. The explosion produced a crater that measured 9 ft deep and 52 ft across.

Calibration Test B

This test, in which 10,650 lb of TNT was placed in a wooden container and primed with a 96-lb charge of C-4, produced a large fireball and blackened the ground to a distance of 150 ft outward in all directions. The average crater diameter was 30 feet. Observers at 3,000 ft, and beyond, reported that the sound of the explosion was less 'sharp' than that produced by the Comp B calibration firing and the motor firings involving class 7 motors.

## ANALYSIS OF BLAST GAGE DATA

The analytical approaches used to compute high explosive equivalency weight for the motor tests are described below; tabulations of blast gage data and derived blast parameters are presented in Tables 1-9.

### COMPARISON WITH PUBLISHED DATA

BRL Memorandum Report No. 1518, Peak Overpressure Versus Scaled Distances for TNT Surface Bursts (April 1964), shows graphical and tabulated data covering results of overpressure measurement in connection with the surface firing of 20- and 100-ton hemispherical TNT charges. Using data from Report 1518 as a reference, yields for the seven motor tests were derived from peak pressure based on the following:

$$W = Wo \frac{p_z}{p_o} \left(\frac{R}{\lambda_1}\right)^3 \text{ (see footnote)}$$

where

$W$ = yield in lb of TNT

$Wo$ = 1 lb of TNT

$p_z$ = ambient air pressure

$p_o$ = standard sea level air pressure 1013 mb

$R$ = distance from center of charge to gage

$\lambda_1$ = scaled distance determined by the ratio:

$$\frac{\text{recorded overpressure}}{\text{ambient pressure}} \text{ (as tabulated in Report 1518)}$$

In application, values of $R/\lambda_1$ were computed for each gage distance for each test, using averaged values of overpressures from all gages at that distance. Values of $R/\lambda_1$ are directly related to $W^{1/3}$ and should, therefore, be of similar magnitude at each gage distance, if the function of overpressure-versus-scaled distance parallels that derived by

*In making the computations, the ratio (ambient air pressure/standard sea level air pressure) was used in lieu of the more precise ratio $\rho_z/\rho_o$ (ambient air density/air density at 1013 mb and 59°F) in order to conform to correction practices employed in BRL Report No. 1518.

BRL. Values of $R/\lambda_1$ were averaged for all gage distances and again for all distances exclusive of those at 80, 110, and 150 feet. The latter average was determined because of the evident tendency of close-in gage recordings from the high explosive calibration firings and motor Tests 3, 5, and 7 to register markedly higher than BRL data.

## OVERPRESSURE COMPARISON WITH HIGH EXPLOSIVE CALIBRATION FIRINGS

In a second approach to computing high explosive equivalency from peak overpressure data, curves of peak overpressure versus scaled distance were prepared from the gage results of each of the calibration firings (Fig. 16). These curves were then used with the motor test overpressure data to determine the TNT and Comp B equivalencies. Thus, the average peak overpressure for each gage distance was used to determine the corresponding scaled distance $\lambda_2$ value, and this value was used to derive $R/\lambda_2$ values (see Tables 1-7). The $R/\lambda_2$ values were then averaged, and this value--which determines an average $W^{1/3}$--was cubed to arrive at the Comp B and TNT equivalencies (Tables 10 and 11). Because the atmospheric changes from test-to-test were small, no attempt was made to introduce an atmospheric correction.

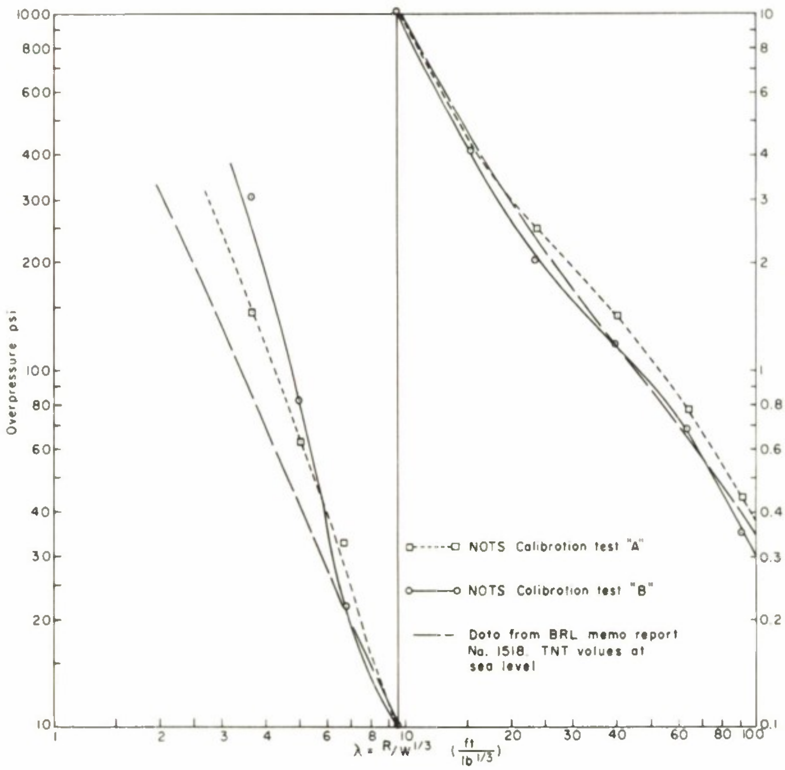



FIG. 16. Overpressure Versus Scaled Distance Calibration Curves.

Comparison of motor test data with the derived calibration curves presented difficulties similar to some of those experienced in comparing the data with the BRL curve, in that the calibration curves do not appear to parallel the function of overpressure-versus-scaled-distance for some tests (notably Tests 1, 2, and 4) as demonstrated by lower-than-average $R/\lambda_2$ values at close-in gage stations for the motor tests. Additionally, there is some concern over the tendency for the blast records from the Calibration A firing to show double and well-separated peaks, particularly at intermediate and long ranges.

While it is not considered that the atypical separated peaks tend to diminish the peak pressure values below normal values (as discussed later in this report), it would be somewhat easier to place confidence in overpressure-time histories of more classical shape.

The Calibration B results agree reasonably well with data in BRL Report No. 1518 at intermediate and longer ranges, but the readings run higher than the BRL data at two close-in gage positions.

Although Calibration B data and the above described BRL data were alike in being derived from TNT explosions, there were differences in the following test parameters:

a. The charge shapes and means of priming
b. The physical condition and density of the TNT
c. Gage arrays, and some differences in gage types
d. Data reduction techniques
e. Terrain
f. Number of tests and variety of explosive weights involved

## IMPULSE COMPARISON WITH HIGH EXPLOSIVE CALIBRATION FIRINGS

Scaled-impulse-versus-scaled-distance values were plotted for the two high explosive calibration firings (Fig. 17). Since these curves cannot be entered directly without first knowing the desired value W, a family of curves (Figs. 18 and 19) were derived relating impulse with $W^{2/3}$ for each gage distance. (The relationship of impulse versus $W^{2/3}$ approximates linearity for a specific gage distance.) The impulse versus $W^{2/3}$ curves were then entered with averaged impulse values for each gage distance. The extracted $W^{2/3}$ values were then averaged for all distances, and this average $W^{2/3}$ was converted to W--or high explosive equivalency.

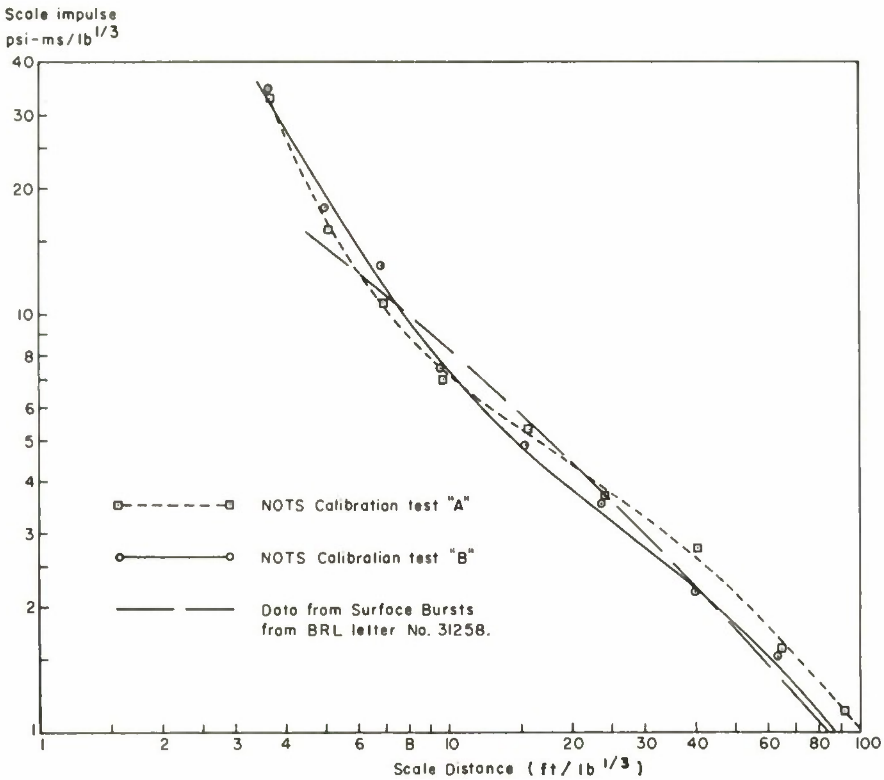



FIG. 17. Scaled Impulse Versus Scaled Distance.

