

REMINGTON ARMS COMPANY, INC.

INTER-DEPARTMENTAL CORRESPONDENCE



Thelma - Fickel May 5

Xc: J.W. Brooks
A.A. Hugick

"CONFINE YOUR LETTER TO ONE SUBJECT ONLY"

Ilion, New York
July 3, 1979

TO: C. B. WORKMAN
FROM: B. I. BENNETT - F. E. MARTIN
SUBJECT: ACCURACY OF MODEL 700 RIFLES ROLLMARKED 7mm/06

[See John Linde]

INTRODUCTION

It is desired to change the rollmark of 2100 Model 700 Rifles from 7mm/06 to 7mm EXP.REM.. A process has been proposed whereby the 7mm/06 rollmark is removed by grinding and the barrel is rerolled with the desired designation.

The Test Lab was asked to evaluate the rerolled rifles. It reported that the rifles produced unacceptable accuracy and partial keyholing using 165 gr. Remington factory loads.

OBJECTIVE

- To determine whether the inaccuracy was due to a problem with the rifle, as rollmarked 7mm/06, or if it was caused by the rerolling process.
- If the problem was inherent in the rifle before the rerolling, the objective was to determine a method to repair the rifles so that they would meet the accuracy specs.

CONCLUSIONS

- The accuracy of the sample of 30 M/700 - 7mm/06 rifles, selected randomly from the warehouse, was found to be adequate.
- Bullet tipping seems to be an ammunition related problem and not a rifle related one. The observed bullet tipping manifested itself in slightly elongated bullet holes in targets 100 yds. distant. The frequency of elongated holes in the target varied considerably with the lot of 165 gr. 280 Rem. ammunition used. The handloads using 162 gr. Hornady bullets exhibited no tipping tendencies. Bullet tipping did not correlate highly to inaccurate shots.

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CONCLUSIONS Continued

- Handloads producing the same velocities and pressures as the Remington factory loads resulted in significantly greater accuracy.
- The gallery accuracy devices give spurious results when testing M/700 7mm/06 rifles. See memorandum: "Gallery Shooting Jack Repeatability", Bennett, B.I., June 1979.
- Testing subsequent to this present work has shown that the proposed rerolling process can be expected to produce 10-15% rejects; i.e. 10-15% of the rifles rerolled to 7mm EXP.REM. will fail to meet the accuracy spec.

TEST RESULTS

- Three of thirty M/700 - 7mm/06 rifles shot from the shoulder failed to meet the 3.5 inch group size accuracy spec. One of the three rifles failed marginally.
- Four of the five rifles tested with handloads had either previously failed the accuracy spec. or had passed the spec. marginally using 165 gr. factory loads. The average group size for these four rifles shooting handloads was 1.98 inches. The handload was not selected by working up a load for these particular rifles, but was chosen on the basis of it being a "standard accuracy load" for the cartridge.
- Two sets of data for the five rifles tested with handloads were compared. One set of data was the average of three 5-shot groups produced by each rifle using 165 gr. factory loads; the other set was the average of three 5-shot groups produced by each rifle using handloaded ammunition. A statistical T test rejected the hypothesis at a 95% confidence level that the handloads did not shoot tighter groups than the factory loads by a margin of .35 inches.
- The pressure and velocity of the handloads were compared to the pressures and velocities of each three lots of 165 gr. factory loaded ammunition. The results of statistical T tests forced the rejection of the hypothesis that the handload pressures and velocities were different in magnitude from the factory load pressures and velocities.

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TEST RESULTS Continued

- Four lots of 165 gr. ammunition were shot for accuracy, from the shoulder, in a 40-X rifle using a 20X scope. Three of the four lots tested produced average groups larger than the manufacturing spec. of 1.80 inches. See the data sheets. In comparison, the shooting of four 5-shot groups using handloads produced an average group size of .84 inches.
- Ammunition identical to the accuracy handload was made, but the 162 gr. Hornady boattail bullet was replaced with the 165 gr. Remington bullet. Three 5-shot groups were fired in the 40-X producing an average group size of 1.80 inches. No other testing was done with the 165 gr. handload.
- Components from forty rounds of 165 gr. factory loaded ammunition were examined. None were observed to be defective in regards to powder charge, uniformity, bullet weight, and bullet diameter.
- Three 5-shot groups were fired from two of the rifles which the Test Lab reported to have failed to meet the accuracy spec. Both of these rifles passed in our testing; the first firing an average group size of 2.68 inches, the second firing an average group size of 2.38 inches.

