

R-TN-76-011

.17 CAL WATER COOLED GUN BARREL

JAMES N. BLECKER

The logo of the U.S. Army Armament Command is a shield-shaped emblem. It features a stylized, symmetrical design in the center, possibly representing a gun barrel or a winged figure. The words "U.S. ARMY" are arched across the top, "ARMAMENT" is on the left side, and "COMMAND" is on the right side. The entire logo is rendered in black and white.

**RESEARCH DIRECTORATE**

JULY 1976

**GENERAL THOMAS J. RODMAN LABORATORY  
ROCK ISLAND ARSENAL  
ROCK ISLAND, ILLINOIS 61201**

.17 CAL WATER COOLED GUN BARREL

TECHNICAL NOTE

R-TN-76-011

BY

JAMES N. BLECKER

July 1976

AMS CODE 662603.11.H7800

DA PROJECT NO. 1W662603AH78

RESEARCH DIRECTORATE  
ROCK ISLAND ARSENAL  
GEN THOMAS J. RODMAN LABORATORY

NOT FOR DISTRIBUTION  
FOR USE AT ROCK ISLAND ARSENAL ONLY

## TABLE OF CONTENTS

	<u>Page</u>
List of Tables	1
List of Illustrations	1
Introduction	2
Test Program	2
Experimental Methodologies	3
Test Results	3
Conclusions	19



## TABLES

	<u>Page</u>
Table I Average Velocity and Extreme Spread	11
Table II Groove Diameter of .17 Cal Water Cooled Barrel	12
Table III Land Diameter of .17 Cal Water Cooled Barrel	13

## ILLUSTRATIONS

Figure 1 .17 Cal Water Cooled Test Barrel	4
Figure 2 Water Cooled .17 Cal Barrel	5
Figure 3 Extreme Spread Vs Rds Fired	7
Figure 4 Bore Diameter Vs Distance (Water Cooled)	8
Figure 5 Bore Diameter Vs Distance (Standard)	9
Figure 6 Velocity Vs Rds Fired	10
Figure 7 Temperature Vs Time (Water Cooled)	15
Figure 8 Temperature Vs Time (Standard)	16
Figure 9 Temperature Vs Time (Comparison)	17
Figure 10 Temperature Vs Time (300 Rds)	18

## INTRODUCTION

The .17 Cal gun barrel has a history of excessive erosion failures. Typical barrel life for a non-plated CHROM-MOLY-VAN-STL barrel is 3000 - 4000 rds operating in the 700°F temperature range. Much effort has been expended in "cut and try fixes" to resolve this problem while very little emphasis has been placed on determining the failure mechanism. Therefore, this effort was concerned with determining if barrel heating is a major contributor in the erosion process for the .17 Cal barrel. Toward this end, a water cooled barrel was fabricated and test fired. Barrel temperatures during firing were maintained at a significantly lower operating temperature than normal. Since the objective of this testing was to determine if lower operating temperature would increase barrel life by reducing the rate of erosion, it was important to subject the water cooled barrel to a standard representative firing schedule. The selected schedule was that of the TPR-SAL-74-I-022 test program. Previous testing under this program of four standard non plated barrels affords a meaningful standard for comparison.

## TEST PROGRAM

A. Each water cooled .17 Cal barrel was fired at 100 meters from a machine rest, so as to produce three 10-round shot groups and 30 velocities. Each (3' x 3') target was checked for projectile yaw and extreme spread. The number of projectiles exhibiting a yaw of more than 15° and those that missed the target were observed and recorded. A continuous record of total number of rounds fired was maintained. The velocity of each round fired for accuracy was determined at 15 feet from the weapon muzzle with an instrumental baseline of 20 feet. Temperature measurements were made during all firing.

B. Each rifle was fired four 20-round series, single shot (30 spm), followed by one 20-round burst (600 spm). After one minute cooling, this was repeated four more times (500 rounds total), at this time the weapon was cleaned and the schedule repeated.

C. After each 1000 rounds, the following procedure was followed:

1. Bore, air gaged at 1 inch interval from muzzle.
2. Borescoped and notes taken on general condition of barrel erosion.

D. Procedures A, B, and C were repeated for a total of 8,760 rounds when the test was stopped.

## EXPERIMENTAL METHODOLOGIES

To obtain a water cooled barrel, the sight assembly was welded to the barrel (to provide a water tight seal at the gas port) and the barrel was enclosed in a one inch I.D. copper tube, as shown in Figures 1 and 2. The ends were sealed and a  $\frac{1}{2}$  gpm water flow was injected at the breech end and drained at the muzzle end. An open loop of city water was used for cooling.

