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Rock Island Arsenal Laboratory

TECHNICAL REPORT

THE DEVELOPMENT OF FIBERBOARD TARGETS FOR THE M31A1 TRAINFIRE MECHANISM

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Rock Island Arsenal
Rock Island, Illinois

ABSTRACT

The military has a need for targetboards for use with the M31A1 Trainfire Mechanism. In the past, targets made of untreated chipboard, fiberglass, wood, etc., have been unsuccessfully used. A program with the dual purpose of (1) providing an acceptable target for field service and (2) developing test procedures to describe adequately such material, was initiated.

It has been ascertained, through developmental work in conjunction with various manufacturers, that fiberboard targets can be made which will adequately fill the field service requirements. One such material was composed of a large percentage of long virgin sulfate fibers in combination with a smaller amount of jute fibers and having a high resin wet strength treatment. The laminating adhesive was highly water resistant and the board was coated on both surfaces with a water repellent plastic.

Properties, important in the determination of firing effectiveness, were found to be thickness, density, water absorption and modulus of elasticity, but the final criterion for evaluation must be the firing test.

RECOMMENDATIONS

A Military Specification for fiberboard targets should be prepared, utilizing information contained in this report, to insure the procurement of materials which will satisfactorily meet field requirements.

THE DEVELOPMENT OF FIBERBOARD TARGETS
FOR THE M31A1 TRAINFIRE MECHANISM

CONTENTS

THE DEVELOPMENT OF FIBERBOARD TARGETS
FOR THE M31A1 TRAINFIRE MECHANISM

OBJECTIVE

(1) To develop or obtain targetboard material conforming to field service requirements to be used in the M31A1 Trainfire Mechanism.

(2) To develop test procedures and determine requirements which will describe a targetboard suitable for field service.

INTRODUCTION

The use of pop-up type targets as a means of simulating combat conditions has been considered advantageous by the Military for some time. The original targets of this nature were operated by a timing device which allowed the target to stand for a given period of time prior to returning it to the horizontal. The determination of "hit" or "miss" was by inspection of the target.

More recent developments have resulted in a target mechanism (M31A1 Trainfire Mechanism) which will automatically return the target to the horizontal when a "hit" is registered. Two switches attached to the base of the target actuate the motor of the mechanism when the target vibrates after impact. A complete description of this mechanism is given in the Quality Assurance Pamphlet, ORDP-608-OW-RIA2.

Certain problems in the operation of this mechanism have arisen due to inadequacies of the target material. Targets made of plastic, wood, metal and coated material have been evaluated but they have been found to have limited value due to cost, safety factors or ineffectiveness on the firing range. Fiberboard products have been used with some success as the target material. However, they have been found to be incapable of transmitting sufficient vibrations to activate the kill switches after exposure to moist conditions.

It was determined that upgrading the targetboard material was within the scope of Rock Island Arsenal's nonmetallic materials mission and a critical review of the engineering requirements for such a material was initiated.

Approximately forty different commercial targetboard materials were tested at the Rock Island Arsenal Laboratory before a satisfactory material for field service was obtained.

The development of testing procedures to describe satisfactory targetboard material for field service and the determination of availability of such material provides the scope for this program.

The firing test performed on the targets is the primary criterion for field service application. This test is time consuming and expensive and it usually cannot be performed by industry. It would, therefore, be advantageous to describe, adequately, a suitable material with simple laboratory tests. An evaluation of the relationship between the firing test data and the results of other tests is included in this report.

PROCEDURE

The standard methods and descriptions of nonstandard methods of testing used on the targetboard materials follow:

A. Test Methods described in SQAP 8426438:

1.	Firing Test	Par. 4.5.1 as revised in IFB(ORD) 11-199-63-43; Par. 14.1.e.
2.	Bending Test	Par. 4.2
3.	Piercing Test	Par. 4.1
4.	Adherence Test	Par. 4.3
5.	Water Absorption	Par. 4.4 except that determinations were made at various times of immersion.
6.	Permanent Deflection	Par. 4.4 except that the load was increased in 0.4 inch-pound intervals to failure.
7.	Puncture Test	Par. 4.1 except that testing temperature was $73^{o} \pm 2^{o}F$ and load was increased in 5# increments to failure. Puncture of material constituted failure.

Note: Refer to Addendum #1 for SQAP 8426438.

B. Standard Paperboard Test Methods:

1.	Thickness	Fed. Spec. UU-P-31b; Method 173
2.	Flexural Resistance	TAPPI T469 Sm-55
3.	Bursting Strength	TAPPI T403-m53 except that a test specimen of 4" x 4" was tested in a Mullen Burst Tester with a range of 0-800 psi.
4.	Density	Fed. Spec. UU-P-31b; Method 110 except that reported units are lbs./ft.^{3}

C. Non-Standard Test Methods:

1. Impact Penetration - A 7/8" penetrator, with base diameter of 0.15 and tapered to a sharp point, attached to a cylinderical rod (the entire apparatus weighing 1.0 pound.) was dropped through a hollow, vertical metal cylinder from increasing heights upon the test specimen. The resistance to complete penetration was measured to the nearest 1/2 inch-pound. The test was performed at a temperature of 73°± 2°F. The specimens (4" x 12") were tested when dry and after subjection to water (spray or immersion) under various conditions.

2. Modulus of Elasticity (Method A) - A complete target, whose dimensions are given in Drawing #8426438, was used as the test specimen. The bottom six inches of the target was held in place on a table 94.5 cm. high, by a 20 pound weight. The distance of the head of the target from the floor was measured. Various weights (in multiples of 3.75 oz. to a total of 15 oz.) were then added to the target at a point 9 inches from the top. The distance of the head of the target from the floor was again measured. The deflection (amount of bending due to the applied weight) was calculated from these figures. Calculations of modulus of elasticity were then made according to the standard formula:

$$ME = \frac{\text{load x length}^3}{\text{4 x deflection x width x thickness}^3}$$

3. Modulus of Elasticity (Method B) - The modulus of elasticity was determined on a 50 inch-pound Tinius Olsen Stiffness Tester. A 2" x 6" specimen was used for the determination. This procedure involves the bending of the sample to a predetermined angle of deflection while the necessary weight is recorded on a dial. The linear deflection can be calculated from the angle of deflection and the bending span.

The formula used for calculation of the M.E. is the same as used in Method A.

D. Water Treatment:

1. Immersion - The specimens were immersed in water at room temperature for specified periods of time.

2. Rain Spray - The specimens were subjected to water spray at room temperature at the rate of 4 inches per hour for specified periods of time.

E. Material Tested:

Fiberboard targets, with dimensions as given in Drawing #8426438, from various suppliers were evaluated. See Addendum #2 for Drawing.

RESULTS

The data obtained for the test procedure evaluations are shown in Figures 1 through 3 and Tables I through V.

The data obtained on the material development are shown in Tables VI through IX.

DISCUSSION

A. Evaluation of Testing Procedures:

The initial work on this program involved the testing of five different commercial fiberboard targets, according to all Laboratory procedures which were considered to be of potential value in rating the materials as to their effectiveness in field service. Since the firing test is considered to be the final criterion, attempts were made to correlate the various properties determined with the firing test data. In the discussion which follows, the conclusions are based solely on the tests performed at this Laboratory on these five targets.

