

12 LEVEL III

AD A090661

AD

AD-E400 473

CONTRACTOR REPORT ARLCD-CR-80024

TNT EQUIVALENCY OF BALL POWDER WC844

F. L. MCINTYRE

COMPUTER SCIENCES CORPORATION

NSTL STATION, MISSISSIPPI

P. PRICE, PROJECT LEADER

D. WESTOVER, PROJECT ENGINEER

ARRADCOM, DOVER, NEW JERSEY

DTIC
ELECTE
OCT 22 1980
S D

SEPTEMBER 1980

B



US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
LARGE CALIBER
WEAPON SYSTEMS LABORATORY
DOVER, NEW JERSEY

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

JDC FILE COPY

80 9 29 201

The views, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other documentation.

Destroy this report when no longer needed. Do not return it to the originator.

The citation in this report of the names of commercial firms or commercially available products or services does not constitute official endorsement or approval of such commercial firms, products, or services by the United States Government.

UNCLASSIFIED

409 824

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Contractor Report ARLCD-CR-80024 ✓	2. GOVT ACCESSION NO. AD-A090	3. RECIPIENT'S CATALOG NUMBER 667
4. TITLE (and Subtitle) TNT EQUIVALENCY OF BALL POWDER WC844		5. TYPE OF REPORT & PERIOD COVERED Final
7. AUTHOR(s) F. L. McIntyre, Computer Sciences Corporation P. Price, Project Leader, ARRADCOM D. Westover, Project Engineer, ARRADCOM		6. PERFORMING ORG. REPORT NUMBER
9. PERFORMING ORGANIZATION NAME AND ADDRESS Computer Sciences Corporation NSTL Station, MS 39529		8. CONTRACT OR GRANT NUMBER(s) NAS 13-50
11. CONTROLLING OFFICE NAME AND ADDRESS ARRADCOM, TSD STINFO Div (DRDAR-TSS) Dover, NJ 07801		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS MMT-5784285
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) ARRADCOM, LCWSL Energetics Systems Process Div (DRDAR-LCM-SP) Dover, NJ 07801		12. REPORT DATE September 1980
		13. NUMBER OF PAGES 62
		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES This project was accomplished as part of the U.S. Army's Manufacturing Methods and Technology Program. The primary objective of this program is to develop, on a timely basis, manufacturing processes, techniques, and equipment for use in the production of Army materiel.		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) MMT-ammunition Shipping containers TNT equivalency Dryer beds Propellant WC844 L/D ratio		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Peak side-on blast overpressure and scaled positive impulse have been measured for ball powder WC844 using configurations that simulate in-plant processing and shipping containers. Quantities of 22.7, 36.3, 45.4, and 72.6 kg were tested in cylindrical shipping containers and in simulated sections of dryer beds. High explosive equivalency values for each test series were obtained as a function of scaled distance by comparison to known pressure and impulse characteristics for TNT surface bursts. Equivalencies were found to depend significantly on geometry.		

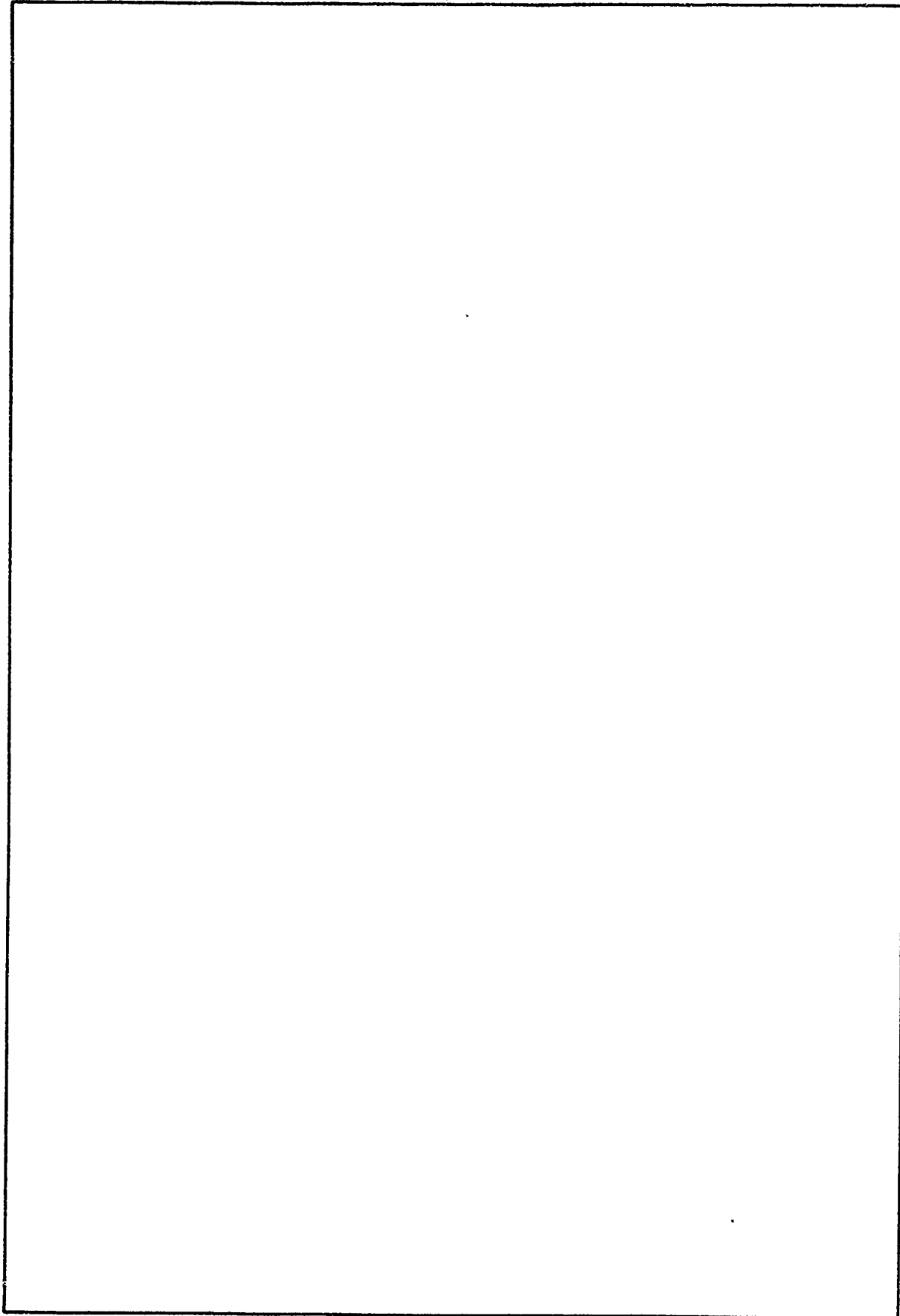
DD FORM 1473
1 JAN 73

EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)



SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

ACKNOWLEDGMENT

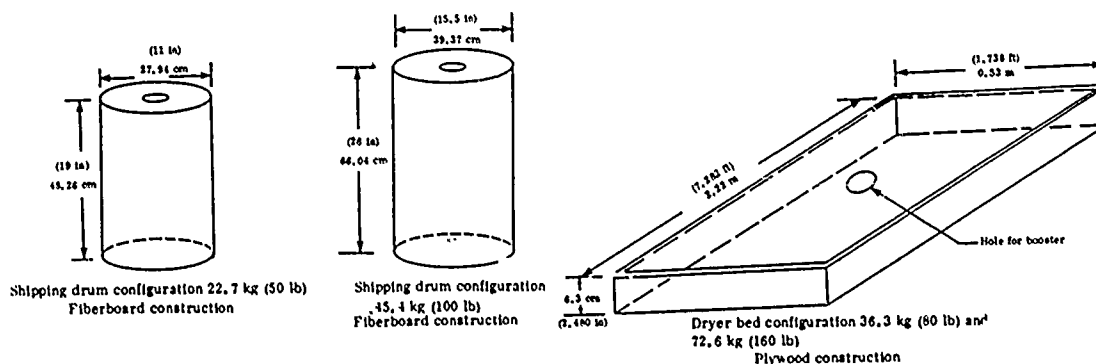
This project was coordinated by D. M. Koger, ARRADCOM Resident Operations Office (DRDAR-TSE-O-A), NSTL Station, Mississippi.

Accession For	
NTIS GRA&I	☒
DTIC TAB	☐
Unannounced	☐
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A	

SUMMARY

Ball powder WC844 (double base propellant) was detonated in configurations representative of shipping containers and simulated in-plant process dryer beds. Blast output parameters were measured and TNT equivalency was computed based on comparison with TNT hemispherical surface bursts. The results of these tests are shown below. To within experimented error, the pressure and impulse of ball powder WC844 with an L/D ratio greater than 1:1 in charge weights of 22.7 kg (50 lb) and 45.4 kg (100 lb) scaled with the cube root of the charge weight. TNT equivalency values for pressure and impulse were generally greater than 100% at all scaled distances. Charge weights of 36.3 kg (80 lb) and 72.6 kg (160 lb), representing the dryer bed configuration scaled as a cube root function of the charge weight. A notable difference existed in pressure and impulse values due to the geometry of the dryer bed. Odd gage values for both pressure and impulse values were generally less than 100% at the near field values $< 7.14 \text{ m/kg}^{1/3}$ and greater than 100% at the far field values $\geq 7.14 \text{ m/kg}^{1/3}$. The even gage line values were found to be generally greater than 100% at all scaled distances with the exception of those values measured at a scaled distance = $2.14 \text{ m/kg}^{1/3}$. TNT equivalency values for the dryer bed configuration were generally less than the values found in the shipping container except at the far field values $\geq 7.14 \text{ m/kg}^{1/3}$, where pressure and impulse values for the dryer bed configuration were greater than those in the shipping container configuration.

Configuration Mass		Pressure (P) and Impulse (I) TNT Equivalency (%) at Scaled Distance											
		1.19 m/kg ^{1/3} (3.0 ft/lb ^{1/3})		1.59 m/kg ^{1/3} (4.0 ft/lb ^{1/3})		2.14 m/kg ^{1/3} (5.4 ft/lb ^{1/3})		3.57 m/kg ^{1/3} (9.0 ft/lb ^{1/3})		7.14 m/kg ^{1/3} (18.0 ft/lb ^{1/3})		15.9 m/kg ^{1/3} (40 ft/lb ^{1/3})	
		P	I	P	I	P	I	P	I	P	I	P	I
Shipping container 22.7 kg 45.4 kg		390	230	325	150	190	120	160	110	160	105	170	95
Dryer bod 36.3 kg 72.6 kg	Odd	80	35	55	25	40	75	75	95	170	135	360	140
	Even	135	105	135	105	85	80	130	70	150	110	200	135



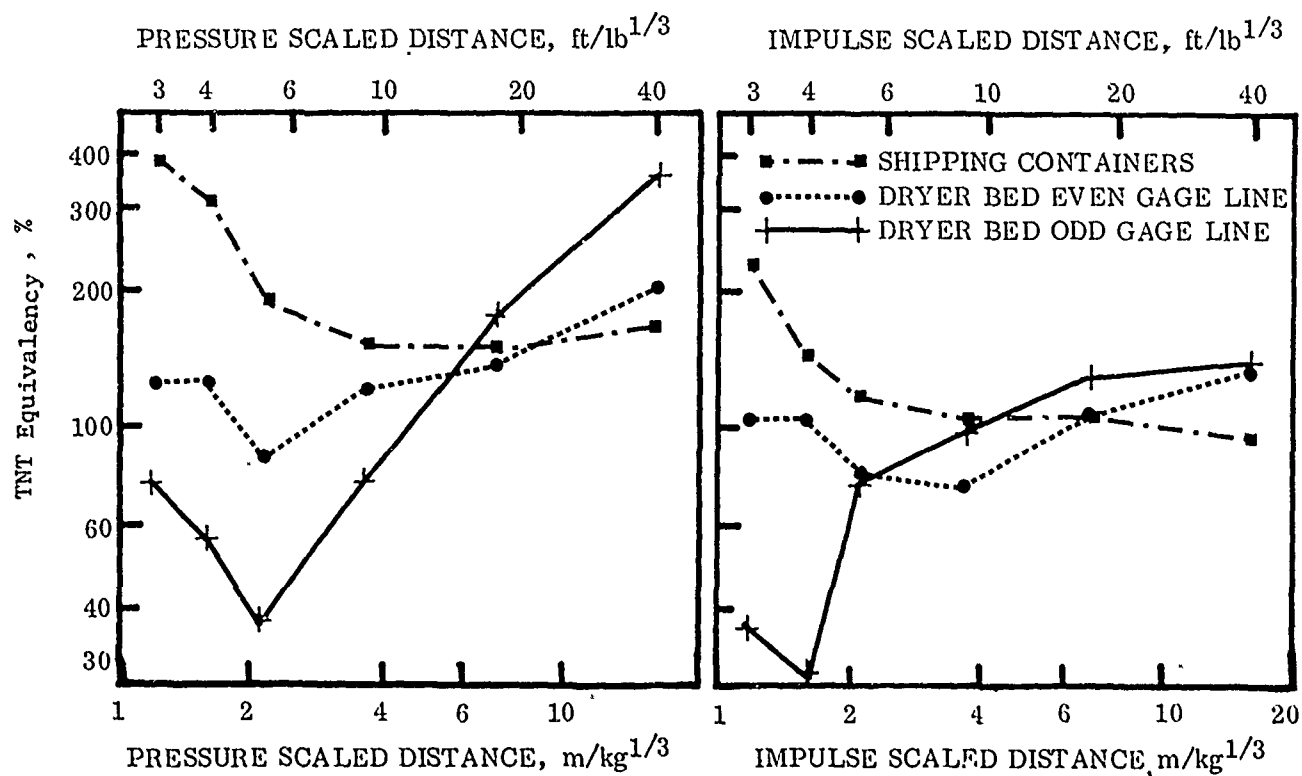
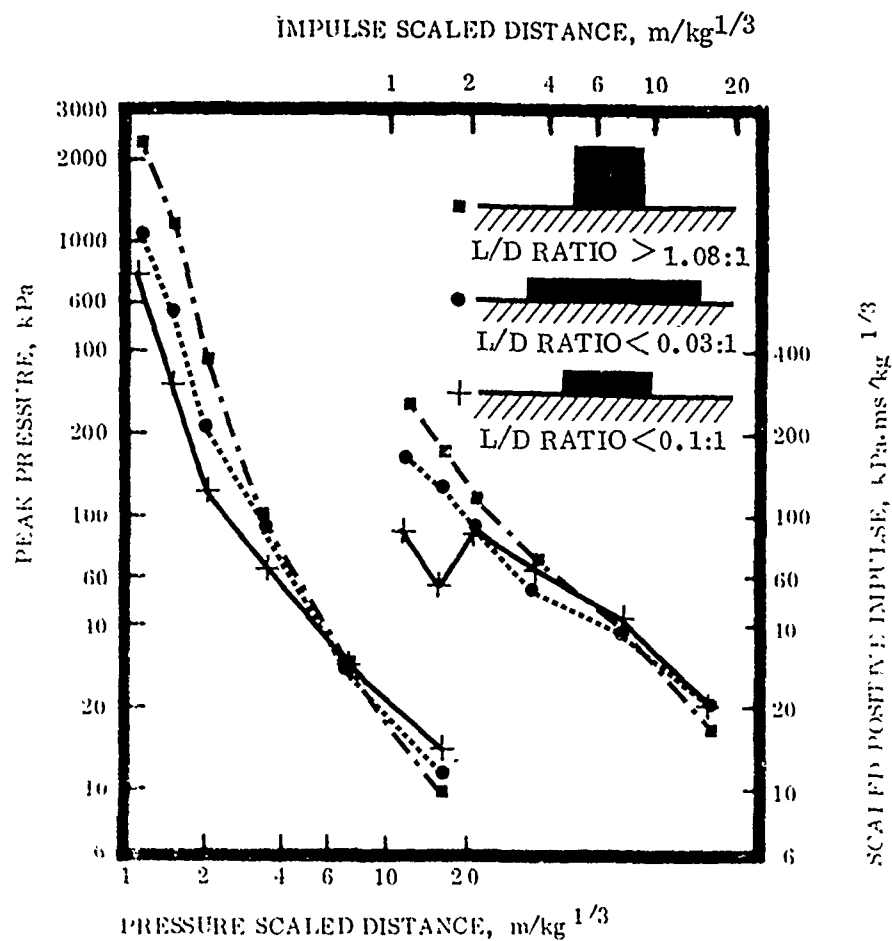


