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U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

REPORT NO. 950

BOMBS AND ASSOCIATED COMPONENTS

32nd Partial Report

PLATE PENETRATION TESTS OF THE
2000 LB. BOMB, G. P. (LOW DRAG),
TYPE EX-11, MOD. 0

FINAL Report

Copy No. 4

Task
Assignment NPG-Re3c-321-1-52

Classification CONFIDENTIAL
SECURITY INFORMATION

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APR 8 1952

540A-0

SECURITY INFORMATION

Plate Penetration Tests of the 2000 lb. Bomb,
G.P. (Low Drag), Type EX-11, Mod O

PART A

SYNOPSIS

1. The tests reported herein were conducted to determine (a) the maximum armor (STS) plate thickness which the 2000 lb. G.P. Low Drag Type EX 11 Mod O bomb body will penetrate and remain in an effective bursting condition, (b) the degree of acceptable deformation of the bomb body resulting from impact, and (c) the conditions under which the bomb will fail. Further, a metallurgical study was made of the recovered bomb bodies in order to determine any points of weakness or causes of failure and to suggest any corrective measures that should be taken to improve the bomb performance or facilitate production.

2. It is concluded that:

a. The maximum STS armor plate thickness the inert loaded 2000 lb. G.P. Low Drag Type EX 11 Mod O bomb will penetrate and remain in effective bursting condition when fired at 1000 ft./sec. velocity at 20° obliquity is 1-7/8".

b. The firing condition which caused failure of the 2000 lb. G.P. Low Drag Type EX 11 Mod O bomb occurred when the bomb was fired at 20° obliquity against 2" STS armor using a striking velocity of 1000 ft./sec.

c. No quantitative figures can be given for the amount of acceptable deformation resulting from impact. Deflagration tests were not conducted and thus it cannot be estimated what conditions would be critical as far as deflagration is concerned. From the manner in which the bomb broke up when fired against 2"35 STS armor at 20° obliquity at 1000 ft./sec. it may be reasonable to assume that deflagration would occur at these conditions. The bomb becomes ineffective when cracking occurs which takes place when bomb is fired at 2" STS armor at 20° obliquity at 1000 ft./sec. velocity.

Plate Penetration Tests of the 2000 lb. Bomb,
G.P. (Low Drag), Type EX-11, Mod 0

d. The primary cause for the failure of Bomb #20 was the segregated condition of the steel in the area 180° from the weld. The other two bombs examined, #3 and #7, were satisfactory metallurgically with the possible exception that the ductility was somewhat low.

3. The A. O. Smith Co. is experimenting with a boron steel for the manufacture of this type of bomb. Also, the National Tube Co. is redesigning the nose section and is modifying its N-80 steel by substituting a small percentage of chromium for the molybdenum content, both of these changes being made for strengthening purposes. Consequently, no recommendation will be made at present pending the outcome of the above mentioned experiments.

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NPG REPORT NO. 950

Plate Penetration Tests of the 2000 lb. Bomb,
G.P. (Low Drag), Type EX-11, Mod 0

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NPG-REPORT NO. 950

Plate Penetration Tests of the 2000 lb. Bomb,
G.P. (Low Drag), Type EX-11, Mod 0

PART B

INTRODUCTION

1. AUTHORITY:

This test was conducted by authority of references (a) and (b). The test was conducted in accordance with enclosure (2) of reference (a).

2. REFERENCES:

- a. BUORD Conf ltr Re3c-REN:mt, NP9, Serial 18721 of 28 March 1951
- b. Task Assignment NPG-25-Re3c-321-3
- c. NPG Report No. 646 of 21 September 1950
- d. NPG Report No. 694 of 29 December 1950
- e. NPG Report No. 748 of 3 April 1951
- f. NPG Report No. 878 of 20 October 1951

3. BACKGROUND:

Presently existing AN standard G.P. bombs, because of excessive drag, materially reduce the maximum performance of high speed aircraft when these bombs are suspended externally. The Bureau of Ordnance, therefore, has developed a new family of bombs designed to reduce the drag when they are suspended externally from aircraft. This new family of bombs is called collectively the Low Drag bomb. The first test of this family involved the 1000 lb. Low Drag bomb, Type EX-10. The results of this test were reported in reference (c). The second test was of the 250 lb. Low Drag, G.P. Bomb, Types EX-1 Mod 0, EX-1 Mod 1, and EX-2 Mod 0. The results of this test were reported in reference (d). The third test involved the 1000 lb. Low Drag G.P. bomb, Type EX-10 Mod 3. The results of this test were reported in reference (e). The fourth test was a further study of the 250 lb. Low Drag G.P. bomb, Type EX-2 Mod 0. Results of this test were reported in reference (f). The present test is the first investigation of the 2000 lb. Low Drag G.P. bomb group. The bomb Type is EX-11 Mod 0.

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SECURITY INFORMATION

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NPG REPORT NO. 950

Plate Penetration Tests of the 2000 lb. Bomb,
G.P. (Low Drag), Type EX-11, Mod 0

4. OBJECT OF TEST:

The tests were conducted (a) to obtain the maximum STS armor plate thickness the 2000 lb. (Low Drag) G.P. bomb, Type EX-11 Mod 0 will penetrate and remain in an effective condition, (b) to determine the conditions which will cause bomb failure, (c) to determine the degree of acceptable deformation resulting from impact and, (d) to determine by metallurgical study any causes of failure in design and suggest any corrective measures pertaining thereto.

5. PERIOD OF TEST:

a. Date Project Letter	28 March 1951
b. Date Material Received	27 June 1951
c. Date Commenced Tests	27 July 1951
d. Date Tests Completed	17 August 1951

PART C

DETAILS OF TEST

7. DESCRIPTION OF ITEM UNDER TEST:

A. O. Smith Corp. Dr. MV-9048-A shows the experimental 2000 lb. Low Drag G.P. bomb, Type EX-11 Mod 0, as modified for gun firing. The bomb bodies were inert loaded with vermiculite cement having a specific gravity of 1.55.

8. DESCRIPTION OF TEST EQUIPMENT:

a. Gun:	18"/47 Rifled Gun Mk A Mod 0 No. 1 L
b. Charge:	60 lbs. of SPDN-3369 powder used with 3 - 5 lb. powder boosters
c. Targets:	Various thickness of STS armor plate.

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Plate Penetration Tests of the 2000 lb. Bomb,
G.P. (Low Drag), Type EX-11, Mod 0

9. PROCEDURE:

a. Eleven (11) EX-11 Mod 0, 2000 lb. Low Drag G.P. bombs were inert loaded with vermiculite cement of specific gravity 1.55. These bombs were fired against various thickness (1.5 through 2.35) of STS armor plate at a velocity of approximately 1000 ft./sec. The targets were set at 20° obliquity to the line of fire. The armor plate targets were backed up by a large sandpile which was used as the recovery medium. The back half of the sandpile was covered with large steel plates to assist in holding the fired bombs in the sandpile. Each bomb was recovered and examined prior to firing the next round. Velocities were measured by using coils and counter chronographs.

b. Method of Metallurgical Sampling

Samples for metallurgical examination were cut from the fractured side walls of Bomb #20, (impact No. 39181) which broke up and from the least deformed side walls of bombs #3 (impact #39196) and #7 (impact #39204) which were intact and only moderately flattened when recovered after firing.

10. RESULTS AND DISCUSSION:

a. Table I, Appendix (A), summarizes the firing conditions and test results. Appendix (B), Tables II through XII, includes the butt impact records. Figures 1 through 10, Appendix (C), show the condition of the bombs after firing.

b. Metallurgical Examination

Metallurgical examination consisted of chemical and spectrographic analyses, tensile, Brinell hardness, Charpy impact, hot acid etch tests and microscopic examination.

Plate Penetration Tests of the 2000 lb. Bomb,
G.P. (Low Drag), Type EX-11, Mod 0

The results of chemical and spectrographic analyses were as follows:

	<u>C</u>	<u>Mn</u>	<u>P</u>	<u>S</u>	<u>Si</u>	<u>Cu</u>	<u>Ni</u>	<u>Cr</u>
Bomb #20	.29	1.32	.012	.034	None	.10	None	None
Bomb #3	.31	1.17	.020	.031	Trace	.07	.06	.07
Bomb #7	.32	1.07	.022	.031	Trace	.07	.06	.07

These analyses represent a medium high manganese carbon steel. The copper, nickel and chromium contents are incidental.

