CONFIDENTIAL

~~SECRET~~

Copy No. 2 of 5 Copies

CONFIDENTIAL

ED28 #2

ENGINEERING TEST REPORT

for the

ED28

LEAFLET BOMB

QK-15-561.1

C-59430

50X1

30 June, 1955

CONFIDENTIAL ~~SECRET~~

I. INTRODUCTION

A. Purpose and Scope of The Program

The Engineering Test Program for the Leaflet Bomb was designed to provide information regarding the operational reliability of the Bomb after it had been subjected to a wide range of simulated storage and operational environments. At the time that the Program was initiated, the Client stated that the field service record of these devices was considered marginal; as a result, special emphasis was to be placed by the Program agenda on the determination of what conditions or combination of conditions would induce failure.

As with the testing programs conducted for other devices, the results obtained from this investigation must be interpreted on a broad basis. Supporting information, from whatever source available, should be sought and considered before any final and detailed conclusions are drawn.

B. Authorization

The Engineering Test Program for the Leaflet Bomb was authorized by and conducted under Work Order QK-15-561.1. A total of three thousand four hundred forty five dollars ($3,445) was authorized by this Work Order to implement the task. Work on the test program began simultaneously with the receipt of a letter of authorization from the Client dated February 11, 1955 and designated EKW-M-36.

TABLE OF CONTENTS

II. SUMMARY AND RECOMMENDATIONS

A. Summary

While the Leaflet Bomb is capable of highly reliable performance in its "as manufactured" condition, it appears subject to two (2) distinct and serious types of storage failure. The first failure lies in the fact that the Bomb cannot survive moderately high storage temperatures for even short periods of time. The second failure lies in the fact that it cannot resist high moisture or water-wetting conditions. Both of these failures are caused by material characteristics of the Bomb components.

The failure to survive moderately high storage temperatures is caused by the fact that, at temperatures of approximately 140°F and above, the bitumen waterproofing wrapper of the black powder time fuze softens and flows. The bitumen then wets and totally desensitizes the fuze powder in both initiating and projectile time delay fuzes.

The low resistance to water and water-vapor is the result of the highly hygroscopic nature of black powder. While the waterproofed time fuze does not suffer from this source of difficulty, the unprotected quickmatch train, propellant charge and projectile burster charge all quickly accumulate moisture when unprotected by the unit-package foil wrapper. Water accumulation in these areas soon causes complete failure of the Bomb.

The combination of these two types of failure acts to limit quite seriously the maximum conditions under which the Leaflet Bomb can be satisfactorily stored for even short periods of time. It is a matter of concern, we feel, that not only the Leaflet Bomb but also those other devices using black powder time trains and charges cannot withstand even the minimum acceptable temperature limit requirements for storage.

B. Recommendations

Based on the results obtained from the Engineering Test Program for the Leaflet Bomb, but without benefit from other sources of information, we recommend that the following minimum steps be initiated to govern its storage and usage:

1) An upper temperature limit of 125°F should be imposed on both the short-and long-term storage conditions for the Leaflet Bomb. No lower temperature limit is required.

2) Extreme care should be recommended to central and field storage points for the protection of the Leaflet Bomb gross- and unit-packages against high humidity and water-wetting conditions.

3) All Leaflet Bombs known to have been stored at temperatures exceeding 125°F or to have been removed from their unit-package or to have been water-wetted in their unit-package should be removed from stock and destroyed.

4) Field personnel should be advised to provide protection for the Leaflet Bomb against water-wetting while it is in position and awaiting firing. Use of the unit-package barrier material as a shelter for the Bomb and a light muzzle-cover for the tube is suggested.

5) The similarity of storage limitations between the Leaflet Bomb and the Thermit Well Incendiary device should be recognized and, if possible, advantage should be taken of their mutual storage requirements.

Based not only on the results of this Engineering Test Program, but also on our general experience in the design of devices for the Client, we also recommend the following as points for long-range consideration in the design of future leaflet-distributing devices:

6) The specification of black powder propellant and burster charges should be discontinued for all devices which are by their nature required to withstand exposure to moisture. While the use of vapor-barrier unit-packaging materials has proven useful in the protection of these devices, the potentially high failure rate caused by the hygroscopic nature of black powder strongly suggests that this cause should be eliminated at its source. The serious consideration of nitrocellulose-base propellants is recommended.

7) The specification of black powder time fuze having a bitumen waterproofing wrapper should be discontinued for all devices which are by their nature required to withstand storage temperatures in excess of 125°F for even short accumulative periods of time (in excess of 12 total hours). While we cannot readily suggest any comparable flame-initiated time fuze as a direct alternative, we recommend that the use of percussion primers for propellants and pressed incendiary time delay pellets for burster ignition be seriously considered.

III. TEST PROGRAM AND TESTING PROCEDURES

A. Test Program

The final test agenda formulated for the Leaflet Bomb was a combination of the efforts of both the Client and [redacted] and is given in its entirety in Appendix A of this report. A brief outline of the agenda is given here, however, to form a general background for the evaluation of results cited later in this report. 50X1

1) Test A: Original Sample Performance Test:

Test of fifteen (15) units in the "as received" condition to establish "normal" sample performance.

2) Test I: Accelerated Aging Test (160°F, 90% RH, for 2 weeks)

3) Test II: Cycling Test: 4 hrs. @ 125°F, 90% RH; 2 hrs. @ 80°F, 90% RH; 2 hrs. @ -10°F; 16 hrs. @ 40°F, 22% RH; total of four 24-hr. cycles.

