

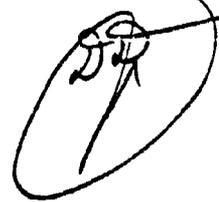
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## HIGH EXPLOSIVE EQUIVALENCY TESTS OF LARGE SOLID PROPELLANT MOTORS

by

URS Systems Corporation  
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Systems Development Department

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**ABSTRACT.** From June 1965 to February 1968, nine solid propellant motor hazard tests and six high-explosive tests were conducted at the Naval Weapons Center, China Lake, to evaluate the explosive potential of large Class 2 and Class 7 solid propellant motors. Test parameters which were varied during the program were propellant type, weight, and orientation and explosive booster type and location. The results of these tests, combined with data from seven previous tests conducted at NWC, indicate that, under the stimulus of a relatively small (50 to 100 lb) explosive booster, the Class 7 motors tested are capable of producing blast yields averaging 130% of TNT, and the Class 2 motors produced yields as large as 40%. When a Class 7 motor with an explosive booster was placed in intimate contact with a Class 2 motor, yields, based on the total propellant weight, ranged from 105 to 123%. The estimated yields for the Class 2 motors alone ranged from 87 to 119%. In tests in which a Class 7 motor with an explosive booster was placed near, but not in intimate contact with, a Class 2 motor, the estimated yields for the Class 2 motors alone ranged from 30 to 50%, considerably lower than the yields obtained in the intimate-contact tests. The separation distances used ranged from 3 to 18 inches.



**NAVAL WEAPONS CENTER**  
CHINA LAKE, CALIFORNIA \* SEPTEMBER 1968

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## CONTENTS

|   |    |
|---|----|
| Introduction . . . . .                          | 1  |
| Motor Tests . . . . .                           | 1  |
| High Explosive Tests . . . . .                  | 5  |
| Test Layout and Instrumentation . . . . .       | 7  |
| Summary of High Explosive Test Results. . . . . | 7  |
| Motor Hazard Test Results. . . . .              | 11 |
| Blast Data . . . . .                            | 11 |
| Tests 8, 9, and 12 . . . . .                    | 13 |
| Tests 10, 11, 13, and 16 . . . . .              | 14 |
| Tests 14 and 15 . . . . .                       | 16 |
| Fragment Studies . . . . .                      | 16 |
| Observations and Conclusions . . . . .          | 19 |
| Class 7 Propellant Tests . . . . .              | 20 |
| Class 2 Propellant Tests . . . . .              | 20 |
| Combined Propellant Tests . . . . .             | 21 |
| Summary. . . . .                                | 22 |
| Appendix . . . . .                              | 23 |
| References . . . . .                            | 45 |

## Figures:

|   |    |
|---|----|
| 1. Test Configurations for Tests 8, 9, and 12 . . . . .                             | 2  |
| 2. Test Configurations for Tests 10, 11, 13, and 16 . . . . .                       | 4  |
| 3. Test Configurations for Tests 14 and 15. . . . .                                 | 5  |
| 4. Test Configurations for Tests 1C, 2C, 3C, 4C, 5C, and 6C . . . . .               | 6  |
| 5. Overpressure Gage Layout for Motor Hazard Tests . . . . .                        | 8  |
| 6. Summary of Peak Overpressure Data From High Explosive Tests . . . . .            | 9  |
| 7. Summary of Positive-Phase-Impulse Data From High Explosive Tests . . . . .       | 10 |
| 8. Crater Profiles for Motor Tests Conducted With Axes Horizontal . . . . .         | 13 |
| 9. Crater Profiles for Motor Tests Conducted With Axes Vertical . . . . .           | 15 |
| 10. Fragment Density by Frequency Versus Ground Range for Test 13 . . . . .         | 17 |
| 11. Fragment Density by Weight Versus Ground Range for Test 13 . . . . .            | 17 |
| 12. Photographs of Some Individual Fragments Found After Test 8 . . . . .           | 18 |
| 13. Orthogonal Profiles of Craters From Tests 1C, 2C, and 5C . . . . .              | 39 |
| 14. Orthogonal Profiles of Craters From Tests 3C, 4C, and 6C . . . . .              | 40 |
| 15. Posttest Ground Zero Photographs for TNT Reference Tests 1C Through 6C. . . . . | 41 |
| 16. Posttest Ground Zero Photographs for Tests 8, 9, and 12 . . . . .               | 42 |
| 17. Posttest Ground Zero Photographs for Tests 10, 11, 13, and 16 . . . . .         | 43 |
| 18. Posttest Ground Zero Photographs for Tests 14 and 15 . . . . .                  | 44 |

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Tables:

|   |    |
|---|----|
| 1. Summary of Tests . . . . .   | 12 |
| 2. Summary of Tests From Reference 1 . . . . .  | 19 |
| 3. Peak Overpressure and Positive-Phase-Impulse Data From<br>High-Explosive Test 1C . . . . . | 24 |
| 4. Peak Overpressure and Positive-Phase-Impulse Data From<br>High-Explosive Test 2C . . . . . | 25 |
| 5. Peak Overpressure and Positive-Phase-Impulse Data From<br>High-Explosive Test 3C . . . . . | 26 |
| 6. Peak Overpressure and Positive-Phase-Impulse Data From<br>High-Explosive Test 4C . . . . . | 27 |
| 7. Peak Overpressure and Positive-Phase-Impulse Data From<br>High-Explosive Test 5C . . . . . | 28 |
| 8. Peak Overpressure and Positive-Phase-Impulse Data From<br>High-Explosive Test 6C . . . . . | 29 |
| 9. Peak Overpressure and Positive-Phase-Impulse Data From Motor Hazard Test 8 . . . . .       | 30 |
| 10. Peak Overpressure and Positive-Phase-Impulse Data From Motor Hazard Test 9 . . . . .      | 31 |
| 11. Peak Overpressure and Positive-Phase-Impulse Data From Motor Hazard Test 10 . . . . .     | 32 |
| 12. Peak Overpressure and Positive-Phase-Impulse Data From Motor Hazard Test 11 . . . . .     | 33 |
| 13. Peak Overpressure and Positive-Phase-Impulse Data From Motor Hazard Test 12 . . . . .     | 34 |
| 14. Peak Overpressure and Positive-Phase-Impulse Data From Motor Hazard Test 13 . . . . .     | 35 |
| 15. Peak Overpressure and Positive-Phase-Impulse Data From Motor Hazard Test 14 . . . . .     | 36 |
| 16. Peak Overpressure and Positive-Phase-Impulse Data From Motor Hazard Test 15 . . . . .     | 37 |
| 17. Peak Overpressure and Positive-Phase-Impulse Data From Motor Hazard Test 16 . . . . .     | 38 |

## INTRODUCTION

This report presents the data from nine propellant and six TNT high explosive tests conducted to evaluate the explosive potential of large Class 2 and Class 7 solid-propellant Minuteman and Polaris missile motors. The tests are part of a continuing series of solid-propellant motor hazard tests being conducted at the Naval Weapons Center, under the auspices of the Armed Services Explosive Safety Board (ASESB).

Seven previous tests, conducted in late 1964 and early 1965, are described in Ref. 1. The results of those tests indicated that under the stimulus of a strong explosive booster, the Class 7 propellant motors tested were capable of producing blast yields exceeding that of TNT, with the Class 2 propellant motors also being capable of producing significant blast yields. In the majority of these early tests, the explosive boosters were placed in the grain perforation in the propellant, which tended to maximize the opportunity for a high-order detonation.

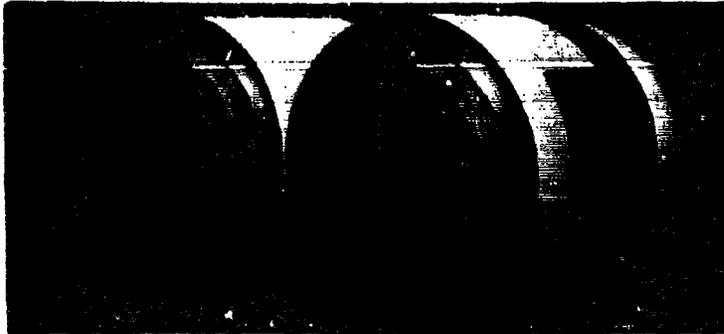
## MOTOR TESTS

Motor tests 8 through 16, described in this report, were of the same general type as the seven earlier tests, except that emphasis was placed on more credible donor-acceptor geometries, in which the explosive boosters were placed external to the motors. Test configurations and parameters, plus estimated yield are listed in Table 1 under test results, page 12.

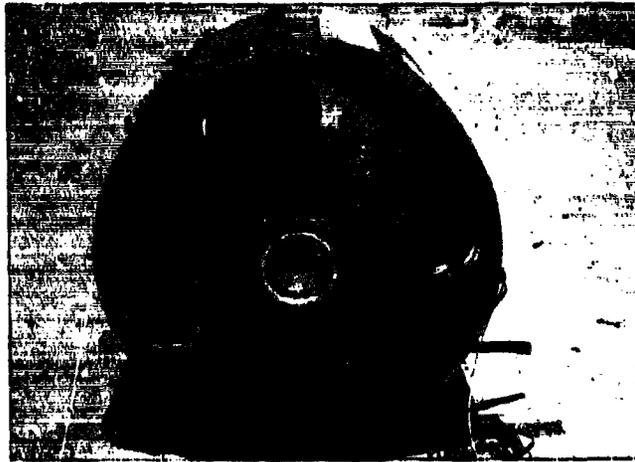
For tests 8\*, 9, and 12, the solid propellant motors were placed horizontally, and the explosive boosters were placed directly in the grain perforation of the propellant. Photographs of these test configurations are shown in Fig. 1. In test No. 8, two second-stage Polaris motors, each containing 7,260 lb of Class 2 propellant, were positioned side by side in contact with each other, and

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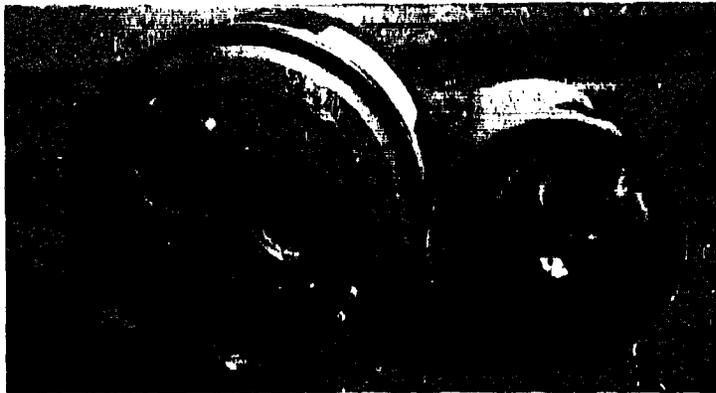
\* Tests 1 through 7 were conducted in an earlier series described in Ref. 1; a summary of the results of the earlier tests, using the same criteria as were used in Table 1, is presented in Table 2, page 19.



LNL 10873



LNL 10744



LNL 11871

FIG. 1. Test Configurations for Tests 8, 9, and 12.

a 48-lb charge of Aerex\* was placed in the grain of the propellant of each motor. A single third-stage Minuteman motor with 3,665 lb of Class 7 propellant and a 48-lb C-4 booster was used in test No. 9, and test No. 12 consisted of an unprimed second-stage Polaris motor with 7,250 lb of Class 2 propellant as an acceptor, in contact with a third-stage Minuteman motor, containing 3,665 lb of Class 7 propellant, used as the donor. The Class 7 motor was primed with a 48-lb C-4 booster placed in the grain perforation.

In tests 10, 11, 13, and 16, solid propellant motors were placed (or stacked) vertically, and the explosive booster was placed external to the motors and on top of the uppermost stage, as shown in Fig. 2. A single third-stage Minuteman motor containing 3,665 lb of Class 7 propellant was used in test No. 10, and two third-stage Minuteman motors, each with 3,665 lb of Class 7 propellant were stacked vertically for test No. 11. A single 50-lb C-4 explosive booster was used in each of the two tests.