Due to the bent and fractured condition of Bomb #20 no tensile test specimens were taken. The results of triplicate longitudinal tensile tests of Bombs 3 and 7 and of transverse Brinell hardness tests are shown below:

	<u>Yld. Str.</u> <u>.2% p.s.i.</u>	<u>Ult. Str.</u> <u>p.s.i.</u>	<u>Elong.</u> <u>% 2"</u>	<u>R.A.</u> <u>%</u>	<u>Brinell</u> <u>3000 Kg.</u>
Bomb #20	-	-	-	-	303
Bomb #3	104000 99000 104000	126300 123500 127400	10.0 11.4 11.4	44.1 43.6 42.8	271
Bomb #7	97100 94000 100000	120300 118000 121200	14.3 15.0 14.3	50.8 48.6 49.1	255

Transverse sections of the three bombs were etched in 50% HCl - 50% H₂O solution at 160°F for twenty minutes and the results are shown in Figures 11 and 12, Appendix (D). Two sections of Bomb No. 20 are shown in Figure 12. At the top is the area of the electric butt weld showing sound steel and a good weld. At the bottom is shown a section 180° from the weld, showing a highly segregated condition in the fractured area. Figure 11 shows sections of Bombs 3 and 7 which are satisfactory although Bomb 3 shows considerable segregation and slight laminations.

Plate Penetration Tests of the 2000 lb. Bomb,
G.P. (Low Drag), Type EX-11, Mod 0

Figures 13 through 18 show photomicrographs of the three bombs taken at magnifications of 250X and 1000X; and are indicative of quenched and drawn heat treatment. Figures 13 and 14 were taken near the fracture in Bomb #20 and show oxides and other indications of segregation.

Table XIII and Figures 19 and 20, Appendix (E) show the values of impact tests obtained from standard V-notch Charpy specimens. On Bomb #20 the impact values obtained from the specimens cut away from the fracture area compare with values obtained on Bombs 3 and 7 at room temperature while the impacts from the fracture area show somewhat more brittleness. On Bombs #3 and #7 impacts were made at temperatures ranging from 100°C to minus 78°C and the results were plotted as shown in Figures 19 and 20. On the basis that the transition from toughness to brittleness is taken to be the point on the curve where the fracture is 50% granular and 50% fibrous, the transition temperatures for Bombs #3 and #7 are +30°C and +25°C respectively which is approximately room temperature or slightly above. This is rather a high temperature for the transition but it may be accounted for in part by the fact that the steel was tested after firing which may have caused some work hardening.

PART D

CONCLUSIONS

11. It is concluded that:

a. The maximum STS armor plate thickness that the inert loaded 2000 lb. Low Drag G.P. bomb Type EX-11, Mod 0 will penetrate and remain in effective bursting condition when fired at 1000 ft./sec. velocity with target set at 20° obliquity is 1-7/8".

b. The firing condition which will cause failure of the 2000 lb. Low Drag G.P. bomb Type EX-11, Mod 0 occurs when the bomb is fired at 20° obliquity against 2" STS armor plate using a velocity of 1000 ft./sec.

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NPG REPORT NO. 950

Plate Penetration Tests of the 2000 lb. Bomb,
G.P. (Low Drag), Type EX-11, Mod 0

c. No quantitative figures can be given for the amount of acceptable deformation resulting from impact. It is conclusive that when cracking occurs the bomb becomes ineffective but the amount of deformation which will cause a bomb to become ineffective has not been determined.

d. The primary cause for the failure of Bomb #20 was the segregated condition of the steel in the area 180° from the weld. The other two bombs examined, No. 3 and No. 7, were satisfactory metallurgically with the possible exception that the ductility was somewhat low.

PART E

RECOMMENDATIONS

12. The A. O. Smith Co. is experimenting with a boren steel for the manufacture of this type of bomb. Also the National Tube Co. is redesigning the nose section and is modifying its N-80 steel by substituting a small percentage of chromium for the molybdenum content, both of these changes being made for strengthening purposes. Consequently, no recommendations will be made at present pending the outcome of the above mentioned experiments.

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SECURITY INFORMATION

Plate Penetration Tests of the 2000 lb. Bomb,
G.P. (Low Drag), Type EX-11, Mod 0

The tests upon which this report is based were conducted by:
W. W. MEYERS, Ordnance Engineer, Plate Battery Officer,
Terminal Ballistics Department

This report was prepared by:
W. W. MEYERS, Ordnance Engineer, Plate Battery Officer,
Terminal Ballistics Department
W. H. HALL, Metallurgist, A & P Laboratory,
Terminal Ballistics Department
E. L. IEVSTIK, Lieutenant Commander, USN, Special Projects
Design and Drafting Officer,
Terminal Ballistics Department

This report was reviewed by:
R. H. LYDDANE, Director of Research,
Terminal Ballistics Department
W. B. ROBERTSON, Lieutenant Commander, USN,
Terminal Ballistics Batteries Officer,
Terminal Ballistics Department
R. T. RUBLE, Lieutenant Commander, USN,
Terminal Ballistics Officer,
Terminal Ballistics Department
C. C. BRAMBLE, Director of Research, Ordnance Group

APPROVED: IRVING T. DUKE
Rear Admiral, USN
Commander, Naval Proving Ground


C. T. MAURO
Captain, USN
Ordnance Officer
By direction

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NPG REPORT NO. 950

U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

Thirty-Second Partial Report

on

Bombs and Associated Components

Final Report

on

Plate Penetration Tests of the 2000 lb. Bomb,
G.P. (Low Drag), Type EX-11, Mod 0

NAVY RESEARCH SECTION
SCIENCE DIVISION
REFERENCE DEPARTMENT

APR 28 1952

Project No.: NPG-Re3c-321-1-52
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No. of Pages: 10

Date: APR 7 1952

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SECURITY INFORMATION

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Plate Penetration Tests of the 2000 lb. Bomb, G.P. (Low Drag), Type EX-11, Mod O NPG REPORT NO. 950

TABLE I

SUMMARY OF FIRING CONDITIONS AND TEST RESULTS

Impact No.	Date Fired 1951	Type	No. of Bombs	Weight lbs.	Target Thickness	Through Opening	Obli.	Powder Charge	Striking Velocity	Tons/in ² Chamber Pressure	Gun	Remarks
39176	7/27	EX-11 Mod O	5	1919	1842	18"x19"	20°	70 lbs. SPDN 3369 15 lbs. black powder booster	1123	1.7	18"/47 Mk A Mod O	Bomb in river - appeared to be intact and in good shape.
39177	7/31	EX-11 Mod O	18	1938	1879	18"x18-3/4"	20°	55 lbs. SPDN 3369 15 lbs. black powder booster	943	1.4	18"/47 Mk A Mod O	Bomb effective and intact - Moderate to severe flattening - Nose plug sheared off.
39181	8/3	EX-11 Mod O	20	1940	2035	19"x20"	20°	70 lbs. SPDN 3369 15 lbs. black powder booster	1120	1.6	18"/47 Mk A Mod O	Bomb completely broken up.
39182	8/6	EX-11 Mod O	6	1963	2015	18"x19"	20°	60 lbs. SPDN 3369 15 lbs. black powder booster	1323	1.3	18"/47 Mk A Mod O	Bomb cracked open on nose section - Severely flattened and bent.
39183	8/7	EX-11 Mod O	15	1954	200	15"x19"	20°	55 lbs. SPDN 3369 15 lbs. black powder booster	817	1.1	18"/47 Mk A Mod O	Bomb effective and intact - Moderate to severe flattening on sides.
39184	8/7	EX-11 Mod O	12	1959	200	17-1/2"x19"	20°	60 lbs. SPDN 3369 15 lbs. black powder booster	980	1.4	18"/47 Mk A Mod O	Bomb cracked open around fuse hole - Severely flattened.
39196	8/10	EX-11 Mod O	3	1937	1884	18-1/2"x18-1/2"	20°	60 lbs. SPDN 3369 15 lbs. black powder booster	914	1.5	18"/47 Mk A Mod O	Bomb effective and intact - Moderate flattening.

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SECURITY INFORMATION

File No.

Butt Firing

U.S. Naval Proving Ground

Dahlgren, Va. 7-27-51. 194

 IMPACT No. 39176
 IMPACT DATE 27 July 1951
 BUTT No. F

 OBJECT BALLISTIC TEST OF 2000 LB. LOW DRAG G.P. BOMB
TYPE EX 11 MOD 0 VS. 1 1/2" STS PLATE AT 0° OBL.
REFERENCE N.P.G. LETTER REPORT NO. 450

DATED

PLATE

G.P. BOMB

PROJECTILE

 Gauge 1.50
 Class STS
 Maker CARNEGIE
 No. 023615 Group 4-526-773
 Contract _____
 Date received 4-11-51
 Dimensions 2.50" X 9.5"
 No. of impact on plate _____
 Thickness at impact 1.42
 OBLIQUITY 20°
 Impact dimensions 19" X 20"
 PENETRATION COMPLETE
 Flaking front 0
 Flaking back 0
 Dist. from top, bottom 31"
 Dist. from right, left 64"
 Dist. from nearest impact 115"
 Dish 3"
 Spur 10"
 Cracks - Bulge 0
 Button (Thrown) (Starter) _____
 Through Opening 18" X 19"

 Caliber 2000 LB.
 Maker A.O. SMITH
 Type LOW DRAG G.P.
 Lot No. - Year of Specification 1951
 Mark EX 11 Mod. 0 No. 5
 Date received -
 Capped or uncapped _____
 Weight (capped) _____
 Weight (uncapped) 1919.0#
 Length (uncapped) _____
 Fuze NONE
 Filler VERMICULITE
 Flight by screen _____
 Condition after firing:-

EFFECTIVE or INEFFECTIVE

Bomb in river - Appeared to be
intact and in good shape


BALLISTIC DATA

NOTE:	1- Desired	2- Oscillograph	3- Chronograph	4- Limit, estimated for this thickness of impact.	5- Actual, adjusted to nominal gauge.	6- Limit, for nominal gauge, based on this impact only. (Adjusted from column 5)	7- Limit, for nominal gauge, established from column 6 and previous impacts.
All limits are for this plate and this obliquity only.		MEAN					
Striking velocity (f.s.)		1123					

REMARKS

PRESS = 1.7 tons/in²73 LBS. OF SPDN-3369 POWDER USED W/ 3-5# Black PPR. BOOSTERS.