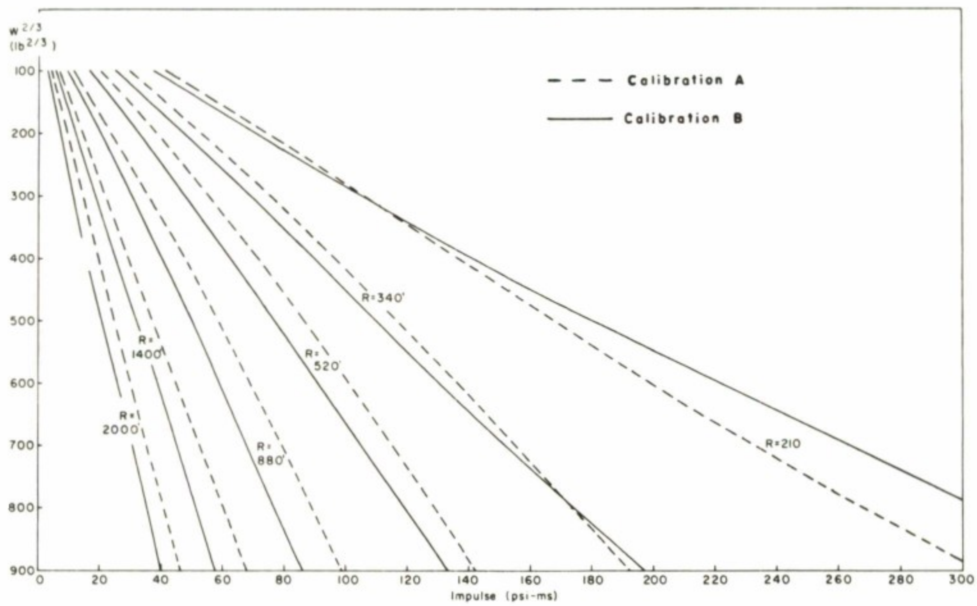



FIG. 18. Impulse Versus $W^{2/3}$ for R Values of 210, 340, 520, 880, 1,400, and 2,000 Feet (Calibration Tests A and B).

TABLE 1. Test #1 (ES-4259)

| R gage distance (ft) | Gage position | Gage type N leg | Gage type E leg | Peak overpres. N leg (psi) | Peak overpres. E leg (psi) | Avg. peak overpres. (psi) | Avg. peak overpres. amb. atmos. | $\lambda_1$ Scaled distance BRL 1518 | $R/\lambda_1$ | $\lambda_2$ Scaled distance overpres. calib. A | $R/\lambda_2$ | Impulse N leg (psi-ms) | Impulse E leg (psi-ms) | Avg. impulse (psi-ms) | $W^{2/3}$ from impulse calib. A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 80 | 1A | K(1) | K | 23.61 | 28.23 | 25.92 | 1.898 | 5.99 | 13.3 | 6.9 | 11.6 | 168.86 | 174.50 | 171.68 | 175 |
| 110 | 2A | P(2) | K | 18.01 | 11.03 | 13.41 | 0.982 | 8.17 | 13.4 | 8.5 | 12.9 | 93.42 | 123.79 | 107.69 | 165 |
| | 2B | K | ** | 11.20 | ** | | | | | | | 105.86 | ** | | |
| 150 | 3A | P | K | 8.63 | 5.71 | 6.27 | 0.459 | 12.14 | 12.3 | 12.4 | 12.1 | 67.38 | 79.37 | 75.25 | 150 |
| | 3B | K | ** | 4.47 | ** | | | | | | | 79.02 | ** | | |
| 210 | 4A | P | P | * | 5.98 | 4.47 | 0.327 | 14.77 | 14.2 | 15.3 | 14.7 | * | 74.10 | 58.14 | 145 |
| | 4B | B(3) | B | 3.26 | 4.18 | | | | | | | 46.37 | 53.96 | | |
| 340 | 5A | B | P | 2.63 | * | 2.39 | 0.175 | 22.17 | 15.3 | 24.7 | 13.7 | 24.13 | * | 27.75 | 95 |
| | 5B | B | B | 1.81 | 2.72 | | | | | | | 28.56 | 30.55 | | |
| 520 | 6A | B | B | 1.13 | 1.02 | 1.10 | 0.081 | 39.65 | 13.1 | 50.0 | 10.4 | 20.37 | 26.92 | 22.32 | 110 |
| | 6B | B | B | 1.16 | * | | | | | | | 19.68 | * | | |
| 880 | 7A | B | P | 0.58 | 0.63 | 0.58 | 0.042 | 66.25 | 13.2 | 76.0 | 11.6 | 11.44 | 14.68 | 13.63 | 115 |
| | 7B | ** | B | ** | 0.54 | | | | | | | ** | 14.77 | | |
| 1400 | 8A | B | B | 0.32 | 0.32 | 0.29 | 0.021 | 106.6 | 13.1 | 115.0 | 12.2 | 6.54 | 7.47 | 7.37 | 100 |
| | 8B | B | B | 0.24 | 0.28 | | | | | | | 7.16 | 8.29 | | |
| 2000 | 9A | B | B | 0.14 | 0.17 | 0.16 | 0.012 | 158.33 | 12.6 | | | 3.94 | 5.18 | 4.56 | 95 |
| Note (1) K = Kistler Gage; (2) P = BRL-PNS Type Gage; (3) B = BRL-PHS Type Gage | | | | | Average for all gage distances | | | | 13.39 | | 12.4 | | | | 128 |
| | | | | | Average excluding distances of 80', 110' and 150' | | | | 13.58 | | 12.5 | | | | 110 |

** No gage.
* Gage failure.

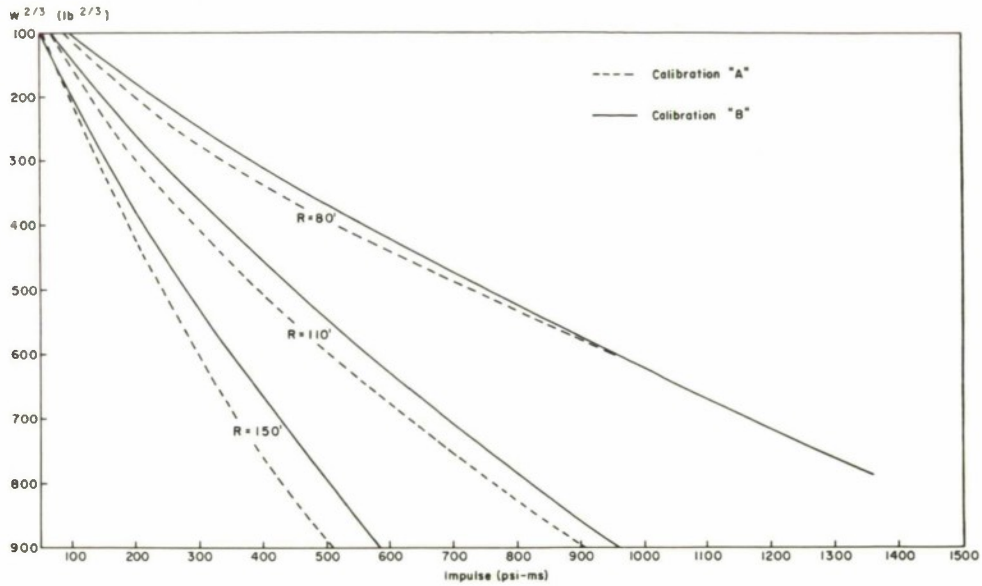



FIG. 19. Impulse Versus $W^{2/3}$ for R Values of 80, 110, and 150 Feet (Calibration Tests A and B).