In tests 13 and 16, a second-stage Polaris motor with 8,870 lb of Class 7 propellant was placed on top of a first-stage Polaris motor with 15,200 lb of Class 2 propellant. In test No. 13, the normal interstage hardware, which provides a clearance of 14 in. between the closest points on the bulkheads between the two motors, was used; in test No. 16, a shortened interstage was used to separate these parts by only 3 in. A 96-lb C-4 booster was used for each of the tests.

A three-stage, Wing 1 Minuteman missile (Fig. 3) was used in each of tests 14 and 15. The first-stage contained 45,040 lb of Class 2 propellant, the second-stage contained 10,250 lb of Class 2 propellant, and the third-stage contained 3,665 lb of Class 7 propellant. Normal interstage hardware, which provides clearances of 32 in. between the closest points on the bulkhead between the first and second stages and 18 in. between the second and third stages, was used in test No. 14; and in test No. 15, a shortened interstage was used to separate these parts by 8 and 9 in., respectively. A 48-lb C-4 booster was used for each test.

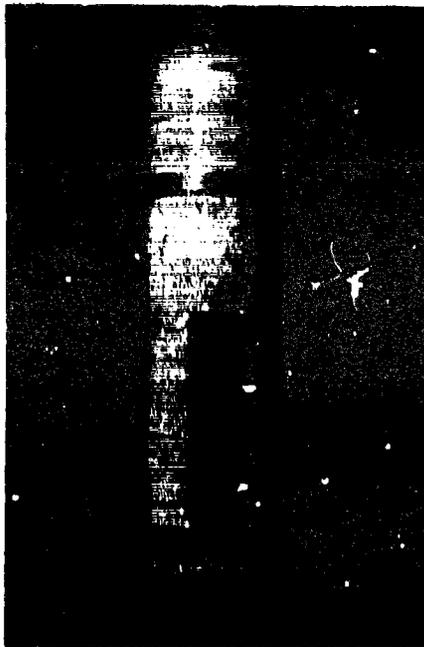
\* Manufactured by the Aerojet General Corporation.



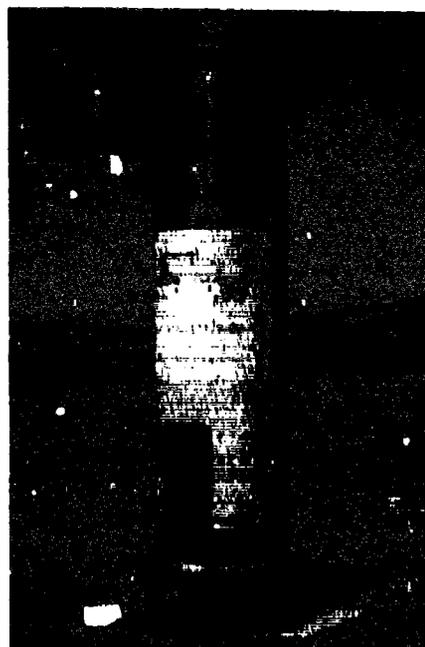
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LNL 107477



LNL 107488

FIG. 2. Test Configurations for Tests 10, 11, 13, and 16.



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LNL 128802

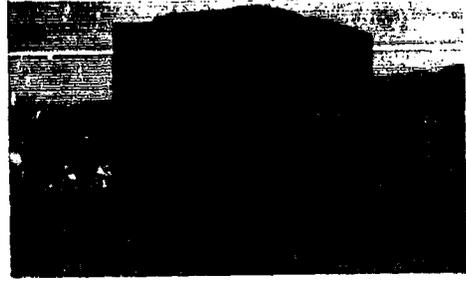
FIG. 3. Test Configurations for Tests 14 and 15.

#### HIGH EXPLOSIVE TESTS

During this program, six TNT high explosive tests (labeled 1C through 6C to distinguish them from the first series of motor tests) were conducted to check out the blast instrumentation systems and test procedures and to obtain information on the effects of charge geometry on air blast measurements. Photographs of the explosive test configurations are presented in Fig. 4.



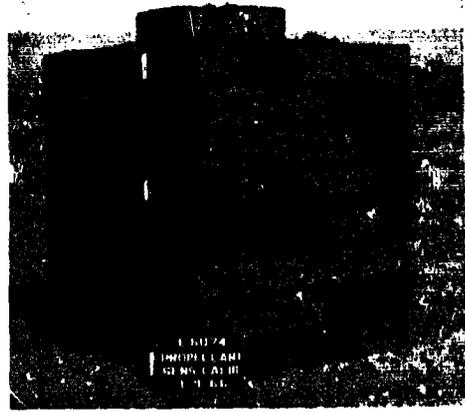
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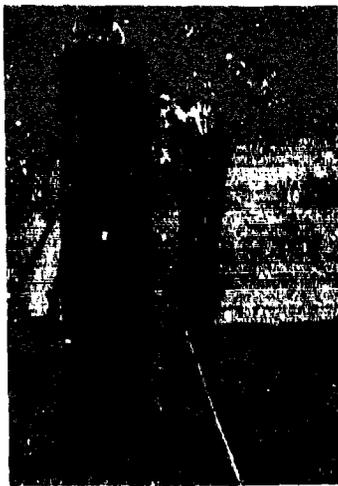
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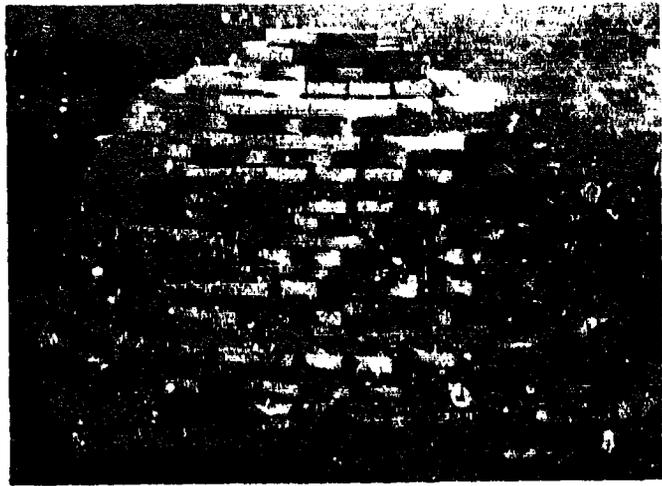
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LNL 11249



LNL 13086

FIG. 4. Test Configurations for Tests 1C, 2C, 3C, 4C, 5C, and 6C.

For tests 1C through 5C, reclaimed TNT was cast in cut-down ammunition boxes with each box containing 50 lb of explosive. In tests 1C, 2C, 3C, and 4C, the boxes were stacked to approximate cubes, with explosive weights of 5,000 lb for test 1C; 20,000 lb for test 2C; and 10,000 lb for tests 3C and 4C. For test 5C, 20,000 lb of TNT was stacked in a configuration approximately 4 ft square and 25 ft high. Test 6C consisted of 10,000 lb of TNT in bare 8-lb blocks stacked in a hemispherical configuration.

### TEST LAYOUT AND INSTRUMENTATION

The general test layout and pressure gage station locations are shown graphically in Fig. 5. Not all gage stations shown were used for every test; however, at least one gage was located at each of seven or more different ground ranges on both legs for every test. Four different types of blast gages were used to measure the overpressure-time pulses: Ballistic Research Laboratory (BRL) mechanical PHS gages, BRL mechanical PNS gages, Kistler piezoelectric gages, and Schaevitz-Bytrex piezoresistance gages. Because of the difference in response time, the Kistler and Schaevitz-Bytrex gages were used relatively close in, PNS gages were located at mid-range, and PHS gages were used in the more distant locations.

### SUMMARY OF HIGH EXPLOSIVE TEST RESULTS

The individual measured peak overpressure and positive-phase-impulse values obtained from the six high explosive tests are presented in Tables 3 through 17 in the appendix of this report, which also contains posttest photos showing the craters resulting from the explosions and sketches of the crater profiles. The data are summarized in Fig. 6, in which peak overpressure is plotted as a function of scaled distance using reference curves from Ref. 2; and in Fig. 7, in which positive-phase-impulse values are also plotted as a function of scaled distance, using reference curves from Ref. 3. It will be noted that, with the exception of the hemispherical charge data, the close-in test data tend to deviate considerably from the reference curves but, at around 10 psi and below, the agreement is quite good. This departure from the reference curve close to the charge is probably not too surprising considering the nonsymmetrical square and rectangular cross-sectional charge geometries used and the fact that the TNT was cased in wooden boxes.

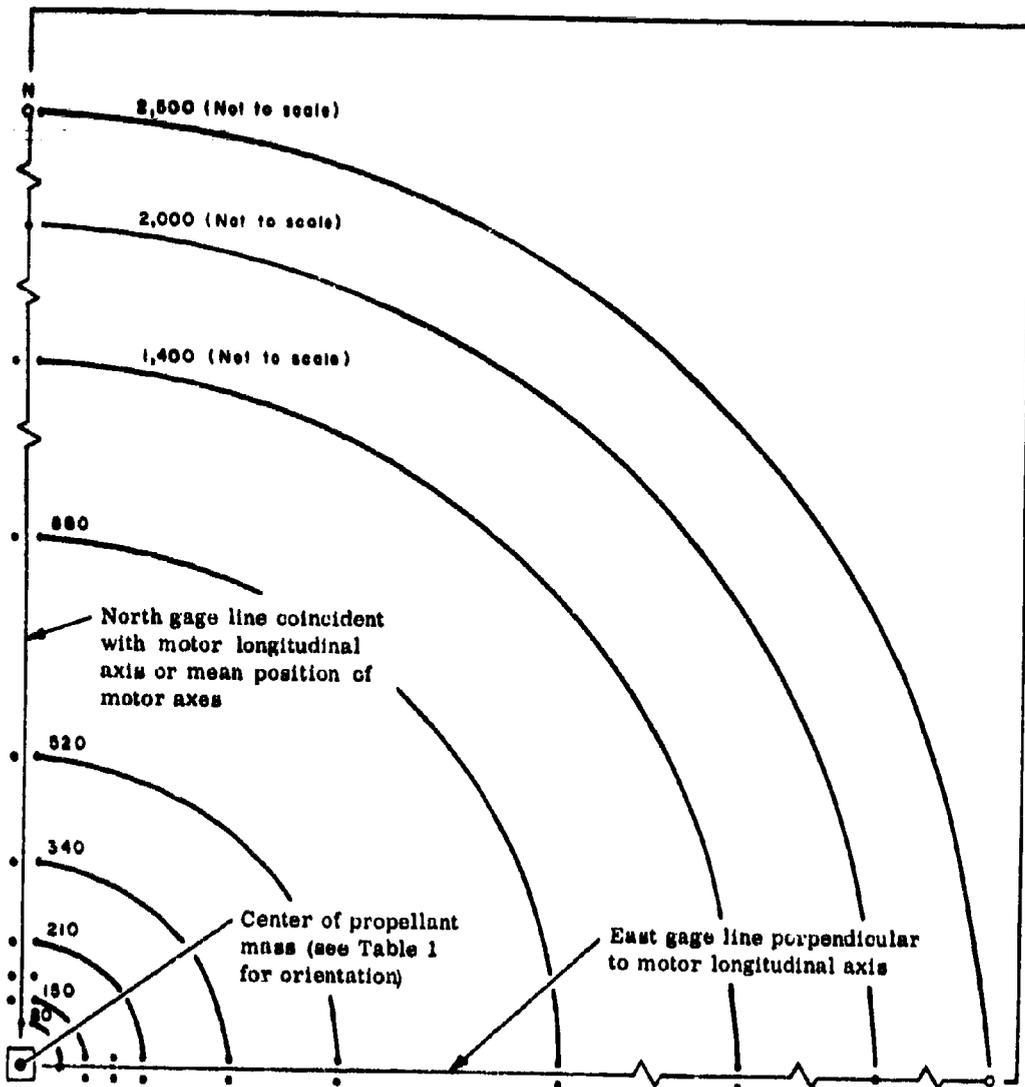


FIG. 5. Overpressure Gage Layout for Motor Hazard Tests.

