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EXAMINATION OF ROTATING BANDS FROM 155MM PROJECTILE, HE, M107, FIRED WITH PROPELLANT CHARGE XM119

Test Report T64-3-1

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Frankford Arsenal
Philadelphia, Pa. 19137

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EXAMINATION OF ROTATING BANDS FROM 155MM PROJECTILE, HE, M107, FIRED WITH PROPELLANT CHARGE XM119

Prepared by: R. E. Hantho

R. E. HANTHO
Mech. Engineer

Reviewed by: B W Bushey

B. W. BUSHEY
Acting Chief
Projectile & Case Branch

Approved by: G S Van Dyke, Jr.

G. S. VAN DYKE, JR.
Acting Chief
Artillery Ammunition
Components Division

ABSTRACT

This study was conducted to determine the adequacy of the rotating band, particularly band retention, of the standard 155mm M107 shell when fired with propelling charge XM119 from the 155mm Howitzer Self-Propelled M109 (T196E1). Rotating bands from sixteen recovered M107 shell were examined.

The bands imparted full spin to the projectile, but showed varying amounts of wear proportional to the pressure and velocity level. This amount of wear did not adversely affect the velocity or range dispersions.

Band fly off was primarily attributed to poor banding practice and lack of band seat undercuts. If the percentage of band fly off warrants rebanding, widening of the band seat and inclusion of 15° band seat undercuts is recommended.

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INTRODUCTION

During testing of the XM119 propellant charge with the M107 projectile, three rotating bands were discarded in flight as shown by the in flight photographs. This condition resulted in short rounds.

To investigate this problem, sixteen recovered M107 projectiles were sent to Frankford Arsenal from Aberdeen Proving Ground for examination of the rotating bands. Four of the sixteen rounds were fired from a new tube at rated maximum pressure and four were fired excess (115%) pressure respectively, the remaining eight rounds were fired with the XM119 charge from a worn tube. Table I shows the firing data for these rounds.

Examination of the rotating bands consisted of:

1. A visual inspection of the engraving.

2. Measuring the band land and groove diameters with micrometers.

3. Measuring the band land width with vernier calipers.

4. Measuring the band gap by machining the band and measuring the OD after the band was machined, then band thickness and band seat OD measured and subtracted from the band OD measurement.

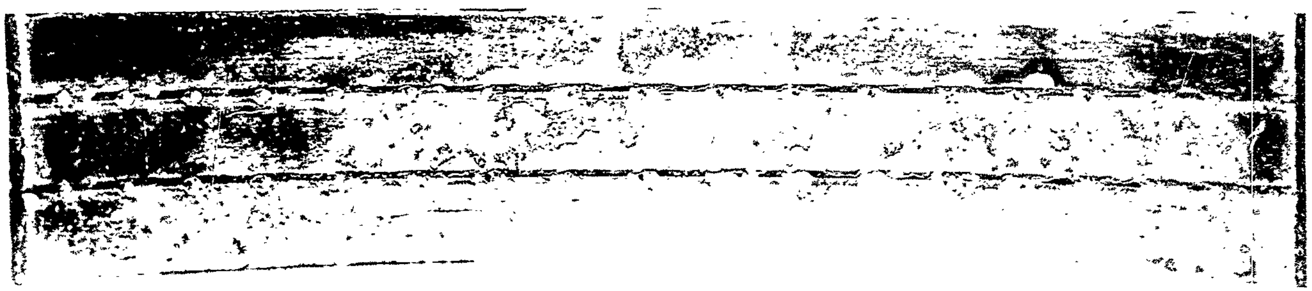
5. A visual inspection of the band seat.

6. A visual inspection of the impression of the band seat knurling on the ID of the band.

DISCUSSION

Examination of the engraving shows considerable but not excessive band "shear"; i.e., wearing away of the driving face thus opening a gap between the nondriving face and the land of the rifling which permits propellant gas blowby and erosion of the nondriving face. See figure 1 showing the band from Shell No. 36 and figure 2 showing the "wear condition" of the band. The wear measurements