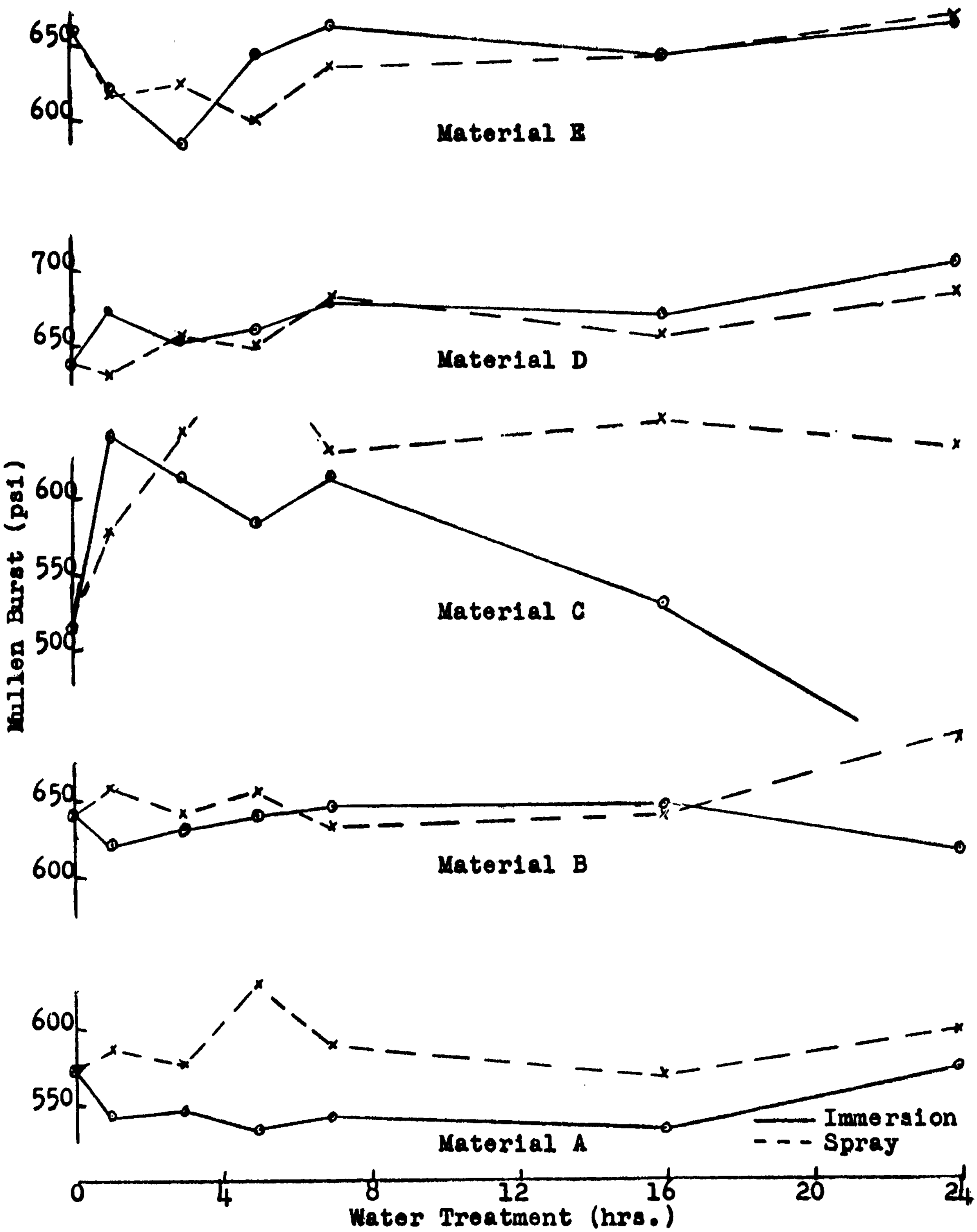
FIRING TEST

Object:

To determine the capabilities of each material to operate in the M31A1 Trainfire Mechanism under various conditions.

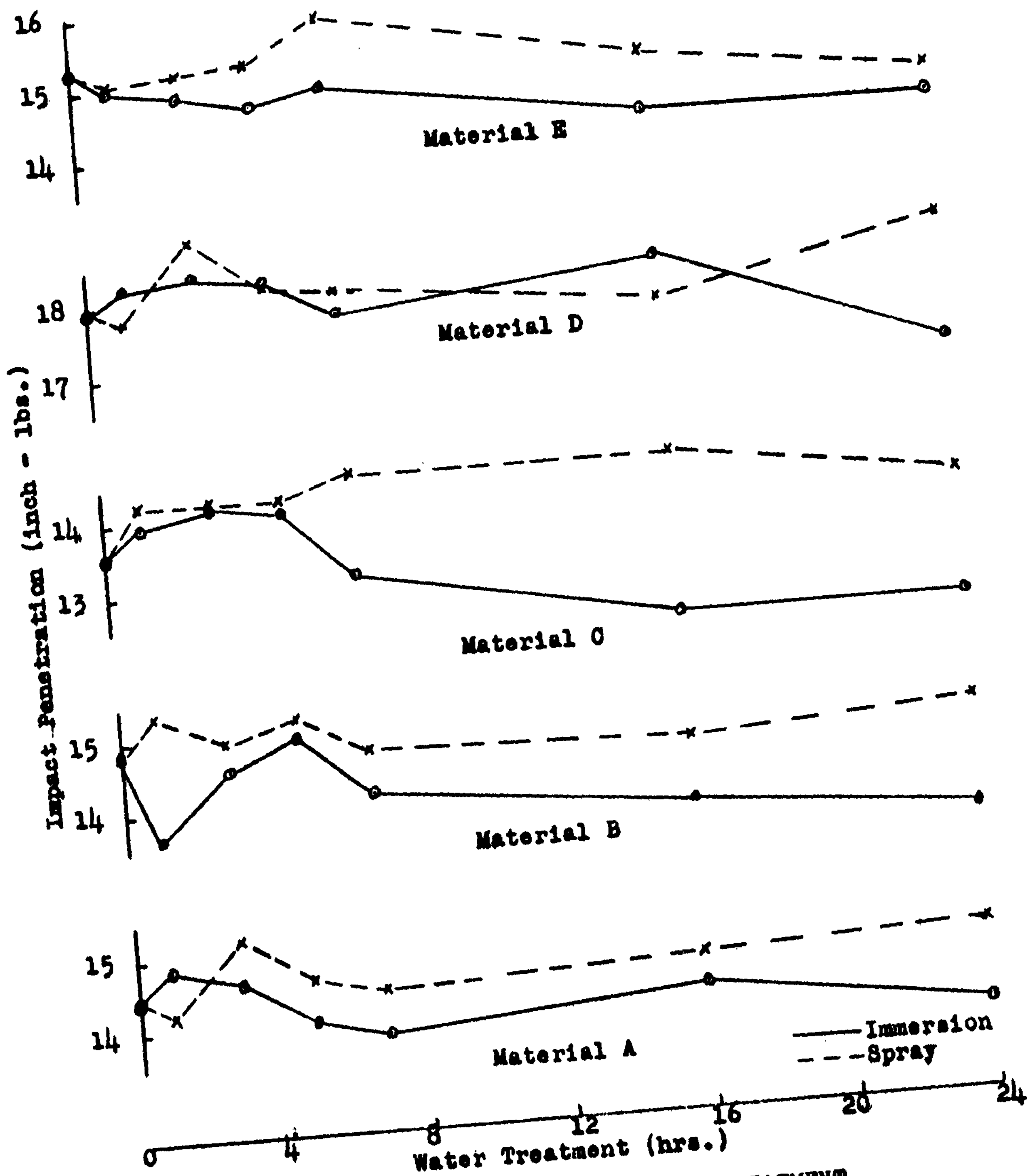
Procedure:

Targets, after water treatment of varying proportions,



BURSTING STRENGTH VS WATER TREATMENT

FIGURE 1



IMPACT PENETRATION VS WATER TREATMENT

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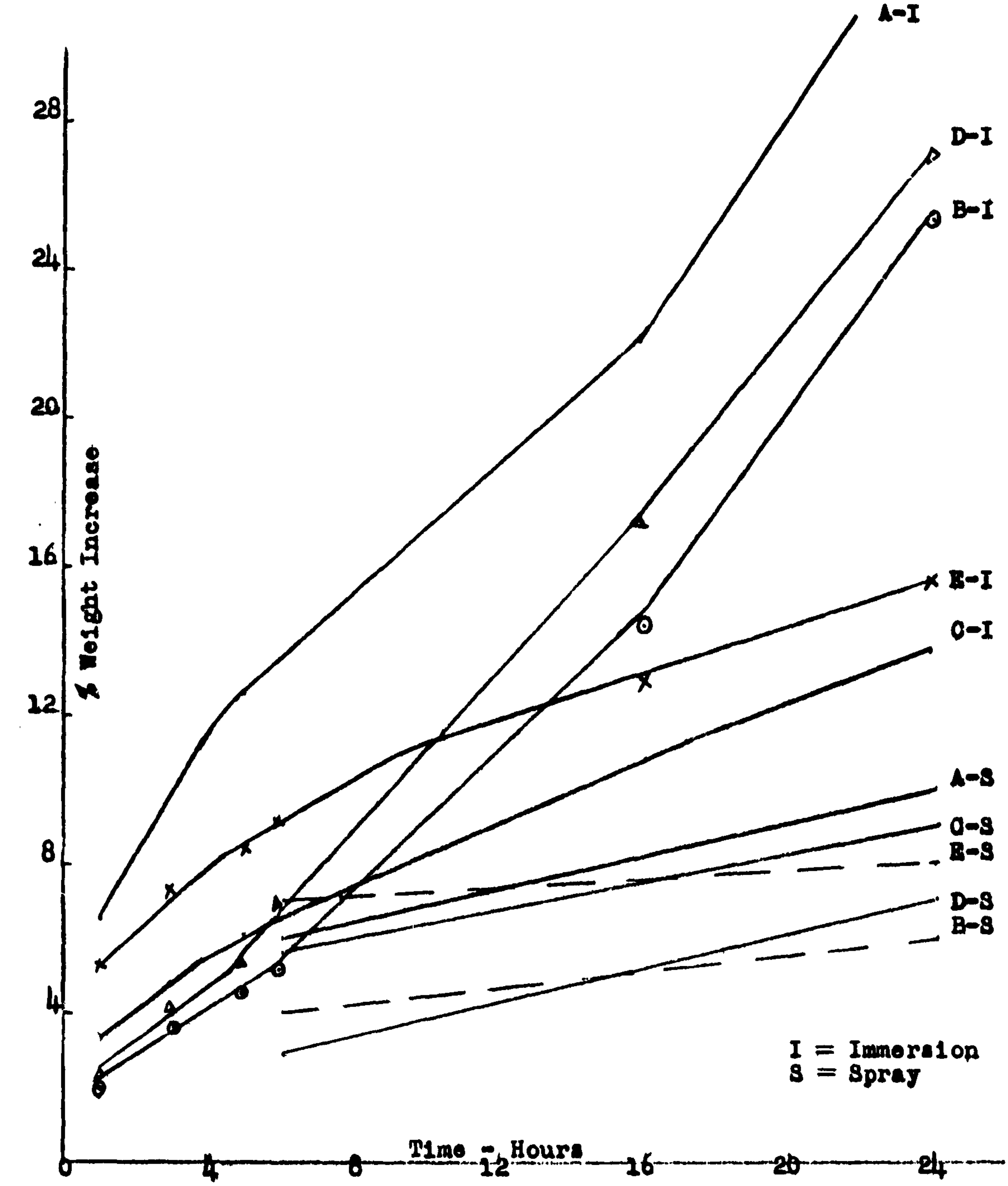
FIGURE 2



WATER ABSORPTION VS TIME

TABLE I

THE PROPERTIES OF THE FIVE TEST EVALUATION MATERIALS COMPARED TO THE REQUIREMENTS OF IFB 11-199-63-43

PROPERTY	REQUIREMENT	A	B	C	D	E
Water Absorption	20% Max. in 24 Hrs.	34.2	25.5	13.8	27.2	15.9
Thickness	0.100" to 0.125"	0.113	0.107	0.110	0.120	0.114
Bending	No crack, separation, etc.	Pass	Pass	Pass	Pass	Pass
Weight, per Target	2.75# Max.	1.94	1.89	2.39	2.17	1.96
Permanent Deflection	3 in-lbs Min.	Pass	Fail	Fail	Pass	Pass
Piercing Test	No loss of material	Pass	Pass	Pass	Pass	Pass
Adherence	No blocking	Pass	Pass	Fail	Pass	Pass
Firing Test (Dry)	34/35 Kills min.	70/70	35/35	69/70	105/105	35/35
Firing Test (Wet)	72/75 Kills min.	56/75	73/75	35/75	64/75	72/75

TABLE II

FIRING TEST RESULTS OF THE FIVE TEST EVALUATION MATERIALS UNDER VARIOUS CONDITIONS (NO. KILS/NO. OF HITS)

CONDITIONS	A	B	C	D	E
Dry	70/70	35/35	69/70	105/105	35/35
3 Hours Immersion	67/75	65/75	-	73/75	65/75
6 Hours Immersion	43/50	41/50	37/50	74/75	72/75
16 Hours Immersion	54/75	62/75	58/75	74/75	75/75
24 Hours Immersion	56/75	73/75	35/75	64/75	72/75
24 Hours Rain Spray	36/50	49/50	27/50	45/50	49/50
Total (Wet Condition)	256/325	290/325	157/250	330/350	333/350
% Kills (Wet Condition)	78.8	89.2	62.8	94.3	95.1

TABLE III

COMPARISON OF PROPERTIES OF THE FIVE TEST EVALUATION MATERIALS WHEN DRY

PROPERTY	A	B	C	D	E
Thickness (inches)	0.113	0.107	0.110	0.120	0.114
Flexural Resis. (#/2" width)	23.0	16.6	20.4	27.8	24.6
Bursting Strength (psi.)	663.6	621.5	515.2	625.4	608.0
Puncture Res. (lbs.)	38	37	30	48	44
Density (#/ft.^{3})	42.8	44.1	58.4	45.6	45.6
Modulus of E. (#/in^2) (Method A)	26,400	26,100	28,000	25,000	32,300
Modulus of E. (#/in^2) (Method B)	33,330	27,990	34,460	33,030	35,530
Firing Test (% Kills)	100	100	98.6	100	100

TABLE IV

COMPARISON OF PROPERTIES OF THE FIVE TEST EVALUATION MATERIALS AFTER SIX HOURS OF WATER IMMERSION

PROPERTY	A	B	C	D	E
Water Absorption (%)	11.5	5.3	6.5	7.0	9.3
Bursting Strength (psi)	554.4	601.0	580.0	633.3	569.6
Puncture Res. (lbs.)	42	49	28	58	51
Mod. of Elas. (#/in^2) (Method A)	27,000	21,600	12,800	17,600	29,900
Firing Test (% Kills)	86.0	82.0	74.0	98.7	96.0

TABLE V

COMPARISON OF PROPERTIES OF THE FIVE TEST EVALUATION MATERIALS AFTER TWENTY-FOUR HOURS OF WATER IMMERSION

Water Absorption (%)	34.2	25.5	13.8	27.2	15.9
Puncture Resistance (lbs)	30	45	23	50	46
Permanent Deflection (in-lbs)	4.2	2.5	2.5	3.7	4.6
Modulus of Elas. (#/in^2) (Method B)	10,320	7,460	10,470	11,890	12,580
Firing Test (% Kills)	74.7	97.3	46.7	85.3	96.0

TABLE VI

PROPERTIES OF MATERIALS DETERMINED FOR IFB-11-199-62-185

PROPERTY	REQUIREMENT	a-1	a-2	a-3	a-4	a-5	a-6	a-7	a-8	a-9
Water absorption (%) 24 hrs. @ 70 - 85°F	20.0 Max.	26.5	20.0	111.0	9.3	12.5	17.5	18.5	14.0	10.7
Thickness (inch)	0.105 Min.	0.102	0.125	0.120	0.115	0.115	0.097	0.121	0.122	0.122
Bending @ 0°F around 12" radius	No cracking, peeling or separating	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Weight (lbs/target)	2.75 Max.	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Permanent Deflection (inch-lbs/inch width) after 24 hr. immersion @ 70 - 85°F.	3 Min.	Fail	Pass	Fail	Pass	Pass	Pass	Pass	Pass	Pass
Piercing Test 1 Hr. @ 0°F	Material displaced shall not separate from piece	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Piercing Test 1 Hr. @ 125°F	Material displaced shall not separate from piece	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Adhesion after aging 2 hrs. @ 150°F and 2 psi.	No adhesion	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Cycling Test, 250 cycles after 24 hr. immersion	Shall not bend or whip to operate kill switches	Fail	Pass	Fail	Pass	Fail	Pass	Pass	Fail	Fail
Firing Test; 10 single rounds on 1 dry target (kills/rounds)	10/10	8/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10
Firing Test; 10 single rounds on each of 3 targets immersed 24 hrs. in water (kills/rounds)	30/30	0/30	13/30	0/30	11/30	16/30	29/30	4/30	16/30	9/30