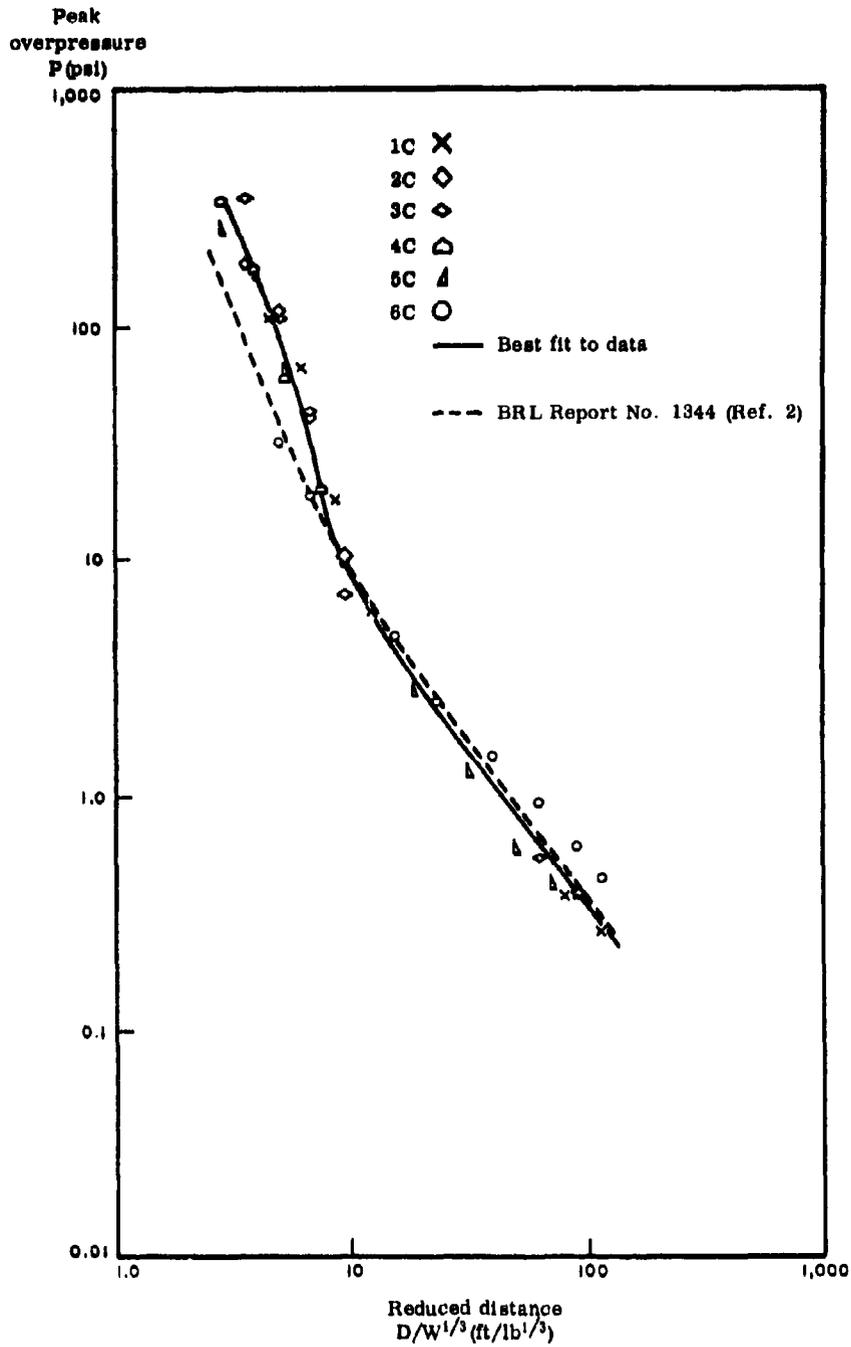


FIG. 6. Summary of Peak Overpressure Data From High Explosive Tests.

Impulse/dist.  
(psi-msec/ft)

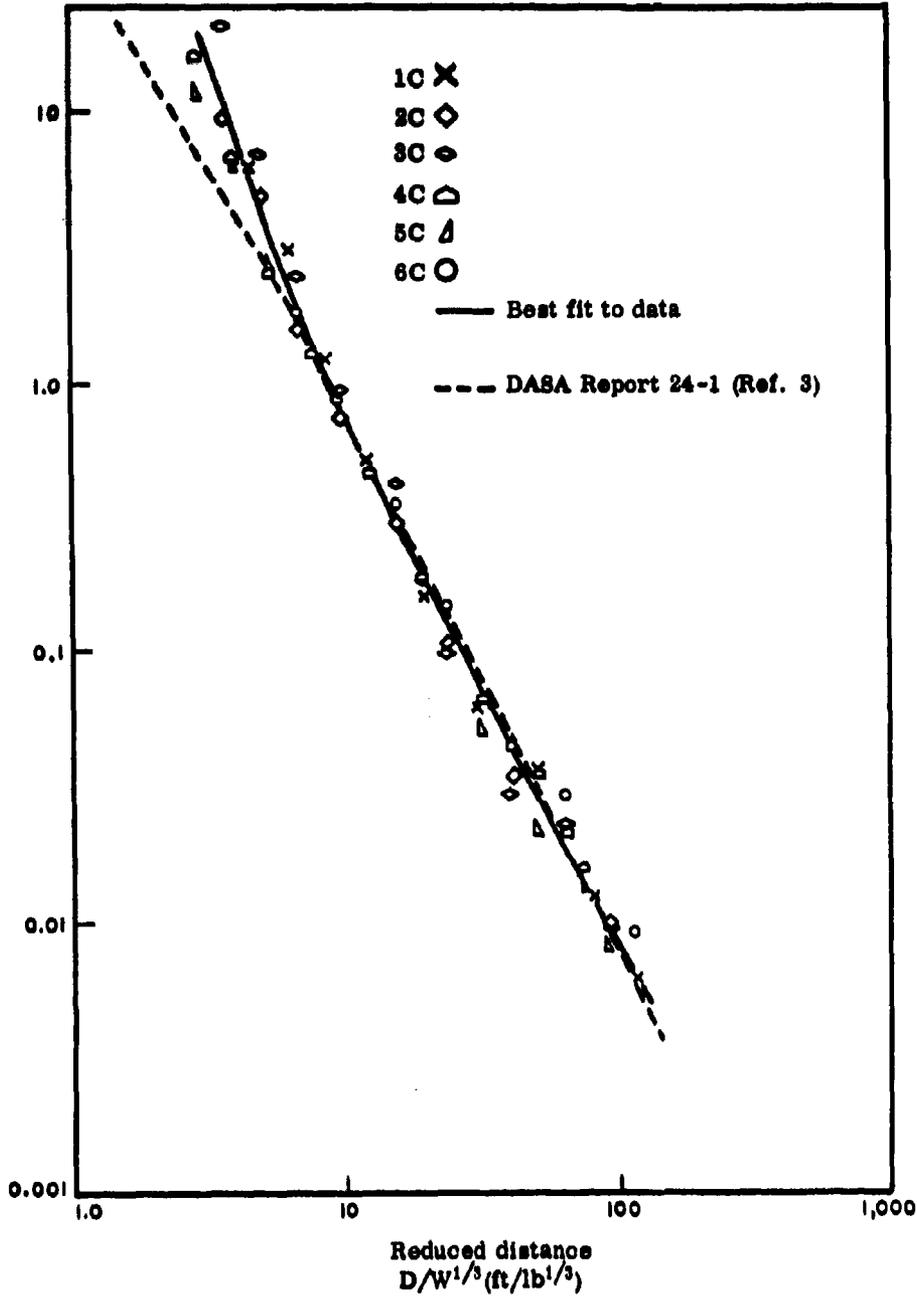


FIG. 7. Summary of Positive-Phase-Impulse Data From High Explosive Tests.

## MOTOR HAZARD TEST RESULTS

## BLAST DATA

A summary of the nine motor hazard tests conducted during this series is presented in Table 1. The explosive yields, which are expressed relative to TNT, were computed by first finding the weight of TNT that, if put in the same position, would produce the same value of the shock wave parameter (peak overpressure or positive-phase impulse) at the same distance as for the propellant explosion.\* This TNT weight was then divided by the total propellant weight\*\* and multiplied by 100 to convert to percent. In many cases, however, the explosive behavior of the propellant mixtures was a function of distance and could not be represented easily by a single value applicable to all distances.

This behavior appeared to take two general forms. For the higher yield tests (> 100%), both the peak overpressure and positive-phase impulse yields tended to decrease with increasing distance, with the yields tending toward a constant value (terminal yield) at long distances. In the lower yield tests (<100%), the positive-phase impulse yields indicated a similar trend; however, the peak overpressure yields tended to increase with increasing distance. An exception to this was in the tests in which the explosive was centered several charge diameters off the ground surface. In these tests, the peak overpressure yields decreased and the positive-phase impulse yields increased with increasing distance. Because of this yield variation with distance and, occasionally, the variation in the shock wave parameter used in the computation, the following method of data presentation has been adopted. For those tests in which the yields computed from the peak overpressure and positive-phase impulse values tended to seek a constant or terminal value, this number is used. For those motor tests in which the peak overpressure and positive-phase impulse yield values did not reach a constant value within the range of measuring stations used, no terminal yield could be determined, and the value quoted was estimated from the higher of the two yields, either peak overpressure or impulse.

From the individual peak overpressure and positive-phase impulse values for each test presented in the appendix, it will be noted that there was considerable scatter in the data, which affects the reliability of the explosive yield values discussed above. Consequently, the standard deviations of the mean yield values were computed for each test as shown in Table 1.

\* The reference data used for this computation were obtained from Ref. 2 for peak overpressure and Ref. 3 for positive-phase impulse.

\*\* The booster weights, which range from 48 to 96 lb, were not included in this computation.

TABLE 1. Summary of Tests

| Test No.     | Test <sup>*</sup> configuration   | Propellant class | Propellant wt (to nearest 5 lb) | Booster         | Estimated <sup>**</sup> yield (%) |
|--------------|---|------------------|---------------------------------|-----------------|-----------------------------------|
| 8 (ES-5203)  |      | 2                | 14,300                          | 2 - 48 lb Aerex | 1.4 ± 0.2 (I)                     |
| 9 (ES-5276)  |      | 7                | 3,665                           | 1 - 48 lb C-4   | 125 ± 8 (T)                       |
| 10 (ES-5277) |      | 7                | 3,665                           | 1 - 50 lb C-4   | 120 ± 13 (I)                      |
| 11 (ES-5278) |      | 7                | 7,330                           | 1 - 50 lb C-4   | 124 ± 12 (I)                      |
| 12 (ES-6068) |    | 2                | 7,250                           | 1 - 48 lb C-4   | 105 ± 3 (T)                       |
|              |   | 7                | 3,665                           |                 |                                   |
| 13 (ES-7040) |  A | 7                | 8,870                           | 1 - 96 lb C-4   | 73 ± 6 (T)                        |
|              |   | 2                | 15,200                          |                 |                                   |
| 14 (ES-7125) |  A | 7                | 3,665                           | 1 - 48 lb C-4   | 13 ± 0.6 (P)                      |
|              |   | 2                | 10,250                          |                 |                                   |
|              |   | 2                | 45,040                          |                 |                                   |
| 15 (ES-7182) |  B | 7                | 3,665                           | 1 - 48 lb C-4   | 16.5 ± 1.3 (P)                    |
|              |   | 2                | 10,250                          |                 |                                   |
|              |   | 2                | 45,040                          |                 |                                   |
| 16 (ES-7217) |  B | 7                | 8,870                           | 1 - 96 lb C-4   | 82 ± 3 (T)                        |
|              |   | 2                | 15,200                          |                 |                                   |

\*A - normal interstage spacing, e - location of booster, B - shortened interstage spacing

\*\*Basis for yield estimate - I-impulse data, P-pressure data, T-both pressure and impulse data (see text). Uncertainty is expressed in terms of the standard deviation of the mean value of the gage readings.