TESTING PROCEDURE

A. General

1. Shoulder shooting was employed for all ammunition and firearms accuracy testing reported in this paper.
2. Group size was measured by determining the distance between the centers of the two holes which were farthest apart in the group.

B. Ammunition

1. At least three 5-shot groups were shot to determine the accuracy potential of the lots of ammunition tested.
2. A 40-X rifle with a 20X scope was used to shoot the groups. The rifle was cooled after each 5-shot group and cleaned after each set of seventeen rounds. (Two rounds were used as sighters.)

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TESTING PROCEDURE Continued

- B. 3. Unless otherwise specified, the following headload was used in all testing which involved handloaded ammunition:

162 gr. Hornady Boattail Bullet
51.0 gr. of IMR 4350 powder
Remington case (280 Rem.)
Remington 9 $\frac{1}{2}$ large rifle primer

4. Forty 165 gr. bullets were pulled from ammunition Lot #H13ND. Their diameters and weights were measured. The powder weight was measured and recorded for each of forty rounds from Lot #H13ND. Refer to the data sheets.
5. Forty 162 gr. Hornady boattail bullets had their diameters measured. Refer to the data sheets.

C. Gallery Accuracy Devices

1. Refer to Memorandum: "Gallery Shooting Jack Repeatability", Bennett, B.I., June 1979.

D. Rifle Accuracy After the Rerolling Process

1. Refer to the report: "Accuracy Testing of M/700 - 7mm/06 Rifles After the Rollmark Change to 7mm EXP.REM.", Bennett, B.I., June 1979.

E. Rifle Accuracy: M/700 Rifles Rollmarked 7mm/06

1. The average of three 5-shot groups was used to determine the accuracy potential of each of thirty rifles selected randomly from the warehouse. A 24X Remington scope was used to facilitate the testing. The rifles were cleaned after each set of 17 rounds. The first two rounds of this set were used as sighters.
2. The rifles were fully cooled before a subsequent 5-shot group was fired.
3. The bore and groove diameters of each rifle were measured using an air gage. For these measurements, refer to the data section of this report.

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Lot #	Sample Size # of Rounds Fired	# of Rounds Showing Tipping in Sample	Percentage of Rounds Showing Tipping in Sample
JO1ED	163*	6	3.7%
G12ED	153*	16	10%
Handload	145 ⁺	0	0.0%

*The sample size is 41% of the population.

+The sample size is 76% of the population.

Bullet tipping was judged on the basis of visually observing slightly elongated holes which the bullet made in the target paper 100 yds. distant.

Gun #	Avg. of 3 5 shot groups FL 165 gr.	Avg. of 3 5 shot groups HL 162 gr.
6	3.58	1.82
10	3.18	2.67
11	3.49	1.79
17	4.93	2.33
18	2.37	1.99
	3.51 avg.	2.12
	$\sigma = .93$.37