LIMITATIONS OF REFERENCE DATA

It should be noted that this is a progress report outlining initial results in a continuing series of tests. There are acknowledged limitations in the use of the BRL data as a standard for comparison, primarily because of differences in charge geometry. There are also acknowledged limitations in the use of the Calibration A and B firing data, for the obvious reason that each set of data is derived from a single test. It is probable that additional high explosive calibration firings will be conducted in the future, thus providing a firmer basis for comparison.

EXPLANATION OF TABLES 1 THROUGH 9

The purpose of the tables is to list blast gage records and to show the methods of computation used. Derived values of $\lambda_1$ and $R/\lambda_1$ are explained above. Derived values of $\lambda_2$, $R/\lambda_2$, and $W^{2/3}$ are based on Calibration A results; therefore, these values relate to Comp B. Identical procedures were used in relating the tests to Calibration B TNT test results; however, these computations are not shown.

TABLE 2. Test #2 (ES-4260)

| R gage distance (ft) | Gage position | Gage type N leg | Gage type E leg | Peak overpres. N leg (psi) | Peak overpres. E leg (psi) | Avg. peak overpres. (psi) | Avg. peak overpres. amb. atmos. | $\lambda_1$ Scaled distance BRL 1518 | $R/\lambda_1$ | $\lambda_2$ Scaled distance overpres. calib. A | $R/\lambda_2$ | Impulse N leg (psi-ms) | Impulse E leg (psi-ms) | Avg. impulse (psi-ms) | $W^{2/3}$ from impulse calib. A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 80 | 1A | K(1) | K | 99.12 | 127.53 | 113.32 | 8.301 | 3.13 | 25.5 | 4.05 | 19.7 | * | * | * | * |
| 110 | 2A | P(2) | K | 86.09 | 51.06 | 60.54 | 4.435 | 4.13 | 26.6 | 5.1 | 21.6 | 425.61 | * | 425.61 | 533 |
| | 2B | K | ** | 44.48 | ** | | | | | | | * | ** | | |
| 150 | 3A | P | K | 21.88 | 18.67 | 18.56 | 1.359 | 6.98 | 21.4 | 7.7 | 19.5 | 271.74 | * | 271.74 | 560 |
| | 3B | K | ** | 15.13 | ** | | | | | | | * | ** | | |
| 210 | 4A | P | P | 6.52 | 9.42 | 8.63 | 0.632 | 10.20 | 20.6 | 10.5 | 20.0 | 173.03 | 165.62 | 166.37 | 465 |
| | 4B | B(3) | B | 6.99 | 11.60 | | | | | | | 167.93 | 158.91 | | |
| 340 | 5A | B | P | 6.15 | 4.85 | 5.32 | 0.389 | 13.45 | 25.3 | 13.6 | 25.0 | 128.77 | 129.84 | 122.36 | 530 |
| | 5B | B | B | 4.92 | 5.36 | | | | | | | 116.09 | 114.75 | | |
| 520 | 6A | B | B | 2.26 | 2.36 | 2.34 | 0.171 | 22.50 | 23.1 | 25.2 | 20.6 | 59.59 | 85.65 | 70.78 | 398 |
| | 6B | B | B | 2.37 | 2.37 | | | | | | | 62.51 | 75.37 | | |
| 880 | 7A | B | P | 1.29 | 1.62 | 1.32 | 0.096 | 34.70 | 25.4 | 43.0 | 20.5 | 37.89 | 46.86 | 43.51 | 365 |
| | 7B | ** | B | ** | 1.05 | | | | | | | ** | 45.79 | | |
| 1400 | 8A | B | B | 0.75 | 0.70 | 0.66 | 0.048 | 59.16 | 23.7 | 71.0 | 19.8 | 32.28 | 27.11 | 29.60 | 404 |
| | 8B | B | B | 0.64 | 0.55 | | | | | | | 32.82 | 26.20 | | |
| 2000 | 9A | B | B | 0.46 | 0.32 | 0.39 | 0.028 | 88.00 | 22.7 | 98.0 | 20.7 | 20.69 | 18.27 | 19.48 | 395 |
| | | | | | Average for all gage distances | | | | 23.81 | | 20.8 | | | | 456 |
| | | | | | Average excluding distances of 80', 110' and 150' | | | | 23.46 | | 21.1 | | | | 426 |

Note (1) K = Kistler Gage
(2) P = BRL-PNS Type Gage
(3) B = BRL-PHS Type Gage

* Gage failure.
** No gage.

TABLE 3. Test #3 (ES-4261-1)

| R gage distance (ft) | Gage position | Gage type N leg | Gage type E leg | Peak overpres. N leg (psi) | Peak overpres. E leg (psi) | Avg. peak overpres. (psi) | Avg. peak overpres. amb. atmos. | $\lambda_1$ Scaled distance BRL 1518 | $R/\lambda_1$ | $\lambda_2$ Scaled distance overpres. calib. A | $R/\lambda_2$ | Impulse N leg (psi-ms) | Impulse E leg (psi-ms) | Avg. impulse (psi-ms) | $W^{2/3}$ from impulse calib. A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 80 | 1A | K (1) | K | 230.84 | 188.53 | 209.68 | 15.361 | 2.37 | 33.7 | 3.2 | 25.0 | 982.66 | 1302.97 | 1142.81 | 690 |
| 110 | 2A | P (2) | K | 92.03 | (42.98) | 108.14 | 7.922 | 3.24 | 33.9 | 4.1 | 26.9 | 456.36 | * | 519.65 | 610 |
| | 2B | K | ** | 124.25 | ** | | | | | | | 582.95 | ** | | |
| 150 | 3A | P | K | 30.85 | 34.23 | 34.25 | 2.509 | 5.31 | 28.2 | 6.4 | 23.5 | 323.36 | 246.53 | 312.40 | 625 |
| | 3B | K | ** | 37.69 | ** | | | | | | | 367.32 | ** | | |
| 210 | 4A | P | P | 10.74 | 12.28 | 13.14 | 0.962 | 8.27 | 25.4 | 8.6 | 24.4 | 239.30 | 251.12 | 237.17 | 625 |
| | 4B | B (3) | B | 15.02 | 14.52 | | | | | | | 233.31 | 224.96 | | |
| 340 | 5A | B | P | 5.74 | 6.72 | 6.07 | 0.444 | 12.35 | 27.5 | 12.5 | 27.2 | 134.39 | 171.53 | 149.71 | 673 |
| | 5B | B | B | 5.08 | 6.77 | | | | | | | (59.95) | 143.23 | | |
| 520 | 6A | B | B | * | 2.93 | 2.97 | 0.217 | 19.20 | 27.0 | 20.5 | 25.3 | * | * | 95.48 | 588 |
| | 6B | B | B | 2.76 | 3.24 | | | | | | | 84.55 | 106.42 | | |
| 880 | 7A | B | P | 1.56 | 2.15 | 1.66 | 0.121 | 29.10 | 30.2 | 34.8 | 25.3 | 62.63 | 60.90 | 63.87 | 548 |
| | 7B | ** | B | ** | 1.27 | | | | | | | ** | 68.10 | | |
| 1400 | 8A | B | B | 0.87 | 0.88 | 0.81 | 0.059 | 50.70 | 27.6 | 62.0 | 22.6 | 41.09 | 45.78 | 44.45 | 600 |
| | 8B | B | B | 0.81 | 0.70 | | | | | | | 56.40 | 34.56 | | |
| 2000 | 9A | B | B | 0.55 | 0.43 | 0.49 | 0.036 | 73.75 | 27.1 | 85.0 | 23.5 | 28.26 | 26.50 | 27.38 | 550 |
| Note (1) K = Kistler Gage; (2) P = BRL-PNS Type Gage; (3) B = BRL-PHS Type Gage | | | | | Average for all gage distances | | | | 29.0 | | 24.87 | | | | 612 |
| | | | | | Average excluding distances of 80', 110', and 150' | | | | 27.4 | | 24.71 | | | | 597 |

( ) Measured value not used in computations.
* Gage failure.
** No gage.