TABLE OF CONTENTS

	Page no.
Introduction	1
Background	1
Objective	1
Experimental Methods	2
Materials	2
Test Plan	2
Instrumentation	2
Results	3
Data Analysis	3
Test Results	3
Discussion	4
Conclusions	6
Recommendation	6
References	7
Appendix	
Data sheets	33
Distribution List	47

TABLES

	Page no.
1 Transducer calibration and placement	9
2 Summary of test results, 22.7 kg (50 lb) cylindrical charge	10
3 Summary of test results, 45.4 kg (100 lb) cylindrical charge	10
4 Summary of test results, 36.3 kg (80 lb) charge, odd gage configuration	11
5 Summary of test results, 36.3 kg (80 lb) charge, even gage configuration	11
6 Summary of test results, 72.6 kg (160 lb) charge, odd gage configuration	12
7 Summary of test results, 72.6 kg (160 lb) charge, even gage configuration	12
8 Summary of test results, composite, odd gage dryer bed configuration	13
9 Summary of test results, composite, even gage dryer bed configuration	13
10 Summary of test results, composite results with L/D ratio greater than 1:1	14
11 Fireball duration and diameter	15

FIGURES

1 Test container configurations	17
2 Typical charge placement for equivalency tests	18
3 Test area showing transducer and camera placement	18
4 TNT hemispherical surface burst	19

5	Pressure and impulse versus scaled distance 22.7 kg (50 lb) charge weights	20
6	Pressure and impulse versus scaled distance 45.4 kg (100 lb) charge weights	21
7	Pressure and impulse versus scaled distance for odd gage line 36.3 kg (80 lb) charge weight, dryer bed configuration	22
8	Pressure and impulse versus scaled distance for even gage line 36.3 kg (80 lb) charge weight, dryer bed configuration	23
9	Pressure and impulse versus scaled distance for odd gage line 72.6 kg (160 lb) charge weight, dryer bed configuration	24
10	Pressure and impulse versus scaled distance for even gage line 72.6 kg (160 lb) charge weight, dryer bed configuration	25
11	Pressure and impulse versus scaled distance 22.7 and 45.4 kg (50 and 100 lb) charge weights combined	26
12	Pressure and impulse versus scaled distance 36.3 and 72.5 kg (80 and 160 lb) charge weights combined for odd and even gage values	27
13	Pretest configuration for 22.7 kg charge	28
14	Posttest configuration for 22.7 kg charge	28
15	Pretest configuration for 45.4 kg charge	29
16	Posttest configuration for 45.4 kg charge	29
17	Pretest configuration for 36.3 kg charge	30
18	Posttest configuration for 36.3 kg charge	30
19	Pretest configuration for 72.6 kg charge	31
20	Posttest configuration for 72.6 kg charge	31

INTRODUCTION

Background

A pilot plant for manufacturing double base propellant in the form of ball powder has been set up at a GOCO plant. The information generated from the pilot plant operation will be used to size the various equipment, material balance, and structural and safe operating procedures for modernization Project 5842879 and expansion project 5843128. Material produced will be ball powder WC844, WC846, and WC870. The basic composition is approximately 86% nitrocellulose (NC), 8.2% nitroglycerin (NG), and 5% dibutylphthalate.

The powder, as it is pumped through the process in a 3:1 (water/powder) slurry, is shaped into spheroidal balls, passed over screens for size classification, pumped in a slurry form to a centrifuge where the powder at 8 to 9% moisture is fed onto dryer beds for drying, and then moved to packout for storage. The finished material is a ball powder, sized from 0.41 to 0.66 mm (0.016 to 0.026 in.) for NATO rounds. The powder is stored and shipped in 22.7 and 45.4 kg (50 and 100 lb) quantities in fiber drums.

Safety engineering and cost effectiveness considerations require knowledge of hazardous material characteristics as an input to facility design requirements. In this instance, specific data are required on the explosive output characteristics of ball powder WC844 in quantities and configurations representative of those found in processing, storage, and shipping facilities.

Objectives

One objective was to determine the maximum output from ball powder WC844 in terms of the airblast overpressure and positive impulse and to determine if the quantities tested scale as a function of the cube root of the charge weight.

Another objective was to compare the measured pressure and impulse with known TNT test data to determine the equivalency of ball powder WC844 in relation to TNT.

EXPERIMENTAL METHODS

Materials

The test material was a double base propellant, ball powder WC844, for the 5.56 round, DAAA-25-70-C-0613, Army lot 46705, Small Lot 50 manufacture date C-5-71 by Olin Corporation, St. Marks, Florida. It was received in 45.4 kg (100 lb) quantities in cylindrical cardboard shipping containers.

Test Plan

Airblast output was evaluated for masses and configuration of ball powder WC844, representative of standard shipping containers at two charge weights and dryer beds at two charge weights. A cylindrical fiberboard container was used as the 22.7 kg (50 lb) shipping container (A, fig. 1), and as the 45.4 kg (100 lb) shipping container (B, fig. 1). An orthorombic fixture was used for 36.3 kg (80 lb) and 72.6 kg (160 lb) dryer bed simulation (C, fig. 1). The fixture was constructed from 0.953 cm (3/8 in.) plywood with dimensions of 2.22 m long by 0.53 m wide by 6.3 cm deep (7.83 ft x 1.738 ft x 2.480 in.). The long side of the box was perpendicular with the even gage line.

A composition C4 conically shaped booster charge with a length-to-diameter ratio of 1:2 (L/D) was centered on top of each test charge. The weight of the booster charge was held constant at 0.454 kg (1 lb) for all tests. The booster was initiated with an engineers' special J2 blasting cap inserted in the apex and embedded to the center of the core.

The test charges in each configuration were placed on a 1010 carbon steel witness plate, 1.27 cm (0.5 in.) thick with dimensions of at least 5.08 cm (2 in.) greater than the size of the test container.

Instrumentation

Twelve side-on pressure transducers were mounted flush to the surface in each of two sand filled 90° arrays, within the test area as shown in figure 2. Distances from the charge to the transducer corresponded to scaled distances from 1.19 to 15.87 m/kg^{1/3} (3 to

40 ft/lb^{1/3}. Scaled distances were held constant throughout the test series for all charge weights and configurations. The transducers were individually calibrated prior to the beginning of each test series with pressure pulses from a standard solenoid actuated air pressure calibration fixture, adjusted to correspond to expected blast pressure based on an assumed TNT equivalency of 100%. Signal line continuity and channelization were checked prior to each test, and electrical calibration of the recording system was checked daily. Details of distances between charge and transducers, calibration pressure, and expected peak blast pressure at each distance are shown in table 1.

Photographic coverage was restricted to one test of each configuration (fig. 3). Motion picture coverage included a Mitchell camera Model H516-E4 operating at 500 frames per second (fps) and one Mitchell camera (same model) operating at 24 fps. Before and after color photographs were taken for each test, showing typical setup and results. Standard meteorological data were recorded for each test.

RESULTS

Data Analysis

Peak blast overpressure and positive impulse information were obtained in digital form. Inconsistent results that could be attributed to instrumentation or test material malfunction were deleted from consideration at calculation. Additionally, the raw test data were averaged and the standard deviation was calculated; all data that fell outside the one standard deviation from the mean were also deleted from the TNT equivalency calculations. The data were then compared to data from the standard TNT hemispherical (fig. 4). McKown (ref 1) describes the computer program which uses an iterative process that factors out the contribution of the booster charge weight and calculates the pressure and impulse equivalencies. With the effect of the booster weight factored out, the calculated TNT equivalencies were tabulated and plotted as functions of sample scaled distances.

Test Results

Data sheets for all tests with pertinent measured parameters are given in the appendix.

Mean pressure, scaled positive impulse, and time of arrival data are summarized by test configuration in tables 2 through 8 and figures 5 through 10. Composite pressure and scaled impulse values for the shipping containers are given in table 10 and 11. The dryer bed combined charge weights are given as results for odd gage and even gage results in tables 8 and 9 and figure 12. Fireball diameter and duration as measured from high speed motion pictures are given in table 11.

Figures 13 through 20 show typical pretest and posttest configurations for the charge weights tested.

Discussion

The plots of peak pressure and scaled positive impulse versus scaled distance for the shipping container configuration are shown in figures 5 and 6. They show that the pressure values are generally greater than 100% at all scaled distances when compared to the same charge weight of TNT at the same scaled distances. Scaled positive impulse for the 22.7 kg (50 lb) charge weight is generally greater than 100% at all scaled distances $< 7.14 \text{ m/kg}^{1/3}$ (18 ft/lb^{1/3}) and less than 100% at $15.9 \text{ m/kg}^{1/3}$ (40 ft/lb^{1/3}) when compared to equal amounts of TNT. The same general trend was noted for the 45.4 kg (100 lb) shipping container except that at a scaled distance of $3.57 \text{ m/kg}^{1/3}$ (9 ft/lb^{1/3}) the scaled positive impulse value was slightly less than 100%. However, when the results of the 22.7 kg and 45.4 kg (50 and 100 lb) shipping container were combined (fig. 11), scaled positive impulse was found to be greater than 100% at scaled distances $< 7.14 \text{ m/kg}^{1/3}$ (18 ft/lb^{1/3}) and less than 100% at scaled distances $> 7.14 \text{ m/kg}^{1/3}$ (18 ft/lb^{1/3}).

Results obtained in the dryer bed configuration showed a significant difference from those values obtained in the shipping container configuration and show the effect of geometry. Test results for the 36.3 kg (80 lb) test are given in table 4 and figure 7 for the odd gage line and table 5 and figure 8 for the even gage line. Equivalency pressure for the odd gage line (short side of dryer bed) was generally less than 100 percent at the near field scaled distance $< 3.57 \text{ m/kg}^{1/3}$ (9 ft/lb^{1/3}). Scaled positive impulse followed the same general trend as the pressure, but there was a significant dip in impulse value at a scaled distance of $1.59 \text{ m/kg}^{1/3}$ (4 ft/lb^{1/3}).

Peak pressure for the even gage line (long side of dryer bed) for the 36.3 kg (80 lb) mass showed significantly different results. Generally, pressure values were greater than 100% at all

scaled distances with the exception found at $2.14 \text{ m/kg}^{1/3}$ ($5.4 \text{ ft/lb}^{1/3}$) where it was less than 100%. Scaled positive impulse values were found to be less than 100% at the near field values $< 7.14 \text{ m/kg}^{1/3}$ ($18 \text{ ft/lb}^{1/3}$), and greater than 100% at scaled distances $\geq 7.14 \text{ m/kg}^{1/3}$ ($18 \text{ ft/lb}^{1/3}$). In this instance there was no pronounced dip in the impulse values at the close-in scaled distance of $1.59 \text{ m/kg}^{1/3}$ ($4 \text{ ft/lb}^{1/3}$) as was detected from the short side of the dryer bed gage line.

Peak pressure and scaled positive impulse values obtained on the dryer bed configuration for the 72.6 kg (160 lb) charge weight followed the same general pattern found for even and odd gage measurement. On the short side or end of the dryer bed, a noticeable dip in impulse value exists and was somewhat more pronounced for the larger mass. The even gage line scaled positive impulse values were greater than 100% at 1.19 and $1.59 \text{ m/kg}^{1/3}$ (3 and $4 \text{ ft/lb}^{1/3}$), less than 100% at 2.14 and $3.57 \text{ m/kg}^{1/3}$ (5.4 and $9 \text{ ft/lb}^{1/3}$), and greater than 100% at far field scaled distance $\geq 7.14 \text{ m/kg}^{1/3}$ ($18 \text{ ft/lb}^{1/3}$).

The significance of the 36.3 and 72.6 kg charge tests in the dryer bed configuration was in the results of the odd gage line and the dip in the impulse value of $1.59 \text{ m/kg}^{1/3}$ ($4 \text{ ft/lb}^{1/3}$). This dip is similar to those values reported by Kingery (ref 2) in the development of impulse curve for 500 and 1000 ton TNT equivalency tests. However, these values occurred at near field value of $0.79 \text{ m/kg}^{1/3}$ ($2 \text{ ft/lb}^{1/3}$). Another difference is noted in the L/D ratio from the long side of the dryer bed versus the short side. The L/D ratio for the short side was 0.06:1 for the 36.3 kg (80 lb) tests and 0.12:1 for 72.6 kg (160 lb) tests whereas the L/D ratios were 0.01 and 0.03 on the long side of the dryer bed configuration for the 36.3 and 72.6 kg (80 and 160 lb) tests respectively, with the difference being the height of the material.

To within experimental error of the instrumentation and variance in explosive material, scaling as a function of the cube root of the charge weight occurred, pressure and impulse values did not necessarily increase or decrease as a function of the charge weight. There were some slight variances in values, but no significant increase or decrease was evident.

CONCLUSIONS

1. Peak positive overpressure TNT equivalency values of ball powder WC844 in two types of shipping containers were found to be greater than 100% at all scaled distances tested when compared to the standard TNT hemispherical reference.
2. Scaled positive impulse TNT equivalency values for the shipping containers were greater than 100% at the near field values $\leq 7.14 \text{ m/kg}^{1/3}$ ($18 \text{ ft/lb}^{1/3}$) and less than 100% at scaled distances greater than $7.14 \text{ m/kg}^{1/3}$ ($18 \text{ ft/lb}^{1/3}$).
3. TNT equivalency values of ball powder WC844 in the dryer bed configuration were dependent upon geometry since there were significant differences in results between the long and short sides of the dryer bed.
4. Pressure equivalency in the dryer bed configuration was generally greater than 100% at all scaled distances on the long side of the dryer bed. Impulse values were greater than 100% at close-in scaled distances, below 100% at the mid-range scaled distances, and greater than 100% at the far field scaled distance.
5. Pressure and impulse equivalency for the short side (odd gage) was generally less than 100% at scaled distance $< 7.14 \text{ m/kg}^{1/3}$ ($18 \text{ ft/lb}^{1/3}$) and greater than 100% at scaled distance $\geq 7.14 \text{ m/kg}^{1/3}$ ($18 \text{ ft/lb}^{1/3}$).
6. Within experimental limits of the instrumentation and explosive material, blast pressure and scaled positive impulse scaled as a cube root function of charge weight when geometries were similar.

RECOMMENDATION

The TNT equivalency of pressure and impulse values determined from this test series should be used in the structural design of protective facilities.

REFERENCES

1. G. L. McKown, "TNT Equivalency of R284 Tracer Composition, I559 Igniter Mix, and I560 Subigniter Mix," ARRADCOM Technical Report ARLCD-TR-79026, ARRADCOM, Dover, NJ, August 1979.
2. C. N. Kingery, "Air Blast Parameters Versus Distance for Hemispherical TNT Surface Bursts," BRL Report 1344, Ballistic Research Laboratory, Aberdeen, MD, September 1966.

Table 1. Transducer calibration and placement

distances between charge and transducers, calibration pressure and expected peak blast pressure at each distance are shown in table 1.

Photographic coverage was restricted to one test of each configuration (figure 3). Motion picture coverage included a Mitchell camera Model H516-E4 operating at 500 frames per second (fps) and one Mitchell camera (same model) operating at 24 fps. Before and after color still photographs were taken of each test showing typical setup and results. Standard meteorological data were recorded for each test.

