

AD-775 478

**XM129 40mm GRENADE LAUNCHER BARREL
IMPROVEMENT PROGRAM**

Maremont Corporation

Prepared for:

Army Armament Command

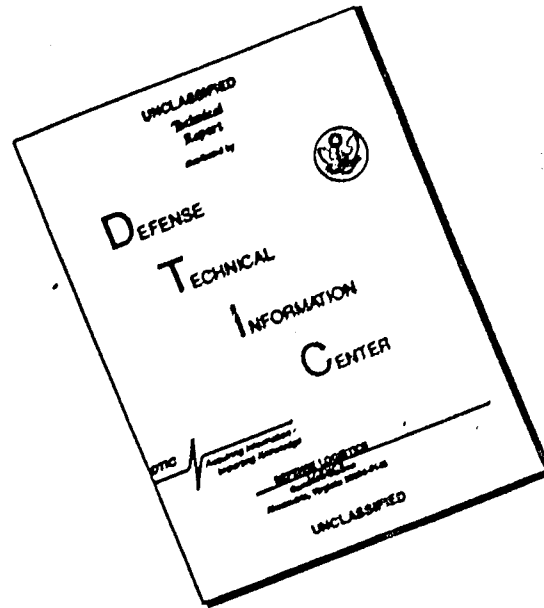
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Final Technical Report
XM129 40mm
Grenade Launcher
Barrel Improvement Program

Contract No. DAAF03-73-C-0140

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INTRODUCTION AND SUMMARY

Various materials, coatings and mechanical changes to improve barrel life were previously tested and evaluated by Maremont under contract DAAF03-71-C-0331. It was concluded by that effort that one of the materials tested, H-11 tool steel, showed promise of significantly extending the average service life of the XM129 40mm barrel and it was recommended that additional testing be accomplished.

The objective of the scope of work under Contract DAAF03-73-C-0140 was to fabricate one (1) hard chrome plated H-11 alloy barrel and test fire it a total of 15,000 rounds or until the barrel was declared unserviceable. In addition, test firing of barrel #H-1 of H-11 material from the previous contract would continue until 15,000 rounds or it became unserviceable. Barrel #H-1 was initially fired 9,359 rounds at which time an in-bore jam occurred when the projectile, during chambering wedged against a piece of rotating band which had been torn loose from the previous round and lodged in the barrel.

The test firing was to be conducted in accordance with the schedule approved for the first contract. This work has been completed, the barrels have been sectioned and examined and the findings are presented in this report.

CONCLUSIONS

The observations made during the metallographic examinations showed that the erosion rate of the chrome plate and the substrate material was much slower in barrels with the H-11 alloy material than with the standard barrel of AISI 4340. The hard chrome plate does not crack and pop off the H-11 alloy as was characteristic with the AISI 4340 and once exposed, the H-11 exhibits a much greater resistance to the erosion action of the hot gas stream.

These factors indicate that the average service life of the XM129 40mm barrel can be significantly increased with the use of H-11 material. Based on the performance of the various barrels tested per the prescribed firing schedule, the H-11 material with a hard chrome plate bore would nearly double the average service life of this barrel.

RECOMMENDATIONS

The following recommendations for increasing the average service life of the XM129 40mm barrel are based on the performance characteristics of those barrels tested under Contract DAAF03-71-C-0331 and the current contract and an in-depth engineering evaluation.

1. Redesign of the cartridge case so the high velocity gases do not impinge directly on the sides of the barrel.
2. Applications of thicker chrome plate on the barrel bore.
3. Use of H-11 alloy steel as the barrel material. H-23 alloy steel would be an alternate if the proper heat treatment can be maintained to avoid brittle failures.

DISCUSSION

Barrel #H-1 was fired a total of 9,359 rounds during the initial test program and was declared unserviceable at that time when an in-bore jam occurred. During the current contract effort, an additional 2,828 rounds were fired for a total count of 12,187 rounds on the barrel. Two in-bore jams were experienced, the first after 1,580 additional rounds and the second after another 1,248 rounds.

There was no visible signs of damage to the barrel because of the in-bore jams after 9,359 and 10,939 rounds but there was evidence after the third in-bore jam after 12,187 rounds. The barrel was, therefore, declared unserviceable. Examination of the barrel bore surface showed a series of ripples/wrinkles beginning about 8 inches from the breech end and continuing to within 2 inches of the muzzle end. The air gages would no longer pass through the barrel indicating significant distortion had occurred. Measurements of the OD indicated the barrel was out of round with the maximum diameter located across the distorted area. The minimum diameter was 1.792 and the maximum diameter was 1.811 in the same plane.