Instrumentation procedures and data acquisition techniques applied in this project have evolved as a consequence of performing similar testing on a large number of past projects. Type K, 30 gauge chromel-alumel thermocouple wire was selected because of its temperature range, low error; good weldability, and excellent corrosion properties.

Intrinsic type thermocouples were used where the junction was formed by fusing a one-eighth inch length of chromel-alumel wire to the barrel with a capacitive discharge welder. At a location one-fourth inch from the junction, a stainless steel support strap was positioned across the wire and welded to the barrel.

The digital data acquisition system utilized in this test consisted of a scanner, digital clock, integrating digital voltmeter, and printer. Eight channels of temperature data in the form of millivolt readings were printed out and reduced to temperatures and plotted via a computer program.

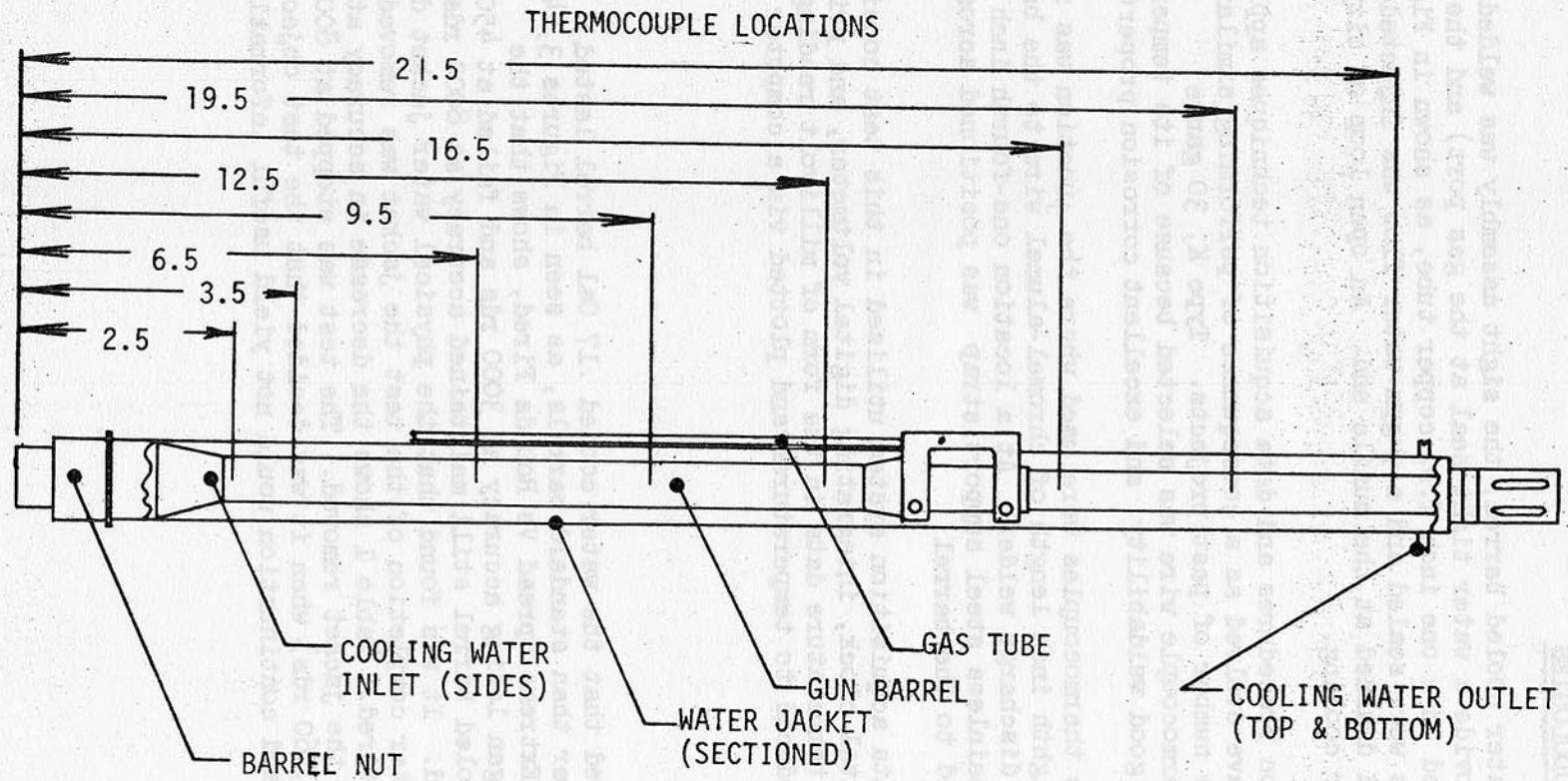
## TEST RESULTS

This test showed that the water cooled .17 Cal barrel lasted significantly longer than standard barrels, as seen in Figures 3, 4, 5, and 6. Figure 3, Extreme Spread Vs Rounds Fired, shows that the standard barrel began losing accuracy at 3000 rds and failed at 4500 rds while the water cooled barrel still maintained accuracy at 8000 rds when the test was halted. It was found that the physical water jacket did help accuracy. After completion of the test the jacket was removed and three targets fired. Table 1 shows the decrease in accuracy at the 8000 rd level with the jacket removed. The test was stopped at 8000 rds (actual count of 8,760 rds) when it was decided that the test objective had been obtained and continuation would not yield useful information.