TABLE 1. TRANSDUCER CALIBRATION AND PLACEMENT

Channel number	Scaled distance $m/kg^{1/3}$ ($ft/lb^{1/3}$)	Full-scale calibration pressure kPa (psig)	Expected pressure kPa (psi)	R ₁ distance in meters (ft) from charge			
				Charge weight 22.68 kg (50)	Charge weight 36.3 kg (80)	Charge weight 45.4 kg (100)	Charge weight 72.6 kg (160)
1, 2	1.19 (3.0)	1379 (200)	917 (133)	3.37 (11.05)	3.94 (12.93)	4.24 (13.92)	4.97 (16.29)
3, 4	1.59 (4.0)	689.5 (100)	479.7 (69.58)	4.49 (14.74)	5.32 (17.45)	5.73 (18.8)	6.7 (21.99)
5, 6	2.14 (5.4)	413.1 (60)	242.5 (35.17)	6.06 (19.89)	7.06 (23.18)	7.61 (24.97)	8.9 (29.2)
7, 8	3.57 (9.0)	206.8 (30)	87.9 (12.74)	10.11 (33.2)	11.82 (38.78)	12.73 (41.77)	14.89 (48.86)
9, 10	7.14 (18.0)	68.9 (10)	24.9 (3.6)	20.21 (66.3)	23.64 (77.56)	25.47 (83.55)	19.78 (97.72)
11, 12	15.87 (40.0)	34.5 (5)	7.58 (1.1)	44.9 (147.4)	52.53 (172.35)	56.59 (185.66)	66.19 (217.15)

Table 2. Summary of test results, 22.7 kg (50 lb) cylindrical charge

Radius meters (ft)	Scaled Distance $m/kg^{1/3}$ (ft/lb ^{1/3})	Time of Arrival (msec)	Peak Pressure kPa (psi)	Scaled Positive Impulse $kPa \cdot ms/kg^{1/3}$ (psi $\cdot$ ms/lb ^{1/3})	Pressure TNT Equivalency %	Impulse TNT Equivalency %
3.37 (11.05)	1.19 (3.0)	3.25	2471.7 (358.49)	309.87 (34.53)	388	231
4.49 (14.74)	1.59 (4.0)	4.45	1123.22 (162.91)	177.95 (19.83)	316	156
6.06 (19.89)	2.14 (5.4)	6.13	390.8 (56.68)	121.6 (13.55)	185	125
10.11 (33.2)	3.57 (9.0)	14.65	112.38 (16.3)	83.73 (9.33)	166	135
20.21 (66.3)	7.14 (18.0)	40.5	31.85 (4.62)	40.38 (4.5)	167	112
44.92 (147.4)	15.87 (40.0)	111.35	10.69 (1.55)	16.33 (1.82)	183	90

Table 3. Summary of test results, 45.4 kg (100 lb) cylindrical charge

Radius meters (ft)	Scaled Distance $m/kg^{1/3}$ (ft/lb ^{1/3})	Time of Arrival (msec)	Peak Pressure kPa (psi)	Scaled Positive Impulse $kPa \cdot ms/kg^{1/3}$ (psi $\cdot$ ms/lb ^{1/3})	Pressure TNT Equivalency %	Impulse TNT Equivalency %
4.24 (13.92)	1.19 (3.0)	3.6	2477.42 (359.32)	284.38 (31.74)	390	231
5.73 (18.8)	1.59 (4.0)	4.36	1091.65 (158.33)	155.25 (17.3)	282	149
7.61 (24.97)	2.14 (5.4)	7.18	413 (59.9)	116.66 (13)	199	117
12.73 (41.77)	3.57 (9.0)	16.94	102.66 (14.89)	66.7 (7.42)	150	93
25.47 (83.55)	7.14 (18.0)	50.5	29.16 (4.23)	37.06 (4.13)	141	100
56.59 (185.66)	15.87 (40.0)	137.63	10.2 (1.48)	17.14 (1.91)	164	98

Table 4. Summary of test results, 36.3 kg (80 lb) charge, odd gage configuration

Radius meters (ft)	Scaled Distance $m/kg^{1/3}$ ($ft/lb^{1/3}$)	Time of Arrival (msec)	Peak Pressure kPa (psi)	Scaled Positive Impulse $kPa \cdot ms/kg^{1/3}$ ($psi \cdot ms/lb^{1/3}$)	Pressure TNT Equivalency %	Impulse TNT Equivalency %
3.94 (12.93)	1.19 (3.0)	3.1	734 (106.45)	105 (11.68)	73	44
5.32 (17.45)	1.587 (4.0)	5.23	314 (45.57)	60.4 (6.73)	57	26
7.07 (23.18)	2.14 (5.4)	9.07	115 (16.62)	86.2 (9.6)	33	70
11.82 (38.78)	3.57 (9.0)	21.27	63.1 (9.15)	68.02 (7.58)	67	96
23.64 (77.56)	7.14 (18.0)	53	29.4 (4.26)	44 (4.9)	145	128
52.53 (172.35)	15.87 (40.0)	133.43	15.4 (2.24)	24.14 (2.69)	420	165

Table 5. Summary of test results, 36.3 kg (80 lb) charge, even gage configuration

Radius meters (ft)	Scaled Distance $m/kg^{1/3}$ ($ft/lb^{1/3}$)	Time of Arrival (msec)	Peak Pressure kPa (psi)	Scaled Positive Impulse $kPa \cdot ms/kg^{1/3}$ ($psi \cdot ms/lb^{1/3}$)	Pressure TNT Equivalency %	Impulse TNT Equivalency %
3.94 (12.93)	1.19 (3.0)	3.97	926 (134.28)	169 (18.78)	101	96
5.32 (17.45)	1.587 (4.0)	5.78	479 (69.45)	125 (13.93)	102	89
7.07 (23.18)	2.14 (5.4)	8.8	210 (30.41)	90.3 (10.06)	77	76
11.82 (38.78)	3.57 (9.0)	19.2	98.3 (14.25)	56.9 (6.34)	141	72
23.64 (77.56)	7.14 (18.0)	49.57	29.9 (4.34)	38.7 (4.31)	150	104
52.53 (172.35)	15.87 (40.0)	130.33	11.16 (1.62)	20.6 (2.3)	200	129

Table 6. Summary of test results, 72.6 kg (160 lb) charge, odd gage configuration

Radius meters (ft)	Scaled Distance $m/kg^{1/3}$ (ft/lb ^{1/3})	Time of Arrival (msec)	Peak Pressure kPa (psi)	Scaled Positive Impulse $kPa \cdot ms/kg^{1/3}$ (psi · ms/lb ^{1/3})	Pressure TNT Equivalency %	Impulse TNT Equivalency %
4.97 (16.29)	1.19 (3.0)	4.23	935 (135.67)	92.5 (10.31)	105	36
6.7 (21.99)	1.587 (4.0)	6.93	286 (41.42)	61.2 (6.82)	50	27
8.9 (29.21)	2.14 (5.4)	11.7	138 (19.98)	98 (10.92)	43	89
14.89 (48.86)	3.57 (9.0)	27.32	75.2 (10.91)	55.7 (6.21)	89	73
29.79 (97.72)	7.14 (18.0)	66.53	40.4 (5.86)	45.9 (5.12)	256	138
66.19 (217.15)	15.87 (40.0)	167.07	12.76 (1.85)	20.3 (2.26)	272	126

Table 7. Summary of test results, 72.6 kg (160 lb) charge, even gage configuration

Radius meters (ft)	Scaled Distance $m/kg^{1/3}$ (ft/lb ^{1/3})	Time of Arrival (msec)	Peak Pressure kPa (psi)	Scaled Positive Impulse $kPa \cdot ms/kg^{1/3}$ (psi · ms/lb ^{1/3})	Pressure TNT Equivalency %	Impulse TNT Equivalency %
4.97 (16.29)	1.19 (3.0)	4.93	1398 (202.82)	195 (21.73)	180	123
6.7 (21.99)	1.587 (4.0)	6.83	606 (87.71)	135 (14.99)	141	100
8.9 (29.21)	2.14 (5.4)	10.23	- (40.83)	92.7 (10.33)	117	80
14.89 (48.86)	3.57 (9.0)	23.6	84.7 (12.28)	54.1 (6.03)	110	67
29.79 (97.72)	7.14 (18.0)	62.3	30 (4.35)	45.8 (5.1)	151	139
66.19 (217.15)	15.87 (40.0)	165.2	11.24 (1.63)	21 (2.34)	204	133

Table 8 Summary of test results, composite odd gage dryer bed configuration

Scaled Distance $m/kg^{1/3}$ ($ft/lb^{1/3}$)	Time of Arrival (msec)	Peak Pressure kPa (psi)	Scaled Positive Impulse $kPa \cdot ms/kg^{1/3}$ ($psi \cdot ms/lb^{1/3}$)	Pressure TNT Equivalency %	Impulse TNT Equivalency %
1.19 (3.0)	0.78	757 (109.85)	92.8 (10.34)	77	36
1.587 (4.0)	1.25	307 (44.51)	58.3 (6.5)	55	25
2.14 (5.4)	2.09	125 (18.14)	90.5 (10.08)	37	76
3.57 (9.0)	4.98	68 (9.86)	68 (7.58)	76	96
7.14 (18.0)	12.34	29.9 (4.34)	45.2 (5.04)	170	134
15.87 (40.0)	31.05	14.3 (2.08)	21.6 (2.41)	361	139

Table 9. Summary of test results, composite even gage dryer bed configuration

Scaled Distance $m/kg^{1/3}$ ($ft/lb^{1/3}$)	Time of Arrival (msec)	Peak Pressure kPa (psi)	Scaled Positive Impulse $kPa \cdot ms/kg^{1/3}$ ($psi \cdot ms/lb^{1/3}$)	Pressure TNT Equivalency %	Impulse TNT Equivalency %
1.19 (3.0)	0.93	1136 (164.73)	178 (19.78)	135	105
1.587 (4.0)	1.26	587 (85.08)	137 (15.24)	135	108
2.14 (5.4)	1.9	225 (32.6)	92 (10.23)	86	78
3.57 (9.0)	4.34	93.5 (13.56)	56.3 (6.27)	130	72
7.14 (18.0)	11.58	29.7 (4.31)	39.2 (4.37)	148	107
15.87 (40.0)	30.34	11.1 (1.61)	21 (2.35)	200	133

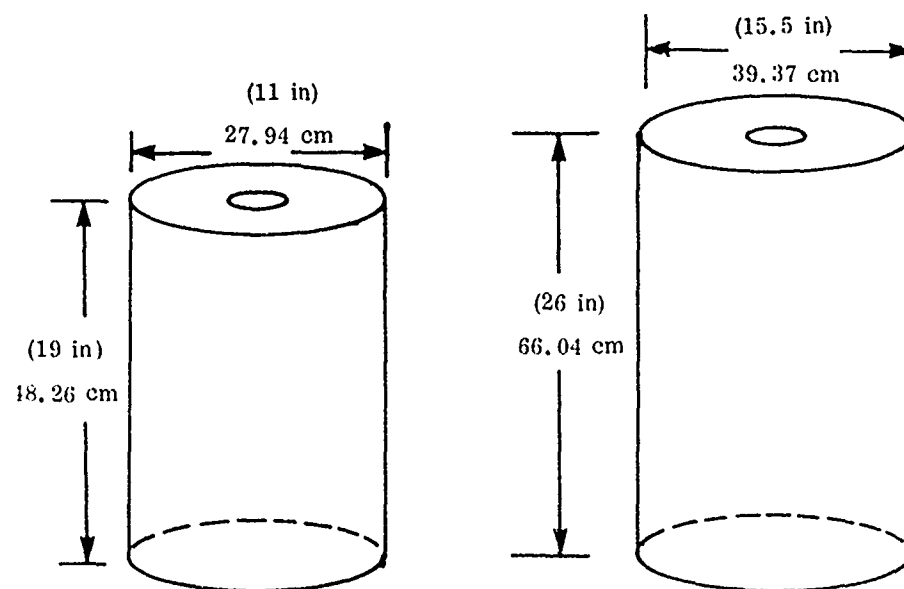
Table 10. Summary of test results, composite results with L/D ratio greater than 1:1

Scaled Distance m/kg ^{1/3} (ft/lb ^{1/3})	Time of Arrival (msec)	Peak Pressure kPa (psi)	Scaled Positive Impulse kPa·ms/kg ^{1/3} (psi·ms/lb ^{1/3})	Pressure TNT Equivalency %	Impulse TNT Equivalency %
1.19 (3.0)	0.75	2498 (362.33)	285 (31.78)	388	231
1.59 (4.0)	1.03	1161 (168.35)	175 (19.49)	326	149
2.14 (5.4)	1.55	398 (57.78)	120 (13.39)	190	122
3.57 (9.0)	3.8	108.4 (15.72)	72.9 (8.12)	157	108
7.14 (18.0)	10.92	31.2 (4.52)	39.3 (4.38)	157	107
15.87 (40.0)	29.92	10.3 (1.49)	16.9 (1.88)	168	94

Table 11. Fireball duration and diameter

TABLE 11. FIREBALL DURATION AND DIAMETER

Charge Weight kg (lb)	Maximum Fireball Diameter meters (ft)	Fireball Duration msec
22.7 (50)	13.72 (45)	112
45.4 (100)	21.34 (70)	148
36.3 (80)	13.72 (45)	192
72.6 (160)	16.76 (55)	375



A. Shipping drum configuration 22.7 kg (50 lb) Fiberboard construction
 B. Shipping drum configuration 45.1 kg (100 lb) Fiberboard construction