Shell No. 36



Shell No. 72

Figure 1. Rotating Band from 155mm HE Shell M107 - Lot FT-3-15 1957

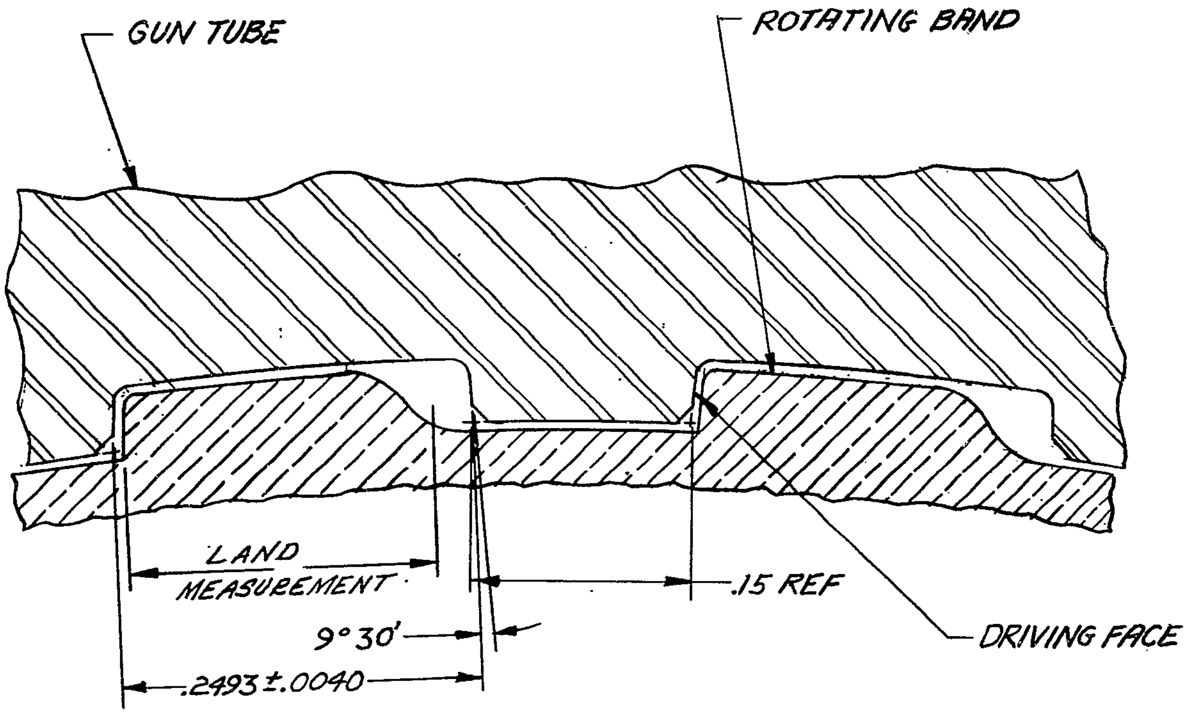


Figure 2. 155mm M107 Rotating Band Wear with Propelling Charge XM119

are given in table IV. Because of the erosion of the nondriving face, it was not possible to accurately measure the band land width. The measurements were taken as shown on figure 2 and the actual percent of band shear or wear is somewhat greater than that shown by the measurements. On three of the four rounds fired at service pressure, the band wear was 19% with one round of 31%. On three of the four rounds fired at excess pressure, the wear was 38% with one round of 47%. From a new tube, two definite wear levels are evident, proportional to pressure and velocity and fairly consistent with an occasional outlier. The wear level (17-36%) from the worn tube is comparable to that of the new tube; however, the variation of the wear level is greater for the worn tube which is expected due to the worn condition of the tube.

Although considerable wear is evident, sufficient working metal was left to satisfactorily impart full spin to the projectile and because of the consistency of the wear, the wear did not adversely effect either the velocity uniformity or range dispersion of the shell (PE range .20% at 18,000 meters). The rotating bands of four recovered T387E1 projectiles fired at 120% of rated maximum pressure were measured for comparison with M107 and the wear of the T387E1 was 3 to 5%. Diametrical measurements of the band do not appear to be too meaningful or significant. Band land and groove diameters are shown in tables II and III. They exceeded the maximum rifling diameters, although the excess cannot be related to excessive band gap. A possible explanation may be that of elastic deformation of the shell body due to the engraving pressure. Similar measurements of the T387E1 shell were generally within dimensional limits, however, the T387E1 band is supported by the solid base section thus minimizing, if not eliminating, elastic deformation of the shell body.

