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USATECOM PROJECT NO. 8-MU-001-374-039
REPORT NO. APG-MT-3587
TEST SPONSOR PROJECT NO. NOT APPLICABLE
USACDC AC NO. NOT AVAILABLE



INITIAL PRODUCTION TEST OF
CARTRIDGE, 81-MM, HE, M374A2
WITH REDUCED BOURRELET AND
WATERPROOFED IGNITION - PROPELLANT SYSTEM

FINAL REPORT

BY

V. H. McCOY

JUNE 1970

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DEPARTMENT OF THE ARMY
HEADQUARTERS, U. S. ARMY TEST AND EVALUATION COMMAND
ABERDEEN PROVING GROUND, MARYLAND 21005

ANSTE-PC

18 JUN 1970

SUBJECT: Final Report on Initial Production Test of Cartridge, 81mm, HE,
M374A2, USATECOM Project No. 8-MU-001-374-039

Commanding General
US Army Munitions Command
Dover, New Jersey 07801

1. Reference.

a. Final Report on Product Improvement Test of Cartridge, 81mm, M374 with Modified Ignition-Propellant System and Reduced Bourrelet, USATECOM Project No. 8-MU-001-374-010, Report No. APG-MT-3311, August 1969.

b. Letter, ANSTE-PC, HQ, USATECOM, 27 June 1969, subject: Suitability of Cartridge, 81mm, HE, M374 with Reduced Bourrelet and Modified Ignition/Propellant System.

2. Approval Statement. Subject report is approved.

3. Background.

a. The Cartridges, 81mm, HE, M374 and WP, M375 were type classified without a moistureproof ignition/propellant system; protection was dependent on exterior packaging. Extensive use of these items in SEA disclosed their performance was significantly degraded when exposed to the humid and wet environment prevalent in SEA due to packaging limitations or exposure after unpackaging. An expedited product improvement effort on the M374 cartridge was initiated to provide a completely waterproof cartridge.

b. Test cartridges incorporated a bourrelet reduced 0.010" as previously approved by Engineering Change Order A90105, dated 11 March 1969, as a means of reducing misfires due to residue then prevalent with the M374 cotton bag cartridges. Subject report does not address the reduced bourrelet per se since this aspect was adequately explored in earlier tests, reference 1a, did not influence velocity levels, and was not directly pertinent to the waterproofing modifications.

AMSTE-BC

18 JUN 1970

SUBJECT: Final Report on Initial Production Test of Cartridge, 81mm, HE, M374A2, USATECOM Project No. 8-KU-001-374-039

c. After selection of a moistureproof ignition/propellant system consisting of a modified fin assembly, modified ignition cartridge, and celcon-silk propellant increment bags, mortar cartridges were subjected to extensive testing as reported in reference 1a. USATECOM concluded the item as tested was suitable for US Army use, reference 1b.

d. The samples submitted for subject initial production test were designated as M374A2 and were identical to those previously tested with one exception; the propellant increment bags tested during the product improvement activity had a total of three heat sealed seams to provide adequate moisture protection to the contents, whereas those submitted for the initial production test had one heat sealed and two sewn seams at the small ends. The sewn ends were substituted pending resolution of temporary fabrication problems.

e. Testing was conducted by Aberdeen Proving Ground between March and May 1970. Personnel of the US Army Infantry Board inspected test cartridges on 24 April 1970 to determine if there were any factors resulting from the modification that would introduce any human factors problems. The test objective was to determine if the production item performed equal to or better than those tested during the product improvement test, to include confirmation of the adequacy of polystyrene muffs to afford rough handling protection.

f. Since there are no QMR's or SDR's against which to evaluate subject cartridge, testing was conducted using criteria quoted in the approved plan of test. Test results generated using these criteria were adequate to evaluate the item relative to its suitability for issue.

4. Test Results.

a. The Cartridge, 81mm, HE, M374A2 met completely, seven of the nine test criteria and met partially, the two remaining criteria. No deficiencies and two shortcomings were reported.

b. Shortcomings (2):

(1) The velocity levels of the test cartridges were statistically different at the 5% level of significance from the control for six of the nine charge levels.

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SUBJECT: Final Report on Initial Production Test of Cartridge, 81mm, HE,
M374A2, USATECOM Project No. 8-MU-001-374-039

- (2) The test cartridge did not pass the simulated rain exposure test.
 - c. No problems relative to residue, safety, or human factors aspects were uncovered during testing. No maintenance was required.
 - d. The provision of polystyrene muffs minimized failures of increments during rough handling tests.

5. Comments.

a. Relative to the two reported shortcomings:

(1) Although the velocity levels of the test and control cartridges are small they are statistically different at the 5% level of significance, i.e., +6 to -6 fps. However, velocity levels are adjustable as part of propellant acceptance procedures.

(2) Failure of the cartridge to pass the simulated rain test was expected prior to testing because of the change in sealing the propellant bags. A production accident during the heat sealing of the bag ends resulted in temporary termination of the process pending corrective implementation. In the interim, bags were produced with seam ends which were not expected to afford the same degree of moisture protection as those with heat sealed ends.

b. It should be noted that the standard cartridge with cotton increment bags was not subjected to any of the waterproofness tests because of the data already available. The performance of standard cotton increments is seriously degraded when exposed directly to storage either in a high-humid environment or when exposed to water; the waterproof fabric and ignition system of subject cartridges are significantly more resistant.

c. Current production methods for propellant increment bags are identical to those used in the manufacture of the items submitted for subject test except for the closures. This command has been informed that the heat sealing process has been reinstated for all seams using the same techniques as used previously. Consequently, all attributes of the cartridges tested during subject test are applicable to fully heat sealed increment bags. Additionally, tests conducted earlier as reported in reference 1a disclosed heat sealed bags afford satisfactory moisture/water protection to the propellant.

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SUBJECT: Final Report on Initial Production Test of Cartridge, 81mm, HE, M374A2, USATECOM Project No. 8-KU-001-374-039

d. Although the Cartridge, 81mm, WP, M375A2 was not tested, all statements and conclusions relative to the M374A2 are applicable to the M375A2 since the same ignition/propelling system is used with both cartridges.

e. US Army Infantry Board, after inspection of the test item at APG, commented on the color of the protective ruff. Those furnished with the test item were white, which is objectionable for reasons of camouflage security.

6. Conclusion. The Cartridge, 81mm, HE, M374A2 and its WP counterpart, M375A2 is suitable for issue.

7. Recommendations.

a. The ruffs used to protect the propelling charge be of a color compatible with current camouflage techniques.

b. The velocity level of future production be adjusted during propellant proof acceptance testing to conform to existing firing tables or to levels currently achieved with M374 cartridges.

FOR THE COMMANDER:

1 Incl
Rept No. APG-MT-3587
(5 cys)

for *H. F. Green, Jr.*
HENRY F. GREEN, JR.
Colonel, GS
DCS for Test and Eval

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FINAL REPORT

BY

V. H. McCOY

JUNE 1970

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21005

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ABSTRACT

An initial production test was conducted at Aberdeen Proving Ground from 30 March to 14 May 1970 on the 81-mm mortar cartridge, HE, M374A2 (M374E5) which features a reduced bourrelet and a water resistant ignition - propellant system. The cartridges tested were inert-loaded and represent the initial production of Milan Army Ammunition Plant. Various tests were conducted to determine if the test item was equal to or better than the M374E5 test cartridge submitted previously for US Army Test and Evaluation Command evaluation. Residue tests were satisfactory; velocity level differences of test rounds were significant though of small magnitude compared with the control (M374), and velocity and range dispersion were equal to or better than the control; pressures were satisfactory; test rounds did not perform as well as previously in waterproofness tests because the ends of the Celcon/silk propellant bags were sewed and not heat-sealed as in the earlier version; there were short rounds in the rain test, but none in the puddle or humidity test; rough handling tests using charge protector muffs were satisfactory; solar-radiation tests with charge protection were satisfactory; and cook-off hazards and maintenance with test rounds were not significantly different from that experienced with control rounds. United States Army Infantry Board representatives found no human factors problems except that the white increment protector muffs should be black or brown to conform with current camouflage techniques. It was concluded that the initial production M374A2 cartridges performed satisfactorily, equal to, or better than the item in the previous US Army Test and Evaluation Command evaluation in all phases except for velocity level and waterproofness. A correction to firing tables to compensate for velocity differences is required.

FOREWORD

The Materiel Testing Directorate was responsible for preparing the test plan, conducting the test, and preparing the test report.

ABERDEEN PROVING GROUND
ABERDEEN PROVING GROUND, MARYLAND 21005

USATECOM PROJECT NO. 8-MU-001-374-039

FINAL REPORT ON INITIAL PRODUCTION TEST OF
CARTRIDGE, 81-MM, HE, M374A2
WITH REDUCED BOURRELET AND
WATERPROOFED IGNITION - PROPELLANT SYSTEM

30 MARCH TO 14 MAY 1970

SECTION 1. SUMMARY

1.1 BACKGROUND

Cartridge, 81-mm, HE, M374 and its WP counterpart, M375, were type-classified without a waterproof ignition - propellant system. Short rounds and misfires were encountered in the field when these cartridges were exposed to excessive moisture. As an interim solution relative to moisture protection, 81-mm mortar ammunition was supplied to the field in a fiber container which in turn was jungle wrapped. Picatinny Arsenal has developed a moisture-resistant ignition - propellant system for use with current 81-mm mortar ammunition. Waterproofing of components has resulted in an acceptable ignition system; testing of a waterproof propelling charge at APG provided sufficient data upon which a choice of propelling-bag materiel was made. USATECOM conducted an independent evaluation under USATECOM Project No. 8-MU-001-374-008 for the M374E4 cartridge and for the M374E5 cartridge under USATECOM Project No. 8-MU-001-374-010. Based on the results of these tests, USATECOM recommended the M374E5 as suitable and the M374E4 as suitable on an interim basis. This test was to evaluate the initial production for the M374A2 (M374E5).

1.2 DESCRIPTION OF MATERIEL

The test ammunition consists of the M374 (modified) HE shell body M374(A1) with a 0.010-inch reduced bourrelet (3.172 - 0.005-inch diameter before paint and 3.174-inch maximum after paint) fitted with a welded split ring delrin obturating band; a potted primer M71A1E1(A2); a Mylar-wrapped ignition cartridge, XM285 (M285) without brass liner, potted into fin assembly XM170 (M170) with RTV; Celcon/silk propellant bags. Celcon/silk propellant bags submitted for this test are sewed at the ends and not heat-sealed, thereby producing an increment that is not waterproof.

The cartridges represent the inert version of the initial production of Milan Army Ammunition Plant with propelling charges from Indiana Army Ammunition Plant. See Figures 1.2-1 through 1.2-4.

The control rounds for the velocity uniformity phase were cartridge, 81-mm, HE, M374 (inert-loaded) with delrin obturator and cotton increment bags. The propellant charge was assessed to the same velocity as the test propellant lot.

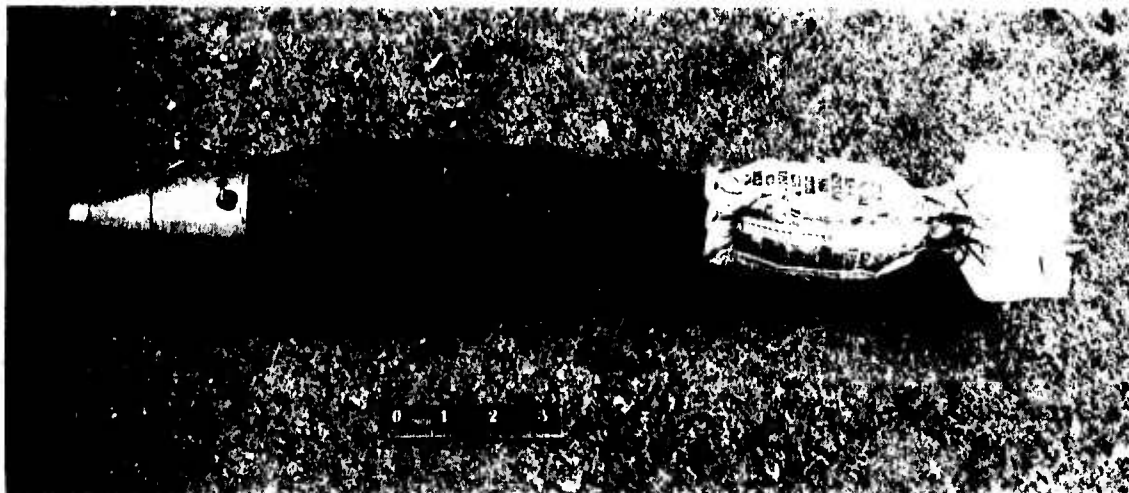


Figure 1.2-1: Cartridge, 81-MM, HE, M374A2 (Inert-Loaded), with Inert M524A6 Fuze.

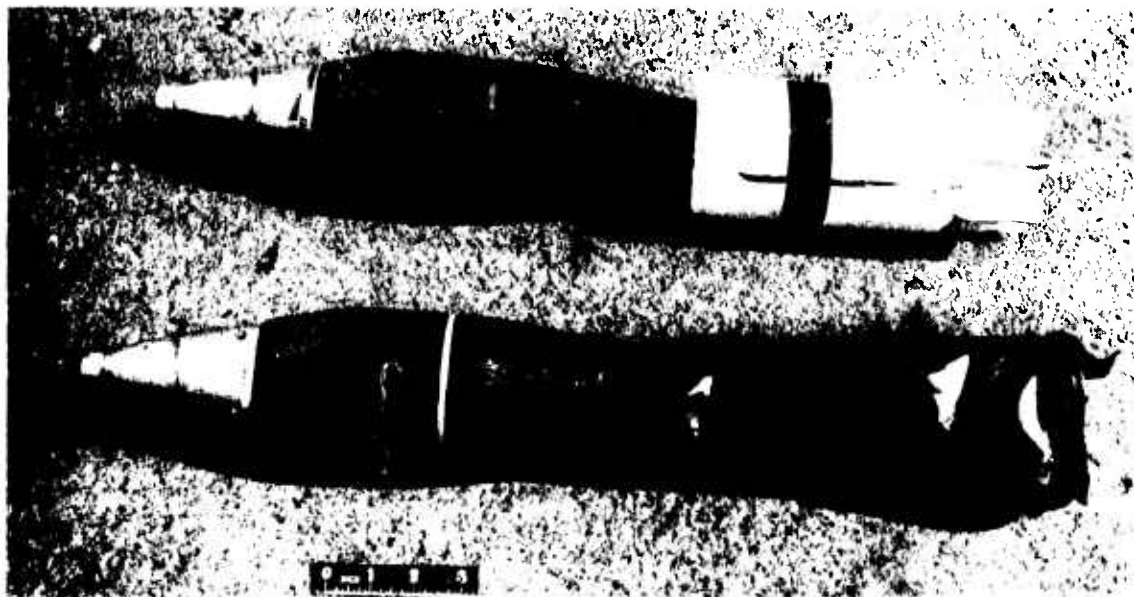


Figure 1.2-2: Cartridge, 81-MM, HE, M374A2 (Inert-Loaded) with Styrofoam Clamshell Charge Protector (Top) and with Black Plastic Bag Charge Protector (Bottom).