TABLE 4. Test #4 (ES-4261-2)

| R gage distance (ft) | Gage position | Gage type N leg | Gage type E leg | Peak overpres. N leg (psi) | Peak overpres. E leg (psi) | Avg. peak overpres. (psi) | Avg. peak overpres. amb. atmos. | $\lambda_1$ Scaled distance BRL 1518 | $R/\lambda_1$ | $\lambda_2$ Scaled distance overpres. calib. A | $R/\lambda_2$ | Impulse N leg (psi-ms) | Impulse E leg (psi-ms) | Avg. impulse (psi-ms) | $W^{2/3}$ from impulse calib. A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 80 | 1A | K(1) | K | (109.35) | 145.20 | 145.20 | 10.63 | 2.90 | 27.6 | 3.65 | 21.9 | 794.62 | 751.93 | 773.27 | 516 |
| 110 | 2A | P(2) | K | * | 80.77 | 92.11 | 6.75 | 3.43 | 32.1 | 4.38 | 25.1 | * | 366.14 | 412.10 | 515 |
| | 2B | K | ** | 103.46 | ** | | | | | | | 458.06 | ** | | |
| 150 | 3A | P | K | 27.45 | 29.64 | 28.91 | 2.12 | 5.72 | 26.2 | 6.75 | 22.3 | 257.91 | 183.90 | 244.54 | 510 |
| | 3B | K | ** | 29.66 | ** | | | | | | | 291.81 | ** | | |
| 210 | 4A | P | P | 10.26 | 14.17 | 11.68 | 0.855 | 8.77 | 23.9 | 8.90 | 23.6 | 209.41 | 197.18 | 202.65 | 605 |
| | 4B | B(3) | B | 10.76 | 11.55 | | | | | | | 201.52 | 202.49 | | |
| 340 | 5A | B | P | 5.93 | 6.25 | 5.95 | 0.436 | 12.5 | 27.2 | 12.8 | 26.5 | 145.16 | 153.81 | 147.45 | 660 |
| | 5B | B | B | 5.68 | * | | | | | | | 143.38 | * | | |
| 520 | 6A | B | B | 2.75 | 2.77 | 2.64 | 0.193 | 20.8 | 25.0 | 22.6 | 23.0 | 86.06 | 99.12 | 87.10 | 505 |
| | 6B | B | B | 2.51 | 2.56 | | | | | | | 96.38 | 66.86 | | |
| 880 | 7A | B | P | 1.62 | 2.08 | 1.67 | 0.122 | 28.9 | 30.4 | 34.8 | 25.3 | 66.73 | 66.30 | 65.32 | 560 |
| | 7B | ** | B | ** | 1.33 | | | | | | | ** | 62.95 | | |
| 1400 | 8A | B | B | 0.82 | 0.94 | 0.80 | 0.0586 | 52.6 | 26.6 | 62.0 | 22.6 | 35.67 | 43.14 | 38.27 | 515 |
| | 8B | B | B | 0.73 | 0.74 | | | | | | | 37.28 | 37.00 | | |
| 2000 | 9A | B | B | 0.54 | 0.43 | 0.48 | 0.0352 | 75.5 | 26.5 | 87.0 | 23.0 | 25.72 | 26.50 | 26.11 | 520 |
| Note (1) K = Kistler Gage; (2) P = BRL-PNS Type Gage; (3) B = BRL-PHS Type Gage | | | | | Average for all gage distances | | | | 27.3 | | 23.7 | | | | 548 |
| | | | | | Average excluding distances of 80', 110', and 150' | | | | 26.6 | | 24.0 | | | | 561 |

( ) Measured value not used in computations.
* Gage failure.
** No gage.

TABLE 5. Test #5 (ES-5001)

| R gage distance (ft) | Gage position | Gage type N leg | Gage type E leg | Peak overpres. N leg (psi) | Peak overpres. E leg (psi) | Avg. peak overpres. (psi) | Avg. peak overpres. amb. atmos. | $\lambda_1$ Scaled distance BRL 1518 | $R/\lambda_1$ | $\lambda_2$ Scaled distance overpres. calib. A | $R/\lambda_2$ | Impulse N leg (psi-ms) | Impulse E leg (psi-ms) | Avg. impulse (psi-ms) | $W^{2/3}$ from impulse calib. A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 80 | 1A | K (1) | K | * | 252.40 | 252.40 | 18.490 | 2.17 | 36.8 | 2.97 | 26.9 | * | 738.94 | 738.94 | 492 |
| 110 | 2A | P (2) | K | 76.60 | 150.92 | 113.76 | 8.334 | 3.12 | 35.3 | 4.05 | 27.2 | 393.11 | 556.80 | 474.95 | 575 |
| | 2B | K | ** | * | ** | | | | | | | * | ** | | |
| 150 | 3A | P | K | 31.39 | 55.01 | 43.20 | 3.164 | 4.79 | 31.3 | 5.80 | 25.9 | 420.00 | 244.00 | 332.00 | 660 |
| | 3B | K | ** | * | ** | | | | | | | * | ** | | |
| 210 | 4A | P | P | * | * | | | | | | | * | * | | |
| | 4B | B (3) | B | * | 13.22 | 13.22 | 0.968 | 8.24 | 25.5 | 8.60 | 24.5 | * | 219.74 | 219.74 | 662 |
| 340 | 5A | B | P | 6.19 | 6.07 | 5.91 | 0.432 | 12.51 | 27.2 | 12.8 | 26.6 | 158.65 | 151.82 | 147.4 | 660 |
| | 5B | B | B | 5.25 | 6.13 | | | | | | | 141.59 | 137.61 | | |
| 520 | 6A | B | B | * | (0.71) | 2.79 | 0.204 | 19.92 | 26.1 | 21.6 | 24.0 | * | (19.13) | 95.7 | 564 |
| | 6B | B | B | * | 2.79 | | | | | | | * | 95.70 | | |
| 880 | 7A | B | P | 1.57 | 1.61 | 1.46 | 0.106 | 32.07 | 27.4 | 39.0 | 22.6 | 60.80 | ** | 57.7 | 490 |
| | 7B | ** | B | ** | 1.22 | | | | | | | ** | 54.69 | | |
| 1400 | 8A | B | B | 0.86 | 0.84 | 0.76 | 0.055 | 53.55 | 26.1 | 65.0 | 21.6 | 40.80 | 29.57 | 35.1 | 475 |
| | 8B | B | B | 0.71 | 0.66 | | | | | | | 37.76 | 32.35 | | |
| 2000 | 9A | B | B | * | 0.39 | 0.39 | 0.028 | 88.00 | 22.7 | 98.0 | 20.7 | * | 28.83 | 28.8 | 570 |
| Note (1) K = Kistler Gage; (2) P = BRL-PNS Type Gage; (3) B = BRL-PHS Type Gage | | | | | Average for all gage distances | | | | 28.71 | | 24.44 | | | | 572 |
| | | | | | Average excluding distances of 80', 110', and 150' | | | | 25.83 | | 23.33 | | | | 570 |

( ) Measured value not used in computations.
* Gage failure.
** No gage.

TABLE 6. Test #6 (ES-5058)

| R gage distance (ft) | Gage position | Gage type N leg | Gage type E leg | Peak overpres. N leg (psi) | Peak overpres. E leg (psi) | Avg. peak overpres. (psi) | Avg. peak overpres. amb. atmos. | $\lambda_1$ Scaled distance BRL 1518 | $R/\lambda_1$ | $\lambda_2$ Scaled distance overpres. calib. A | $R/\lambda_2$ | Impulse N leg (psi-ms) | Impulse E leg (psi-ms) | Avg. impulse (psi-ms) | $W^{2/3}$ from impulse calib. A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 80 | 1A | K (1) | K | * | * | | | | | | | * | * | | |
| 110 | 2A | ** | ** | ** | ** | | | | | | | ** | ** | | |
| | 2B | * | * | * | * | | | | | | | * | * | | |
| 150 | 3A | P (2) | P | 14.55 | * | 14.55 | 1.075 | 7.82 | 19.2 | 8.30 | 18.1 | 176.8 | * | 177 | 375 |
| | 3B | ** | ** | ** | ** | | | | | | | ** | ** | | |
| 210 | 4A | P | P | 8.48 | * | 8.62 | 0.633 | 10.19 | 20.6 | 10.5 | 20.0 | 137.0 | * | 129 | 368 |
| | 4B | B (3) | B | 8.87 | 8.50 | | | | | | | 120.37 | * | | |
| 340 | 5A | B | P | 3.88 | (1.44) | 3.27 | 0.240 | 17.95 | 19.0 | 19.0 | 17.9 | 70.20 | (35.43) | 64 | 250 |
| | 5B | B | B | 2.90 | 3.03 | | | | | | | 55.62 | 66.27 | | |
| 520 | 6A | B | B | 1.74 | 1.59 | 1.74 | 0.128 | 27.86 | 18.7 | 33.0 | 15.8 | 41.01 | 48.00 | 45.6 | 240 |
| | 6B | B | B | 1.81 | 1.82 | | | | | | | 43.26 | 50.02 | | |
| 880 | 7A | B | P | 0.96 | 0.82 | 0.89 | 0.0653 | 47.15 | 18.7 | 58.0 | 15.2 | 30.11 | 26.64 | 28.9 | 245 |
| | 7B | ** | B | ** | 0.90 | | | | | | | ** | 29.77 | | |
| 1400 | 8A | B | B | 0.62 | 0.46 | 0.52 | 0.0382 | 71.14 | 19.6 | 82.0 | 17.1 | * | 17.80 | 17.0 | 235 |
| | 8B | B | B | 0.42 | 0.59 | | | | | | | 16.10 | * | | |
| 2000 | 9A | B | B | 0.24 | 0.27 | 0.25 | 0.0183 | 120.6 | 16.6 | 125.0 | 16.0 | 11.47 | 12.66 | 12.1 | 245 |
| Average for all gage distances | | | | | | | | | 18.9 | | 17.16 | | | | 280 |
| Average excluding distances of 80', 110', and 150' | | | | | | | | | 18.9 | | 17.01 | | | | 264 |