4) Test III: Safe Storage Test: a) 160°F, 22% RH for 24 hrs., test at room temperature. b) -60°F for 24 hrs., test at room temperature.

5) Test IV: Operating Temperature Limits Test: a) 120°F, 22% RH for 24 hrs. b) -40°F for 24 hrs.

6) Test V: Safe Transport Test: 4 hrs. @ 40,000 ft. altitude, room temperature.

7) Test VI: Vibration Test: Vibrate from 25 to 60 cps, 5 cps increments, 15 min. each.

8) Test VII: Salt Fog Test: Eliminated from this Program.

9) Test VIII: Rough Handling: Multiple drops from 6' height to solid surface.

10) Test IX: Plunge Test: Eliminated from this Program.

11) Test X: Impact Test: " " " "

12) Test XI: Water Submergence: Eliminated from this Program.

B. Testing Procedures

1) Environmental Conditioning

The conditioning of the Leaflet Bombs during the various phases of this program was for the most part the same as that normally used for this type of work in other cases, and, as a result, is not repeated here. The few exceptions to this normal procedure are noted in the applicable sections of the test program agenda, as presented in Appendix A.

2) Moisture Determination

(a) Instrumentation: Moisture Detector, Model RC-1, Serial 2187, Delmhorst Instrument Co., Boonton, New Jersey.

(b) Procedure: Moisture measurements were made at three (3) locations, approximately 120° apart, at stations at the top, middle and bottom of both the mortar tube and projectile body. The moisture measurements made by the instrument are a function of electrical conductivity between two fixed pins driven into the material to be tested. The results reported are the average of all stations.

Moisture content of the propellant and burster charges was determined by the weight loss of weighed samples after 72 hours' dessication. All moisture determinations were made immediately after the removal of the unit package wrapper.

3) Field Operation of Bombs

The Leaflet Bombs tested were normally ignited by means of the black powder initiating fuze provided. In cases where the fuze was desensitized as the result of bitumen-wetting, it was clipped off and the initiating quick-match fuze was ignited directly.

In those cases where the internal projectile time fuze failed to function, the projectile was later disassembled and the burster charge ignited to determine its condition. If satisfactory ignition were obtained in these cases, the burster charge was marked as "OK" in the following tabulations.

Immediately prior to their test-firing, all bomb cannisters were filled with 14 ounces of dry sand and paper. The sand provided a simple method of obtaining the maximum weight loading allowed by the specifications; the paper provided an easily visual check on the air burst point of the projectile.

4) Field Observations

The height of projectile burst was measured by triangulation, using a transit to sight the burst point over a 200 foot base line. Accuracy of this method is believed to be within plus or minus five (5) feet. The estimation of the maximum height attained by a Leaflet Bomb projectile was made by adding a correction to the observed burst height. This correction, in feet, approximated the drop of the projectile from its apex of trajectory to its burst point. The accuracy of these corrections is, of course, open to question since they were based on non-instrumented estimates; we believe, however, that they were accurate to within plus or minus ten (10) feet.

Where no projectile burst was obtained, the height observed with the transit is the maximum trajectory height achieved.

IV. DESCRIPTION OF LEAFLET BOMBS TESTED

The Leaflet Bombs tested were standard service items received directly from a stock which had been stored in igloos for an estimated two-year period. These items were manufactured by the [redacted] 50X1

[redacted]; the date of manufacture was not shown on the gross 50X1 packages, although it was believed to be during early 1953.

The storage conditions of the Leaflet Bombs, prior to their receipt at the Reservation and assignment to permanent storage in igloos was again unknown. The satisfactory test results obtained from the "as received" bombs indicated, however, that these initial storage conditions could not have been extreme. Subsequent storage conditions in the igloos is somewhat better known, although the time-cycle factors involved are wholly open to conjecture. It is estimated that the temperatures involved under these conditions were:

Maximum igloo temperature	:	80°F
Minimum " "	:	32°F
Maximum " humidity	:	90% R.H.
Minimum " "	:	50% R.H.

The transportation factor involved in the original "as-received" sample of Leaflet Bombs was also unknown, although it cannot have been adverse. It was known, however, that only rail and truck transport were involved.

V. RESULTS

A. Test A: Original Sample Performance Test (Test Firing "as received")

1) Physical Inspection:

A total of 20 samples were inspected at the start of this test, fifteen (15) for firing tests and five (5) for disassembly and internal inspection. No variation from the original drawings and specifications was observed.

Although there was no section in the specifications specifically pointing out the possible area for inspection, there did appear, however, two (2) cases in which the leaflet cannister was held tightly in the projectile body by a slight excess of glue used in assembly; this was not considered a serious fault, as the chamber could be removed with a small amount of effort.

2) Moisture Content:

The moisture content of the "as received" mortar tubes and projectile bodies was determined by conductivity measurements immediately after the unit-package wrappers were removed from the bombs. The propellant and burster charges were removed from five (5) samples and immediately placed under dessication for moisture determination by weight loss. These results were as follows:

TABLE I

% MOISTURE CONTENT OF ORIGINAL SAMPLE

Location of Measurement	Avg.	Max.	Min.	No. Samples
a) Mortar tube	9.6	10.2	9.1	15 samples
b) Projectile base	9.7	9.3	8.8	15 samples
c) Propellant charge	4.30	—	—	5 samples
d) Burster charge	4.39	—	—	5 samples

3) Firing Test

In the preparation of the bombs for firing, the single-faced corrugated cardboard liner, used to protect the projectile in the tube during shipment, was not removed. This error introduced a considerable increase in friction between the projectile and the mortar tube during firing; its effects should be taken into account when the firing results are considered, since it prevented many of the projectiles from reaching the expected maximum height of trajectory. It also very probably caused the relatively large number of mortar tube bursts experienced in this test.