FIG 1

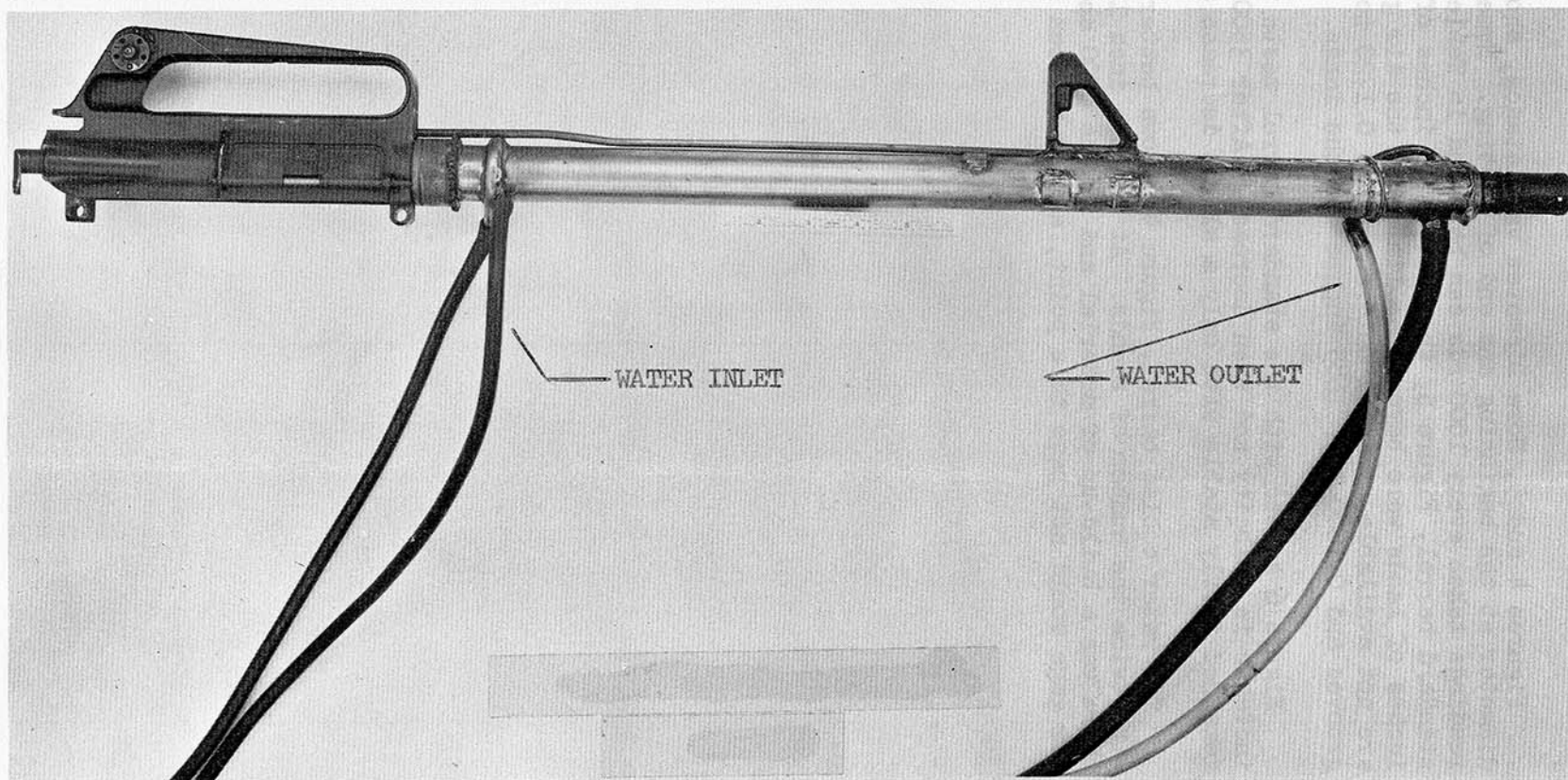
SKETCH OF BARREL SHOWING THERMOCOUPLE LOCATIONS AND WATER JACKET



.17 CAL WATER COOLED TEST BARREL

FIGURE 2

Water Cooled .17 Cal Barrel





Figures 4 and 5, Bore Diameter vs Distance, shows land and groove diameter at the beginning and end of testing. Numerical values of readings taken every 1000 rds can be found in Tables II & III. For the standard barrel, Figure 5, the last three inches of grooves and two inches of lands were beyond the limits of the air gage and thus readings are not available. Barrel tolerances are 0.1720 to 0.1725 inches for the grooves and 0.1680 to 0.1685 inches for the lands.

Figure 6 agreed with the standard barrel tests with an initial increase in velocity and then decrease. After 3500 rds the velocity remained fairly stable with only a slight decrease as the test progressed.

The water cooled barrel, Figure 4, shows better wear characteristic with twice the number of rounds. At the ten inch location (gas port) there was a build-up of material and at the 6000 and 8000 rd levels the air gage would not pass this point, as can be seen in Table III.

