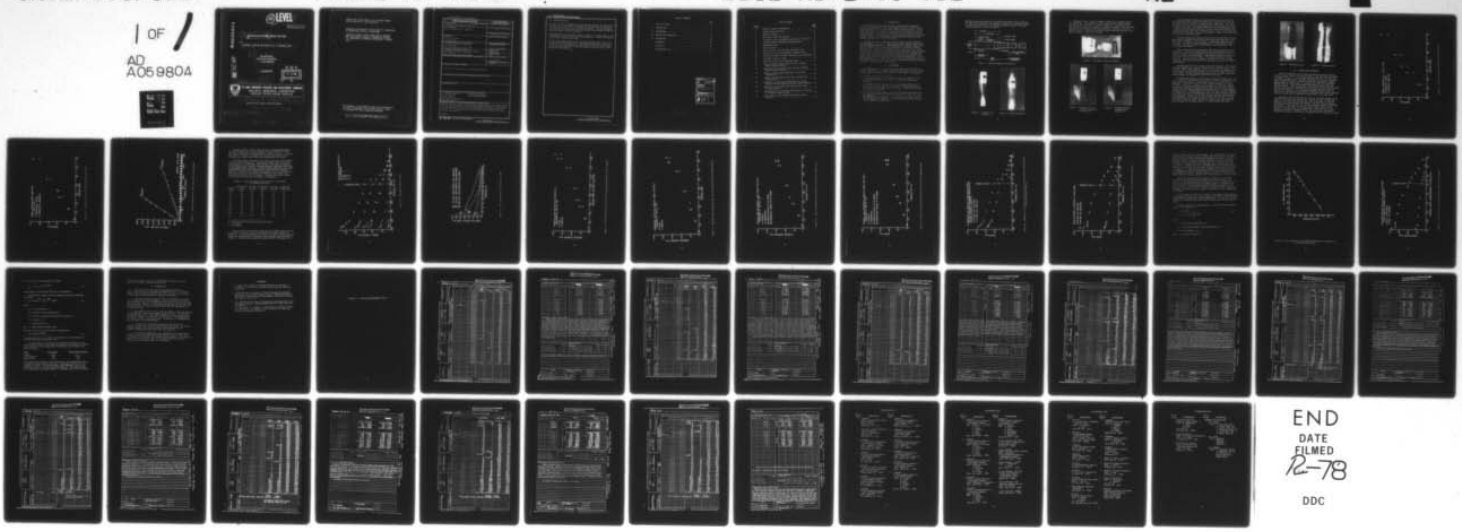
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(10) George Samos,
Bertram B. Grollman
J. Richard Ward

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Wear Prediction Models

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)* (meg)

The 60mm gun, BG3, used in the Anti-Armor Automatic Cannon Technology Program (AAAC), fired 69 rounds with various wear-reducing additives. The wear rate per round measured on the vertical land diameter 20.75 inches (527mm) from the rear face of the tube was 0.7-0.8 mil/rd (0.018-0.020 mm/rd) for each additive configuration.

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20. Abstract (Cont'd)

In order to test the hypothesis that the various additives were not affecting the wear rate of the cannon, ten rounds were fired without any additives. The wear rate increased to 2.0 mils/rd (0.051 mm/rd). The ten round group was followed by a five round series with additive which showed the same low wear rate seen in the first 69 rounds.

The wear profile of the MC-AAAC cannon is similar to the wear profile of the 105mm M68 tank cannon firing rounds without additive. However, the MC-AAAC did not have a secondary wear peak.

The wear rate without additive was predicted reasonably well by both the Frankle and Smith-O'Brasky models. The Smith-O'Brasky model, which has a correction to the propellant flame temperature to account for the presence of the wear-reducing additive, correctly predicted the wear rate of the MC-AAAC with the additive.

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I. INTRODUCTION

Erosion of gun tubes has long been a problem which appears to worsen as technology proceeds towards higher pressures and velocities. Various additives are currently being used to reduce erosion. In the 105mm tank cannon, for example, TiO_2/wax liners decreased the erosion rate from 0.075 inch (1.9mm) per 100 rounds to the same wear rate per 10,000 rounds[1]. A Canadian report[2] claims that polyurethane foam failed to reduce erosion in a smoothbore, high velocity gun operating with chamber pressures near 75 kpsi (517 MPa).

During the course of the Anti-Armor Automatic Cannon Technology Program (AAAC), various tests were conducted with 60mm gun tubes firing slug and APFSDS projectiles. Three different wear reducing additives were utilized in order to keep tube erosion at a minimum. Average pressures were about 80 kpsi (551 MPa), with velocities close to 5000 fps (1524 m/s). Stargage measurements of the tube showed that regardless of the type of additive used, the wear rate was 0.7 mil (0.018mm) per round. This led to speculation that the wear-reducing additives were ineffective in reducing erosion under the 60mm gun conditions. To test this hypothesis, a ten round group of slugs was fired without additive. The data from this test were also useful in determining how well existing models[3,4] can predict gun erosion rates.

II. EXPERIMENTAL

The 60mm guns used in the program were fabricated by Watervliet Arsenal. Ballistic Gun 3 (BG3), the second gun used, has a total length of 226 inches (5.74 meters) and a travel of 217 inches (5.51 meters).

---

1. *I. Ahmad, "The Problem of Gun Barrel Erosion, An Overview", Proceedings of Tri-Service Gun Tube Wear and Erosion Symposium, March 1977.*
2. *G. Bertrand and J.J. Maroney, "A High Performance Experimental Smooth Bore Gun 1965-1967 Coolant Trials at Chamber Pressures of 75,000 psi", Defense Research Establishment, Valcartier Technical Note 1887/70, June 1970.*
3. *J.M. Frankle and L.R. Kruse, "A Method for Estimating Service Life of a Gun or Howitzer", BRL Memorandum Report No. 1852, June 1967.* (AD #818348)
4. *C.S. Smith and J.S. O'Brasky, "A Procedure for Gun Barrel Erosion Life Estimation", Proceedings of the Tri-Service Gun Tube Wear and Erosion Symposium, March 1977.*

Rifling in the tube consists of 16 lands and grooves, with a twist of one turn in 200 calibers. The chamber configuration is shown in Figure 1. The slug projectile fired from BG3 is shown in Figure 2 and the APFSDS projectile is shown in Figure 3.

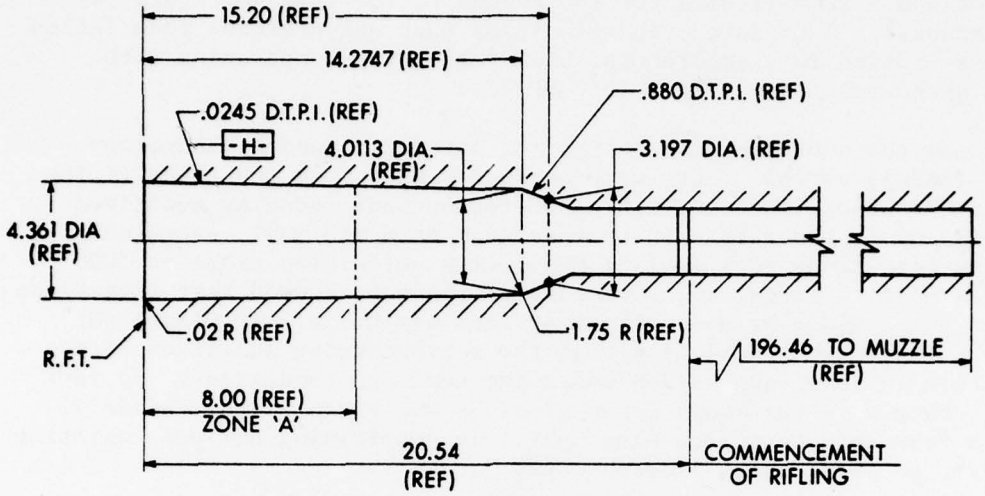


Figure 1. 60mm BG3 Chamber Configuration

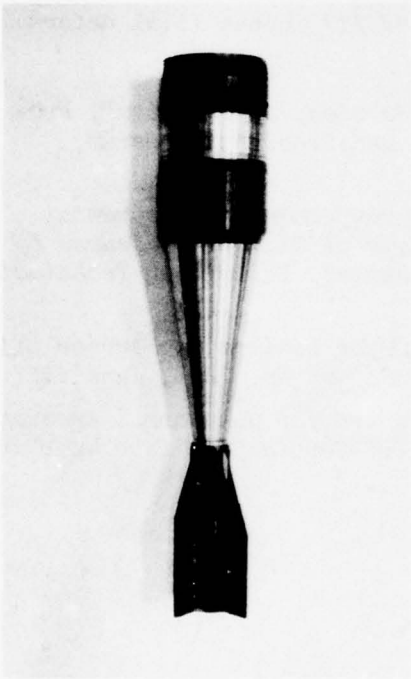


Figure 2. Standard Plug Projectile

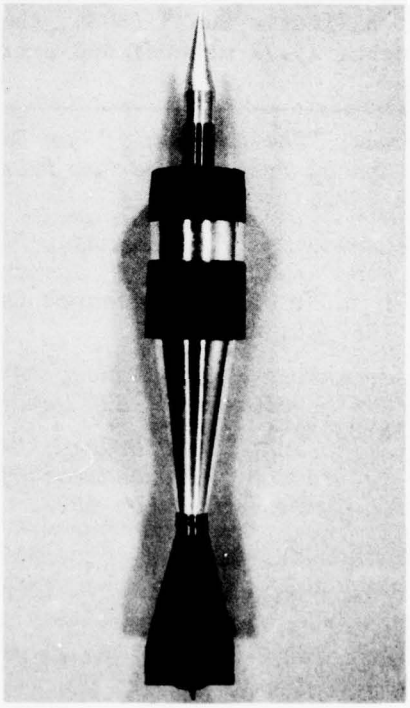


Figure 3. APFSDS Projectile

Stub-steel cases, shown in Figure 4, were used to contain part of the propellant. The remainder of the propellant was arranged around the rear of the projectile, as shown in Figure 5. Talc/wax and TiO_2/wax additives, which are available in nominal thickness of 1/8 inch (3mm) sheet form, were wrapped around the propellant, as shown in Figure 6. The M83 electric primer and a 650 grain black powder base igniter, also shown in Figure 4, ignited the charge.



Figure 4. Stub Case, Primer and Igniter

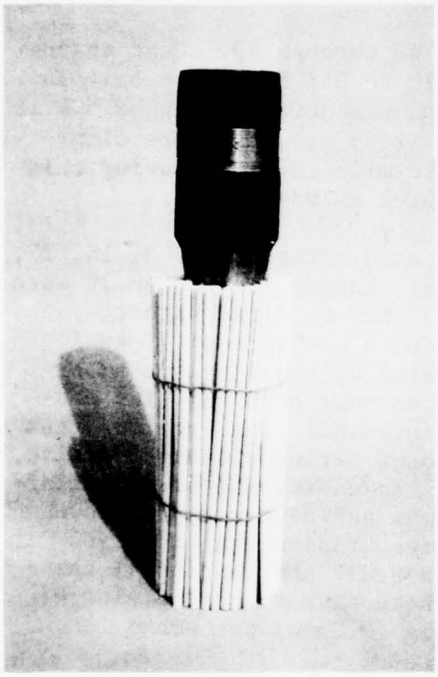


Figure 5. Propellant Sticks Arranged Around Rear of Projectile

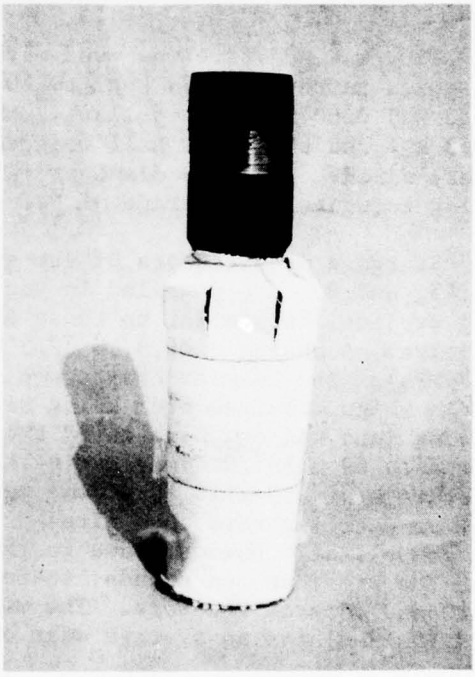


Figure 6. TiO_2/Wax Additive Wrapped Around Propellant

The M30 propellant used in the tests with BG3 were Lot No. PA-E 03795 and PA-E 03796, 0.068" web, single perf, slotted stick, and Lot No. RAD-PE 472-24, 0.078" web, single perf, slotted stick. The latter was used only in one series of firings, when a combustible case, shown in Figure 7 was used. The additive used with the combustible case was a Cabosil silicone grease placed in a plastic sleeve approximately one and one-half inches wide and 10 inches long (4 x 25cm). The sleeve was wrapped around the base of the rear band prior to loading the combustible case with the propellant sticks.

Talc/wax additive was used with the first 27 rounds fired from BG3. Peak chamber pressures ranged from 74 kpsi to 80 kpsi (510 MPa to 552 MPa), with a charge of 5.2 lb (2.36 kg). Projectile weight was 5.8 lb (2.63 kg). The vertical land diameter at 20.75 inches RFT (527.0mm) increased by 22 mils (0.56mm) corresponding to an average wear rate of 0.8 mil/rd (0.02 mm/rd).

Cabosil grease and the combustible case were used with rounds 28 through 47. 5.03 lb (2.28 kg) of 0.078" web stick propellant was used since the impetus of the combustible case was equivalent to 0.25 lb (0.11 kg) of the stick propellant. Peak chamber pressures ranged from 76 kpsi to 81 kpsi (524 to 559 MPa). Projectile weight was 5.8 lb (2.63 kg). The vertical land diameter increased by 13 mils (0.33mm) during the nineteen round group for an average wear rate of 0.7 mil/rd (0.018 mm/rd).

TiO_2/wax additive was used with rounds 48 through 69. Peak chamber pressures ranged from 74 kpsi to 80 kpsi (510 to 552 MPa) with 5.14 lb (2.33 kg) 0.067" web propellant. Half of the projectiles weighed 5.8 lb (2.63 kg) and the other half weighed 5.5 lb (2.49 kg), and were alternately fired. The bore diameter increased 16 mils (0.41mm) during this firing sequence, an average of 0.8 mil/rd (0.02 mm/rd).