4) Summary of Results

The results obtained in the Original Sample Performance Test are tabulated in Table II, page 11 of this report.

B. Test I: Accelerated Aging Test (160°F, 90% R.H., for 2 weeks)

1) Physical Inspection

A total of thirty seven units were used in this test; twenty-eight (28) were stripped from their unit package wrappers and were inspected immediately. No variation from the original drawings and specifications was observed.

2) Moisture Content of Bare Units

Using the same points of measurement and methods for determination, the moisture content of the bare (without unit-package wrapper) units under various conditions of test were as follows:

(a) Prior to Test ("as received")

	% Moisture Content, Avg.		
Location of Measurement	Max.	Min.	No. Samples
Mortar Tube	11.7	7.1	28 samples
Projectile Base	12.2	9.0	28 samples

SECRET

TABLE II

TABULATION OF RESULTS FOR TEST A

ORIGINAL SAMPLE PERFORMANCE TEST

Bomb Number	Pre-Firing Condition: Packaging Used In Test	Pre-Firing Condition: % Moisture Avg. Tube	Pre-Firing Condition: % Moisture Avg. Proj.	Firing Record: Component Action: Time Fuze	Quick Match	Prop Chg.	Proj. Fuze	Burst Chg.	Height, Ft.: Est. Max.	Obs. Burst	Remarks
A-1	Unit Packaged, "As Received"	9.1	9.2	OK	OK	OK	OK	OK	125	115	
A-2		10.1	9.2	"	"	"	"	"	85	75	
A-3		9.8	9.2	"	"	"	"	"	150	132	
A-4		10.0	9.4	"	"	"	"	"	-	26	Tube burst, went up with projectile.
A-5		10.2	9.4	"	"	"	"	"	153	153	Tube burst, but projectile unhampered.
A-6		9.2	9.1	"	"	"	"	"	150	132	
A-7		9.4	8.8	"	"	"	Slow	"	115	75	Tube burst; proj. burst poor.
A-8		9.5	9.7	"	"	"	"	"	150	132	
A-9		9.7	9.4	"	"	"	"	"	150	132	Tube burst, but projectile unhampered.
A-10		9.5	9.4	"	"	"	"	"	140	132	
A-11		9.5	9.5	"	"	"	"	"	-	-	Unobserved; projectile height and burst good.
A-12		9.7	9.4	"	"	"	"	"	85	79	
A-13		10.1	9.6	"	"	"	"	"	153	153	
A-14		9.5	9.0	"	"	"	"	"	110	91	Tube burst, but projectile unhampered.
A-15		9.4	8.9	"	"	"	"	"	110	118	" " " " "

Note: 1. Inner wrapper of single-faced corrugated chipboard was left in place around projectiles during this test. This error accounts for poor heights observed.

SECRET

	% Moisture Content, Avg.		
Location of Measurement	Max.	Min.	No. Samples
b) After 24 Hours in Test			
Mortar Tube	44	26	28 samples
Projectile Base	43	24	28 samples
c) After 48 Hours in Test			
Mortar Tube	55	29	25 samples
Projectile Base	70	28	25 samples

On the basis of continued total failure in firing, the test was concluded at this point.

3) Moisture Content of Unit-Packaged Units

a) After 7 days in Test			
Mortar Tube	12.5	11.8	11 samples
Projectile Base	12.6	12.1	11 samples

On the basis of significant failure in firing, the test was concluded at this point.

4) Firing Test Results

a) Bare Units

After the first period in test (24 hours' duration) none of the three (3) bare bombs withdrawn for test firing could be fired. All time fuzes were found to be totally desensitized by melted bitumen from the fuze covering. All quickmatch igniter trains were totally ruined by water-wetting; the same condition was found in the black powder propellant and projectile burster charges. In each of the above cases the black powder was soggy with water; none could be ignited by an open flame.

After 48 hours in test, the bare units were in worse physical condition than before, in that water-wetting had progressed further to render entire units soggy and without physical strength. The units could not be handled without their collapsing and tearing.

b) Unit-Packaged Units

After 24 hours in test none of the three (3) packaged Leaflet Bombs could be ignited by their original ignition time fuzes. Substitution of new fuzes in these test units allowed the ignition and satisfactory performance of the propellant charge. The projectile time fuzes, however, had suffered the same desensitization by melted bitumen and, as a result, no projectile bursts were obtained.

The moisture content of the unit packaged Bombs, however, showed no significant increase above that of the original sample range at either the 24 hour test mark or the 7-day test mark.

In view of their continued initiating and projectile fuze failures, however, the unit-packaged Bombs were removed from test at this point.

Some difficulty was experienced with the unit-packaged units which had been conditioned at 160°F for 7 days, in that the cannisters in five (5) units were glued tightly into the projectile and could not be removed.

5) Summary of Results

In view of the fact that no units subjected to this test could be fired either at all (in the case of bare units) or only by means of new fuzes (in the case of unit-packaged units) firing results do not exist in useful form and are therefore omitted

from this section. A summary appears, however, in Table IX, page of this report.