The average band gap for each shell from the new tube is shown in table V and was within tolerance (.006") except for Shell No. 72 which had an average gap of .008". Band gap for shell fired from the worn tube was not determined. This gap in itself is not significant, but the condition of the band seat and the engraving of the band seat knurling on the band is significant. The band seats were rusted and/or dirty. The rust may have been formed from phosphatizing the shell after banding. The shell with the largest amount of dirt and rust also had a buildup on the ID of the band after removal from the shell body. The worst buildup was encountered with Shell No. 72 which also had the largest band gap. The condition of the band ID and band seats indicated inadequate preparation prior to band application and is not commensurate with good banding procedure. Examination of the imprint of the band seat knurling on the band ID indicated slippage of the band on several shells and particulary on Shell No. 72. Figures 1 and 3 show the dirt buildup and the slippage on Shell No. 72. The band from Shell No. 43 is shown for comparison.

Finally, the band seat profile was examined for its ability to retain the band. The edges of the band seat are not undercut and due to the large relief groove behind the band, the depth at the rear of the seat is only about .070" or one-half that of the forward edge of the seat (.140"). Therefore, band retention is primarily dependent upon the strength and tightness of the band.

CONCLUSIONS & RECOMMENDATIONS

In evaluating the above factors, with respect to the problem of band retention, only band gap, band slippage, dirt and rust between the band and band seat, and band seat profile (design) appear pertinent. Band land "shear" from either a new or worn tube, althrough undesirable, was at most 50% consistent, and not great enough to prevent the band from transmitting full spin to the projectile; hence, this can be eliminated as affecting shell performance. Of the pertinent factors, band slippage is the most serious and combined with a large band gap and considerable rust and dirt under the band, could cause the rotating band to come off, particularly, since the rear edge of the band is only seated approximately .070".

The above is the most probable cause of band failure except for failure of the band in hoop tension, and could probably be overcome by proper application of the bands. However, if the problem is serious enough to warrant rebanding, then it is recommended that the seat profile be modified to include 15° undercuts of the edges and widened to increase the depth of the rear edge of the seat to a minimum of 85% of the depth of the forward edge. A proposed band seat and band profile is given in figure 4.

Shell No. 43

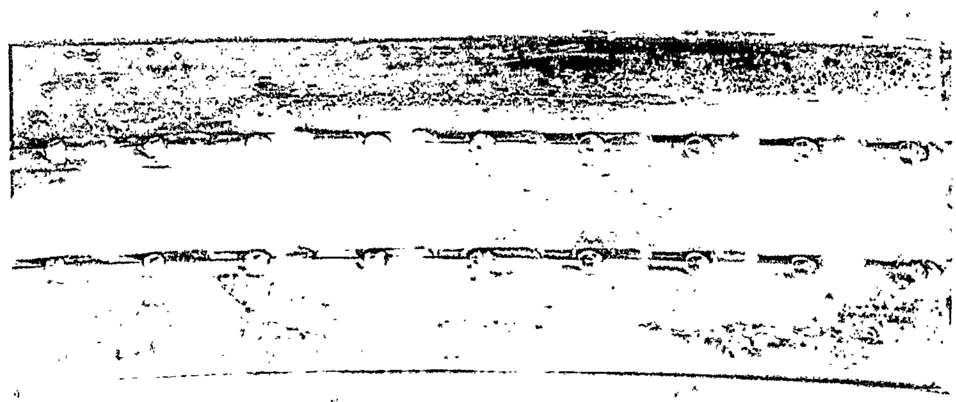


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Figure 3. Rotating Band from 155mm HE Shell M107 - Lot FT-3-15 1957