Stargage measurements of the gun tube, made after rounds 3, 14, 27, 34, 47, and 69, are compiled in the Appendix. Rounds 70 through 79 were slug projectiles similar to those shown in Figure 8, fired without additive. A charge of 5.5 lb (2.5 kg) yielded a pressure of 75 kpsi (517 MPa). The heavier charge was necessitated by the larger chamber volume which resulted from using slugs without the sabot and fins protruding into the chamber behind the obturating band. The bore diameter increased 19 mils (0.48mm) during the ten-round series without additive, an average of 1.9 mils (0.048mm) per round. An additional five similar slug projectiles were then fired with TiO_2/wax additive wrapped around the propellant. However, due to the excessive erosion that occurred with the previous ten rounds, these five slugs did not seat until the rear band entered the bore. The wear for these five rounds totaled 6 mils (0.15mm) for an average wear of 1.2 mils (0.03mm) per round.

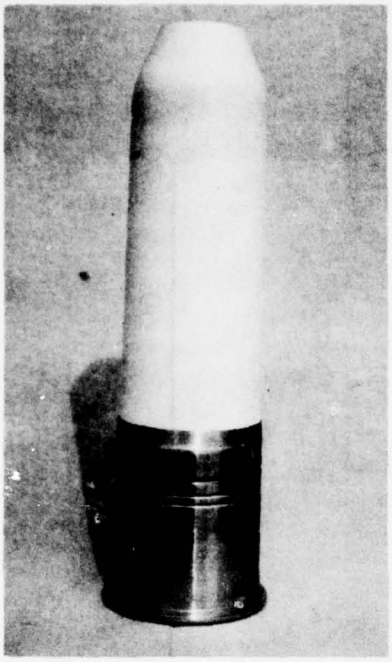


Figure 7. Combustible Case

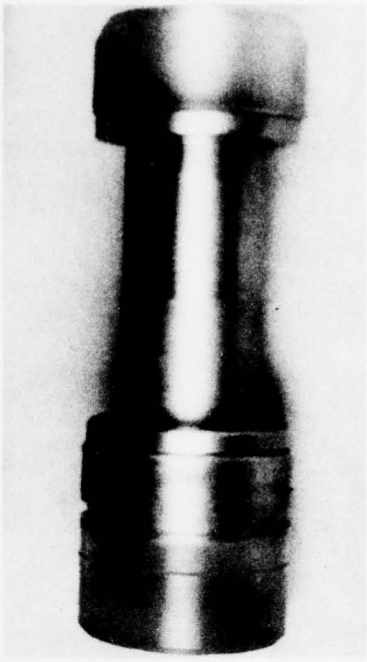


Figure 8. Slug Projectile

III. RESULTS AND DISCUSSION

Plots of horizontal and vertical land and groove wear, measured at 20.75 inches (527mm) from the rear face of the tube (RFT), are shown in Figures 9 and 10. It is evident from the plots that the wear rate per round is linear and is the same regardless of the type of additive used. Another feature of interest is that the land wear is slightly greater than the groove wear, 0.7 mil/rd vs 0.6 mil/rd (0.018 mm/rd vs 0.015 mm/rd). The vertical lands wear slightly faster than the vertical grooves, while the grooves in the vertical and horizontal planes wear at the same rate. The datum for horizontal land wear after 34 rounds fired appears to be an erroneous stargage reading, since the wear rate of the vertical lands and both horizontal and vertical grooves after 34 rounds fell on the slope of wear/round to 69 rounds fired.

The linear wear rate for BG3 is similar to the wear pattern of the 105mm M68 gun mounted on the M60 tank. Figure 11 shows the M68 tube wear at 25.25 inches RFT (641.4mm) for APDS rounds with no additive (M392A1), with polyurethane foam (M392A2), and with TiO_2/wax additive. Of interest is that the wear rate of BG3 through 69 rounds is about the same as that of the M68 cannon firing APDS or HEAT rounds without additive. The M68 cannon is condemned after firing 100 such rounds. Assuming BG3 would be condemned at the same two percent increase in initial bore diameter, BG3 would be condemned after 60 rounds were fired.

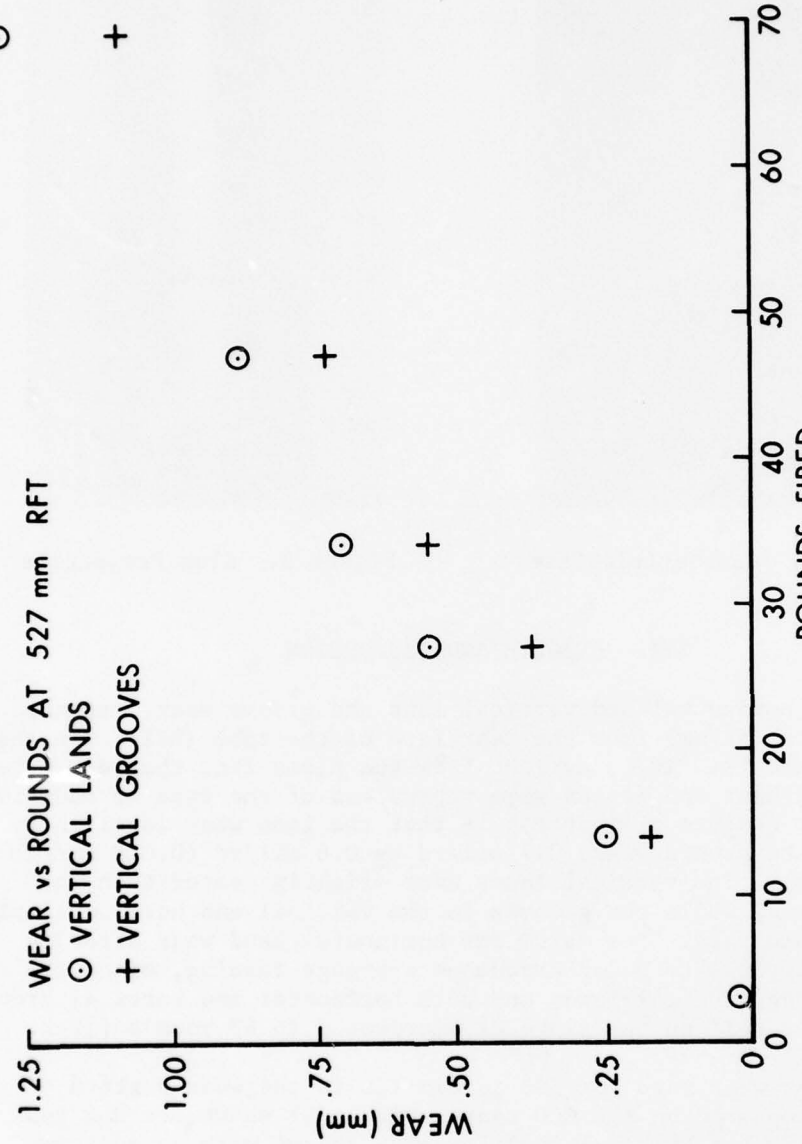


Figure 9. Vertical Groove and Land Wear vs Rounds Fired

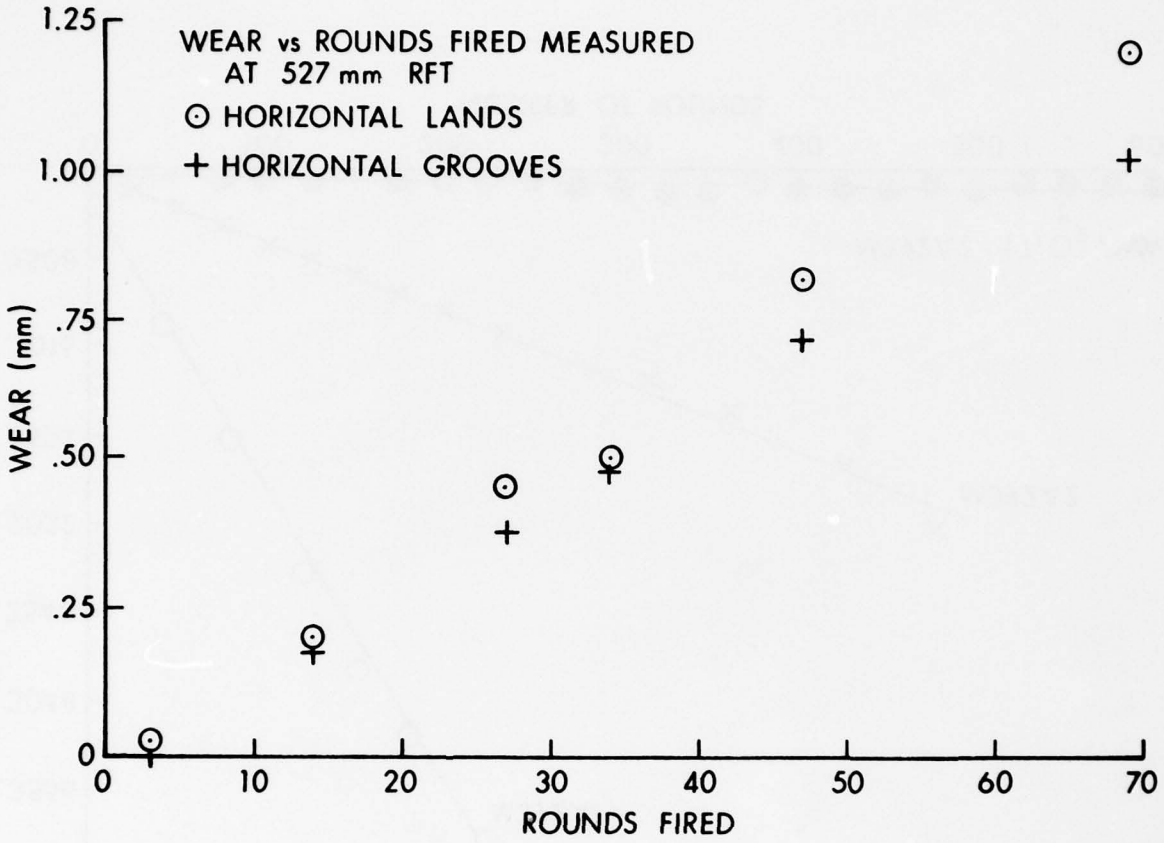


Figure 10. Horizontal Groove and Land Wear vs Rounds Fired

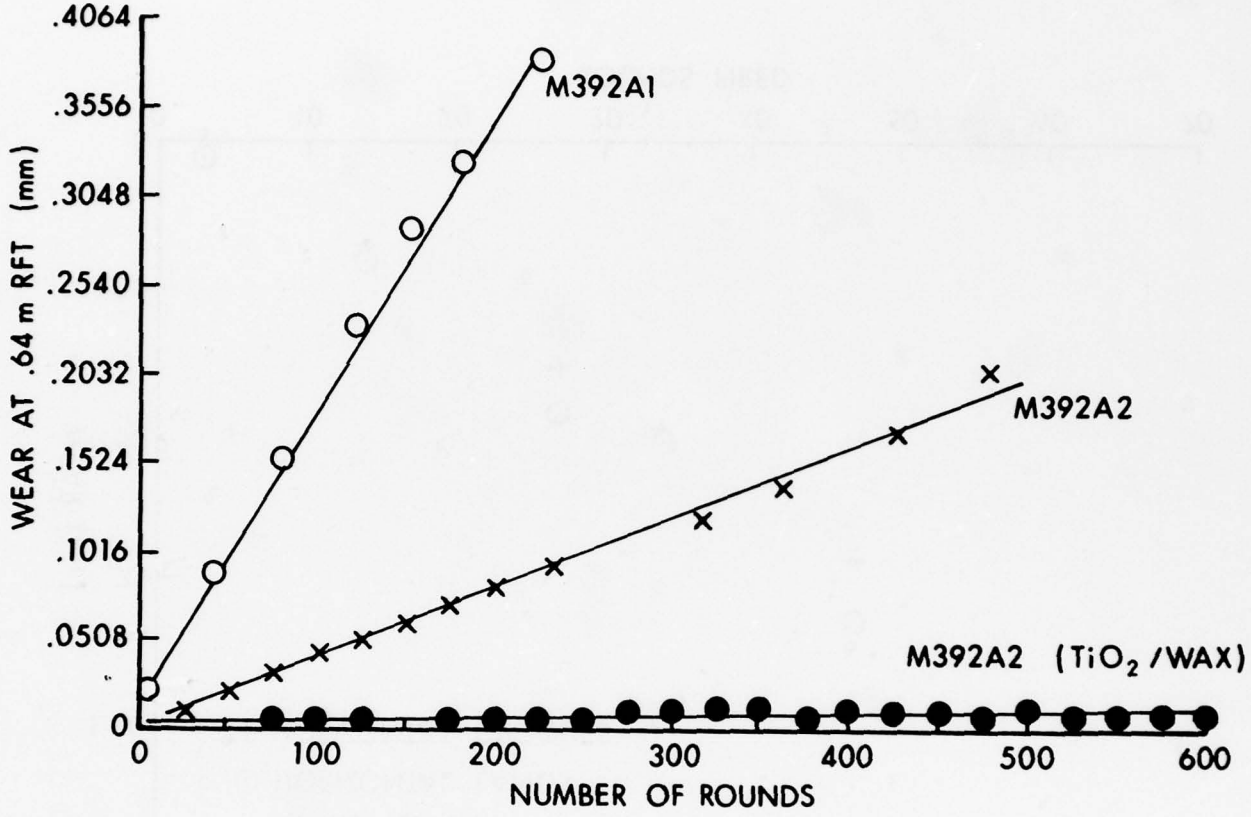


Figure 11. Vertical Land Wear for M392 Projectiles with Additives

The wear profile for BG3 after each set of stargage measurements is shown in Figure 12. This is similar to the wear profile for the M68 cannon firing rounds without additive, shown in Figure 13. However, BG3 shows no evidence of secondary wear while the M68 cannon shows secondary wear when firing rounds with polyurethane foam liners.

The bore diameter increase in BG3, after firing ten rounds (Rounds 70-79) is shown in Figure 14. Wear rate increased from 0.7 mil/round (0.018 mm/rd) to 2 mils/round (0.051 mm/rd). Both lands and grooves in the vertical and horizontal positions exhibit larger wear rates when firing rounds without additive. The bore diameter increase after firing the subsequent five rounds (Rounds 80-84) with additive is shown in Figure 15. Wear rate for these rounds dropped to the rate obtained for the first 69 rounds as illustrated in Figures 16 and 17 where only rounds fired with additive are plotted. Stargage measurement records for these two tests are also included in the Appendix.