C. Test II: Cycling Test

1) Physical Inspection

A total of nine (9) unit-packaged units were used in this section and were given a physical inspection immediately after their removal from test. No variation from the original drawings or specifications was observed.

2) Moisture Content of Packaged Units

Using the same points and methods for determination, the moisture content for each of the units in this test was found to be as shown in the tabulation of results, Table III, page 15 of this report.

3) Firing Tests

All firings except one were quite satisfactory; the single exception was caused by a mortar tube burst.

4) Summary of Results

The results obtained in the Cycling Test are tabulated in Table III, page 15 of this report.

D. Test III: Safe Storage Test

1) Physical Inspection

A total of twelve (12) units, six (6) bare and six (6) in unit-package wrappers, were used in this test. The bare units were inspected immediately prior to conditioning, and the unit-packaged were given a similar inspection immediately before firing. No variation from the original drawings or specifications was observed.

TABLE III

TABULATION OF RESULTS FOR TEST II

CYCLING TEST

	Pre-Firing Condition				Firing Record						
		% Moisture Avg.			Component Action				Height, Ft.		
Bomb Number	Packaging Used In Test	Tube	Proj.	Time Fuze	Quick Match	Prop Chg.	Proj. Fuze	Burst Chg.	Est. Max.	Obs. Burst	Remarks
II-1	Unit Pkg.	9.8	10.5	OK	OK	OK	OK	OK	130	117	
II-2	"	10.0	10.3	"	"	"	"	"	150	142	
II-3	"	9.7	10.3	"	"	"	"	"	140	127	
II-4	"	10.0	10.6	"	"	"	"	"	145	132	
II-5	"	10.5	10.0	"	"	"	"	"	140	123	
II-6	"	10.1	10.3	"	"	"	"	"	40	GND	Tube burst, went up with projectile.
II-7	"	9.8	9.7	"	"	"	"	"	140	127	
II-8	"	10.8	11.0	"	"	"	"	"	140	127	
II-9	"	10.4	11.5	"	"	"	"	"	125	112	

SECRET

2) Moisture Content

Moisture content of all units was measured after conditioning in the test chamber. The results are tabulated in Table IV, page 17 of this report.

3) Firing Tests

In general, those units subjected to high temperature (160°F) failed because of time fuze desensitization by melted bitumen. While the tabulation of results shows operational failure of several fuzes the actual burster charge powder was in excellent condition and was readily ignited in each case by an open flame soon after the firing test.

Two (2) tube bursts were experienced in this test.

4) Summary of Results

The results obtained in the Safe Storage Test are tabulated in Table IV, page 17 of this report.

E. Test IV: Operating Temperature Limits Test

1) Physical Inspection

A total of eighteen (18) units were used in this test. No variation from the original drawings and specifications was observed.

2) Moisture Content

Moisture content of only the bare units was determined, since previous tests had indicated that the unit package wrapper was capable of preventing the entrance of water vapor into the package. The results are tabulated in Table V, page 18 of this report.

3) Firing Tests

As previously experienced with high temperature conditioning, those units in the 160°F part of this test all showed failure of the initiating

TABLE IV

TABULATION OF RESULTS FOR TEST III

SAFE STORAGE TEST

Pre-Firing Condition				Firing Record								
		% Moisture Avg.		Component Action					Height, Ft.			
Bomb Number	Packaging Used In Test	Tube	Proj.	Time Fuze	Quick Match	Prop Chg.	Proj. Fuze	Burst Chg.	Est. Max.	Obs. Burst		Remarks
III-1	Bare	9.7	10.7	Fail	OK	OK	Poor	OK	*111	GND	160°F - 22% RH Conditioning	
III-2	"	10.3	11.0	Fail	"	"	Fail	"	*106	None		
III-3	"	9.2	11.2	Fail	"	"	Fail	"	*106	None		
III-4	Unit Pkg.	12.2	11.9	Fail	"	"	Fail	"	*120	None		
III-5	"	11.6	10.7	Fail	"	"	Fail	"	*130	None		
III-6	"	11.8	11.2	Fail	"	"	Poor	"	* 50	GND		Tube burst, went up with projectile.
III-7	Bare	9.3	10.4	OK	OK	OK	OK	OK	135	125	-60°F Conditioning	
III-8	"	10.4	11.7	"	"	"	Fail	"	*125	None		
III-9	"	9.8	11.0	"	"	"	OK	"	140	135		
III-10	Unit Pkg.	11.0	10.8	"	"	"	"	"	127	107		
III-11	"	11.7	11.8	"	"	"	"	"	135	125		
III-12	"	11.4	11.7	"	"	"	"	"	* 46	GND		Tube burst, went up with projectile.