Limit shots only

Limit Initial

Acceptance or Rejection recommended

e/d

F(e/d, 0)

Table II
1571
Ord. Eng.

N.P.G. Photo. No.

U.S. Navy

GUN: 18"/47 MK. A MOD 0 #1 LAppendix B

File No.

Butt Firing

U. S. Naval Proving Ground

Dahlgren, Va. 7-31-51 194

IMPACT No. 39177

IMPACT DATE 7-31-51

BUTT No. F.

OBJECT EXPERIMENTAL BALLISTIC TEST OF 2000 L.B. G.P.LOW DRAG Bomb vs. 2" PLATE AT 20° OBLIQUITYREFERENCE N.P.G. ~~LETTER~~ Report No 950

DATED

PLATE

G.P. Bomb

PROJECTILE

Gauge 2.0
 Class STS
 Maker U.S. STEEL
 No. 016358 Group U-526-780
 Contract N600-1555-9928
 Date received 5-3-51
 Dimensions 93" X 250"
 No. of impact on plate 4
 Thickness at impact 1.97
 OBLIQUITY 20°
 Impact dimensions 21" X 23"
 PENETRATION COMPLETE
 Flaking front 0
 Flaking back 0
 Dist. from top, bottom 33"
 Dist. from right, left 63"
 Dist. from nearest impact 170"
 Dish 4"
 Spur 10"
 Cracks - Bulge 0
 Button (Thrown)(Started)
 Through Opening 18" X 18 3/4"

Caliber 17.95
 Maker A.O. SMITH
 Type LOW DRAG
 Lot No. - Year of Specification -
 Mark EX 11 Mod. - No. 18
 Date received -
 Capped or uncapped -
 Weight (capped) -
 Weight (uncapped) 1998.6
 Length (uncapped) -
 Fuze NONE
 Filler VERMICULITE
 Flight by screen -
 Condition after firing:-
EFFECTIVE or INTERFERITIVE
Intact - Moderate to Severe
Flattening - Nose plug sheared
off



BALLISTIC DATA

NOTE:	-1- Desired	-2- Oscillograph	-3- Chronograph	-4- Limit, estimated for this thickness of impact.	-5- Actual, adjusted to nominal gauge.	-6- Limit, for nominal gauge, based on this impact only. (Adjusted from column 4)	-7- Limit, for nominal gauge, established from column 6 and previous impacts.
All limits are for this plate and this obliquity only.		MEAN					
Striking velocity (f.s.)		943					

REMARKS

PRESS - 1.4 Tons/IN²USED 55.0# 5PON-3369 WITH 3-5# B.C. FOR BOOSTERS.

Limit shots only

e/d

F(e/d, e)

N.P.G. Photo. No.

ConfidentialTable IIIAcceptance or Rejection recommendedW.W. Thompson
Ord. Eng.U.S. NavyAppendix BGUN: 18" 47 MK II MOD 0 #12

File No.

Butt Firing

U.S. Naval Proving Ground
Dahlgren, Va. 223-57 191IMPACT No. 39181
IMPACT DATE 5 Nov. 1951
BUTT No. FOBJECT EXPERIMENTAL BALLISTIC TEST OF 3000 LB. G.P.
LEAD VARIOUS VS. 2 1/4" PLATE AT 20' C.B.
REFERENCE N.P.G. REPORT R-101-950 DATED

PLATE

PROJECTILE

Gauge 5.748
Class 575
Maker H. I. ...
No. H-1191 Group H-1191
Contract N 12-4-51
Date received July 4
Dimensions 9 1/4" x 19 1/2"
No. of impact on plate 3
Thickness at impact 1.35
OBLIQUITY 1.35
Impact dimensions 31" x 55"
PENETRATION 2015 ft.
Flaking front
Flaking back
Dist. from top, bottom
Dist. from right, left 55"
Dist. from nearest impact 54"
Dish 4"
Spur
Cracks - Bulge
Button (Thrown) (Started)
Through Opening 19" V-50

Caliber 17.99
Maker HILLMAN
Type HILLMAN
Lot No. Year of Specification
Mark EX 11 Mod. No. 50
Date received
Capped or uncapped
Weight (capped)
Weight (uncapped) 360#
Length (uncapped) 10 1/2"
Fuze NOAI
Filler
Flight by screen
Condition after firing:
~~EFFECTIVE~~ or INEFFECTIVE
Bomb broken up



BALLISTIC DATA

Notes	1.	2.	3.	4.	5.	6.	7.
All units are for this plate and the obliquity only.	24-2	Chronograph	Chronograph	Limit, estimated for this distance & impact	Actual adjusted for wind & distance	Limit for nominal range, based on the above only (Adjusted from column 4)	Limit for nominal range, established for this distance & obliquity from previous impacts.
Striking velocity (ft/s)		MEFA					
		1150					

REMARKS

116 TST over pressure
to the SPON-3360 Powder - 15 lbs Black Powder Powder

Limit shots only

Confidential

Acceptance or Rejection recommended

c/o

F(t/d/e)

Table IV

W. H. Thayer
Ord. Insp.

N.P.G. Photo. No.

G.R. 100 D.E.H. 7000 #12

Appendix B

File No.

Butt Firing

IMPACT NO. 39182

IMPACT DATE 8-6-51

BUTT NO. F

U. S. Naval Proving Ground

Dahlgren, Va. 8-6-51 194

OBJECT BALLISTIC TEST OF INERT LOADED 2000 LB. LOW DRAG G.P.

Bomb TYPE EX II MOD 0 VS. 2 1/4" STS PLATE

REFERENCE N.P.G. LETTER Repeat No. 950

DATED

PLATE

G.P. Bomb

PROJECTILE

Gauge 2.15

Class STS

Maker CARNEGIE

No. 0110864 Group C-526-522

Contract H-447

Date received 25 JAN. '45

Dimensions 89 1/16" X 20 7/8"

No. of impact on plate 2

Thickness at impact 2.15

OBLIQUITY 20°

Impact dimensions 20" X 21"

PENETRATION COMPLETE

Flaking front 0

Flaking back 0

Dist. from top, bottom 59"

Dist. from right, left 61"

Dist. from nearest impact 50"

Dish 5"

Spur 7"

Cracks - Bulge 0

Button (Thrown) (Started)

Through Opening 18" X 19"

Caliber 17.99

Maker A.O. SMITH

Type LOW DRAG

Lot No. - Year of Specification -

Mark EX II Mod. - No. #6

Date received -

Capped or uncapped

Weight (capped)

Weight (uncapped) 1963.0#

Length (uncapped) 10.3165

Fuze NONE

Filler VERMILITE

Flight by screen

Condition after firing:-

EFFECTIVE or INEFFECTIVE

Cracked open on nose section

Severely Flattened and bent

BALLISTIC DATA

NOTE:	1- Degree	2- Oscillograph	3- Chronograph	4- Janot, mounted for this thickness of impact	5- Actual adjusted to nominal gauge	6- Limit for nominal gauge, based on this impact only. (Adjusted from previous impacts)	7- Limit for nominal gauge, established from column 6 and previous impacts.
All limits are for this plate and this obliquity only.		mean					
Striking velocity (f.s.)		823					

REMARKS

Pressure - 1.3 tons/in²

55 lbs SPDN-3369 Powder - 15 lbs. Black Powder Booster

Limit shots only

Confidential

Acceptance or Rejection

c/d

E(c/d, a)

Table I

V. W. H. H. H.

Ord. Eng.

N.P.G. Photo. No.

GUN: 18/47 MK. A MOD. 0 #1 L

Appendix B

File No.