Tests 8, 9, and 12

In these tests, the solid propellant motors were placed with their axes horizontal, and the explosive boosters were placed directly in the grain perforation of the propellant as shown in Fig. 1.

Test 8 consisted of two immediately adjacent second-stage Polaris motors, each containing 7,250 lb of Class 2 propellant and having steel cases. A 48-lb Aerex booster was placed in each motor. In this test, a great deal of burning and unignited fragments of propellant and casing material was scattered over the area, with large pieces of the metal casing being left in and near the crater. Although the crater (Fig. 8) was indicated to be approximately 10 ft in diameter and about 1 ft deep, no profile was given. The volume was estimated as 100 cu ft by assuming the crater profile to be as shown. The estimated terminal yield, based on a total propellant weight of 14,500 lb, was 1.4 percent.

Test 9 was a single third-stage Minuteman motor containing 3,665 lb of Class 7 propellant in a fiberglass casing, and with a 48-lb C-4 booster charge placed in the grain of the propellant. No burning fragments were visible in the films of the test, and no casing fragments were found. The crater shown in Fig. 8 was about 28 ft in diameter, had a maximum depth of 3 ft below the initial ground surface, and had an estimated volume of about 800 cu ft. The estimated terminal yield for this test was 125 percent.

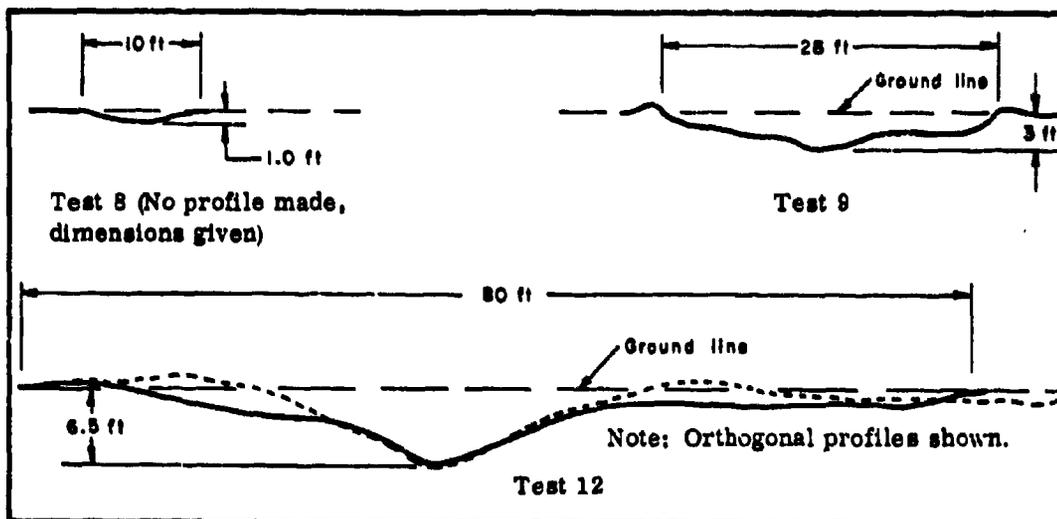


FIG. 8. Crater Profiles for Motor Tests Conducted With Axes Horizontal.

Test 12 consisted of a motor identical to that used in test 9 placed adjacent to, and in contact with, a steel-cased second-stage Polaris motor containing 7,250 lb of Class 2 propellant. As in test 9, no burning fragments of propellant were observed, and no casing fragments were found, even though a search extended to 5,000 ft from ground zero. The crater was the largest produced in this entire series of motor tests, and its maximum diameter was about 70 ft. The estimated volume was 2,600 cu ft; the estimated terminal yield, based on the total propellant weight of 10,915 lb, was 105 percent.

Tests 10, 11, 13, and 16

In these tests the solid propellant motors were placed vertically, and the explosive boosters were placed external to the motors and on the uppermost stage.

Test 10 used a single third-stage Minuteman motor containing 3,665 lb of Class 7 propellant with a 50-lb C-4 booster placed on top of the motor. With the exception of this external booster and the vertical orientation of the motor axis, this test was similar to test 9. No burning fragments of propellant were observed, and no casing fragments were found. The crater (Fig. 9) was about 28 ft in diameter, the maximum depth was approximately 3 ft, and the volume was on the order of 700 cu ft. The estimated impulse yield was approximately 120 percent, or almost the same yield as obtained in test 9. The crater volumes were also comparable.

In test 11, two Class 7 motors were stacked vertically, with the upper one acting as the donor and the lower one as the acceptor; i. e., only the upper motor was primed with a C-4 booster (see Table 1). Again, no fragments were observed. The approximate crater dimensions were 28 ft diameter and 4 ft depth (Fig. 9). The estimated volume was 800 cu ft; the estimated impulse yield, based on a total propellant weight of 7,330 lb, was approximately 124 percent, or essentially the same as for test 10. Though the effective TNT weight (and the actual propellant weight) was twice that of test 10, the crater volume was only slightly larger. This is not too surprising since the effective scaled height of the explosion burst was at least twice as large as for test 10.

In test 13, a second-stage Polaris motor containing 8,870 lb of Class 7 propellant was placed on top of a first-stage Polaris motor with 15,200 lb of Class 2 propellant, using normal interstage hardware with nozzles which provided a clearance of 14 in. between the closest points on the bulkheads. In this test, burning propellant was scattered over a wide area and pieces of unburned propellant were found out to 1,800 ft. Motor parts were found at distances out to 2,500 ft. No significant crater was formed (Fig. 9), and the estimated terminal yield, based on a total propellant weight of 24,070, was 73 percent.

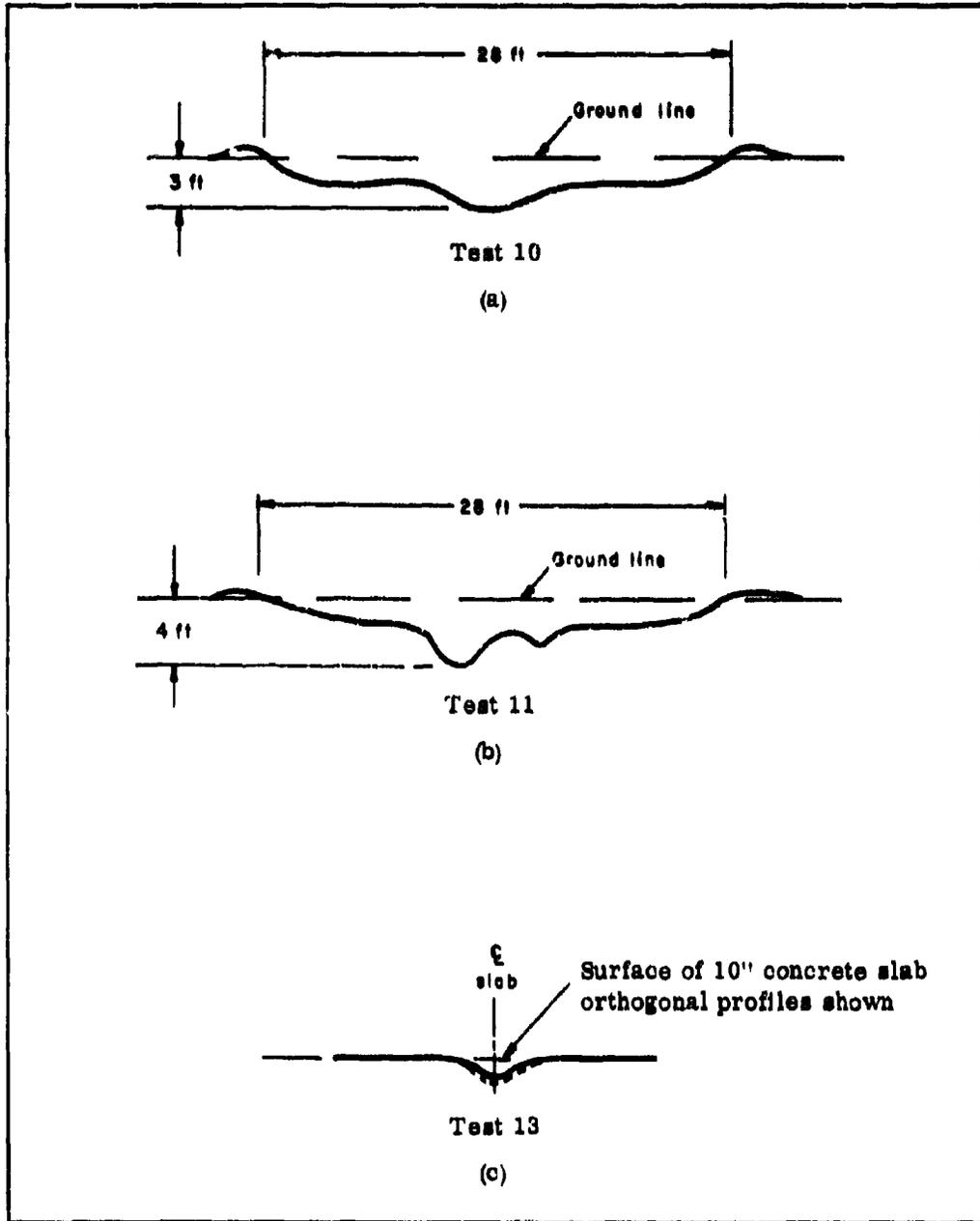


FIG. 9. Crater Profiles for Motor Tests Conducted With Axes Vertical.

Test conditions for test 16 were similar to those of test 13; that is, a 96-lb C-4 explosive booster was used; and an 8,870-lb Class 7 second-stage motor was placed on top of the 15,200-lb, Class 2 first-stage motor. However, a shortened interstage, which provided only 3 in. of separation between the propellants, was used. Burning fragments were thrown out to about 2,000 ft and, again, there was no significant crater. The estimated terminal yield was approximately 82 percent.

#### Tests 14 and 15

A three-stage Wing 1 Minuteman missile was used in each of these tests, with a 48-lb C-4 booster placed on top of the third stage. The first stage of this missile contains 45,040 lb of Class 2 propellant, the second stage 10,250 lb of Class 2 propellant, and the third stage 3,665 lb of Class 7 propellant. In test 14, the normal interstage hardware, which provides clearance of 32 in. between the closest point on the bulkhead between the first and second stages and 18 in. between the second and third stages, was used. The third stage (donor) and part of the second stage (acceptor) were consumed in the explosion. The first stage fell over and burned for approximately 4 minutes. There was no crater. The estimated terminal yield, based on the total weight of 58,955 lb of propellant, was 13 percent. However, if only the weight of the second and third stages (13,915 lb) is considered, since the first stage apparently merely burned, the estimated pressure yield is 53 percent.

In test 15, shortened interstage hardware was used, which reduced the clearance between the first and second stages to 8 in. and the clearance between the second and third stages to 9 in. All other test conditions remained the same as for test 14. Propellant fragments were thrown about 800 ft, and aluminum fragments were thrown to about 800 ft. The first stage fell over and burned, and there was no apparent crater. The estimated pressure yield, based on the total propellant weight of 58,955 lb, was 16.5 percent, not significantly different from that of the same weight of propellant for test 14.