* Observed Height

SECRET

TABLE V

TABULATION OF RESULTS FOR TEST IV

OPERATING TEMPERATURE LIMITS TEST

	Pre-Firing Condition			Firing Record								
		% Moisture Avg.		Component Action					Height, Ft.			
Bomb Number	Packaging Used In Test	Tube	Proj.	Time Fuze	Quick Match	Prop Chg.	Proj. Fuze	Burst Chg.	Est. Max.	Obs. Burst		Remarks
IV-1	Bare	9.7	10.2	Fail	OK	Poor	Poor	OK	25	GND	160°F - 22% RH Conditioning	Delayed burst after proj. fell to ground.
IV-2	"	10.3	10.6	Fail	"	OK	Poor	"	-	-		Disassembled for individual component tests.
IV-3	"	10.5	10.7	Fail	"	Poor	Fail	"	25	None		
IV-4	Unit Pkg.	-	-	Fail	"	OK	Poor	"	*137	GND		15 second delay in projectile burst.
IV-5	" "	-	-	Fail	"	"	Poor	"	* 97	GND		" " " "
IV-6	" "	-	-	Fail	"	"	Fail	"	* 97	None		
IV-7	Bare	9.9	10.8	OK	OK	OK	OK	OK	147	137	+40°F Conditioning	
IV-8	"	10.3	11.1	"	"	"	"	"	133	113		
IV-9	"	10.5	11.1	"	"	"	"	"	130	118		
IV-10	Unit Pkg.	-	-	"	"	"	"	"	148	133		
IV-11	" "	-	-	"	"	"	"	"	108	93		
IV-12	" "	-	-	"	"	"	"	"	137	122		
IV-13	Bare	9.5	9.6	OK	OK	OK	OK	OK	135	120	120°F - 22% RH Conditioning	
IV-14	"	10.3	10.2	"	"	"	"	"	* 38	GND		Tube burst and went up with projectile.
IV-15	"	10.1	10.0	"	"	"	"	"	140	120		
IV-16	Unit Pkg.	12.0	13.4	"	"	"	"	"	147	132		
IV-17	" "	12.0	13.6	"	"	"	"	"	136	121		
IV-18	" "	11.9	12.9	"	"	"	"	"	134	119		

* Observed Heights

time fuze. The failure of the projectile time fuze was not as frequent in this test, however, as in the Accelerated Aging Test Section. No failure of propellant or burster charge was noted. Those units subjected to both the 120°F and -40°F sections of this test were entirely satisfactory as regards firing results, although one (1) tube burst was experienced.

4) Summary of Results

The results obtained in the Operating Temperature Limits Test are tabulated in Table V, page 18 of this report.

F. Test V: Safe Transport Test

1) Physical Inspection

A total of twelve (12) units were used in this test; six (6) were stripped of their unit-package wrapper, while the remainder were left packaged. Inspection of both lots showed that there was no variation from the original drawings and specifications.

2) Moisture Content

Moisture content of the units stripped from the unit package wrappers was measured immediately before conditioning; that of the packaged units was measured immediately after testing. The results are tabulated in Table VI, page 20 of this report.

3) Altitude Testing

No effect of increased altitude was noted in any of the units themselves, whether or not they were packaged during the test. The unit-packages themselves, however, were found to be subject to "bloating" as the result of a relative increase in internal pressure during the simulated climb to higher altitudes. This "bloating" of the package

TABLE VI

TABULATION OF RESULTS FOR TEST V

SAFE TRANSPORT TEST

Bomb Number	Pre-Firing Condition: Packaging Used In Test	% Moisture Avg. Tube	% Moisture Avg. Proj.	Firing Record: Component Action: Time Fuze	Quick Match	Prop Chg.	Proj. Fuze	Burst Chg.	Height, Ft.: Est. Max.	Obs. Burst	Remarks
V-1	Bare	9.9	10.4	OK	OK	OK	OK	OK	203	188	
V-2	"	11.6	11.8	"	"	"	"	"	192	182	
V-3	"	11.4	11.0	"	"	"	"	"	174	164	
V-4	"	11.9	11.2	"	"	"	"	"	186	176	Tube burst at base.
V-5	"	10.6	10.8	"	"	"	Slow	"	146	106	Late projectile burst (fuze slow)
V-6	"	11.6	11.7	"	"	"	OK	"	119	109	
V-7	Unit Pkg.	10.8	10.6	"	"	"	"	"	133	118	
V-8	" "	11.9	11.8	"	"	"	"	"	128	123	
V-9	" "	11.4	10.5	"	"	"	"	"	115	100	
V-10	" "	11.9	11.3	"	"	"	"	"	142	137	
V-11	" "	11.9	11.8	"	"	"	"	"	124	109	
V-12	" "	11.8	11.6	"	"	"	Slow	"	157	127	Late projectile burst (fuze slow)

Note: 1. All projectiles loaded with 14 oz. of sand and paper.

by entrapped air from within the Bombs, caused a very slight rupture of only one package; the remainder held without failure. Four (4) of the unit packages exhibited symptoms of slight pin-hole leaks, since they did not bloat to any significant degree except under very high rates of simulated climb (i.e., quick reduction in external air pressure).

4) Test Firing

The units subjected to the Safe Transport Test were satisfactory as regards the results of test firing, although one (1) tube burst was observed. The tabulation shows two (2) projectile time fuzes which were slow in acting; this is believed to be a manufacturing fault rather than the result of test conditioning.

5) Summary of Results

The results obtained in the Safe Transport Test are tabulated in Table VI, page 20 of this report.

G. Test VI: Vibration Test

1) Physical Inspection

A total of twelve (12) units were used in this test, all of which were kept in the unit packages throughout the testing procedure. Physical examination was performed after the vibration testing was completed. No variation from the original drawings and specifications was observed.

2) Moisture Content

Moisture content was measured immediately after the Vibration Testing. The results of these measurements are tabulated in Table VII, page 22 of this report.