TABLE I. Comparison Between Wear Profiles for the M392A1 and M392A2 Projectiles

RFT, cm[a]	M392A1 wear[b] mils	wear/rd, cm x 10^4	M392A2 wear[c] mils	wear/rd, cm x 10^4	% reduction in wear rate
64.14	123	18.	80	4.7	74
66.	83	12.	60	3.6	71
71.	80	11.	68	4.1	64
76.	70	10.	75	4.3	58
81.	60	8.6	75	4.3	50
91.	45	6.4	70	4.1	36
101.	35	5.1	63	3.8	25
112.	25	3.6	50	3.0	14
123.	16	2.	43	2.5	0
142.	10	1.5	32	1.8	0

a - distance from the rear face of the tube (RFT).
b - 177 rounds.
c - 432 rounds.

The wear profile of BG3 after firing the ten rounds without additive in contrast to the wear profile for the first 69 rounds is shown in Figure 18. To better appreciate the effect of the wear reducing additives on BG3, the wear profile is converted to the wear per round and shown in Figure 19. One sees that through 60 inches from RFT (1.52 meters) the

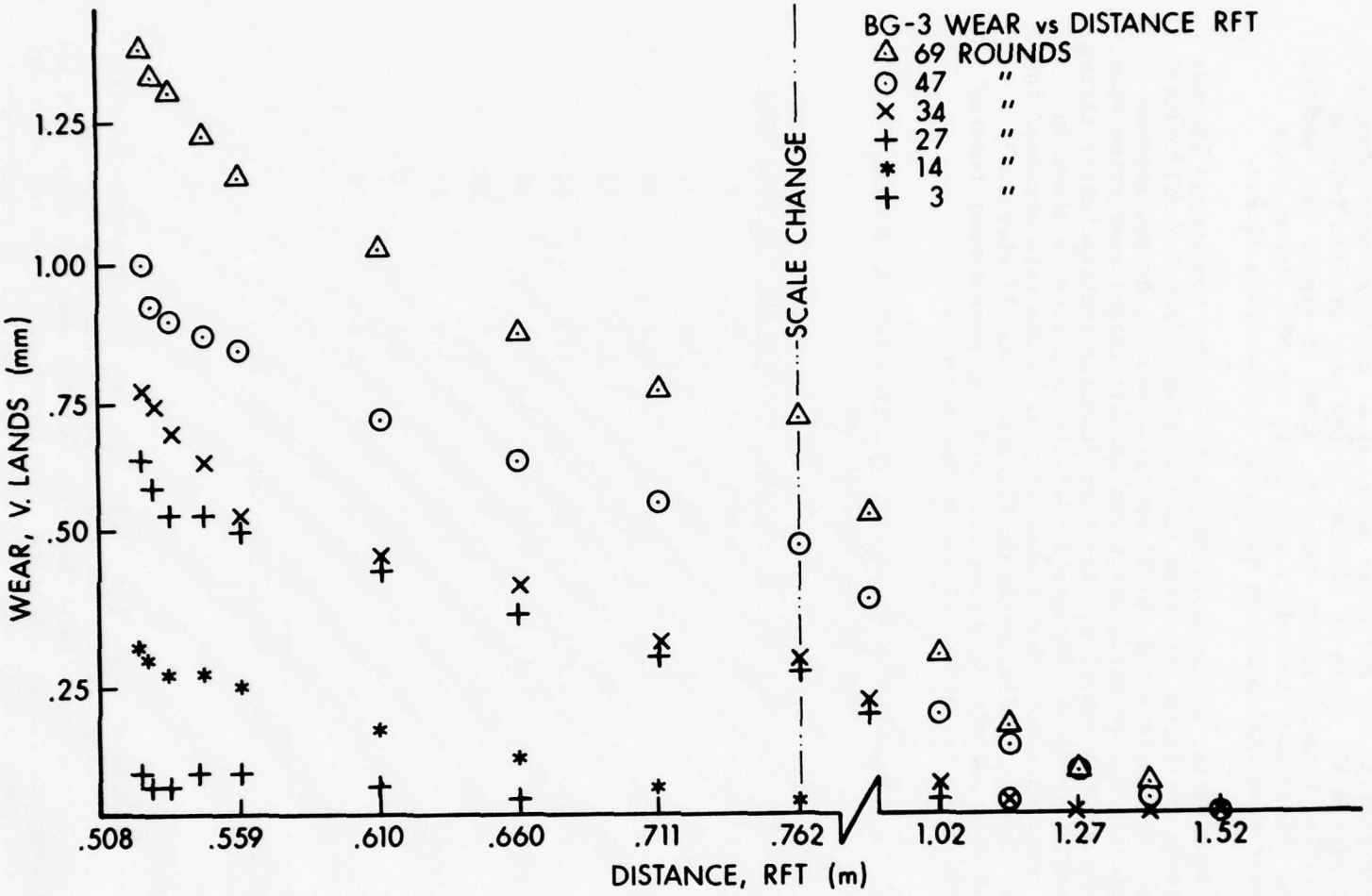


Figure 12. Tube Wear Profile for BG3

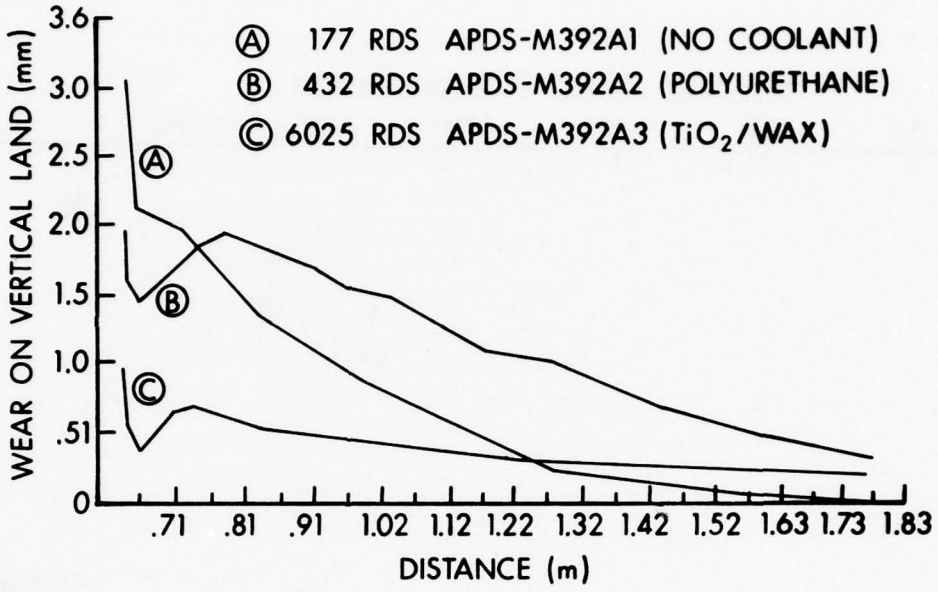


Figure 13. Tube Wear Profile for 105mm Tubes, M68

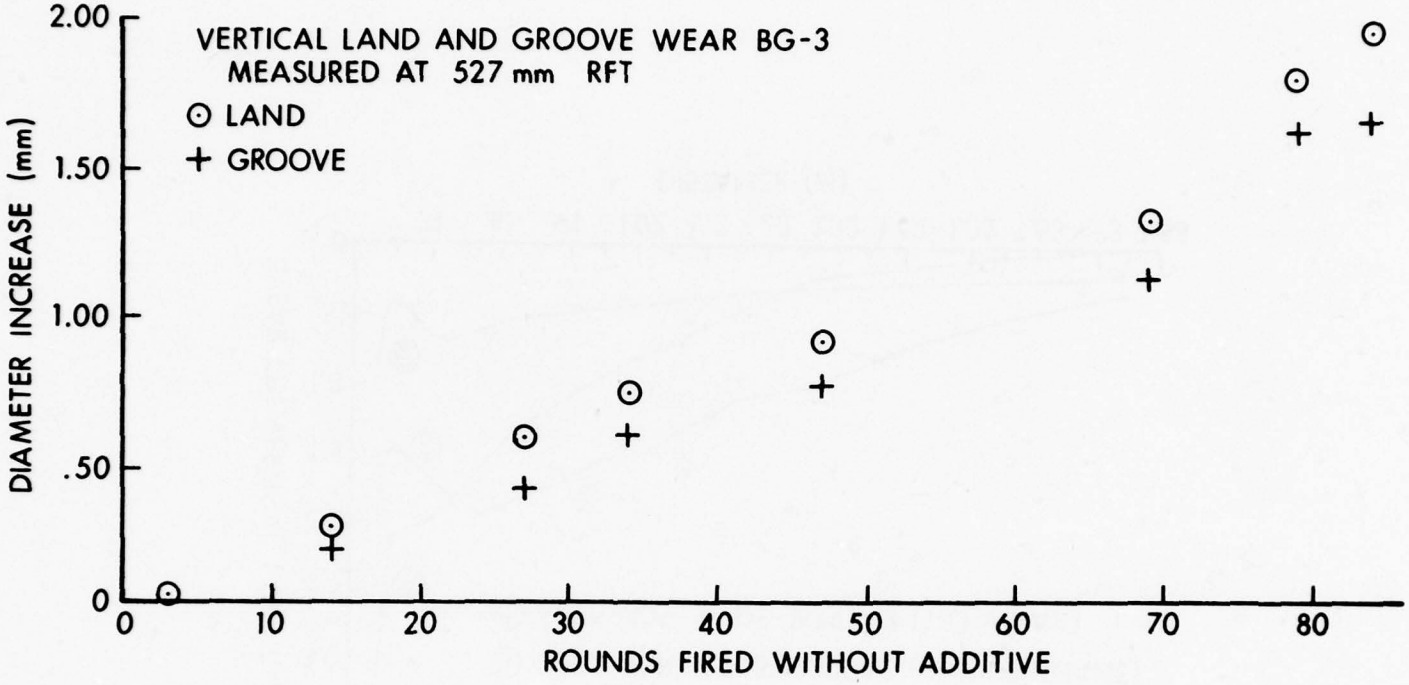


Figure 14. Vertical Land and Groove Wear for BG3 Including Rounds without Additive

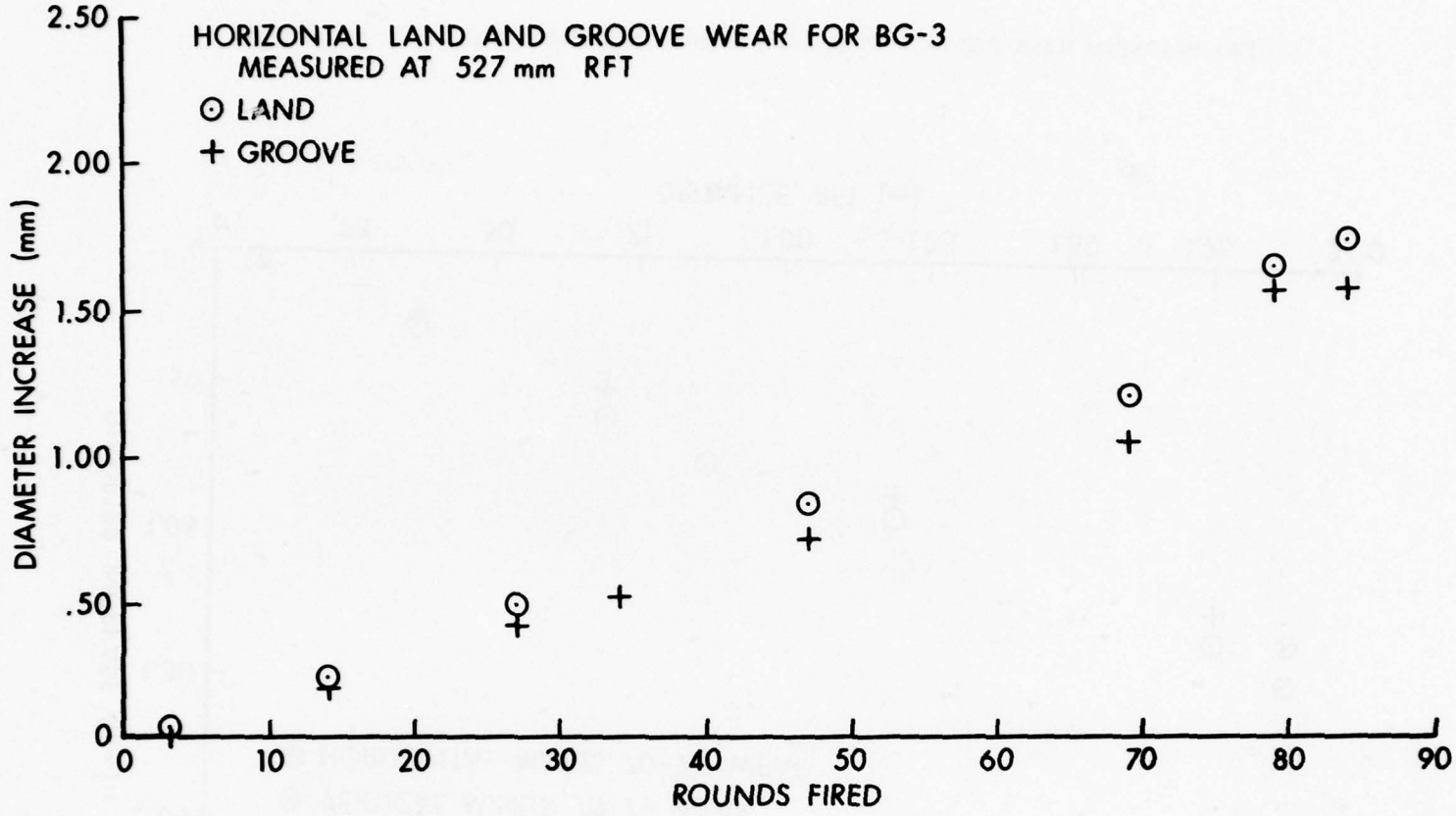


Figure 15. Horizontal Land and Groove Wear for BG3 Including Rounds without Additive