#### FRAGMENT STUDIES

Only those tests involving motors with metal casings resulted in significant fragment debris. After test 13, a detailed search for fragments was made in 200-ft<sup>2</sup> areas laid out along the two gage lines in 20-ft radial increments. A plot of frequency of fragments per 100 ft<sup>2</sup> versus ground range is shown in Fig. 10, in which one curve is plotted for each gage leg and a third is plotted to show the combined data for both legs. Figure 11 shows a corresponding summary

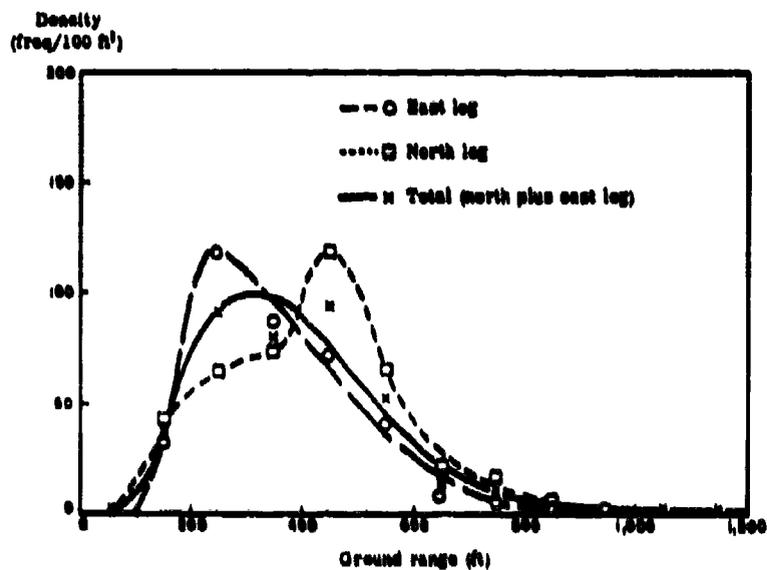


FIG. 10. Fragment Density by Frequency Versus Ground Range for Test 13.

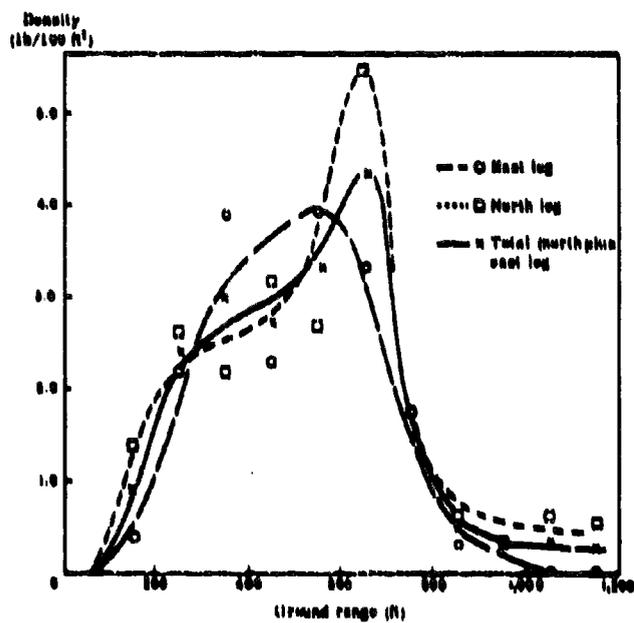


FIG. 11. Fragment Density by Weight Versus Ground Range for Test 13.

based on total weight of fragments per 100-ft<sup>2</sup> area. A comparison of the two sets of data indicates that the larger-size fragments were found at the greater ground distances. A search of the entire area revealed that the maximum ground range for any fragment from this test was 2,510 ft.

For the remainder of the tests, less detailed information was available. Figure 12 shows photographs of individual fragments found after test 8, but a detailed map was not available. Eighteen large pieces of debris were found after test 14 at ground ranges out to about 800 ft. Included were pieces of the second stage. Fourteen large fragments were found after test 15, at a maximum ground range of about 600 ft. Included in fragments from this test was a part of the bottom of the third stage.

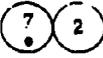
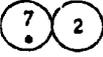
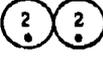


FIG. 12. Photographs of Some Individual Fragments Found After Test 8.

OBSERVATIONS AND CONCLUSIONS

To enable comparison of the data from the seven earlier tests (summarized in Table 2) with the data from the nine tests described in this report, certain of the explosive yield values reported in Ref. 1 have been reevaluated, applying the terminal yield estimation procedures used for the later tests (described on p. 11).

TABLE 2. Summary of Tests From Reference 1

| Test No. | Test configuration  | Propellant |             | Terminal yield (%) |
|----------|---|------------|-------------|--------------------|
|          |   | Class      | Weight (lb) |                    |
| 1        |    | 2          | 7,250       | 25                 |
| 2        |    | 7          | 7,360       | 140                |
| 3        |  | 7          | 7,360       | 123                |
|          |   | 2          | 7,250       |                    |
| 4        |  | 7          | 7,360       | 110                |
|          |   | 2          | 7,250       |                    |
| 5        |  | 7          | 7,360       | 114                |
|          |   | 2          | 7,250       |                    |
| 6        |  | 2          | 14,500      | 40                 |
| 7        |  | 7          | 7,360       | 107                |
|          |   | 2          | 7,250       |                    |

**Class 7 Propellant Tests**

During the two test series, the following four tests were conducted in which Class 7 propellants were tested alone:

| Test No. | Propellant weight (lb) | Booster  |             | Terminal yield (%) |
|----------|------------------------|----------|-------------|--------------------|
|          |                        | Location | Weight (lb) |                    |
| 2        | 7,360                  | Internal | 96          | 140                |
| 9        | 3,665                  | Internal | 48          | 125                |
| 10       | 3,665                  | External | 50          | 120                |
| 11       | 7,330                  | External | 50          | 124                |

It will be noted, that the yields from the three tests in which the booster weighed approximately 50 lb were about the same, and that the yield from the test with the 96-lb booster was slightly, but probably not significantly, larger.

**Class 2 Propellant Tests**

The following three tests were conducted with Class 2 propellants tested alone:

| Test No. | Propellant weight (lb) | Booster  |             | Terminal yield (%) |
|----------|------------------------|----------|-------------|--------------------|
|          |                        | Location | Weight (lb) |                    |
| 1        | 7,250                  | Internal | 96          | 25                 |
| 6        | 14,500                 | Internal | 96*         | 40                 |
| 8        | 14,500                 | Internal | 48*         | 1.4                |

\* in each of two motors

A single motor was used in test 1, and two motors were placed side by side for tests 6 and 8. In tests 1 and 6, each motor contained a 96-lb C-4 booster, and in test 8 each motor contained a 48-lb Aerex booster.

It will be noted that in test 8, with the relatively low detonation velocity explosive, the yield was quite low. The test with one motor and a larger 96-lb booster gave a 25 percent yield, and the test with two motors and the two larger size boosters gave a yield of 40 percent.

**Combined Propellant Tests**

In tests 3, 4, 5, 7, 12, 13, 14, 15, and 16, a Class 7 motor with booster was used as a donor for a Class 2 motor. Using the terminal yields from these nine tests, an estimate has been made of the explosive yield of the Class 2 motors by deducting the estimated yields of the Class 7 donors from the total measured yields, as illustrated below. (The estimated Class 7 yield used was 127 percent, or the average of the yields from tests 2, 9, 10, and 11.)

| Test No. | Class 2 propellant weight (lb) | Class 7 propellant weight (lb) | Booster weight (lb) | Terminal yield (%) | Estimated yield Class 2 propellant (%) * |
|----------|--------------------------------|--------------------------------|---------------------|--------------------|--|
| 3        | 7,250                          | 7,360                          | 96                  | 123                | 119                                      |
| 4        | 7,250                          | 7,360                          | 96                  | 110                | 93                                       |
| 5        | 7,250                          | 7,360                          | 96                  | 114                | 101                                      |
| 7        | 7,250                          | 7,360                          | 100                 | 107                | 87                                       |
| 12       | 7,250                          | 3,665                          | 48                  | 105                | 94                                       |
| 13       | 15,200                         | 8,870                          | 96                  | 73                 | 41                                       |
| 14       | 10,250 & 45,040                | 3,665                          | 48                  | 13                 | 30**                                     |
| 15       | 10,250 & 45,040                | 3,665                          | 48                  | 16.5               | 50**                                     |
| 16       | 15,200                         | 8,870                          | 96                  | 82                 | 56                                       |

\* Yield Class 2 = 
$$\frac{(\text{Total propellant weight})(\text{Terminal yield}) - (1.27)(\text{Class 7 weight})}{\text{Class 2 propellant weight}}$$

\*\* Only the second and third stage propellant weight was used in this computation

It will be noted that the estimated yields for the Class 2 propellant in tests 3, 4, 5, 7, and 12, in which there was intimate contact between the motors, are remarkably similar, ranging from 87 to 119 percent. Either the two motors were laid side by side in contact or, when stacked one on top of the other, their domes were in contact. In tests 13 through 16, however, the motors were not in intimate contact, and the acceptor yields (Class 2 propellant) were considerably lower. In test 13, normal interstage hardware was used, which separated the propellants by 14 in. The acceptor yield of this test was 41 percent. In test 16, the same type motors were used with shortened interstage hardware, which separated the propellants by 3 in., and the yield was 56 percent. Similarly, in test 14, where a separation distance of 18 in. was used between the second and third stages, the acceptor yield was 30 percent, and in test 15, with the same type of second and third stage motors and a separation distance of 9 in., the yield was 50 percent.

#### SUMMARY

The results obtained to date indicate that, under the stimulus of a relatively small (50 to 100 lb) explosive booster, the Class 7 motors tested are capable of producing blast yields averaging 130 percent of TNT.

Under similar test conditions, the Class 2 motors tested produced yields as large as 40 percent.

When a Class 7 motor with an explosive booster is placed in intimate contact with a Class 2 motor, yields, based on the total propellant weight, ranged from 105 to 123 percent. The estimated yields for the Class 2 motors alone in these tests ranged from 87 to 119 percent.

One interesting trend is the reduction in yield when the Class 7 and Class 2 motors are not in intimate contact, but are separated by very small distances.

Appendix

PEAK OVERPRESSURE AND POSITIVE-  
PHASE-IMPULSE DATA

Peak overpressure and positive-phase-impulse data for the six high-explosive and nine motor hazard tests conducted during this series are presented in Tables 3 through 17. Figures 13 and 14 show crater profiles from the high-explosive tests, Fig. 15 includes photographs taken after the high-explosive tests, and Fig. 16-18 are post-test photographs of the motor hazard tests.