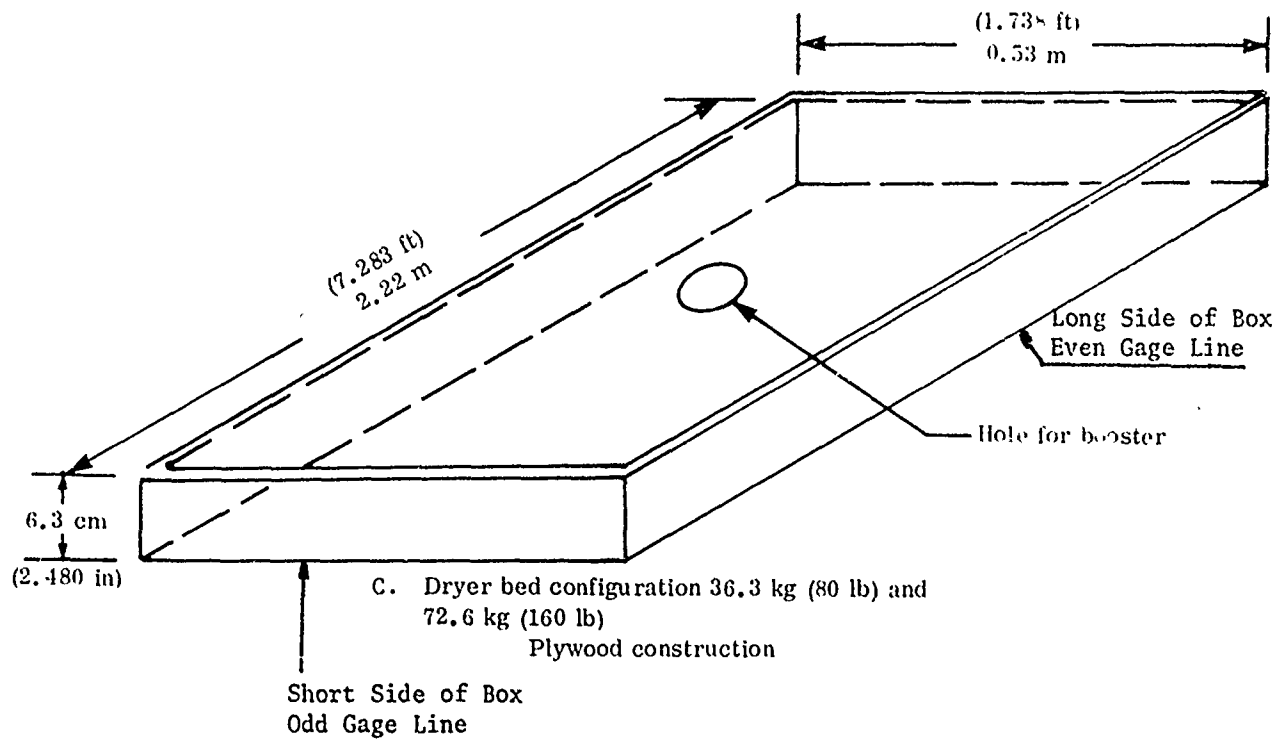


Figure 1. Test Container Configurations

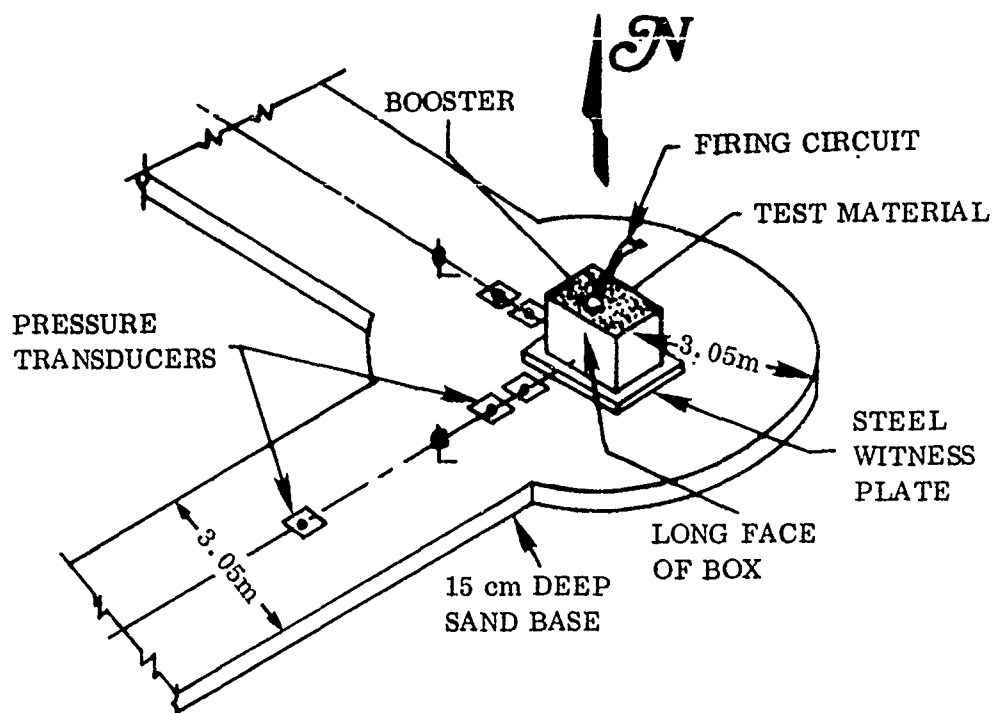


Figure 2. Typical Charge Placement for Equivalency Tests

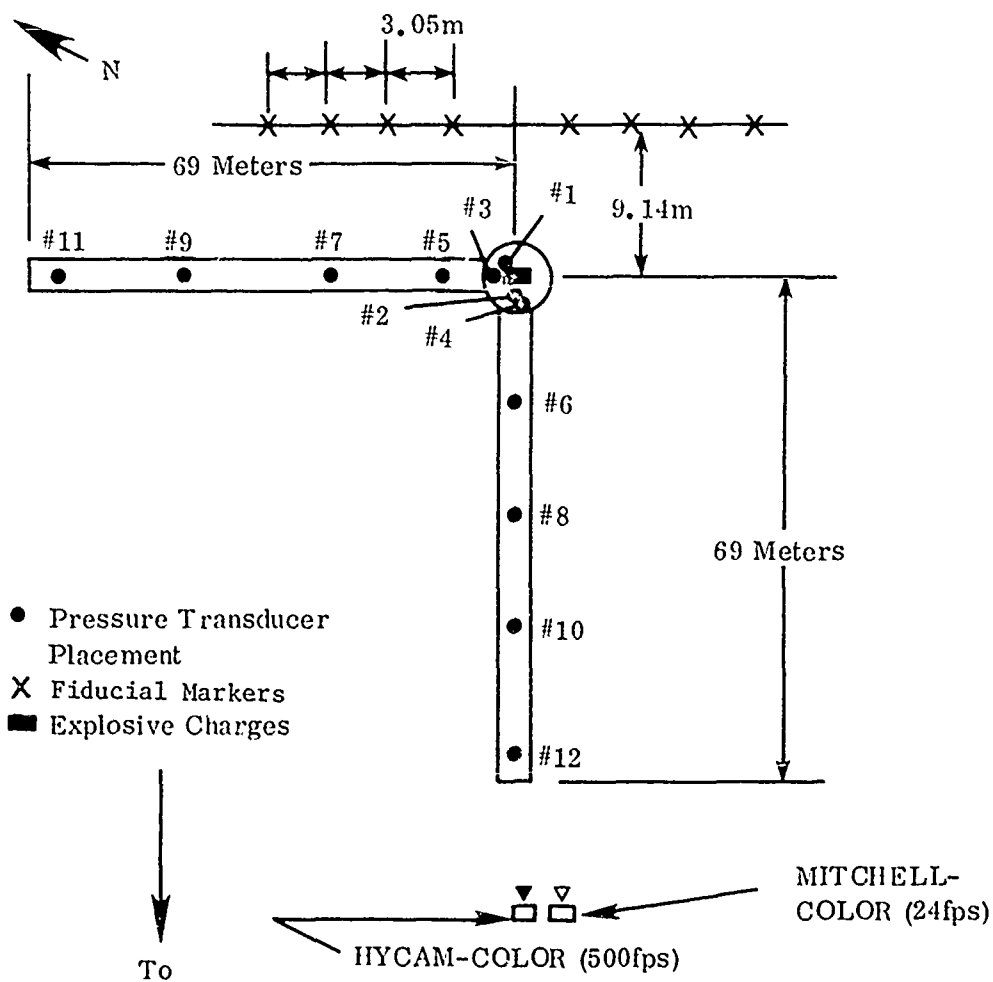


Figure 3. Test Area Showing Transducer and Camera Placement

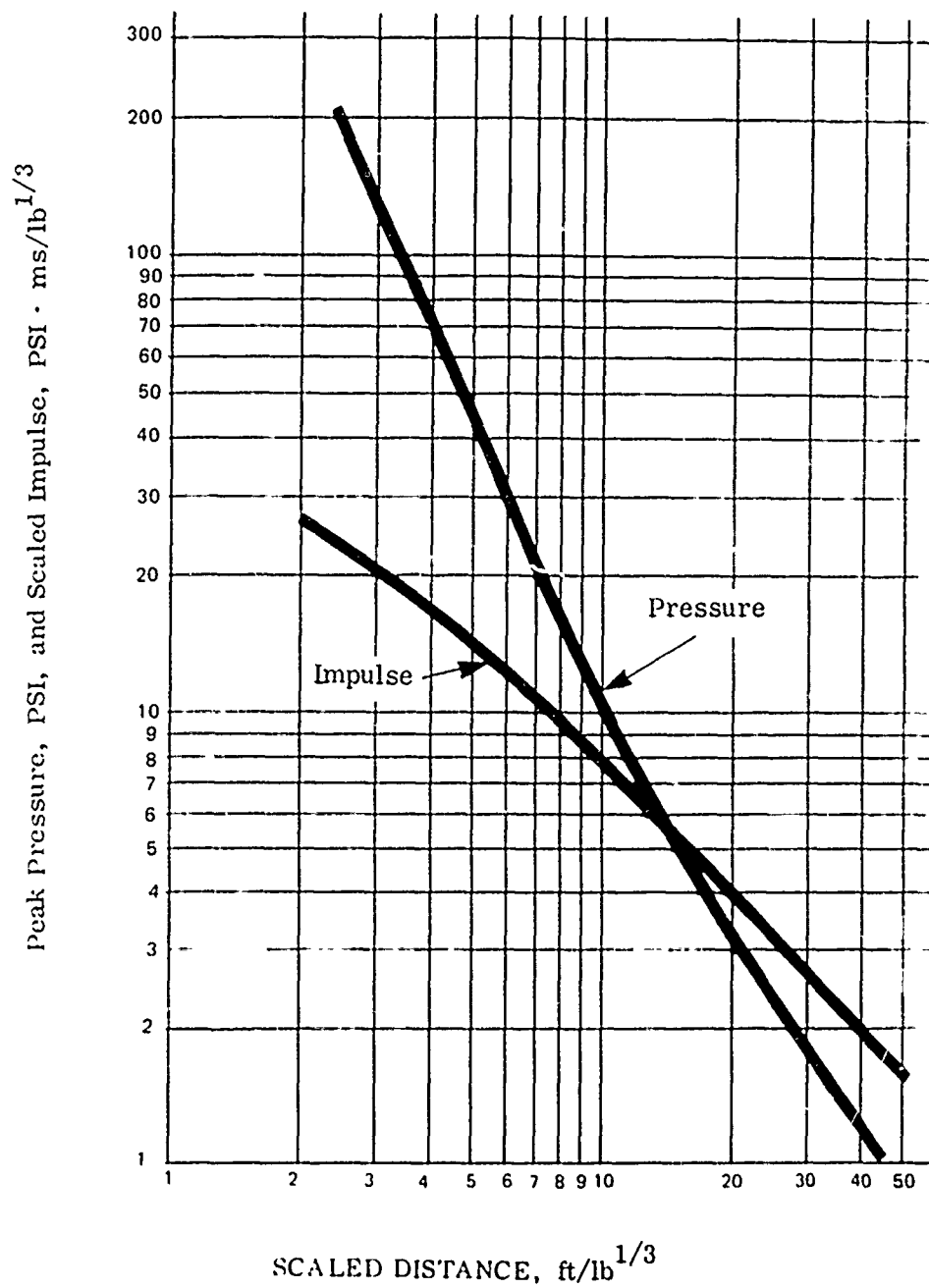


Figure 4. TNT Hemispherical Surface Burst

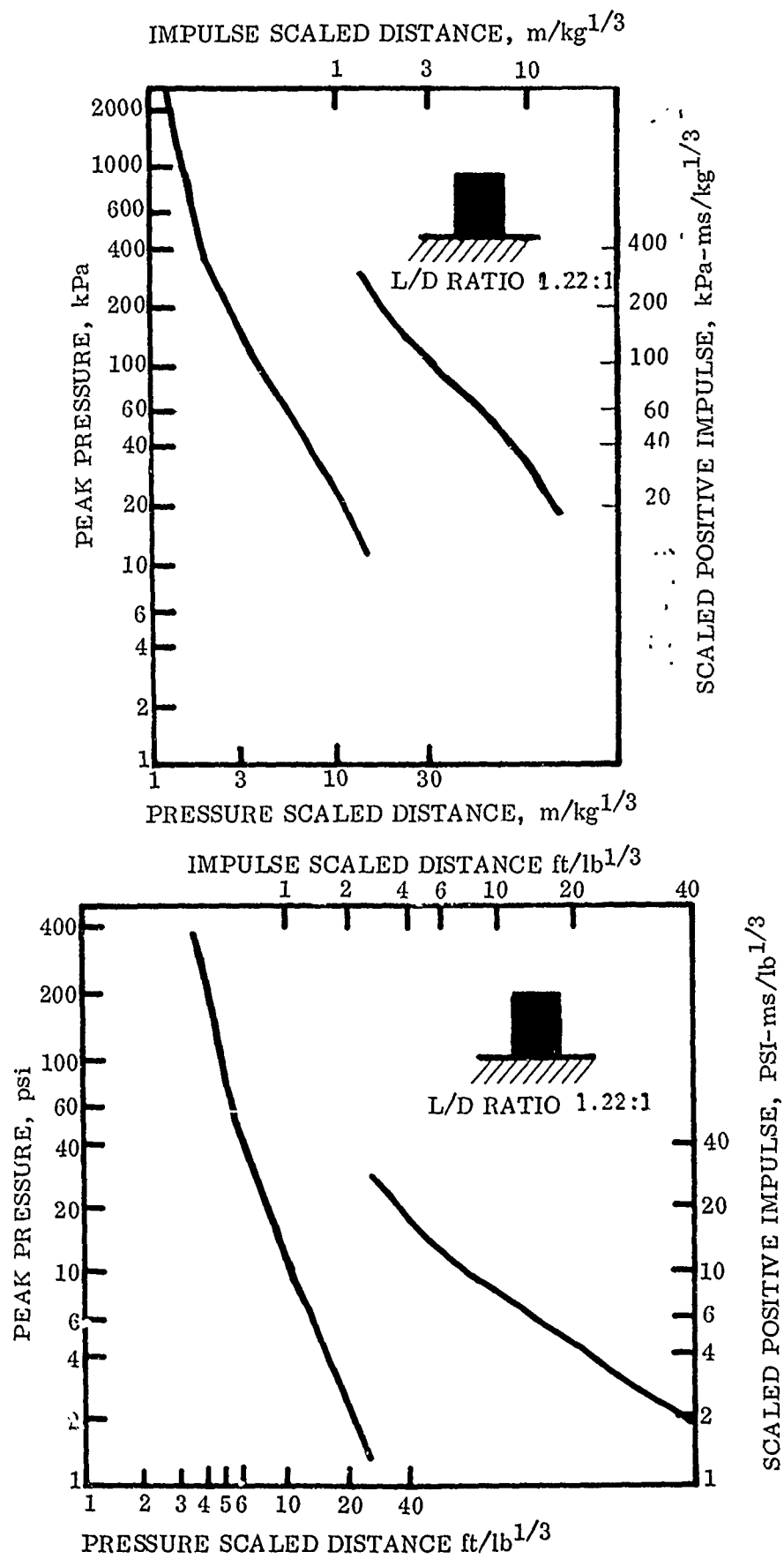


Figure 5. Pressure and Impulse versus Scaled Distance 22.7 kg (50 lb) Charge Weights

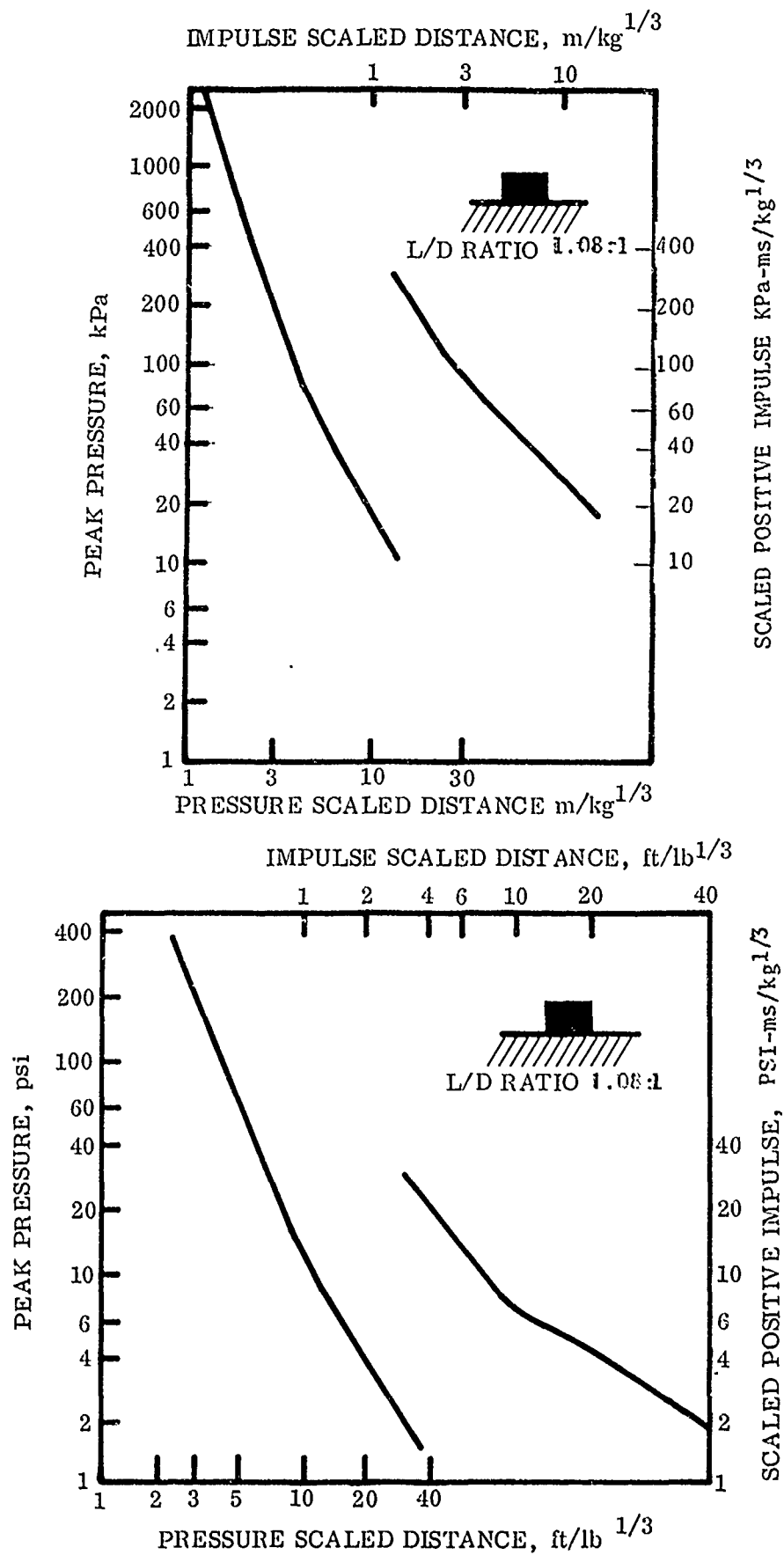


Figure 6. Pressure and Impulse versus Scaled Distance 45.4 kg (100 lb)
Charge Weights