Note (1) K = Kistler Gage
(2) P = BRL-PNS Type Gage
(3) B = BRL-PHS Type Gage

( ) Measured value not used in computations.
* Gage failure.
** No gage.

TABLE 7. Test #7 (ES-5065)

| R gage distance (ft) | Gage position | Gage type N leg | Gage type E leg | Peak overpres. N leg (psi) | Peak overpres. E leg (psi) | Avg. peak overpres. (psi) | Avg. peak overpres. amb. atmos. | $\lambda_1$ Scaled distance BRL 1518 | $R/\lambda_1$ | $\lambda_2$ Scaled distance overpres. calib. A | $R/\lambda_2$ | Impulse N leg (psi-ms) | Impulse E leg (psi-ms) | Avg. impulse (psi-ms) | $W^{2/3}$ from impulse calib. A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 80 | 1A | K(1) | K | (*176.04) | 281.77 | 281.77 | 20.8 | 2.05 | 39.0 | 2.85 | 28.0 | (*432.61) | 840.33 | 840 | 552 |
| 110 | 2A | ** | ** | ** | ** | | 10.4 | 2.83 | 38.9 | 3.70 | 29.7 | ** | ** | 454 | 555 |
| | 2B | K | K | 187.56 | 95.37 | 141.46 | | | | | | 470.98 | 438.02 | | |
| 150 | 3A | P(2) | P | 31.23 | * | 31.32 | 2.31 | 5.49 | 27.3 | 6.60 | 22.7 | 386.4 | * | 386 | 740 |
| | 3B | ** | ** | ** | ** | | | | | | | ** | ** | | |
| 210 | 4A | P | P | 11.61 | * | 12.45 | 0.919 | 8.47 | 24.8 | 8.75 | 23.7 | 210.1 | * | 209 | 570 |
| | 4B | B(3) | B | 13.66 | 12.08 | | | | | | | 207.13 | * | | |
| 340 | 5A | B | P | 5.88 | 5.97 | 5.68 | 0.419 | 12.80 | 26.6 | 13.2 | 25.8 | 144.82 | (7.8) | 133 | 583 |
| | 5B | B | B | 4.66 | 6.21 | | | | | | | 119.79 | 135.83 | | |
| 520 | 6A | B | B | 2.78 | 2.62 | 2.69 | 0.198 | 20.39 | 25.5 | 22.3 | 23.3 | 90.70 | 92.00 | 91.6 | 535 |
| | 6B | B | B | * | 2.68 | | | | | | | * | 92.12 | | |
| 880 | 7A | B | P | 1.59 | 1.35 | 1.41 | 0.104 | 32.66 | 26.9 | 40.0 | 22.0 | 64.77 | 61.94 | 58.8 | 500 |
| | 7B | ** | B | ** | 1.28 | | | | | | | ** | 50.71 | | |
| 1400 | 8A | B | ** | 0.87 | ** | 0.76 | 0.0561 | 53.07 | 26.4 | 65.0 | 21.6 | 37.49 | ** | 34.0 | 460 |
| | 8B | B | B | 0.71 | 0.71 | | | | | | | 33.37 | 31.15 | | |
| 2000 | 9A | | B | 0.46 | 0.42 | 0.44 | 0.0325 | 79.84 | 25.1 | 91.0 | 22.0 | 22.65 | 22.76 | 22.70 | 455 |
| | | | | | Average for all gage distances | | | | 29.0 | | 24.3 | | | | 561 |
| | | | | | Average excluding distances of 80', 110', and 150' | | | | 25.9 | | 23.1 | | | | 517 |

Note (1) K = Kistler Gage
(2) P = BRL-PNS Type Gage
(3) B = BRL-PHS Type Gage

( ) Measured value not used in computations.
* Gage failure.
** No gage.

TABLE 8. Calibration Test "A" (ES-4262)

| R gage distance (ft) | Gage position | Gage type N leg | Gage type E leg | Peak overpres. N leg (psi) | Peak overpres. E leg (psi) | Avg. peak overpres. (psi) | Avg. peak overpres. amb. atmos. | $\lambda_1$ Scaled distance BRL 1518 | $R/\lambda_1$ | Impulse N leg (psi-ms) | Impulse E leg (psi-ms) | Avg. impulse (psi-ms) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 80 | 1A | K[1] | K | 131.73 | 158.36 | 145.04 | 10.63 | 2.95 | 27.1 | 773.16 | 635.10 | 704.13 |
| 110 | 2A | P[2] | K | 61.02 | 64.21 | 62.61 | 4.59 | 4.06 | 27.1 | 326.16 | 427.73 | 347.19 |
| | 2B | K | ** | (32.43) | ** | | | | | 287.70 | ** | |
| 150 | 3A | P | K | 38.52 | 34.57 | 32.79 | 2.40 | 5.32 | 28.2 | 343.83 | 158.17 | 229.68 |
| | 3B | K | ** | 25.30 | ** | | | | | 187.05 | ** | |
| 210 | 4A | P | P | 9.30 | 9.94 | 10.06 | 0.73 | 9.50 | 22.1 | 132.10 | 195.82 | 151.11 |
| | 4B | B[3] | B | 10.95 | * | | | | | 125.41 | * | |
| 340 | 5A | B | P | 4.91 | 4.36 | 4.28 | 0.313 | 15.1 | 22.5 | 94.18 | 155.66 | 115.14 |
| | 5B | B | B | 3.78 | 4.09 | | | | | 83.53 | 127.19 | |
| 520 | 6A | B | B | 2.30 | 2.69 | 2.50 | 0.183 | 21.6 | 24.1 | 77.16 | 93.09 | 79.26 |
| | 6B | B | B | 2.11 | 2.92 | | | | | 54.84 | 91.95 | |
| 880 | 7A | B | P | 1.12 | 1.69 | 1.42 | 0.104 | 32.6 | 26.9 | (17.47) | 63.98 | 59.57 |
| | 7B | ** | B | ** | 1.47 | | | | | ** | 55.17 | |
| 1400 | 8A | B | B | 0.69 | 1.05 | 0.78 | 0.057 | 52.5 | 26.6 | 37.71 | 30.21 | 34.55 |
| | 8B | B | B | 0.57 | 0.81 | | | | | 35.88 | 34.42 | |
| 2000 | 9A | B | B | 0.43 | 0.45 | 0.44 | 0.032 | 81.0 | 24.7 | 25.12 | 23.60 | 24.36 |

Note (1) K = Kistler Gage
(2) P = BRL-PNS Type Gage
(3) B = BRL-PHS Type Gage

Average for all gage distances: 25.47

Average excluding distances of 80', 110', and 150': 24.48

( ) Measured value not used in computations.
** No gage.
* Gage failure.