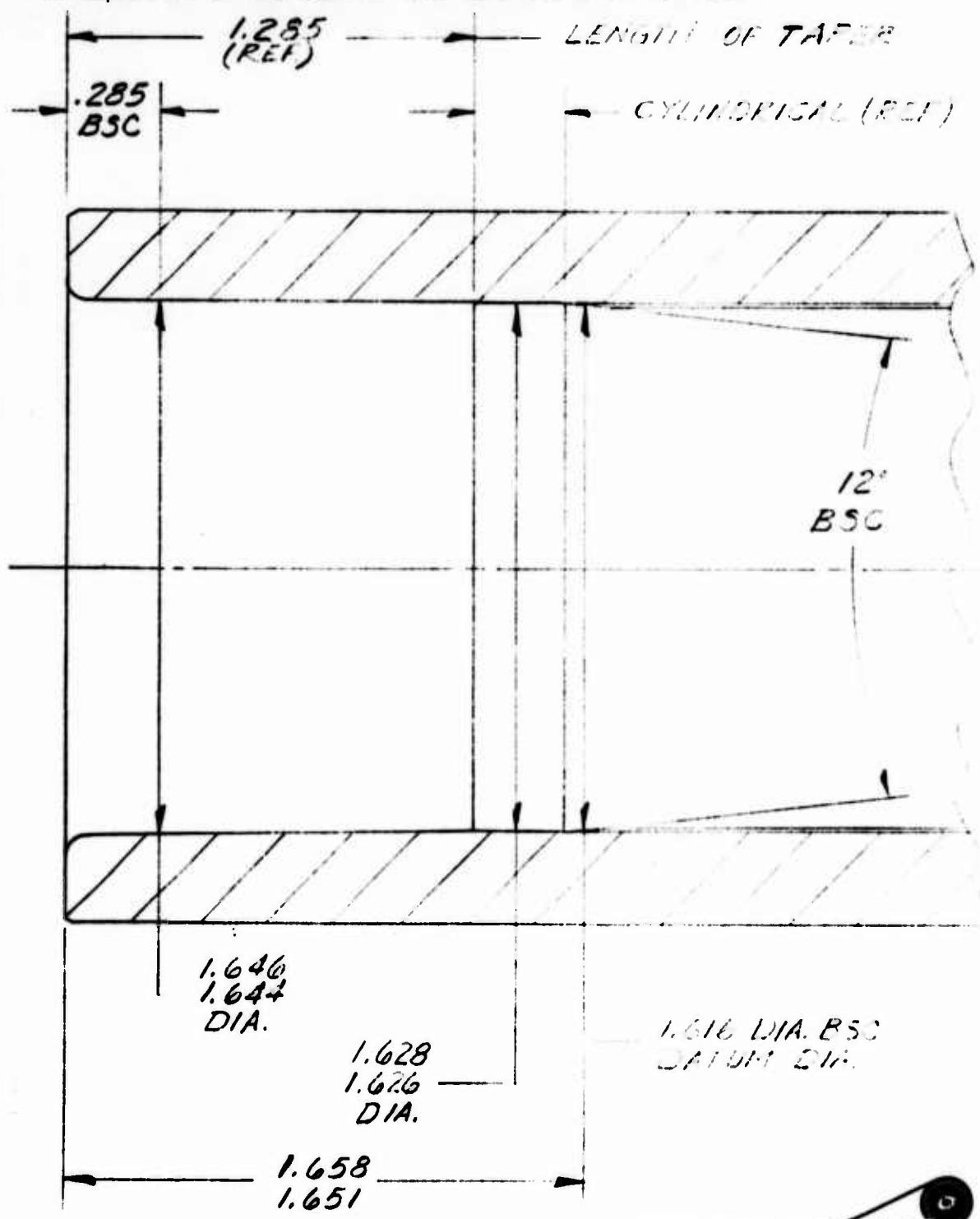
It was observed that the out of roundness and wrinkles followed the twist of the rifling. The conclusion was made that a piece of rotating band tore loose from a projectile and remained in the barrel. When the next round was fired, the projectile carried the piece of band forward until it became wedged in the bore. The momentum was sufficient enough to launch the projectile but tended to swage and distort the barrel under the circumstances. Because of this damage and the fact that a third in-bore jam occurred, firing of this barrel was terminated.

Figures 1 and 2 shows the erosion pattern on barrel #H-1 at the origin of rifling and along both sides of the rifling.

It appears that the chrome plating tends to wear/erode away initially at a step in the chamber at the intersection of the 1.626 diameter and the 12° included angle taper at the origin of rifling. The sketch below shows a section through the chamber. After the chrome flakes away, the base material is prone to erosion and a relatively sharp edge is formed. See Figure 4. As the projectile moves down the bore, the rotating band tends to catch on this edge and be torn apart occasionally leaving a portion in the bore.

Figures 3 through 7 are magnified views of various areas along the bore surface of barrel #H-1. Figure 3 shows the surface just aft of the erosion groove shown in Figure 4. Cracks in the chrome plate extend into the base metal and erosion eventually undercuts the chrome until it flakes off thus exposing the base material. The erosion groove shown is approximately .015" deep and .035" wide.

Figure 5 shows the bore condition just forward of the erosion groove. The areas shown in Figures 6 and 7 are from sections of the rifling groove adjacent to a land showing a difference in chrome thickness. This difference is believed to be a resultant of the plating process whereby a thinner layer is deposited at the base of the land and not from wear.



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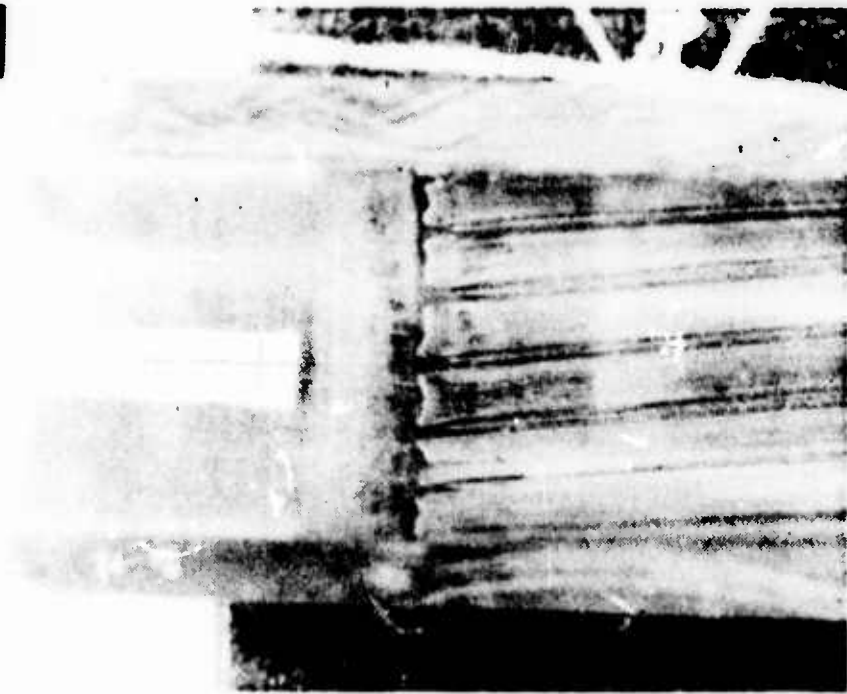


Figure 1. View of Bore Erosion on Barrel #H-1.