TABLE VII

PROPERTIES OF MATERIALS DETERMINED FOR IFB-11-199-63-43

PROPERTY	REQUIREMENT	b-1	b-2	b-3
Water absorption (%) 24 hrs. @ 70 - 85°F	20.0 Max.	14.2	9.4	11.6
Thickness (inch)	0.100 to 0.125	0.120	0.110	0.112
Bending @ 0°F around 12" radius	No cracking, peeling or separating	Pass	Pass	Pass
Weight (#/target)	2.75 Max.	1.94	1.86	2.50
Permanent deflection (inch-lbs/in width) after 24 hrs. immersion	3	Pass	Pass	Pass
Piercing Test - 1 hr. @ 0°F.	Material displaced shall not separate from piece.	Pass	Pass	Pass
Piercing Test - 1 hr. @ 125°F.	Material displaced shall not separate from piece	Pass	Pass	Pass
Adhesion after aging 2 hrs. @ 150°F and 2 psi.	No adhesion	Pass	Pass	Fail
Cycling Test, 250 cycles after 24 hrs. immersion	No buckling or breaking	Pass	Pass	Pass
Firing Test; 35 single rounds on 1 dry target (kills/rounds)	34/35	34/35	35/35	34/35
Firing Test, 25 single rounds on each of 3 targets immersed 24 hrs. in water (kills/rounds)	72/75	33/75	14/75	21/75

TABLE VIII

PROPERTIES OF MATERIALS DETERMINED FOR IFB-11-199-63-231

PROPERTY	REQUIREMENT	c-1	c-2	c-3	c-4	c-5	c-6	c-7	c-8	c-9
Water absorption (%) 24 hrs. @ 70 - 85°F.	20.0 Max.	18.2	55.6	23.0	10.6	40.2	14.3	71.6	9.7	17.7
Thickness (inch)	0.100 to 0.125	0.120	0.101	0.114	0.124	0.114	0.106	0.120	0.122	0.119
Bending @ 0°F. around 12" radius	No cracking, peeling or separating	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Weight, (lbs/target)	2.75 max.	2.1	1.6	1.9	2.0	2.0	2.4	2.2	2.2	2.0
Permanent Deflection (inch-lbs/inch width) after 24 hr. immersion @ 70 - 85°F.	3 Min.	Pass	Fail	Pass	Pass	Fail	Pass	Fail	Pass	Pass
Piercing Test - 1 hr. @ 0°F	Material displaced shall not separate from piece	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Piercing Test - 1 hr. @ 125°F	Material displaced shall not separate from piece	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Adhesion after aging 2 hrs. @ 150°F and 2 psi.	No adhesion	Pass	Pass	Pass	Pass	Fail	Pass	Pass	Fail	Pass
Cycling Test, 250 cycles after 24 hrs. immersion	No buckling or breaking	Pass	Fail	Pass	Pass	Pass	Pass	Fail	Pass	Pass
Firing Test; 35 single rounds on 1 dry target (kills/rounds)	34/35 Min.	35/35	29/35	31/35	35/35	20/35	19/35	35/35	32/35	35/35
Firing Test; 25 single rounds on each of 3 targets immersed 6 hrs. in water (kills/rounds)	72/75 min.	27/75	0/75	70/75	73/75	59/75	31/75	49/75	72/75	74/75

TABLE IX

COMPARISON OF PROPERTIES OF ORIGINAL AND RECENTLY DEVELOPED TARGET BOARDS

SAMPLE	THICKNESS (inch)	WEIGHT #/TARGET	M.E.-DRY METHOD B (#/in^2)	M.E.-WET METHOD B (#/in^2)	ADHESION	WATER ABSORPTION (%)	FIRING-DRY (KILLS/ROUNDS)	24 HRS. IMMER. FIRING-WET (KILLS/ROUNDS)
Original	0.125	1.95	16,930	2,560	Pass	90.9	32/35	0/75
F	0.118	2.10	32,700	13,000	Pass	10.9	34/35	75/75
G	0.107	2.25	39,650	15,620	Pass	5.2	69/70	75/150
H	0.121	2.30	29,540	15,520	Pass	13.5	35/35	75/75
I	0.105	1.86	30,120	13,830	Pass	7.4	70/70	150/150
J	0.117	1.98	26,400	11,530	Pass	24.2	34/35	10/75
K	0.118	1.93	28,190	8,180	Pass	43.5	34/35	2/25
L	0.099	1.86	44,180	13,780	Fail	11.5	29/35	69/75
M	0.138	2.40	24,790	13,050	Pass	9.1	35/35	100/100
N	0.118	2.16	37,700	15,030	Pass	13.7	35/35	61/75

were installed in the trainfire mechanism and were fired upon from a distance of 50 yards with an M-1 rifle. Operation of or failure of the mechanism to function following a hit on the target was termed "kill" or "no kill," respectively.

Discussion:

See Table II for complete firing results. The overall effectiveness of the material (when wet) in the mechanism is in order: E, D, B, A and C. All of the materials were effective when dry. Inconsistencies in the firing data (example: higher percentage of kills on Material B after 24 hours immersion than after three hours immersion) indicates variability in material of each type between targets as well as within the individual targets or possible malfunctioning of the mechanism.

Conclusion:

(1) None of the materials tested satisfactorily met the requirements of the firing test after water immersion. Types D and E did not fail badly, however, as their percentage of kills was 94.3 and 95.1.

(2) Poor reproducibility of results was obtained on all materials. This may be due to variability in material quality or in the testing equipment.

(3) To meet the requirements for field service, a material must be produced whereby that portion of the target which is of poorest quality must have properties above the minimum requirement for successful activation of the kill switches under the specified conditions. In other words, the target must have a built in safety factor.

BURSTING STRENGTH

Object:

(1) To determine the variation of bursting strength of each material with water treatment variation.

(2) To determine the relationship of bursting strength to firing.

Procedure:

(1) The bursting strength was determined on a Mullen Burst Tester after subjection of the material to various time intervals of water immersion and water spray.

(2) The bursting strength was determined from random samples of each material, dry and after six hours of water immersion

Discussion:

(1) Poor reproducibility of the test, due either to material or procedural variations, was evident in this test. Testing variations between five and ten percent were obtained. Averages of five results from each target at each condition were used in the preparation of the curves included in Figure 1. These averaged results tend to be erratic when correlated with wetting conditions. In some cases, the bursting strength after twenty-four hours immersion in water was higher than the original (dry). The bursting strength of the "sprayed" material was very similar to, and sometimes lower than, the immersed samples. This is inconsistent since the rate of water absorption of samples under the spray is considerably lower than those immersed (see Figure 3).

(2) Thirty-six samples from each type of target were tested for bursting strength while dry and after six hours immersion. A randomized testing sequence was used to limit the procedural variations as much as possible. The averages of these results are shown in Tables III and IV with their relationship to other properties. The problems of poor reproducibility and poor correlation between wet and dry targets existed as in (1) above. The material with the highest bursting strength also had the best firing record at these conditions but no other correlation was found.

Conclusions:

(1) No correlation exists between water treatment and retention of bursting strength.

(2) Bursting strength alone is not a measure of efficiency in the firing test.

WATER ABSORPTION

Object:

To determine the weather resistance of the material and its effect on firing properties.

Procedure:

4" x 12" specimens of each material were subjected to various water conditions and the water absorption determined by weight pickup.

Discussion:

In all cases, the water absorption proceeded at a reasonably constant rate throughout the period of exposure (see Figure 3). This rate, as expected, was much more rapid under immersion than when sprayed. Types A, B and D absorbed 34.2, 25.5 and 27.2%, respectively, when immersed for 24 hours, as compared to 13.8 and 15.9% for Types C and E.