TABLE 9. Calibration Test "B" (ES-5064)

| R gage distance (ft) | Gage position | Gage type N leg | Gage type E leg | Peak overpres. N leg (psi) | Peak overpres. E leg (psi) | Avg. peak overpres. (psi) | Avg. peak overpres. amb. atmos. | $\lambda_1$ Scaled distance BRL 1518 | $R/\lambda_1$ | $\lambda_2$ Scaled distance overpres. calib. | $R/\lambda_2$ | Impulse N leg (psi-ms) | Impulse E leg (psi-ms) | Avg. impulse (psi-ms) | $W^{2/3}$ from impulse calib. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 80 | 1A | K(1) | K | * | 308.25 | 308.25 | 22.6 | 1.97 | 40.6 | 2.90 | 27.5 | * | 764.43 | 764 | 517 |
| 110 | 2A | ** | ** | ** | ** | | 6.04 | 3.60 | 30.6 | 4.60 | 23.9 | ** | ** | | |
| | 2B | K | K | * | 82.35 | 82.35 | | | | | | * | 397.96 | 398 | 505 |
| 150 | 3A | P(2) | P | * | 21.84 | 21.84 | 1.61 | 6.47 | 23.2 | 7.25 | 20.7 | * | 286.1 | 286 | 580 |
| | 3B | ** | ** | ** | ** | | | | | | | ** | ** | | |
| 210 | 4A | P | P | * | * | 10.20 | 0.748 | 9.37 | 22.4 | 9.60 | 21.9 | * | * | 163 | 485 |
| | 4B | B(3) | B | 9.95 | 10.45 | | | | | | | 149.84 | 176.82 | | |
| 340 | 5A | B | P | 4.85 | 4.07 | 4.18 | 0.306 | 15.33 | 22.2 | 15.7 | 21.6 | 100.84 | 118.4 | 106 | 447 |
| | 5B | B | B | 3.58 | 4.24 | | | | | | | 86.53 | 119.18 | | |
| 520 | 6A | B | B | 2.07 | 1.99 | 2.05 | 0.151 | 24.67 | 21.0 | 28.3 | 18.4 | 79.58 | 68.43 | 76.7 | 435 |
| | 6B | B | B | 2.10 | 2.07 | | | | | | | 87.79 | 70.88 | | |
| 880 | 7A | B | P | 1.34 | 1.20 | 1.20 | 0.0880 | 37.18 | 23.6 | 46.2 | 19.0 | 46.49 | 48.4 | 44.8 | 375 |
| | 7B | ** | B | ** | 1.06 | | | | | | | ** | 39.28 | | |
| 1400 | 8A | B | ** | 0.75 | ** | 0.68 | 0.0499 | 58.07 | 24.1 | 70.0 | 20.0 | 35.42 | ** | 33.2 | 450 |
| | 8B | B | B | 0.60 | 0.70 | | | | | | | 31.05 | * | | |
| 2000 | 9A | B | B | 0.40 | 0.31 | 0.35 | 0.0257 | 94.74 | 21.1 | 105.0 | 19.1 | 20.54 | 19.12 | 19.83 | 400 |
| Note (1) K = Kistler Gage; (2) P = BRL-PNS Type Gage; (3) B = BRL-PHS Type Gage | | | | | Average for all gage distances | | | | 25.3 | | 21.33 | | | | 466 |
| | | | | | Average excluding distances of 80', 110', and 150' | | | | 22.4 | | 20.0 | | | | 432 |

* Gage failure.
** No gage.

# ANALYSIS OF BLAST YIELD COMPARISONS

## COMPARISON WITH TNT

In Table 10, which summarizes TNT equivalent yields for the tests conducted, six different yield values are identified for each motor test, representing three different approaches to yield determination. It is not considered that all columns of values are equally valid; e.g., the $W_{T1}$ column is believed to exaggerate the yield for some tests. However, the multiple listing of values does serve to illustrate the variation that can result with different choices of gage distance ranges and calibration standards, and when different blast characteristics, such as impulse versus overpressure, are used in yield determination.

The multiplicity of values also illustrates the difficulty of making an arbitrary choice of a single value of TNT equivalency for any of the tests. Some comments on the differences are presented below:

1. The differences between $W_{T3}$ and $W_{T4}$ and those between $W_{T5}$ and $W_{T6}$ simply suggest that the blast decay patterns of the propellants tested do not parallel those of TNT as tested in the Calibration B firing.

2. The differences between $W_{T1}$ and $W_{T2}$ also suggest nonparallel decay patterns; however, they also include differences in charge geometry and differences in test techniques, including gage recording and interpretation of data at close-in positions. The agreement between $W_{T2}$ and $W_{T4}$ is good, which suggests that the above described differences diminish in significance when close-in gage records are disregarded.

3. Differences between $W_{T3}$ and $W_{T5}$ and between $W_{T4}$ and $W_{T6}$ are considered acceptable, since it is not anticipated that equivalent yields based on impulse would be the same as those based on overpressure.

## COMPARISON WITH COMPOSITION B

Table 11 summarizes Composition B equivalency yields for the tests conducted, based on overpressure and impulse comparisons of like values from the Calibration A Comp B firing.

As in Table 10, values are shown with all gages considered, and also with records of the three close-in positions omitted. Again, there are differences between values for an individual test in each of the four columns, but these are generally of less magnitude than the corresponding differences appearing in Table 10.

TABLE 10. Summary of TNT Equivalent Yield

| Test number | Yield from overpressure calibration BRL Report 1518 all gages | Yield from overpressure calibration BRL Report 1518 excluding gages at 80, 110 & 150' | Yield from overpressure Calib. "B" all gages | Yield from overpressure from Calib. "B" excluding gages at 80, 110 & 150' | Yield from impulse Calib. "B" all gages | Yield from impulse from Calib. "B" excluding gages at 80, 110 & 150' |
|---|---|---|---|---|---|---|
| | $W_{T1}$ | $W_{T2}$ | $W_{T3}$ | $W_{T4}$ | $W_{T5}$ | $W_{T6}$ |
| 1 | 2,250 | 2,360 | 2,330 | 2,570 | 1,660 | 1,500 |
| 2 | 12,700 | 12,200 | 10,600 | 12,300 | 10,900 | 10,900 |
| 3 | 22,900 | 19,400 | 17,000 | 19,600 | 16,000 | 16,800 |
| 4 | 18,400 | 17,700 | 15,500 | 18,400 | 13,500 | 15,200 |
| 5 | 22,200 | 16,300 | 15,600 | 16,500 | 14,300 | 15,300 |
| 6 | 6,350 | 6,350 | 6,530 | 6,530 | 5,200 | 5,330 |
| 7 | 22,600 | 16,100 | 15,500 | 16,000 | 13,700 | 13,800 |
| Calib. A | 15,400 | 13,700 | 12,500 | 14,100 | 11,100 | 12,300 |
| B | 15,000 | 10,400 | ---- | ---- | ---- | ---- |

TABLE 11. Summary in Terms of Composition "B" Equivalent Yield

| Test number | Yield from overpressure Calib. "A" all gages | Yield from overpressure Calib. "A" excluding gages at 80, 110 & 150' | Yield from impulse Calib. "A" all gages | Yield from impulse Calib. "A" excluding gages at 80, 110 & 150' |
|---|---|---|---|---|
| | $W_{C1}$ | $W_{C2}$ | $W_{C3}$ | $W_{C4}$ |
| 1 | 1,910 | 1,950 | 1,520 | 1,160 |
| 2 | 9,000 | 9,400 | 9,800 | 8,800 |
| 3 | 15,400 | 15,100 | 15,200 | 14,100 |
| 4 | 13,300 | 13,800 | 12,800 | 13,300 |
| 5 | 14,300 | 12,600 | 13,700 | 13,600 |
| 6 | 5,060 | 4,920 | 4,690 | 4,290 |
| 7 | 14,300 | 12,300 | 13,300 | 11,800 |
| Calib. "B" | 9,700 | 8,000 | 10,100 | 8,980 |

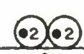
## GENERAL OBSERVATIONS CONCERNING DERIVED YIELDS

Comparison of Tables 10 and 11 suggests that the propellants tested are behaving more like Comp B than like TNT. A comparison of the yields derived in the high explosive calibration firings is also of interest.

For example, when Comp B is expressed in TNT equivalency, using overpressure and the full range of gages ($W_{T3}$), the ratio value becomes (12,500 lb/10,340 lb) or 1.20, which compares to the commonly accepted value of 1.13. Using impulse and all gages ($W_{T5}$), the ratio value becomes (11,100/10,340) or 1.07, which is quite close to the commonly accepted 1.06 value. However, when records of close-in gages are omitted, these values change from 1.20 to 1.36 (14,100/10,340) when using $W_{T4}$, and from 1.07 to 1.19 (12,300/10,340) when using $W_{T6}$.

It should be noted that these changes with gage distances in TNT-versus-Composition B relationships are reflected in cross comparison of propellant values in Columns $W_{T3}$ through $W_{T6}$ of Table 10 with corresponding columns of Table 11.