Figure 3

Extreme Spread Vs Rounds Fired

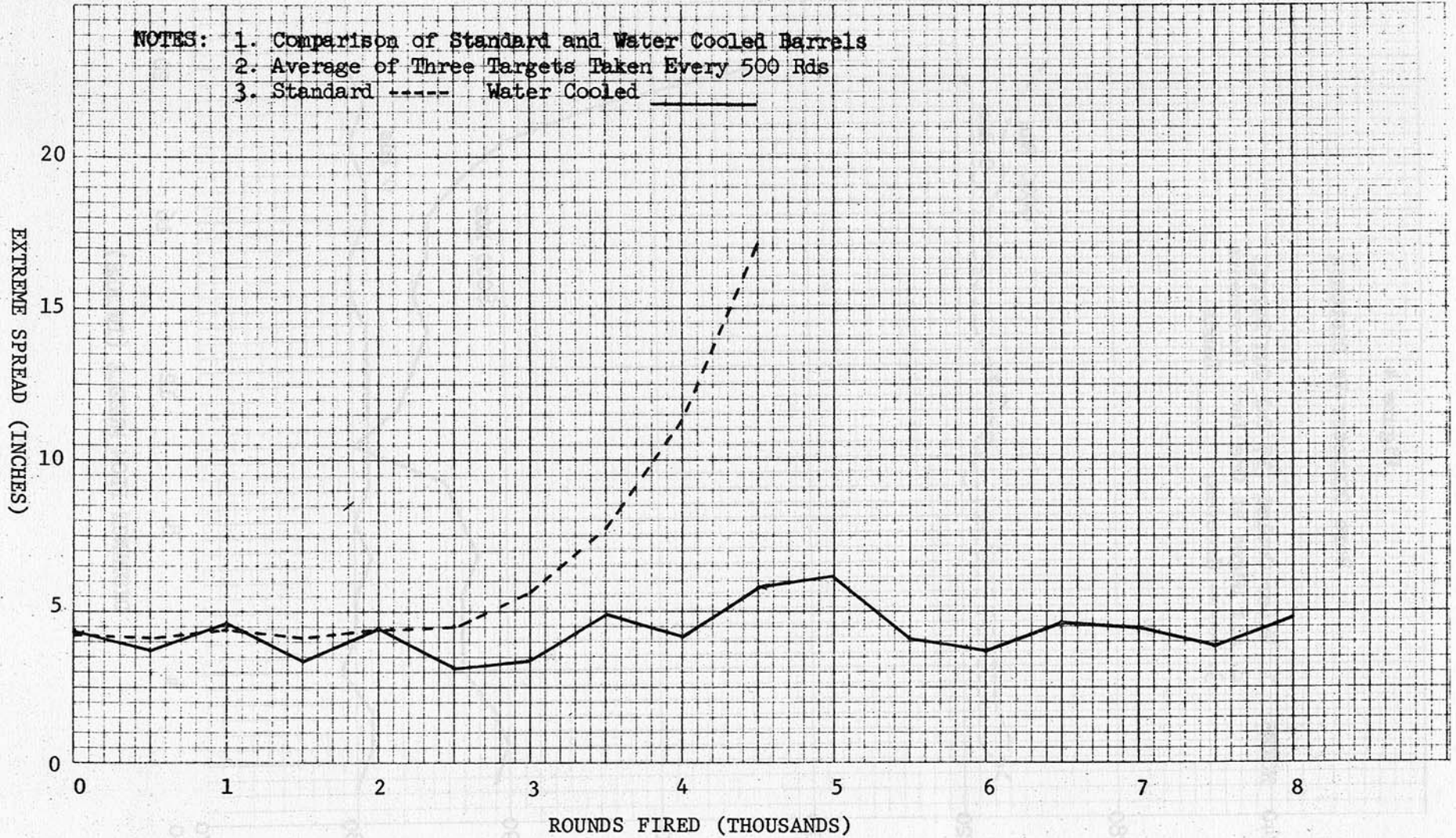




Figure 4

Bore Diameter Vs Distance

- NOTES: 1. Water Cooled .17 Cal Gun Barrel  
2. Air Gaged at One Inch Increments  
3. ---- Grooves, ——— Lands