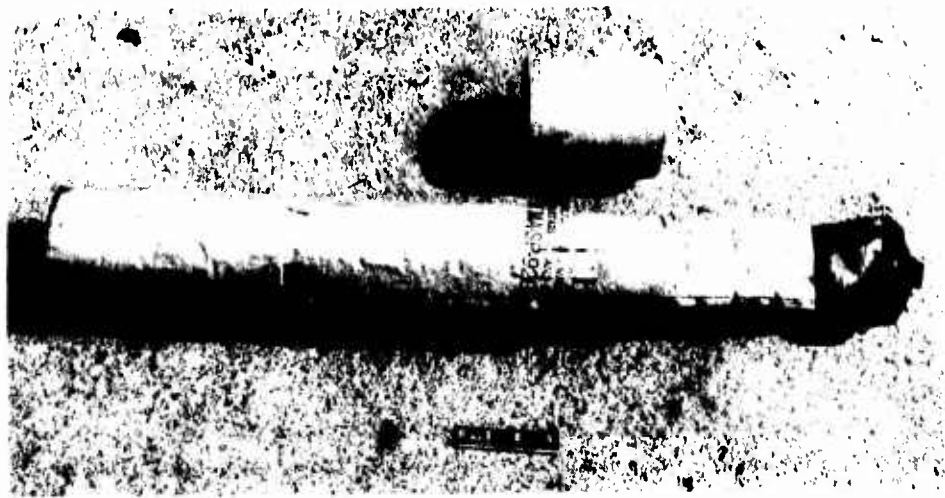


Figure 1.2-3: Fiber Container with Jungle Wrap for Cartridge, 81-MM, HE, M374A2, Showing Black Plastic Bag Charge Protector and Dehumidification Package As Packed with the Round.

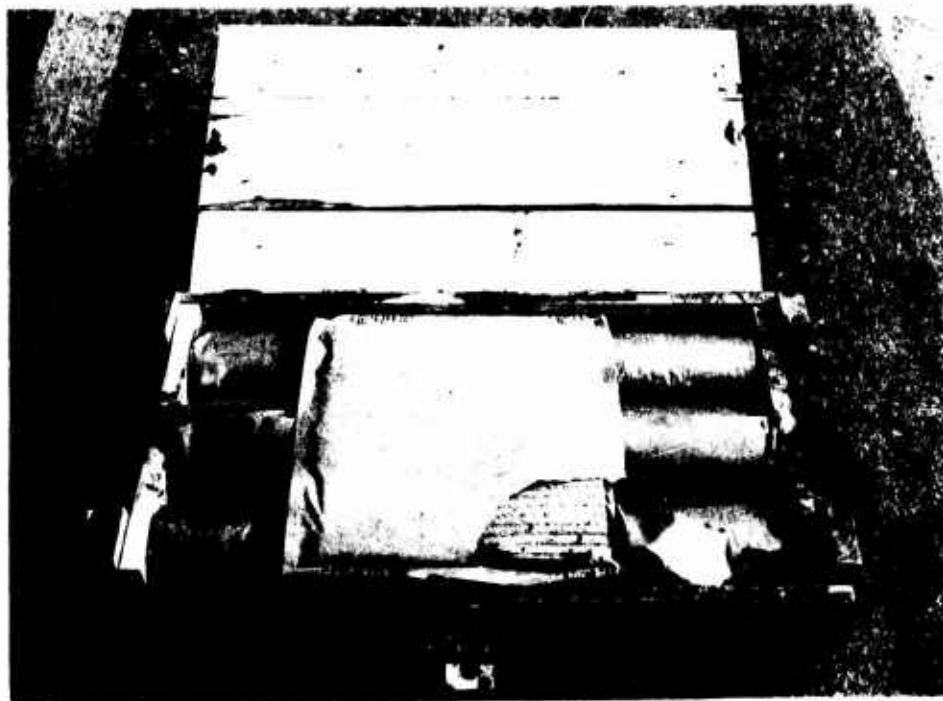


Figure 1.2-4: Ammunition Box and Packing for Use with Cartridge, 81-MM, HE, M374A2.

1.3 TEST OBJECTIVE

The objective was to verify that the quality of the initial production item was equal to or better than the item submitted for USATECOM evaluation.

1.4 SCOPE

The M374A2 cartridges were subjected to tests in the following phases, tests, and evaluation:

- a. Residue Phase: Effect of residue in relation to misfires.
- b. Velocity - Uniformity Phase: Comparison of velocity and range characteristics of test (M374A2) and control (M374) cartridges.
- c. Waterproofing Phase: Effects of puddle, rain, and warm - wet humidity tests in relation to low velocities and short ranges.
- d. Bump Test: Effect of rough handling on performance.
- e. Maintenance Evaluation: Maintenance requirements were observed throughout the tests.
- f. Solar Radiation Phase: Effect on performance after being subjected to solar radiation.
- g. Cook-Off Phase: Cook-off characteristics of test (M374A2) and control (M374) cartridges.

1.5 SUMMARY OF RESULTS

The test results were summarized in the following phases, tests, and evaluation.

1.5.1 Residue Phase

Three hundred test cartridges (M374A2) were fired in 25-round groups at the rate of 12 rounds per minute. Groups at charges 1, 2, 3, 2, 4, 2, 5, 2, 7, 2, 9, and 2 were fired in that order. No misfires occurred and only occasional small pieces of bag residue were found in the weapon after each 25-round group. Test criterion was met.

1.5.2 Velocity - Uniformity Phase

A velocity comparison between test (M374A2) and control (M374) rounds at various charges and temperatures is shown in Table 1.5-I. These data were obtained in 10-round groups. Pressures at charge 9 only are also shown. Velocities and pressures are corrected to a shell-weight of 9.12 pounds.

Range data were also requested and obtained in this phase of the test. A comparison of range results between test and control rounds, both observed and corrected, is shown in Table 1.5-II. Ranges are corrected to a shell-weight of 9.12 pounds, to control round average velocity, and to ICAO standard atmospheric structure.

The velocity level of the test cartridge was significantly different from the control cartridge, but the differences were small (a maximum of 6 fps at +70°F).

Velocity and range dispersion for the test cartridge was equal to or better than for the control cartridge with significantly better results in three cases.

The Firing Tables Branch of BRL, after a complete analysis of the test data, has stated that a correction to muzzle velocity must be made for one cartridge when attempting to use the same aiming data for both.

Pressure levels were within test requirements.

A ballistic match as fired did not exist; there was a ballistic match, however, when velocities were corrected.

The test criteria were partially met.

1.5.3 Waterproofing Phase

Velocities obtained upon firing the test and control rounds following the various waterproofing tests are contained in Table 1.5-III. Control rounds were test rounds which were not conditioned.

Test cartridges exhibited velocity characteristics equal to those of the M374E5 cartridges in the USATECOM evaluation as reported in Report No. APG-MT-3311 during the puddle and the 10-day high-humidity tests. The results of the rain test showed that the test cartridge velocity characteristics were not as good.

The test criteria were partially met.

1.5.4 Bump Test

When bumped, no damage occurred to any test rounds packed in boxes in jungle-wrapped fiber containers with clamshell charge protectors. When fired for functioning at charge 9 with control rounds, all rounds fired satisfactorily. Test rounds, not conditioned, averaged a velocity of 866 fps; test rounds that had been bump-tested averaged 863 fps.

Test criterion was met.

Table 1.5-I. Comparison of Velocity and Pressure Mean and Standard Deviation for Test (M374A2) and Control (M374) Rounds

Charge, No. Incr	QE, deg	Muzzle Velocities, fps				Vel Difference T-C	Pressure Avg, psi per 1000	
		Test		Control			Test	Cont
		Avg	Std Dev	Avg	Std Dev			
Conditioning Temperature: +70°F.								
1	45	348	1.7	344	2.7	a+ 4	-	-
2	45	431	2.6	427	2.2	a+ 4	-	-
3	45	507	^b 1.9	502	3.4	a+ 5	-	-
4	45	573	1.8	^c 567	1.7	a+ 6	-	-
5	45	635	1.2	^d 634	1.5	+ 1	-	-
6	45	695	1.9	694	1.8	+ 1	-	-
7	45	750	^b 1.4	752	2.6	a- 2	-	-
8	65	806	2.0	808	2.9	- 2	-	-
9	65	859	1.8	865	1.3	a- 6	8.0	8.0
Conditioning Temperature: +145°F.								
2	45	443	2.3	441	3.7	+ 2	-	-
4	45	588	1.7	585	1.8	a+ 3	-	-
9	65	878	2.7	888	2.4	a-10	8.8	8.8
Conditioning Temperature: -50°F.								
2	45	411	4.8	403	7.8	a+ 8	-	-
4	45	553	^b 3.6	^c 540	8.5	a+13	-	-
9	65	828	3.2	823	5.0	a+ 5	7.1	7.3

^aAverage test round velocity significantly different from control.

^bStd dev of test significantly less than controls.

^cNine rounds; one round misfired.

^dEight rounds; two rounds misfired.

Note: Velocities corrected to projectile weight of 9.12 pounds.

Table 1.5-II. Comparison of Range Results with Test (M374A2) and Control (M374) Rounds

Charge, No. Incr	QE, deg	Observed Range, meters						Corrected Range, meters								
		Test			Control			Test			Control					
		Avg	Std Dev	Diff T-C	Avg	Std Dev	Diff T-C	Avg	Std Dev	Diff T-C	Avg	Std Dev	Diff T-C			
Conditioning Temperature: +70°F.																
1	45	1034	a 8.1	1009	14.6	b+25	1018	3.2	1014	3.1	b+4	1018	3.2	1014	3.1	b+4
2	45	1508	17.9	1474	14.6	b+34	1495	6.0	1489	4.0	b+6	1495	6.0	1489	4.0	b+6
3	45	1983	15.4	1945	23.6	b+38	1974	11.5	1971	4.8	b+3	1974	11.5	1971	4.8	b+3
4	45	2405	18.4	d2364	12.9	b+41	2408	9.5	d2411	7.3	-3	2408	9.5	d2411	7.3	-3
5	45	2814	16.9	c2796	11.9	b+18	2869	13.0	c2870	7.3	-1	2869	13.0	c2870	7.3	-1
6	45	3234	18.6	3218	17.6	+16	3304	12.6	3301	13.4	+3	3304	12.6	3301	13.4	+3
7	45	3615	24.4	3632	21.8	-17	3715	14.0	3727	11.3	b-12	3715	14.0	3727	11.3	b-12
8	65	2960	24.9	2964	22.0	-4	3116	21.9	3114	15.6	+2	3116	21.9	3114	15.6	+2
9	65	3223	32.5	3270	23.3	b-47	3390	27.1	3408	17.0	-18	3390	27.1	3408	17.0	-18
Conditioning Temperature: +145°F.																
2	45	1585	18.0	1570	23.2	+15	1575	11.1	1576	6.1	-1	1575	11.1	1576	6.1	-1
4	45	2495	11.7	2474	11.2	b+21	2540	8.1	2537	5.5	+3	2540	8.1	2537	5.5	+3
9	65	3341	23.1	3410	20.2	b-69	3547	24.4	3564	17.6	b-17	3547	24.4	3564	17.6	b-17
Conditioning Temperature: -50°F.																
2	45	1377	a26.4	1322	49.0	b+55	1335	4.7	1324	13.5	b+11	1335	4.7	1324	13.5	b+11
4	45	2238	a26.7	d2150	60.6	b+88	2178	11.7	d2179	12.7	-1	2178	11.7	d2179	12.7	-1
9	65	3010	25.8	2978	36.2	b+32	3119	22.6	3119	22.4	0	3119	22.6	3119	22.4	0

a Std dev of test significantly less than control.
 b Average test round range significantly different from control.
 c Eight rounds; two rounds misfired.
 d Nine rounds; one round misfired.

Note: Ranges corrected to average corrected velocity of the control group and ICAO standard atmospheric structure.

Table 1.5-III. Summary of Velocities and Short Rounds after Puddle, Rain, and Humidity Tests

Type Test	No. Rds		Muzzle Velocity, fps					Test Rounds Not Cond		
	Fired	Short ^a	No. Rds Cons	Avg	Std Dev	Min	Max	No. Rds Cons	Avg	Std Dev
Charge: 4 increments.										
Puddle	30	0	b 15	559	5.24	552	568	10	572	1.99
			c 15	548	10.22	524	560			
10-min rain	20	1	b 9	550	8.07	d442	557	10	572	1.90
			c 10	544	12.35	511	555			
30-min rain	20	0	b 10	533	14.05	510	554			
			c 10	542	11.25	515	552			
2-hr rain	20	3	b 10	497	38.30	402	539			
			e,c 9	478	80.03	317	547			
10-day humidity	15	0	15	560	2.46	554	562	10	570	2.01
Charge: 9 increments.										
Puddle	30	0	b 15	839	5.69	827	849	10	856	3.83
			c 15	806	14.83	779	828			
10-min rain	20	1	b 10	818	17.38	796	844	10	855	1.77
			c 9	824	14.00	800	837			
30-min rain	20	6	b 9	805	27.84	d406	834			
			c 7	744	127.40	d219	830			
2-hr rain	20	7	b 9	744	86.60	d138	836			
			c 7	769	54.24	d164	823			
10-day humidity	15	0	15	844	3.11	838	850	10	854	2.41

^aRounds with less than 80% of average velocity for control rounds with the same charge.