SECRET

TABLE VII

TABULATION OF RESULTS FOR TEST VI

VIBRATION TEST

Bomb Number	Pre-Firing Condition: Packaging Used In Test		Pre-Firing Condition: % Moisture Avg. Tube	% Moisture Avg. Proj.	Firing Record: Component Action: Time Fuze	Quick Match	Prop Chg.	Proj. Fuze	Burst Chg.	Height, Ft.: Est. Max.	Obs. Burst		Remarks
VI-1	Unit	Pkg.	11.5	12.0	OK	OK	OK	OK	OK	124	109	Vibrated Horizontally	
VI-2	"	"	11.5	12.0	"	"	"	"	"	135	120		
VI-3	"	"	11.6	11.7	"	"	"	"	"	135	120		
VI-4	"	"	11.2	11.5	"	"	"	"	"	130	115		
VI-5	"	"	12.1	12.1	"	"	"	"	"	135	120		
VI-6	"	"	11.6	11.8	"	"	"	"	"	109	94		
VI-7	"	"	8.6	10.2	OK	OK	OK	OK	OK	126	111	Vibrated Horizontally	
VI-8	"	"	9.5	10.3	"	"	"	"	"	140	125		
VI-9	"	"	10.2	10.5	"	"	"	"	"	135	120		
VI-10	"	"	10.0	10.9	"	"	"	"	"	126	111		
VI-11	"	"	10.2	11.0	"	"	"	"	"	155	140		
VI-12	"	"	9.3	11.3	"	"	"	"	"	150	135		

SECRET

3) Vibration Testing

Physical inspection of the packaging, packing and the units themselves showed no damage attributed to the test conditioning.

4) Test Firing

The units subjected to the Vibration Test were satisfactory as regards the results of firing; in view of the fact that these units were uniformly excellent in their performance, the results of this test can be used to supplement those from the Original Sample Performance Test, page 11 of this report.

5) Summary of Results

The results obtained in the Vibration Test are tabulated in Table VII, page 22 of this report.

H. Test VII: Rough Handling Test

1) Physical Inspection

A total of twelve (12) units were used for this test. In view of the fact that these units were to be intentionally damaged to determine their physical resistance characteristics, only the bare units were given a physical inspection at the beginning of the test. There was no variation observed from the original drawings and specifications.

2) Moisture Content

Only the projectile moisture was measured in this test, since it was believed that physical damage to the tubes would cause a large number of tube bursts in firing and this, in turn, might mistakenly be attributed to tube moisture content. The results of these measurements are tabulated in Table VIII, page 24 of this report. Measurement of moisture in all units was made immediately after removal of the unit package wrapper.

TABLE VIII

TABULATION OF RESULTS FOR TEST VII

ROUGH HANDLING TEST

	Pre-Firing Condition			Firing Record							
		% Moisture Avg.		Component Action					Height, Ft.		
Bomb Number	Packaging Used In Test	Tube	Proj.	Time Fuze	Quick Match	Prop Chg.	Proj. Fuze	Burst Chg.	Est. Max.	Obs. Burst	Remarks
VII-1	Unit Pkg.	-	10.3	OK	OK	OK	OK	OK	123	93	
VII-2	" "	-	10.2	"	"	"	"	"	101	81	
VII-3	" "	-	9.7	"	"	"	"	"	150	130	
VII-4	" "	-	10.1	"	"	"	"	"	131	111	
VII-5	" "	-	9.9	"	"	"	"	"	131	111	
VII-6	Bare	-	9.3	"	"	"	"	"	140	130	
VII-7	"	-	9.9	"	"	"	"	"	116	106	
VII-8	"	-	11.5	"	"	"	"	"	108	98	
VII-9	Unit Pkg.	-	10.8	"	"	"	"	"	123	108	Tube burst, but projectile unhampered.
VII-10	" "	-	10.5	"	"	"	"	"	* 25	GND	Tube burst, went up with projectile; ground burst.
VII-11	Bare	-	10.5	"	"	"	"	"	126	111	
VII-12	"	-	10.5	"	"	"	"	"	123	108	

* Observed Heights

SECRET

3) Drop Testing

All drop testing consisted of a free fall from a height of seven (7) feet, the unit being dropped to strike in the required position on a concrete slab. The results obtained were as follows:

Bomb No.	Extent of Testing	Results Observed
VII-1	2 drops each end; total 4 drops. Unit bare.	None significant; slight fraying of mortar tube muzzle end.
VII-2	2 drops each end; total 4 drops. Unit bare.	As above.
VII-3	2 drops each side; total 4 drops. Unit bare.	None significant; mortar tube knocked slightly elliptical.
VII-4	2 drops each side; total 4 drops. Unit bare.	As above.
VII-5	Alternate end drops to destruction. Unit bare.	4th drop: Propellant cavity cover paper split slightly. 7th drop: Slight show of powder leakage; cannister of projectile opened up slightly. 120th drop: Tube base wooden plug split. Unit useless.
VII-6	Alternate side drops to destruction. Unit bare.	8th drop: Slight split in propellant cavity paper cover; small leakage. 10th drop: Increased above split, opened second split in paper cover. 12th drop: Black powder leakage apparent in considerable quantity. 16th drop: Significant leakage of propellant powder from cavity. 28th drop: Large leak, unit useless.

VII-7 through -12: same procedure and sequence was used for testing these unit-packaged units as was used for the bare units. No damage was observed in any of these units.

4) Test Firing

All of the units subjected to the Rough Handling Test were satisfactory as regards the results of firing. These results are tabulated in Table VII, page 22 of this report.