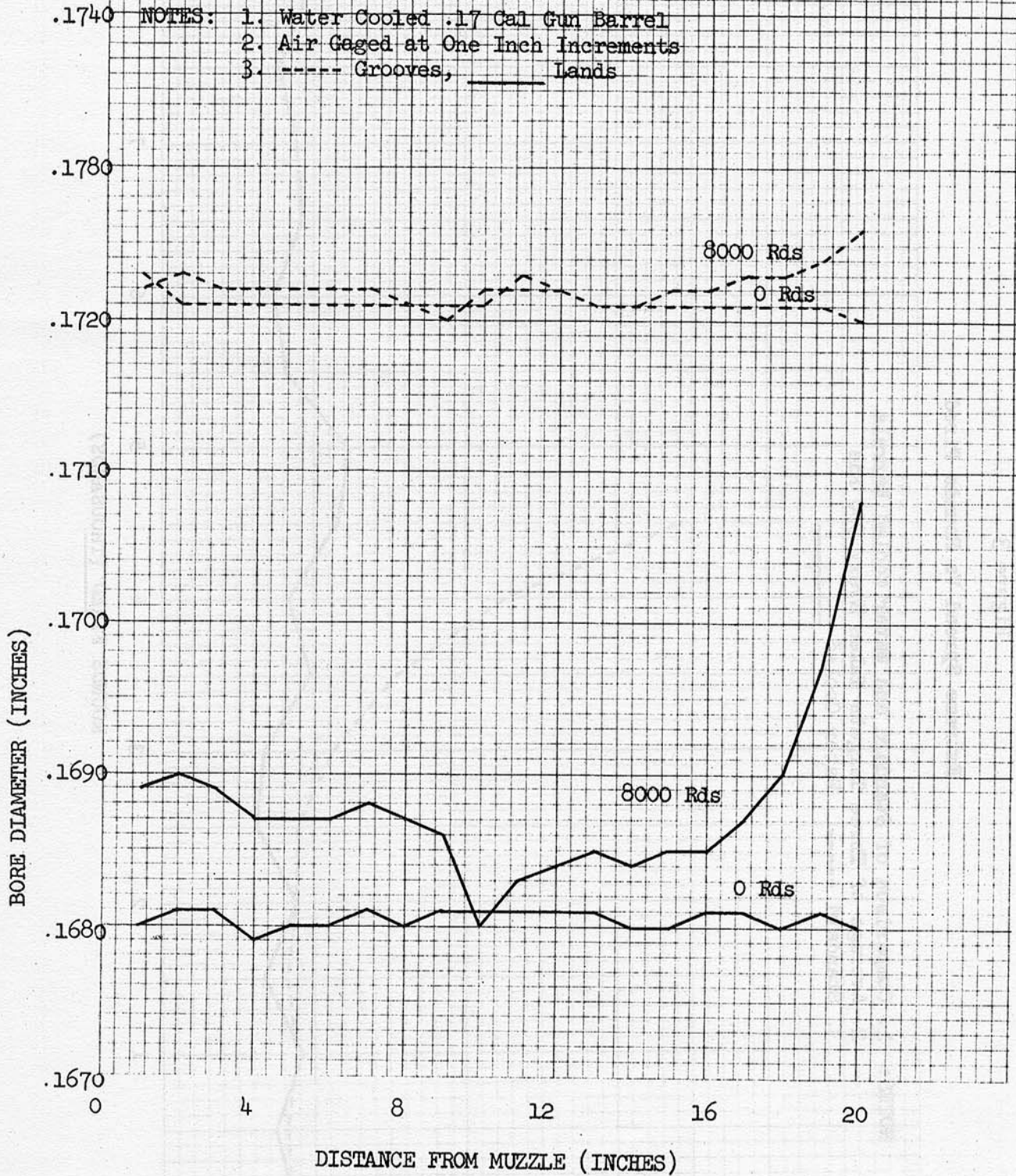




Figure 5

Bore Diameter Vs Distance

- NOTES: 1. Standard .17 Cal Gun Barrel  
2. Air Gaged At One Inch Increments  
3. --- Grooves, ——— Lands