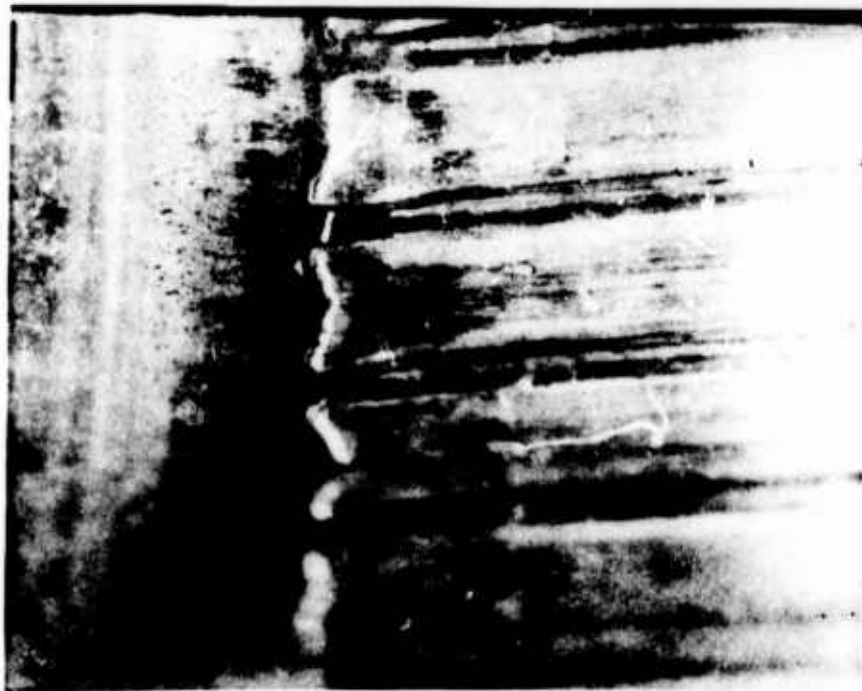


Figure 2. Magnified View of Bore Erosion on Barrel #H-1.

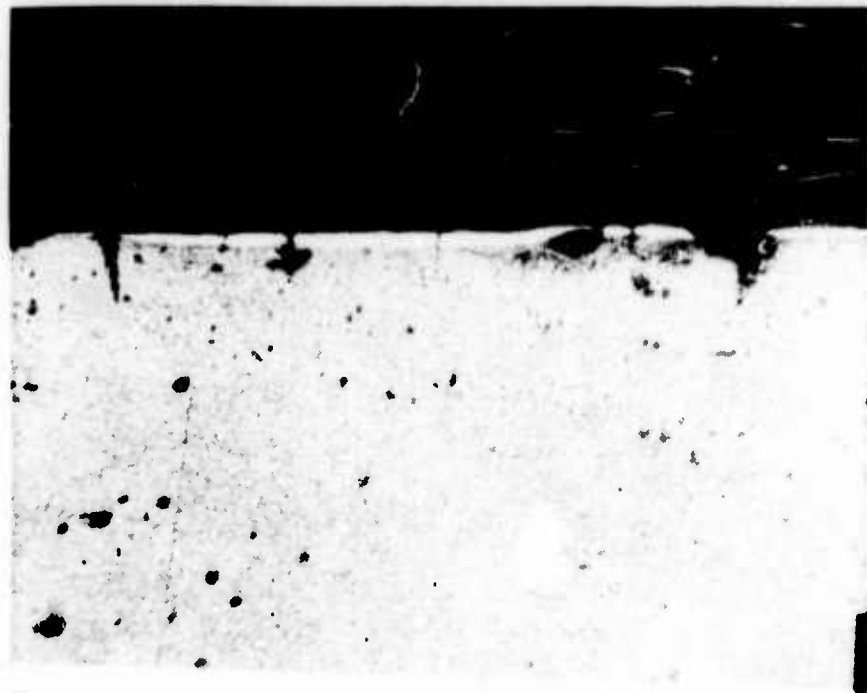


Figure 3. Longitudinal Section of Barrel #H-1 Showing Bore Surface
1 $\frac{19}{32}$ " from Breech End.

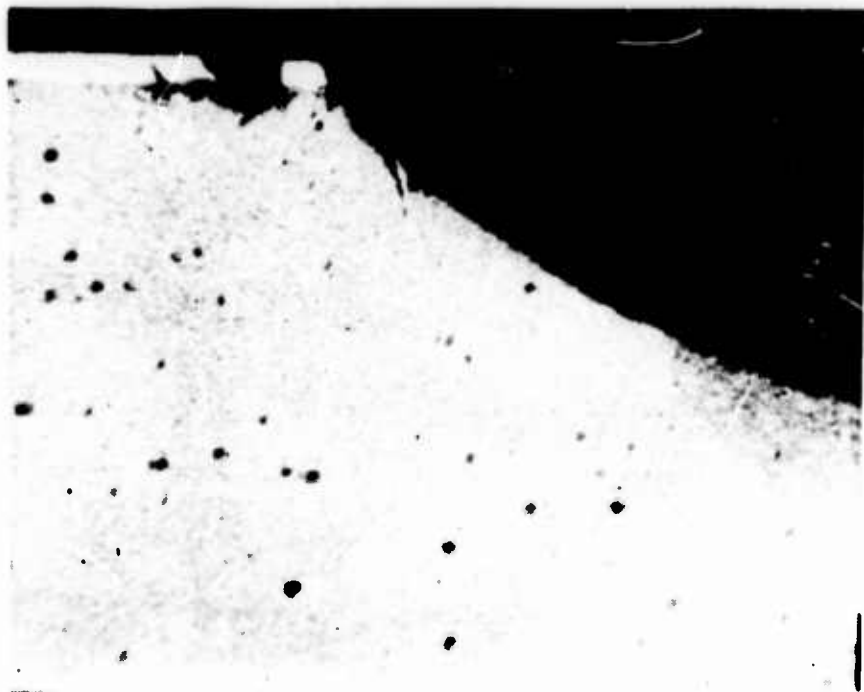
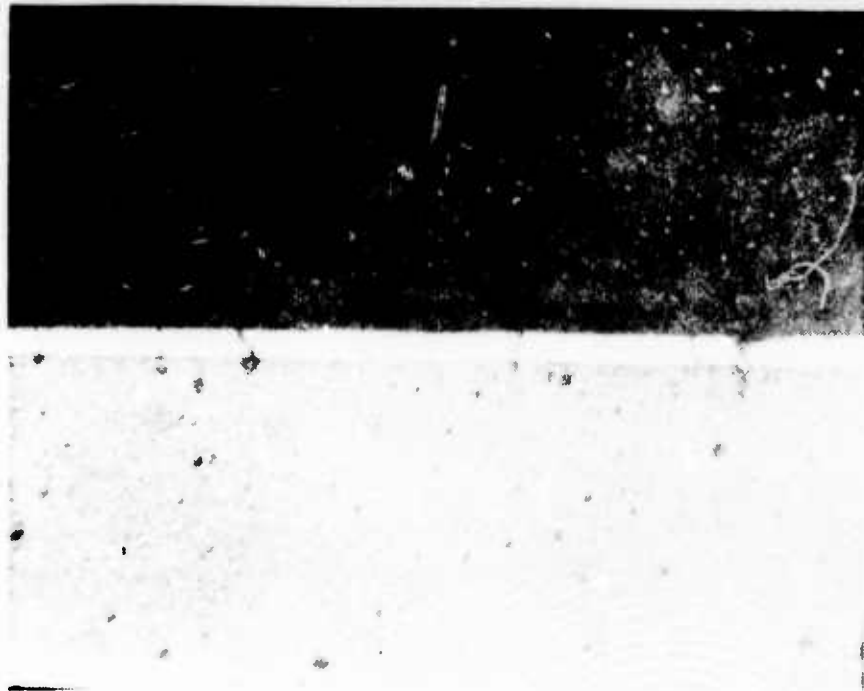