If columns $W_{T3}$ and $W_{T5}$ of Table 10 and the corresponding columns, $W_{C1}$ and $W_{C3}$, of Table 11 are arbitrarily selected for derivation of percentage equivalencies, the following values are obtained.

| Test No. | TNT equiv. over-pressure | TNT equiv. impulse | Comp. "B" equiv. overpressure | Comp. "B" equiv. impulse | Test geometry* |
|---|---|---|---|---|---|
| 1 | 32% | 23% | 26% | 21% |   |
| 2 | 144% | 148% | 122% | 133% |   |
| 3 | 116% | 109% | 105% | 104% |   |
| 4 | 106% | 92% | 91% | 88% |   |
| 5 | 107% | 98% | 98% | 94% |   |
| 6 | 45% | 36% | 35% | 32% |   |
| 7 | 106% | 94% | 98% | 91% |   |

*The dot in the geometry configuration for each test shows the placement of the charge; the numbers 2 and 7 indicate the class of propellant.

In the above grouping, only two tests--3 and 4--were essentially identical; however, they did not produce identical results.

Tests 3, 4, 5, and 7 used identical motor combinations, but were different in motor attitude and method of priming. The results are similar despite the differences in test conditions.

Test 1 used only one class 2 motor, and test 6 used two class 2 motors involving twice as much propellant; however, there is a substantial increase in percentages between the two tests. This suggests that the added mass, or the distribution of mass and relative positioning of of priming charge, influenced the increase.

If Tests 1, 2, 3, 4, and 6 are compared, and if it is assumed that the class 7 motor in Test 2 was producing near maximum yield, then it follows that the class 2 motors in Tests 3 and 4 were producing a higher yield than they were in Tests 1 or 6. Using TNT overpressure values ($W_{T3}$) and averaging results of Tests 3 and 4, the following defines average yield of the class 2 motor in Tests 3 and 4:

$$Y \text{ (class 2 yield)} = \frac{16{,}200 - 10{,}600}{7{,}250} = \frac{5{,}600}{7{,}250} = 0.77 \text{ or } 77\%$$

Using Comp B overpressure values ($W_{C1}$), the following applies:

$$Y = \frac{14{,}350 - 9{,}000}{7{,}250} = 0.74 \text{ or } 74\%$$

This indicates that the large application of externally applied energy from the exploding class 7 motor produced greater yield in the class 2 motor than the yield produced in a similar motor by the explosion of 96 lb of C-4 placed in the grain perforation.

## CONCLUSIONS

The derived percentage values of high explosive equivalency are considered to represent a convenient expression of potential blast damage effects in terms of common explosives; however, it is acknowledged that there are differences in structure and rates of decay of blast waves produced by different explosives and propellants so that expressions of high explosive equivalency are limited to generalizations without specific identification of quantities, distances, and types of energy measured.

Additionally, it is emphasized that the measurements made and the analytical approaches used in this evaluation required the cubing of the derived $W^{1/3}$ values to arrive at the W values shown in Tables 10 and 11. Thus, errors in measurement (and the possible real anomalies in the blast wave itself) are amplified in the expression of W.

With the above qualifications in mind, the tests show that, under strong stimulus, motors of the class 7 type tested are capable of producing blast yields that exceed those of some common explosives. Motors of the class 2 type tested are also capable of producing significant blast yields, the magnitude of which tends to vary with the strength of the stimulus and with propellant mass, or the distribution of mass and relative positioning of the priming charge.

Fragment type, size, quantity, and distribution were considered to be consistent with the explosive effects noted with each test. In general, the estimated total weight of unburned propellant fragments varied inversely with the blast effectiveness, as might be expected.

No attempt has been made to correlate blast yield with crater size for two main reasons: (1) the craters tended to assume different shapes according to the configuration and orientation of the propellant and explosive charges, and (2) the same site was used for all tests in order to maintain consistent gage position; therefore, there was progressive pulverization and change of soil structure with each explosion and subsequent re-leveling operation.

## Appendix

## ARMED SERVICES EXPLOSIVES SAFETY BOARD SOLID PROPELLANT MOTOR HAZARDS TESTS

Summaries of conditions associated with each test are shown on the following pages.

| | | |
|---|---|---|
| Conducted by: US NOTS | Test No. 1 | E.S. No. E-4259 |
| Funds: | Date 5 Nov 1964 | Test Site Victor "C" |

**PRIMED MOTOR**

| | | |
|---|---|---|
| Number 1 | Type | Serial No. |
| Propellant Class 2 | Propellant Weight 7250 lbs | Motor Case Mat. Steel |

Position relative to ground In contact with: horizontal

Position of main motor axis Horizontal, head end NE

Remarks (including motor deficiencies) Four nozzles in aft bulkhead

**PRIMING SYSTEM**

| | | |
|---|---|---|
| Priming Explosive: Type C-4 | Amount 96 lbs | Position Grain perforation |
| Detonators: Type Engine Sp. | Number 2 | Position One fore; one aft |

Remarks Some of the explosive was packed into the cavity where the nozzle chambers join the grain perforation at the aft end of the motor

**ACCEPTOR MOTORS**

| | | |
|---|---|---|
| Number None | Type | Serial No. |
| Propellant Class | Propellant Weight | Motor Case Mat. |

Position relative to primed motor

Remarks (including motor deficiencies)

**WEATHER**

| | | |
|---|---|---|
| Pressure mb 941.7 | Temperature °F 75 | Density Slugs |
| Humidity 18% | Wind Direction 095° | Wind Velocity, ft/sec 8 |

| | | |
|---|---|---|
| Conducted by: US NOTS | Test No. 2 | E.S. No. E-4260 |
| Funds: | Date 16 Nov 1964 | Test Site Victor "C" |

**PRIMED MOTOR**

| | | |
|---|---|---|
| Number 1 | Type | Serial No. |
| Propellant Class 7 | Propellant Weight 7358 | Motor Case Mat. Fiberglass |

Position relative to ground On ground: horizontal

Position of main motor axis Horizontal; head end NE

Remarks (including motor deficiencies) There were no nozzles on this motor.

**PRIMING SYSTEM**

| | | | |
|---|---|---|---|
| Priming Explosive: | Type C-4 | Amount 96 lbs | Position Grain perforation |
| Detonators: | Type Electric | Number 2 | Position One fore; one aft |

Remarks Two electric blasting caps were fired simultaneously.

**ACCEPTOR MOTORS**

| | | |
|---|---|---|
| Number None | Type | Serial No. |
| Propellant Class | Propellant Weight | Motor Case Mat. |

Position relative to primed motor

Remarks (including motor deficiencies)

**WEATHER**

| | | |
|---|---|---|
| Pressure mb 940.6 | Temperature °F 47 | Density Slugs |
| Humidity 40 | Wind Direction 080° | Wind Velocity, ft/sec 10 |

| | | | |
|---|---|---|---|
| Conducted by: US NOTS | | Test No. 3 | E.S. No. 4261-1 |
| Funds: | | Date 18 Nov 1964 | Test Site Victor "C" |
| PRIMED MOTOR | Number 1 | Type | Serial No. |
| | Propellant Class 7 | Propellant Weight 7358 | Motor Case Mat. Fiberglass |
| | Position relative to ground On ground: horizontal | | |
| | Position of main motor axis Horizontal; head end NE | | |
| | Remarks (including motor deficiencies) Rear bulkhead but no nozzles in this motor. | | |
| PRIMING SYSTEM | Priming Explosive: Type C-4 | Amount 96 lbs | Position Grain perforation |
| | Detonators: Type Electric | Number 2 | Position One fore; one aft |
| | Remarks | | |
| ACCEPTOR MOTORS | Number 1 | Type | Serial No. |
| | Propellant Class 2 | Propellant Weight 7250 | Motor Case Mat. Steel |
| | Position relative to primed motor Side by side: touching | | |
| | Remarks (including motor deficiencies) Rear bulkhead complete with nozzle bosses (no nozzles) was on this motor. | | |
| WEATHER | Pressure mb 935.7 | Temperature °F 54 | Density Slugs |
| | Humidity 12% | Wind Direction S | Wind Velocity, ft/sec 7 |

| | | |
|---|---|---|
| Conducted by: US NOTS | Test No. 4 | E.S. No. 4261-2 |
| Funds: | Date 20 Nov 1964 | Test Site "C" |

**PRIMED MOTOR**

| | | |
|---|---|---|
| Number 1 | Type | Serial No. |
| Propellant Class 7 | Propellant Weight 7358 | Motor Case Mat. Fiberglass |

Position relative to ground On ground: horizontal

Position of main motor axis Horizontal; head end NE

Remarks (including motor deficiencies) No nozzles on this motor.