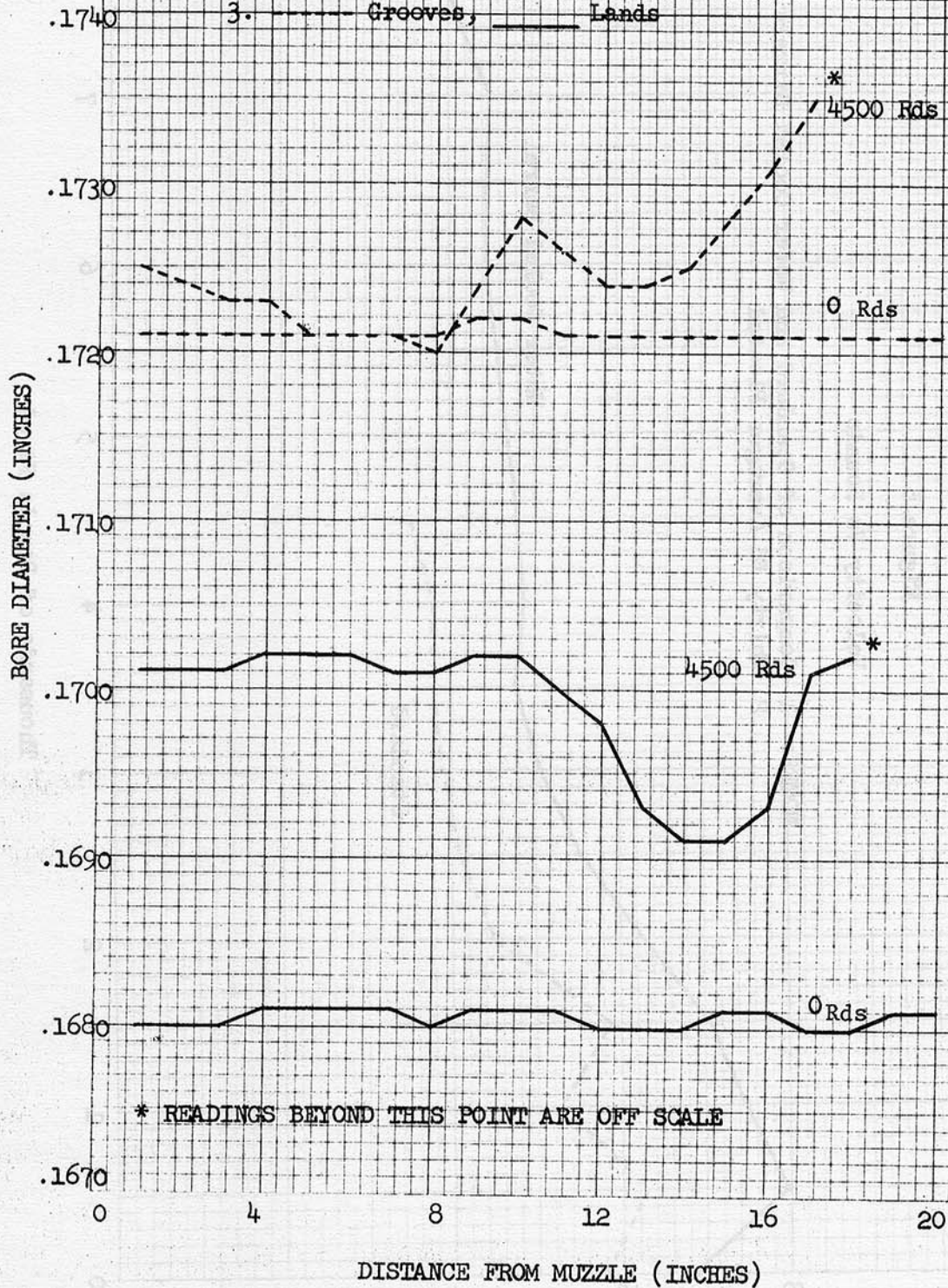


Figure 6

Velocity Vs Rounds

NOTES: 1. Comparison of Standard and Water Cooled Barrels  
2. Thirty Rd Averages Plotted