Degrees of Freedom = 8

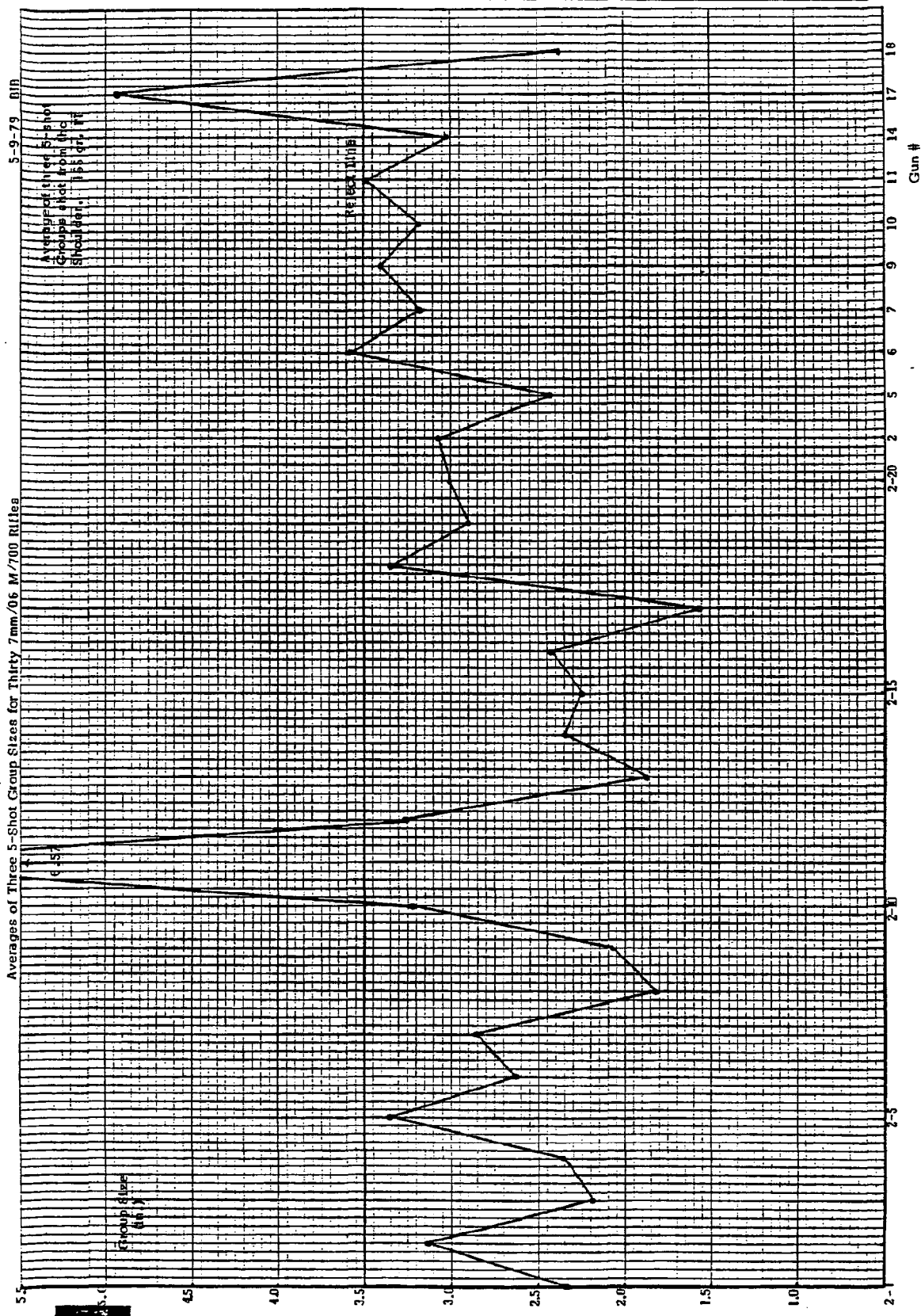
at 95% confidence

T must equal at least 2.306

F must equal at least 6.39

$\Delta M = .35$
 T = 2.328
 F = 6.10

There is a sig.diff. between the means of samples, but not between the standard deviations.



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Three 5 Shot Groups

Shoulder Shooting

Ammunition: 165 gr. FL Lot #G12ED

<u>Gun #</u>	<u>Group #1</u>	<u>Group #2</u>	<u>Group #3</u>	<u>Average</u>
2	2.48	3.16	3.58	3.07
5	2.70	1.34	3.26	2.43
6	3.27	3.83	3.65	3.58
7	2.91	3.66	2.98	3.18
9	2.81	3.38	4.01	3.40
10	2.90	3.73	2.90	3.18
11	2.56	3.18	4.74	3.49
14	3.94	2.42	2.72	3.03
17	6.81	4.28	3.70	4.93
18	2.19	2.36	2.57	2.37

Three 5 Shot Groups

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5/7/79 - 5/8/79 Shoulder Shooting

Ammunition: 165 gr. FL Lot #J01ED

Data Set #1

<u>Gun #</u>	<u>Group #1</u>	<u>Group #2</u>	<u>Group #3</u>	<u>Average</u>
2-1	2.76	2.08	2.19	2.34
2-2	4.01	2.87	2.50	3.13
2-3	1.94	1.44	3.18	2.19
2-4	2.98	1.63	2.45	2.35
2-5	4.36	3.01	2.68	3.35
2-6	2.30	2.80	2.78	2.63
2-7	3.17	3.16	2.24	2.86
2-8	2.19	1.37	1.90	1.82
2-9	2.18	2.26	1.76	2.07
2-10	3.25	3.26	3.19	3.23
2-11	9.06	7.53	3.11	6.57
2-12	4.22	3.06	2.52	3.27
2-13	1.52	2.44	1.68	1.88
2-14	2.32	2.84	1.88	2.35
2-15	2.27	1.82	2.67	2.25
2-16	1.82	3.41	2.06	2.43
2-17	2.22	1.32	1.18	1.57
2-18	1.17	4.84	4.02	3.34
2-19	1.60	3.12	3.94	2.89
2-20	2.10	3.60	3.34	3.01