^bShaken (excess water shaken off round before firing).

^cNot shaken before firing.

^dOne high velocity (608 fps) not considered.

^eNot considered in average.

1.5.5 Maintenance Evaluation

No maintenance problems were encountered with the M374A2 cartridges other than those normally expected with M374 standard cartridges. Test criterion was met.

1.5.6 Solar Radiation Phase

Visual examination of the ammunition with the three type-packaging tested showed slight-to-heavy discoloration of the Celcon charge increments. There was no indication of deterioration of the Celcon fabric as was experienced when the directly-exposed cartridges were previously tested. None of the increment bags were brittle.

Discoloration varied with the different packaging methods used and is described as follows:

- a. Styrofoam Clamshell. Slight discoloration of the Celcon fabric at both ends extending approximately 1/2 inch toward the center.
- b. Black Plastic Bag. Slight discoloration of all Celcon fabric charge increments.
- c. Fiber Container. Heavy discoloration of all Celcon fabric charge increments.

There was no indication of deterioration of any of the three types of packaging. When the solar-radiation rounds were fired for functioning at charge 9 with unconditioned test rounds, all rounds fired satisfactorily. Unconditioned test rounds average velocity was 872 fps; the test rounds from solar-radiation conditioning averaged from 14 to 21 fps less, depending on the type of packaging. Test criterion was met.

1.5.7 Cook-Off Phase

Test rounds, M374A2, cooked-off with charge 9 at a minimum tube temperature of +500°F. One did not cook-off at +520°F. A control (M374) round with charge 9 cotton-bag increments failed to cook-off at +580°F. In the USATECOM evaluation of the M374E4 cartridge (Report No. APG-MT-3285), the control (M374) cartridge cooked-off at a minimum tube temperature of +440°F; one did not cook-off at +435°F.

Test round cook-off times for each round tested were 36 seconds or less. Control round cook-off times in the above-referenced report were a maximum of 89 seconds.

All test rounds that cooked-off had ranges from 20 to 40 meters.

Test criterion was met.

1.5.8 Human Factors Phase (USAIB)

Representatives of the USAIB, who examined the test cartridges, made the following comments:

- a. No actual or potential human factors problems were detected.
- b. The color of the increment protector muffs (white) is tactically unacceptable.
- c. The muffs should be black or brown to conform with current camouflage techniques.

1.6 CONCLUSIONS

It is concluded that:

- a. Cartridge, HE, M374A2 is equal to or better than the item subjected to an independent USATECOM evaluation with the following exceptions:
 - 1) Mean velocity differs by a statistically significant amount for certain charge levels (ref par. 1.5.2).
 - 2) The ability to withstand rain is less (ref par. 1.5.3).
- b. A muzzle velocity correction must be made when using M374 aiming data (ref pars. 1.5.2, 2.3.5, and Appendix V).
- c. The white protective muffs are a deterrent to security (ref pars. 1.5.8 and 2.9.4 and Appendix V).
- d. Removal of excess moisture by shaking reduced percentage of erratic rounds (ref par. 2.4.4).

1.7 RECOMMENDATIONS

Not applicable.

SECTION 2. DETAILS OF TEST

2.1 INTRODUCTION

This test is designed to provide an evaluation of the initial production of the 81-mm cartridge containing four basic modifications, each of which has been previously evaluated (par. 1.2). Items under test (M374A2) were referred to as test cartridges. Where required for comparison, test cartridges not subjected to conditioning were used throughout the test. Control cartridges (M374) using cotton increment bags were used in the velocity uniformity phase.

Testing was performed at Aberdeen Proving Ground using trained civilian gun crews.

All safety considerations are unchanged in the test rounds and have been adequately tested in previously reported test firings.

Testing was conducted using M29E1 tubes in new condition (maximum dimension 0.004 inch over drawing tolerance). Testing has been conducted in a worn tube and is not considered necessary in this program.

Although range and accuracy performance of this design has demonstrated a ballistic match with the present standard cartridge, the design agency requested that range data be included to allow for instances where a statistical difference might exist due to a low standard deviation of velocity, but where little absolute difference would exist in range due to external effects on cartridge during flight.

The bump test is used to evaluate transportability as this is considered the most severe of the rough-handling tests.

Results of this test are considered applicable to the M375A2 WP cartridge.

2.2 RESIDUE PHASE

2.2.1 Objective

The objective was to determine if the test cartridge would fire properly without excessive misfires.

2.2.2 Criterion

The criterion is that there shall be less than 1% misfires caused by propellant bag residue remaining in the tube.

2.2.3 Method

The mortar was elevated to 45° and fired at a rate of 12 rounds per minute. All rounds were inert-loaded to standard weight (9.12 ± 0.1 lb) and fired at ambient temperature.

Thermocouples were attached to the tube 36 inches from the muzzle, and a temperature recorder was used to monitor tube temperature when firing at charge 9 to coordinate this phase with the cook-off phase.

Test rounds were fired in the numbers and at the charges shown in Table 2.2-I.

Table 2.2-I. Number of Rounds and Charges to be Fired

<u>No. Rds to Fire</u>	<u>Charge, increments</u>
25	1
25	2
25	3
25	2
25	4
25	2
25	5
25	2
25	7
25	2
25	9
25	2

The tube was dry-swabbed after each group and allowed to cool to ambient temperature between groups.

A simulated misfire test cartridge with full service charge was inserted after firing the charge 7 and charge 9 groups to determine if a cook-off would occur. After charge 9 firing, a second, third, and fourth simulated misfire test cartridge was inserted to determine cook-off potential. This became a part of the cook-off phase.

If the criterion was not met during the above firing as a result of propellant bag residue, the firing was to be repeated using standard M374 cartridges. This was not necessary.

2.2.4 Results

No misfires occurred. Some small pieces of bag residue were found in the tube or on the swab after each of the 12 25-round groups were fired. Table 2.2-II indicates remaining amounts of bag residue.

Table 2.2-II. Remaining Amounts of Bag Residue

<u>Test No.</u>	<u>Chg Used</u>	<u>Misfires</u>	<u>Amount of Bag Residue</u>
1	1	None	None
2	2	None	None
3	3	None	1 small piece
4	2	None	Small pieces
5	4	None	Large piece in bottom of tube
6	2	None	Small piece
7	5	None	None
8	2	None	None
9	7	None	Small piece
10	7	None	Small piece
11	9	None	None
12	2	None	None

2.2.5 Analysis

The test criterion was met.

2.3 VELOCITY - UNIFORMITY PHASE

2.3.1 Objective

The objective was to determine if the test cartridge velocity characteristics are significantly different from the M374 cartridge.

2.3.2 Criteria

The criteria are as follows:

- a. The velocity levels of the test and control cartridges shall not differ significantly at the 95% confidence level. The standard deviation of the test cartridge shall not be significantly worse than that of the control cartridge at the same level.
- b. No individual peak chamber pressure with the test cartridge conditioned at +145°F shall exceed 10,600 psi.
- c. A ballistic match shall exist between test and control cartridges.

2.3.3 Method

The mortar was emplaced on a base of crushed stone and clay. Solenoid coils were positioned for measuring velocity. Copper crusher gages were used for measuring peak pressures. Using inert rounds with live M524A5

fuzes, test and control cartridges were fired alternately as shown in Table 2.3-I for velocity and complete range data. Pressure was measured only on the charge 9 rounds.

Table 2.3-I. Firing Schedule

Chg, incr	Elev, deg	Temp, °F	No. Rds	
			Test (M374A2)	Control (M374)
9	65	+ 70	10	10
8	65	+ 70	10	10
7	45	+ 70	10	10
6	45	+ 70	10	10
5	45	+ 70	10	10
4	45	+ 70	10	10
3	45	+ 70	10	10
2	45	+ 70	10	10
1	45	+ 70	10	10
9	65	+145	10	10
4	45	+145	10	10
2	45	+145	10	10
9	65	- 50	10	10
4	45	- 50	10	10
2	45	- 50	10	10

Firings were conducted in accordance with MTP 3-2-819 (Interim Pamphlet 70-35).

2.3.4 Results

The results of the firings in this phase are contained in Table 2.3-II. Comparisons of results between test and control cartridges in this phase are shown in Figures 2.3-1, 2.3-2, and 2.3-3.

The velocity levels for the test and control rounds are significantly different by amounts varying from +6 to -6 fps at +70°F with an apparent relationship with the charge used. At the lower charges (1 through 4) the test rounds were significantly higher in velocity than the control rounds by amounts of 4 to 6 fps, while there was no significant difference for charges 5 through 8. However, at charge 9, the velocity level of the test rounds was significantly lower by 6 fps. This pattern was generally repeated in the extreme temperature groups but with differences decreasing at +145°F and increasing at -50°F.

There were no instances of the test rounds velocity standard deviations being significantly greater than those of the control rounds. In three cases they were significantly smaller.

The observed range data obtained in the test showed essentially the same results as the velocity data. At +70°F the ranges for the test cartridges were significantly longer than for the control cartridges by as much as 41 meters at charge 4. Shorter ranges, by as much as 47 meters, were recorded for the test rounds at charge 9. At the extreme temperatures these differences were magnified.

The observed range dispersions for the test cartridges were equal to or better than those of the control cartridges.

The differences in corrected range data between test and control show that the flight ballistics of the two rounds are matched. When velocity, projectile weight, and metrological corrections were applied the greatest differences in average range at +70°F were +8 meters and -18 meters, occurring at charge 3 and charge 9 respectively. Differences at the extreme temperatures also fell within these limits.

The highest individual pressure with the test rounds was 9000 psi with rounds conditioned at +145°F, compared to 9200 psi for a control rounds.

Eleven hang-ups and misfires occurred with the control rounds which were fired alternately with the test rounds. No hang-ups or misfires occurred with the test rounds.

Three hang-ups with control rounds fired when the tube was struck. These were: one charge 3 and one charge 8 at +70°F, and one charge 4 at +145°F.

Of the other eight misfires with control rounds, four fired on a second attempt and four failed to fire, two after two attempts and two after only one attempt. The misfires that fired on a second attempt were: one charge 7 at +70°F, two charge 4 and one charge 2 at -50°F. The misfires that failed completely were: one charge 4 (two attempts) at +70°F, two charge 5 (one attempt) at +70°F, and one charge 4 (two attempts) at -50°F.

2.3.5 Analysis

The test criteria was partially met.

The velocity data showed that the test rounds were significantly different in velocity level from the control rounds in six of nine charges at +70°F by as much as +6 fps. At extreme temperatures these differences increased to -10 fps and +13 fps. In all cases the velocity dispersions of the test rounds was equal to or better than the control rounds. The Firing Tables Branch of BRL has stated (letter in Appendix V) that the velocity differences are significant enough to require a correction for velocity when using tables with M374 aiming data. However, they also state that present tables will suffice until more data are available.

The pressure data indicated no difference between test and control rounds.

The range data showed a response to the velocities in that for the observed ranges, the test rounds were significantly different from the control for six of the nine charges at +70°F by amounts of approximately ±45 meters. After correcting the range data, the test cartridges were different at +70°F for four charges by approximately ±10 meters.

The velocities and observed ranges of the test cartridges, while not statistically matched with those of the control cartridges, showed differences no greater than lot-to-lot differences experienced with production M374 cartridges. From a practical standpoint when considering production variations the test cartridges may be considered as matching the control rounds.

Hang-ups which occurred with the control rounds, after firing test rounds, are believed to be caused by residue from the test round which obstructed the larger diameter of the control rounds, but which would not affect the smaller diameter test rounds. Similar hang-ups might occur in the field if rounds with different bourrelets were alternated.