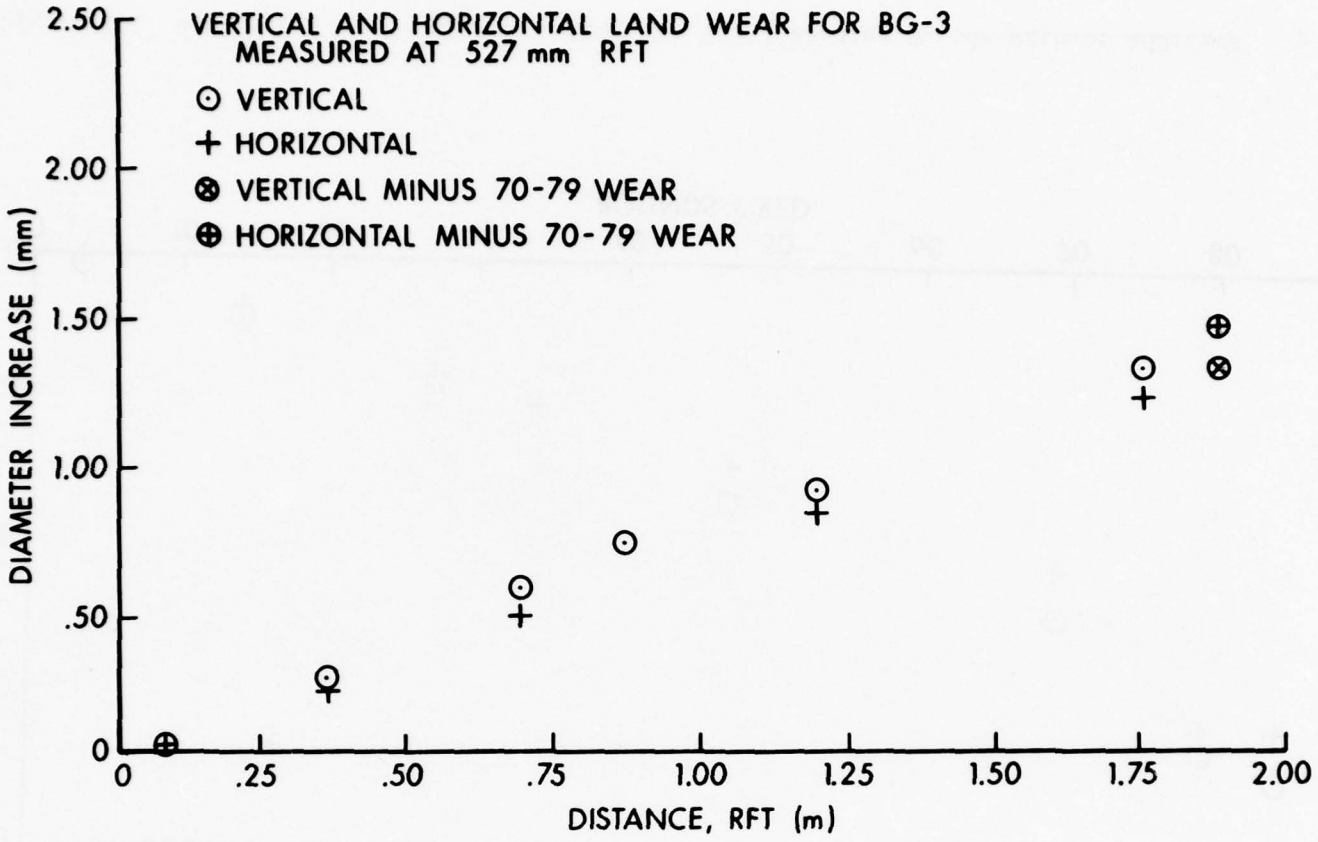


Figure 16. Vertical and Horizontal Land Wear for BG3 with Additive Only

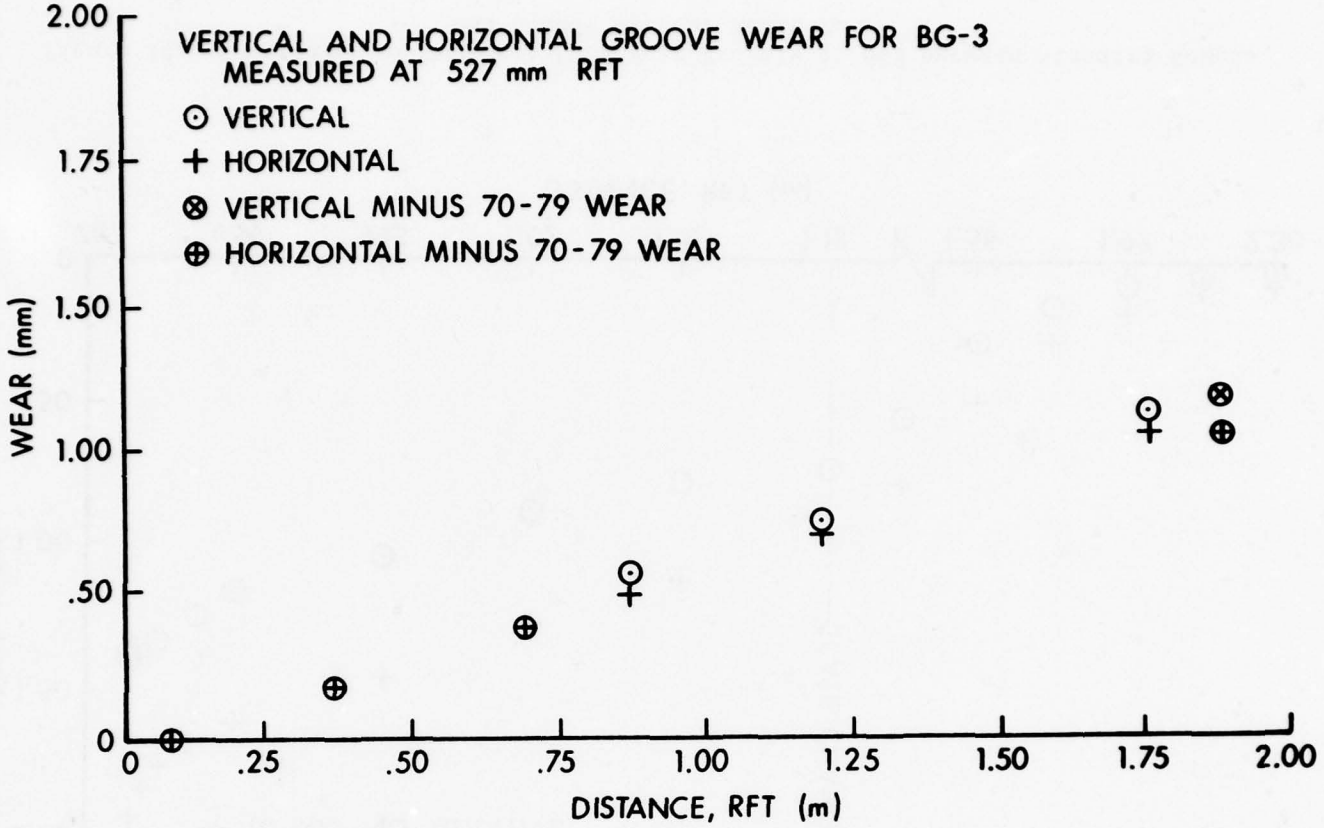


Figure 17. Vertical and Horizontal Groove Wear for BG3 with Additive Only

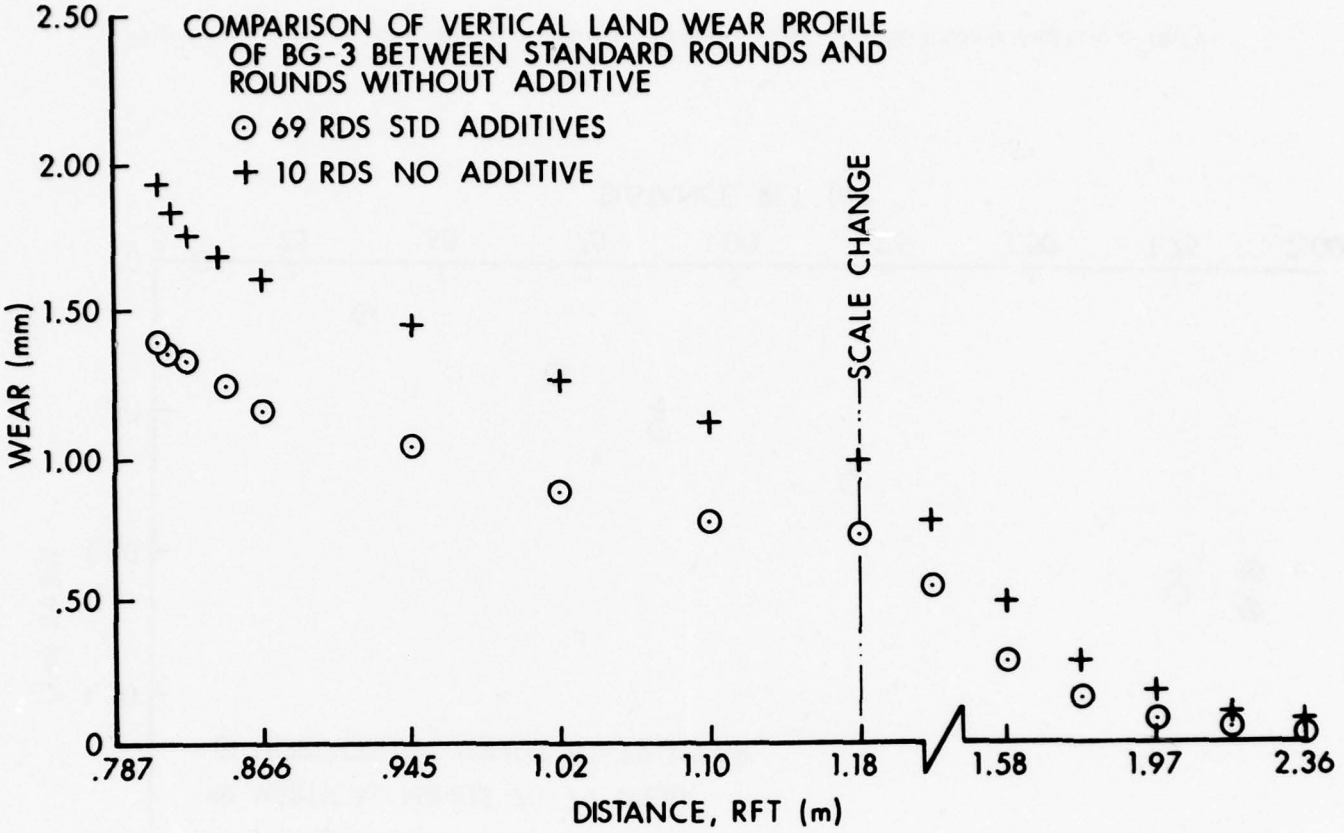


Figure 18. Comparison of Vertical Land Wear Profile of BG3 between Standard Rounds and Rounds without Additive

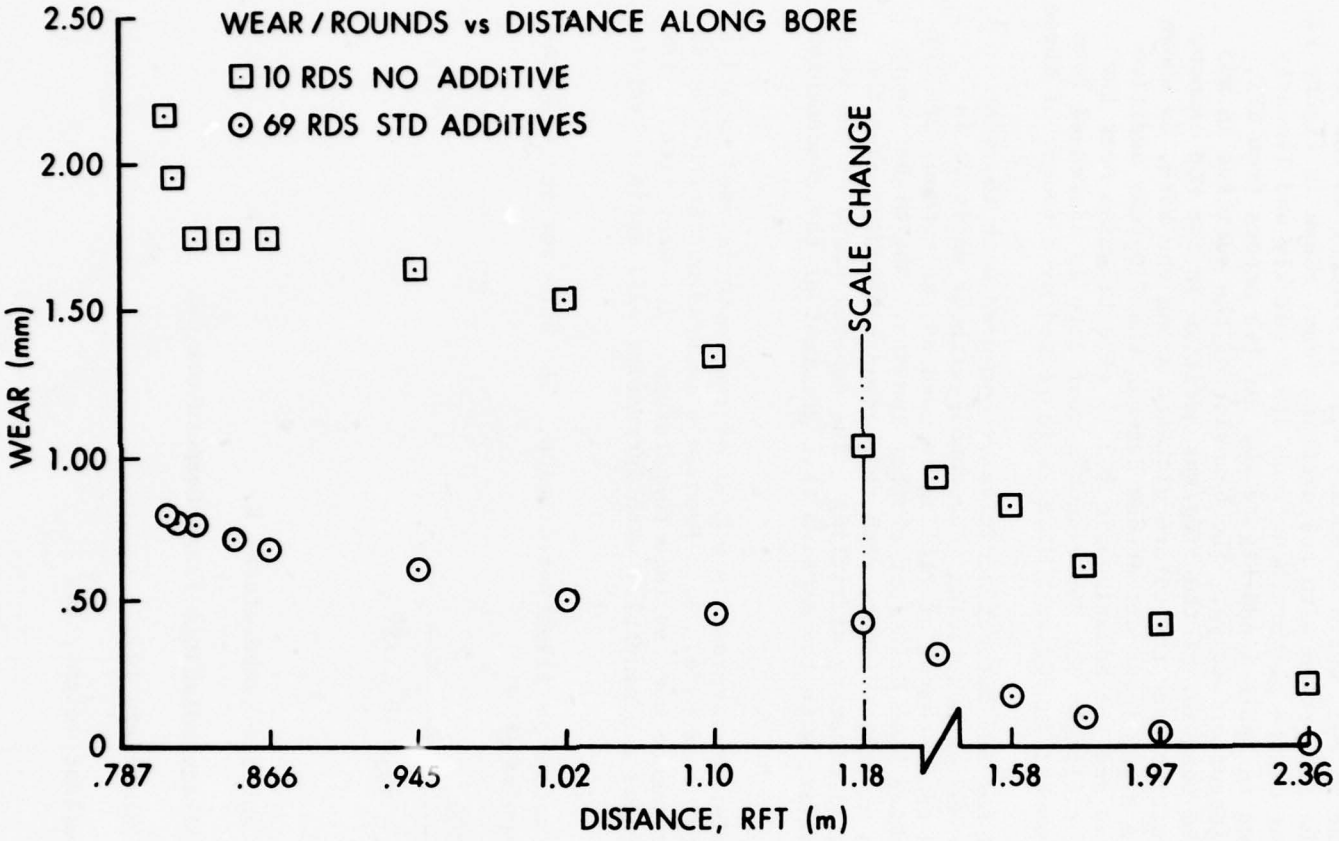


Figure 19. Wear Profile for Rounds with Additive and Rounds without Additive

additive reduces the wear of the cannon. This could explain the absence of secondary wear in BG3, while secondary wear is evident in the M68 cannon firing the APDS round with polyurethane foam, shown in Figure 13. The effectiveness of the polyurethane foam drops quickly and linearly downbore, as seen in Table I and Figure 20. At 1.2 meters from RFT, the foam is no longer effective. The behavior of the additive in BG3 is similar to the behavior of the TiO_2/wax additive in the M68 cannon, where it is effective over the entire distance along the bore, as shown in Figure 13. A significant difference between the TiO_2/wax additive in the M68 cannon and the additives in BG3 is effectiveness near the commencement of rifling. The M68 cannon's wear life is increased from 100 to 10,000 rounds; in BG3 wear life is increased by a factor of three.