Conclusions:

(1) Water absorption proceeds at a constant rate.

(2) Water absorption characteristics vary widely among types.

(3) No correlation exists between water absorption and firing effectiveness.

IMPACT PENETRATION

Object:

To determine the relationship of firing to a Laboratory impact penetration test.

Procedure:

A one-pound penetrator was dropped from varying heights upon the test specimen. Resistance to penetration was determined by a reading of the lowest height resulting in penetration of the specimen.

Discussion:

The results of this test (see Figure 2) indicate that Type D is more resistant to impact (18.2 inch-lbs after 16 hours immersion) than the other four. Materials A, B, C and E are very similar in this property, having a resistance of 14.2, 13.7, 12.3 and 14.2 inch-lbs., respectively, after 16 hours water immersion. Variations of the property with time and conditions of water treatment are not easily detectable. The reproducibility of the test results is acceptable but the sensitivity is apparently very poor because it rates all materials alike.

Conclusions:

(1) The test does not have the sensitivity required for control testing.

(2) Correlation with firing is not good.

(3) There is no correlation with water exposure.

PUNCTURE RESISTANCE

Object:

To determine the relationship of firing to puncture resistance.

Procedure:

Increasing amounts of weight were added to a vertical penetrator until the specimen was punctured.

Discussion:

With the exception of Type C, the weight required for puncture increased after six hours water immersion. The values obtained after twenty-four hours immersion were all lower than for the specimens immersed for six hours. Higher values were obtained for Types D and E at all levels of water treatment than for the others (see Tables III, IV and V for results). Acceptable reproducibility and poor sensitivity were features of this test.

Conclusions:

(1) Test is not sensitive enough for control testing.

(2) Some correlation with firing exists among types but there is little correlation between wet and dry samples.

THICKNESS

Object:

To correlate thickness with firing data.

Procedure:

Thickness was measured with a Federal Thickness Gauge.

Discussion:

The average thicknesses varied as follows among the types: A = 0.113", B = 0.107", C = 0.110", D = 0.120" and E = 0.114". Minor variations in thickness within samples were found.

Conclusions:

(1) No direct correlation exists between thickness and firing.

(2) The material shows some variation in thickness within and between samples.

(3) The thickness in conjunction with other tests is possibly useful in firing data correlation.

PERMANENT DEFLECTION

Object:

To determine relationship between permanent deflection and firing data.

Procedure:

Increasing weight was added to the end of a 4" x 12" specimen, which had been immersed in water for 24 hours, until the elastic limit was exceeded. The specimen was held with a device in such a way that bending occurred at a point 3" from the weight attachment.

Discussion:

The average results in inch-pounds of each type of material follows: A = 4.2, B = 2.5, C = 2.5, D = 3.7 and E = 4.6. The test is quite crude and the sensitivity, as a result, is very poor. Reproducibility of the values among samples was within 0.3 of the mean.

Conclusions:

(1) Some correlation exists with the firing data.

(2) Procedure is not sensitive enough for control testing.

FLEXURAL RESISTANCE

Object:

To determine the relationship between flexural resistance and firing data.

Procedure:

The amount of pressure required to fold a dry paperboard specimen of two inch width around a one-quarter inch rod was measured on the Thwing Albert Tensile Tester.

Discussion:

Very limited data was obtained using this procedure. The average results for the five materials in descending order are: D, E, A, C and B (see Table III).

Conclusions:

(1) The data is too limited to make valid conclusions regarding the relationship to the firing data.

(2) With certain modifications, the procedure is promising as a means of obtaining the modulus of elasticity of the material.

DENSITY

Object:

To determine the relationship of density to the firing data.

Procedure:

Samples of measured volume were accurately weighed and the density calculated.

Discussion:

Type C, which is a wax impregnated material, was higher in density than the other four. These four, however, were very nearly equivalent in density (see Table III).

Conclusions:

(1) The additives to the various types of target materials make correlation of density with firing data difficult.

(2) Variations among types is generally not sufficient for control testing.

MODULUS OF ELASTICITY

Object:

To determine the relationship of firing to the modulus of elasticity of the targetboards.

Procedure:

The deflection resulting from known or measured weight additions to specimens of standard width and length was determined. This data, along with accurately determined thickness, was used to calculate modulus of elasticity.

Discussion:

Rather limited data has been obtained on this test but it appears to have value in the characterization of material. The data obtained using Method A were erratic (see Tables III and IV) but sufficient correlation with the firing data was found to support the purchase of the Tinius Olsen Stiffness Tester for more precise measurements. The data obtained using this equipment, Method B, (see Table V) correlate reasonably well with firing except for Sample B. The high percentage of kills reported for Sample B after 24 hours immersion is probably not representative of the material, as data obtained under less rigorous conditions indicate it to be a much poorer material (see Table II).

The lower results of M.E. obtained on the target material after 24 hours by Method B are due more to the sample size than the extended water treatment.

Conclusions:

(1) The modulus of elasticity is not, alone, capable of defining material as to firing characteristics.

(2) It is of possible value in describing target materials when used in conjunction with other properties, such as density, water absorption, thickness, etc.

GENERAL

Discussion:

In the attempt to find a substitute for the firing test, it was established that the puncture type tests were of little value. It is believed that the resistance to puncture is sufficient in all of the materials tested. The quality not present is the ability to transmit sufficient vibration from the point of impact to the kill switches. A test capable of measuring the vibration transmission properties is a possible solution.

Water absorption characteristics, density and thickness, while not being direct measures of the firing capabilities, are surely related. In conjunction with other tests, a relationship to firing should exist.

The tests performed, which in some way are measurements of stiffness, are the most promising. Two of these tests (flexural resistance and permanent deflection) take measurements beyond the elastic limit of the material. This is not expected to give valid correlations, as the elastic limit is not exceeded in the firing test. The test for modulus of elasticity is within the elastic limit, however.

The modulus of elasticity is a measurement of the material rather than the product. Since a one mil sheet of target material with a very high M.E. would not be expected to pass the firing test, it follows that the thicker the material, the more apt it is to pass the test. Modulus of elasticity, then, must be considered in conjunction with other tests before correlation with firing can be expected.

Conclusions:

It is believed that a targetboard made of material possessing a high modulus of elasticity, with the highest allowable thickness, and incorporating an effective weatherproofing agent, will meet the requirements for field service. Until it has been established conclusively, however, through future testing, that such Laboratory tests adequately define acceptable material, the firing test must be used as the final criterion for target procurement.

B. Development of Material:

ORIGINAL CHIPBOARD

In the original use of the M31A1 target mechanism, an untreated chipboard material was used for the target. This material was found to be reasonably efficient in operating the mechanism as long as the material was perfectly dry. It was impossible to maintain the targets in a dry condition, however, as each target was fired at a large number of times (see Figure 4) over a period of several days. When the target was subject to moisture, it was found to have so little resistance to the impact of the bullet that it would not trigger the mechanism. In many cases of rather severe moisture conditions, the target would not even stand up in the mechanism (see Figure 5).

WOOD, FIBERGLASS, ETC.

Since the chipboard targets were not satisfactory, targets fabricated from various types of material were used experimentaly in the mechanism. These materials, including fiberglass, plastic, wood and metal, were found to be either ineffective or excessively expensive.

TARGET AS RECEIVED FROM FT. JACKSON, S. C.

Neg. No. 4380
63-2879

FIGURE 4

COMPARISON OF ORIGINAL CHIPBOARD AND UPGRADED
WEATHER RESISTANT TARGET BOARD

FIGURE 5

Neg. No. 4396
63-2879

TREATED CHIPBOARD

After the unsuccessful evaluation of the more rigid types of material, it was decided to upgrade the original chipboard by incorporating various weatherproofing agents. A number of treated samples were submitted for evaluation. No specific program for evaluation was in effect at this time, and as a result, the recorded data on these targets is very limited. These samples included plastic coated and wax impregnated materials. Certain of these samples appeared to be satisfactory, and as a result, the first Invitation for Bids was issued to all interested suppliers.