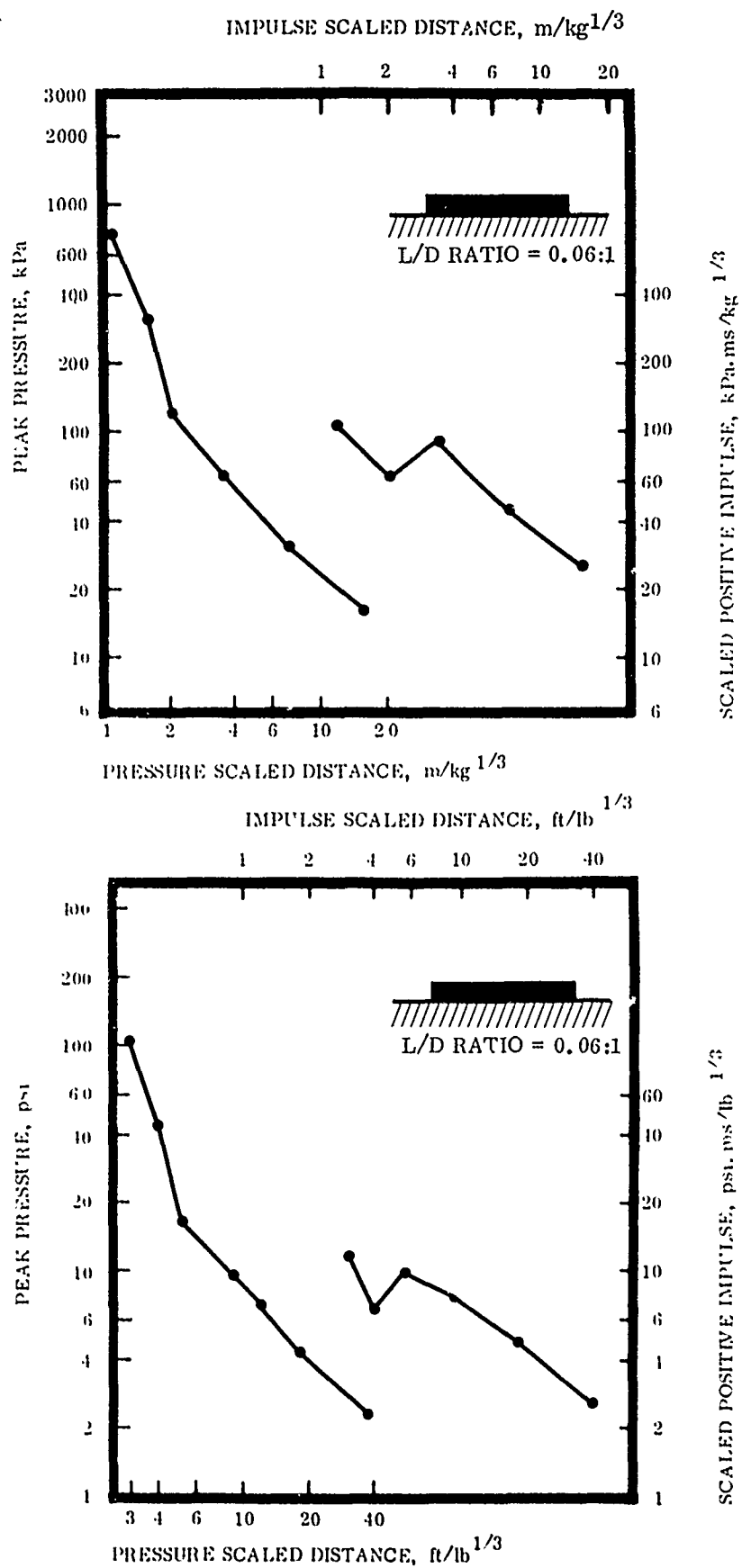


Figure 7. Pressure and Impulse versus Scaled Distance for Odd Gage Line
36.3 kg (80 lb) Charge Weight, Dryer Bed Configuration

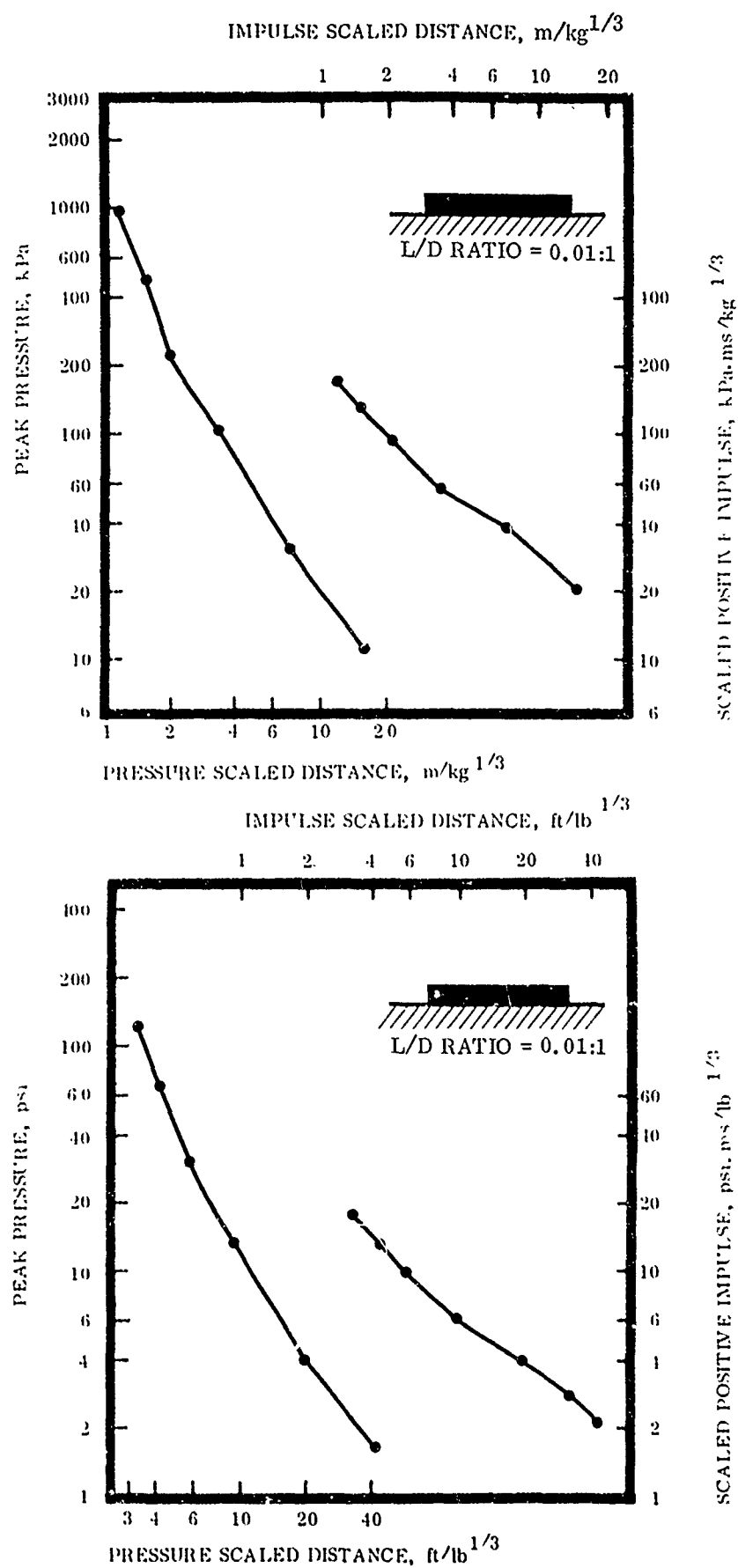


Figure 8. Pressure and Impulse versus Scaled Distance for Even Gage Line
36.3 kg (80 lb) Charge Weight, Dryer Bed Configuration

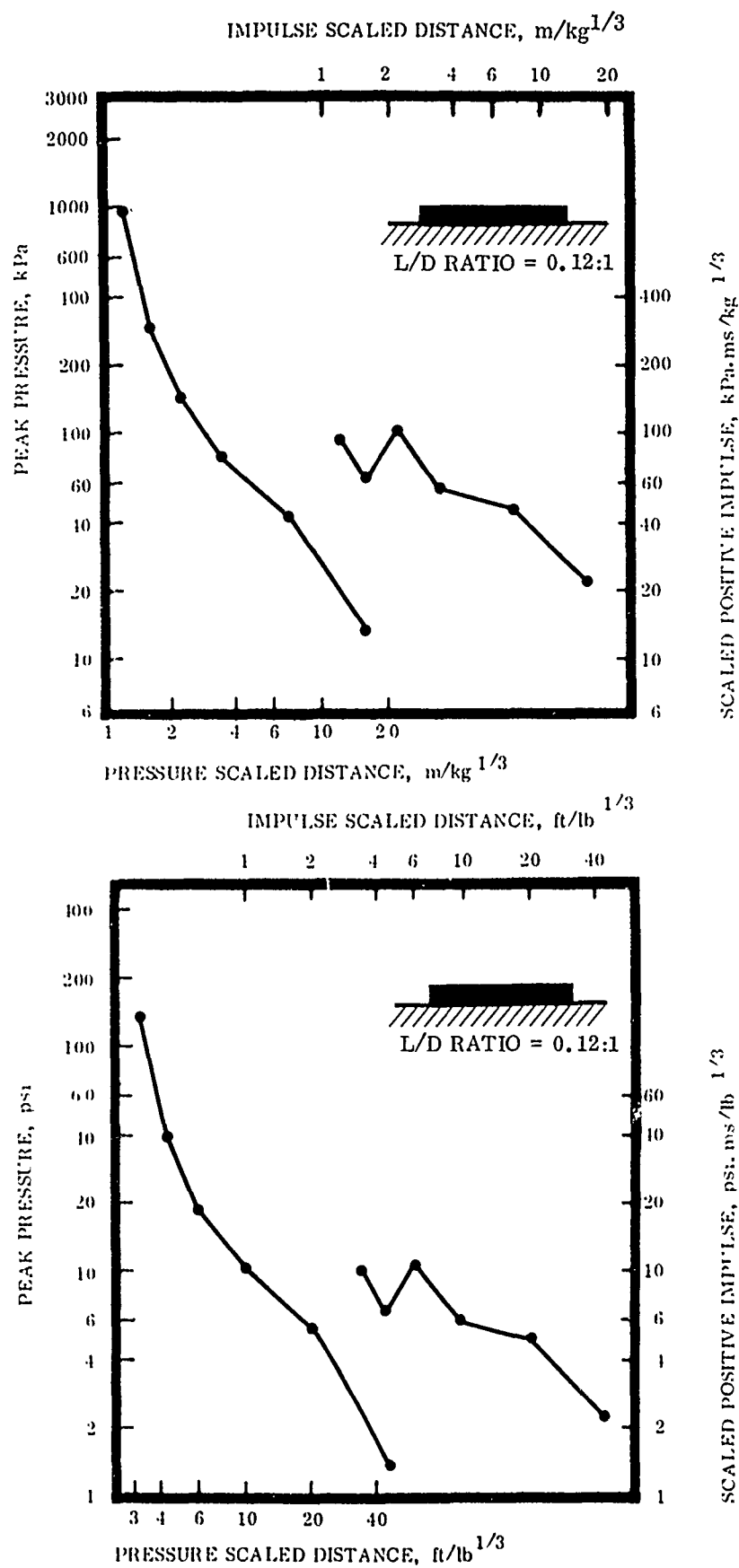


Figure 9. Pressure and Impulse versus Scaled Distance for Odd Gage Line
72.6 kg (160 lb) Charge Weight, Dryer Bed Configuration

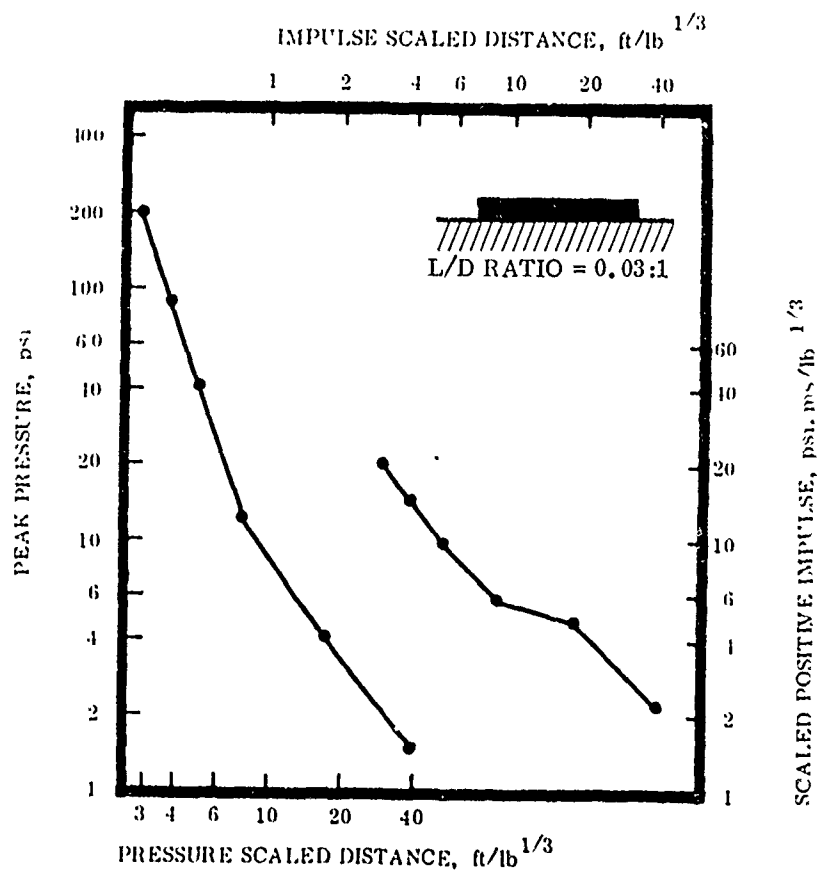
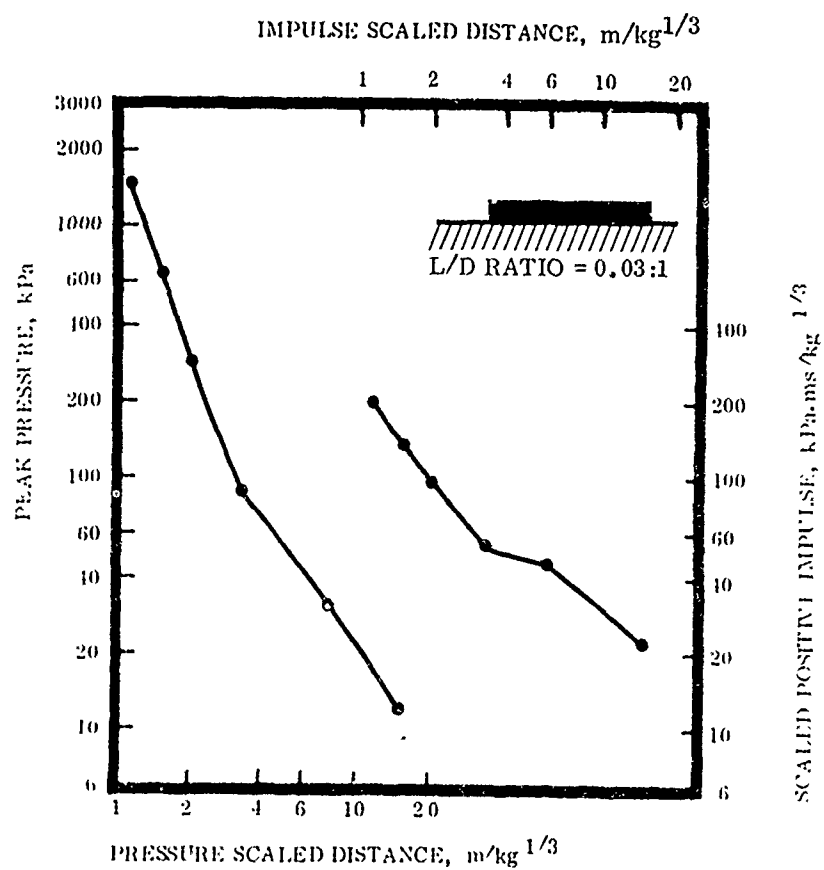