Table 2.3-11. Summary of Results for II Test of Cartridges for 81-NM, HE, M374A2

Test Rd No.	Type Rd	Chg. Incr	Avg. Proj. Wt. lb.	No. Rds. Cons.	Velocity ^a , fps			Pressure ^a , psi/100			Range, meters			Deflection, meters			
					Avg.	Std Dev	PE	Avg.	Std Dev	PE	No. Rds. Cons.	Observed	Corrected ^b	Obs. Avg.	Corrected ^c	PE	
Velocity - Uniformity Phase Date: 8 April 1970. Elevation: 45 degrees. Conditioning Temperature: +70°F.																	
1 to 19	C	1	9.12	10	344	2.7		ET	1009	14.6	9.9	1014	3.1	2.1	0	1.9	1.3
2 to 20	T	1	9.06	10	d348	1.7		NT	d1034	d 8.1	5.5	d1018	3.2	2.2	0	2.1	1.4
21 to 39	C	2	9.12	10	427	2.2		NT	1474	14.6	9.9	1489	4.0	2.7	3	2	2.0
22 to 40	T	2	9.06	10	d431	2.6		NT	d1508	17.9	12.1	d1495	6.0	4.0	3	2	1.8
Date: 10 April 1970. Conditioning Temperature: +145°F.																	
261 to 279	C	2	9.14	10	441	3.7		NT	1570	23.2	15.7	1576	6.1	4.1	20	5	4.0
262 to 280	T	2	9.08	10	443	2.3		NT	1585	18.0	12.1	1575	d11.1	7.5	21	6	4.2
Conditioning Temperature: -50°F.																	
281 to 299	C	2	9.12	10	403	7.8		NT	1322	49.0	33.0	1324	13.5	9.1	21	8	2.5
282 to 300	T	2	9.08	10	d411	4.8		NT	d1377	d26.4	17.8	d1335	4.7	3.2	21	8	2.3
Date: 8 April 1970. Conditioning Temperature: +70°F.																	
41 to 59	C	3	9.11	10	502	1.4		NT	1945	23.6	15.9	1971	4.8	3.3	4	0	3.4
42 to 60	T	3	9.09	10	d507	d1.9		NT	d1983	15.4	10.4	1976	11.5	7.7	4	0	2.2
61 to 79	C	4	9.11	R 9	567	1.7		NT	R 2364	12.9	8.7	2411	7.3	4.9	7	1	3.4
62 to 80	T	4	9.10	10	d573	1.8		NT	d2405	18.4	12.4	2408	9.5	6.4	10	2	4.0
Date: 9 April 1970. Conditioning Temperature: +145°F.																	
221 to 239	C	4	9.12	10	585	1.8		NT	b 2474	11.2	7.6	2537	5.5	3.7	412	425	4.5
222 to 240	T	4	9.10	10	d588	1.7		NT	d2495	11.7	7.9	2540	8.1	5.5	414	427	4.1

Table 4.1-II (Cont'd)

Test Rd No.	Type	Chg Rd	Incr	Avg Proj Ht, Ft	No. Rd. Cons	Velocity ^a , fps	Pressure ^a , Psi/100		No. Rds Cons	Range, meters			Deflection, meters						
							Avg	Std Dev		Avg	Std Dev	PE	Obs Avg	Obs Std Dev	Corrected ^b Avg	Corrected ^b Std Dev	PE		
Conditioning Temperature: -50°F.																			
241 to 259	C	4	4	9.14	R 9	840	8.5	NT	8	2150	60.6	40.9	2179	12.7	8.6	361	396	8.5	5.7
242 to 260	T	4	4	9.07	10	d553	d3.6	NT	10	d2238	d26.7	18.0	2178	11.7	7.9	371	396	7.5	5.1
Date: 8 April 1970.																			
Conditioning Temperature: +70°F.																			
81 to 99	C	5	5	9.16	1 8	634	1.5	NT	1 8	2796	11.9	d.0	2870	7.3	4.9	- 15	- 9	4.2	2.9
82 to 100	T	5	5	9.08	10	635	1.2	NT	10	d2814	16.9	11.4	2869	13.0	8.8	- 11	- 5	3.8	2.5
101 to 119	C	6	6	9.13	10	694	1.8	NT	10	3218	17.6	11.9	3301	13.4	9.0	- 16	- 4	2.0	1.4
102 to 120	T	6	6	9.10	10	695	1.9	NT	10	3236	18.6	12.5	3304	12.6	8.5	- 17	- 5	4.2	2.8
121 to 139	C	7	7	9.04	10	752	2.6	NT	10	3632	21.8	14.7	3727	11.3	7.6	- 22	- 11	4.8	3.2
122 to 140	T	7	7	9.08	10	d750	d1.4	NT	10	3615	24.4	16.5	d3715	14.0	9.4	- 21	- 10	5.8	3.9
Date: 9 April 1970.																			
Elevation: 65 degrees.																			
141 to 159	C	8	8	9.10	10	808	2.9	NT	10	2964	22.0	14.8	3114	15.6	10.5	394	498	6.1	4.1
142 to 160	T	8	8	9.08	10	806	2.0	NT	10	2960	24.9	16.8	3116	21.9	14.7	396	500	9.0	6.1
161 to 179	C	9	9	9.17	10	865	1.3	80	1 1	3270	23.3	15.7	3408	17.0	11.4	406	521	8.3	5.6
162 to 180	T	9	9	9.16	10	d859	1.8	80	1 2	d3223	32.5	21.9	3390	27.1	18.3	415	530	19.4	13.1
Conditioning Temperature: +145°F.																			
181 to 199	C	9	9	9.15	10	888	2.4	88	1 6	3410	20.2	13.6	3564	17.6	11.9	415	535	10.5	7.1
182 to 200	T	9	9	9.08	10	d878	2.7	88	1 2	d3341	23.1	15.6	d3547	24.4	16.5	413	533	13.3	9.0
Conditioning Temperature: -50°F.																			
201 to 219	C	9	9	9.15	10	823	5.0	73	3 7	2978	36.2	24.4	3119	22.4	15.1	414	490	11.0	7.4
202 to 220	T	9	9	9.08	10	d828	3.2	71	2 6	d3010	25.8	17.4	3119	22.6	15.3	419	495	7.0	4.7

^aVelocities and pressures were corrected to a standard projectile weight of 9.12 pounds. Deflection of the control group, and to changes were corrected to a projectile weight of 9.12 pounds, to the average velocity of the control group, and to the ICAO Standard Atmospheric Structure. Deflections were corrected to the ICAO Standard Atmospheric Structure. Deflections significantly different on the 5% level. Significant estimated range of 1275 meters for round No. 299. Deflection not obtained. Limiting estimated range of 1962 and 1967 meters for rounds No. 56 and 60 respectively omitted. Statistical outliers. One round misfired. Limiting estimated range of 1700 meters for round No. 225. Deflection not obtained. Two rounds misfired. Limiting estimated range of 2930 meters for round No. 178. Deflection not obtained.

Legend:

- C = Control lot MA-SP-9208.
- T = Test lot MA-SP-912A.
- NT = Not taken.

Cond Temp: 70°F

Observed Data

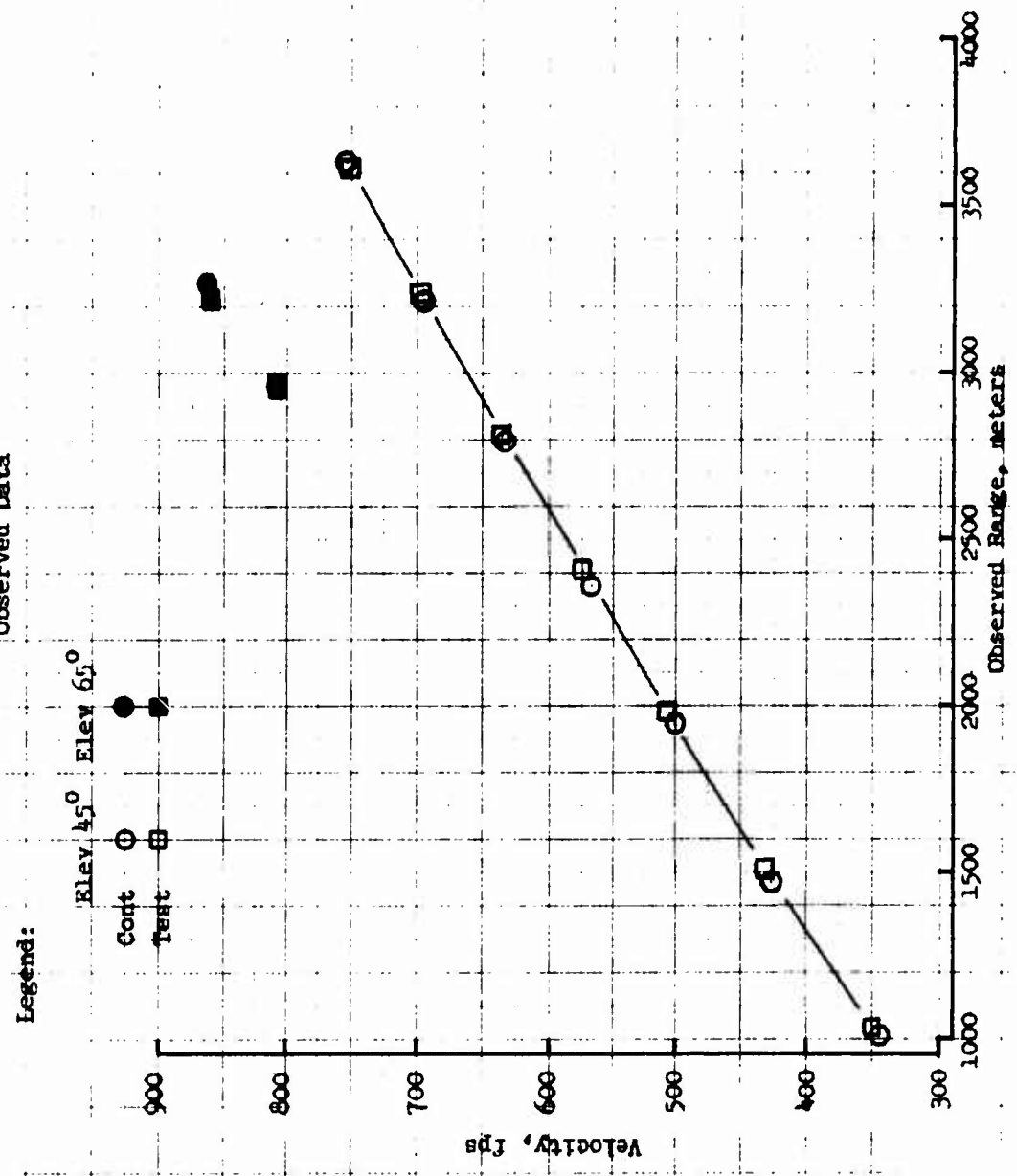


Figure 2.3-1: Velocity versus Range for 81-MM M374 and M374A2 Cartridges.

Corrected Data for 81-mm M374 and M374A2 Cartridges

Legend:

- | Temp 70°F | | Temp +145°F | | Temp -50°F | |
|-----------|-------------|-------------|-------------|------------|-------------|
| ○ | Elev 45 deg | ▲ | Elev 45 deg | ● | Elev 45 deg |
| □ | Elev 65 deg | ▲ | Elev 65 deg | ● | Elev 65 deg |

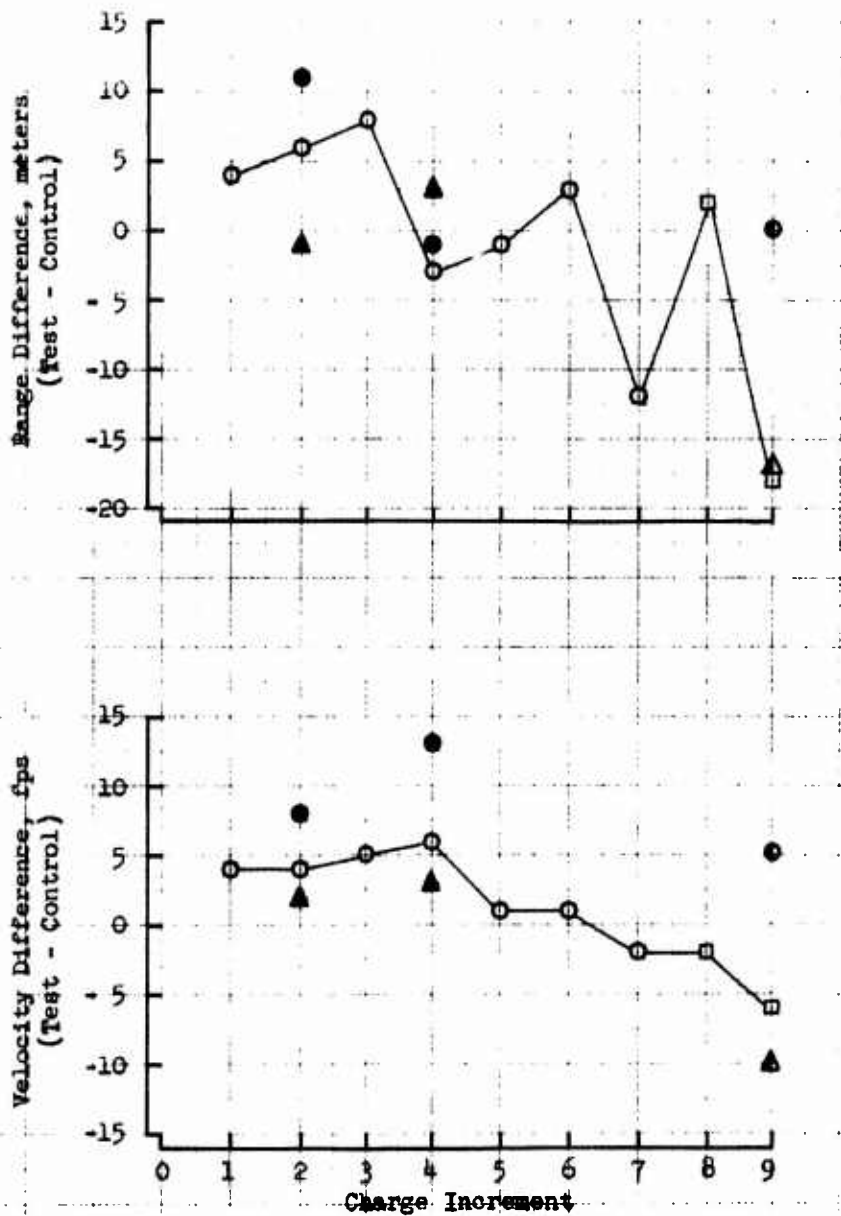


Figure 2.3-2: Range and Velocity Differences versus Charge Increment.