Figure 4. Longitudinal Section of Barrel #H-1 Showing Bore Surface
In the Erosion Cavity 1 $\frac{11}{16}$ " From Breech End.



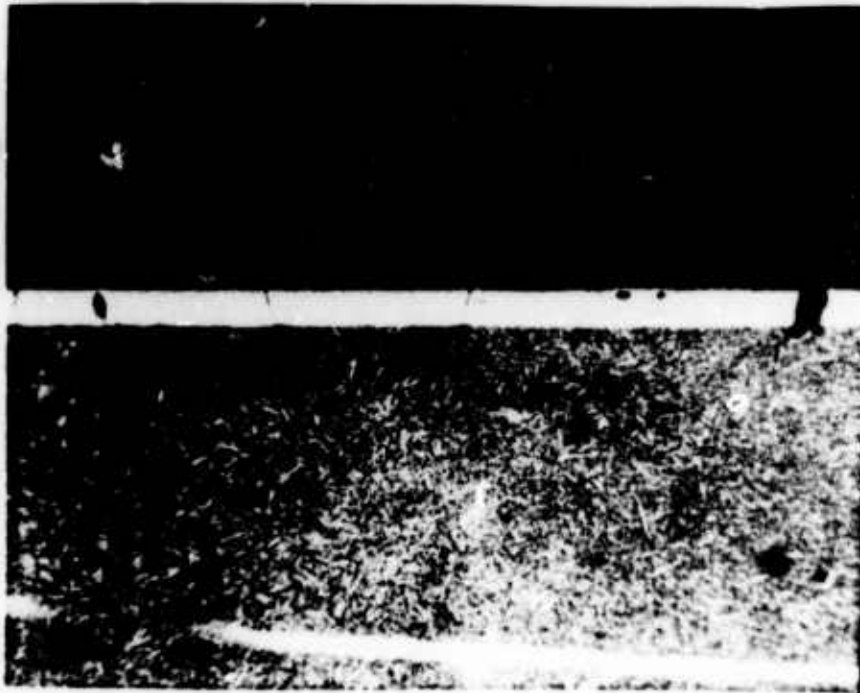
Breech
End
100X

Figure 5. Longitudinal Section of Barrel #H-1 Showing Bore Surface
1 $\frac{25}{32}$ " From Breech End.



Breech
End
100X

Figure 6. Longitudinal Section of Barrel #H-1 Showing Bore Surface
2 $\frac{1}{2}$ " From Breech End.



Breech
End
100X

Figure 7. Longitudinal Section of Barrel #H-1 Showing Bore Surface
3 13/32" From Breech End.

Barrel #H-3 was fired a total of 15,000 rounds without a malfunction. Examination of the bore at the origin of rifling, Figures 8 and 9, after firing was completed showed the erosion was not as severe in this barrel as in #H-1 and significantly less than on #H-2. The wear/erosion was not uniform around the circumference with very little erosion over approximately $\frac{1}{4}$ of the distance as can be seen in Figure 9.

Appendix I contains the measurement records for the three H-11 alloy barrels and two of the standard barrels. Comparing data shows the rate of wear of the H-11 barrels on the average was much less than those of standard material and #H-3 much slower than the others. In general, the distance to the origin of rifling is the best indicator of barrel degradation for example: #H-3 was .034 over maximum after 15,000 rounds, #H-1 was .048 over at 10,939 rounds and #H-2 was .039 over at 4,500 rounds. The standard barrels exhibited .035 and .063 over maximum after 3,000 rounds were fired.

Figures 10 through 14 are magnified views of various areas along the bore surface of barrel #H-3. The condition of the chrome plating and the base material is quite similar on all the H-11 alloy barrels. Propellant gases tend to attack the base metal through the cracks in the chrome plate but not as severely as with the AISI 4340 alloy barrels. The cracks do not have a tendency to propagate after the chrome plate has eroded away. Effective life of the barrel appears to have been extended because of a greater bond characteristic of the chrome plate with the H-11 alloy substrate.