Figure 10. Pressure and Impulse versus Scaled Distance for Even Gage Line
72.6 kg (160 lb) Charge Weight, Dryer Bed Configuration

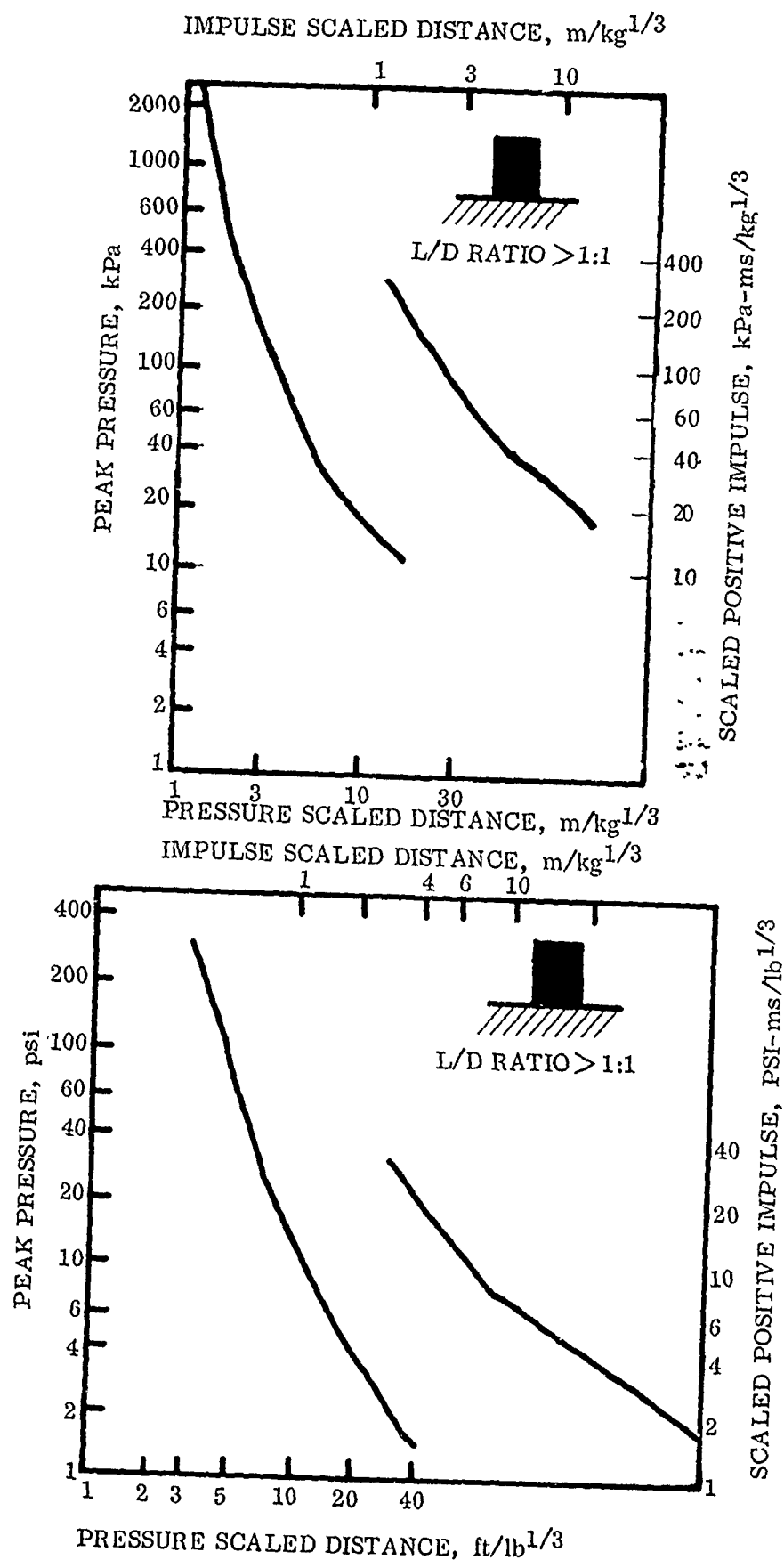


Figure 11. Pressure and Impulse versus Scaled Distance 22.7 and 45.4 kg (50 and 100 lb) Charge Weights Combined

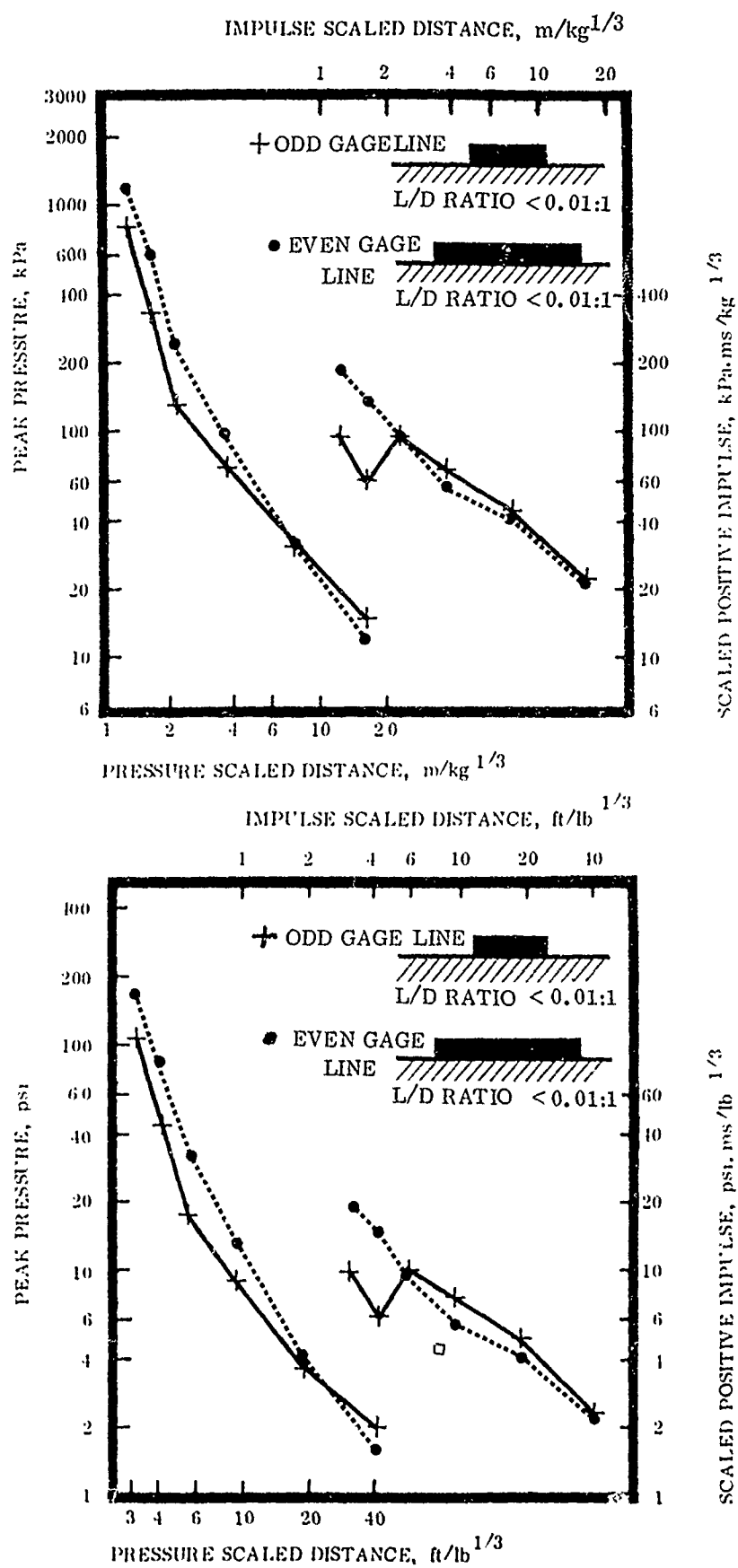


Figure 12. Pressure and Impulse versus Scaled Distance 36.3 and 72.5 kg (80 and 160 lb) Charge Weights Combined for Odd and Even Gage Values

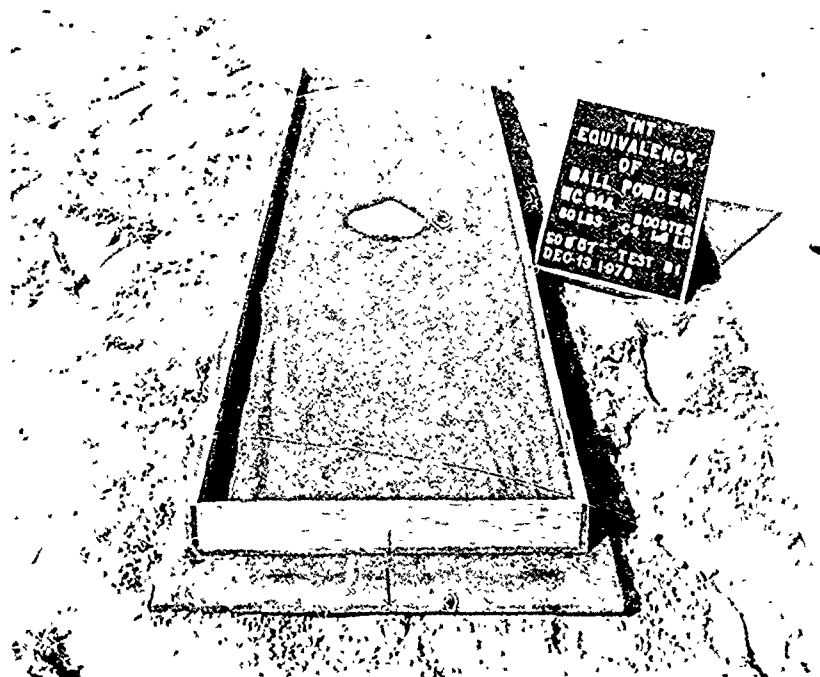


Figure 15. Pretest configuration for 45.4 kg charge

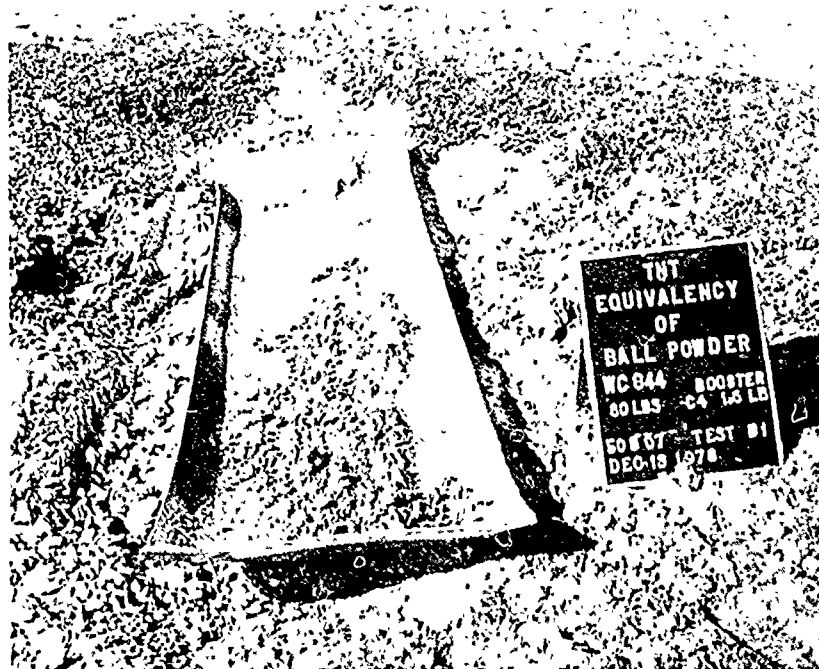


Figure 16. Posttest configuration for 45.4 kg charge



Figure 17. Pretest configuration for 36.3 kg charge



Figure 18. Posttest configuration for 36.3 kg charge



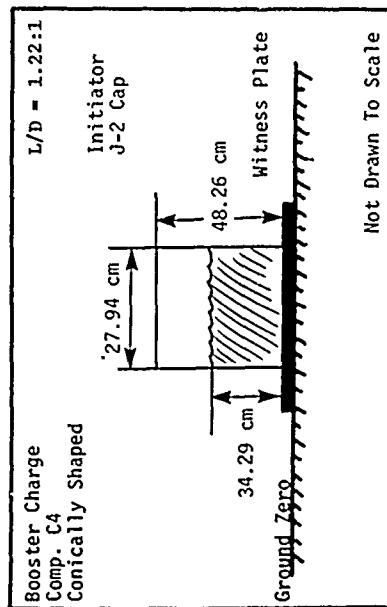
Figure 19. Pretest configuration for 72.6 kg charge



Figure 20. Posttest configuration for 72.6 kg charge

APPENDIX
DATA SHEETS

TEST TITLE TNT Equivalency DATE 12/11/78
 TEST SAMPLE WC844 Ball Powder TIME 1209
 SAMPLE WEIGHT 22.7 kg (50 lb) TEMP. 50°F
 IGN. SOURCE J2 Blasting Cap HUMIDITY 26%
 BOOSTER WT. 0.45 kg (1.0 lb) BAR. PRESS. 30.42
 TEST NO. 50-8-01 WIND DIR. 330°
 CONTRACT NO. NAS13-50 WIND VEL. 7 mph



FIELD EVALUATION: Detonation Occurred

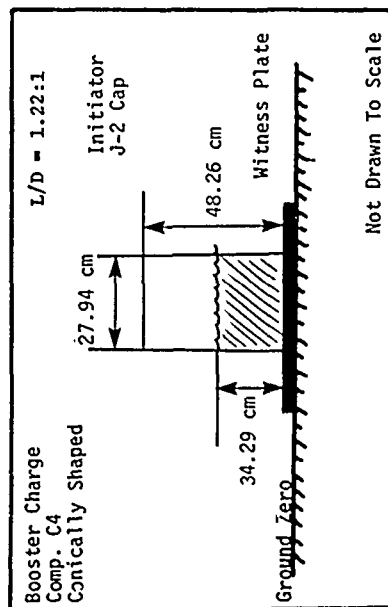
Motion Picture Coverage

Crater Dimensions: 2.13 m dia by 0.58 m deep

Channel Number	Distance Meters (ft)	Peak Pressure kPa (psi)	Scaled Positive Impulse kPa msec/kg $1/3$ (psi msec/lb $1/3$)	Time of Arrival (msec)
1	3.37	2451 (355.49)	288 (32.13)	3.45
2	(11.05)	2222 (322.25)	250 (27.84)	3.6
3	4.49	1124 (163.01)	173 (19.3)	-
4	(14.74)	1225 (177.61)	185 (20.61)	4.7
5	6.06	390 (56.53)	118 (13.13)	6.7
6	(19.89)	449 (65.07)	125 (13.91)	6.8
7	10.11	113.2 (16.42)	65.3 (7.28)	15.2
8	(33.2)	116 (16.83)	83.5 (9.3)	14.8
9	20.21	31.7 (4.6)	35.6 (3.99)	41.6
10	(66.3)	26.2 (3.8)	41.3 (4.6)	41.5
11	44.92	9.9 (1.43)	15.8 (1.76)	112.4
12	(147.4)	9 (1.31)	15.4 (1.72)	112.1

Figure A-1. Data sheet for test 1, 22.7 kg charge

TEST TITLE INT Equivalency DATE 12/11/78
 TEST SAMPLE WC844 Ball Powder TIME 1209
 SAMPLE WEIGHT 22.7 kg (50 lb) TEMP. 52°F
 IGN. SOURCE J2 Blasting Cap HUMIDITY 23%
 BOOSTER WT. 0.45 kg (1.0 lb) BAR. PRESS. 30.38
 TEST NO. 50-8-02 WIND DIR. 330°
 CONTRACT NO. NAS13-50 WIND VEL. 5 mph