Butt Firing

U. S. Naval Proving Ground
Dahlgren, Va. 8-7-51IMPACT NO. 39183
IMPACT DATE 8-7-51
BUTT NO. FOBJECT BALL TEST OF INERT LOADED 2000 LB. LOW DRAG G. P.
BOMB TYPE EX 11 MOD 0 VS 2" STS PLATEREFERENCE N.P.G. ~~LETTER~~ Report TW. 950

DATED

PLATE

G. P. Bomb

PROJECTILE

Gauge 2.0
 Class STS
 Maker CARNEGIE
 No. 081221 Group —
 Contract NORD 10280
 Date received —
 Dimensions 98" X 288"
 No. of impact on plate 14
 Thickness at impact 2"
 OBLIQUITY 20°
 Impact dimensions 17" X 22"
 PENETRATION COMPLETE
 Flaking front 0
 Flaking back 0
 Dist. from top, bottom 34"
 Dist. from right, left 59"
 Dist. from nearest impact 36"
 Dish 4"
 Spur 8"
 Cracks - Bulge 0
 Button (Thrown) (Started)
 Through Opening 15" X 19"

Caliber 17.99
 Maker A. O. SMITH
 Type G. P. Low DRAG
 Lot No. — Year of Specification —
 Mark EX 11 Mod. — No. 15
 Date received —
 Capped or uncapped —
 Weight (capped) —
 Weight (uncapped) 1954 #
 Length (uncapped) 103.65
 Fuze NONE
 Filler VERMICULITE
 Flight by screen —
 Condition after firing:
 EFFECTIVE or ~~INEFFECTIVE~~
Intact = Moderate to
severe Flattening on
sides



BALLISTIC DATA

NOTE:	1- Desired	2- Oscillograph	3- Chronograph	4- Limit, estimated for this thickness of impact.	5- Actual, adjusted to nominal gauge.	6- Limit, for nominal gauge, based on this impact only. (Adjusted from column 4)	7- Limit, for nominal gauge, established from column 6 and previous impacts.
All limits are for this plate and this obliquity only.		MEAN					
Striking velocity (f.s.)		517					

REMARKS:

Press 1-1 tons per sq
55 lbs SPDN - 3369 Powder - 15 lbs Black Powder
Booster

Limit shots only

Acceptance or Rejection recommended

e/d

F(e/d, 0)

N.P.G. Photo No.

Confidential
Table II

W. W. Meyer
Dir. Eng.

U. S. Navy

Appendix B

File No.

Butt Firing

U. S. Naval Proving Ground

Dahlgren, Va. 8-7-51

IMPACT No. 39184

IMPACT DATE 8-7-51

BUTT No. F

OBJECT BALL TEST OF 2000 LB G. P. Low DRAG Bomb Vs.
2" STS PLATE AT 20° OBL.

REFERENCE N.P.G. LETTER Report No. 950

DATED

PLATE

G. P. Bomb PROJECTILE

Gauge 2" 0
 Class STS
 Maker CARNEGIE
 No. 081221 Group —
 Contract Nord 10280
 Date received —
 Dimensions 98" X 288"
 No. of impact on plate 15
 Thickness at impact 2"
 OBLIQUITY 20°
 Impact dimensions 19" X 22"
 PENETRATION COMPLETE
 Flaking front 0
 Flaking back 0
 Dist. from top, bottom 68"
 Dist. from right, left 65"
 Dist. from nearest impact 64"
 Dish 5"
 Spur 7"
 Cracks - Bulge 0
 Button (Thrown) (Started)
 Through Opening 17 1/2" X 19"

Caliber 17.99
 Maker A. O. SMITH
 Type G. P. Low DRAG
 Lot No. — Year of Specification —
 Mark EX11 Mod. — No. 13
 Date received —
 Capped or uncapped —
 Weight (capped) —
 Weight (uncapped) 1959 #
 Length (uncapped) 103.65
 Fuze NONE
 Filler VERMICULITE
 Flight by screen —
 Condition after firing:-

EFFECTIVE or INEFFECTIVE
 Cracked open around fuze
 hole - Severely flattened



BALLISTIC DATA

NOTE:	1- Desired	2- Oscillograph	3- Chronograph	4- Limit, estimated for this thickness of impact.	5- Actual, adjusted to nominal gauge.	6- Limit, for nominal gauge, based on this impact only, (Adjusted from column 4)	7- Limit, for nominal gauge, established from column 6 and previous impacts.
All limits are for this plate and this obliquity only.		MEAN					
Striking velocity (ft/sec)		7500					

Remarks

Time 1.47 sec for 2"

60 lbs SPDN 3369 Powder - 15 lbs Black Powder
Booster

Limit shots only

e/d

F (e/d, 6)

N.P.G. Photo. No.

Confidential

Table VI

Acceptance or Rejection recommended

W. W. Meyers

Det. Engr

U. S. Navy

Expenditure

File No.

Buff Firing

IMPACT NO. 39196

U.S. Naval Proving Ground

IMPACT DATE 8-12-51

Dahlgren, Va. 8-10-51

BUTT No. G

OBJECT BALLISTIC TEST OF 2000 LB. LOW DRAG G.P.
Bomb vs. 1-3/4" PLATE AT 20° OBLIQUITY

REFERENCE N.P.G. LETTER Report No. 950

DATED

PLATE

G.P. Bomb

PROJECTILE

Gauge 1.849
 Class STS
 Maker CARNEGIE
 No. 091460 Group C-526-736
 Contract C-N6005-5-5615
 Date received 8-16-50
 Dimensions 95" x 25.1"
 No. of impact on plate 3
 Thickness at impact 1.84
 OBLIQUITY 20°
 Impact dimensions 19" x 21"
 PENETRATION Complete
 Flaking front 0
 Flaking back 0
 Dist. from top, bottom 63"
 Dist. from right, left 90"
 Dist. from nearest impact 42"
 Dish 4"
 Spur 8"
 Cracks - Bulge 0
 Button (Thrown) (Started)
 Through Opening 18 1/2" x 18 1/2"

Caliber 17.983
 Maker A.O. SMITH
 Type LOW DRAG G.P. Bomb
 Lot No. — Year of Specification —
 Mark EX II Mod. 0 No. 3
 Date received —
 Capped or uncapped —
 Weight (capped) —
 Weight (uncapped) 1937#
 Length (uncapped) 103.65"
 Fuze NONE
 Filler VERMIGULITE
 Flight by screen —
 Condition after firing:-
 EFFECTIVE or ~~INEFFECTIVE~~
 Intact - Moderate
 Flattening



BALLISTIC DATA

NOTE:	1- Desired	2- Oscillograph	3- Chronograph	4- Limit, estimated for this thickness of impact.	5- Actual adjusted to nominal gauge.	6- Limit, for nominal gauge, based on this impact only. (Adjusted from column 4)	7- Limit, for nominal gauge, established from column 6 and previous impacts.
All limits are for this plate and this obliquity only.		MEAN					
Striking velocity (f.s.)		914					

REMARKS

Press 15 tons per sq

60 lbs SPON 3369 Powder & 15 lbs Black Powder Booster

Limit shots only

Confidential

Acceptance or Rejection recommended

e/d

F(e/d, a)

Tabl VIII

WWM
Ord. Eng.
Appendix B

N.P.G. Photo. No.

File No.

Butt Firing

Impact No. 37197

U. S. Naval Proving Ground

Impact Date 8-10-51

Dahlgren, Va. 8-10-51 194

Butt No. G

OBJECT BALLISTIC TEST OF 2000 LB. LOW DRAG G.P.

Bomb vs. 1- $\frac{3}{4}$ " PLATE AT 30° OBliquity

REFERENCE N.P.G. LETTER Report No. 950

DATED

PLATE

G.P. Bomb PROJECTILE

Gauge 1.847
 Class STS
 Maker CARNEGIE
 No. 091460 Group C-526-736
 Contract C-N6005-5-5615
 Date received 8-14-51
 Dimensions 95" x 250"
 No. of impact on plate 4
 Thickness at impact 1.84
 OBliquity 20°
 Impact dimensions 20" x 22"
 PENETRATION Comp. 57.5
 Flaking front
 Flaking back
 Dist. from top, bottom 34"
 Dist. from right, left 62"
 Dist. from nearest impact 96"
 Dish 4"
 Spur 7"
 Cracks - Bulge 0
 Button (Thrown) (Started)
 Through Opening 18" x 18 $\frac{1}{2}$ "

Caliber 17.960
 Maker A.O. SMITH
 Type LOW DRAG G.P. BOMB
 Lot No. Year of Specification
 Mark EX 11 Mod. No. 11
 Date received
 Capped or uncapped
 Weight (capped)
 Weight (uncapped) 1946.[#]
 Length (uncapped) 103.65"
 Fuze NONE
 Filler VERMICULITE
 Flight by screen
 Condition after firing:-
 EFFECTIVE or INEFFECTIVE
 Intact - Moderate
 Flattening

BALLISTIC DATA

NOTE:	1- Desired	2- Oscillograph	3- Chronograph	4- Limit, estimated for this thickness of impact.	5- Actual adjust- to nominal gauge.	6- Limit for nominal gauge, based on this impact only. (Adjusted from column 4).	7- Limit for nominal gauge, established from column 6 and previous impacts.
All limits are for this plate and this obliquity only.		MEAN					
Striking velocity (f.s.)		928					

REMARKS

Press - 15 tons ft
 60 lbs SPDN 3369 Powder & 15 lbs Black Powder
 Powder

Limit shots only

e/d

F(e/d, 0)

N.P.G. Photo. No.