IFB-11-199-62-185

Nine materials were obtained for testing according to this IFB. The major requirement of this IFB was 100% kills in the firing test after 24 hours immersion in water. One material (a-6) almost met the requirements (see Table VI) but none of the others were close.

IFB-11-199-63-43

Since the requirements of the first IFB were not met, it was decided to lower the requirements by allowing three of seventy-five shots to be "no-kills" and thus, be able to procure the best available targets for military use while development of acceptable material continued. As a result, IFB-11-199-63-43 was issued. Three materials were obtained for this evaluation including one (b-2) from the supplier of a-6. Unfortunately none of these materials met these reduced requirements (see Table VII).

TEST EVALUATION MATERIALS

Targetboards from five suppliers were then obtained for test evaluation to obtain information on the properties of materials required for meeting the firing test qualifications. The information gathered from this evaluation (see Section A of this report) was discussed with various fiberboard manufacturers, resulting in company sponsored programs for improving the target materials. Certain materials were then obtained having improved properties.

IFB-11-199-63-231

Since the military was still in need of targets, a third IFB was issued (see Table VIII) with further reduced requirements. Three "no-kills" in seventy-five shots were allowed after only six hours of water immersion.

Evaluation of these materials resulted in two satisfactory targetboards (c-4 and c-9) and one other (c-8) which failed only the adhesion test. As a result of these tests the manufacturer of c-4 was awarded a contract to supply the training depots with fiberboard targets.

RECENTLY DEVELOPMED MATERIAL

The development of upgraded material continued, however, with the goal in mind to provide targets which would be 100% effective after 24 hours of submersion in water. Some material was received which was little better than the original (see Table IX) but four targetboards (F, H, I, and M) were received which met these rigid requirements.

PREPARATION OF SPECIFICATION

Since targetboard material is now available which will meet the military requirements for field service, it is in order to prepare a specification containing the necessary qualifications and providing for the procurement of satisfactory material.

As can be seen from the results (Table V and IX), no material passes the firing requirements whose modulus of elasticity when wet is below 13,000 $\#/in^2$ or whose water absorption is above 13.5%. The specification should include these requirements. Certain materials (G and L) having these characteristics fail to meet the firing requirements, however, and as a result, the firing test is still needed for complete characterization of the targetboards.

In the material now used (c-4) a problem of colorfastness to light has arisen. A requirement for this property should also be included in the specification per Addendum #3.

COMPOSITION OF ACCEPTABLE MATERIAL

A fiberboard target material that has been found acceptable for field service includes a high percentage of long virgin kraft fibers in combination with a lesser amount of jute (reclaim) fibers and having a high resin wet strength treatment. In the preparation of such a target, the laminating adhesive must be highly water resistant and a water repellant coating, such as polyethylene or polyvinylidene chloride film must be applied to both surfaces of the board to prevent water penetration.

It should be noted that in forming the fibers on a cylinder machine, extreme care should be taken to insure that the fibers be tightly oriented to form a very dense structure.

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ADDENDUM #1

SUPPLEMENTARY QUALITY ASSURANCE PROVISIONS FOR: Target, Kneeling	SQAP 8426438 SHEET 1 of 4 DWG NO. C8426438 ORDNANCE CORPS DEPT OF THE ARMY ROCK ISLAND ARSENAL

1. Refer to SQAP-APPENDIX-RIA for General Provisions. Paragraphs 2, 3.1 and 3.4.4 of SQAP-APPENDIX-RIA are not applicable.

2. Preliminary inspection. Prior to actual production the contractor, under Government surveillance, shall subject three (3) sample targets to all inspection requirements herein. Failure of any target of the sample to pass this inspection shall delay initiation of acceptance inspection until corrective action by the contractor has been verified. The Government representative will select and approve a sample target from the initial lot which will be used when "visual" is specified as a method of inspection in the classification of defects herein.

3. Examination.

3.1 Sampling. Unless otherwise specified, sampling for examination of targets shall be in accordance with inspection level L4 of MIL-STD-105. One target shall be considered as one sample. Not more than one target shall be selected from a unit pack in developing sample size.

3.2 Target examination. Each sample target shall be examined for all the characteristics listed in the classification of defects of 3.2.1.

3.2.1 Classification of defects.

Defect	Inspection Method
CRITICAL	None defined
MAJOR	None defined
MINOR	AQL=4.0% defective
51. Nonconformance to contour dimensions	Visual
52. Nonconformance to thickness requirements	Measure

REV SYM	REVISION DATE SQAP	REVISION DATE DWG	REV SYM	REVISION DATE SQAP	REVISION DATE DWG	SUBMITTED / APPROVED
ORIG	5 Jan 61	17 May 61				SUBMITTED O. Kendall ORD CORPS
A	2 Oct 61					APPROVED Harold A. Carlson ORD CORPS

SUPPLEMENTARY QUALITY ASSURANCE PROVISIONS	SQAP	8426438
FOR: Target, Kneeling		SHEET 2 of 4
	DWG NO. C8426438	
	ORDNANCE CORPS DEPT OF THE ARMY ROCK ISLAND ARSENAL	

53.	Nonconformance to machine direction (grain) requirements	Visual
54.	Nonconformance to color requirement	Visual
55.	Nonconformance to weight requirement	Measure
56.	Rough or broken edges	Visual
57.	Delaminated or warped areas	Visual
58.	Mutilated areas	Visual

4. Inspection testing.

4.1 Piercing Test for Material Displacement. Two targets shall be selected at random from each 10,000 targets produced and tested for compliance with the material displacement requirements. The targets shall be aged for 1 hour at 0°F after which and at 0°F two holes shall be pierced in each target. The targets shall then be aged for 1 hour at 125°F after which and at 125°F two holes shall be pierced in each target. The rod used for piercing and the piercing load shall conform to the target drawing requirements.

4.2 Bending Test. The two targets used in the piercing test shall be tested for compliance with the drawing requirement of target being bent and clamped at bottom edge on a 12-inch radius. The targets shall be aged for 1 hour at 0°F after which and at 0°F the bottom edge of the target shall be bent and clamped on a 12-inch radius bar.

4.3 Adherence Test. The two targets used in the piercing and bending tests shall be tested for compliance with the drawing requirement for non-adherence. A sample piece, 4 inches square, shall be cut from an unmutilated portion of each target. The 2 pieces shall be aged for 1 hour at 150°F after which and at 150°F the 2 pieces shall be pressed together and subjected to a load of 2 lbs per square inch for 2 hours at 150°F. The two pieces, under load, shall then be cooled to 70°F ± 10°.

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FOR: Target, Kneeling		SHEET 3 of 4
	DWG NO. C8426438	
	ORDNANCE CORPS DEPT OF THE ARMY ROCK ISLAND ARSENAL	

4.4 Water Absorbtion and Permanent Deflection Test. One (1) target, selected at random from each 10,000 targets produced, shall be tested for drawing requirements of water absorbtion and permanent deflection. A test piece 4 inches by 12 inches shall be taken from the center of the target and pierced as specified on the target drawing and then weighed. The test piece shall then be submerged in water at 70°F ± 10°for 24 hours after which it shall be removed from the water and weighed. The test piece shall then be clamped at one end and subjected to a bending load of 3 inch pounds per inch of width.

4.5 Material Characteristics after Submersion. One (1) target shall be selected at random from each 10,000 targets produced and tested by Rock Island Arsenal for compliance with the drawing requirement of characteristics after submersion. The target shall be submerged in water at 70°F ± 10° for 24 hours after which the target shall then be assembled to a M31 or M31A1 Target Holding Mechanism and subjected to the following tests.

4.5.1 Firing Test. The target shall transmit the vibration necessary to actuate the switch to indicate a hit when penetrated by a Cal. .30 projectile. Firing at the target shall be performed at a range of 25 to 30 yards using ten rounds of cartridge ball Cal. .30 M2 ammunition. The shot pattern shall be dispersed in the upper 12 inches of the target.

4.5.2 Cycling Test. Upon completion of the firing test, the target shall be cycled 1000 times. A complete downward and upward movement of the target shall be counted as 1 cycle. Target shall not bend or whip to operate the vibration sensitive switch during the up cycle.