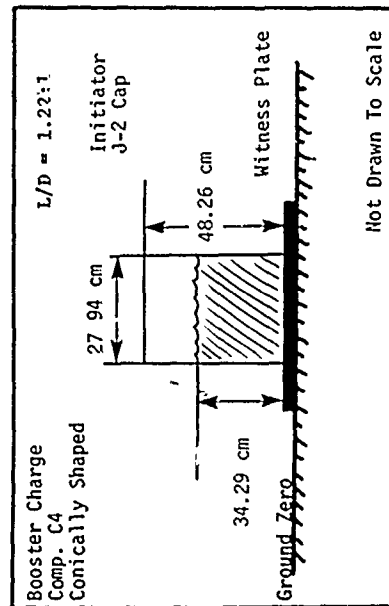
FIELD EVALUATION: Detonation Occurred

Crater Dimensions: 2.08 m dia. by 0.51 m deep

Channel Number	Distance Meters (ft)	Peak Pressure kPa (psi)	Scaled Positive Impulse kPa msec/kg ^{1/3} (psi msec/lb ^{1/3})	Time of Arrival (msec)
1	3.37	2749 (398.69)	384 (42.81)	2.2
2	(11.05)	2107 (305.64)	156 (17.4)	2.3
3	4.49	1122 (162.67)	177 (19.75)	-
4	(14.74)	1124 (163)	188 (20.91)	3.4
5	6.06	456 (66.06)	136 (15.1)	5.2
6	(19.89)	346 (50.24)	114 (12.71)	5.5
7	10.11	-	-	-
8	(33.2)	108 (15.65)	84 (9.36)	13.85
9	20.21	31.6 (4.59)	39.5 (4.4)	40
10	(66.3)	32.4 (4.7)	-	40.1
11	44.92	11 (1.6)	15.9 (1.77)	110.9
12	(147.4)	11.1 (1.61)	16.5 (1.84)	110.15

Figure A-2. Data sheet for test 2, 22.7 kg charge

TEST TITLE TNT Equivalency DATE 12/11/78
 TEST SAMPLE WC844 Ball Powder TIME 15.20
 SAMPLE WEIGHT 22.7 kg (50 lb) TEMP. 52°F
 IGN. SOURCE J2 Blasting Cap HUMIDITY 23%
 BOOSTER WT. 0.45 kg (1.0 lb) BAR. PRESS. 30.37
 TEST NO. 50-8-03 WIND DIR. 360°
 CONTRACT NO. HA513-50 WIND VEL. 6 mph



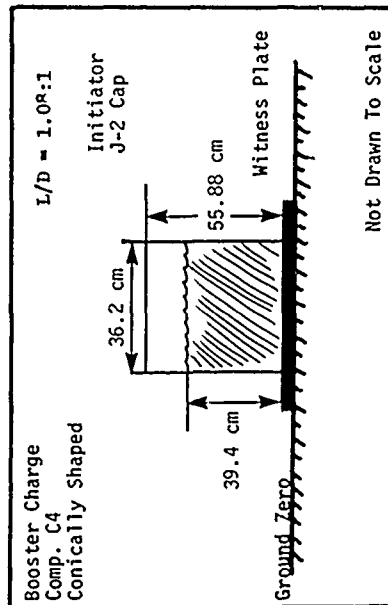
FIELD EVALUATION: Detonation Occurred

Crater Dimensions: 2.13 m dia. by 0.55 m deep

Channel Number	Distance Meters (ft)	Peak Pressure kPa (psi)	Scaled Positive Impulse kPa msec/kg ^{1/3} (psi msec/lb ^{1/3})	Time of Arrival (msec)
1	3.37	2635 (382.17)	382 (42.56)	3.1
2	(11.05)	2579 (374.06)	319 (35.57)	3.2
3	4.49	1124 (162.95)	166 (18.49)	-
4	(14.74)	1247 (180.91)	176 (19.65)	4.2
5	6.06	377 (54.67)	145 (16.11)	6.1
6	(19.89)	406 (58.85)	116 (12.88)	6.2
7	10.11	-	-	-
8	(33.2)	129 (18.64)	83.3 (9.34)	14.5
9	20.21	31.1 (4.51)	40.5 (4.51)	40.7
10	(66.3)	32.4 (4.7)	40.2 (4.48)	40.7
11	44.92	11 (1.6)	19 (2.12)	111.5
12	(147.4)	10.5 (1.53)	17.9 (1.99)	110.9

Figure A-3. Data sheet for test 3, 22.7 kg charge

TEST TITLE INT Equivalency DATE 12/12/78
 TEST SAMPLE WC844 Ball Powder TIME 1400
 SAMPLE WEIGHT 45.4 kg (.00 lb) TEMP. 68°F
 IGN. SOURCE J2 Blasting Cap HUMIDITY 25%
 BOOSTER WT. 0.45 kg (1.0 lb) BAR. PRESS. 30.32
 TEST NO. 50-8-04 WIND DIR. 300°
 CONTRACT NO. NAS13-50 WIND VEL. 2 mph



FIELD EVALUATION: Detonation Occurred

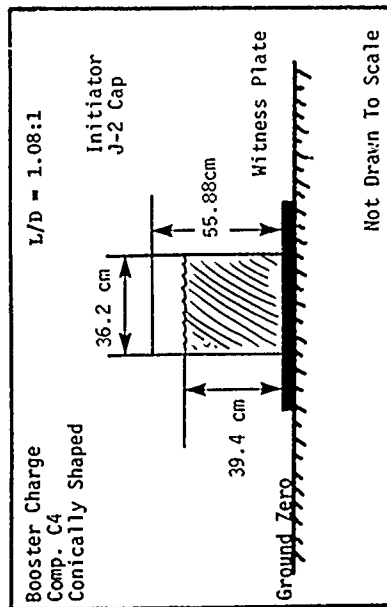
Motion Picture Coverage

Crater Dimensions: 3.05 m dia. by 0.74 m deep

Channel Number	Distance Meters (ft)	Peak Pressure kPa (psi)	Scaled Positive Impulse kPa msec/kg ^{1/3} (psi msec/lb ^{1/3})	Time of Arrival (msec)
1	4.24	1816 (263.35)	71.2 (7.93)	2.4
2	(13.92)	2440 (353.89)	323 (36.01)	2.5
3	5.73	701 (101.7)	46.6 (5.19)	3.2
4	(18.8)	1198 (173.71)	149 (16.62)	3.55
5	7.61	411 (59.55)	106 (11.8)	5.55
6	(24.97)	310 (45.01)	119 (13.3)	5.5
7	12.73	116 (16.85)	68.1 (7.59)	15.6
8	(41.77)	74.3 (10.77)	48.3 (5.44)	14.5
9	25.47	30.1 (4.37)	41.4 (4.61)	48.85
10	(83.55)	25.2 (3.65)	37.3 (4.16)	49
11	56.59	9.2 (1.33)	16.1 (1.79)	137
12	(185.66)	10.5 (1.52)	18.4 (2.05)	136.4

Figure A-4. Data sheet for test 4, 45.4 kg charge

TEST TITLE INT Equivalency DATE 12/12/78
 TEST SAMPLE WC844 Ball Powder TIME 1447
 SAMPLE WEIGHT 45.4 kg (100 lb) TEMP. 69°F
 IGN. SOURCE J2 Blasting Cap HUMIDITY 24%
 BOOSTER WT. 0.45 kg (1.0 lb) BAR. PRESS. 30.30
 TEST NO. 50-8-05 WIND DIR. 320°
 CONTRACT NO. NAS13-50 WIND VEL. 2 mph



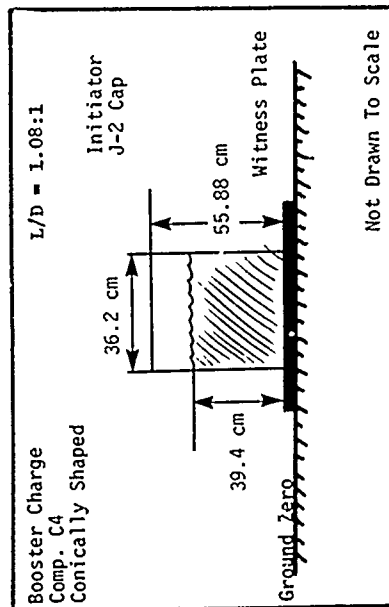
FIELD EVALUATION: Detonation Occurred

Crater Dimensions: 2.44 m dia by 0.51 m deep

Channel Number	Distance Meters (ft)	Peak Pressure kPa (psi)	Scaled Positive Impulse kPa msec/kg ^{1/3} (psi msec/lb ^{1/3})	Time of Arrival (msec)
1	4.24	2433 (352.9)	233.1 (25.98)	3.65
2	(13.92)	2950 (427.89)	310 (34.59)	3.75
3	5.73	623 (90.4)	92.3 (10.34)	5
4	(18.8)	1178 (170.82)	176 (19.62)	5.1
5	7.61	490 (71.11)	130 (14.45)	7.3
6	(24.97)	561 (81.4)	115 (12.79)	7.4
7	12.73	119 (17.31)	72.7 (8.1)	17
8	(41.77)	92 (13.28)	57 (6.35)	17
9	25.47	27.5 (3.99)	41.6 (4.54)	50.5
10	(83.55)	26.8 (3.88)	36.4 (4.06)	50.55
11	56.59	10.9 (1.58)	17.2 (1.92)	137.7
12	(185.66)	9.7 (1.4)	16.9 (1.88)	137.8

Figure A-5. Data sheet for test 5, 45.4 kg charge

TEST TITLE TNT Equivalency DATE 12/12/78
 TEST SAMPLE WC844 Ball Powder TIME 1545
 SAMPLE WEIGHT 45.4 kg (100 lb) TEMP. 65°F
 IGN. SOURCE J2 Blasting Cap HUMIDITY 32%
 BOOSTER WT. 0.45 kg (1.0 lb) BAR. PRESS. 30.30
 TEST NO. 50-8-06 WIND DIR. 330°
 CONTRACT NO. MAS13-50 WIND VEL. 4 mph



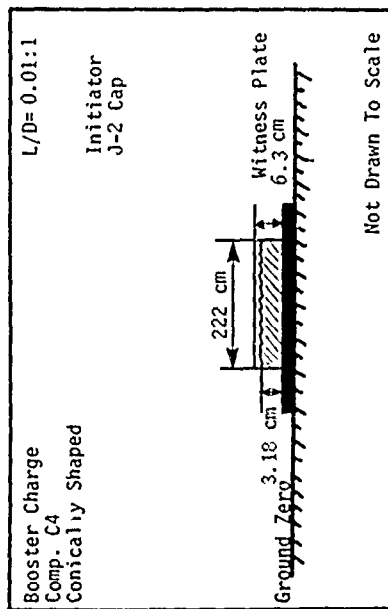
FIELD EVALUATION: Detonation Occurred

Crater Dimensions: 3.05 m dia. by 0.51 m deep

Channel Number	Distance Meters (ft)	Peak Pressure kPa (psi)	Scaled Positive Impulse kPa msec/kg ^{1/3} (psi msec/lb ^{1/3})	Time of Arrival (msec)
1	4.24 (13.92)	2597 (376.6)	252 (28.07)	3.4
2		2440 (353.89)	306 (34.05)	3.5
3	5.73 (18.8)	899.5 (130.46)	194 (21.65)	4.2
4		1337 (193.98)	164 (18.25)	4.7
5	7.61 (24.97)	362 (52.44)	109 (12.15)	6.9
6		390 (56.5)	125 (13.91)	7.1
7	12.73 (41.77)	95.4 (13.84)	68.8 (7.67)	17.5
8		107 (15.57)	53.8 (5.99)	17.6
9	25.47 (83.55)	32.2 (4.67)	38.6 (4.3)	50.6
10		33.7 (4.89)	35.9 (4)	50.5
11	56.59 (185.66)	10.4 (1.51)	17.1 (1.91)	138.4
12		10.2 (1.48)	17.1 (1.91)	138

Figure A-6. Data sheet for test 6, 45.4 kg charge

TEST TITLE TNT Equivalency DATE 12/13/78
 TEST SAMPLE WC844 Ball Powder TIME 1216
 SAMPLE WEIGHT 36.3 kg (80 lb) TEMP. 65°F
 IGN. SOURCE J2 Blasting Cap HUMIDITY 33%
 BOOSTER WT. 0.73 kg (1.6 lb) BAR. PRESS. 30.37
 TEST NO. 50-8-07 WIND DIR. 315°
 CONTRACT NO. NAS13-50 WIND VEL. 7 mph

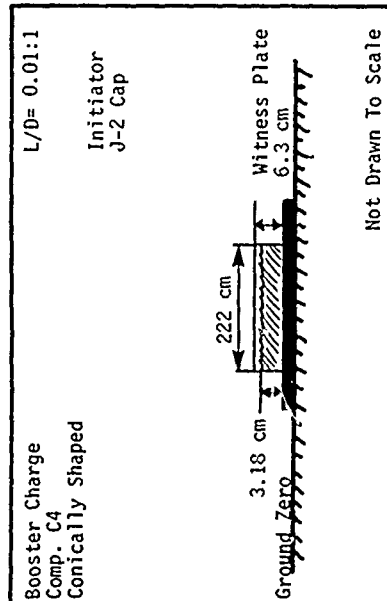


Motion Picture Coverage
 Crater Dimensions: 3.2 m long by 1.82 m wide by 0.3 m deep

Channel Number	Distance Meters (ft)	Peak Pressure kPa (psi)	Scaled Positive Impulse kPa msec/kg ^{1/3} (psi msec/lb ^{1/3})	Time of Arrival (msec)
1	3.94	649 (94.19)	104 (11.55)	2.5
2	(12.93)	1043 (151.25)	181 (20.12)	3.1
3	5.32	327 (47.41)	57.9 (6.45)	4.8
4	(17.45)	532 (77.17)	144 (16.1)	5
5	7.07	96 (13.85)	79.5 (8.86)	8.6
6	(23.18)	210 (30.41)	80.8 (9.1)	8
7	11.82	129 (18.77)	62.5 (6.97)	20.7
8	(38.78)	96 (13.93)	58.1 (6.47)	18.2
9	23.64	26.3 (3.82)	41.5 (4.63)	52.4
10	(77.56)	29.8 (4.32)	37.2 (4.15)	48.6
11	52.53	15.2 (2.21)	22.8 (2.54)	133.4
12	(172.35)	11.2 (1.62)	21.4 (2.38)	129.7

Figure A-7. Data sheet for test 7, 36.3 kg charge

TEST TITLE TNT Equivalency DATE 12/13/78
 TEST SAMPLE WC844 Ball Powder TIME 1355
 SAMPLE WEIGHT 36.3 kg (80 lb) TEMP. 68°F
 IGN. SOURCE J2 Blasting Cap HUMIDITY 25%
 BOOSTER WT. 0.73 kg (1.6 lb) BAR. PRESS. 30.32
 TEST NO. 50-8-08 WIND DIR. 300°
 CONTRACT NO. NAS13-50 WIND VEL. 2 mph



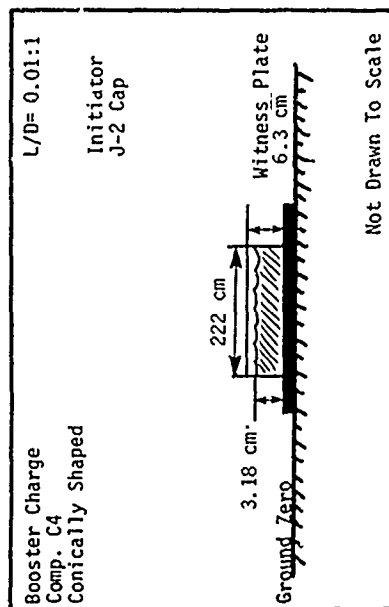
FIELD EVALUATION: Detonation Occurred

Crater Dimensions: 3.2 m long by 1.83 m wide by 0.3 m deep

Channel Number	Distance Meters (ft)	Peak Pressure kPa (psi)	Scaled Positive Impulse kPa msec/kg ^{1/3} (psi msec/lb ^{1/3})	Time of Arrival (msec)
1	3.94	812 (117.74)	128 (14.29)	3.4
2	(12.93)	983 (142.52)	168 (18.73)	4.5
3	5.32	354 (51.36)	69.7 (7.77)	5.2
4	(17.45)	426 (61.73)	106.3 (11.85)	6.2
5	7.07	127 (18.46)	85.5 (9.53)	8.9
6	(23.18)	210 (30.41)	83.6 (9.32)	9.2
7	11.82	58.9 (8.54)	67.8 (7.55)	21.4
8	(38.78)	99.4 (14.41)	56.6 (6.31)	19.7
9	23.64	30.6 (4.44)	45.2 (5.04)	53.3
10	(77.56)	29.8 (4.32)	39.5 (4.4)	50.1
11	52.53	16.4 (2.38)	25.3 (2.82)	133.4
12	(172.35)	11.2 (1.62)	19.7 (2.19)	130.6