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BIB:T

Three 5 Shot Groups

5/15/79 Shoulder Shooting

Ammunition: .165 gr. FL Lot #J01ED

<u>Gun #</u>	<u>Group #1</u>	<u>Group #2</u>	<u>Group #3</u>	<u>Average</u>
5392 (rerolled)	3.26	2.46	2.32	2.68
4602	2.46	2.31	2.37	2.38

These two rifles failed the original Test Lab accuracy tests using another lot of factory ammunition. No data is available concerning the accuracy potential of the lot used.

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BIB:T

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20 - 7mm-06 From Warehouse

4-4-79

Gun	Bore Dia. .277 .278		Groove Dia. .2837 .2847		Remarks
	Breech	Muzzle	Breech	Muzzle	
1	.2778	2.775	.2841	.2838	
2	.2778	.2775	.2841	.2838	
3	.2779	.2776	.2841	.2839	
4	.2779	.2775	.2840	.2838	x
5	.2779	.2776	.2841	.2839	
6	.2778	.2774	.2841	.2839	x
7	.2778	.2774	.2841	.2839	x
8	.2779	.2775	.2842	.2839	
9	.2779	.2775	.284	.2839	
10	.2778	.2774	.284	.2838	x
11	.2778	.2775	.284	.2839	
12	.2778	.2775	.284	.2838	
13	.2777	.2774	.2842	.2839	
14	.2777	.2774	.2841	.2838	x
15	.2778	.2775	.284	.2838	x
16	.2779	.2775	.284	.2838	
17	.2777	.2774	.2842	.2839	x
18	.2779	.2775	.2842	.2839	x
19	.2779	.2774	.2841	.2837	x
20	.2779	.2775	.2841	.2839	

Second Set of 20 Set #2

5-1-79

2-1	.2779	.2775	.2841	.2838	
2-2	.278	.2775	.2841	.2838	*
2-3	.2778	.2775	.2841	.2839	
2-4	.2779	.2774	.2841	.2838	
2-5	.278	.2776	.2842	.2839	
2-6	.278	.2775	.284	.2838	*
2-7	.2779	.2776	.2841	.2838	
2-8	.278	.2775	.2841	.2838	*
2-9	.2781	.2776	.2841	.2838	
2-10	.278	.2776	.2841	.2838	*
2-11	.2779	.2775	.2842	.2839	
2-12	.278	.2776	.2842	.2838	
2-13	.278	.2776	.2842	.2838	
2-14	.278	.2775	.2841	.2838	*
2-15	.278	.2775	.2842	.2839	*
2-16	.278	.2775	.2841	.2837	*
Bore crooked unable to use gage thru.					
2-17	.278	.2774	.2842	.2839	
2-18	.278	.2776	.2842	.2839	
2-19	.2781	.2776	.2842	.2838	*
2-20	.278	.2776	.2841	.2837	*

x Groove gage enters and removes hard at muzzle.

* Groove gage enters hard at muzzle.

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All testing done
from shoulder using
40X with 20 power
scope

	<u>Extreme Spread (in.) 5 Shot Group</u>	<u>Average</u>	<u>Standard Deviation</u>	
Handloads	.52			
162 gr. BT Bullet (Hornady)	.91 1.07	.84	.232	
51.0 gr. 4350	.87			
Rem. Case				
Rem. 9 $\frac{1}{2}$ Primer				
Lot #	1.87			
H13ND4352	1.30	1.87	.575	
165 gr SP	2.45			
Lot #	1.09			
	2.52			
G12ED3156	1.64			
	2.44	1.95	.595	
165 gr. SP	2.08			
Lot #	1.63			
J31LD4837	2.49	2.14	.450	Average of all FL 5 shot groups =
165 gr. SP	2.29			1.79 σ = .596
Lot #	.75			
LJ01ED	1.18	1.11	.326	
165 gr. SP	1.39			
Handloads	1.46			
165 gr. Rem. Bullet	1.66	1.80	.422	These shot as well as the average FL.
51.0 gr. 4350	2.27			
Rem. case				
Rem. 9 $\frac{1}{2}$ primer				

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 Comparisons of the pressures and velocities of handloads and various lots of
 280 Rem. ammunition, via statistical T and F tests.