Wear/round for BG3 without additive is compared with the wear profile for the M68 cannon firing APDS rounds without additive in Figure 21. The commencement of rifling is used as the common zero for the two tubes which have different chamber lengths. The higher wear rate for BG3 is clearly evident, with this trend continuing over the first 40 inches (1.0 meter) of rifling. The general shape of the wear profiles is similar, with the erosion rate greatest at the commencement of rifling.

A final point of interest is a test of two commonly used equations to compute barrel wear rate. Both Frankle's method[3] and Smith-O'Brasky's[4] model compute a pseudo bore surface temperature. The wear rate is then assumed to increase exponentially with increasing wall surface temperature.

Frankle's method is illustrated below. The bore surface temperature, θ, is computed from

$$\theta = \frac{T_o - 300}{1.7 + 0.38d^{\frac{1}{2}} \left(\frac{d^2}{c}\right) .86} \quad , \qquad (1)$$

where

θ = bore surface temperature, K,

T_o = propellant adiabatic flame temperature, K,

d = bore diameter, in.,

and c = propellant weight, lb.

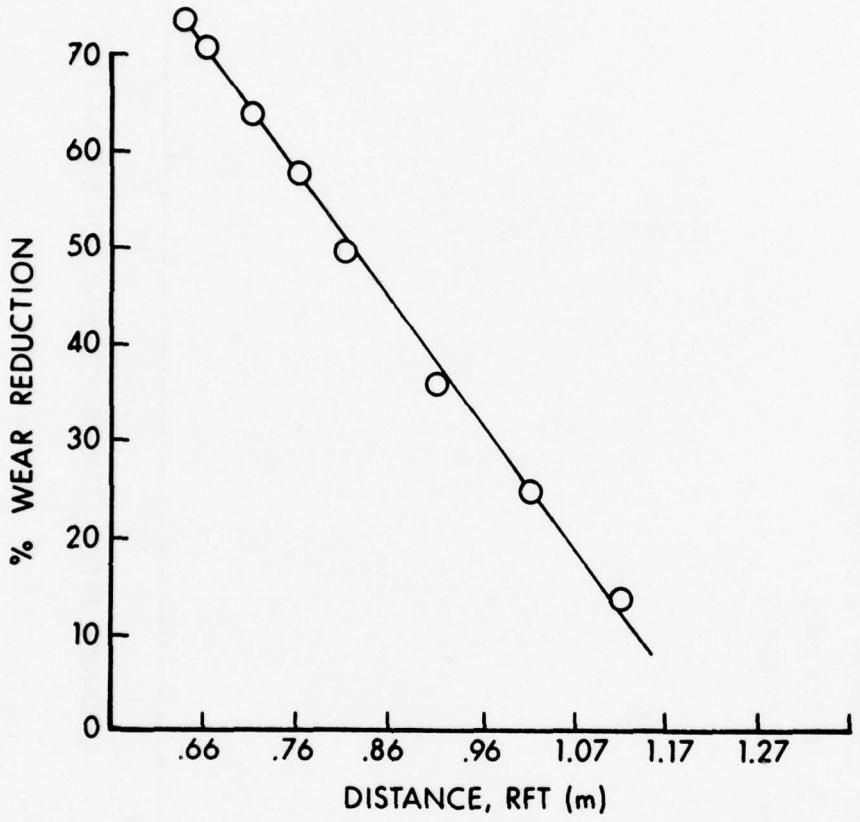


Figure 20. Wear Reduction in the M392A2 Projectile as a Function of Distance Along the Tube

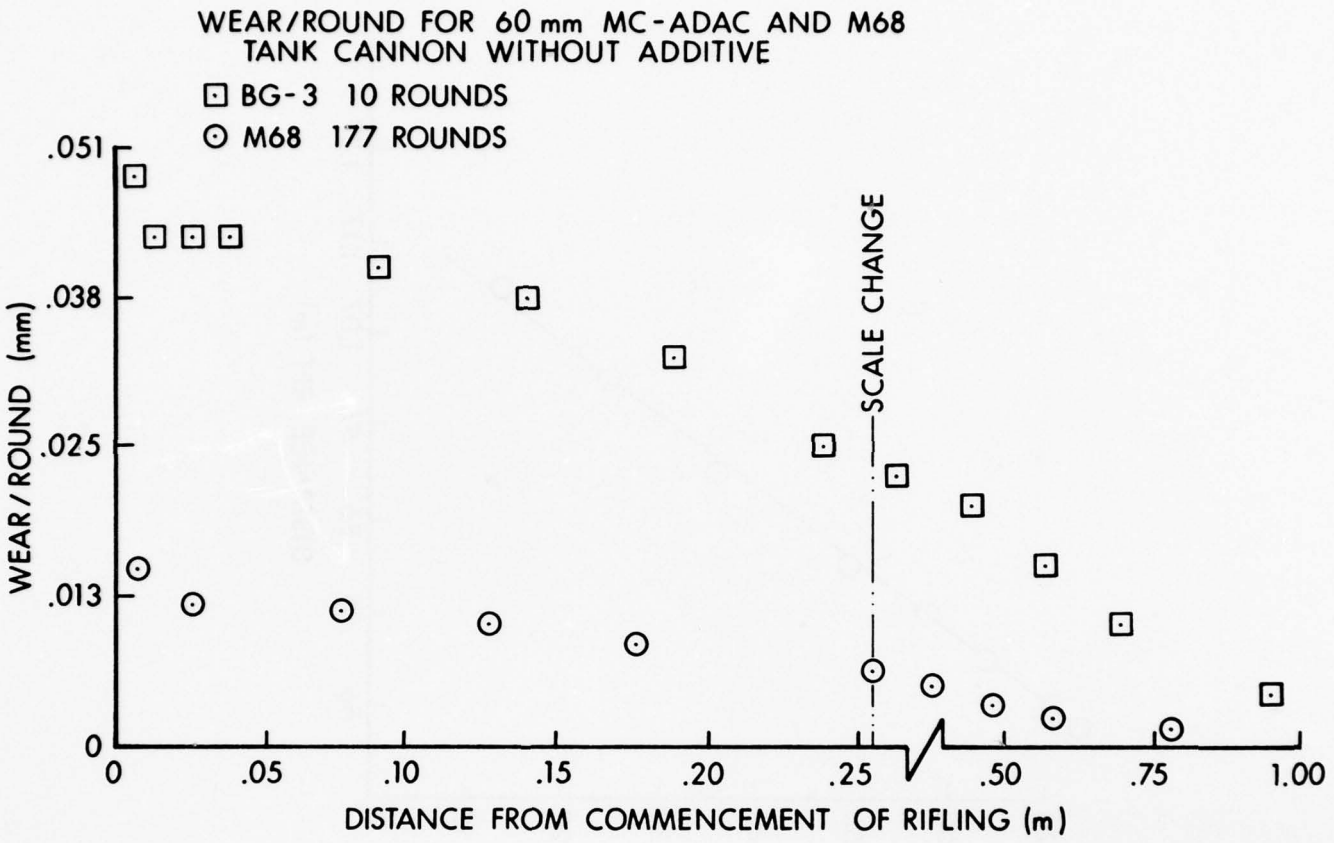


Figure 21. Wear Profile of BG3 and M68 Tank Cannon without Additive

The wear rate is then computed as follows:

$$\frac{W}{\sqrt{d}} = 8.48 \times 10^{-8} \, e^{.007850} \qquad (2)$$

which yields the diametrical wear rate in microinches.

Smith-O'Brasky compute the wall temperature with the following expression:

$$T_w = 0.0763 \, \frac{T_F - T_c - 600}{d} \, (CP)^{\frac{1}{2}}, \qquad (3)$$

where

T_w = wall temperature, K,

T_F = propellant flame temperature, K,

T_c = effective temperature reduction by coolant, K,

d = diameter, in.,

C = charge weight, lb,

and P = peak chamber pressure, kpsi.

The wear rate in 0.1 mil per round is computed from:

$$W = 0.0166 \, e^{0.0049 T_w} . \qquad (4)$$

The typical value of T_c is 500K. An expression is also available for computing wear rate during burst fire.

The predictions by each model are listed below assuming a 2.5 kg charge weight, 83,655 psi (577 MPa) peak chamber pressure, M30 propellant with a propellant flame temperature of 3040K, and T_c of 500K for the additive rounds:

Model	Wear, mm/rd	Wear, mm/rd, Additive
Frankle	0.038	-----
Smith-O'Brasky	.099	0.020
Experimental	.051	.018

The Frankle model predicts a wear rate closer to the experimental value, although both models predict the order of magnitude correctly for the nonadditive rounds. The Smith-O'Brasky comes remarkably close to predicting the wear rate of the rounds with additive. The Frankle method is not applicable on additive rounds. It appears, then, for the interior

ballistic parameters typical of the MC-AAAC, the empirical erosion models may be used to estimate erosion rates.

IV. CONCLUSIONS

1. The wear rate of BG3 without wear-reducing additives is significantly higher than the wear rate with additives. At the axial distance used to measure remaining tube life, the wear rate increased from 0.7 mil/rd (0.018 mm/rd) to 2 mils/rd (0.05 mm/rd).

2. The wear-reducing additives in BG3 exert influence on erosion over a considerable distance downbore. This is similar to the action of the TiO_2/wax liner in the M392A2 APDS projectile fired from the 105mm M68 tank cannon. However, the BG3 additives decrease the wear rate near the commencement of rifling threefold rather than the hundredfold in the M68 tank cannon.

3. The downbore wear profile of BG3 was similar to the wear profile for the M68 tank cannon firing rounds without additive. In this sense, the 60mm MC-AAAC wears in the fashion observed for other high-velocity, direct-fire cannons. In particular, the wear rate at the commencement of rifling is linear with rounds fired. In addition, no secondary wear peak is evident in the 60mm MC-AAAC.

4. Two empirical formulae for estimating tube wear rates correctly estimate the order of magnitude wear rate of BG3. The Smith-O'Brasky equation which estimates wear rate with additives also correctly estimates the wear rate of BG3 with additive.

5. If the 60mm MC-AAAC were to be condemned for the same percent increase in wear as the M68 tank cannon, BG3 would have a useful life of 60 rounds with additive and 20 rounds without additive. This suggests guns with this performance level in the 60mm caliber will require platings or coatings before they can be fielded.

REFERENCES

1. I. Ahmad, "The Problem of Gun Barrel Erosion, An Overview", Proceedings of Tri-Service Gun Tube Wear and Erosion Symposium, March 1977.

2. G. Bertrand and J.J. Maroney, "A High Performance Experimental Smooth Bore Gun 1965-1967 Coolant Trials at Chamber Pressures of 75,000 psi", Defense Research Establishment, Valcartier Technical Note 1887/70, June 1970.

3. J.M. Frankle and L.R. Kruse, "A Method for Estimating Service Life of a Gun or Howitzer", BRL Memorandum Report No. 1852, June 1967. (AD #818348)

4. C.S. Smith and J.S. O'Brasky, "A Procedure for Gun Barrel Erosion Life Estimation", Proceedings of the Tri-Service Gun Tube Wear and Erosion Symposium, March 1977.

APPENDIX A. STAR-GAGE MEASUREMENTS FOR BG3

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SHEET 1 OF 2

60 M/M Tube, MC-AAAC

MULTIPLE STARGAGE MEASUREMENT & INSPECTION DATA FORM

CASTING NUMBER:

MANUFACTURER: WVT ARS.

PROOF OFFICER: MR SAMOS W.O. 445-30601-93

MODEL: MC-AAAC

NUMBER OF ROUNDS BEFORE FIRE:

NUMBER: 03

FIRING STATUS (Check One): BEFORE ✓ AFTER

DATE OF GAUGING: 22 MARCH 1976

60 M/M Tube

	Rear Face Of Tube	Gage Meas. indicated in 1/1000" of Inch			
		2.362" GAGE PINS ZERO		2.362" GAGE PINS ZERO	
		VERT	HOR	VERT	HOR
	216.90	+.003	+.001	+.027	+.026
	215.00	1	1	27	27
	210.00	1	1	27	27
	205.00	1	1	27	27
	200.00	1	1	27	27
	195.00	1	1	27	27
	190.00	.000	1	27	27
	185.00	0	1	27	27
	180.00	0	1	27	27
Junction →	175.35	0	1	27	27
	175.15	0	1	27	27
	170.00	0	1	27	27
	165.00	0	1	27	27
	160.00	0	1	27	27
	155.00	0	1	27	27
	150.00	0	1	27	27
	145.00	0	1	27	27
	140.00	0	1	27	27
	135.00	0	1	27	27
	130.00	0	1	27	27
	125.00	0	1	27	27
	120.00	0	1	27	27
	115.00	0	1	27	27
	110.00	0	1	27	27
	105.00	0	1	27	27
	100.00	0	1	27	27
	95.00	0	1	27	27
	90.00	0	.000	27	27
	85.00	0	0	27	27
	80.00	0	0	27	27
	75.00	0	0	27	27
	70.00	+.001	0	27	27
	65.00	1	0	27	27
	60.00	1	0	27	27
	55.00	1	0	27	27
	50.00	1	0	27	27
	45.00	1	0	27	27
	40.00	1	+.001	27	27
	35.00	1	1	27	27
	30.00	1	1	27	27
	28.00	1	1	27	27
	26.00	1	1	27	27
	24.00	1	1	27	27
	22.00	1	1	27	27
	21.50	1	1	27	27
	21.00	1	1	27	27
	20.75	1	1	27	27
	20.60	+.001	+.001	+.027	+.027

STEAP-DS Form 106, 17 Jun 64 (Part I)

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60 M/M, MC-AAAC, TUBE #03
22 MAR 76 BEFORE FIRE AT APG
FOR: MR SAMOS W.O. 445-30601-93

WHEEL 201

60 M/M Tube MC-AAAC — CHROME

DISTANCE (Inches) FROM REAR FACE OF BREECH	DISTANCE (Inches) FROM MUZZLE FACE	DISTANCE (Inches) FROM REAR FACE OF TUBE	BASIC DIAMETER	ZERO	GAUGE MEASUREMENTS INDICATED IN 1/1000 OF AN INCH [redacted] X GAUGE READING	[redacted] X ACTUAL DIAMETER	[redacted] X DIFFERENCE	[redacted] Y GAUGE READING	[redacted] Y ACTUAL DIAMETER	[redacted] Y DIFFERENCE
		20.05				2.393			2.393	
		19.00				2.400			2.400	
		17.00				2.413			2.413	
		16.20				2.427			2425	
		14.00				4020			4020	
		12.00				4070			4070	
		10.00				4118			4119	
		8.00				4166			4167	
		6.00				4216			4217	
		4.00				4266			4266	
		2.00				4315			4316	
		1.00				4340			4340	
		.50				4352			4352	
		.10				4362			4363	

Borescoped: (Not chrome plated)
Numerous light scratches with light stains and other deposits thru-out chamber and centering cylinder. The eccentricity of the origin of rifling in the 3:30 o'clock area measured 19.75" from rear face of tube (RFT), and in the 9:00 o'clock area measured 20.30" from (RFT); therefore the eccentricity of the origin of rifling is considered to be elongated. Several light scratches with light stains and other deposits thru-out bore. Four piezo gage holes were noted drilled through tube wall. One 60.55" from (RFT) in the 11:45 o'clock area, one 99.50" from (RFT) in the 7:00 o'clock area, one 148.25" from (RFT) in the 7:00 o'clock area, and one 200.50" from (RFT) in the 7:00 o'clock area. Appearance of no separation at the junction of tube and extension. Photos taken of origin of rifling (general view), 12:00 and 6:00 o'clock (direct shots) and a (general view) of the junction (tube and extensions).