4.6 Failure of any sample target to pass all of the tests designated above shall be cause for rejection of the 10,000 targets which the sample(s) represents.

4.7 Material (pasteboard). For each inspection lot the contractor shall provide the Government representative with a certified

REV SYM	REVISION DATE SQAP	REVISION DATE DWG	REV SYM	REVISION DATE SQAP	REVISION DATE DWG	
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SUPPLEMENTARY QUALITY ASSURANCE PROVISIONS FOR: Target, Kneeling	SQAP 8426438 SHEET 4 of 4 DWG NO. C8426438 ORDNANCE CORPS DEPT OF THE ARMY ROCK ISLAND ARSENAL

Statement of compliance with MIL-P-13521

5. With the exception of the inspection equipment required for the firing and cycling tests (4.5.1 and 4.5.2), inspection equipment required for examination and testing shall be furnished by the contractor and approved by the Government.

6. Applicable Documents:

C8426438	Target, Kneeling
IEL-8426438	Acceptance Inspection Equipment List
MIL-I-45607	Inspection Equipment, Supply and Maintenance for Ordnance
MIL-P-14232	Parts, Equipment and Tools for Ordnance Materiel, Packaging of
MIL-P-13521	Pasteboard for Targets
MIL-STD-105	Sampling Procedures and Tables for Inspection by Attributes
SQAP-APPENDIX-RIA	General Supplementary Quality Assurance Provisions

REV SYM	REVISION DATE SQAP	REVISION DATE DWG	REV SYM	REVISION DATE SQAP	REVISION DATE DWG	
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U. S. ARMY
ORDNANCE CORPS

SQAP-APPENDIX-RIA
Approved: 3 Apr 61

GENERAL SUPPLEMENTARY QUALITY ASSURANCE PROVISIONS
FOR

ARTILLERY, ROCKET LAUNCHERS AND RELATED MATERIEL

1. General Quality Assurance Provisions.

1.1 Scope. The quality assurance provisions contained herein, together with those contained in the Supplementary Quality Assurance Provisions (SQAP) and applicable documents, cover the minimum Government prescribed inspection necessary to assure compliance with established requirements.

1.2 Contractor Inspection. Unless otherwise specified, the contractor is responsible for the performance of all inspection requirements specified herein. Except as otherwise specified, the contractor may utilize his own or any other inspection facilities and services acceptable to the Government. Inspection records of the examinations and tests shall be kept complete and be available to the Government upon request.

1.3 Contractor Inspection System. Prior to initiation of production, the contractor shall submit, to the contracting officer, a written description of his inspection system covering the supplies under the contract. The written description will be considered acceptable when it provides the quality assurance required by the applicable contractual documents and assures control of all drawing requirements.

1.4 Government Verification. All quality assurance operations performed by the contractor shall be subject to Government verification at unscheduled intervals. Verification will consist of (a) surveillance of the operations to determine that practices, methods and procedures of the contractor's written inspection plan are being properly applied and (b) Government product inspection to measure quality of product offered for acceptance.

2. Preliminary Detail Inspection. Prior to initiating inspection for acceptance on a sampling basis, the Government inspector will inspect three (3) completed items, selected at random from the items submitted by the contractor. This detail inspection shall determine compliance with all established drawing requirements, including those not covered by examination and testing in the applicable SQAP. Failure of any item to pass this inspection, shall delay acceptance until corrective action to all items submitted has been assured and verified by additional sampling.

SQAP-APPENDIX-RIA

3. Inspection Provisions.

3.1 Examination. Examination for the defects listed in the classification of defects of the SQAP for the item being procured shall be performed utilizing single sampling, inspection level II and procedures of MIL-STD-105.

3.1.1 Notes Governing Examination.

a. The acceptable quality levels (AQL's) apply to the group and not to each listed defect.

b. Where "visual" is specified as the method of dimensional inspection, the sample should be either scaled or compared with a specimen of known acceptable quality.

c. Where "visual" is specified as the method of inspection for protective coating, the sample should be compared with a specimen of known acceptable quality.

d. Where "visual-measure" is specified as the method of inspection for surface roughness (AA) a surface roughness scale, comparison standard, conforming to MIL-STD-639 shall be used. If determination of surface roughness by a visual standard is questionable, a surface roughness measuring instrument shall be used.

e. Where "measure" is specified as the method of inspection, the contractor may use standard or special inspection equipment which has been approved by the Government.

f. Inspection for "workmanship" shall include examination for missing operations and the presence of nicks, burrs, cracks, scratches, tool marks, deformations, or other signs of poor workmanship on important areas. Items shall be compared with a specimen of known acceptable quality.

g. Dimensions are given only as a guide in locating surfaces specified. Refer to latest revision of drawing included in the contract for the acceptable dimension.

3.2 Packaging Inspection. Inspection to determine compliance with cleaning, preservation, packaging, packing and marking requirements shall be as specified in MIL-P-14232 for the level designated.

3.3 Certification. Certification required shall be as specified in the SQAP for the item being procured.

3.4 Inspection Equipment

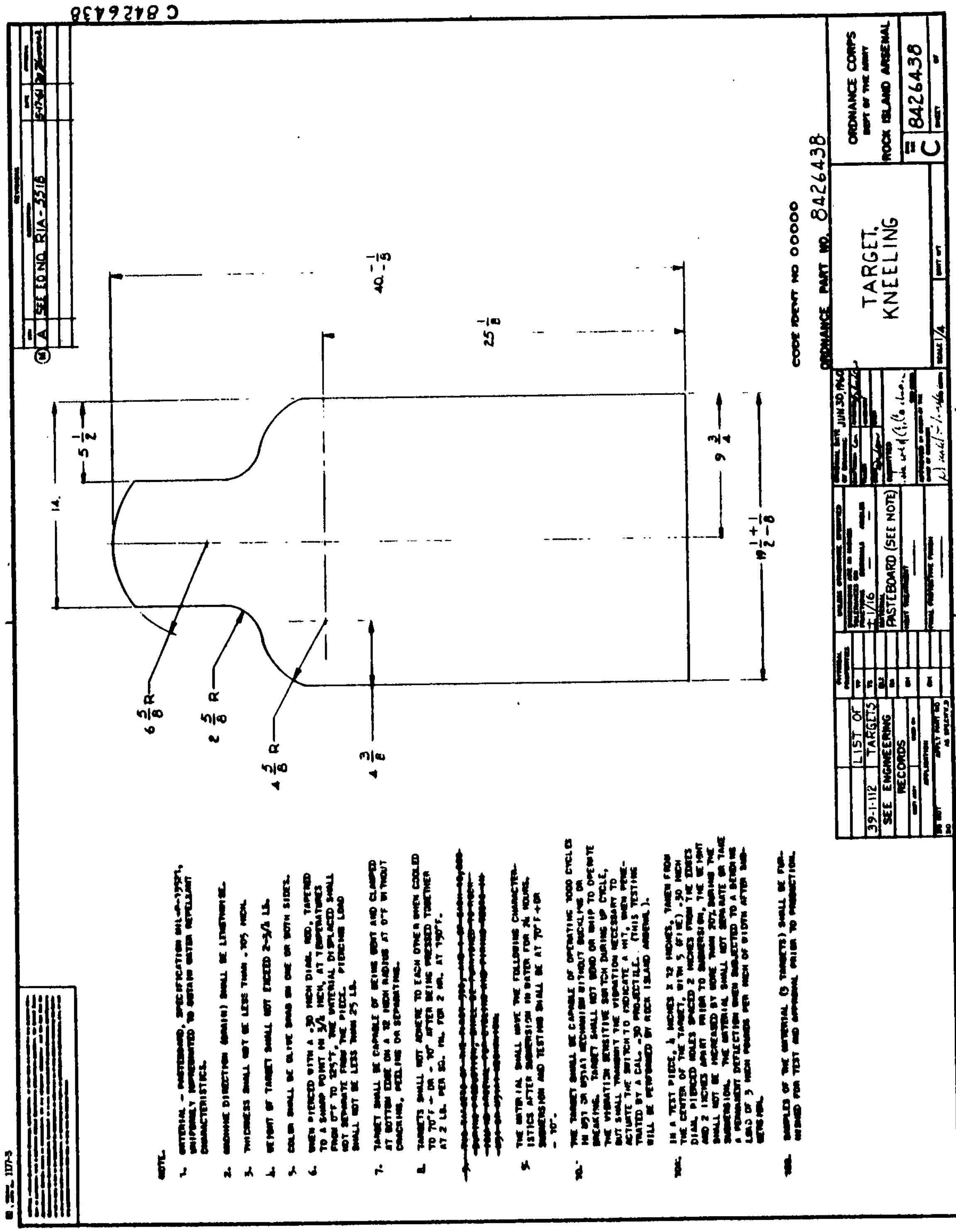
3.4.1 Unless otherwise specified, responsibility for acquisition, maintenance and disposition of acceptance inspection equipment prescribed on the applicable acceptance inspection equipment list (when designated in SQAP), shall be in accordance with Specification MIL-I-45607.