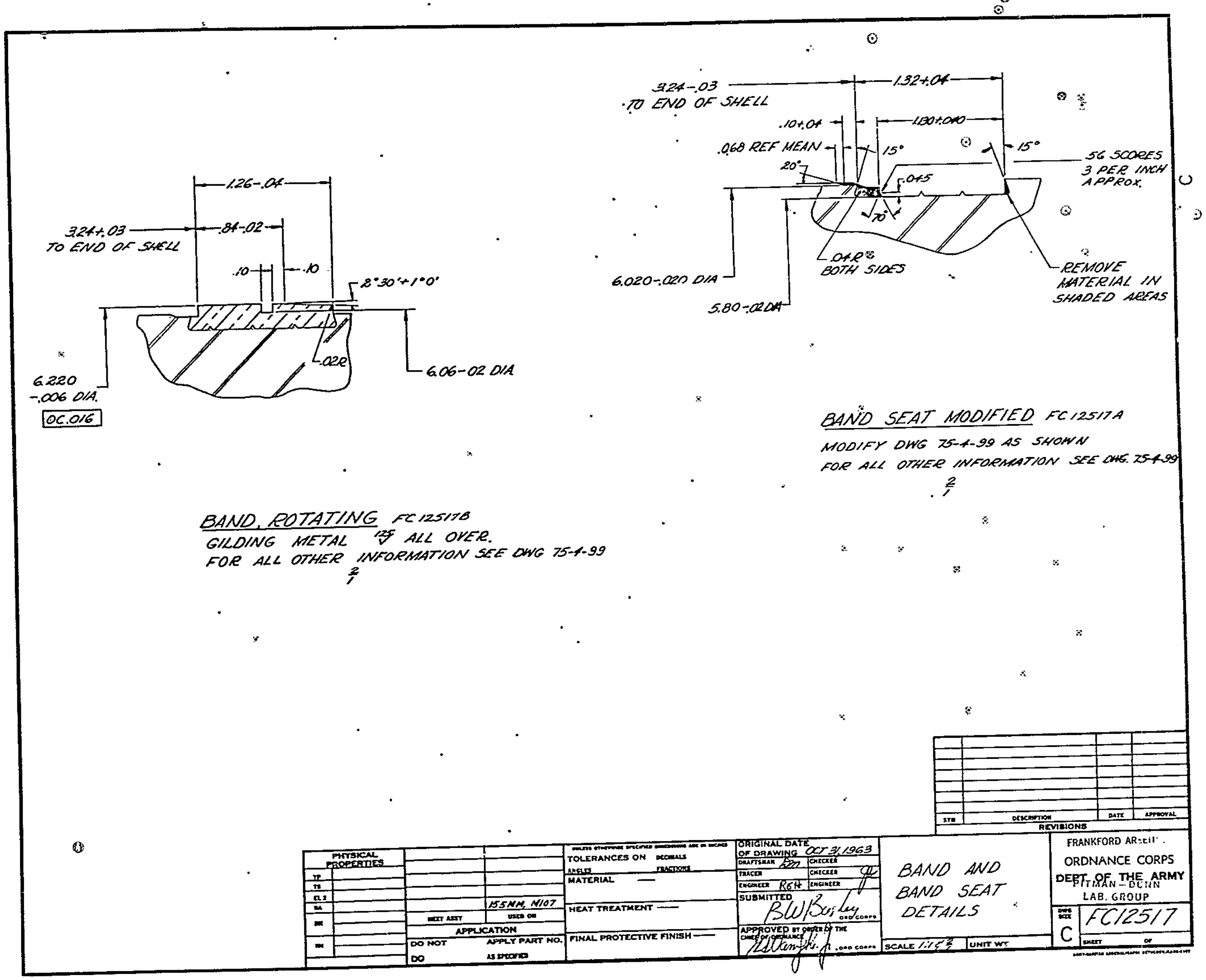

Figure 4. Band and Band Seat Details

TABLE I

Firing Data

Shell fired at 417 mil elevation from T255 tube with XM119 charge

Rd. No.	(psi) Pressure	(fps) Velocity	(meters) Range	(meters) Deflection
33	51,100	2249	14,477	194
36	52,100	2262	14,463	185
42	50,300	2262	14,503	170
43	50,800	2269	14,515	181

Shell fired at 373 mil elevation from T255 tube with XM119 charge plus one increment to adjust pressure to 115% of max rated pressure

Rd. No.	(psi) Pressure	(fps) Velocity	(meters) Range	(meters) Deflection
56	59,100	2353	14,456	146
61	56,900	2349	14,411	159
62	56,900	2340	14,456	142
72	57,700	2344	14,462	127

M107 Shell from worn tube with XM119 charge

Rd. No.	(psi) Pressure	(fps) Velocity	(meters) Range	(meters) Deflection
199	38,800	--	data not available	
200	38,700	2094	"	"
202	39,300	2109	"	"
203	40,600	2110	"	"
204	38,200	2110	"	"
205	40,000	2112	"	"
206	39,500	2102	"	"
207	38,600	2099	"	"

TABLE II

Band Land Diameter (4 readings per shell)