TABLE 3. Peak Overpressure and Positive-Phase-Impulse Data From High-Explosive Test 1C

| GROUND RANGE<br>(ft) | PEAK OVERPRESSURES |       | IMPULSE<br>(psi - msec) |       |
|----------------------|--------------------|-------|-------------------------|-------|
|                      | East (psi)         | North | East                    | North |
| 80                   | 131                | 86.2  | 605                     | 375   |
|                      | 134                | 73.2  | 662                     | 344   |
| 110                  | 63.1               | 50.4  | 323                     | 260   |
|                      | 109                | 46.6  | 642                     | 223   |
| 150                  | 17.8               | 18.5  | 198                     | 215   |
|                      |                    | 18.2  |                         | 122   |
| 210                  | 5.80               |       | 108                     |       |
|                      |                    |       |                         |       |
| 340                  | 2.81*              | 2.20* | 54.6                    | 49.0  |
|                      |                    |       |                         |       |
| 520                  | 0.97*              | 1.26* | 30.9                    | 37.3  |
|                      | 1.11*              | 0.81* | 30.0                    |       |
| 880                  | 0.49*              | 0.71* | 19.2                    | 55.4  |
|                      | 0.60*              |       | 26.0                    |       |
| 1400                 | 0.32               | 0.31  | 15.0                    | 13.3  |
|                      | 0.35               | 0.43  | 15.6                    | 17.6  |
| 2000                 | 0.22               | 0.28  |                         | 12.4  |
|                      |                    |       |                         |       |

\*Non-classical multiple peak trace--number quoted is highest peak

TABLE 4. Peak Overpressure and Positive-Phase-Impulse Data From High-Explosive Test 2C

| GROUND RANGE<br>(ft) | PEAK OVERPRESSURES |       | IMPULSE<br>(psi - msec) |       |
|----------------------|--------------------|-------|-------------------------|-------|
|                      | East (psi)         | North | East                    | North |
| 80                   | 274                | 458   | 1280                    |       |
|                      | 337                | 323   | 1273                    |       |
| 110                  | 144                | 204   | 795                     | 813   |
|                      | 145                | 208   | 721                     | 610   |
| 150                  | 56.8               | 63.8  | 378                     | 436   |
|                      | 53.3               | 65.5  | 316                     | 366   |
| 210                  | 15.3               | 23.6  |                         | 262   |
|                      | 19.7               |       |                         |       |
| 340                  | 5.73*              | 5.34* |                         | 110   |
|                      |                    | 5.82* |                         | 223   |
| 520                  | 2.26*              | 3.14* |                         | 122   |
|                      | 2.15*              | 1.90* |                         |       |
| 880                  | 1.22*              | 1.01* |                         | 59.3  |
|                      |                    |       |                         |       |
| 1400                 | 0.56*              | 0.56* |                         | 59.7  |
|                      | 0.55*              | 0.57* |                         | 38.3  |
| 2000                 | 0.63**             | 0.47* |                         | 31.0  |
|                      |                    |       |                         |       |

\* Non-classical multiple peak trace--number quoted is highest peak

TABLE 5. Peak Overpressure and Positive-Phase-Impulse Data From High-Explosive Test 3C

| GROUND RANGE<br>(ft) | PEAK OVERPRESSURES |       | IMPULSE<br>(psi - msec) |       |
|----------------------|--------------------|-------|-------------------------|-------|
|                      | East (psi)         | North | East                    | North |
| 80                   | 374                | 381   | 1273                    | 2028  |
|                      | 391                | 284   | 1554                    | 1705  |
| 110                  | 127                | 109   | 661                     | 963   |
|                      | 117                | 101   | 715                     | 666   |
| 150                  | 30.6               | 37.0  | 294                     | 392   |
|                      | 44.6               | 44.5  | 317                     | 402   |
| 210                  | 8.33*              | 4.49* | 143                     |       |
|                      | 8.10*              |       |                         |       |
| 340                  | 4.13*              | 5.16* | 149                     | 135   |
|                      | 2.80*              | 3.73* |                         |       |
| 520                  | 1.08*              | 1.43* |                         | 49.8  |
|                      | 1.33*              |       |                         |       |
| 880                  | 0.62*              | 0.85* |                         | 37.1  |
|                      | 0.59*              | 0.94* | 17.7                    | 21.3  |
| 1400                 | 0.46               | 0.44  | 24.3                    | 45.7  |
|                      | 0.51               | 0.66  | 24.6                    | 30.9  |
| 2000                 | 0.39               | 0.36  | 17.7                    | 18.5  |
|                      |                    |       |                         |       |

\* Non-classical multiple peak trace--number quoted is highest peak

TABLE G. Peak Overpressure and Positive-Phase-Impulse Data From High-Explosive Test 4C

| GROUND RANGE<br>(ft) | PEAK OVERPRESSURES |       | IMPULSE<br>(psi - msec) |       |
|----------------------|--------------------|-------|-------------------------|-------|
|                      | East (psi)         | North | East                    | North |
| 80                   | 264                | 133   | 564                     | 750   |
|                      | 272                | 133   | 840                     | 650   |
| 110                  | 139                | 124   | 611                     | 485   |
|                      | 110                | 86.4  | 608                     | 397   |
| 150                  | 49.0               | 31.3  | 229                     | 232   |
|                      | 41.6               | 40.3  | 267                     | 199   |
| 210                  | 9.64               | 10.0  | 143                     | 163   |
|                      | 8.98               | 11.5  |                         |       |
| 340                  | 4.71*              | 4.99* | 141                     | 139   |
|                      | 3.98*              | 3.44* | 108                     | 95.4  |
| 320                  | 2.14*              | 1.36* | 53.7                    | 57.0  |
|                      | 2.08*              |       |                         |       |
| 880                  | 1.01*              | 0.65* | 31.7                    | 27.7  |
|                      | 1.04*              | 0.71* | 29.6                    | 31.6  |
| 1400                 | 0.62*              | 0.42* | 21.3                    | 41.1  |
|                      | 0.78*              | 0.48* | 27.3                    |       |
| 2000                 | 0.40*              | 0.38* | 17.0                    | 22.6  |
|                      |                    |       |                         |       |

\*Non-classical multiple peak trace--number quoted is highest peak

TABLE 7. Peak Overpressure and Positive-Phase-Impulse Data From High-Explosive Test 3C

| GROUND RANGE<br>(ft) | PEAK OVERPRESSURES |       | IMPULSE<br>(psi - msec) |       |
|----------------------|--------------------|-------|-------------------------|-------|
|                      | East (psi)         | North | East                    | North |
| 80                   | 258                | 222   | 1043                    | 923   |
|                      | 278                | 299   | 923                     | 814   |
| 110                  | 158                | 171   | 718                     | 692   |
|                      | 169                | 153   | 675                     | 700   |
| 180                  | 67.7               | 66.3  | 386                     | 479   |
|                      | 65.5               | 65.2  | 348                     | 406   |
| 210                  | 22.0               | 18.5  | 278                     | 265   |
|                      |                    | 17.8  |                         | 281   |
| 340                  | 6.46               | 7.78  | 174                     | 182   |
|                      | 6.85               | 7.62  | 140                     | 146   |
| 520                  | 2.93               | 3.00  | 92.0                    | 119   |
|                      | 2.68               | 2.50  | 82.5                    | 87.1  |
| 880                  | 0.95               | 1.65  | 50.9                    |       |
|                      | 1.03               | 1.19  | 39.5                    | 47.0  |
| 1400                 | 0.45               | 0.54  | 20.9                    | 27.2  |
|                      | 0.72               | 0.58  | 40.2                    | 31.4  |
| 2000                 | 0.37               | 0.40  | 25.1                    | 28.5  |
|                      |                    |       |                         |       |
| 2500                 | 0.29               | 0.44  | 17.4                    | 29.4  |
|                      |                    |       |                         |       |

TABLE 8. Peak Overpressure and Positive-Phase-Impulse Data From High-Explosive Test 6C

| GROUND RANGE<br>(ft) | PEAK OVERPRESSURES |           | IMPULSE<br>(psi-msec) |           |
|----------------------|--------------------|-----------|-----------------------|-----------|
|                      | East (psi)         | North     | East                  | North     |
| 110                  | 31.8               |           |                       |           |
|                      |                    |           |                       |           |
| 150                  | 28.0               |           | 275                   |           |
|                      | 18.7               |           | 244                   |           |
| 210                  | 13.1               | 11.9      | 188                   | 191       |
|                      |                    | 8.37      |                       |           |
| 340                  | 4.72               | 4.81      | 119                   | 121       |
|                      | 4.35               | 4.70/4.88 | 119                   | 107/117   |
| 520                  | 2.11               | 2.30      | 60.8                  | 66.3      |
|                      | 2.43               | 2.39/2.44 | 79.9                  | 91.1/85.0 |
| 880                  | 1.22               | 1.43      | 49.8                  | 24.1      |
|                      |                    | 1.41      |                       | 40.8      |
| 1400                 | 0.87               | 0.98      | 39.8                  | 46.2      |
|                      |                    | 0.79      |                       | 39.8      |
| 2000                 | 0.87               |           | 23.4                  |           |
|                      |                    |           |                       |           |
| 2800                 | 0.43               |           | 22.6                  |           |
|                      |                    |           |                       |           |

TABLE 9. Peak Overpressure and Positive-Phase-Impulse Data From Motor Hazard Test 8

| GROUND RANGE<br>(ft) | PEAK OVERPRESSURES |       | IMPULSE<br>(psi - msec) |       |
|----------------------|--------------------|-------|-------------------------|-------|
|                      | East (psi)         | North | East                    | North |
| 80                   | 9.33               |       |                         |       |
|                      |                    |       |                         |       |
| 110                  | 2.19               | 1.81  | 38.0                    | 18.9  |
|                      |                    |       |                         | 30.7  |
| 150                  | 2.58               | 1.13  |                         |       |
|                      | 2.31               | 1.79  |                         |       |
| 210                  | 1.58               |       | 15.7                    |       |
|                      | 1.58               |       | 20.7                    |       |
| 340                  |                    | 0.74  |                         | 7.01  |
|                      | 0.87               | 0.45  | 9.05                    | 4.70  |
| 520                  | 0.33               | 0.27  | 4.63                    | 3.08  |
|                      |                    | 0.31  |                         | 4.13  |
| 880                  | 0.21               | 0.14  | 3.44                    | 2.38  |
|                      |                    | 0.20  |                         | 2.67  |
| 1400                 | 0.20               | 0.17  | 3.63                    | 2.66  |
|                      |                    |       |                         |       |
| 2000                 | 0.06               | 0.04  | 1.70                    | 1.08  |
|                      |                    |       |                         |       |

TABLE 10. Peak Overpressure and Positive-Phase-Impulse Data From Motor Hazard Test 9

| GROUND RANGE<br>(ft) | PEAK OVERPRESSURES<br>(psi) |           | IMPULSE<br>(psi - msec) |          |
|----------------------|-----------------------------|-----------|-------------------------|----------|
|                      | East                        | North     | East                    | North    |
| 80                   |                             | 120       | 700                     |          |
|                      |                             |           |                         |          |
| 110                  | 77.2                        | 31.2      | 490                     | 290      |
|                      | 53.5                        |           | 365                     |          |
| 150                  | 12.2                        |           | 236                     | 211      |
|                      | 15.3                        | 15.7      | 208                     | 104      |
| 210                  | 5.86                        | 5.26      | 93.5                    | 92.0     |
|                      | 5.93                        | 6.37      | 88.6                    | 125      |
| 340                  | 4.79                        | 2.60      | 76.9                    | 57.0     |
|                      | 2.73                        | 4.17/2.88 | 49.9                    | 106/58.5 |
| 520                  | 0.99                        | 1.37      | 29.5                    | 36.6     |
|                      | 1.78                        | 1.49      | 53.8                    | 37.1     |
| 880                  | 0.71                        | 1.04      | 21.6                    | 29.8     |
|                      | 0.60                        | 1.09      | 35.9                    | 32.4     |
| 1400                 | 0.45                        | 0.43      | 22.0                    | 19.5     |
|                      | 0.59                        | 0.65      | 22.1                    | 23.5     |
| 2000                 | 0.16                        | 0.27      | 9.13                    | 10.2     |
|                      | 0.17                        |           | 7.31                    |          |

TABLE 11. Peak Overpressure and Positive-Phase-Impulse Data From Motor Hamard Test 10

| GROUND RANGE<br>(ft) | PEAK OVERPRESSURES |           | IMPULSE<br>(psi - msec) |          |
|----------------------|--------------------|-----------|-------------------------|----------|
|                      | East (psi)         | North     | East                    | North    |
| 110                  | 29.5               |           | 316                     |          |
|                      | 24.2               |           | 333                     |          |
| 150                  | 12.2               | 11.8      |                         | 228      |
|                      | 13.0               |           |                         |          |
| 210                  | 6.12               | 7.02      | 90.3                    | 129      |
|                      | 6.38               | 6.07      | 93.4                    | 85.6     |
| 340                  | 3.35               | 2.64      | 72.9                    | 53.2     |
|                      | 2.62               | 3.20/2.51 | 50.4                    | 108/49.9 |
| 520                  | 1.88               | 1.20      | 65.3                    | 31.4     |
|                      | 1.17               | 1.10      | 25.9                    | 21.5     |
| 880                  | 0.86               | 0.80      | 21.6                    | 24.4     |
|                      | 0.83               | 0.92      | 38.8                    | 24.7     |
| 1400                 | 0.51               | 0.38      | 19.4                    | 15.2     |
|                      | 0.54               | 0.54      | 20.4                    | 19.3     |
| 2000                 | 0.17               | 0.22      |                         |          |
|                      | 0.18               | 0.22      | 7.01                    | 8.13     |