VI. DISCUSSION AND CONCLUSIONS

A. Discussion

Initial inspection of Table IX, "Summary of Failures from All Test Conditions" appears to indicate that failures in the Leaflet Bomb occur in 80% (8 out of 10) of the test conditions considered. Closer inspection and evaluation of these failures, however, brings the entire picture into clearer focus and points out quite clearly those areas in which the Leaflet Bomb is most susceptible. The analysis of these areas is as follows:

1) Time Fuze Failure

Occurs only under 160°F conditions. Occurs in both packaged and unpackaged units. Can be definitely attributed to the melting of the bitumen fuze covering.

2) Quick Match Failure

Occurs only in unpackaged units. Occurs only under high moisture conditions. Can be definitely attributed to water-wetting.

3) Propellant Charge Failure

Occurs only under same conditions as (2). Can be definitely attributed to water-wetting.

4) Projectile Fuze Failure

Occurs only under same conditions as (1). Can be definitely attributed to the same causes as (1).

5) Burster Charge Failure

Occurs only under same conditions as (2) and (3). Can be definitely attributed to the same causes as (2) and (3)

TABLE IX

SUMMARY OF FAILURES
FROM ALL TEST CONDITIONS

Test Conditioning	No. Samples		Time Fuze	Quick Match	Prop. Chg.	Proj. Fuze	Burst Chg.	Tube Burst	Tube Moisture % Min.	Avg.	Max.
"As Received"	Bare	-	-	-	-	-	-	-	-	-	-
	Pkg.	15	0	0	0	0	0	6	9.1	9.6	10.2
160°F - 90% RH	Bare	28	28	28	28	28	28	-	-	-	-
	Pkg.	11	11	0	0	11	0	-	11.8	-	12.5
160°F - 22% RH	Bare	6	6	0	0	3	0	0	9.2	9.9	10.5
	Pkg.	6	6	0	0	3	0	1	11.6	11.9	12.2
120°F - 22% RH	Bare	3	0	0	0	0	0	1	9.5	10.0	10.3
	Pkg.	3	0	0	0	0	0	0	11.9	12.0	12.0
-40°F	Bare	3	0	0	0	0	0	0	9.9	10.2	10.5
	Pkg.	3	0	0	0	0	0	0	-	-	-
-60°F	Bare	3	0	0	0	1	0	0	9.3	9.8	10.4
	Pkg.	3	0	0	0	0	0	1	11.0	11.4	11.7
Cycling	Bare	-	-	-	-	-	-	-	-	-	-
	Pkg.	9	0	0	0	0	0	1	9.7	10.1	10.8
Altitude 40,000 ft.	Bare	6	0	0	0	0	0	1	9.9	11.1	11.9
	Pkg.	6	0	0	0	0	0	0	10.8	11.6	11.9
Vibration	Bare	-	-	-	-	-	-	-	-	-	-
	Pkg.	12	0	0	0	0	0	0	8.6	10.6	12.1
Rough Handling	Bare	6	0	0	0	0	0	0	-	-	-
	Pkg.	6	0	0	0	0	0	2	-	-	-

SECRET

6) Tube Bursting

Occurs under a wide range of conditions, including the "as received" sample. Occurs primarily but not exclusively in the units which were tested in the packaged condition. Occurs in tubes having widely differing moisture contents.

Since this information is inconclusive, and there was no pattern observed in the method or configuration of tube bursts, this type of failure would appear to be random. It is certainly caused by excessive breech pressure during firing; this was adequately proven in Test A, when the cardboard liner was left wrapped around the projectile during firing.

If this failure is random and is caused by excessive breech pressure, then it must be attributed to the fact that the design and material of the tube has only marginal strength for its function.

B. Conclusions

1) The Leaflet Bomb will not function after being stored at a temperature of 160°F, but can survive a temperature of 120°F.
2) The Bomb cannot survive high humidity without being protected by its unit package.
3) When stored in its unit package at temperatures not exceeding approximately 120°F, the bomb appears to be reliable under all the simulated test conditions to which it was exposed.
4) Tube failure is random, not depending on any controllable variable. It appears to be caused by only marginal strength for its function.

SECRET

APPENDIX A

FROM LETTER TO CLIENT, DATED DECEMBER 6, 1954

Subject: Proposal for the Modified Engineering Testing of the Leaflet Bomb

During the writer's recent visit to your office, Messrs. [redacted] and [redacted] requested that [redacted] submit a proposal for a modified engineering test agenda of the Leaflet Bomb and its unit packaging. At that time [redacted] briefly outlined the test areas of interest for the bomb. The following reflects the agenda developed here at [redacted] based on [redacted] outline and later modified slightly during a telephone conversation on December 2, 1954, between [redacted] 50X1

In general it is our belief that these tests should be performed primarily to obtain the maximum amount of information possible on the effects of moisture on the black powder propellant and burster charges of the bomb and on the physical strength of the mortar tubes. Knowing these effects, the protection afforded by the present unit package can be quite easily determined. With this view point in mind, we propose the following agenda.

Test A: Original Sample Performance Test

Since it has been reported to us that a relatively high failure rate has been experienced in the field with this unit, it is felt that an original sample performance test should be conducted before any other environmental tests are performed. In this manner the reliability of the igloo-stored units and possible causes for their field failures can be established. Should deterioration already have occurred during storage, the test will signal this condition and allow the necessary early revision of the following test agenda.

1) Fifteen (15) units required for test.