Tube Groove Diameter, 6.200 ± .006

Shell No.	(in) Avg Diameter	(in) Max Diameter	(in) Min Diameter	(in) Variation
M107 Test Shell				
33	6.204	6.209	6.202	.007
36	6.206	6.209	6.201	.008
42	6.208	6.210	6.206	.004
43	6.206	6.208	6.204	.004
56	6.211	6.214	6.207	.007
61	6.203	6.207	6.201	.006
62	6.214	6.216	6.212	.004
72	6.210	6.211	6.208	.003
M107 Test Shell (worn tube)				
199	6.208	6.209	6.207	.002
200	6.211	6.212	6.209	.003
202	6.204	6.209	6.200	.009
203	6.208	6.216	6.202	.014
204	6.192	6.198	6.187	.011
205	6.205	6.203	6.208	.005
206	6.215	6.216	6.213	.003
207	6.212	6.214	6.211	.003
T387E1 Test Shell				
8	6.206	6.207	6.206	.001
21	6.207	6.208	6.205	.003
27	6.203	6.206	6.200	.006
31	6.205	6.206	6.204	.002

TABLE III

Band Groove Diameter (4 readings per shell)

Tube Land Diameter, 6.100 ≠ .002

M107 Test Shell

Shell No.	(in) Avg Diameter	(in) Max Diameter	(in) Min Diameter	(in) Variation
33	6.109	6.112	6.108	.004
36	6.109	6.111	6.106	.005
42	6.108	6.109	6.107	.002
43	6.104	6.104	6.103	.001
56	6.105	6.106	6.103	.003
61	6.108	6.109	6.105	.004
62	6.109	6.111	6.106	.005
72	6.118	6.121	6.115	.006

M107 Test Shell (worn tube)

Shell No.	(in) Avg Diameter	(in) Max Diameter	(in) Min Diameter	(in) Variation
199	6.104	6.105	6.103	.002
200	6.108	6.109	6.106	.003
202	6.105	6.106	6.104	.002
203	6.118	6.128	6.114	.014
204	6.107	6.109	6.105	.004
205	6.106	6.108	6.105	.003
206	6.109	6.111	6.108	.003
207	6.107	6.109	6.105	.004

T387E1 Test Shell

Shell No.	(in) Avg Diameter	(in) Max Diameter	(in) Min Diameter	(in) Variation
8	6.105	6.107	6.103	.004
21	6.101	6.102	6.101	.001
27	6.102	6.105	6.100	.005
31	6.102	6.102	6.100	.001

TABLE IV

Band Land Measurements (8 readings per shell)

Tube Groove Width .2493"

M107 Shell

Shell No.	(in) Avg Width	(in) Max Width	(in) Min Width	(in) Variation	(%) Wear
33	.201	.212	.180	.032	19
36	.203	.210	.190	.020	18
42	.172	.190	.153	.037	31
43	.202	.215	.185	.030	19
56	.157	.162	.150	.012	37
61	.155	.162	.140	.022	38
62	.151	.156	.145	.011	39
72	.133	.146	.120	.026	47

M107 Shell (Worn tube)

Shell No.	(in) Avg Width	(in) Max Width	(in) Min Width	(in) Variation	(%) Wear
199	.189	.191	.186	.005	25
200	.206	.210	.202	.008	17
202	.195	.199	.192	.007	22
203	.205	.200	.193	.027	18
204	damaged	--	--	--	--
205	.179	.185	.175	.010	28
206	.172	.179	.160	.019	31
207	.158	.172	.152	.020	36

T387E1 Shell

Shell No.	(in) Avg Width	(in) Max Width	(in) Min Width	(in) Variation	(%) Wear
8	.243	.252	.235	.027	3
21	.241	.258	.232	.026	3
27	.239	.248	.226	.022	4
31	.238	.248	.228	.020	5

TABLE V

Band Gap Measurements

Allowable Gap .006"

M107 Shell

Shell No.	(in) Avg Gap	(in) Max Gap	(in) Min Gap	(in) Variation
33	.003	.004	.002	.002
42	.002	.005	.000	.005
43	.002	.004	.000	.004
56	.003	.003	.000	.003
61	.003	.003	.002	.001
62	.004	.007	.001	.006
72	.008	.013	.003	.010

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The bands imparted full spin to the projectile, but showed varying amounts of wear proportional to the pressure and velocity level. This amount of wear did not adversely affect the velocity or range dispersions.

Band fly off was primarily attributed to poor banding practice and lack of band seat undercuts. If the percentage of band fly off warrants rebanding, widening of the band seat and inclusion of 15° band seat undercuts is recommended.

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3. Howitzer, 155mm
4. 155mm Projectile M107

I. R. E. Hantho
II. AMCMS 5520.12.426

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