<u>Quantity Compared</u>	<u>Comparison Between Lot Numbers</u>	<u>Value of T Computed</u>	<u>Value of F Computed</u>	$T_c = 2.101$ $F_c = 3.18$
Pressures	G12ED J 01ED	3.066*	1.170	
Pressures	J 01ED Handload	1.480	2.080	
Pressures	G12ED J 31LD	2.557*	2.921	
Pressures	G12ED Handload	1.964	1.778	
Pressures	J 31LD Handload	1.517	1.642	
Velocities	G12ED J 01ED	3.543*	2.725	
Velocities	J 01ED Handloads	1.418	3.577*	
Velocities	G12ED J 31LD	.815	2.394	
Velocities	G12ED Handloads	1.451	1.275	
Velocities	J 31LD Handloads	.417	1.823	

+ This value indicates a significant difference at a 95% confidence level
 between the standard deviations of the velocities.

* These values show a significant difference at a 95% confidence level
 between the means of the appropriate quantities of the samples of ammunition.

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165 gr. bullets pulled from Lot #H13N D4352
 Bullet Weights (gns.)

Sample of 40

Avg. measured wt.	$\overline{Wt.}$	165.125 gn.
	σ	= .2889
	Max.	.875
Variation	Min.	-.0625

Bullet Diameters (in.)

Sample of 40

Avg. measured dia.	\overline{D}	= .2836"
	σ	= .0001
	Max.	.0002
Variation	Min.	-.0001

Powder Wt. (gns.)

Sample of 40

Avg. measured wt.	$\overline{Wt.}$	= 54.065
	σ	= .2131
	Max.	+.54
Variation	Min.	-.56

Bullet Diameters (in.)

Sample of 40

Hornady 7mm 162 gn. Boattail (BT)

Avg. measured dia.	\overline{D}	= .2839
	σ	= .00005
Extreme Variation	Max.	+.0001
	Min.	-.0001

BIBennett:T
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Standard

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DATE 4/12/79 MODEL 40X SERIAL NO 6874078 TEST TITLE PRESSURE VELOCITY OPERATOR CJM WORK ORDER G0460

AMMUNITION DESCRIPTION R250R2 G12E D3158 NO SHOTS 10 NO PEAK VELS 1 NO CHRON 1

SHOT NO CHAMBER PRESSURE
PSI. PCB

MUZZLE VELOCITY
FT/SEC

April-12-1977

1	0.648380E 05	0.276394E 04
2	0.668690E 05	0.277775E 04
3	0.661920E 05	0.277159E 04
4	0.655150E 05	0.275631E 04
5	0.655150E 05	0.277469E 04
6	0.689000E 05	0.279950E 04
7	0.661920E 05	0.277697E 04
8	0.699150E 05	0.281213E 04
9	0.705920E 05	0.282322E 04
10	0.689000E 05	0.279559E 04

MINIMUM 0.648380E 05 0.275631E 04

MAXIMUM 0.705920E 05 0.282322E 04

EV 0.575400E 04 0.669062E 02

MEAN 0.673428D 05 0.278517D 04

STAN. DEV. 0.205080D 04 0.215725D 02

ALL PREDICTED VALUES CALCULATED AT 95 PERCENT CONFIDENCE

MINIMUM 0.633232D 05 0.274289D 04

MAXIMUM 0.713624D 05 0.282745D 04

MIN AVG 0.658758D 05 0.276974D 04

MAX AVG 0.688098D 05 0.280060D 04

2 Hand load

DATE	MODEL	SERIAL NO	TEST TITLE	OPERATOR	WORK ORDER
4-19-79	M700	6874078	PRESSURE	VELOCITY	CJM

AMMUNITION DESCRIPTION	NO SHOTS	NO PEAK VBLS.	NO CHRON
280 51GR 4350-162GR BULLET	10	1	1

SHOT NO	CHAMBER PRESSURE PSI-PCB	MUZZLE VELOCITY FT/SEC
---------	-----------------------------	---------------------------