TABLE 12. Peak Overpressure and Positive-Phase-Impulse Data From Motor Hazard Test 11

| GROUND RANGE<br>(ft) | PEAK OVERPRESSURES<br>(psi) |           | IMPULSE<br>(psi - msec) |          |
|----------------------|-----------------------------|-----------|-------------------------|----------|
|                      | East                        | North     | East                    | North    |
| 80                   | 141                         | 92.0      | 915                     | 746      |
|                      |                             |           |                         |          |
| 110                  | 64.5                        | 69.4      | 684                     | 590      |
|                      | 47.5                        | 59.8      | 370                     | 671      |
| 150                  | 24.3                        | 25.6      | 413                     | 464      |
|                      | 26.8                        | 24.5      | 481                     | 397      |
| 210                  | 10.6                        | 11.7      | 165                     | 150      |
|                      | 9.55                        | 13.0      | 145                     | 207      |
| 340                  | 5.19                        | 4.17      | 125                     | 98.5     |
|                      | 3.64                        | 3.83/5.34 | 89.6                    | 87.7/146 |
| 520                  | 2.29                        | 1.71      | 108                     | 49.9     |
|                      | 1.77                        | 1.85      | 47.5                    | 53.6     |
| 880                  | 1.09                        | 1.08      | 60.4                    | 37.1     |
|                      | 1.11                        | 1.20      | 33.3                    | 41.3     |
| 1400                 | 0.61                        | 0.53      | 28.1                    | 24.9     |
|                      | 0.82                        | 0.70      | 31.1                    | 30.3     |
| 2000                 | 0.28                        | 0.37      | 9.29                    | 17.6     |
|                      | 0.21                        | 0.29      | 11.6                    | 13.2     |

TABLE 13. Peak Overpressure and Positive-Phase-Impulse Data From Motor Hazard Test 12

| GROUND RANGE<br>(ft) | PEAK OVERPRESSURES |       | IMPULSE<br>(psi - msec) |       |
|----------------------|--------------------|-------|-------------------------|-------|
|                      | East (psi)         | North | East                    | North |
|                      |                    |       |                         |       |
| 80                   | 80.0               | 80.0  | 500                     |       |
|                      | 78.6               |       | 459                     | 505   |
| 110                  | 57.0               |       | 277                     |       |
|                      | 55.3               |       | 313                     |       |
| 150                  | 16.2               | 37.1  | 158                     | 307   |
|                      | 20.0               | 37.5  | 155                     | 277   |
| 210                  | 10.5               | 9.67  | 167                     | 186   |
|                      | 10.6               | 6.11  | 152                     | 198   |
| 340                  | 4.54               | 4.38  | 151                     | 130   |
|                      | 4.98               | 4.82  | 119                     | 136   |
| 520                  | 2.65               | 2.38  | 62.4                    | 79.8  |
|                      | 2.61               |       | 65.3                    |       |
| 880                  | 1.19               | 1.17  | 40.4                    | 35.3  |
|                      | 1.24               | 1.49  | 31.4                    | 42.4  |
| 1400                 | 0.67               | 0.62  | 29.7                    |       |
|                      | 0.67               | 0.64  | 32.6                    | 49.9  |
| 2000                 | 0.47               | 0.49  | 28.7                    | 28.1  |
|                      |                    |       |                         |       |

TABLE 14. Peak Overpressure and Positive-Phase-Impulse Data From Motor Hazard Test 13

| GROUND RANGE<br>(ft) | PEAK OVERPRESSURES |       | IMPULSE<br>(psi - msec) |       |
|----------------------|--------------------|-------|-------------------------|-------|
|                      | East (psi)         | North | East                    | North |
| 110                  | 47.0               | 65.4  | 447                     | 635   |
|                      |                    | 69.3  |                         | 635   |
| 150                  | 24.4               | 26.1  | 254                     | 262   |
|                      |                    |       |                         |       |
| 210                  | 12.8               | 16.1  |                         | 228   |
|                      | 14.4               |       |                         |       |
| 340                  | 7.01               | 7.18  | 118                     |       |
|                      | 6.27               |       | 166                     |       |
| 520                  | 3.18               | 3.07  | 110                     | 100   |
|                      |                    |       |                         |       |
| 880                  | 1.49               | 1.37  | 47.5                    | 48.1  |
|                      |                    |       |                         |       |
| 1400                 | 0.74               | 0.72  | 36.4                    | 39.4  |
|                      |                    |       |                         |       |
| 2000                 | 0.52               | 0.56  |                         | 34.2  |
|                      |                    |       |                         |       |
| 2500                 | 0.40               | 0.38  |                         | 13.2  |
|                      |                    |       |                         |       |

TABLE 15. Peak Overpressure and Positive-Phase-Impulse Data From Motor Hazard Test 14

| GROUND RANGE<br>(ft) | PEAK OVERPRESSURES |       | IMPULSE<br>(psi - msec) |       |
|----------------------|--------------------|-------|-------------------------|-------|
|                      | East (psi)         | North | East                    | North |
| 80                   | 76.1               | 67.0  | 261                     | 288   |
| 110                  | 32.4               | 28.5  | 245                     | 233   |
| 150                  | 10.5               |       | 140                     |       |
| 210                  | 7.79               |       | 130                     |       |
| 340                  | 3.92               |       | 59.2                    |       |
| 520                  | 2.11               |       | 41.4                    |       |
| 880                  | 0.82               | 1.16  | 21.0                    | 35.5  |
| 1400                 | 0.53               | 0.66  | 17.6                    | 21.3  |
| 2000                 |                    | 0.42  |                         | 19.0  |
| 2500                 | 0.22               | 0.30  | 10.0                    | 12.9  |

TABLE 16. Peak Overpressure and Positive-Phase-Impulse Data From Motor Hazard Test 15

| GROUND RANGE<br>(ft) | PEAK OVERPRESSURES<br>(psi) |       | IMPULSE<br>(psi- msec) |       |
|----------------------|-----------------------------|-------|------------------------|-------|
|                      | East                        | North | East                   | North |
| 80                   | 94.1                        |       | 636                    |       |
|                      |                             |       |                        |       |
| 110                  | 36.6                        | 29.9  | 266                    | 219   |
|                      |                             |       |                        |       |
| 150                  | 14.9                        | 17.1  | 136                    | 177   |
|                      |                             |       |                        |       |
| 210                  | 10.5                        | 12.5  | 134                    | 140   |
|                      |                             |       |                        |       |
| 340                  |                             | 4.24  |                        | 80.1  |
|                      |                             |       |                        |       |
| 520                  |                             | 2.24  |                        | 54.4  |
|                      |                             |       |                        |       |
| 880                  |                             | 1.27  |                        | 18.7  |
|                      |                             |       |                        |       |
| 1400                 | 0.81                        | 0.76  | 18.9                   | 27.8  |
|                      | 0.84                        | 0.87  | 19.5                   | 23.6  |
| 2000                 | 0.40                        | 0.42  | 15.9                   | 17.4  |
|                      |                             |       |                        |       |
| 2500                 | 0.28                        | 0.34  | 12.2                   | 13.1  |
|                      |                             |       |                        |       |

TABLE 17. Peak Overpressure and Positive-Phase-Impulse Data From Motor Hazard Test 16

| GROUND RANGE<br>(ft) | PEAK OVERPRESSURES |       | IMPULSE<br>(psi-msec) |       |
|----------------------|--------------------|-------|-----------------------|-------|
|                      | East (psi)         | North | East                  | North |
| 110                  | 60.3               |       | 439                   |       |
|                      |                    |       |                       |       |
| 150                  | 27.5               | 30.7  | 326                   | 344   |
|                      |                    |       |                       |       |
| 210                  | 15.4               | 16.7  | 251                   | 237   |
|                      |                    |       |                       |       |
| 340                  | 7.03               | 6.94  | 169                   | 171   |
|                      |                    |       |                       |       |
| 520                  | 3.11               | 3.50  | 111                   | 110   |
|                      | 3.49               | 3.22  | 104                   | 104   |
| 880                  | 1.50               | 1.72  |                       | 54.7  |
|                      | 1.73               | 1.89  | 76.0                  | 63.2  |
| 1400                 | 0.91               | 0.98  | 28.5                  | 55.8  |
|                      | 0.82               | 1.03  | 39.9                  | 50.9  |
| 2000                 | 0.47               | 0.58  | 30.1                  | 36.1  |
|                      | 0.43               | 0.50  | 28.2                  | 28.6  |
| 2800                 | 0.34               | 0.43  | 24.8                  |       |
|                      |                    |       |                       |       |

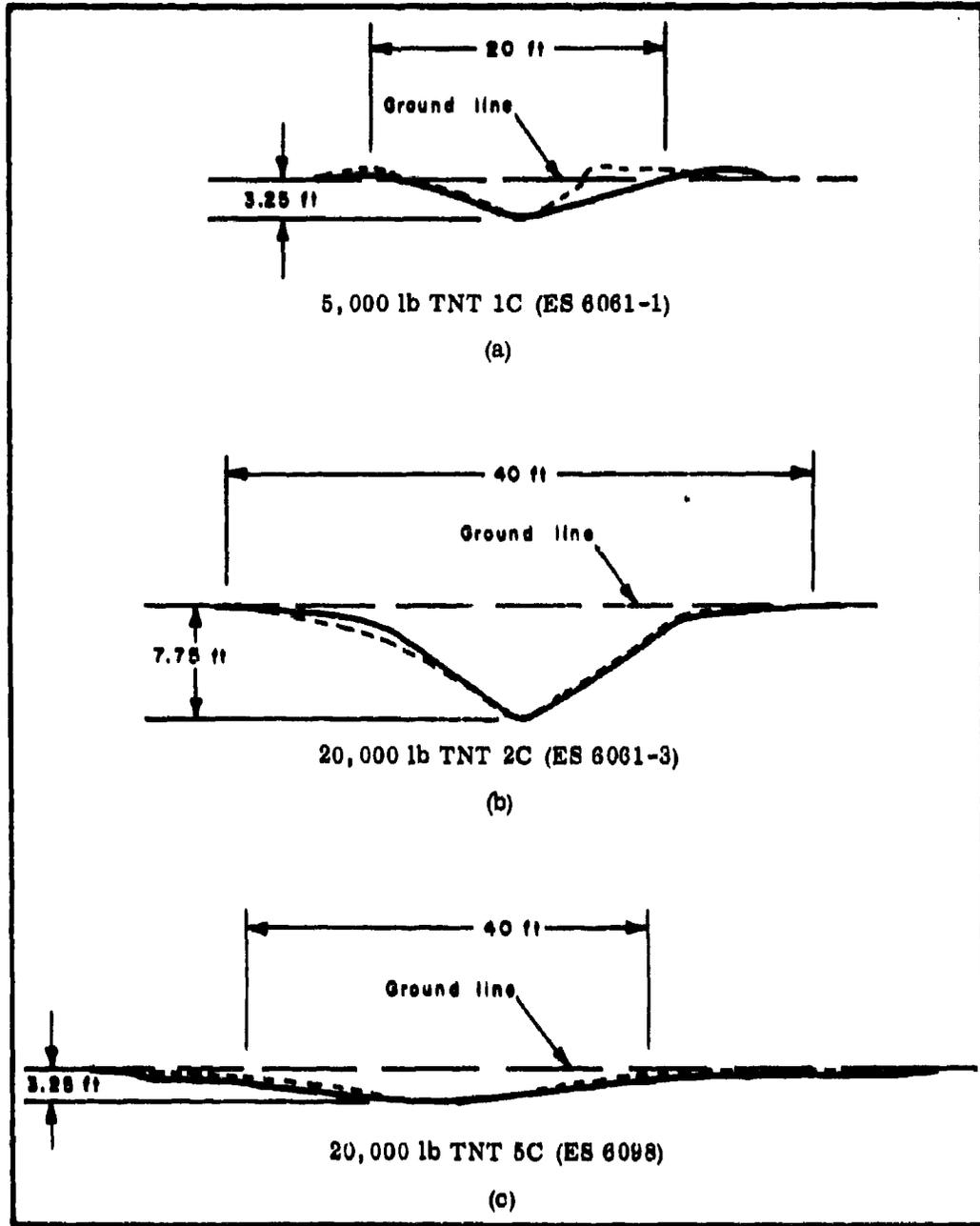


FIG. 13. Orthogonal Profiles of Craters From Tests 1C, 2C, and 5C.