Confidential
 Table IX

Acceptance or Rejection recommended

C. Lewick

U. S. Navy

Appendix B

File No.

Butt Firing

U.S. Naval Proving Ground

Dahlgren, Va. 8-17-51 194

Impact No. 39202

Impact Date 8-17-51

Butt No. F

OBJECT BALL: TC TEST OF 2000 LB. LOW DRAG G.P. BOMB

EX II VERMICULITE LOADED VS. 1-3/4" PLATE

REFERENCE N.P.G. ~~REPORT~~ Report 710,950

DATED

PLATE

G.P. Bomb

PROJECTILE

Gauge 1.849
 Class STS
 Maker CARNEGIE
 No. 091460 Group C-526-736
 Contract C-N6005-S-3615
 Date received 8-16-50
 Dimensions 95" X 250"
 No. of impact on plate 5
 Thickness at impact 1.84
 OBLIQUITY 30°
 Impact dimensions 18" X 19"
 PENETRATION COMPLETE
 Flaking front 0
 Flaking back 0
 Dist. from top, bottom 32"
 Dist. from right, left 86"
 Dist. from nearest impact 40"
 Dish 2"
 Spur 8"
 Cracks - Bulge 0
 Button (Thrown) (Started)
 Through Opening 16" X 18"

Caliber 17.966
 Maker A.O. SMITH
 Type LOW DRAG BOMB
 Lot No. — Year of Specification —
 Mark EX II Mod. — No. 10
 Date received —
 Capped or uncapped —
 Weight (capped) —
 Weight (uncapped) 1956.00#
 Length (uncapped) 103.65
 Fuze NONE
 Filler VERMICULITE
 Flight by screen —
 Condition after firing: —
 EFFECTIVE or ~~INEFFECTIVE~~
 Intact - Moderate
 Flattening



BALLISTIC DATA

Notes	-1-	-2-	-3-	-4-	-5-	-6-	-7-
All limits are for this plate and this obliquity only.	Impact	Geod. graph	Chronograph	Impact measured for this thickness of impact	Actual w.p. to nominal range	Limit for nominal range, based on this impact only. (Adjusted from column 4)	Limit for nominal range, established from column 6 and previous impacts
Striking velocity (f.s.)		MEAN					
		932					

REMARKS

Pressure - 1.5 tons/in²

60 lbs SPON 3369 Powder & 15 lbs Black Powder Booster

Limit shots only

e/d

F(e/d, e)

N.P.G. Photo. No.

Confidential

Table X

Acceptance or rejection recommended

E. Levitt

17

U.S. Navy

GUN: 18" / 47 MK A MOD 0 # 1 L

Appendix B

File No.

Butt Firing

IMPACT No. 39203

U. S. Naval Proving Ground

IMPACT DATE 8-17-51Dahlgren, Va. 8-17-51 194BUTT No. FOBJECT BALLISTIC TEST OF 2000 LB. LOW DRAG E.P.
BOMB EX II VERMICULITE LOADED VS. 1 3/4" PLATEREFERENCE N.P.G. REPORT NO. 950

DATED

PLATE

E.P. BOMB

~~PROJECTILE~~

Gauge 1.849
 Class ST3
 Maker CARNEGIE
 No. 091460 Group C-526-736
 Contract C-N6003-S-5615
 Date received 8-16-50
 Dimensions 95" X 250"
 No. of impact on plate 6
 Thickness at impact 1.84
 OBLIQUITY 20°
 Impact dimensions 19" X 21"
 PENETRATION COMPLETE
 Flaking front 0
 Flaking back 0
 Dist. from top, bottom 32"
 Dist. from right, left 140"
 Dist. from nearest impact 46"
 Dish 2"
 Spur 4"
 Cracks - Bulge 0
 Button (Thrown) (Started)
 Through Opening 17" X 24"

Caliber 17.987
 Maker A.O. SMITH
 Type LOW DRAG BOMB
 Lot No. - Year of Specification -
 Mark EX II Mod. - No. 19
 Date received -
 Capped or uncapped -
 Weight (capped) -
 Weight (uncapped) 1975.00*
 Length (uncapped) 103.65
 Fuze NONE
 Filler VERMICULITE
 Flight by screen -
 Condition after firing:
EFFECTIVE or INEFFECTIVE
Intact - Moderate
Flattening



BALLISTIC DATA

NOTE:	1	2	3	4	5	6	7
All limits are for this plate and this obliquity only.	Desired	Oscillograph	Chronograph	Limit estimated for this thickness of impact.	Actual adjusted to test range	Limit for nominal range based on this impact only. (Admitted from column 4)	Limit for nominal range established from column 6 and previous impacts.
Rolling velocity (f.s.)		MEAN 848					

REMARKS

Press - 1.7 Tonbolts SPDX-3369 Powder 15 lbs. Black
Powder Box

Limit shots only

Confidential

e/d.

F(e/d, +)

Table IIE. Linch

N.P.G. Photo. No.

GUN: 18 1/4 MK A MOD 0 #11Appendix B

File No.

Butt Firing

IMPACT NO. 39204

U.S. Naval Proving Ground

IMPACT DATE 8-17-51

Dahlgren, Va. 8-17-51

BUFT NO. F

OBJECT BALLISTIC TEST OF 2000 LB. LOW DRAG G.P.
BOMB EX II VERMICULITE LOADED VS. 1 3/4" PLATE

REFERENCE N.P.G. LETTER Report No. 950

DATED

PLATE

G.P. BOMB

PROJECTILE

Gauge 1.849
Class STS
Maker CARNEGIE
No. 091460 Group C-526-736
Contract C-H6005-S-5615
Date received 8-16-50
Dimensions 95" X 250"
No. of impact on plate 7
Thickness at impact 1.84
OBLIQUITY 20°
Impact dimensions 19" X 20"
PENETRATION COMPLETE
Flaking front 0
Flaking back 0
Dist. from top, bottom 70"
Dist. from right, left 110"
Dist. from nearest impact 46"
Dish 2"
Spur 9"
Cracks - Budge 0
Button (Thrown) (Started)
Through Opening 18" X 26"

Caliber 17.981
Maker A.O. SMITH
Type LOW DRAG BOMB
Lot No. Year of Specification
Mark EX II Mod. No. 7
Date received
Capped or uncapped
Weight (capped)
Weight (uncapped) 1968.0#
Length (uncapped) 130.65
Fuze NONE
Filler VERMICULITE
Flight by screen
Condition after firing:
EFFECTIVE or INEFFECTIVE
Intact - Moderate
Flattening

BALLISTIC DATA

NOTE:	1- Desired	2- Oscillograph	3- Chronograph	4- Limit, estimated 6.2 mm thickness of impact.	5- Actual adjusted to nominal gauge.	6- Limit, for nominal gauge, based on this impact only. (Adjusted from column 3)	7- Limit, for nominal gauge, established from columns 6 and previous impacts.
All limits are for this plate and this obliquity only.		MEAN					
Striking velocity (f.s.)		1013					

REMARKS

Press - 15 tons per in

60 lbs SPDN - 3369 powder & 15 lbs Black Powder
Booster

Limit shots only

e/d

F(e/d, e)

N.P.G. Photo. No.

Confidential

Table XII

C. Levitch
Lt.

U.S. Navy

GUN: 18 1/4" MK A MOD 0 #1L

Appendix B

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SECURITY INFORMATION

EX-11 Mod O went down river after impact
striking velocity was 1323 f.s.

Appendix 0

Figure 1

omb (low drag)
of obliquity

NP9-48450

Impact 39176, 2000 lb. G.P. at
against T-4, all in total



IMP. 39176

~~GROUND~~

IMP 39177

1968

1275

۱۰۵۲

616

Impact 3517%, force 18.7 lb. (low) - 11 lb. after in-
against 18.7 lb. plate at 0° difficulty. Striking velocity was
CA. P.S. Appendix C

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SECURITY INFORMATION

Figure 3

Low Altitude Bomb

COOL

NP9-48448

Impact 09181

09181

18/81

CONFIDENTIAL

SECURITY INFORMATION

NP9-46447

Impact 39182, 2000 lb. G.P. bomb (low drag) EX-11 Mod 0 after impact against 2.75
SPS plate at 20° obliquity. Striking velocity was 823 f.s. Appendix C

Figure 4



215 plate vs 0110864

20. VHT

39182

IP9-48446

Impact 39183, 2000 lb. C.P. bomb

plate at 20° obliquity. Striking velocity was 17 f.s.