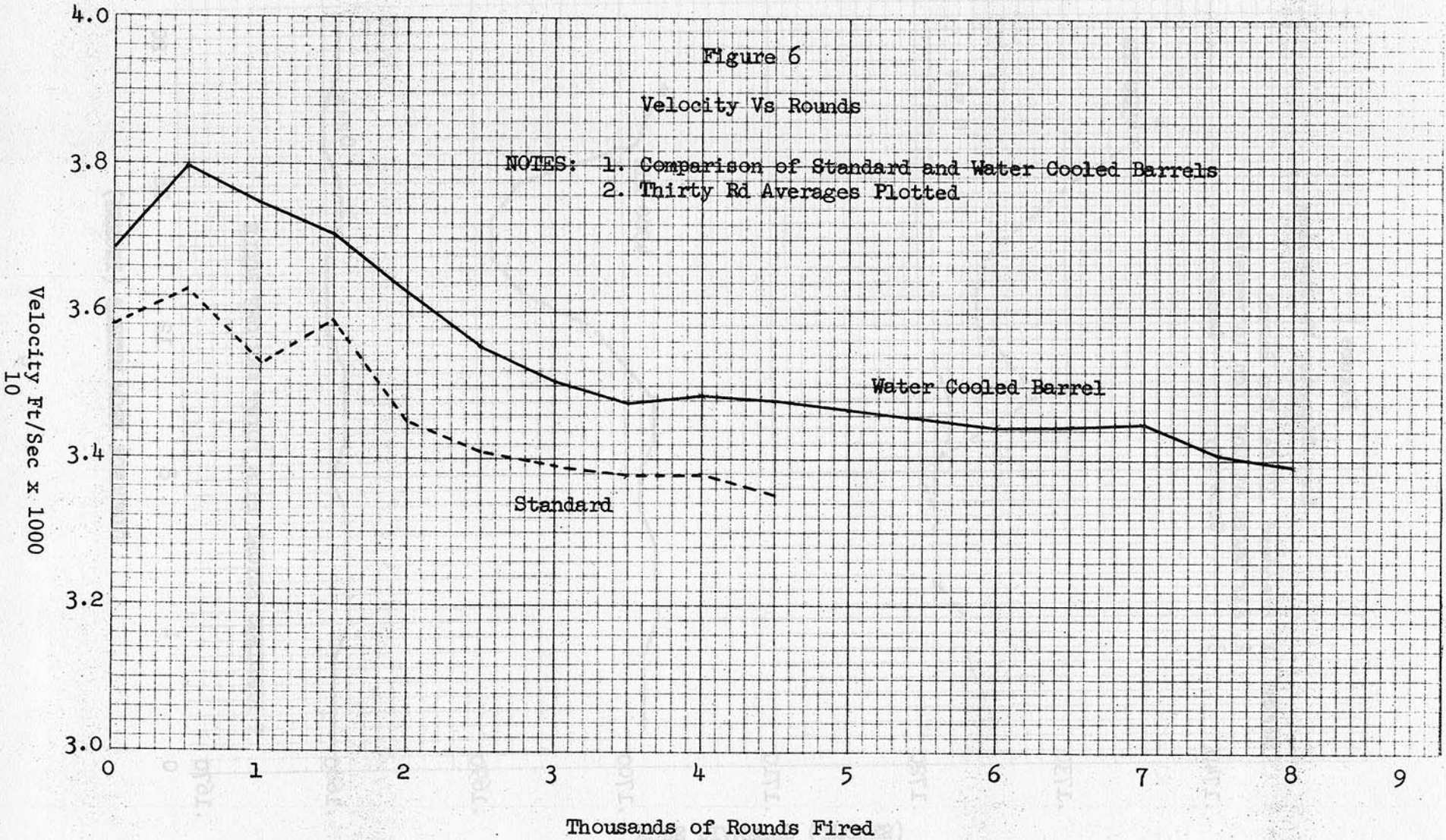




TABLE I

## AVERAGE VELOCITY AND EXTREME SPREAD

Number of Rounds	Actual RD Count	Average Velocity FT/SEC	Extreme Spread			AVG
			TGT 1	TGT 2	TGT 3	
0	-	3681	2.78	3.85	3.35	4.43
500	-	3795	4.20	3.87	3.11	3.73
1000	-	3752	4.46	4.10	5.12	4.56
1500	-	3707	3.64	4.16	2.33	3.38
2000	2190	3638	3.74	5.18	4.59	4.50
2500	2720	3554	3.15*	3.45*	2.47*	3.02*
3000	3250	3504	3.48*	3.41*	3.22*	3.37*
3500	-	3478	5.15	4.16	5.35	4.95
4000	4310	3489	3.69	4.46	3.89	4.01
4500	-	3480	7.16	5.42	4.79	5.79
5000	5377	3472	10.79	3.77	3.65	6.07
5500	-	3454	3.96	4.24	3.83	4.01
6000	-	3446	4.74	2.88	3.07	3.56
6500	-	3444	4.33	4.75	4.54	4.54
7000	-	3451	4.48	3.98	4.98	4.48
7500	-	3401	3.85	3.24	4.49	3.86
8000	8760	3393	5.63	3.72	5.07	4.81
8000**	8790	-	7.73	10.14	8.68	8.85

\* 100 YDS

\*\* WITHOUT WATER JACKET



TABLE II

GROOVE DIAMETER OF .17CAL WATER COOLED BARREL

RDS INCH	0	1000	2000	3000	4000	5000	6000	7000	8000
1	.1723	.1722	.1723	.1722	.1722	.1723	.1723	.1723	.1722