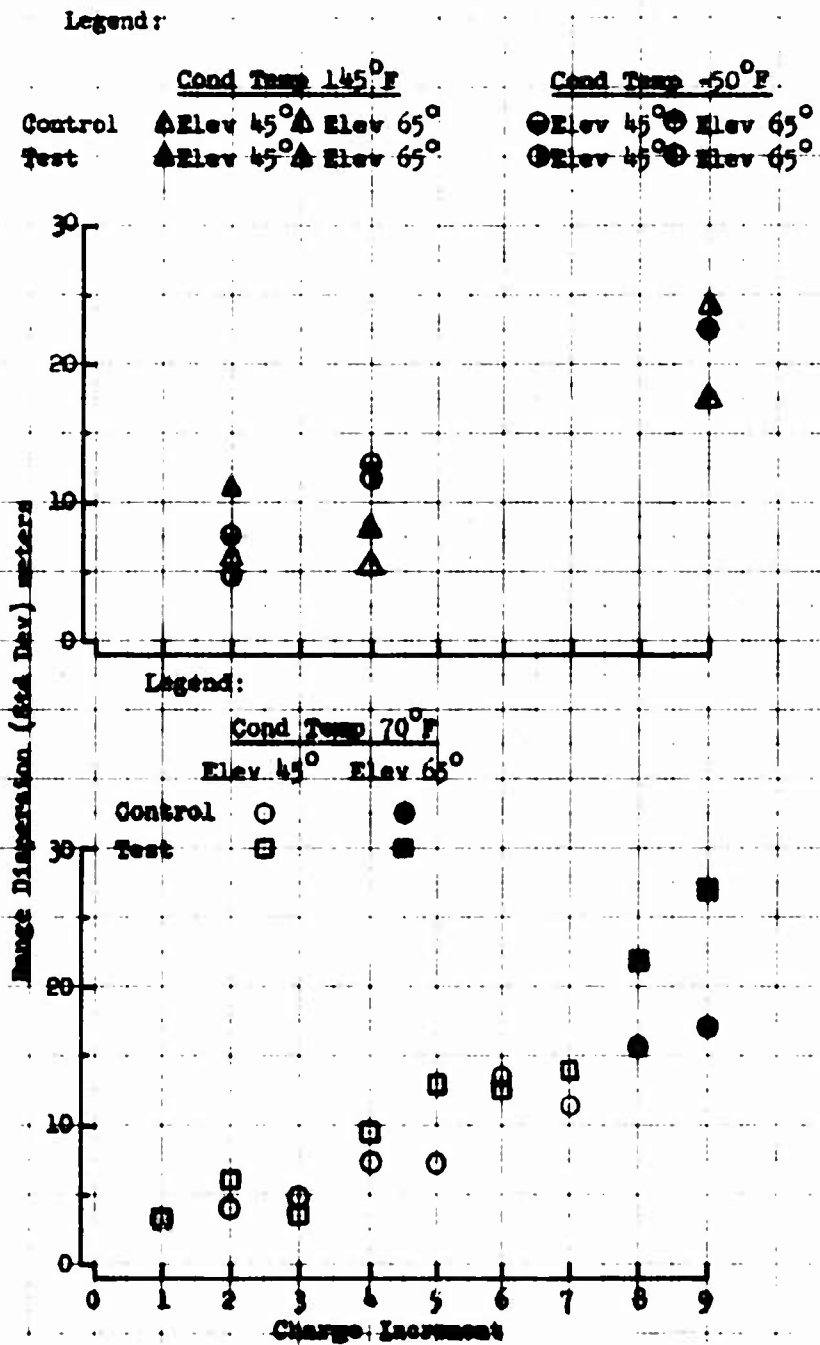


Figure 2.3-3: Range Dispersion (Std Dev) versus Charge Increment for 81-MM M374 and M374A2 Cartridges.

2.4 WATERPROOFING PHASE

2.4.1 Objective

The objective is to determine if the bare test cartridge provides sufficient protection against moisture contamination to eliminate or significantly reduce the occurrence of low velocities which would result in short rounds.

2.4.2 Criterion

The criterion is that the test cartridge performance shall be equal to or significantly better than that obtained in the USATECOM evaluation when submitted to the following environments:

- a. Puddle.
- b. Rain.
- c. Ten-day warm-wet humidity test.

2.4.3 Method

2.4.3.1 Puddle Test. This test simulated the dropping of a cartridge into a water puddle by individually immersing 60 inert test cartridges into sufficient water to cover all propellant increments. They were removed after 2 seconds. They were then fired in accordance with Table 2.4-I. Ten dry test cartridges were fired at each charge.

Table 2.4-I. Schedule for Puddle Test

<u>No.</u> <u>Rds</u>	<u>Chg</u> <u>Incr</u>	<u>Shaken</u> <u>Before</u> <u>Firing</u>
15	4	Yes
15	4	No
15	9	Yes
15	9	No

2.4.3.2 Rain Test. Inert test cartridges were subjected to a simulated rain test of 4 ± 1 inch per hour as shown in Table 2.4-II.

The rain test was repeated for durations of 30 minutes and 2 hours. The cartridge groups were fired within 10 minutes after removal from the rain for velocity uniformity at a convenient elevation. Cartridges were in containers for transport from rain test facility to firing position. Ten dry test cartridges were fired at each charge.

Table 2.4-II. Schedule for Rain Test

<u>No. Rds</u>	<u>Chg Incr</u>	<u>Shaken Before Firing</u>	<u>Duration, min</u>
10	9	Yes	10
10	9	No	10
10	4	Yes	10
10	4	No	10

2.4.3.3 Humidity Test. In this test, 30 inert test cartridges were subjected to a warm-wet humidity cycle for 10 days in accordance with MTP 4-2-820 (Interim Pamphlet 70-84). One-half the cartridges were fired at charge 4 and one-half at charge 9 for velocity uniformity at a convenient elevation. Firings were performed when the cartridges were at their high humidity cycle. Twenty inert test cartridges, not subjected to the humidity test, were fired with the test rounds, 10 at charge 4 and 10 at charge 9.

2.4.4 Results

2.4.4.1 Puddle Test. Table 2.4-III summarizes the firing results.

Table 2.4-III. Velocity Results of the Puddle Test

<u>No. Rds</u>	<u>No. Rds Cong</u>	<u>Type Rd</u>	<u>Charge No. Incr</u>	<u>MV, fps</u>		
				<u>Mean</u>	<u>Std Dev</u>	<u>Diff</u>
10	10	Test, not conditioned ^a	4	572	1.99	0
15	15	Test, shaken	4	559	5.24	-13
15	15	Test, not shaken	4	548	10.22	-24
10	10	Test, not conditioned ^a	9	856	3.83	0
15	15	Test, shaken	9	839	5.69	-17
15	15	Test, not shaken	9	806	14.83	-50

^aSame ammunition as test but not conditioned (dry).

There was no low velocity for any round fired which would result in a short range (defined as less than 80% of the anticipated range). One misfire occurred, due to residue, at charge 4 (shaken) but it fired on a second attempt.

2.4.4.2 Rain Test. Table 2.4-IV summarizes the firing results.

Table 2.4-IV. Velocity Results of the Rain Test

No. Rds.	No. Rds Cons	Type Rd	Charge, No. Incr	MV, fps		
				Mean	Std Dev	Diff
10	10	Test, not conditioned ^a	9	855	1.77	0
10	10	Test, not conditioned ^a	4	572	1.90	0
Ten-Minute Soak						
10	10	Test, shaken	9	818	17.38	- 37
10	^b 9	Test, not shaken	9	824	14.00	- 31
10	^c 9	Test, shaken	4	550	8.07	- 22
10	10	Test, not shaken	4	544	12.35	- 28
Thirty-Minute Soak						
10	^d 9	Test, shaken	9	805	27.84	- 50
10	^e 7	Test, not shaken	9	744	127.40	-111
10	10	Test, shaken	4	533	14.05	- 39
10	10	Test, not shaken	4	542	11.25	- 30
Two-Hour Soak						
10	^b 9	Test, shaken	9	744	86.60	-111
10	^f 7	Test, not shaken	9	769	54.24	- 86
10	10	Test, shaken	4	497	38.30	- 75
10	^g 9	Test, not shaken	4	478	80.03	- 94

^aSame ammunition as test but not conditioned (dry).

^bShort-range round (approximately 50 yards) not considered.

^cOne low velocity (442 fps) not considered.

^dOne very low velocity (406 fps) not considered.

^eOne very low velocity (388 fps) and two short-range rounds (approximately 50 yards) not considered.

^fOne very low velocity (428 fps) and two short-range rounds (approximately 50 yards) not considered.

^gOne high velocity (608 fps) not considered. This high velocity, +36 fps greater than expected, was probably due to an accumulation in the tube of unburned propellant from the previous round which had a very low velocity indicating poor ignition.

In the 10-minute soak, two test rounds had critically low velocities which would result in a short range (less than 80% of anticipated range): one of 10 with charge 9, shaken, and one of 10 with charge 4, not shaken.

In the 30-minute soak, six test rounds had critically low velocities with charge 9: one of 10 shaken and five of 10 not shaken. None with charge 4 had a critically low velocity.

In the 2-hour soak, three of 10 test rounds with charge 9, shaken, had critically low velocities. Four of 10 with charge 9, not shaken; one of 10 with charge 4, shaken; and two of 10 with charge 4, not shaken also had critically low velocities.

All test rounds were fired within 10 minutes, or less, from the time of removal from the simulated rain facility.

2.4.4.3 Humidity Test. Table 2.4-V summarizes the firing results.

Table 2.4-V. Velocity Results of the Humidity Test

No. Rds	No. Rds Cons	Type Rd	Charge, No. Incr	MV, fps		
				Mean	Std Dev	Diff
10	10	Test, not conditioned ^a	4	570	2.01	0
15	15	Test	4	560	2.46	-10
10	10	Test, not conditioned ^a	9	854	2.41	0
15	15	Test	9	844	3.11	-10

^aSame ammunition as test but not conditioned (dry).

Inspection of test rounds after the 10-day warm-wet humidity cycle showed a brownish discoloration of the Celcon/silk increment bags on the rounds. No weakening damage of any kind was apparent.

No short rounds occurred during firing although the velocity level with test rounds was 10 fps lower than with control.

All test rounds were fired within 7 minutes, or less, from the time of removal from the humidity cabinet.

2.4.5 Analysis

Test criterion was partially met. The performance of test cartridges met the criteria of equal to or better than previous USATECOM evaluation in the puddle test and the humidity test, but did not meet the criterion in the rain test, probably because the ends of the Celcon/silk propellant bags were sewed and not heat-sealed as previously.

2.5 BUMP TEST

2.5.1 Objective

The objective was to determine if the cartridges will survive rough handling and be operational.

2.5.2 Criterion

The test cartridge shall be operational and safe to fire after this test.

2.5.3 Method

Twenty-one rounds (7 boxes) were subjected to a bump test which consists of a constant table displacement of 1 inch, double amplitude at a speed of 300 rpm imparting an acceleration of 1.3 g for a period of 30 minutes. This test was conducted at ambient temperature. The rounds were unpacked, inspected for damage and fired for velocity at charge 9. Test rounds, not subjected to the bump test, were fired at the same charge. Firings were at ambient temperature. Velocity and pressure were measured for each round.

2.5.4 Results

There was no visual evidence of damage to the cartridges or packing materials and no loss of propellant increment charges from the cartridge fin assembly as a result of the bounce. The firing results after the bump test are contained in Table 2.5-I.

Table 2.5-I. Velocity and Pressure Results with Bump-Test Rounds

No. Rds Cons	Type Round	Charge, No. Incr	MV, fps		Chamber Pressure, psi	
			Mean	Std Dev	Mean	Std Dev
21	Test, not conditioned ^a	9	866	3.37	8050	825
21	Test	9	863	2.40	8075	430

^aSame ammunition as test but from a different lot and not subjected to the bump test.

2.5.5 Analysis

The test criterion was met.

2.6 MAINTENANCE EVALUATION

The modification to the M374 cartridge is not expected to affect the maintenance requirements that are presently associated with the standard cartridge. Observations were made throughout the program for any maintenance problems with the test cartridge.

2.6.1 Results

Maintenance problems with the test M374A2 cartridge appear to be no different from those with the standard M374 cartridge.

2.6.2 Analysis

Not applicable.

2.7 SOLAR RADIATION PHASE

2.7.1 Objective

The objective was to determine if the test cartridge will perform properly after being subjected to solar radiation.

2.7.2 Criterion

The test cartridge will not be adversely affected by the simulated desert cycle of solar radiation.

2.7.3 Method

The test cartridges were subjected to a simulated desert cycle for 2 weeks (Figure 2.7-1). Twenty-seven test cartridges were conditioned in accordance with the procedure outlined in MIL-STD-210A (World-Wide Program), as follows:

- a. Nine each with bare round and clamshell (styrofoam) over increments (Figure 2.7-2).
- b. Nine each with bare round and black bag (plastic) over increments (Figure 2.7-3).
- c. Nine each in fiber container without jungle wrap or clamshells.

All test components were examined visually to determine serviceability.

All cartridges that appeared to be serviceable were fired for velocity with maximum service charge after being conditioned at ambient temperature and at a convenient elevation.

Ten test cartridges that had not been conditioned were fired to establish normal velocity level.

An M29 mortar with pressure taps and external copper-crusher gages was used to record peak pressures on all rounds fired.

2.7.4 Results

Upon completion of the 14-day test:

- a. Test cartridges with clamshell charge increment protectors showed slight discoloration on each end of the increment bag. On two rounds, the clamshells were not closed tightly and this allowed more discoloration of the increment bags.
- b. Test cartridges with the black bag charge increment protectors showed only slight discoloration of increment bags.
- c. Test cartridges in fiber containers showed only slight discoloration of increment bags.
- d. None of the Celcon/silk increment bags appeared to have become brittle during the test.
- e. Firing results after the solar radiation test are contained in Table 2.7-I. Figures 2.7-2 and 2.7-3 show black bag and clamshell charge protectors.

Table 2.7-I. Velocity and Pressure Results with
with Solar-Radiation Rounds

Legend:

- (A) = Rounds with the black bag charge protector.
 (B) = Rounds with the clamshell charge protector.
 (C) = Rounds in the fiber containers.

No. Rds Cons	Type Round	Charge No. Incr	MV, fps		Chamber Pressure, psi	
			Mean	Std Dev	Mean	Std Dev
10	Test, not conditioned ^a	9	872	2.22	8190	147
9	Test (A)	9	852	4.09	7780	97
9	Test (B)	9	851	3.73	7815	79
9	Test (C)	9	858	3.02	8070	112

^aSame ammunition as test but from a different lot and not subjected to solar-radiation conditioning.

2.7.5 Analysis

Test criterion was met. The protectors on the rounds appear to have performed with some degree of success since the Celcon/silk increment bags were not brittle and broken open as in the previous USATECOM product improvement test. Velocity levels, however, were from 14 to 21 fps lower than similar rounds not conditioned.