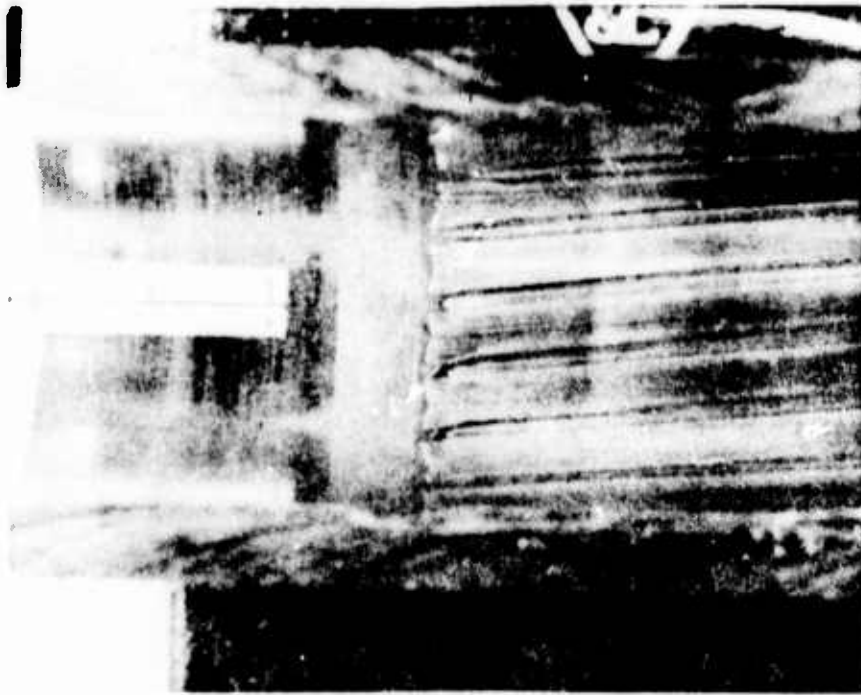


Figure 8. View of Bore Erosion of Barrel #H-3 Half Section #1.

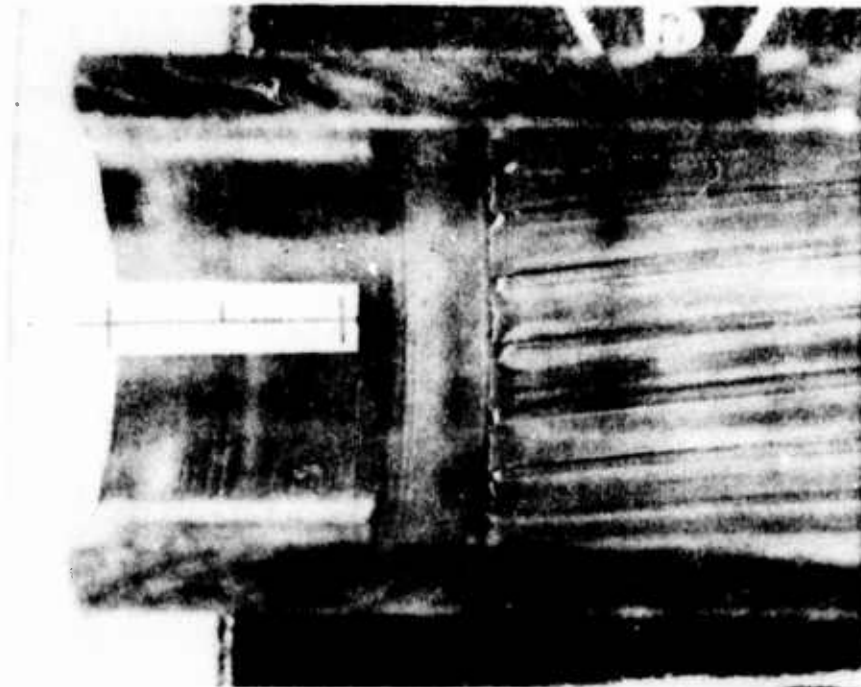


Figure 9. View of Bore Erosion of Barrel #H-3 Half Section #2.

Breech
End
100X

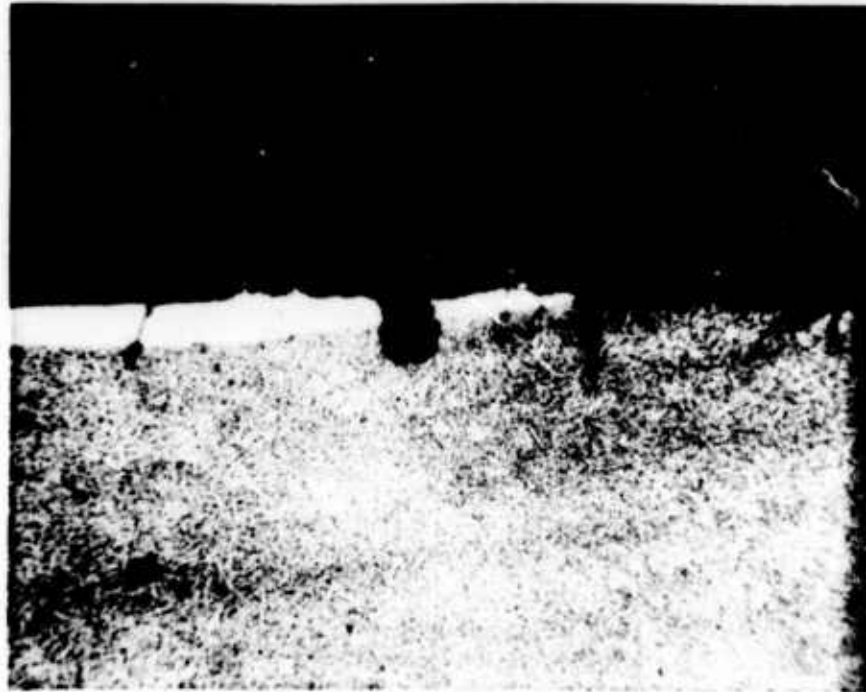


Figure 10. Longitudinal Section of Barrel #H-3 Showing Bore Surface 1 5/8" From Breech End.

Breech
End
100X



Figure 11. Longitudinal Section of Barrel #H-3 Showing Bore Surface In the Erosion Cavity 1 1/16" From Breech End.

Breech
End
100X



Figure 12. Longitudinal Section of Barrel #H-3 Showing Bore Surface
1 3/4" From Breech End.

Breech
End
100X



Figure 13. Longitudinal Section of Barrel #H-3 Showing Bore Surface
2 1/2" From Breech End.