1	0.692380E 05	0.277928E 04
2	0.661920E 05	0.273819E 04
3	0.712690E 05	0.279169E 04
4	0.726230E 05	0.279797E 04
5	0.655150E 05	0.275022E 04
6	0.682230E 05	0.277313E 04
7	0.685610E 05	0.277313E 04
8	0.719460E 05	0.280734E 04
9	0.655150E 05	0.274722E 04
10	0.658530E 05	0.274419E 04

MINIMUM	0.655150E 05	0.273819E 04
MAXIMUM	0.726230E 05	0.280734E 04
EV	0.710800E 04	0.691563E 02
MEAN	0.684935D 05	0.277023D 04
STAN DEV	0.273496D 04	0.243604D 02

ALL PREDICTED VALUES CALCULATED AT 95 PERCENT CONFIDENCE

MINIMUM	0.631330D 05	0.272249D 04
MAXIMUM	0.738540D 05	0.281798D 04
MIN AVG	0.665372D 05	0.275281D 04
MAX AVG	0.704498D 05	0.278766D 04

3

DATE	MODEL	SERIAL NO	TEST TITLE	OPERATOR	WORK ORDER
4-23-79	40X	6874078	PRESSURE VELOCITY	CJM REN	

AMMUNITION DESCRIPTION	NO SHOTS	NO PEAK VBLS.	NO CHRON
R280R2 J311D4836	10	1	1

April 23 1979

SHOT NO	CHAMBER PRESSURE
	PSI PCB

MUZZLE VELOCITY

FT/SEC

1	0.651765E 05	0.271737E 04
2	0.739770E 05	0.278547E 04
3	0.678840E 05	0.275022E 04
4	0.702540E 05	0.278241E 04
5	0.719460E 05	0.280106E 04
6	0.702540E 05	0.279797E 04
7	0.722850E 05	0.279950E 04
8	0.753310E 05	0.281213E 04
9	0.655150E 05	0.272625E 04
10	0.736390E 05	0.278391E 04

MINIMUM	0.651765E 05	0.271737E 04
MAXIMUM	0.753310E 05	0.281213E 04
EV	0.101550E 05	0.947500E 02
MEAN	0.706261D 05	0.277563D 04
STAN DEV	0.350482D 04	0.328912D 02

DATE MODEL SERIAL NO TEST TITLE OPERATOR WORK ORDER
 4-23-79 40X 6874078 PRESSURE VELOCITY CJM REN

AMMUNITION DESCRIPTION NO SHOTS NO PEAK VELS NO CHRON
 R280R2 J01ED3816 10 1 1

SHOT NO CHAMBER PRESSURE
 PSI PCB

April 23 1979

MUZZLE VELOCITY
 FT/SEC

1	0.712690E 05	0.276241E 04
2	0.692380E 05	0.274722E 04
3	0.689000E 05	0.275175E 04
4	0.705920E 05	0.276850E 04
5	0.719460E 05	0.276394E 04
6	0.689000E 05	0.274872E 04
7	0.668690E 05	0.273969E 04
8	0.692380E 05	0.276241E 04
9	0.699150E 05	0.275022E 04
10	0.736390E 05	0.278391E 04

MINIMUM 0.668690E 05 0.273969E 04

MAXIMUM 0.736390E 05 0.278391E 04

EV 0.577000E 04 0.442188E 02

MEAN 0.700506D 05 0.275788D 04

STAN DEV 0.189608D 04 0.128783D 02

11 0.736390E 05 0.278391E 04

12 0.763244E 04 0.278391E 04

13 0.932487E 04 0.278391E 04

14 0.100019E 05 0.278391E 04

15 0.110174E 05 0.278391E 04

16 0.110174E 05 0.278391E 04

17 0.113599E 05 0.278391E 04

18 0.116944E 05 0.278391E 04

19 0.123714E 05 0.278391E 04

20 0.127099E 05 0.278391E 04

MINIMUM 0.763244E 04 0.278391E 04

MAXIMUM 0.736390E 05 0.278391E 04

EV 0.660070E 05 0.000000E 00

MEAN 0.170764D 05 0.278391D 04

STAN DEV 0.199300D 05 0.104167D 01

DO YOU WANT HIGH SPEED SYS 1=YES 0=NO

LINBR,CHNBR

2,1

2, 1

R280R2 J3ILD4836

LINBR,CHNBR

99

PRED MIN MAX

0

7777