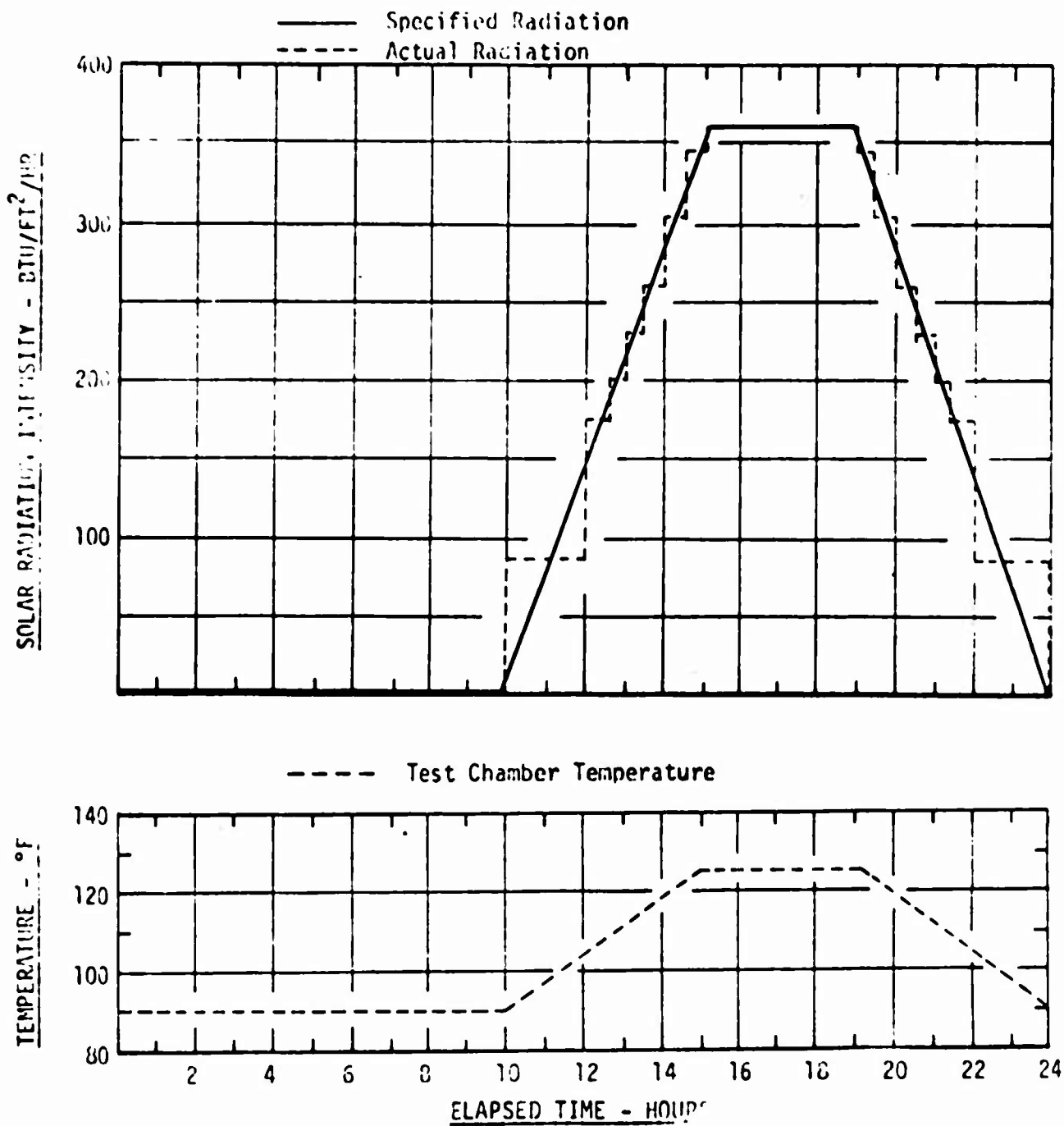


Figure 2.7-1: Solar-Radiation Intensities and Test Chamber Temperatures (per cycle) Following Specification MIL-STD-210A.

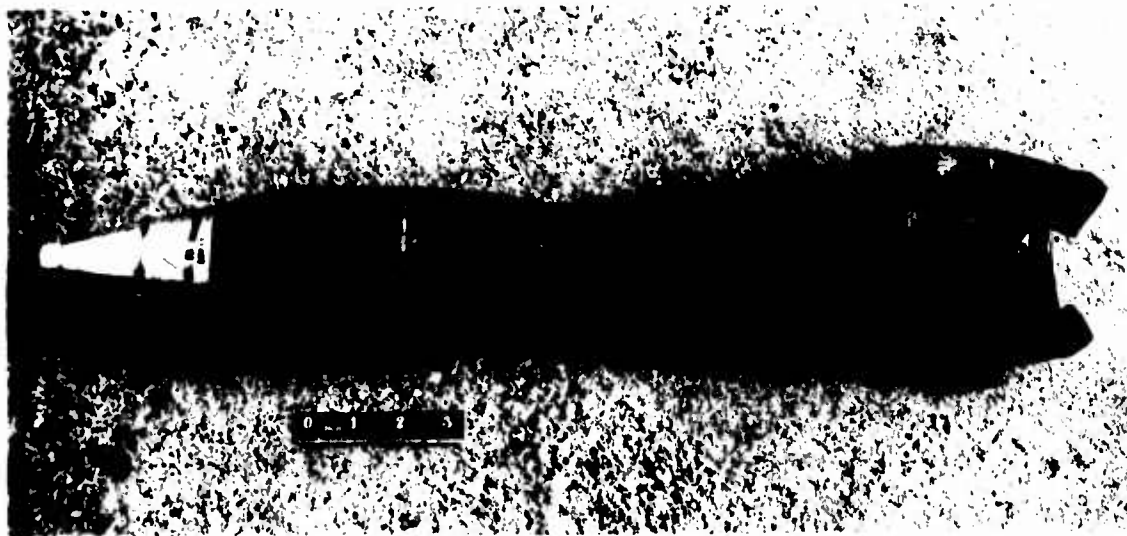


Figure 2.7-2: M374A2 Cartridge with Black Bag (Plastic) Charge Protector.

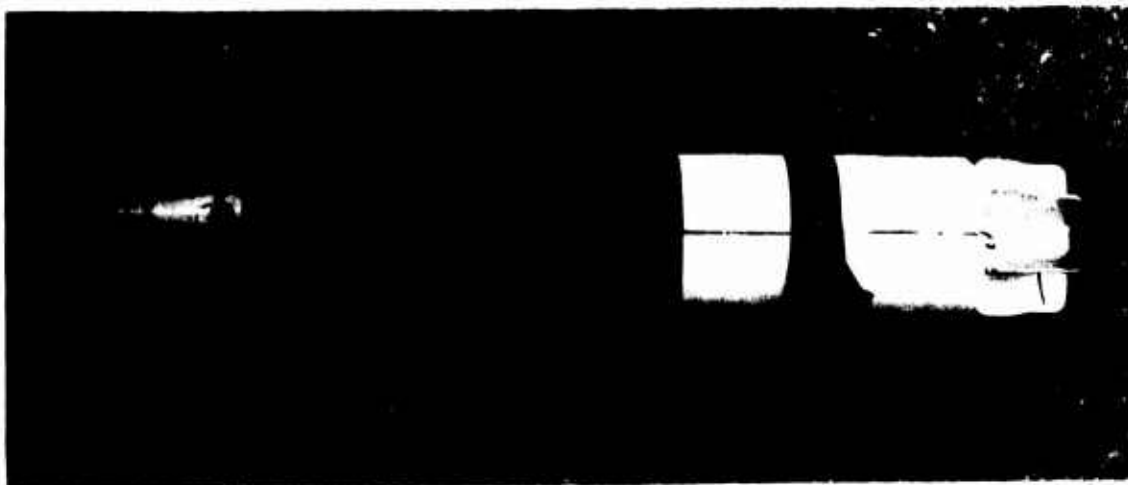


Figure 2.7-3: M374A2 Cartridge with Clamshell (Styrofoam) Charge Protector.

2.8 COOK-OFF PHASE

2.8.1 Objective

The objective was to determine if the test cartridge assembled to simulate a misfire will cook-off in the M29 mortar barrel.

2.8.2 Criteria

The test cartridge will not introduce additional safety hazards to the mortar crew when compared to the control cartridge.

2.8.3 Method

An 81-mm mortar was assembled with thermocouples attached 36 inches from the muzzle of the tube and a temperature recorder was used to monitor tube temperature.

During the residue phase, after firing charge 7 and charge 9 groups, a simulated misfire was inserted in the tube to determine cook-off potential.

Sufficient control rounds were fired at charge 9 to heat the tube to +550°F. When this temperature was reached, a test round, at charge 9, less primer, was inserted in the tube. If a cook-off occurred, a second and then a third round were inserted after every 25° temperature drop and continued until no cook-off occurred. The temperature and elapsed time were recorded for each cook-off.

The test was repeated by again heating the tube to 550°F but this time the control round, less primer, was inserted.

The entire test was repeated by lowering the starting weapon temperatures in 100-degree increments until no cook-off occurred with either round.

The simulated misfire cartridge was left in the mortar for a minimum of 10 minutes before removing it if no cook-off occurred.

2.8.4 Results

Results of the cook-off phase are presented in Table 2.8-I.

2.8.5 Analysis

Test criterion was met. Results of present test indicate that the M374A2 test round with Celcon/silk increment bags will cook-off at lower tube temperatures than M374 rounds with cotton bag increments. Tests reported in Report No. APG-MT-3285 indicated that the M374 cartridge will cook-off at a temperature as low as +440°F and after 89 seconds.

The shorter cook-off time of well under 1 minute for the test cartridges reduces the safety hazard as compared to the M374 cartridge with cook-off times well over 1 minute.

All cook-off rounds in the test had very short ranges.

Table 2.8-I. Cook-Off Data

Cook-Off Rd No.	Phase and Phase Test No.	No. Heating Rds and Chg	Cook-Off Rd Type	Tube Temp, °F		Time to Cook-Off, sec	Approx Range, yd
				Insert	Cook-Off		
1	Residue, 9	25, 7	M374A2	aUnkn	aUnkn	6	30
b2	Residue, 11	25, 9	M374A2	618	598	20	20 to 40
3	Residue, 11	25, 9	M374A2	618	570	21	20 to 40
4	Residue, 11	25, 9	M374A2	618	535	9	20 to 40
5	Residue, 11	25, 9	M374A2	618	500	27	20 to 40
6	Cook-off, 1	24, 9	M374A2	592	565	36	20
c7	Cook-off, 1	24, 9	M374A2	520	No	-	-
d8	Cook-off, 2	21, 9	M374	580	No	-	-

^aTube temperature not recorded.

^bCook-off round No. 2 was inserted in the tube immediately after the last heating round was fired.

Cook-off rounds Nos. 3, 4, and 5 were inserted immediately after the preceding round cooked-off.

^cCook-off round No. 7 was inserted after No. 6 when the tube temperature was at +520°F, but it failed to cook-off.

^dAn M374 cook-off round (cotton bag increments) was inserted immediately after the last heating round was fired, but it failed to cook-off. Waited 10 minutes.

2.9 HUMAN FACTORS PHASE

2.9.1 Objective

The objective was to evaluate any human factors associated with the test item.

2.9.2 Criterion

No human factors shall be introduced which will interfere with the performance of the intended mission.

2.9.3 Method

Observations were made throughout the test for any possible factors which would require modification to present training or use of warnings. In addition, representatives of USAIB at Ft. Benning visited APG for an examination of the test item and a briefing on test results.

2.9.4 Results

The white color of the muffs was considered objectionable by the USAIB representatives due to the problem of concealment (Appendix V). The cartridge presented no potential or real problems in human factors.

2.9.5 Analysis

The test criteria are considered to be met when the USAIB recommendation is included in production.

SECTION 3. APPENDICES

APPENDIX I - TEST DATA

Items Under Test

- Cartridge, 81-mm, HE, XM374A2 (inert-loaded), with inert M524A6 fuze, lot MA-SP-912A (data card lists this cartridge as M374 but it is M374A2).
- Cartridge, 81-mm, HE, M374A2 (inert-loaded), with empty M524A5 fuze, lot MA-SP-920C.
- Cartridge, 81-mm, HE, M374 (inert-loaded), with empty M524A5 fuze, lot MA-SP-920B.

Supporting Facilities and Materials

Weapons:

- Mortars, 81-mm, M29E1, Nos. 9434 and 9431.
- Mounts, mortar, M23A1, Nos. 7922, 4388, and 8416.
- Baseplate, 81-mm mortar, M3, No. unknown.

Ammunition:

- Cartridge, 81-mm, HE, M374 and M362 (inert-loaded), with dummy fuze, lots various (conditioning rounds).

Facilities:

- Firing positions (see round-by-round data).

Instrumentation:

- Velocities (where pertinent) were measured by two 30-inch solenoid coils at various distances from the mortar muzzle and connected to recording chronographs.
- Heat measurements of the mortar in the residue and cook-off phases, were obtained by two iron-constantan thermocouples attached to the mortar tube by ceramic (alumina) spray, 36 inches from the muzzle, recorded by two single-channel continuous-trace temperature recorders.
- Ranges were determined by transit triangulation by observers at three or more observation points downrange.
- Chamber pressures were measured by two external T13 copper-crusher gages per round. The average reading for the two gages was recorded.
- Sheet No. 29 of Round-by-Round Data (Improvised Assembled Mortar Test). This 6-round firing was for information only and had no particular bearing on the product improvement test of the M374A2 cartridge.

The round-by-round data are filed under Firing Record No. P-79630 at APG.