Breech
End
100X

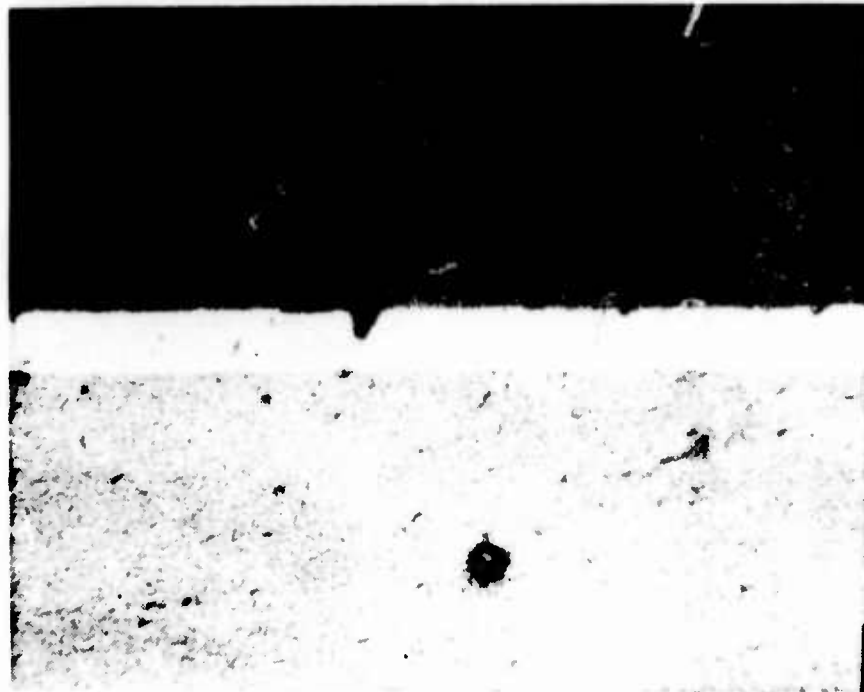


Figure 14. Longitudinal Section of Barrel #H-3 Showing Bore Surface
3 7/16" From Breech End.

APPENDIX I

FIRING SCHEDULE

The firing, cleaning and inspection schedule for each barrel was as follows:

- a. 100 round burst followed by a 3 minute cooling.
- b. 3 - 25 round bursts with 1 minute cooling between bursts.
- c. 50 round burst followed by a 2 minute cooling.
- d. 3 - 25 round bursts with 1 minute cooling between bursts.
- e. 50 round burst followed by a 2 minute cooling.
- f. 2 - 25 round bursts with a 1 minute cooling between bursts.
- g. 50 round burst followed by a 2 minute cooling.
- h. 3 - 25 round bursts with a 1 minute cooling between bursts.
- i. 50 round burst followed by a 2 minute cooling.
- j. 2 - 25 round bursts with a 1 minute cooling between bursts.
- k. 100 round burst followed by a 3 minute cooling.
- l. 25 round burst for accuracy check.
- m. Clean after 750 rounds and clean/inspect after 1,500 rounds.

MID. Sig. P 0001

CONTRACT NO. DAAG03-71-C-0321

DATE 8-16-72

BARREL NO. M-1

**XM129 GRENADE LAUNCHER
BARREL IMPROVEMENT TEST RECORD**



12,187 RDS TOTAL RDS FIRED FROM M-1 BARREL

Handwritten notes:
 #9359
 #9359 is out of round except
 diameter of rounds fired 9.357"
 1.55"
 10.937"
 1.241"

NO. OF ROUNDS	BORE DIA										RIFLING DIA										DIA OF REAR BODY	DIST. TO ORIGIN OF RIFLING	NECK DIA	REMARKS
	A	B	C	D	E	F	G	H	J	A	B	C	D	E	F	G	H	J						
0	1.666	1.686	1.681	1.673	1.677	1.677	1.677	1.677	1.677	1.677	1.677	1.677	1.677	1.677	1.677	1.677	1.677	1.677	1.644	1.651	1.626			
1500	1.672	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.644	1.651	1.626	OK		
3000	1.674	1.672	1.670	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.667	1.644	1.651	1.626	OK		
4500	1.673	1.673	1.673	1.673	1.673	1.673	1.673	1.673	1.673	1.673	1.673	1.673	1.673	1.673	1.673	1.673	1.673	1.673	1.644	1.651	1.626	OK		
6000	1.673	1.674	1.674	1.674	1.674	1.674	1.674	1.674	1.674	1.674	1.674	1.674	1.674	1.674	1.674	1.674	1.674	1.674	1.644	1.651	1.626	OK		
7500	1.675	1.675	1.675	1.675	1.675	1.675	1.675	1.675	1.675	1.675	1.675	1.675	1.675	1.675	1.675	1.675	1.675	1.675	1.644	1.651	1.626	OK		
9000	1.677	1.677	1.677	1.677	1.677	1.677	1.677	1.677	1.677	1.677	1.677	1.677	1.677	1.677	1.677	1.677	1.677	1.677	1.644	1.651	1.626	OK		
10,937	off rif	1.672	1.687	1.683	1.683	1.683	1.683	1.683	1.683	1.683	1.683	1.683	1.683	1.683	1.683	1.683	1.683	1.683	1.644	1.651	1.626	OK		
12,187	off rif	ence case	1.671	1.671	1.671	1.671	1.671	1.671	1.671	1.671	1.671	1.671	1.671	1.671	1.671	1.671	1.671	1.671	1.644	1.651	1.626	OK		
13,500																								
15,000																								
16,500																								
18,000																								
20,000																								

LEGEND: DISTANCE FROM BREACH END
 A - 1.75 IN D - 3.50 IN G - 10.00 IN
 B - 2.00 IN E - 5.00 IN H - 13.00 IN
 C - 2.50 IN F - 7.00 IN J - 16.00 IN

MAREMONT CORPORATION
 SACO, MAINE
 XM129 GRENADE LAUNCHER
 BARREL IMPROVEMENT
 TEST RECORD
 MAY 21, 1971 WCM

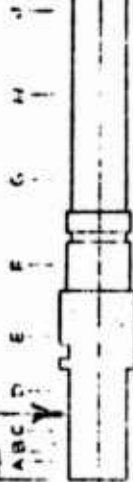
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XM129 GRENADE LAUNCHER
BARREL IMPROVEMENT TEST RECORD

CONTRACT NO.