2) Select ten (10) units for immediate firing, after determining:

   a) Per cent surface moisture of the mortar tube.

   b) General condition of the bomb exterior and its packaging.

3) Select five (5) units for propellant and burster powder inspection.

   a) Remove powder charges, obtain representative samples of each and dessicate to determine moisture content.

   b) Inspect internal components, such as joint bonding, wrappers, etc.

Test I, Accelerated Aging Test (160°F, 90% RH for 2 weeks)

1) Thirty seven (37) units required for test.

2) Place 28 bare units in test after determining surface moisture content of each mortar tube.

   a) Measure surface moisture content of mortar tube each day.

   b) Test fire one unit each alternate day.

   c) Draw charges and determine powder moisture content, one unit each alternate day.

   d) Continue (a), (b) and (c) above until a firing failure point has been reached; at this point attempt test firing of two additional units from sample. Make moisture determinations of powder and inspect internal components of all units failing to fire.

   e) Dry remaining samples at 120°F, 50% RH for one week and test fire to determine recovery.

3) Place nine (9) unit packaged units in test and run for two weeks.

   a) At completion of run, strip six (6) units, determine surface moisture content of mortar tubes and fire immediately.

b) Draw powder charges of remaining three (3) units and determine moisture content.

Test II, Cycling Test

Four cycles as follows:

4 hours @ 125°F, 90% RH

2 hours @ 80°F, 90% RH

2 hours @ -10°F

16 hours @ 40°F, 22% RH

1) Nine (9) unit packaged items required for test. Strip six (6) units from unit package after test, determine surface moisture of mortar tube and fire immediately.

2) Draw powder charge from three (3) remaining units and determine moisture content. Inspect internal components.

3) Compare results with those from Test A.

Test III, Safe Storage Test, Part A (160°F, 22% RH, 36 hours)

1) Six (6) units required for test; three (3) unit packaged, three (3) bare.

2) After conditioning, remove items and fire after 24 hours at room temperature.

3) In view of the insulating properties of both the packaging and the unit construction, these units shall be allowed to remain in the conditioning chamber at 160°F for 12 hours longer than required by the nominal test.

Test III, Safe Storage Test, Part B (-60°F for 36 hours)

1) Six (6) units required for test; three (3) unit packaged, three (3) bare.

2) After conditioning, remove items and fire after 24 hours at room temperature.

3) In view of the insulating properties of both the packaging and the unit construction, these units shall be allowed to remain in the conditioning chamber for 12 hours longer than required by the nominal test.

Test IV, Operating Temperature Limits Test

1) Twelve (12) units required for this test.

2) Depending on the results obtained from Test I, Accelerated Aging Test, the high temperature test of this unit to determine its operational limits may or may not be eliminated. If successful firing is made at 160°F after 24 hours at this temperature in Test I, further high temperature testing shall be eliminated.

3) If Test I shows failure of the units to fire, six (6) units will be tested at 120°F, 22% RH. Failure of units to fire at this temperature will be followed by successively reduced temperatures until a satisfactory upper firing temperature limit has been determined.

4) Six (6) samples each will be subjected to -40°F; an unsuccessful firing of the unit at this temperature will be followed by successive increased temperatures until the successful lower firing temperature limit is determined.

Test V, Safe Transport Test (4 hours at 40,000 feet altitude at room temperature)

1) Twelve (12) units required for test.

2) Subject six (6) unpackaged units to test; fire four (4) immediately after units have been brought back to ambient temperature, break down two (2) units for internal inspection.

3) Subject six (6) packaged units to test; fire four (4) immediately after units have been brought back to ambient temperature, break down two (2) and inspect.

4) Should the unit package envelope burst because of the high pressure differential encountered in this test, six (6) additional packaged units shall be substituted and a limit determined for the maximum safe altitude at which these units can be transported.

Test VI, Vibration Test (10-60 cps, in 5 cps increments, 15 minutes per increment, minimum acceleration of 2 g's)

1) Twelve (12) units required for this test.

2) Submit six (6) units to vibration test with longitudinal axes horizontal. Fire four (4) units immediately, break down two (2) and inspect.

3) Submit six (6) units to vibration test with longitudinal axes vertical. Fire four (4) immediately, break down two (2) for inspection.

Test VII, Salt Fog Test

This test shall not be performed, since it is firmly believed that the Salt Fog Test would cause immediate and total deterioration of the unit, with no possibility of recovery by drying. No effect would be made on the packaging.

Test VIII, Rough Handling Test (Multiple drops from 6 foot height)

1) Twelve (12) units required for this test.

2) Subject six (6) unpackaged units to the following drops, two (2) units per drop.

a) Two drops each end from 6 feet onto steel plate, longitudinal axis vertical. Inspect for damage and test fire.

b) Four drops from 6 feet onto steel plate, longitudinal axis horizontal. Inspect and test fire immediately.

c) One unit dropped from 6 feet, alternating ends, longitudinal axis vertical, until obvious failure occurs. Evaluate damage and, if possible, test fire. One unit dropped from 6 feet, longitudinal axis horizontal; continue drops until obvious failure. Evaluate failure and, if possible, test fire.

3) Repeat procedure outlined in (2) above, using packaged units. Evaluate damage, and record additional protection if any afforded by the unit package. Test fire at completion.

Test IX, Plunge Test

This test shall not be performed in view of the fact that the effects of packaging "breathing" can be observed during other tests, in addition to the fact that it is believed that a high rate of temperature change would not cause physical damage to this unit.