Figure A-8. Data sheet for test 8, 36.3 kg charge

TEST TITLE INI Equivalency DATE 12/13/78
 TEST SAMPLE WC844 Ball Powder TIME 1505
 SAMPLE WEIGHT 36.3 kg (80 lb) TEMP. 69°F
 IGN. SOURCE J2 Blasting Cap HUMIDITY 24%
 BOOSTER WT. 0.73 kg (1.6 lb) BAR. PRESS. 30.30
 TEST NO. 50-8-09 WIND DIR. 320°
 CONTRACT NO. NAS13-50 WIND VEL. 2 mph



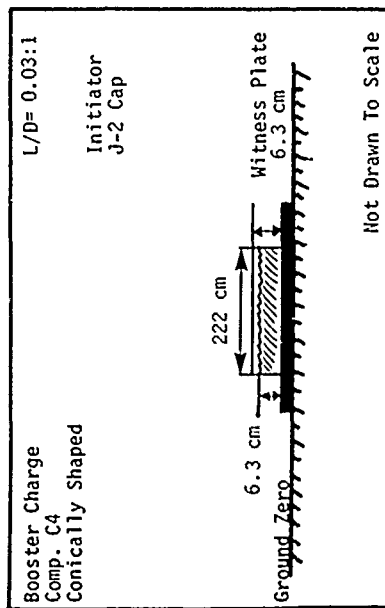
FIELD EVALUATION: Detonation Occurred

Crater Dimensions: 3.05 m long by 2.44 m wide by 0.3 m deep

Channel Number	Distance Meters (ft)	Peak Pressure kPa (psi)	Scaled Positive Impulse kPa msec/kg ^{1/3} (psi msec/lb ^{1/3})	Time of Arrival (msec)
1	3.94	741 (107.43)	82.27 (9.21)	3.4
2	(12.93)	752 (109.07)	157 (17.48)	4.3
3	5.32	262 (37.93)	53.6 (5.97)	5.7
4	(17.45)	-	-	6.15
5	7.07	121 (17.54)	93.4 (10.41)	9.7
6	(23.18)	210 (30.41)	107 (11.87)	9.2
7	11.82	70 (10.15)	73.9 (8.23)	21.7
8	(38.78)	99.4 (14.41)	56.1 (6.25)	19.7
9	23.64	31.1 (4.51)	15 (5.02)	53.3
10	(77.56)	30.3 (4.39)	39.2 (4.37)	50
11	52.53	15.2 (2.21)	24.4 (2.72)	133.5
12	(172.35)	11.2 (1.62)	20.8 (2.32)	130.7

Figure A-9. Data sheet for test 9, 36.3 kg charge

TEST TITLE TNT Equivalency DATE 12/7/78
 TEST SAMPLE WC844 Ball Powder TIME 1255
 SAMPLE WEIGHT 72.6 kg (160 lb) TEMP. 80°F
 IGN. SOURCE J2 Blasting Cap HUMIDITY 90%
 BOOSTER WT. 0.73 kg (1.6 lb) BAR. PRESS. 30.0
 TEST NO. 50-8-10 WIND DIR. 165
 CONTRACT NO. NAS13-50 WIND VEL. 7 mph



FIELD EVALUATION: Detonation Occurred

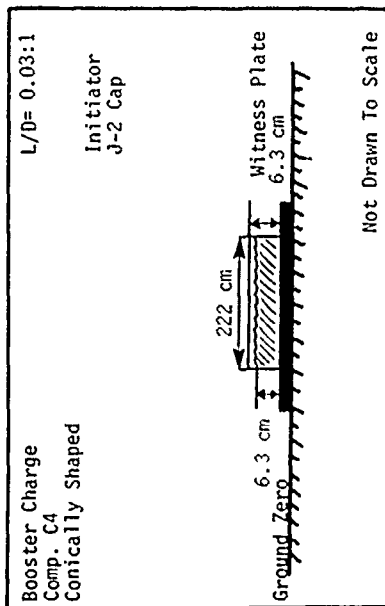
Crater Dimensions: 4.04 m long by 3.76 m wide by 0.91 m deep

Motion Picture Coverage

Channel Number	Distance Meters (ft)	Peak Pressure kPa (psi)	Scaled Positive Impulse kPa msec/kg ^{1/3} (psi msec/lb ^{1/3})	Time of Arrival (msec)
1	4.97	964 (139.8)	84.9 (9.46)	4.2
2	(16.29)	1139 (165.14)	181 (20.11)	5
3	6.7	311 (45.16)	51.5 (5.74)	-
4	(21.99)	615 (89.14)	44.7 (14.98)	7
5	8.9	161 (23.38)	66.2 (7.38)	11.3
6	(29.21)	270 (39.16)	75.1 (8.37)	10.5
7	14.89	70.1 (10.17)	63.2 (7.04)	26.3
8	48.86	81.2 (11.77)	46.8 (5.22)	23.4
9	29.79	49.4 (7.16)	47.3 (5.27)	65
10	(97.72)	29.2 (4.23)	39.8 (4.44)	61.5
11	66.19	18.5 (2.69)	19.9 (2.22)	162.6
12	(217.15)	-	-	-

Figure A-10. Data sheet for test 10, 72.6 kg charge

TEST TITLE TNT Equivalency DATE 12/14/78
 TEST SAMPLE WC844 Ball Powder TIME 1145
 SAMPLE WEIGHT 72.6 kg (160 lb) TEMP. 61°F
 IGN. SOURCE J2 Blasting Cap HUMIDITY 22%
 BOOSTER WT. 1.45 kg (3.2 lb) BAR. PRESS. 30.35
 TEST NO. 50-8-11 WIND DIR. 100°
 CONTRACT NO. NAS13-50 WIND VEL. 4 mph



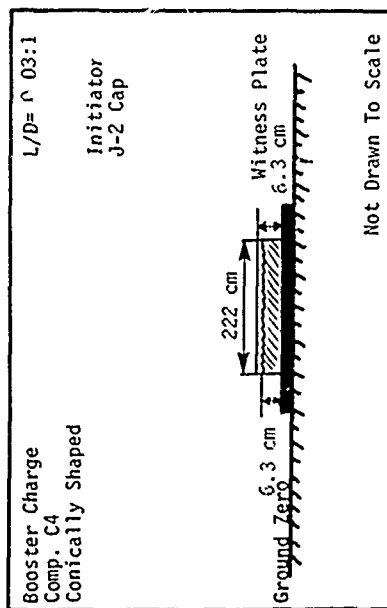
FIELD EVALUATION: Detonation Occurred

Crater Dimensions: 3.96 m long by 2.74 m wide by 0.51 m deep

Channel Number	Distance Meters (ft)	Peak Pressure kPa (psi)	Scaled Positive Impulse kPa msec/kg ^{1/3} (psi msec/lb ^{1/3})	Time of Arrival (msec)
1	4.97	621 (90.07)	79.8 (8.89)	4.3
2	(16.29)	1678 (243.32)	181 (20.14)	4.8
3	6.7	218 (31.68)	59 (5.57)	7.25
4	(21.99)	589 (85.47)	143 (15.96)	6.5
5	8.9	129 (18.75)	125 (13.87)	12.3
6	(29.21)	287 (41.67)	99.8 (11.12)	9.8
7	14.89	84.3 (12.22)	72.6 (8.09)	28.2
8	(48.86)	84.7 (12.29)	54.1 (6.03)	23.5
9	29.79	36.5 (5.29)	45.5 (5.07)	67.2
10	(97.72)	31.4 (4.56)	57.4 (6.4)	62.4
11	66.19	12.8 (1.85)	20.3 (2.26)	169.2
12	(217.15)	11 (1.59)	21.2 (2.36)	165

Figure A-11. Data sheet for test 11, 72.6 kg charge

TEST TITLE INT Equivalency DATE 12/14/78
 TEST SAMPLE WC844 Ball Powder TIME 1414
 SAMPLE WEIGHT 72.6 kg (160 lb) TEMP. 56°F
 IGN. SOURCE J2 Blasting Cap HUMIDITY 24%
 BOOSTER WT. 1.45 kg (3.2 lb) BAR. PRESS. 30.30
 TEST NO. 50-8-12 WIND DIR. 25°
 CONTRACT NO. NAST3-50 WIND VEL. 5 mph



FIELD EVALUATION: Detonation Occurred

Crater Dimensions: Not Available

Channel Number	Distance Meters (ft)	Peak Pressure kPa (psi)	Scaled Positive Impulse kPa msec/kg ^{1/3} (psi msec/lb ^{1/3})	Time of Arrival (msec)
1	4.97	1221. (177.13)	113 (12.58)	4.2
2	(16.29)	1379. (199.99)	244 (24.94)	5
3	6.7	327. (47.52)	73 (8.14)	6.6
4	(21.99)	610. (88.52)	126 (14.01)	7
5	8.9	118. (17.18)	103 (11.51)	11.5
6	(29.21)	287. (41.67)	103 (11.49)	10.4
7	14.89	71. (10.34)	31.5 (3.51)	27.45
8	(48.86)	88. (12.78)	61.3 (6.83)	23.8
9	29.79	35. (5.13)	45.1 (5.03)	67.4
10	(97.72)	29. (4.25)	40.1 (4.47)	63
11	66.19	12.7 (1.85)	20.6 (2.29)	169.4
12	(217.15)	11.5 (1.67)	20.8 (2.32)	165.4

Figure A-12. Data sheet for test 12, 72.6 kg charge

DISTRIBUTION LIST

Commander
US Army Armament Research and
Development Command
ATTN: DRDAR-CG
DRDAR-LCM-E
DRDAR-LCM-S (20)
DRDAR-SF
DRDAR-TSS (5)
Dover, NJ 07801

Chairman
Department of Defense
Explosive Safety Board (2)
Room 856C, Hoffman Building I
2461 Eisenhower Avenue
Alexandria, VA 22331

Defense Technical Information Center (12)
Cameron Station
Alexandria, VA 22314

Commander
Department of the Army
Office, Chief of Research, Development
and Acquisition
ATTN: DAMA-CSM-P
Washington, DC 20310

Office, Chief of Engineers
ATTN: DAEN-MCZ
Washington, DC 20314

Commander
US Army Materiel Development
and Readiness Command
ATTN: DRCSF
DRCDE
DRCRP
DRCIS
5001 Eisenhower Avenue
Alexandria, VA 22333

Director
US Army TRADOC Systems Analysis Activity
ATTN: ATAA-SL (Tech Library)
White Sands Missile Range, NM 88002

Commander
DARCOM Installations and Services Agency
ATTN: DRCIS-RI
Rock Island, IL 61299

Director
Industrial Base Engineering Activity
ATTN: DRXIB-MT
DRXIB-EN
Rock Island, IL 61299

Commander
US Army Munitions Production Base
Modernization Agency
ATTN: SARPM-PBM
SARPM-PBM-T
SARPM-PBM-L (2)
SARPM-PBM-E (2)
SARPM-PBM-LN-CE
Dover, NJ 07801

Commander
US Army Armament Materiel
Readiness Command
ATTN: DRSAR-SF (3)
DRSAR-SC
DRSAR-EN
DRSAR-IRC
DRSAR-RD
DRSAR-IS
DRSAR-ASF
DRSAR-LEP-L
Rock Island, IL 61299

Director
DARCOM Field Safety Activity
ATTN: DRXOS-ES (2)
Charlestown, IN 47111

Commander
Volunteer Army Ammunition Plant
Chattanooga, TN 37401

Commander
Kansas Army Ammunition Plant
Parsons, KS 67357

Commander
Newport Army Ammunition Plant
Newport, IN 47966

Commander
Badger Army Ammunition Plant
Baraboo, WI 53913

Commander
Indiana Army Ammunition Plant
Charlestown, IN 47111

Commander
Holston Army Ammunition Plant
Kingsport, TN 37660

Commander
Lone Star Army Ammunition Plant
Texarkana, TX 75501

Commander
Milan Army Ammunition Plant
Milan, TN 38358

Commander
Iowa Army Ammunition Plant
Middletown, IA 52638

Commander
Joliet Army Ammunition Plant
Joliet, IL 60436

Commander
Longhorn Army Ammunition Plant
Marshall, TX 75760

Commander
Louisiana Army Ammunition Plant
Shreveport, LA 71130

Commander
Ravenna Army Ammunition Plant
Ravenna, OH 44266

Commander
Radford Army Ammunition Plant
Radford, VA 24141

Division Engineer
US Army Engineer Division, Huntsville
ATTN: HNDCD
P.O. Box 1600, West Station
Huntsville, AL 35809

Division Engineer
US Army Engineer Division, Southwestern
ATTN: SWDCD
1200 Main Street
Dallas, TX 75202

Division Engineer
US Army Engineer Division, Missouri River
ATTN: MRDCD
P.O. Box 103, Downtown Station
Omaha, NE 68101

Division Engineer
US Army Engineer Division, North Atlantic
ATTN: NADCD
90 Church Street
New York, NY 10007

Division Engineer
US Army Engineer Division, South Atlantic
30 Pryor Street, S.W.
Atlanta, GA 30303

District Engineer
US Army Engineer District, Norfolk
803 Front Street
Norfolk, VA 23510

District Engineer
US Army Engineer District, Baltimore
P.O. Box 1715
Baltimore, MD 21203

District Engineer
US Army Engineer District, Omaha
215 N. 17th Street
Omaha, NE 68102

District Engineer
US Army Engineer District, Philadelphia
Custom House
2nd and Chestnut Street
Philadelphia, PA 19106

District Engineer
US Army Engineer District, Fort Worth
P.O. Box 17300
Fort Worth, TX 76102

District Engineer
US Army Engineer District, Kansas
601 E. 12th Street
Kansas City, MO 64106

District Engineer
US Army Engineer District, Sacramento
650 Capitol Mall
Sacramento, CA 95814

District Engineer
US Army Engineer District, Mobile
P.O. Box 2288
Mobile, AL 36628

Commander
US Army Construction Engineering
Research Laboratory
Champaign, IL 61820

Commander
Dugway Proving Ground
ATTN: STEDP-MT-DA-HD (2)
Dugway, UT 84022

Civil Engineering Laboratory
Naval Construction Battalion Center
ATTN: L51
Port Hueneme, CA 93043

Commander
Naval Facilities Engineering Command
(Code 04, J. Tyrell)
200 Stovall Street
Alexandria, VA 22322

Commander
Atlantic Division
Naval Facilities Engineering Command
Norfolk, VA 23511

Commander
Chesapeake Division
Naval Facilities Engineering Command
Building S7
Washington Navy Yard
Washington, DC 20374

Commander
Northern Division
Naval Facilities Engineering Command
Building 77-L
US Naval Base
Philadelphia, PA 19112

Commander
Southern Division
Naval Facilities Engineering Command
ATTN: J. Watts
P.O. Box 10068
Charleston, SC 29411

Commander
Western Division
Naval Facilities Engineering Command
ATTN: W. Moore
San Bruno, CA 94066

Commander
Naval Ammunition Depot
Naval Ammunition Production
Engineering Center
Crane, IN 47522

Technical Library
ATTN: DRDAR-CLJ-L
Aberdeen Proving Ground, MD 21010

Director
US Army Ballistic Research Laboratory
ARRADCOM
ATTN: DRDAR-TSB-S
Aberdeen Proving Ground, MD 21005

Benet Weapons Laboratory
Technical Library
ATTN: DRDAR-LCB-TL
Watervliet, NY 12189

Ammann and Whitney (10)
2 World Trade Center
New York, NY 10048

Weapon System Concept Team/CSL
ATTN: DRDAR-ACW
Aberdeen Proving Ground, MD 21010

US Army Materiel System Analysis Activity
ATTN: DRXSY-MP
Aberdeen Proving Ground, MD 21005