**PRIMING SYSTEM**

| | | | |
|---|---|---|---|
| Priming Explosive: | Type C-4 | Amount 96 lbs | Position In grain perforation |
| Detonators: | Type Electric | Number 2 | Position One fore; one aft |

Remarks

**ACCEPTOR MOTORS**

| | | |
|---|---|---|
| Number 1 | Type | Serial No. |
| Propellant Class 2 | Propellant Weight 7250 | Motor Case Mat. Steel |

Position relative to primed motor Side by side: touching

Remarks (including motor deficiencies) No rear bulkhead in this motor.

**WEATHER**

| | | |
|---|---|---|
| Pressure mb 943.7 | Temperature °F 55 | Density Slugs |
| Humidity 22 | Wind Direction Calm | Wind Velocity, ft/sec -- |

| | | |
|---|---|---|
| Conducted by: US NOTS | Test No. 5 | E.S. No. 5001 |
| Funds: | Date 8 Jan 1965 | Test Site Victor "C" |

**PRIMED MOTOR**

| | | |
|---|---|---|
| Number 1 | Type | Serial No. |
| Propellant Class 7 | Propellant Weight 7358 | Motor Case Mat. Fiberglass |

Position relative to ground Above ground, resting on acceptor motor

Position of main motor axis Vertical, head end down

Remarks (including motor deficiencies)

**PRIMING SYSTEM**

| | | | |
|---|---|---|---|
| Priming Explosive: | Type C-4 | Amount 96 lbs | Position Grain perforation |
| Detonators: | Type Electric | Number 2 | Position One fore; one aft |

Remarks

**ACCEPTOR MOTORS**

| | | |
|---|---|---|
| Number 1 | Type | Serial No. |
| Propellant Class 2 | Propellant Weight 7250 | Motor Case Mat. Steel |

Position relative to primed motor On ground; vertical head end up

Remarks (including motor deficiencies)

**WEATHER**

| | | |
|---|---|---|
| Pressure mb 941.2 | Temperature °F 45 | Density Slugs |
| Humidity 30% | Wind Direction 100° | Wind Velocity, ft/sec 5 |

| | | |
|---|---|---|
| Conducted by: US NOTS | Test No. 6 | E.S. No. 5058 |
| Funds: | Date 16 Mar 1965 | Test Site C |

**PRIMED MOTOR**

| | | |
|---|---|---|
| Number 2 | Type | Serial No. |
| Propellant Class 2 | Propellant Weight 14,500 | Motor Case Mat. Steel |

Position relative to ground On ground - horizontal - side-by-side

Position of main motor axis Horizontal - head ends NE

Remarks (including motor deficiencies) No nozzles on either motor.

**PRIMING SYSTEM**

| | | | |
|---|---|---|---|
| Priming Explosive: | Type C-4 | Amount 96#/motor | Position Grain perforation |
| Detonators: | Type Electric | Number 2/motor | Position One fore; one aft |

Remarks

**ACCEPTOR MOTORS**

| | | |
|---|---|---|
| Number | Type | Serial No. |
| Propellant Class | Propellant Weight | Motor Case Mat. |

Position relative to primed motor

Remarks (including motor deficiencies)

**WEATHER**

| | | |
|---|---|---|
| Pressure mb 937.1 | Temperature °F 70.5 | Density Slugs 0.00215 |
| Humidity 16% | Wind Direction Calm | Wind Velocity, ft/sec calm |

| | | |
|---|---|---|
| Conducted by: US NOTS | Test No. 7 | E.S. No. 5065 |
| Funds: | Date 17 Mar 1965 | Test Site C |

**PRIMED MOTOR**

| | | |
|---|---|---|
| Number 1 | Type | Serial No. |
| Propellant Class 7 | Propellant Weight 7358 | Motor Case Mat. Fiberglass |

Position relative to ground On top of acceptor - 6' above ground

Position of main motor axis Vertical

Remarks (including motor deficiencies) There were no nozzles on this motor.

**PRIMING SYSTEM**

| | | | |
|---|---|---|---|
| Priming Explosive: | Type Comp B | Amount 100# | Position On top of donor motor |
| Detonators: | Type Electric | Number 2 | Position On top of primer charge |

Remarks

**ACCEPTOR MOTORS**

| | | |
|---|---|---|
| Number 1 | Type | Serial No. |
| Propellant Class 2 | Propellant Weight 7250# | Motor Case Mat. Steel |

Position relative to primed motor On ground directly under donor.

Remarks (including motor deficiencies)

**WEATHER**

| | | |
|---|---|---|
| Pressure mb 935.9 | Temperature °F 72.5 | Density Slugs 0.00215 |
| Humidity 14% | Wind Direction 125° | Wind Velocity, ft/sec 10 |

| | | |
|---|---|---|
| Conducted by: US NOTS | Test No. Calibration-A | E.S. No. 4262 |
| Funds: | Date 25 Nov 1964 | Test Site Victor "C" |

**PRIMED MOTOR**

| | | |
|---|---|---|
| Number 216 cans | Type Reclaimed Comp. B | Serial No. |
| Propellant Class | Propellant Weight 10,260 | Motor Case Mat. |

Position relative to ground On pallets

Position of main motor axis

Remarks (including motor deficiencies) 216 metal cans 9x9x9 in. Stack was 9 cans x 6 cans x 4 cans high.

**PRIMING SYSTEM**

| | | | |
|---|---|---|---|
| Priming Explosive: | Type C-4 | Amount 80 lbs | Position Each side |
| Detonators: | Type Electric | Number 4 | Position 2/each primer chg. |

Remarks

**ACCEPTOR MOTORS**

| | | |
|---|---|---|
| Number | Type | Serial No. |
| Propellant Class | Propellant Weight | Motor Case Mat. |

Position relative to primed motor

Remarks (including motor deficiencies)

**WEATHER**

| | | |
|---|---|---|
| Pressure mb 933.1 | Temperature °F 64 | Density Slugs |
| Humidity 18 | Wind Direction E | Wind Velocity, ft/sec 3.5 |

| | | |
|---|---|---|
| Conducted by: US NOTS | Test No. Calibration B | E.S. No. 5064 |
| Funds: | Date 19 Mar 1965 | Test Site C |

**PRIMED MOTOR**

| | | |
|---|---|---|
| Number 213 boxes | Type Flake TNT | Serial No. |
| Propellant Class | Propellant Weight 10,650 | Motor Case Mat. |

Position relative to ground Loose in one large wooden box

Position of main motor axis Box oriented NEXSW

Remarks (including motor deficiencies) 10 boxes, containing 500#, were stacked on top of the loose TNT.

**PRIMING SYSTEM**

| | | | |
|---|---|---|---|
| Priming Explosive: | Type C-4 | Amount 96# | Position E of box |
| Detonators: | Type Electric | Number 2 | Position One fore; one aft |

Remarks The 96# of priming explosive were contained in a 6-in. x 6-in. wooden box which extended from one end to the other at the exact center of the main explosive charge.

**ACCEPTOR MOTORS**

| | | |
|---|---|---|
| Number | Type | Serial No. |
| Propellant Class | Propellant Weight | Motor Case Mat. |

Position relative to primed motor

Remarks (including motor deficiencies)

**WEATHER**

| | | |
|---|---|---|
| Pressure mb 940.0 | Temperature °F 65 | Density Slugs |
| Humidity 13% | Wind Direction 150° | Wind Velocity, ft/sec 3.4 |

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| Ballistics Research Lab Memorandum Report 1S18, dated April 1964, used as comparison reference. | ASESB<br>Department of Defnese, Washington, D. C. 2031S |

13. ABSTRACT


ABSTRACT. From November 1964 to 19 March 196S seven solid propellant motor hazard tests and two high explosive calibration tests were conducted at the U. S. Naval Ordnance Test Station, China Lake, California. The primary purpose of the tests was to assess the blast yield of two classes of solid propellant material, when subjected to severe explosive shock, and to compare the propellant blast yields to those produced by a standard explosive. The following yields, in percent of TNT equivalency by weight, were determined from overpressure and impulse data from a blast gage array: The highest yield of class 2 propellants tested alone approximated 40%; class 7 propellants tested alone produced well over 100%; and a combination of equal amounts of each class produced approximately 100%. The quantity and dispersion of fragments varied widely with the propellants used and with the test configuration.

Additional tests are planned using different motor configurations, different propellants, and varying explosive stimuli.


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Unclassified
Security Classification

| 14. KEY WORDS | LINK A ROLE | LINK A WT | LINK B ROLE | LINK B WT | LINK C ROLE | LINK C WT |
|---|---|---|---|---|---|---|
| Propellant hazard | | | | | | |
| Explosive equivalency | | | | | | |
| Rocket motor safety | | | | | | |

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