Figure 5

L-11 model Q after impact

at 17 f.s.

CONFIDENTIAL

SECURITY INFORMATION
Appendix C

IMP 39183

PLATE NO.

108 221

39183

TPG-28445

Impact 39484, 2000 lb. G.P. bomb
STS plate at 20° obliquity.

Figure 6

(low drag) 11-11-68 O after
striking velocity was 920 f.s.

CONFIDENTIAL
SECURITY INFORMATION
Impact against 240
Appendix C

9784

39196

IMP 39196
PLATE NO.
091460

NP9-48444

Figure 7

CONFIDENTIAL
SECURITY INFORMATION

Impact 39196, 2000 lb. G.P. bomb (low drag) EX-11 Mod O after impact against H24 STS plate at 20° obliquity. Striking velocity was 914 f.s.

Appendix C

IMP 39197
PLATE NO.
11160

16160

NP9-48443

Figure 8

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SECURITY INFORMATION

Impact 39197, 2000 lb. G.E. bomb (low drag) Mod O after
impact against 1" x 4" steel plate at 0° obliquity. Striking
velocity was 68 ft/sec.

Appendix C

NR9-48442

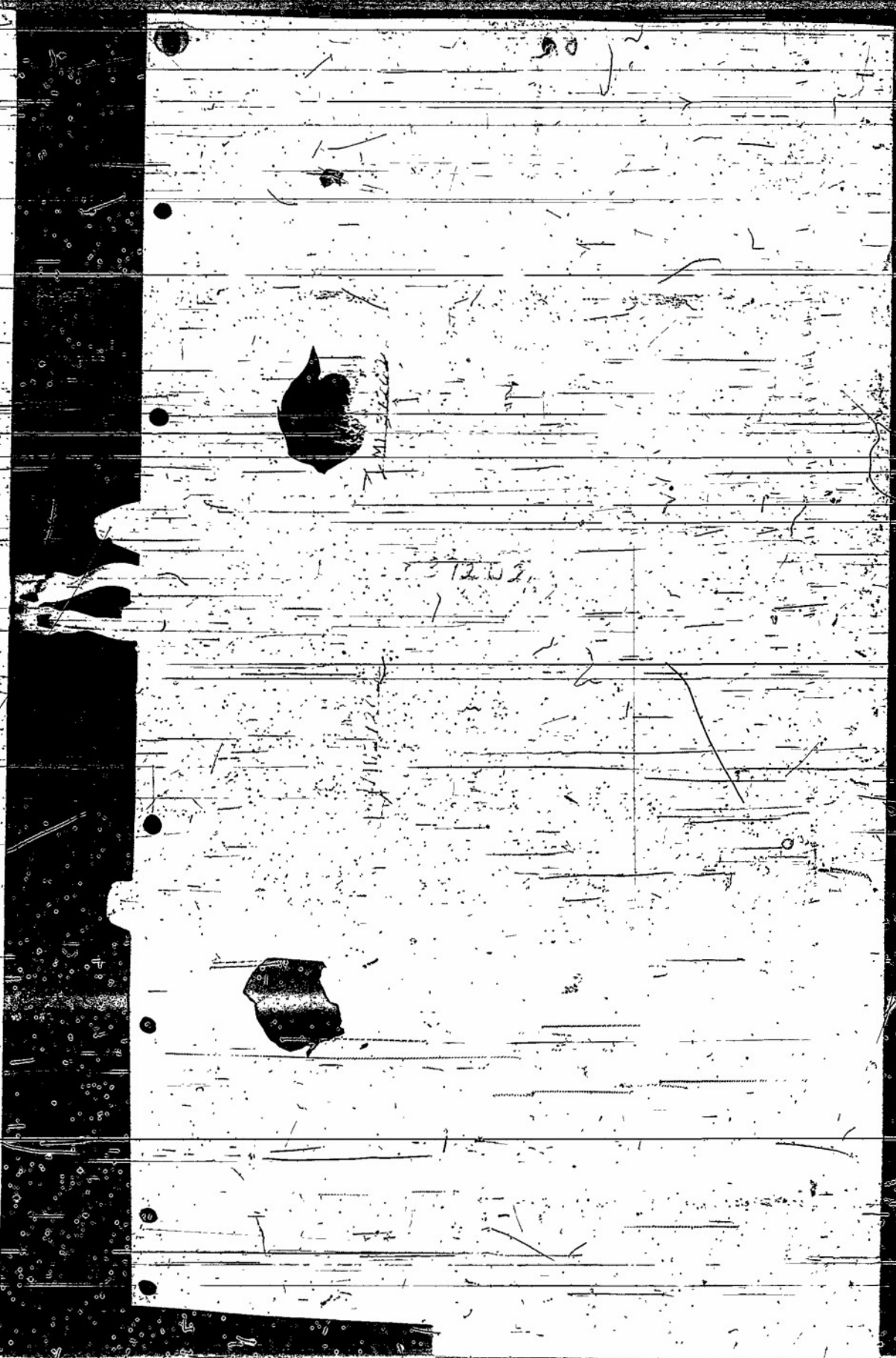
Impacts 39202 and 39203, 2000 lb. G.P. bomb (low drag) EX-111 Mod Q after impact against 1484 STS plate at 20° obliquity. Striking velocity of impact 39,002 was 932 f.s. and 848 f.s. for impact 39203.

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SECURITY INFORMATION

Appendix C

Figure 9



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SECURITY INFORMATION

Figure 10

NP9-48441
Impact 39204, 2000 lb. C.P. bomb (low drag) Ex-11 Mod 0 after impact against 1"84
STS plate at 20° obliquity. Striking velocity was 1013 f.s.

31201

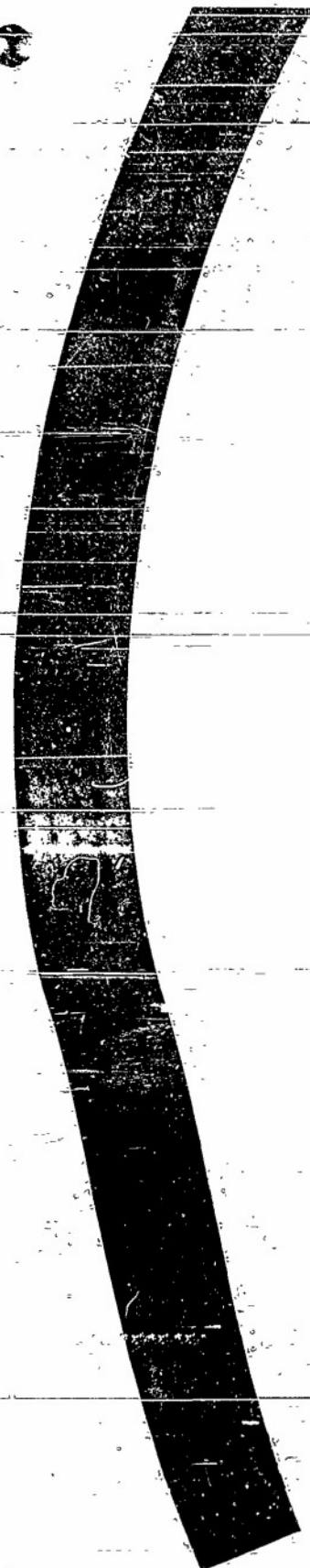
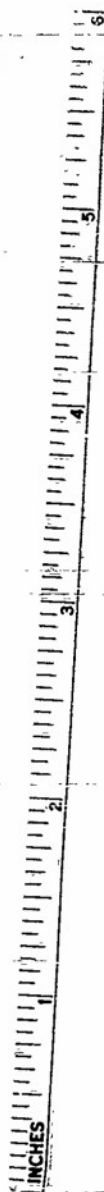
Transverse Section of 2000# Low Drag G.P. Bomb, Type Ex-11, Mod. 0.
Etched in 50% HCl-50% H₂O for 20 Min. at 160°F.
Magn. 1X.

Top:- Bomb No. 3, Impact No. 39196.
Bottom:- Bomb No. 7, Impact No. 39204.

NP9-45700

Figure 11.

APPENDIX D.
CONFIDENTIAL



Transverse Section of 2000# Low Drag G.P. Bomb, Type Ex-11, Mod.O.
Etched in 50% HCl-50% H₂O for 20 Min. at 180°F. Magn. 1X.

Top:- Weld Area - Sound Steel - Good Weld.