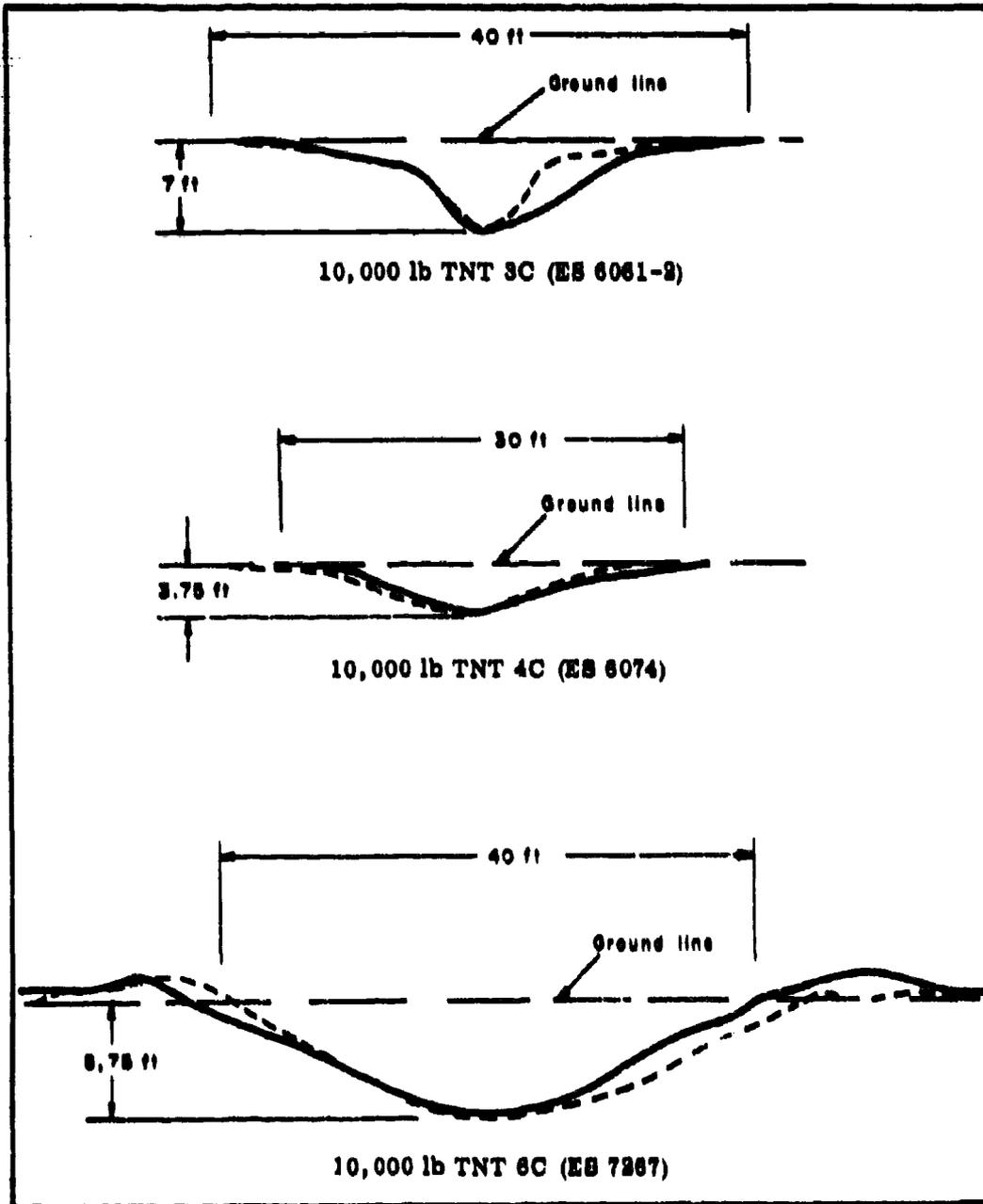
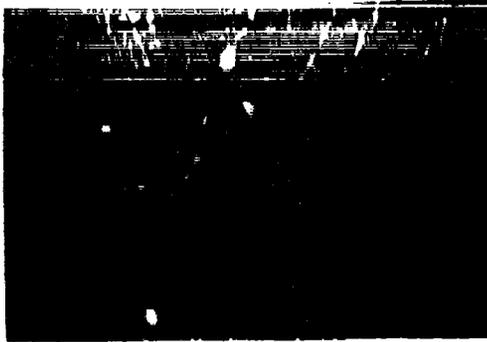
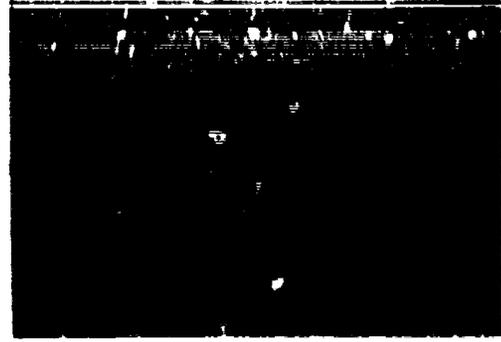


FIG. 14. Orthogonal Profiles of Craters From Tests 3C, 4C, and 6C.



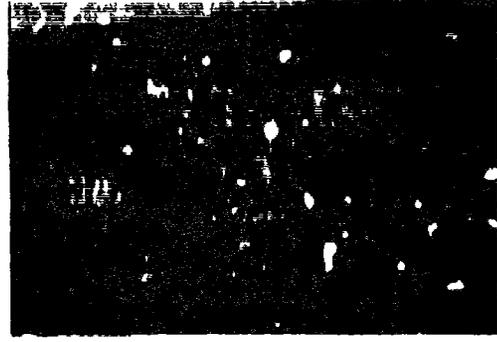
LWL 111798



LWL 118000



LWL 111799



LWL 111800

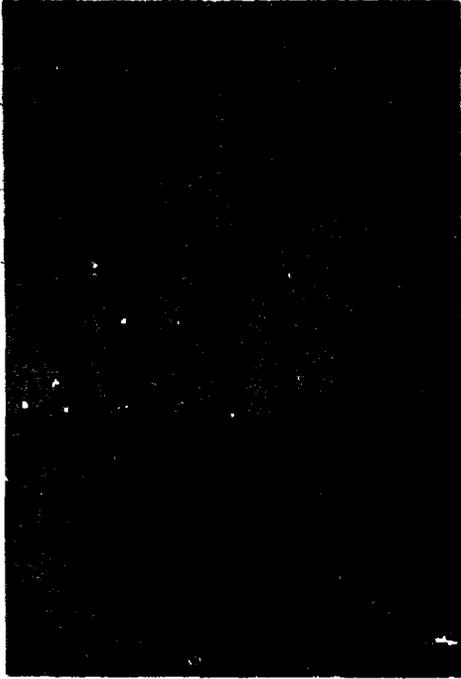


LWL 118005



LWL 118006

FIG. 18. Posttest Ground Zero Photographs for TNT Reference Tests IC Through 6C.



L.M. 007001

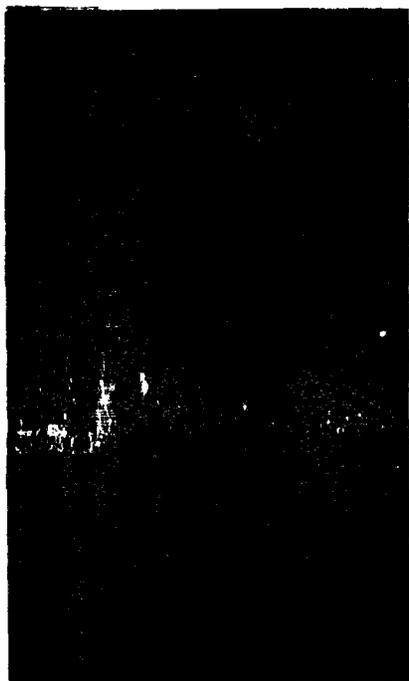


L.M. 007020



L.M. 012008

FIG. 16. Posttest Ground Zero Photographs for Tests 8, 9, and 12.



LNL 007373



LNL 007383



LNL 007385

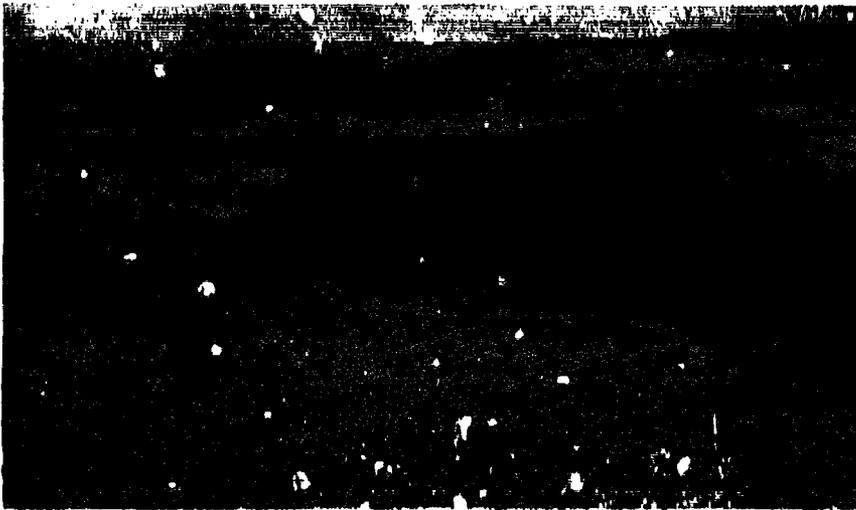


LNL 007385

FIG. 17. Posttest Ground Zero Photographs for Tests 10, 11, 13, and 16.



LNL 188000



LNL 188000

FIG. 18. Posttest Ground Zero Photographs for Tests 14 and 15.

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| 13. ABSTRACT<br><p>From June 1968 to February 1968, nine solid propellant motor hazard tests and six high-explosive tests were conducted at the Naval Weapons Center, China Lake, to evaluate the explosive potential of large Class 8 and Class 7 solid propellant motors. Test parameters which were varied during the program were propellant type, weight, and orientation and explosive booster type and location. The results of these tests, combined with data from seven previous tests conducted at NWC, indicate that, under the stimulus of a relatively small (80 to 100 lb) explosive booster, the Class 7 motors tested are capable of producing blast yields averaging 130% of TNT, and the Class 8 motors produced yields as large as 40%. When a Class 7 motor with an explosive booster was placed in intimate contact with a Class 8 motor, yields, based on the total propellant weight, ranged from 108 to 138%. The estimated yields for the Class 8 motors alone ranged from 87 to 119%. In tests in which a Class 7 motor with an explosive booster was placed near, but not in intimate contact with, a Class 8 motor, the estimated yields for the Class 8 motors alone ranged from 30 to 80%, considerably lower than the yields obtained in the intimate-con- tact tests. The separation distances used ranged from 3 to 18 inches.</p> |  |  |                             |

DD FORM 1473

(PAGE 1)

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| 14<br>KEY WORDS   | LINK A |    | LINK B |    | LINK C |    |
|---|--------|----|--------|----|--------|----|
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**DD FORM 1473** (BACK)  
(NOV 66)  
(PAGE 2)

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