DATE 8-13-72

BARREL NO. H 2



NO OF ROUNDS	BORE DIA 1.606 ± .003										RIFLING DIA 1.6215 ± .003										DIA OF REAR BODY	DIST. TO ORIGIN OF RIFLING	NECK DIA	REMARKS
	A	B	C	D	E	F	G	H	J	A	B	C	D	E	F	G	H	J						
0																				1.644	1.651	1.626		
1500																				1.642	1.651	1.626	OK	OK
3000																				1.642	1.651	1.626	OK	OK
4500																				1.642	1.651	1.626	OK	OK
5500																				1.642	1.651	1.626	OK	OK
7500																				1.642	1.651	1.626	OK	OK
9000																				1.642	1.651	1.626	OK	OK
10,500																				1.642	1.651	1.626	OK	OK
12,000																				1.642	1.651	1.626	OK	OK
13,500																				1.642	1.651	1.626	OK	OK
15,000																				1.642	1.651	1.626	OK	OK
20,000																				1.642	1.651	1.626	OK	OK

LEGEND: DISTANCE FROM BREACH FWD
 A - 1.75 IN D - 3.50 IN G - 10.00 IN
 B - 2.00 IN E - 5.00 IN H - 13.00 IN
 C - 2.50 IN F - 7.00 IN J - 16.00 IN

VAREMONT CORPORATION
 SACO, MAINE
 XM129 GRENADE LAUNCHER
 BARREL IMPROVEMENT
 TEST RECORD
 MAY 29, 1971
 WPM

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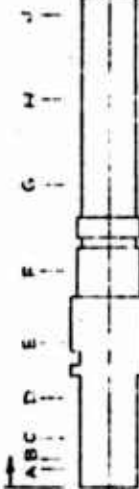
CONTRACT NO. 106603-73-C-142

XM129 GRENADE LAUNCHER
BARREL IMPROVEMENT TEST RECORD

DATE 12-17-73

BARREL NO. H 3

1003 Barrel was fired
1004 Barrel was fired
1005 of round 1005



NO. OF ROUNDS	BORE DIA 1.606 ± .003										RIFLING DIA 1.6215 ± .003										DIA OF REAR BODY	DIST. TO ORIGIN OF RIFLING	NECK DIA	REMARKS
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J				
0																					1.644	1.651	1.626	
1500	1.607	1.607	1.607	1.607	1.607	1.607	1.607	1.607	1.607	1.607	1.623	1.623	1.623	1.623	1.623	1.623	1.623	1.623	1.623	1.623	OK	OK	OK	OK
3000	1.605	1.605	1.605	1.605	1.605	1.605	1.605	1.605	1.605	1.605	1.623	1.623	1.623	1.623	1.623	1.623	1.623	1.623	1.623	1.623	OK	OK	OK	OK
4500	1.605	1.605	1.605	1.605	1.605	1.605	1.605	1.605	1.605	1.605	1.623	1.623	1.623	1.623	1.623	1.623	1.623	1.623	1.623	1.623	OK	OK	OK	OK
6000	1.606	1.606	1.606	1.606	1.606	1.606	1.606	1.606	1.606	1.606	1.623	1.623	1.623	1.623	1.623	1.623	1.623	1.623	1.623	1.623	OK	OK	OK	OK
7500	1.604	1.604	1.604	1.604	1.604	1.604	1.604	1.604	1.604	1.604	1.623	1.623	1.623	1.623	1.623	1.623	1.623	1.623	1.623	1.623	OK	OK	OK	OK
9000	1.609	1.609	1.609	1.609	1.609	1.609	1.609	1.609	1.609	1.609	1.623	1.623	1.623	1.623	1.623	1.623	1.623	1.623	1.623	1.623	OK	OK	OK	OK
10500	1.605	1.605	1.605	1.605	1.605	1.605	1.605	1.605	1.605	1.605	1.623	1.623	1.623	1.623	1.623	1.623	1.623	1.623	1.623	1.623	OK	OK	OK	OK
12000	1.607	1.607	1.607	1.607	1.607	1.607	1.607	1.607	1.607	1.607	1.623	1.623	1.623	1.623	1.623	1.623	1.623	1.623	1.623	1.623	OK	OK	OK	OK
13500	1.607	1.607	1.607	1.607	1.607	1.607	1.607	1.607	1.607	1.607	1.623	1.623	1.623	1.623	1.623	1.623	1.623	1.623	1.623	1.623	OK	OK	OK	OK
15000	1.607	1.607	1.607	1.607	1.607	1.607	1.607	1.607	1.607	1.607	1.623	1.623	1.623	1.623	1.623	1.623	1.623	1.623	1.623	1.623	OK	OK	OK	OK
16500																								
18000																								
20000																								

LEGEND: DISTANCE FROM BREACH END

- A - 1.75 IN
- B - 2.00 IN
- C - 2.50 IN
- D - 3.50 IN
- E - 5.00 IN
- F - 7.00 IN
- G - 10.00 IN
- H - 13.00 IN
- J - 16.00 IN

MAREMONT CORPORATION
SACO, MAINE
XM129 GRENADE LAUNCHER
BARREL IMPROVEMENT
TEST RECORD
MAY 21, 1971 WSK

XM129 Barrel Improvement Program

Firing Test Record

Contract No. DAAFO3-71-G-0331

Date Tested 1/9/74

Barrel No. HL

TEST SER.	ROUNDS FIRED												
	0	750	1500	2250	3000	3750	4500	5250	6000	6750	7500	7500	
50 100	✓	✓											
25	✓	✓											
25	✓	✓											
25	✓	✓											
50	✓	✓											
25	✓	✓											
25	✓	✓											
25	✓	✓											
50	✓	✓											
25	✓	✓											
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9380
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 10550
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 10900

XM129 Barrel Improvement Program

Firing Test Record

Contract No. DAAFO3-71-C-0331

Date Tested 1/10/74
 Barrel No H-1

TEST SER.	ROUNDS FIRED											
	0	750	1500	2250	3000	3750	4500	5250	6000	6750	7500	7500
100	750	1500	2250	3000	3750	4500	5250	6000	6750	7500	8250	
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Clean after 750 rounds.
 Inspect after 1500 rounds.