SPECIAL MEASUREMENTS

	BASIC	ACTUAL		BASIC	ACTUAL
TOTAL LENGTH OF GUN	—	226.00	ROTATION OF TUBE AT BREECH	—	—
TOTAL LENGTH OF TUBE	—	217.00"	MOVEMENT OF TUBE AT BREECH	—	—
DEPTH OF BREECH RECESS	—	9.00"	NUMBER OF LANDS AND GROOVES	—	16

Inspection Remarks (Main Bore 20.50" to 175.00", Extension 175.00 to 217.00")

STAMPED	STARGAUGED AND INSPECTED BY Bowles C.	REVIEWED BY
ROGMAN Crabb D	TIME —	COMPILATOR
RECORDER Tildon M.	PLACE 525	GRAPHED BY

EAP-DS Form 106, 17 Jun 64 (Part II)

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MULTIPLE STARGAGE MEASUREMENT & INSPECTION DATA FORM

SHEET 1 OF 2

60 M/M Tube, MC-AAAC

CASTING NUMBER: X

MANUFACTURER: WVT. ARS.

PROOF OFFICER MR. BOYER W.O. 445-7677-94

MODEL: MC-AAAC

NUMBER OF ROUNDS: 3

NUMBER: 03

FIRING STATUS (Check One): BEFORE / AFTER X

DATE OF GAUGING: 4 MAY 76

60 M/M TUBE

	Rear Face Of Tube	Gage Meas. indicated in 1/1000" of Inch. 2.326" Bore		2.362" Bore	
		VERT	HOR	VERT	HOR
	216.90	.000	.000	+.025	+.025
	215.00	-.001	-.001	25	25
	210.00			25	25
	205.00			25	25
	200.00			26	25
	195.00			26	25
	190.00			26	25
	185.00			26	25
	180.00			26	26
Junction >	175.35			26	26
	175.15			26	26
	170.00			26	26
	165.00			25	26
	160.00			25	26
	155.00	.000		25	26
	150.00	0		25	26
	145.00	0		25	26
	140.00	0		25	26
	135.00	0		25	26
	130.00	0		25	26
	125.00	0		25	26
	120.00	-.001		25	24
	115.00			25	24
	110.00			25	24
	105.00			25	24
	100.00			25	25
	95.00			25	25
	90.00		.000	25	25
	85.00		0	25	25
	80.00	.000	0	25	25
	75.00	0	0	25	25
	70.00	0	0	25	25
	65.00	0	0	25	25
	60.00	0	0	25	25
	55.00	0	0	25	25
	50.00	0	0	25	25
	45.00	0	0	25	25
	40.00	0	0	25	25
	35.00	0	0	26	26
	30.00	0	0	27	27
	28.00	0	0	27	27
	26.00	+.001	+.001	27	27
	24.00	2	1	27	28
	22.00	2	2	28	28
	21.50	3	2	28	27
	21.00	2	2	28	27
	20.75	2	2	27	27
	20.60	+.003	+.002	+.026	+.027

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SHEET 2 OF 2

60 M/M Tube MC-AAAC — CHAMBER

DISTANCE (Inches) FROM REAR FACE OF BREECH	DISTANCE (Inches) FROM MUZZLE FACE	DISTANCE (Inches) FROM REAR FACE OF TUBE	BASIC DIAMETER	ZERO	GAUGE MEASUREMENTS INDICATED IN 1/1000 OF AN INCH — [redacted] X: GAUGE READING	[redacted] X: ACTUAL DIAMETER	[redacted] X: DIFFERENCE	[redacted] Y: GAUGE READING	[redacted] Y: ACTUAL DIAMETER	[redacted] Y: DIFFERENCE
		20.05				2.382			2.382	
		19.00				2.402			2.402	
		17.00				2.415			2.414	
		16.20				2.425			2.425	
		14.00				4.020			4.020	
		12.00				4.070			4.070	
		10.00				4.118			4.119	
		8.00				4.166			4.167	
		6.00				4.216			4.217	
		4.00				4.266			4.266	
		2.00				4.315			4.316	
		1.00				4.340			4.340	
		.50				4.352			4.352	
		.10				4.362			4.363	

Borescoped: (Not chrome plated)
Numerous light scratches with light carbon and other deposits thru-out chamber. Two score marks were noted in chamber. One in the 4:00 o'clock area between 1" to 2.5" from rear face of tube (RFT) and one in the 8:00 o'clock area between 2" to 2.75" from (RFT). The eccentricity of the origin of rifling in the 3:30 o'clock area measured 19.75" from rear face of tube (RFT), and in the 9:00 o'clock area measured 20.30" from (RFT); therefore the eccentricity of the origin of rifling is considered to be elongated. Several light scratches with light stains and other deposits thru-out bore. Four piezo gage holes were noted drilled through tube wall. One 60.55" from (RFT) in the 11:45 o'clock area, one 99.50" from (RFT) in the 7:00 o'clock area, one 148.25" from (RFT) in the 7:00 o'clock area, and one 200.50" from (RFT) in the 7:00 o'clock area. Appearance of no separation at the junction of tube and extension.
Impression taken of the two score marks in chamber. No photos taken at this time.

SPECIAL MEASUREMENTS

	BASIC	ACTUAL		BASIC	ACTUAL
TOTAL LENGTH OF GUN	—	226.00"	ROTATION OF TUBE AT BREECH	—	—
TOTAL LENGTH OF TUBE	—	217.00"	MOVEMENT OF TUBE AT BREECH	—	—
DEPTH OF BREECH RECESS	—	9.00"	NUMBER OF LANDS AND GROOVES	—	16

STAMPED	STARGAUGED AND INSPECTED BY	REVIEWED BY
RODMAN SEARS	TIME —	COMPILATOR
RECORDER SCARBOROUGH	PLACE TRANSONIC RANGE	GRAPHED BY

60 M/M, MC-AAAC, TUBE #03
4 MAY 76 AF 3 RDS.
FOR: MR. BOYER
W.O. 445-77677-94

STEAP-DS Form 106, 17 Jun 64 (Part II)

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MULTIPLE STARGAGE MEASUREMENT & INSPECTION DATA FORM

SHEET 1 OF 2

60 M/M Tube, MC-AAAC

CASTING NUMBER: X

MANUFACTURER: WVT, ARS

PROOF OFFICER MR. BOYER W.O. 445-77677-94

MODEL: MC-AAAC

NUMBER OF ROUNDS: 14

NUMBER: 03

FIRING STATUS (Check One): BEFORE ☐ AFTER ☒

DATE OF GAUGING: 12 MAY 76

60 M/M TUBE

		Rear Face Of Tube	Gage Meas. Indicated in 1/1000" of Inch			
			2.362" ZERO		2.362" ZERO	
			VERT	HOR	VERT	HOR
		216.90	+.001	.000	+.026	+.026
		215.00	.000	-.001	26	26
		210.00	-.001	2	26	26
		205.00	2	3	26	25
		200.00	3	3	25	25
		195.00	3	3	25	25
		190.00	4	2	26	25
		185.00	3	2	26	25
		180.00	2	2	26	25
Junction	↓	175.35	2	3	26	25
		175.15	2	3	26	25
		170.00	2	3	26	25
		165.00	4	3	26	25
		160.00	4	3	26	25
		155.00	4	3	25	25
		150.00	3	3	25	25
		145.00	3	2	25	25
		140.00	3	2	25	25
		135.00	4	3	25	25
		130.00	4	3	25	25
		125.00	4	4	25	25
		120.00	4	4	25	25
		115.00	4	4	25	25
		110.00	4	4	25	25
		105.00	4	4	25	25
		100.00	4	4	25	25
		95.00	3	3	25	25
		90.00	3	3	25	25
		85.00	3	2	25	25
		80.00	3	3	25	25
		75.00	3	2	25	25
		70.00	3	2	25	25
		65.00	3	2	25	25
		60.00	3	2	25	25
		55.00	3	2	25	25
		50.00	3	2	25	25
		45.00	3	1	25	25
		40.00	2	1	26	25
		35.00	+.001	1	27	26
		30.00	1	+.001	28	27
		28.00	2	3	28	28
		26.00	4	2	30	28
		24.00	6	4	31	31
		22.00	9	7	33	33
		21.50	10	8	33	33
		21.00	10	9	34	34
		20.75	11	9	34	34
		20.60	+.012	+.011	+.034	+.034

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Sheet 2 of 2

60 M/M Tube MC-AAAC — Chamber

DISTANCE (Inches) FROM REAR FACE OF BREECH	DISTANCE (Inches) FROM MUZZLE FACE	DISTANCE (Inches) FROM REAR FACE OF TUBE	BASIC DIAMETER	ZERO	GAUGE MEASUREMENTS INDICATED IN 1/1000 OF AN INCH — X GAUGE READING	X ACTUAL DIAMETER	X DIFFERENCE	Y GAUGE READING	Y ACTUAL DIAMETER	Y DIFFERENCE
		20.05		2.392"		2.402			2.404	
		19.00				2.411			2.412	
		17.00				2.426			2.427	
		16.20				2.443			2.443	
		14.00				4.020			4.020	
		12.00				4.069			4.070	
		10.00		4.200"		4.118			4.118	
		8.00				4.166			4.167	
		6.00				4.216			4.217	
		4.00				4.264			4.266	
		2.00				4.314			4.315	
		1.00				4.340			4.340	
		.50				4.352			4.352	
		.10				4.362			4.362	

BORESCOPED: (Not chrome plated) Light scratches, stains, and deposits throughout chamber. Light smooth erosion encircling centering cylinder beginning 16.10" from rear face of tube (RFT) and continuing forward into main bore to 33" from (RFT). Lands are rounded throughout eroded area of bore with edges of lands rounded as far forward as 60" from (RFT). Light heat checking on lands and in grooves between forcing cone and 45" from (RFT). Heavy powder fouling and other deposits throughout bore. No noticeable erosion around piezo gauge holes. No separation at the junction of the tube and extension was noted. Casts were made of the score marks at 4:00 o'clock and 8:00 o'clock in the chamber. No photographs taken at this time.

SPECIAL MEASUREMENTS

	BASIC	ACTUAL		BASIC	ACTUAL
TOTAL LENGTH OF GUN	—	226.00"	ROTATION OF TUBE AT BREECH	—	—
TOTAL LENGTH OF TUBE	—	217.00"	MOVEMENT OF TUBE AT BREECH	—	—
DEPTH OF BREECH RECESS	—	9.00"	NUMBER OF LANDS AND GROOVES	—	16

STAMPED NOT STAMPED.	STARGAUGED AND INSPECTED BY TESCH	REVIEWED BY
ROOMAN McWILLIAMS	TIME —	COMPILATOR
RECORDER SCARBOROUGH	PLACE TRANSONIC RANGE	GRAPHED BY

STEAP-DS Form 106, 17 Jun 64 (Part II)

60 M/M, MC-AAAC, TUBE #03
12 MAY 76 AF 14 RDS
FOR: MR Boyer
W.O. 445-77677-94

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MULTIPLE STARGAGE MEASUREMENT & INSPECTION DATA FORM

CASTING NUMBER: X

MANUFACTURER: WVT. ARS.

MODEL: MC-AAAC

NUMBER: 03

FIRING STATUS (Check One): BEFORE ☐ AFTER ☒

DATE OF GAUGING: 18 may 1976

60mm TUBE

NUMBER OF ROUNDS: 27

PROOF OFFICER: M2. BOYER
W.O. 1145-77677-94

Muzz. Face of Tube	Rear Face of Tube				
.10	215.50	+.001	+.001	+.026	+.026
2.00	213.60			26	26
7.00	210.60		.8	26	26
12.00	205.60	.00		26	26
17.00	200.00			26	26
22.00	195.00			26	26
27.00	190.00			26	26
32.00	185.00			26	26
37.00	180.00			26	26
41.65	175.35			26	26
Junction → 41.85	175.15			26	26
47.00	170.00			26	26
52.00	165.00			26	26
57.00	160.00			26	26
62.00	155.00			26	26
67.00	150.00			26	26
72.00	145.00			26	26
77.00	140.00	+.001	+.8	26	26
82.00	135.00			26	26
87.00	130.00	.08	.8	26	26
92.00	125.00			26	26
97.00	120.00			26	26
102.00	115.00			26	26
107.00	110.00			26	26
112.00	105.00			26	26
117.00	100.00			26	26
122.00	95.00			26	26
127.00	90.00			26	26
132.00	85.00			26	26
137.00	80.00			26	26
142.00	75.00			26	26
147.00	70.00			26	26
152.00	65.00	+.001		26	26
157.00	60.00			26	26
162.00	55.00			26	26
167.00	50.00			26	26
172.00	45.00			26	26
177.00	40.00		+.8	26	26
182.00	35.00	.07	.4	30	29
187.00	30.00	.07	.7	34	34
189.00	28.00	.07	.9	36	35
191.00	26.00	.07	1.1	37	36
193.00	24.00	.07	1.3	38	38
195.00	22.00	.20	1.6	40	40
195.50	21.50	.21	1.7	41	40
196.00	21.00	.21	1.8	41	41
196.25	20.75	.23	1.9	42	42
196.40	20.60	+.025	+.020	+.042	+.042

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Page 1 of 2.