DEPARTMENT OF DEFENSE ACTIVITY DATA CARD		FORM APPROVED BUDGET BUREAU NO. 22-RC269		LOT NUMBER MA-SP-920C		
ITEM NOMENCLATURE M374A2		FSM N/A		PACKING OF LOT 1 Rd./Fiber Container M252 U, W/Insert & increment shell, double wrapped; 3 Containers/Box, Dwg. 9230176; 36 Wood Box, 1/4 way fallet.		
MANUFACTURING, LOADING OR ASSEMBLING ACTIVITY MILAN ARMO PLANT		NET QUANTITY 210				
CONTRACTOR ALUMINUM SALES, INC.	CONTRACT OR ORDER NO. DA-11-173-AMC-520(A)	DRAWING OR REVISION See Note 1		SPECIFICATION & REVISION M374A2		
DATE STARTED 3-6-70	DATE COMPLETED 3-6-70	DATE INSPECTED 3-6-70		LINE C	ZONE WT SHELL	
GRADE WEIGHT	INDEX OF POWDER	MFG IN INCHES		PPDR IN INCHES		
EXPLOSIVE WT PER Pkg	EXPECTED MUZZLE VELOCITY	EXPECTED PRESSURE		SHELL WEIGHT 1.5 lbs		
NUMBER OF TEST SAMPLES	SENT TO	DATE AND MODE OF SHIPMENT				
COMPONENTS (CONTINUE ON REVERSE, IF NECESSARY)						
COMPONENTS	DRAWING NO.	MODEL	MANUFACTURER	DATE MFG	LOT NO.	QUANTITY
Projectile Metal Parts	10543025	M374A1	Burlington Army Ammo Plt	1970	SP-12-3	210
Ring, Coating	10534925/B		Reo Plastics, Inc.	1970	RFP-2-72	
Filler "E"						
Consisting of:						
Glyceride of 12 Hydroxy Stearic Acid - 35%	FA-PD-721		Baker Castor Oil Co.	Unk.	Unk.)	
Stearic Acid - 60%	FA-PD-722		U. S. Gypsum Co.	Unk.	Unk.)	
DISPOSITION			TYPED NAME OF GOVERNMENT INSPECTOR			
ACCEPTED			MALCOLM INGRAM			
			SIGNATURE <i>Malcolm Ingram</i>			

COMPONENT (CONT' FROM FRONT)	DRAWING NO.	MODEL	MANUFACTURER	DATE MFG	LOT NO.	QUANTITY
Filler "E" (cont'd)						
Resin - 5%	111-P-126B		Pittsburgh Plate Glass	Unk.	Unk.)	
Inner	7549012		Anaconda American Brass	1969	ARB-43-12	
Fir Assembly	10551892	M170	Grand Machining Co.	1969	GYR-1-2	
Cartridge, Ignition	9240950	M285	Security Signals, Inc.	1970	SSK-1-7	
Plate, Pressure	9218640		FTS Corp.	1969	FTS-11-42	
Increment Holder	7549026/Unk		Hunter-Springs	1969	HS-8-3	
Fuze, P.C.	9205729/H (ref)	M524A5	Milan Army Ammo Plant	1970	None	
Increment, Propellant	9233369	M90A1	Radford Arsenal	1970	RAD-66693	
Inc. A						
Increment, Propellant	9233371	M90A1	Radford Arsenal	1970	RAD 67155	1,680
Inc. B						
Primer, Percussion	7549173/G	M71A1E1	Milan Army Ammo Plant	1970	MA-2-121	
Stop Packing	8838116		Barry County Precision	1969	BAC-2-11	
Container, Fiber	9230175	M252A3	United Armo Container	1970	None	
W/Insert & Increment Shell (1 Foil)						
Box, Wood, Packing	9230176		F & S Box Co.	1955)	None	70
(Untreated)			Milan Box Co.	thru		
			W & W Construction	1967)		

REMARKS: (SYMBOLS: *CHANGES IN PROCESS; **DEVIATIONS FROM DWG. OR SPEC; ***UNUSUAL OCCURRENCES OR DIFFICULTIES)

- Dwg. 9240950, Rev. A (ref).
- This lot was inert loaded, assembled W/Empty M524A5 Fuze, M374A1 projectiles and M90A1 propellant increments, and packed as inert test rounds as directed by AFSA 7050 Megs AEP-MA-23-70 dtd 2-13-70, and AEP-MA-52-30 dtd 2-24-70.

DEPARTMENT OF DEFENSE APPLICATION DATA CARD
 FORM APPROVED BUDGET BUREAU NO. 22-80260
 LOT NUMBER MA-SP-921A & B

ITEM NOMENCLATURE
 Cartridge, SIMM, Inert, M374
 W/Inert M52446 Fuze
 F/Mortars M1 and M29
 F&N N/A
 PACKING OF LOT
 1 Rd./Plastic Container, M513,
 3 Containers/Wood Box,
 Dwg. 9230120;
 36 Boxes/4-Way Pallet.

MANUFACTURING, LOADING OR ASSEMBLING ACTIVITY
 THE ARMY AMMUNITION PLANT
 NET QUANTITY 1,361
 CONTRACT OR ORDER NO.
 DA-11-173-MC-626(A)
 DRAWING OR REVISION
 See Note 1
 SPECIFICATION & REVISION
 M.L. 45595
 DATE STARTED 2-27-70
 DATE COMPLETED 3-2-70
 DATE INSPECTED 3-2-70
 LINE C
 ZONE WT SHELL
 CHANGE WEIGHT
 INDEX OF POWER
 MPD IN INCHES
 PPD IN INCHES
 EXPLOSIVE WT PER P&R
 EXPECTED MUZZLE VELOCITY
 EXPECTED PRESSURE
 SHELL WEIGHT
 APPROX. 9.18 lbs.
 NUMBER OF TEST SAMPLES
 SENT TO
 DATE AND MODE OF SHIPMENT

COMPONENTS (CONTINUE ON REVERSE, IF NECESSARY)

COMPONENTS	DRAWING NO.	MODEL	MANUFACTURER	DATE MFG	LOT NO.	QUANTITY
Projectile Metal Part	10543025	M374A1	The Aestolite Co.	1970	PFE-1-2	1,361
Filler "E" inert Pad	PA-PD-796					
Consisting of						
Glyceride of 12 Hydroxy Stearic Acid - 35%	PA-PD-721		Wallace & Tiernan, Inc.	1968	M-301	
Gypsum, Dead Burned - 65%	PA-PD-722		U. S. Gypsum Co.	Unk.	Unk.	

DISPOSITION
ACCEPTED
 TYPED NAME OF GOVERNMENT INSPECTOR
 MALCOLM INGRAM
 SIGNATURE
Malcolm Ingram

COMPONENT (CONT' FROM FRONT)	DRAWING NO.	MODEL	MANUFACTURER	DATE MFG	LOT NO.	QUANTITY
Filler "E" (cont'd)						
Rosin - 5%	LLL-F-626B		Pittsburgh Plate Glass	Unk.	Unk.	
Ring, Obturating	10534925/B		Reo Plastics, Inc.	1970	REF-2-72	
Liner	7549011		Anaconda American Brass	1969	AA8-43-12	
Fin Assembly	10551892	M170	Grand Machining Co.	1970	CYI-2-3	
Cartridge Ignition	9240960	M285	Security Signals, Inc.	1969	SSK-2-7	
Plate, Pressure	9218640		FIS Corp.	1969	FIS-1-42	
Increment Holder	7549026/Unk		Hunter-Springs	1969	ES-6-2	
Fuze, P.D.	9205729/L (ref)	M52446	Milan Army Ammo Plant	1970	None	
Increment, Propellant Chg. A	9233369	M90E1	Radford Arsenal	1969	PAL-66693	
Increment, Propellant Chg. B	9233371	M90E1	Radford Arsenal	1969	PAL-67155	10,888
Primer, Percussion	7549173/C	M1A1E1	Milan Army Ammo Plant	1970	MA 2-120	
Label, Warning	7549014/B		J. S. Tape & Label Co.	1969	None	
Stop Packing	8838116		Garry County Precision	1969	B4C-2-11	
Container, Plastic	8864657/D	M513	Dow Chemical Co.	Unk.	Unk.	
"C" Ring	MIL-STI-417		Precision Rubber Co.	Unk.	Unk.	
Box, Wood, Packing (Preservative treated)	9230120		Milan Box Corp.	1967	None	455

REMARKS: (SYMBOLS: *CHANGES IN PROCESS; **DEVIATIONS FROM DWG. OR SPEC; ***UNUSUAL OCCURRENCES OR DIFFICULTIES)
 1. 8881026 Rev. R, W/FAN 6900131 (ref).
 2. This lot loaded with Filler "E", and assembled, completely inert, as directed by AFSA 1050 Msg. No. AEF-MA-44-70 dtd 1-21-70.
 (MA-SP-921a & B, M374)

DEPARTMENT OF DEFENSE AMMUNITION DATA CARD		FORM APPROVED SUBJECT BUREAU NO. 22-R0289		LOT NUMBER MA-SP-920B		
ITEM NOMENCLATURE Cartridge, 81MM, Inert, M374 W/Empty M524A5 Fuze F/Mortars M1 and M29		P&M N/A		PACKING OR LOT 1 Rd./Fiber Container, M252A3, Jungle Wrap; 3 Containers/Wood Box Dwg. 9230176; 36 Wood Boxes/4-Way Pallet.		
MANUFACTURING, LOADING OR ASSEMBLING ACTIVITY MILAN ARMY AMMUNITION PLANT		REV QUANTITY 380				
CONTRACTOR HAYES ALUMINUM SALES, INC.	CONTRACT OR ORDER NO. DA-11-173-AMC-520(A)	DRAWING OR REVISION See Note 1		SPECIFICATION & REVISION MIL-C-10995C (M1)		
DATE STARTED 3-6-70	DATE COMPLETED 3-6-70	DATE INSPECTED 3-6-70		LINE C	ZONE BY SHELL	
CHARGE WEIGHT	INDEX OF POWDER	MPD IN INCHES		PPDR IN INCHES		
EXPLOSIVE WT PER Pkg	EXPECTED MUZZLE VELOCITY	EXPECTED PRESSURE		SHELL WEIGHT Approx. 9.18 lbs.		
NUMBER OF TEST SAMPLES 3	SENT TO	DATE AND MODE OF SHIPMENT				
COMPONENTS (CONTINUE ON REVERSE, IF NECESSARY)						
COMPONENTS	DRAWING NO.	MODEL	MANUFACTURER	DATE MFG	LOT NO.	QUANTITY
Projectile Metal Parts	10543025	M374	Hayes-Albion	1966	ALR-5-1	29
					ALR-5-2	40
					ALP-5-3	33
					ALR-5-4	8
					ALP-4-2	172
					ALP-4-2	4
					ALR-4-3	2
DISPOSITION			TYPED NAME OF GOVERNMENT INSPECTOR MALCOLM INGRAM			
			SIGNATURE <i>Richard B. ...</i>			

COMPONENT (CONT' FROM FRONT)	DRAWING NO.	MODEL	MANUFACTURER	DATE MFG	LOT NO.	QUANTITY
Projectile Metal Parts (cont'd)					ALR-4-4	10
					ALF-4-5	7
					ALP-2-1	7
					ALP-2-2	24
					ALP-2-3	24
					ALP-1-4	7
					ALF-1-5	3
					ALP-2-7	5
ALP-2-1	1					
Ring, Obturating Filler "E"	10534925/B		Reo Plastics, Inc.	1970	REP-2 72	380
Consisting of:						
Glyceride of 12 Hydroxy Stearic Acid -35%	PA-PD-721		Baker Castor Oil Co.	Unk.	Unk.	
Gypsum, Dead Burned -60%	PA-PD-722		U. S. Gypsum Co.	Unk.	Unk.	
Rosin - 5%	LLL-R-626B		Pittsburgh Plate Glass	Unk.	Unk.	
Liner	7549011		Anaconda American Brass	1959	AAB-43-12	
Fin Assembly	10551892	M170	Stewart-Warner	1970	SW 1-4	
Cartridge, Ignition	9240960	M285	Security Signals, Inc.	1970	SSK-1-7	
Plate, Pressure	9218640		FTS Corp.	1969	FTS-11-42	
Increment Holder	7549026/Unk		Hunter-Springs	1969	HS-8-3	
Fuze, P.D.	9205729/H (ref)	M524A5	Milan Army Ammo Plant	1970	None	
(MA-SP-920B, M374)		(CONTINUED ON ATTACHED CARD)				

MA-SF-920B

COMPONENT (CONT' FROM FRONT)	DRAWING NO.	MODEL	MANUFACTURER	DATE MFG.	LOT NO.	QUANTITY
Increment, Propellant Chg. A	8881021/Unk	M90	Radford Arsenal	1970	RAD-66692	
Increment, Propellant Chg. B	8881023/Unk	M90	Hercules Powder Plant	1970	HEP-67312	3,040
Primer, Percussion	7549173/G M71A1E1	M71A1E1	Milan Army Ammo Plant	1970	MA-2-121	
Bag, Protective Ass'y	9229185		Crystal-X Corp.	1969	None	
Tape, Filament, Black	9233459		Armour Industrial Prod.	1969	None	
Stop, Packing	8838116		Barry County Precision	1969	BAC-2-11	
Container, Fiber (1 Foil)	9230175	M252A3	United Ammo Container	1970	None	
Box, Wood, Packing (Untreated)	9230176		J & S Box Co. Milan Box Co. W & W Box Co.	1955 1957	None	127

(MA-SF-920B, M374)

REMARKS: (SYMBOLS: *CHANGES IN PROCESS; **DEVIATIONS FROM DWS. OR SPEC; ***UNUSUAL OCCURRENCES OR DIFFICULTIES)

1. Dwg. 8881026, Rev. H, W/PAN 6900131 (ref).
2. This lot was inert loaded, assembled W/Empty M524A5 fuze, M374 projectiles, and M90 propellant increments, and packed as inert control rounds as directed by AFSA 1050 Msgs AEP-MA-23-70 dtd 2-13-70 and AEP-MA-52-30 dtd 2-24-70.

APPENDIX II - TEST FINDINGS

<u>Item</u>	<u>Source</u>	<u>Requirements</u>	<u>Applicable Subtest</u>	<u>Remarks</u>
1	See note below	There will be less than 1% misfires caused by propellant bag residue remaining in the tube.	2.2	Met.
2		The velocity levels of the test and control cartridges shall not differ significantly at the 95% confidence level. The standard deviation of the test cartridge shall not be significantly worse than that of the control cartridge at the same level.	2.3	Not fully met. Averages varied to a significant degree.
3		No individual peak chamber pressure with the test cartridge conditioned at +1450F shall exceed 10,600 psi.	2.3	Met.
4		A ballistic match shall exist between test and control cartridges.	2.3	Met.
5		The test cartridge performance shall be equal to or significantly better than that obtained in the USATECOM evaluation when	2.4	Not fully met. Rain test results worse than USATECOM evaluation rounds, but better than cartridge, M374 with cotton bags.