Remarks: ACCEPTED BAND AT 50 RDS

XM129 Barrel Improvement Program

Firing Test Record

Contract No. DAAF03-71-C-0331

Date Tested 1/27/74

Barrel No H 1

TEST SER.	ROUNDS FIRED											
	0	750	1500	2250	3000	3750	4500	5250	6000	6750	7500	
	750	1500	2250	3000	3750	4500	5250	6000	6750	7500	8250	
100	✓	✓										
25	✓	✓										
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Clean after 750 rounds.
 Inspect after 1500 rounds.

Remarks: Accepted Band at 1248 rds
 Total rds on Barrel 12,187

XM129 Barrel Improvement Program

1503112

Firing Test Record

Date Tested

1/15/74

Contract No. DAAFO3-71-0-0331

Barrel No

H 3

TEST SER.	ROUNDS FIRED											
	0	750	1500	2250	3000	3750	4500	5250	6000	6750	7500	7500
	750	1500	2250	3000	3750	4500	5250	6000	6750	7500	7500	8250
100	✓	✓										
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Clean after 750 rounds.

Inspect after 1500 rounds.

Remarks: **BAD CHUTE LINKAGE**

3000 RDS

XM129 Barrel Improvement Program

Firing Test Record

Contract No. DAAFO3-71-C-0331

Date Tested 1/17/74
 Barrel No H 3

50
50

TEST SER.	ROUNDS FIRED											
	0	750	1500	2250	3000	3750	4500	5250	6000	6750	7500	7500
	750	1500	2250	3000	3750	4500	5250	6000	6750	7500	7500	8250
100	✓	✓										
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Clean after 750 rounds.
 Inspect after 1500 rounds.

Remarks:

1050 RDS

4500 RDS

XM129 Barrel Improvement Program

Firing Test Record

Contract No. DAAFO3-71-C-0331

Date Tested 1/18/74

Barrel No 173

TEST SER.	ROUNDS FIRED											
	0	750	1500	2250	3000	3750	4500	5250	6000	6750	7500	7500
	750	1500	2250	3000	3750	4500	5250	6000	6750	7500	7500	8250
100	✓	✓										
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Clean after 750 rounds.
 Inspect after 1500 rounds.

Remarks: REPAIRED IMPACT PLATE 1/21/74 - 1/24/74
 RESUMED FIRING 1/24/74

6000 R102

XM129 Barrel Improvement Program

Firing Test Record

Contract No. DAAF03-71-C-0331

Date Tested 1/26/74

Barrel No H3

TEST SER.	ROUNDS FIRED											
	0	750	1500	2250	3000	3750	4500	5250	6000	6750	7500	7500
	750	1500	2250	3000	3750	4500	5250	6000	6750	7500	8250	
100	✓	✓										
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Clean after 750 rounds.
 Inspect after 1500 rounds.

Remarks:

730
 150

1000
 17200
 28

XM129 Barrel Improvement Program

Firing Test Record

Contract No. DAAF03-71-C-0331

Date Tested 2/5/74

Barrel No H 3

TEST SER.	ROUNDS FIRED											
	0	750	1500	2250	3000	3750	4500	5250	6000	6750	7500	7500
	750	1500	2250	3000	3750	4500	5250	6000	6750	7500	8250	
100	✓	✓										
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Clean after 750 rounds.
 Inspect after 1500 rounds.

Remarks: LIGHT BLOWS BROKEN FIRING PIN
NEEDS NEW SPRING + CAM GEAR

XM129 Barrel Improvement Program

Firing Test Record

Contract No. DAAFO3-71-C-0331

Date Tested 2/7/74

Barrel No H 3

TEST SER.	ROUNDS FIRED											
	0	750	1500	2250	3000	3750	4500	5250	6000	6750	7500	7500
	750	1500	2250	3000	3750	4500	5250	6000	6750	7500	7500	8250
100	✓	✓										
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Clean after 750 rounds.
 Inspect after 1500 rounds.

Remarks:

XM129 Barrel Improvement Program

Firing Test Record

Contract No. DAAF03-71-C-0331

Date Tested 2/10/74

Barrel No H-3

TEST SER.	ROUNDS FIRED												
	0	750	1500	2250	3000	3750	4500	5250	6000	6750	7500	7500	
100	✓	✓											
25	✓	✓											
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Clean after 750 rounds.

Inspect after 1500 rounds.

Remarks:

XM129 Barrel Improvement Program

Firing Test Record

Contract No. DAAFO3-71-C-0331

Date Tested 2/13/74

Barrel No H 3

TEST SER.	ROUNDS FIRED											
	0	750	1500	2250	3000	3750	4500	5250	6000	6750	7500	7500
	750	1500	2250	3000	3750	4500	5250	6000	6750	7500	7500	8250
100	✓	✓										
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Clean after 750 rounds.
 Inspect after 1500 rounds.

Remarks:

XM129 Barrel Improvement Program

Firing Test Record

Contract No. DAAFO3-71-C-0331

Date Tested 1/16/74

Barrel No H 3

TEST SER.	ROUNDS FIRED										
	0	750	1500	2250	3000	3750	4500	5250	6000	6750	7500
	750	1500	2250	3000	3750	4500	5250	6000	6750	7500	8250
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Clean after 750 rounds.

Inspect after 1500 rounds.

Remarks:

13,500 RDS

XM129 Barrel Improvement Program

Firing Test Record

Contract No. DAAFO3-71-C-0331

Date Tested 2/19/74

Barrel No. 43

TEST SER.	ROUNDS FIRED										
	0	750	1500	2250	3000	3750	4500	5250	6000	6750	7500
	750	1500	2250	3000	3750	4500	5250	6000	6750	7500	8250
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Clean after 750 rounds.
 Inspect after 1500 rounds.

Remarks: 15,000 RPS COMP.