60 MM TUBE NO. 03 MC-AAC WVTARS. FOR: MR. BOYER
18 MAY 76 AF. 27RDS. WO:445-77677-94

DISTANCE (INCHES) FROM REAR FACE OF BREECH	DISTANCE (INCHES) FROM MUZZLE FACE	DISTANCE (INCHES) FROM REAR FACE OF TUBE	BASIC DIAMETER	ZERO	GAUGE MEASUREMENTS INDICATED IN .0001s OF AN INCH — Position Y — GAUGE READING	Position Y — ACTUAL DIAMETER	Position Y — DIFFERENCE	Position X — GAUGE READING	Position X — ACTUAL DIAMETER	Position X — DIFFERENCE
	190.99	20.01		2.332		2.408			2.410	
	194.00	17.00				2.417			2.419	
	200.00	17.00				2.432			2.435	
	200.80	16.20				2.453			2.455	
	203.00	14.00		4.200"		4.018			4.018	
	205.00	12.00				4.070			4.069	
	207.00	10.00				4.119			4.118	
	209.00	8.00				4.168			4.169	
	211.00	6.00				4.217			4.217	
	213.00	4.00				4.266			4.267	
	215.00	2.00				4.315			4.315	
	216.00	1.00				4.339			4.340	
	216.50	.50				4.351			4.351	
	216.90	.10				4.361			4.361	

SPECIAL MEASUREMENTS

	BASIC	ACTUAL		BASIC	ACTUAL
TOTAL LENGTH OF GUN	-----	226.00"	ROTATION OF TUBE AT BREECH	-----	-----
TOTAL LENGTH OF TUBE	-----	217.00"	MOVEMENT OF TUBE AT BREECH	-----	-----
DEPTH OF BREECH RECESS	-----	9.00"	NUMBER OF LANDS AND GROOVES	16	16

Borescoped: (Not chrome plated) Light scratches, stains, and deposits thru-out chamber. Light smooth erosion encircling centering cylinder beginning 16.10" from rear face of tube (RFT) and continuing forward into main bore to 38" from (RFT). Lands are rounded thru-out eroded area of bore with edges of lands rounded as far forward as 85" from (RFT). Very light longitudinal scoring between 16.10" and 22" from (RFT). Light heat checking encircling bore between 16.10" and 45" from (RFT). Any further heat checking is obscured by heavy powder fouling and other deposits thru-out remaining bore. No noteceable erosion around piezo holes. No separation at the junction of the tube and extension was noted. No photos or impressions taken at this time.

NOT STAMPED. STAMPED	STARGAUGED AND INSPECTED BY TESCH	REVIEWED BY
RODMAN TILDON M.	TIME —	COMPILATOR
RECORDER CPT. D.	PLACE TRANSONIC RANGE	GRAPHED BY

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MULTIPLE STARGAGE MEASUREMENT & INSPECTION DATA FORM

SHEET 1 OF 2

CASTING NUMBER: X

MANUFACTURER: WVT. ARS.

PROOF OFFICER: MR OWENS W.O. 445-77677-94

MODEL: MC-AAAC

NUMBER OF ROUNDS: 34

NUMBER: 03

FIRING STATUS (Check One): BEFORE ; AFTER ✓

60MM TUBE

DATE OF GAUGING: 28 OCT 76

	Muzz. Face of Tube	Rear Face Of Tube	2.35" VERT.	2.35" HOR.	2.21" VERT.	2.21" HOR.
	.10	216.90	+.001	+.002	+.026	+.026
	2.00	215.00	2	1	26	26
	7.00	210.00	1	2	26	26
	12.00	205.00	.000	1	26	26
	17.00	200.00	0	.000	26	26
	22.00	195.00	0	0	26	26
	27.00	190.00	0	0	26	26
	32.00	185.00	0	0	26	26
	37.00	180.00	0	0	26	26
Junction →	41.55	175.35	0	0	26	26
	41.85	175.15	0	0	26	26
	47.00	170.00	0	0	26	26
	52.00	165.00	0	0	26	26
	57.00	160.00	0	0	26	26
	62.00	155.00	0	0	26	26
	67.00	150.00	0	0	26	26
	72.00	145.00	0	0	26	26
	77.00	140.00	+.001	+.001	26	26
	82.00	135.00	1	1	26	26
	87.00	130.00	.000	.000	26	26
	92.00	125.00	0	0	26	26
	97.00	120.00	0	0	26	26
	102.00	115.00	0	0	26	26
	107.00	110.00	0	0	26	26
	112.00	105.00	0	0	26	26
	117.00	100.00	0	0	26	27
	122.00	95.00	0	0	26	27
	127.00	90.00	0	0	26	27
	132.00	85.00	0	0	26	27
	137.00	80.00	0	0	26	27
	142.00	75.00	0	0	25	27
	147.00	70.00	0	0	25	27
	152.00	65.00	0	0	25	27
	157.00	60.00	0	0	25	27
	162.00	55.00	0	0	26	27
	167.00	50.00	0	+.001	27	27
	172.00	45.00	+.001	2	27	28
	177.00	40.00	2	4	28	29
	182.00	35.00	8	8	32	32
	187.00	30.00	11	11	37	36
	189.00	28.00	12	11	39	39
	191.00	26.00	16	13	42	39
	193.00	24.00	18	16	44	41
	195.00	22.00	21	18	48	45
	195.50	21.50	25	20	48	46
	196.00	21.00	27	20	49	46
	196.25	20.75	29	21	49	46
	196.40	20.60	+.030	+.022	+.049	+.047
			VERT	HORZ.		
Pullover	MEAS.	20.75"	2.391"	2.383		

NO BASIS FOR ESTIMATE OF REMAINING LIFE.

STEAP-DS Form 106, 17 Jun 66 (Part I)

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60 MM, MC-AAAC, TUBE #03
28 OCT 76 AF 34 RDS. FOR: MR. OWENS
W.O. HES-77677-94

DISTANCE (inches) FROM

REAR FACE OF BREECH	MUZZLE FACE	REAR FACE OF TUBE	BASIC DIAMETER	ZERO	VERTICAL GAUGE READING	VERTICAL ACTUAL DIAMETER	VERTICAL DIFFERENCE	HORIZONTAL GAUGE READING	HORIZONTAL ACTUAL DIAMETER	HORIZONTAL DIFFERENCE
	196.95	20.95		2.392"	+.019	2.411		+.023	2.415	
	198.00	19.00			28	.420		32	.424	
	200.00	17.00			44	.436		47	.439	
	200.80	16.20			+.064	2.456		+.064	2.456	
	203.00	14.00			-.182	4.018		-.181	4.019	
	205.00	12.00			132	.068		132	.068	
	207.00	10.00			82	.118		82	.118	
	209.00	8.00			34	.164		34	.164	
	211.00	6.00		4.209"	+.016	.216		+.016	.216	
	213.00	4.00			64	.264		65	.265	
	215.00	2.00			113	.313		114	.314	
	216.00	1.00			137	.337		138	.338	
	216.50	.50			149	.349		149	.349	
	216.90	.10			+.161	4.361		+.161	4.361	

SPECIAL MEASUREMENTS

	BASIC	ACTUAL		BASIC	ACTUAL
TOTAL LENGTH OF GUN	-----	226.00"	ROTATION OF TUBE AT BREECH	-----	-----
TOTAL LENGTH OF TUBE	-----	217.00"	MOVEMENT OF TUBE AT BREECH	-----	-----
DEPTH OF BREECH RECESS	-----	9.00"	NUMBER OF LANDS AND GROOVES	16	16

Borescoped: (Not chrome plated)

Light scratches, stains, and deposits thru-out chamber. Light smooth erosion encircling centering cylinder beginning 16.10" from rear face of tube (RFT) and continuing forward into main bore to 38" from (RFT). Lands are rounded thru-out eroded area of bore with edges of lands rounded as far forward as 85" from (RFT). Very light longitudinal scoring between 16.10" and 26" from (RFT). Light heat checking encircling bore between 14" and 65" from (RFT). No noticeable erosion around piezo gauge holes. No separation at the junction of the tube and extension was noted.

No photos or impressions taken at this time.

STAMPED —	STARGAUGED AND INSPECTED BY TESCH	REVIEWED BY
ROOMAN SEARS	TIME —	COMPILATOR
RECORDER SCARBOROUGH	PLACE TRANSONIC RANGE	GRAPHED BY

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MULTIPLE STARGAGE MEASUREMENT & INSPECTION DATA FORM

Sheet 1 of 2

60 MM Tube, MC-AAAC

CASTING NUMBER: X

MANUFACTURER: WVT. ARS.

PROOF OFFICER: MR. BOYER W.O. 445-77677-94

MODEL: MC-AAAC

NUMBER OF ROUNDS: 47

NUMBER: 03

FIRING STATUS (Check One): BEFORE ✓ AFTER

DATE OF GAUGING: 19 Nov 76

60MM Tube

	Rear Face Of Tube	Stage Gage Indication in 1/1000" of Inch			
		2.362" Z-R0		2.362" Z-R0	
		VERT	HOR	VERT	HOR
	216.90	+.001	+.002	+.026	+.027
	215.00	2	1	26	27
	210.00	1	2	26	27
	205.00	.000	1	26	27
	200.00	0	.000	26	27
	195.00	0	0	26	27
	190.00	0	0	26	27
	185.00	0	+.001	26	27
	180.00	0	1	26	27
Junction >	175.35	0	.000	26	27
	175.15	0	0	26	27
	170.00	0	0	26	27
	165.00	0	0	26	27
	160.00	0	0	26	27
	155.00	0	0	26	27
	150.00	0	0	26	27
	145.00	0	0	26	27
	140.00	0	0	26	27
	135.00	0	0	26	27
	130.00	0	0	26	27
	125.00	0	0	26	27
	120.00	0	0	26	27
	115.00	0	0	26	27
	110.00	0	0	26	27
	105.00	0	0	26	27
	100.00	0	0	26	27
	95.00	0	0	26	27
	90.00	0	0	26	27
	85.00	0	0	26	27
	80.00	0	0	26	27
	75.00	0	0	26	27
	70.00	0	0	27	27
	65.00	0	0	27	27
	60.00	0	+.001	27	27
	55.00	+.001	2	27	27
	50.00	3	3	28	28
	45.00	5	5	30	30
	40.00	7	7	33	33
	35.00	15	14	39	38
	30.00	19	17	45	44
	28.00	22	20	47	46
	26.00	25	24	49	48
	24.00	28	25	52	50
	22.00	33	30	54	53
	21.50	34	31	55	54
	21.00	35	32	55	55
	20.75	36	33	56	55
	20.60	+.039	+.035	+.056	+.056
		VERT.	HOR.		
Pullover Meas.	20.75"	2.398"	2.395"		

No basis for estimate of remaining life.

STEAP-DS Form 106, 17 Jun 64 (Part I)

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SHEET 2 OF 2

60 X [illegible] AAC

DISTANCE (Inches) FROM REAR FACE OF BREECH	DISTANCE (Inches) FROM MUZZLE FACE	DISTANCE (Inches) FROM REAR FACE OF TUBE	BASIC DIAMETER	ZERO	GAUGE MEASUREMENTS INDICATED IN [illegible] OF BORE — VERTICAL X — GAUGE READING	VERTICAL X — ACTUAL DIAMETER	VERTICAL X — DIFFERENCE	HORIZONTAL Y — GAUGE READING	HORIZONTAL Y — ACTUAL DIAMETER	HORIZONTAL Y — DIFFERENCE
	196.95	20.05		2.352"	+.028	2.420		+.031	2.423	
	198.00	19.00			37	.429		40	.432	
	200.00	17.00			51	.443		51	.443	
	200.80	16.20			+.065	2.457		+.066	2.458	
	203.00	14.00			-.182	4.018		-.181	4.019	
	205.00	12.00			132	.068		132	.068	
	207.00	10.00			82	.118		82	.118	
	209.00	8.00			34	.166		34	.166	
	211.00	6.00			+.016	.216		+.016	.216	
	213.00	4.00			64	.264		64	.264	
	215.00	2.00		4.200"	114	.314		114	.314	
	216.00	1.00			137	.337		138	.338	
	216.50	.50			150	.350		149	.349	
	216.90	.10			+.161	4.361		+.161	4.361	

SPECIAL MEASUREMENTS

	BASIC	ACTUAL		BASIC	ACTUAL
TOTAL LENGTH OF GUN	-----	-----	ROTATION OF TUBE AT BREECH	-----	-----
TOTAL LENGTH OF TUBE	-----	217.00"	MOVEMENT OF TUBE AT BREECH	-----	-----
DEPTH OF BREECH RECESS	-----	-----	NUMBER OF LANDS AND GROOVES	16	16

Borescoped: (Not chrome plated)

Light scratches, stains, and deposits thru-out chamber. Light smooth erosion encircling centering cylinder beginning 16.10" from rear face of tube (RFT) and continuing forward into main bore to 58" from (RFT). Lands are rounded thru-out eroded area of bore with edges of lands rounded as far forward as 90" from (RFT). Very light longitudinal scoring between 16.10" and 26" from (RFT). Light heat checking encircling bore between 14" and 65" from (RFT). Very light erosion encircling piezo gauge holes. No separation at the junction of the tube and extension was noted.

No photos or impressions taken at this time.

60 MM, M.C. AAC, TUBE #03 FOR: MR BOYER.
AF 47 RDS.
W.O. 445-77677-94

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RODMAN GILLEY	TIME —	COMPILATOR
RECORDER SCARBOROUGH	PLACE TRANSONIC RANGE	GRAPHED BY

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MULTIPLE STARGAGE MEASUREMENT & INSPECTION DATA FORM

SHEET 1 OF 2

60 M/M Tube, MC-AAAC

CASTING NUMBER:

MANUFACTURER: WVT. ARS.

PROOF OFFICER: MR. BRANDON W.O. 445-77677-94

MODEL: MC-AAAC

NUMBER OF ROUNDS: 69

NUMBER: 03

FIRING STATUS (Check One): BEFORE / AFTER

DATE OF GAUGING: 12 MAY 77

60mm TUBE

	Muzz. Face of Tube	Rear Face of Tube	1st Gage VERT	1st Gage HOR	2nd Gage VERT	2nd Gage HOR
	.10	216.90	+.001	+.001	+.025	+.026
	2.00	215.00			26	26
	7.00	210.00	.000	.000	26	26
	12.00	205.00	-.001	0	26	26
	17.00	200.00		-.001	26	26
	22.00	195.00			26	26
	27.00	190.00			26	26
	32.00	185.00			26	26
	37.00	180.00			26	26
Junction →	41.65	175.35			26	26
	41.85	175.15			26	26
	47.00	170.00			26	26
	52.00	165.00			26	26
	57.00	160.00			26	26
	62.00	155.00			26	26
	67.00	150.00		.000	26	26
	72.00	145.00		0	26	26
	77.00	140.00		0	26	26
	82.00	135.00		0	26	26
	87.00	130.00		0	26	26
	92.00	125.00	.000	0	26	26
	97.00	120.00	0	0	26	26
	102.00	115.00	0	0	26	26
	107.00	110.00	0	0	26	26
	112.00	105.00	+.001	0	27	27
	117.00	100.00		0	27	27
	122.00	95.00		+.001	27	28
	127.00	90.00		1	28	28
	132.00	85.00		2	28	28
	137.00	80.00		2	28	28
	142.00	75.00		2	28	28
	147.00	70.00		2	28	28
	152.00	65.00		2	28	28
	157.00	60.00		2	28	28
	162.00	55.00	2	2	28	28
	167.00	50.00	3	2	28	28
	172.00	45.00	6	2	28	28
	177.00	40.00	1	3	38	38
	182.00	35.00	2	3	45	45
	187.00	30.00	3	3	53	53
	189.00	28.00	4	3	56	56
	191.00	26.00	4	3	60	58
	193.00	24.00	4	3	63	63
	195.00	22.00	4	4	67	67
	195.50	21.50	4	4	68	68
	196.00	21.00	5	4	69	69
	196.25	20.75	5	4	70	69
	196.40	20.60	+.054	+.051	+.071	+.068
			VERT	HOR		
	PULLOVER DIST	20.75"	2.414"	2.412"		
			NO BASIS FOR ESTIMATE OF REMAINING LIFE.			