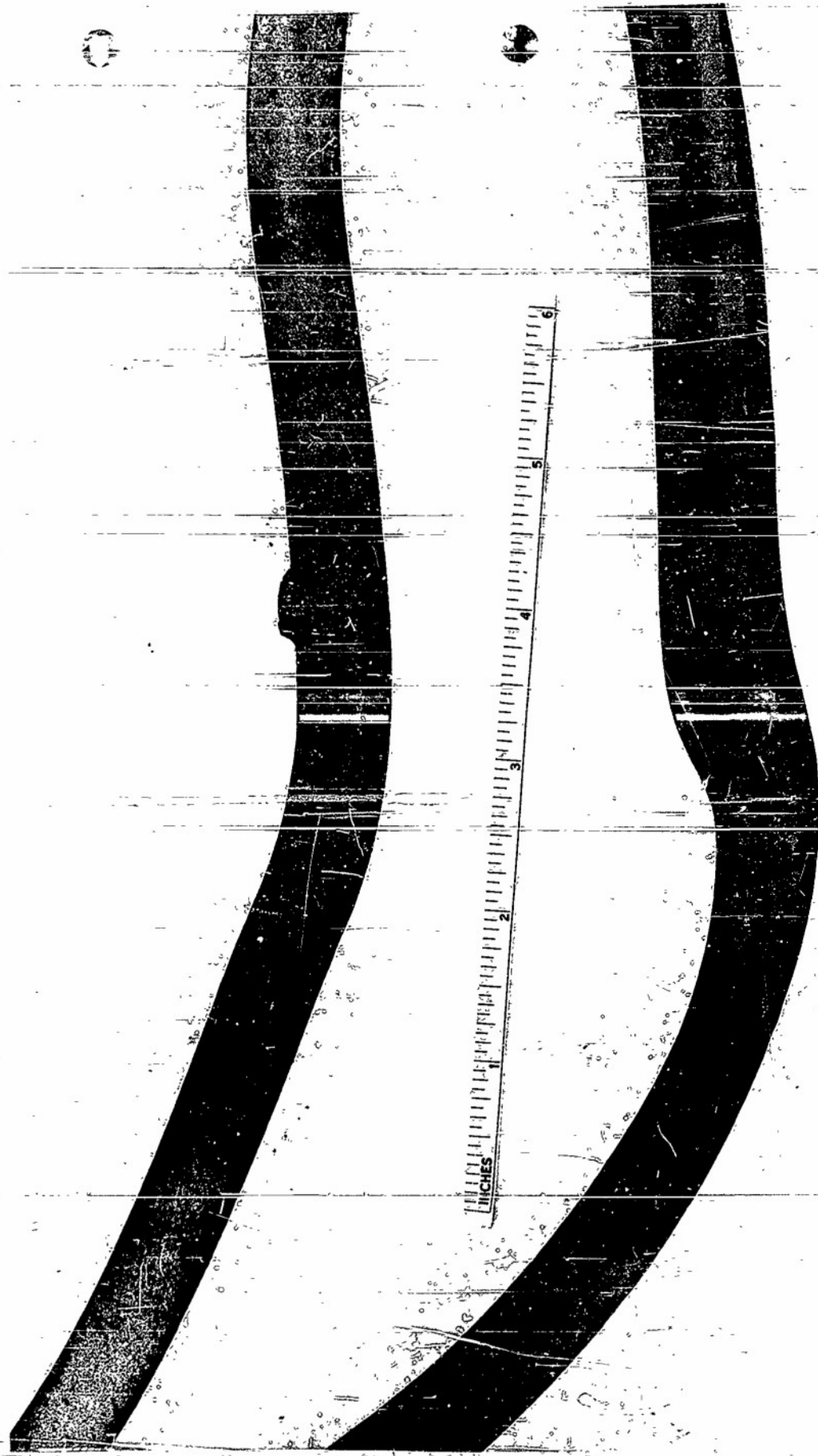
Bottom:- 180° from weld showing fracture in segregated area.

NP9-45699

Figure 12.

APPENDIX D.

CONFIDENTIAL



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NPG REPORT NO. 950

Plate Penetration Tests of the 2000 lb. Bomb,
G.P. (Low Drag), Type EX-11, Mod. 0



Figure 13

250X

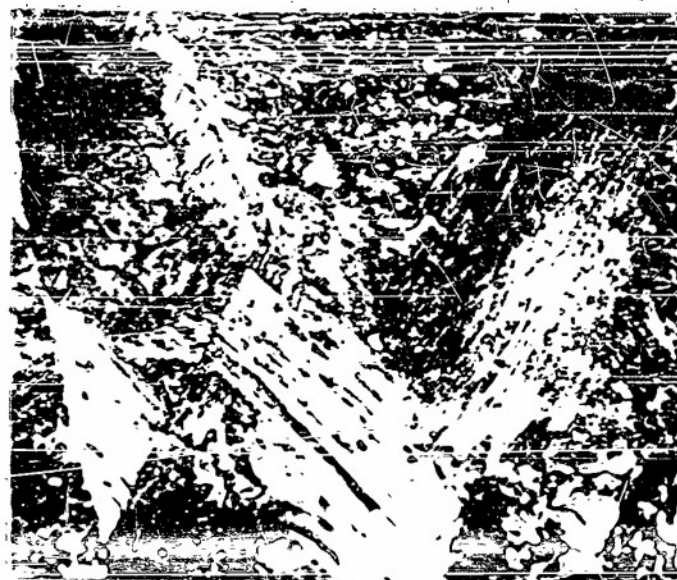


Figure 14

1000X

Bomb No. 20 - Impact No. 39181 - Nital-Picral Etch.



Figure 15

250X



Figure 16

1000X

Bomb No. 3 - Impact No. 39196 - Nital-Picral Etch.

NP9-45701

CONFIDENTIAL
SECURITY INFORMATION

APPENDIX D

CONFIDENTIAL

NPG REPORT NO. 950

Plate Penetration Tests of the 2000 lb. Bomb,
G.P. (Low Drag), Type EX-11, Mod. 0

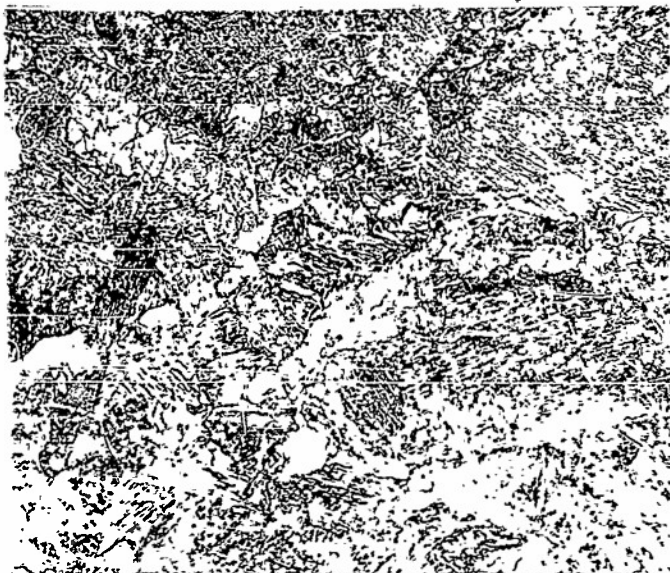


Figure 17

250X Figure 18

1000X

Bomb No. 7 = Impact No. 39204 - Nital-Picral Etch.

NP9-45702

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SECURITY INFORMATION

APPENDIX D

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NPG REPORT NO. 950

Plate Penetration Tests of the 2000 lb. Bomb,
G.P. (Low Drag), Type EK-11, Mod 0

TABLE XIII

CHARPY IMPACT TESTS AT VARIOUS TEMPERATURES

Testing Temp. °C	Bomb No. 20		Bomb No. 3		Bomb No. 7	
	Charpy Ft. Lbs.	Fracture *	Charpy Ft. Lbs.	Fracture *	Charpy Ft. Lbs.	Fracture *
-78	See Note No. 1		10	G	11	G
"			15	G	10	G
"			13	G		
-40			14	G	15	G
"			13	G	16	G
0			20	10F	18	20F
"			18	20F	23	30F
+25	30	60F	25	50F	27	50F
"	32	60F	22	40F	29	50F
"	28	50F				
"	27	50F				
"	19	10F				
"	13	30F				
+100			47	F	51	F
"			45	F	50	97F

Note 1: On Bomb No. 20 Charpy impact tests were made only at room temperature (25°C). The first four values shown were from an area away from the fracture in the bomb. The last two values were from specimens taken near the fracture.

* F denotes 100% Fibrous Fracture.
60F " 60% " " and 40% Granular.
G " 100% Granular Fracture.