3.4.2 Use of contractor's or Government furnished inspection equipment, when desired by the Government representative, shall be permitted without charge.

3.4.3 The Government representative shall determine that the contractor has available and utilizes correctly, gaging, measuring and test equipment of required accuracy and precision and that the instruments are of proper type and range to make measurements of the required accuracy. The contractor shall have available a set of master gages, standards and appropriate instruments for regularly scheduled calibration of his inspection equipment. Records of such calibration shall be maintained by the contractor and made available for review by the Government.

3.4.4 When inspection equipment is specified in the SQAP under "Inspection Method" and an equipment design is listed for the characteristic on the Inspection Equipment List, the design shall serve as a standard for determining the adequacy of the contractor's inspection equipment for that characteristic. When inspection equipment is specified and no equipment design is listed for the characteristic, the contractor may use standard or special inspection equipment approved by the Government.

ADDENDUM #2


C 8426438
SEE EO NO. RIA-5518
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5 1/2
6 5/8 R
2 5/8 R
4 5/8 R
4 3/8
25 1/8
40 - 1/8
9 3/4
19 1/2 + 1/8
CODE IDENT NO 00000
ORDNANCE PART NO. 8426438
TARGET, KNEELING
ORDNANCE CORPS
ROCK ISLAND ARSENAL
C
8426438
PASTEBOARD (SEE NOTE)
LIST OF TARGETS
39-1-112
SEE ENGINEERING RECORDS
JUN 30, 1961

ADDENDUM #3

DD FORM 1749 1 AUG 54 REPORTS CONTROL SYMBOL ORDFX-100	ORDNANCE CORPS ORDNANCE TECHNICAL REPORT	DATE 10 June 1963

TO: Commanding General
U. S. Army Weapons Command
ATTN: AMSWE-SMM/Mr Fegley

ADDRESS: Rock Island Arsenal
Rock Island, Illinois

SUBJECT (One subject per report):

Target E Kneeling FSN 6920-795-1806

DETAILS (Include all pertinent data such as part numbers where applicable)

1. Subject target, manufacturers lot number 1465, manufactured by Fiberboard Paper Products Corporation, San Francisco, California, fades when exposed to sunlight. The front or green side changes to about the same color as the rear side of the target after approximately two days of exposure to sunlight.

2. Fading of the green side causes loss of camouflage effect on Trainfire Record Ranges. This is detrimental to the training of troops as the target is much easier to see and target detection training is adversely affected.

3. The color of new targets is not as dark a green as is desired by the Trainfire Committee OIC. I am forwarding under separate cover a target with a green front of the shade desired and also which does not fade.

4. The durability of the new targets has been highly satisfactory in the rain as well as in fair weather. The targets have been in use since 21 May 1963. Records are being maintained on all ranges to obtain usage and durability information.

5. It is not desired that any corrective action be taken which would cause a shortage of targets as the targets can and will be used in their present condition. However, it is suggested that proper color and non-fade characteristics be included in future specifications.

6. I am forwarding under separate cover four new targets, two used targets which show how they fade and one green target referred to in paragraph 3.

FROM (Signature, Name, and Position)

JAMIE W. STONE
USAWCMT

ADDRESS

Field Maintenance Section
Fort Jackson, South Carolina

63-2879

U. S. ARMY
ROCK ISLAND ARSENAL
ROCK ISLAND, ILLINOIS

IN REPLY REFER TO:
SWERI-RDL-9320:Saunders 19 June 1963

SUBJECT: Target Board

TO: Commanding General
U. S. Army Weapons Command
ATTN: AMSWE-PPR(J. Linnberg)
Rock Island Arsenal
Rock Island, Illinois

The Laboratory of Rock Island Arsenal recommends that all future IFB documents, concerning the procurement of types "E" and "F" target board, include the following additional requirements:

Color: Unless otherwise specified in the contract or order, the color of the front side of both "E" Kneeling and "F" Prone target board shall correspond reasonably in shade to color chip number 34079 of Federal Standard Number 595.

Note: Color chips of color number 34079 per Federal Standard may be obtained from:

Business Service Center
Region 3
Seventh and D Streets, S. W.
Washington 25, D. C.

Colorfastness to Light: The color side of both "E" and "F" target board shall show a "Good" rating as interpreted and described in Method 5662, paragraph 4.10.2 of Federal Specification CCC-T-191b after exposure for a minimum of 20 hours in a Fade-Ometer as described in Method 5660 of Federal Specification CCC-T-191b.

Note: Method 5660 describes a method intended for determining the colorfastness of cloth to light. For the purpose of a colorfastness requirement for target board, the use of the word "cloth" in Method 5660 shall be deleted and the words "fiberboard targets" shall be used.

FOR THE COMMANDER:

A. C. HANSON
Laboratory Director

Copies furnished:
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AMSWE-SMM(Fegley)
AMSWE-QAA(Potthoff)

63-2879

AD   Accession No.

Rock Island Arsenal Laboratory, Rock Island, Illinois

THE DEVELOPMENT OF FIBERBOARD TARGETS FOR THE M31A1 TRAINFIRE MECHANISM, by A. C. Saunders, L. W. Lynch and W. F. Garland

RIA Lab. Rep. 63-2879, 5 Sep 63, 49 p. incl. illus. tables, (DA Project No. 1-A-0-13001-A-039, AMC Code No. 5016.11.844) Unclassified report.

The Military has a need for targetboards for use with the M31A1 Trainfire Mechanism. In the past, targets made of untreated chipboard, fiberglass, wood, etc., have been unsuccessfully used. A program with the dual purpose of (1) providing an acceptable target for field service and (2) developing test procedures to describe adequately such material, was initiated.

It has been ascertained, through developmental work in conjunction with various manufacturers, that fiberboard targets can be made which will adequately fill the field service requirements. One such material was composed of a large percentage of long virgin sulfate fibers in combination with a smaller amount of jute fibers and

(continued)   over

UNCLASSIFIED

1. Targets
2. Paper Materials

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THE DEVELOPMENT OF FIBERBOARD TARGETS FOR THE M31A1 TRAINFIRE MECHANISM, by A. C. Saunders, L. W. Lynch and W. F. Garland

RIA Lab. Rep. 63-2879, 5 Sep 63, 49 p. incl. illus. tables, (DA Project No. 1-A-0-13001-A-039, AMC Code No. 5016.11.844) Unclassified report.

The Military has a need for targetboards for use with the M31A1 Trainfire Mechanism. In the past, targets made of untreated chipboard, fiberglass, wood, etc., have been unsuccessfully used. A program with the dual purpose of (1) providing an acceptable target for field service and (2) developing test procedures to describe adequately such material, was initiated.

It has been ascertained, through developmental work in conjunction with various manufacturers, that fiberboard targets can be made which will adequately fill the field service requirements. One such material was composed of a large percentage of long virgin sulfate fibers in combination with a smaller amount of jute fibers and

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Properties, important in the determination of firing effectiveness, were found to be thickness, density, water absorption and modulus of elasticity, but the final criterion for evaluation must be the firing test.

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