STEAP-DS Form 106, 17 Jun 64 (Part I)

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SHEET 2 OF 2

60MM TUBE, MCAAAC, #03
12 MAY 77 A.F. 69 RDS.
FOR: MR BRANDON W.O. 445-77677-94

DISTANCE (Inches) FROM REAR FACE OF BREECH	DISTANCE (Inches) FROM MUZZLE FACE	DISTANCE (Inches) FROM REAR FACE OF TUBE	BASIC DIAMETER	ZERO	GAUGE READING	ACTUAL DIAMETER	DIFFERENCE	GAUGE READING	ACTUAL DIAMETER	DIFFERENCE
	196.95	20.05		2.392"	+.041	2.433		+.046	2.438	
	198.00	19.00			51	.443		55	.447	
	200.00	17.00			66	.458		70	.462	
	200.80	16.20			+.088	2.480		+.091	2.483	
	203.00	14.00		4.00"	+.018	4.018		+.018	4.018	
	205.00	12.00			68	.068		68	.068	
	207.00	10.00			118	.118		118	.118	
	209.00	8.00			166	.166		165	.165	
	211.00	6.00			216	.216		215	.215	
	213.00	4.00			264	.264		264	.264	
	215.00	2.00			314	.314		314	.314	
	216.00	1.00			337	.337		337	.337	
	216.50	.50			350	.350		350	.350	
	216.90	.10			+.361	4.361		+.361	4.361	

SPECIAL MEASUREMENTS

	BASIC	ACTUAL		BASIC	ACTUAL
TOTAL LENGTH OF GUN	-----	-----	ROTATION OF TUBE AT BREECH	-----	-----
TOTAL LENGTH OF TUBE	-----	217.00"	MOVEMENT OF TUBE AT BREECH	-----	-----
DEPTH OF BREECH RECESS	-----	-----	NUMBER OF LANDS AND GROOVES	16	16

Borescoped: Not Chrome Plated

Moderate to light heat checking encircling chamber slope beginning 14" from rear face of tube (RFT) and extending forward into bore to 70" from (RFT). Moderate to light smooth erosion with light traces of scoring encircling centering cylinder beginning 16.10" from (RFT) and extending forward into bore to 23" from (RFT), then becoming light as far forward as 58" from (RFT). Lands rounded thru-out eroded area with driving edge rounded as far forward as 90" from (RFT). Very light erosion encircling piezo gauge holes in bore. No separation was noted between the extension.

No photos or impressions taken at this time.

— STAMPED	STARGAUGED AND INSPECTED BY H. BOWERS	REVIEWED BY
RODMAN T. SEARS	TIME —	COMPILATOR
RECORDER M. SCARBOROUGH	PLACE TRANSONIC RANGE	GRAPHED BY

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MULTIPLE STARGAGE MEASUREMENT & INSPECTION DATA FORM

SHEET 1 OF 2 — 60 M/M Tube, MC-AAAC

CASTING

MANUFACTURER: WIT. ARS.

PROOF OFFICER: MR. BOWAN W.O. 445-36852-91

MODEL: MC-AAAC

NUMBER OF ROUNDS: 74

NUMBER: 03

FIRING STATUS (Check One): BEFORE / AFTER ✓

DATE OF GAUGING: 7 MARCH 78

60MM TUBE

Muzz. Face of Tube	Rear Face of Tube	LANDS 2.362" ZERO		GROOVES 2.362" ZERO	
.10	210.20	.000	+001	+027	+028
2.00	210.00	+002	2	27	27
7.00	210.00	1	2	27	27
12.00	205.00	.000	0	27	27
17.00	200.00	0	0	27	27
22.00	195.00	0	0	27	27
27.00	190.00	0	0	27	27
32.00	185.00	0	0	27	27
37.00	180.00	0	0	27	27
Junction → 41.60	175.40	0	0	27	27
41.85	175.15	0	0	27	27
42.00	175.00	0	0	27	27
52.00	165.00	0	0	27	27
57.00	160.00	0	0	27	27
62.00	155.00	0	0	27	27
67.00	150.00	0	0	27	27
72.00	145.00	0	0	27	27
77.00	140.00	0	0	27	27
82.00	135.00	0	0	27	27
87.00	130.00	0	0	27	27
92.00	125.00	0	.000	27	27
97.00	120.00	0	0	27	27
102.00	115.00	+001	0	27	27
107.00	110.00	1	0	27	28
112.00	105.00	2	+001	27	29
117.00	100.00	2	1	28	30
122.00	95.00	2	2	28	30
127.00	90.00	2	2	29	30
132.00	85.00	2	3	29	30
137.00	80.00	2	3	29	30
142.00	75.00	2	3	29	30
147.00	70.00	2	3	29	30
152.00	65.00	2	3	29	30
157.00	60.00	3	4	29	31
162.00	55.00	4	5	31	32
167.00	50.00	7	8	33	34
172.00	45.00	12	13	39	38
177.00	40.00	19	20	44	45
182.00	35.00	30	28	54	53
187.00	30.00	38	38	64	62
189.00	28.00	43	41	67	67
191.00	26.00	49	44	73	71
193.00	24.00	56	50	80	79
195.00	22.00	62	57	86	83
195.50	21.50	65	58	87	86
196.00	21.00	68	62	90	88
196.25	20.75	71	65	90	88
196.40	20.60	+075	+070	+091	+089
			VERT.	HOR.	
	FOLLOWER DIST.	2.075"	2.433"	2.427"	

STEAP-DS Form 106, 17 Jun 64 (Part I)

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60 M/M Tube MC-4AAC — CHAMBER

DISTANCE (Inches) FROM REAR FACE OF BREECH	DISTANCE (Inches) FROM MUZZLE FACE	DISTANCE (Inches) FROM REAR FACE OF TUBE	BASIC DIAMETER	ZERO	GAUGE MEASUREMENTS INDICATED IN 1/1000 OF AN INCH — VERTICAL — GAUGE READING	VERTICAL — ACTUAL DIAMETER	VERTICAL — DIFFERENCE	HORIZONTAL — GAUGE READING	HORIZONTAL — ACTUAL DIAMETER	HORIZONTAL — DIFFERENCE
		20.05		2.392"	+058	2.450		+064	2.456	
		19.00			70	462		75	467	
		17.00			87	479		90	482	
		16.20			+118	2.510		+121	2.513	
		14.00		4.000"	+019	4.019		+020	4.020	
		12.00			69	69		68	68	
		10.00			118	118		118	118	
		8.00			166	166		166	166	
		6.00			216	216		215	215	
		4.00			265	265		265	265	
		2.00			314	314		314	314	
		1.00			338	338		337	337	
		.50			350	350		350	350	
		.10			+361	4.361		+361	4.361	

SPECIAL MEASUREMENTS

	BASIC	ACTUAL		BASIC	ACTUAL
TOTAL LENGTH OF GUN			ROTATION OF TUBE AT BREECH		
TOTAL LENGTH OF TUBE		217.08"	MOVEMENT OF TUBE AT BREECH		
DEPTH OF BREECH RECESS			NUMBER OF LANDS AND GROOVES	16	16

Borescoped: (Not Chrome Plated)

Light scratches, stains with moderate to heavy carbon and other deposits thru-out main bore. Moderate to light heat checking encircling chamber slope beginning 14" from rear face of tube (RFT) and extending forward into bore to 85" from (RFT). Heavy to moderate erosion with light longitudinal scoring encircling centering cylinder beginning 16.10" from (RFT) and extending forward into bore to 35" from (RFT), then becoming light as far forward as 115" from (RFT). Light erosion encircling piezo gauge holes in bore. No seperation was noted between tube and extension.

No photos or impressions taken at this time.

STAMPED	STAMPED AND INSPECTED BY A TESCH	REVIEWED BY
RODMAN J. McWilliams	TIME	COMPILATOR
RECORDER T. SEARS	PLACE 525 SANDY POINT	GRAPHED BY

STEAP-MT Form 181. 7 Dec 71 (Replaces Stea 48 orm 181, 17 June 64, which May Be Used)

7 March 78. 60 MM Tube #03 MC-4AAC WUT. ARS. FOR: MR. BOWARD O.O.: 445-36852-91

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PAGE 1 of 2

MULTIPLE STARGAGE MEASUREMENT & INSPECTION DATA FORM

60 MM Tube, MC-AAAC

Gage Data Indicated in Units of Inch

Muzz. Face of Tube	Rear Face OF Tube	2.352" Gauge	2.352" Gauge	2.362" Gauge	2.362" Gauge
.10	216.90	.000	+.001	+.026	+.027
2.00	215.00	+.001	1	27	28
7.00	210.00	.000	1	27	27
12.00	205.00	0	.000	27	27
17.00	200.00	0	0	27	27
22.00	195.00	0	0	27	27
27.00	190.00	0	0	27	27
32.00	185.00	0	+.001	27	27
37.00	180.00	0	1	27	27
Junction → 41.65	175.35	0	1	27	27
41.85	175.15	0	1	27	27
47.00	170.00	0	1	27	27
52.00	165.00	0	1	27	27
57.00	160.00	0	1	27	27
62.00	155.00	0	1	27	27
67.00	150.00	0	1	27	27
72.00	145.00	0	1	27	27
77.00	140.00	0	1	27	27
82.00	135.00	0	1	27	27
87.00	130.00	0	1	27	27
92.00	125.00	0	1	27	27
97.00	120.00	0	1	27	27
102.00	115.00	0	1	27	27
107.00	110.00	+.001	1	28	28
112.00	105.00	2	1	28	29
117.00	100.00	2	1	28	29
122.00	95.00	2	2	29	30
127.00	90.00	2	3	30	30
132.00	85.00	2	3	30	30
137.00	80.00	2	3	30	30
142.00	75.00	2	3	30	30
147.00	70.00	2	3	29	30
152.00	65.00	2	3	29	30
157.00	60.00	4	5	29	31
162.00	55.00	5	6	31	32
167.00	50.00	8	9	34	35
172.00	45.00	14	15	39	39
177.00	40.00	20	23	46	47
182.00	35.00	32	32	56	54
187.00	30.00	43	39	65	64
189.00	28.00	47	44	70	69
191.00	26.00	53	47	75	73
193.00	24.00	59	53	81	79
195.00	22.00	68	61	86	84
195.50	21.50	70	62	88	86
196.00	21.00	74	65	90	87
196.25	20.75	77	69	91	88
196.40	20.60	+.081	+.072	+.092	+.089
			VERT.	HOR.	
		Pullover Dist.	20.95"	2.439"	2.428"

CASTING NUMBER: X

MANUFACTURER: WVT. ARS.

PROOF OFFICER: MR. BRANDON W.O. 445-36852-91

MODEL: MC-AAAC

NUMBER OF ROUNDS: 84

NUMBER: 03

FIRING STATUS (Check One): BEFORE ___ AFTER X

DATE OF GAUGING: 20 MAR 78

60mm Tube

PAGE 2 of 2

60 MM Tube MC-AAAC — CHAMBER

DISTANCE (Inches) FROM REAR FACE OF BREECH	DISTANCE (Inches) FROM MUZZLE FACE	DISTANCE (Inches) FROM REAR FACE OF TUBE	BASIC DIAMETER	ZERO	GAUGE MEASUREMENTS INDICATED IN 1/1000 OF AN INCH — VERTICAL Y: GAUGE READING	VERTICAL Y: ACTUAL DIAMETER	VERTICAL Y: DIFFERENCE	HORIZONTAL X: GAUGE READING	HORIZONTAL X: ACTUAL DIAMETER	HORIZONTAL X: DIFFERENCE
		20.05		2.394"	+.062	2.454		+.067	2.459	
		19.00			74	.466		78	.470	
		17.00			90	.482		94	.486	
		16.20			+.121	2.513		+.129	2.521	
		14.00			+.020	4.020		+.020	4.020	
		12.00			70	.070		70	.070	
		10.00			118	.118		119	.119	
		8.00			167	.167		167	.167	
		6.00		4.000"	217	.217		217	.217	
		4.00			266	.266		266	.266	
		2.00			315	.315		315	.315	
		1.00			338	.338		339	.339	
		.50			352	.352		352	.352	
		.10			+.361	4.361		+.361	4.361	

(cont.) in bore. No seperation was noted between tube and extension.

No photos or impressions taken at this time.

60 MM MOR TUBE 703 MC-AAAC FOR: MIC BOWEN
20 MAR 78 WVT. ARS. W.O. 445-36852-91

SPECIAL MEASUREMENTS

	BASIC	ACTUAL		BASIC	ACTUAL
TOTAL LENGTH OF GUN	—	—	ROTATION OF TUBE AT BREECH	—	—
TOTAL LENGTH OF TUBE	—	217.00"	MOVEMENT OF TUBE AT BREECH	—	—
DEPTH OF BREECH RECESS	—	—	NUMBER OF LANDS AND GROOVES	16	16

BORESCOPED: (Not Chrome Plated)

Light scratches, stains, rust and rust pitting with moderate to heavy carbon and other deposits throughout chamber and main bore. Moderate to light heat checking encircling chamber slopebeginning 14" from rear face of tube (RFT) and extending forward into bore to 85" from (RFT). Heavy to moderate erosion with light longitudinal scoring encircling centering cylinder beginning 16.10" from (RFT) and extending forward into bore to 99" from (RFT), then becoming light as far forward as 115" from (RFT). Light erosion encircling piezo gauge holes in

STAMPED	STARGAUGED AND INSPECTED BY O. Tasch	REVIEWED BY (Cont. above)
RODMAN T. Sears	TIME	COMPILATOR
RECORDER J. Clark	PLACE Sandy Point	GRAPHED BY

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