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SECURITY INFORMATION

APPENDIX E

NP9-45712

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CHARPY IMPACT TESTS

at

VARIOUS TEMPERATURES

Bomb No. 3

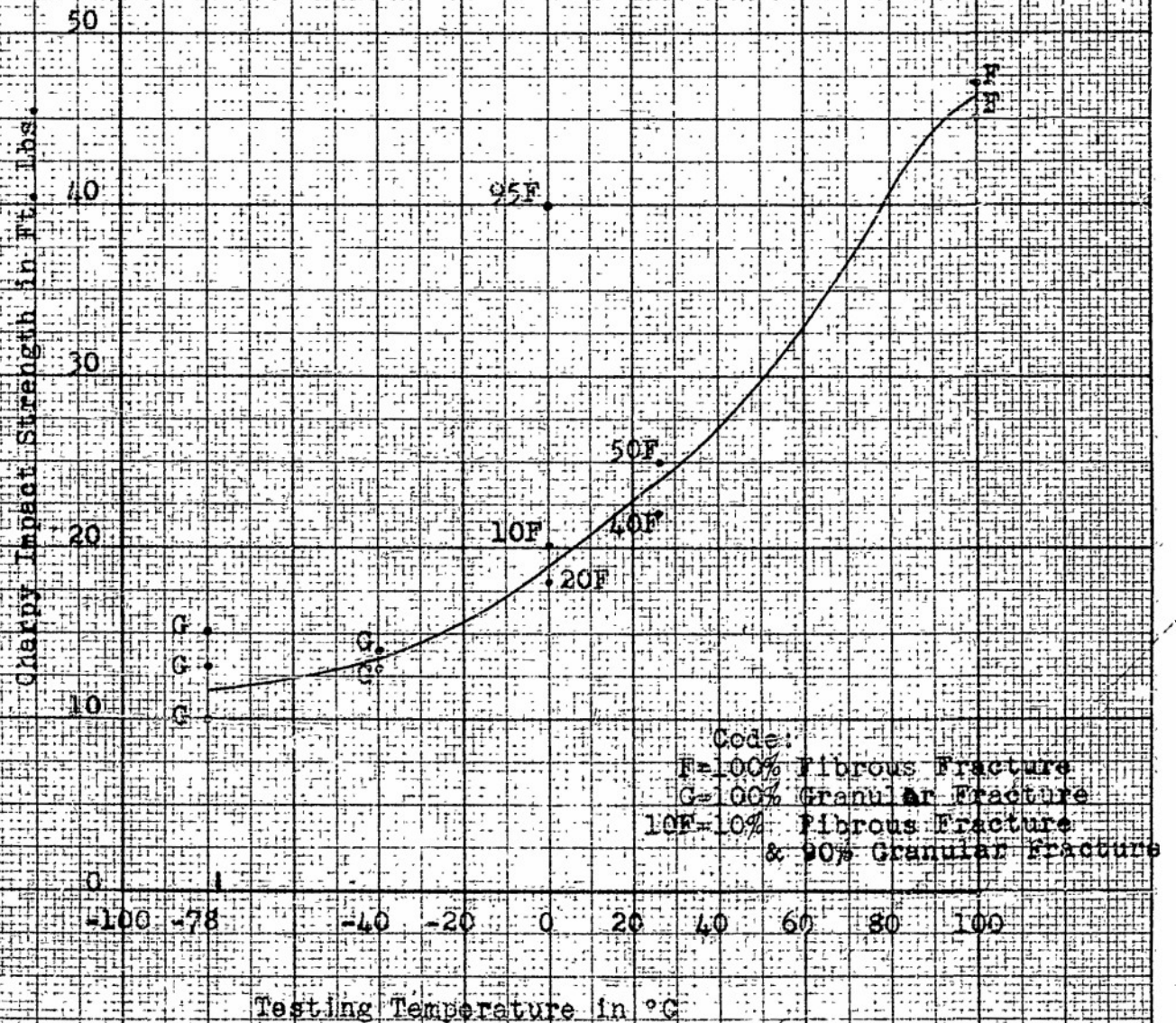


FIGURE 19

APPENDIX E

NP9-45713

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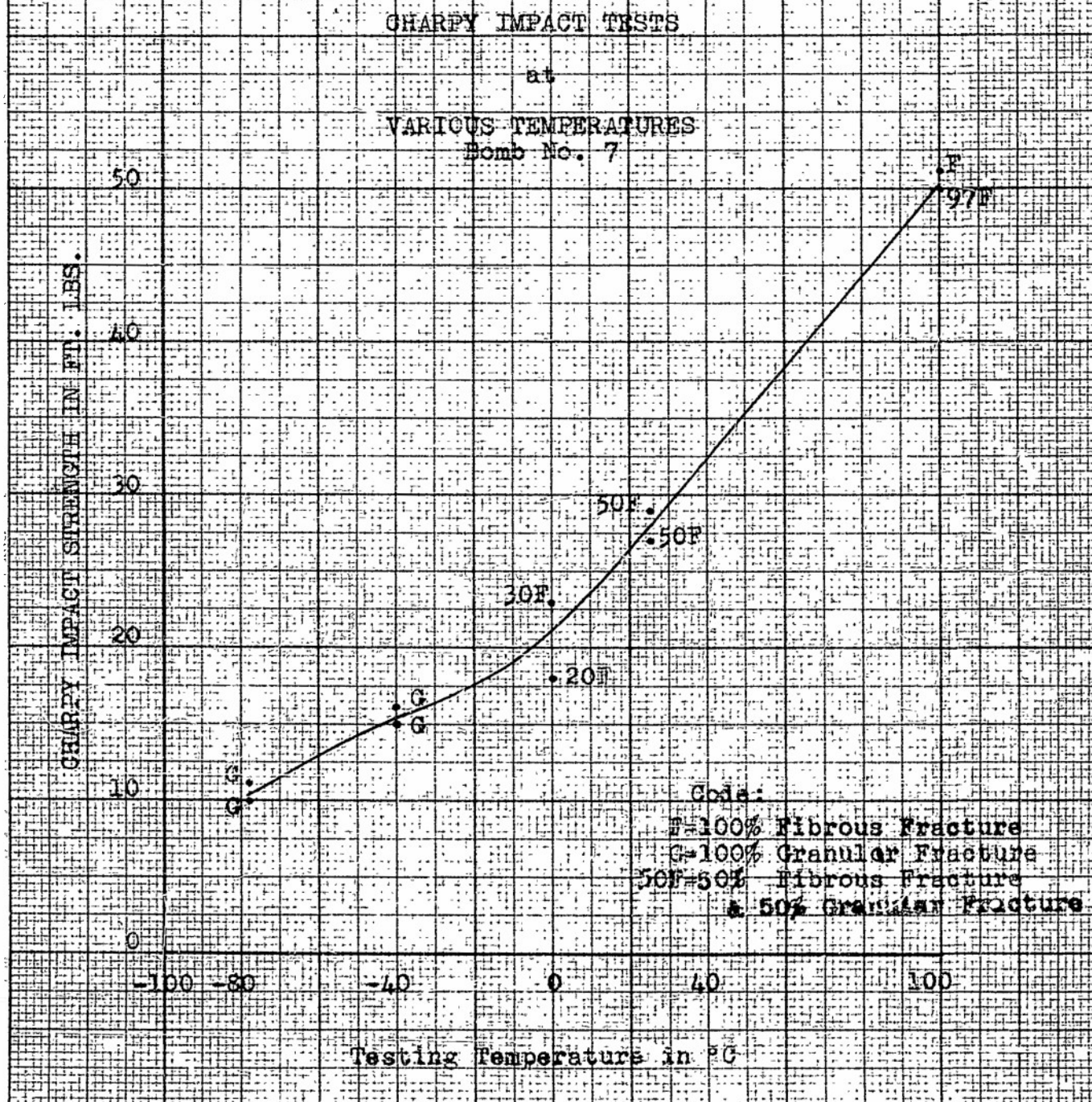


FIGURE 20

APPENDIX E

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Plate Penetration Tests of the 2000 lb. Bomb,
G.P. (Low Drag), Type EX-11, Mod 0

DISTRIBUTION

Bureau of Ordnance	
Ad3	1
Re3c	6
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Commanding General, Aberdeen Proving Ground Aberdeen, Maryland Attn: Technical Information Section Development and Proof Services	1
Commander, Operational Development Force U. S. Atlantic Fleet, U. S. Naval Base Norfolk 11, Virginia	1
Navy Research Section, Library of Congress Washington 25, D. C. (Via Re3c)	2
Naval Gun Factory Attn: Aircraft Armament Section	1
Bureau of Aeronautics Attn: Armament Section	2
NATC, Patuxent River, Maryland	3
NAOTS, Chincoteague, Virginia	1
Air Materiel Command Liaison Officer Wing 3 Headquarters, Aberdeen Proving Ground Aberdeen, Maryland	2
Naval Liaison Officer USAFPGC, Eglin Field, Florida	1
NOTS, Inyokern, California	1
NOTS, Inyokern, California Attn: Aviation Ordnance and Test Department	1

CONFIDENTIAL

~~CONFIDENTIAL~~

REF ID: A67888

Plate Penetration Tests of the 2000 lb. Bomb,
G.P. (Low Drag), Type EX-11, Mod C

DISTRIBUTION (Continued)

Naval Air Development Center
Johnsville, Pa.

U. S. Air Force
AMC Engineering Field Office
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Navy Department, Washington, D. C.

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Frankford Arsenal
Philadelphia, Pa.

Local:

OT
OTP
OTL
OR
File

1
1
2
1
1

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SECURITY INFORMATION