Item	Source	Requirements	Applicable Subtest	Remarks
		submitted to the following environments:		
		a. Puddle.		
		b. Rain.		
		c. Ten day warm - wet humidity test.		
6		The test cartridge shall be operational and safe to fire being subjected to rough handling.	2.5	Met.
7		The test cartridge will not be adversely affected by the simulated desert cycle of solar radiation.	2.7	Met.
8		The test cartridge will not introduce additional safety hazards to the mortar crew when compared to the control cartridge.	2.8	Met.

Source of the requirements was the test plan mutually agreed upon by USATECOM and USAMUCOM to determine that the test cartridge was equal to or better than the cartridge tested in the USATECOM evaluation of the design.

APPENDIX III - DEFICIENCIES AND SHORTCOMINGS

1. Deficiencies

None

2. Shortcomings

None

APPENDIX IV - MAINTENANCE EVALUATION

No maintenance problems were noted. Present maintenance instructions for 81-mm mortar ammunition should be adequate for this cartridge.

APPENDIX V - CORRESPONDENCE

COPY/she

DEPARTMENT OF THE ARMY
HEADQUARTERS, U.S. ARMY TEST AND EVALUATION COMMAND
ABERDEEN PROVING GROUND, MARYLAND 21005

S - 7 Mar 1969

AMSTE-BC

3 MAR 1969

SUBJECT: Directive for Product Improvement Test of Cartridge, 81mm, HE, M374 with Reduced Bourrelet and Waterproofed Ignition/Propellant System, USATECOM Project No. 8-9-3010-20

Commanding Officer
Aberdeen Proving Ground
ATTN: STEAP-CO-P
APG, Maryland 21005

1. Reference: Message, AMCPM-MT 02-0594 for AMSTE-BC, 12 Feb 1969, subject: Independent USATECOM Evaluation of Product Improved 81mm M374 Cartridge, Inclosure 1.
2. Background: Currently, Cartridge, 81mm, HE, M384 and its WP counterpart, M375, does not feature a waterproof ignition/propellant system. As a result, short rounds and misfires have been encountered in the field when these cartridges have been exposed to excessive moisture. As an interim solution relative to moisture protection, 81mm mortar ammunition is currently supplied to the field in a fiber container, which in turn is "Jungle Wrapped." As the section of the cartridge containing the ignition/propelling charge is protected by a waterproof barrier bag, the cartridge can be removed from its shipping container and still be waterproof, however, once the barrier bag is removed the item is again susceptible to moisture contamination. Because of ammunition preparation requirements at combat mortar positions, this is undesirable. Picatinny Arsenal has been tasked to develop a moisture resistant ignition/propellant system for use with current 81mm mortar ammunition. Waterproofing of components has resulted in an acceptable ignition system; testing of a waterproof propelling charge is currently underway at APG and is expected to provide sufficient data upon which a choice of propelling bag material can be made. This command has been tasked by AMCPM-MT to conduct an independent evaluation of the final waterproof design and submit conclusions relative to item suitability for US Army use.

COPY/she

SUBJECT: Directive for Product Improvement Test of Cartridge, 81mm, HE, M374 with Reduced Bourrelet and Waterproofed Ignition/Propellant System, USATECOM Project No. 8-9-3010-20

3. Description of Materiel: The test item will feature the Cartridge, 81mm, M374 with a reduced bourrelet; an ignition cartridge container with 24 - 0.125 inch flash holes; a 108 grain mylar wrapped ignition cartridge without brass liner and primer with sealant applied to the primer threads. The final selection of a waterproof propellant bag materiel has not yet been made, however, current testing favors use of a celcon/silk bag materiel.

4. Test Objectives:

a. To determine if the waterproofed ignition/propellant system will provide sufficient protection against moisture to eliminate or significantly reduce field problems with short rounds.

b. To determine if performance characteristics in temperature extremes, of pressure, velocity, range, accuracy, signature, etc., are affected by the waterproofed ignition/propellant system and the bourrelet reduction.

c. To assure that no safety or human factors problems have been induced into the system.

d. To determine suitability for US Army use as an alternate for the induced standard cartridge.

5. Responsibilities: Aberdeen Proving Ground will:

a. Review and analyze all data from previous tests at Picatinny Arsenal and at Aberdeen Proving Ground.

b. Prepare a formal test plan in accordance with USATECOM Regulation 705-2 that will satisfy the objectives of paragraph 4.

c. Conduct the Product Improvement Test, prepare the final report, and provide this headquarters with a recommended USATECOM position relative to suitability for US Army use of the waterproofed ignition/propellant system as an alternate for the current standard system.

d. Prepare an Initial Production Test Plan to satisfy the requirements of AMC Regulation 700-34 and forward this plan through this headquarters to Picatinny Arsenal for concurrence, approval and assignment. The Initial Production Test will be assigned to separate USATECOM project number upon receipt of a test request from Picatinny Arsenal.

COPY/she

SUBJECT: Directive for Product Improvement Test of Cartridge, 81mm, HE, M374 with Reduced Bourrelet and Waterproofed Ignition/Propellant System, USATECOM Project No. 8-9-3010-20

6. Coordination: Aberdeen Proving Ground is to coordinate the Initial Production Test Plan with Picatinny Arsenal.

7. Special Instructions:

a. USATECOM Project No. 8-9-3010-20 is assigned as per STE Form 1028, Inclosure 2.

b. If actual or potential human factors problems can be associated with the test ammunition, i.e., loading, rate of fire, handling of charges, etc., they should be discussed with the US Army Infantry Board, and if deemed necessary, additional tests will be imposed with the participation of the USAIB to resolve mutual concerns. The degree of participation of the USAIB is to be resolved at an early date and this headquarters is to be advised accordingly so as to permit direction to USAIB as deemed necessary.

c. Aberdeen Proving Ground is to submit funding requirements to this headquarters.

c. APG recommendations will not be included in the test report, but will be forwarded this headquarters under separate cover.

8. Test Plans and Reports:

a. Aberdeen Proving Ground will submit 10 copies of the formal test plan as stated in paragraph 5b to this headquarters no later than 7 March 1969.

b. A final test report will be prepared in accordance with USATECOM Regulation 705-2 and 30 copies will be forwarded to this headquarters for approval and distribution.

c. As per paragraph 5d, an Initial Production Test Plan will be prepared by Aberdeen Proving Ground. A complete formal test plan is not required, but Section 2, "Details of Test" of USATECOM Regulation 705-2 should be included as a minimum.

9. Safety: Sufficient testing should be conducted to provide assurance that the product improved ignition/propellant system is as safe as the current standard system.

10. Security: Test Materiel, data and reports will be unclassified.

COPY/she

SUBJECT: Directive for Product Improvement Test of Cartridge, 81mm, HE,
M374 with Reduced Bourrelet and Waterproofed Ignition/Propel-
lant System, USATECOM Project No. 8-9-3010-20

FOR THE COMMANDER:

- 3 Incl *w/d*
1. Msg, AMCPM-MT
2. STE Form 1028
3. Dist List

/s/ C. J. Molloy, Jr.
/t/ C. J. MOLLOY, JR.
Colonel, GS
Dir, Inf Mat Test Dir

Copies furnished: (w/o incl)
Pres USAIB
CG USAJUCOM ATTN: AMSPM-MT
AMSMU-RE
CO PA ATTN: SMUPA-DA4



DEPARTMENT OF THE ARMY
UNITED STATES ARMY INFANTRY BOARD
Fort Benning, Georgia 31905

STEBC-SW

15 May 1970

SUBJECT: Initial Production Test of Cartridge, 81-mm, HE, M374, with
Reduced Bourrelet and Waterproofed Ignition/Propellant System
USATECOM Project No MU-001-374-039

Commanding Officer
Aberdeen Proving Ground
ATTN: STEAP-MT-TA (Mr. Lavery)
Aberdeen Proving Ground, Maryland 21005

1. Reference is made to IPT of Cartridge, 81-mm, HE, M374, with Reduced Bourrelet and Waterproofed Ignition/Propellant System, to include Protective Muff, (test item).
2. On 24 April 1970, representatives from USAIB inspected the test item at the Materiel Test Directorate, Aberdeen Proving Ground, to determine if the modifications made to the test item had any actual or potential human factor problems.
3. No actual or potential human factor problems were detected; however, the color of the muff (white) is tactically unacceptable.
4. It is recommended that the muff be black or brown to conform with current camouflage techniques.

FOR THE PRESIDENT:

Robert L. Vick
ROBERT L. VICK
CW2, USA
Adjutant



DEPARTMENT OF THE ARMY Mr. Nelson/ajb/3661
BALLISTIC RESEARCH LABORATORIES
U S ARMY ABERDEEN RESEARCH AND DEVELOPMENT CENTER
ABERDEEN PROVING GROUND, MARYLAND 21005

AMXRD-BEL-FT

9 June 1970

SUBJECT: Ballistic Match Test of Cartridges, HE,
M374A2 Versus HE, M374

Commanding Officer
Aberdeen Proving Ground
ATTN: STEAP-MT-TA
Mr. R. Holwager
Aberdeen Proving Ground, Md. 21005

1. This office was asked by Picatinny Arsenal to evaluate range data fired at APG on 8, 9 and 10 April 1970. The evaluation is to determine if the subject cartridges are ballistically matched to the extent that they can be fired effectively using the same firing tables.
2. Analysis of the data included statistical tests of the variances in range and muzzle velocity which revealed the following:
 - a. Significant differences exist in the mean values for most charges.
 - b. No significant differences were noted in dispersion.
 - c. Most differences in range are directly related to differences in velocity.
 - d. A muzzle velocity cross-over occurs between charges six and seven.
3. In order to provide more accurate aiming data when firing the subject cartridges, a correction to muzzle velocity must be made for one cartridge when attempting to use the same aiming data for both.
4. Present firing tables for Cartridge, HE, M374 will suffice for firing Cartridge, HE, M374A2 until more aiming data are available.

FOR THE DIRECTOR:


CHARLES H. LEBEGERN, JR.
Chief, Firing Tables Branch

APPENDIX VI - REFERENCES

1. Cheater, H. W., Test Plan on Initial Production Test of Cartridge, 81-MM, HE, M374 with Reduced Bourrelet and Waterproofed Ignition/Propellant System, with Change No. 1, USATECOM Project No. 8-MU-001-374-039. Aberdeen Proving Ground.
2. Cheater, H. W., Final Report on Product Improvement Test of Cartridge, 81-MM, M374 with Modified Ignition - Propellant System and Reduced Bourrelet. USATECOM Project No. 8-MU-001-374-010. Aberdeen Proving Ground. APG-MT-3311, August 1969. (Distribution controlled by Project Manager, US Army Munitions Command, ATTN: AMCPM-MT, AD 858 986.)
3. Cheater, H. W., Final Report on Product Improvement Test of Cartridge, 81-MM, HE, M374 with Reduced Bourrelet and Waterproof Ignition/Propellant System, USATECOM Project No. 8-MU-001-374-008. Aberdeen Proving Ground. Report No. APG-MT-3285, August 1969. (Distribution controlled by Project Manager, US Army Munitions Command, ATTN: AMCPM-MT, AD 858 984L.)

APPENDIX VII - ABBREVIATIONS

APG	= Aberdeen Proving Ground
Avg	= average
BRL	= Ballistic Research Laboratories
cond	= condition
cons	= considered
deg	= degree
dev	= deviation
diff	= difference
F	= Fahrenheit
fps	= feet per second
g	= acceleration due to gravity
HE	= high explosive
ICAO	= International Civil Aviation Organization
incr	= increment
IP	= initial production
max	= maximum
MIL STD	= Military Standard
min	= minimum or minute
MTP	= Materiel Testing Pamphlet
mv	= muzzle velocity
No.	= number
PE	= probable error
press.	= pressure
psi	= pounds per square inch
QE	= quadrant elevation
rd	= round
rpm	= revolutions per minute
RTV	= room type vulcanizing silicone rubber
std	= standard
T-C	= between test and control rounds
temp	= temperature
USAIB	= US Army Infantry Board
USAMUCOM	= US Army Munitions Command
USATECOM	= US Army Test and Evaluation Command
vel	= velocity
WP	= white phosphorus
wt	= weight

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INITIAL PRODUCTION TEST OF CARTRIDGE, 81-MM, HE, M374A2 WITH REDUCED HOURRELET AND WATERPROOFED IGNITION - PROPELLANT SYSTEM			
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13. ABSTRACT			
<p>An initial production test was conducted at Aberdeen Proving Ground from 30 March to 14 May 1970 on the 81-mm mortar cartridge, HE, M374A2 (M374E5) which features a reduced bourrelet and a water resistant ignition - propellant system. The cartridges tested were inert-loaded and represent the initial production of Milan Army Ammunition Plant. Various tests were conducted to determine if the test item was equal to or better than the M374E5 test cartridge submitted previously for US Army Test and Evaluation Command evaluation. Residue tests were satisfactory; velocity level differences of test rounds were significant though of small magnitude compared with the control (M374), and velocity and range dispersion were equal to or better than the control; pressures were satisfactory; test rounds did not perform as well as previously in waterproofness tests because the ends of the Celcon/silk propellant bags were sewed and not heat-sealed as in the earlier version; there were short rounds in the rain test, but none in the puddle or humidity test; rough handling tests using charge protector muffs were satisfactory; solar-radiation tests with charge protection were satisfactory; and cook-off hazards and maintenance with test rounds were not significantly different from that experienced with control rounds. United States Army Infantry Board representatives found no human factors problems except that the white increment protector muffs should be black or brown to conform with current camouflage techniques. It was concluded that the initial production M374A2 cartridges performed satisfactorily, equal to, or better than the item in the previous US Army Test and Evaluation Command evaluation in all phases except for velocity level and waterproofness. A correction to firing tables to compensate for velocity differences is required.</p>			

DD FORM 1473
1 NOV 66

REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

Unclassified
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Bourrolet, reduced, 81-mm Ignition - propellant system, 81-mm Cartridge, 81-mm, HE Waterproofed ignition - propellant, 81-mm Mortar cartridge, 81-mm, HE						