2	.1721	.1722	.1723	.1722	.1722	.1722	.1723	.1723	.1723
3	.1721	.1722	.1723	.1722	.1722	.1722	.1723	.1723	.1722
4	.1721	.1722	.1723	.1722	.1722	.1722	.1722	.1722	.1722
5	.1721	.1722	.1722	.1722	.1722	.1722	.1722	.1723	.1722
6	.1721	.1722	.1722	.1722	.1722	.1722	.1722	.1722	.1722
7	.1721	.1722	.1722	.1722	.1721	.1721	.1722	.1722	.1722
8	.1721	.1721	.1722	.1721	.1721	.1721	.1722	.1721	.1721
9	.1721	.1722	.1723	.1723	.1722	.1722	.1722	.1721	.1720
10	.1721	.1723	.1722	.1722	.1726	.1725	.1722	.1722	.1722
11	.1723	.1723	.1722	.1722	.1722	.1721	.1721	.1722	.1722
12	.1722	.1722	.1722	.1722	.1721	.1721	.1721	.1722	.1722
13	.1721	.1722	.1721	.1721	.1722	.1722	.1722	.1722	.1721
14	.1721	.1722	.1721	.1721	.1722	.1722	.1722	.1722	.1721
15	.1721	.1721	.1721	.1721	.1721	.1721	.1722	.1721	.1722
16	.1721	.1721	.1721	.1721	.1722	.1722	.1722	.1721	.1722
17	.1721	.1721	.1721	.1721	.1721	.1722	.1722	.1722	.1723
18	.1721	.1721	.1721	.1722	.1721	.1723	.1723	.1722	.1723
19	.1721	.1720	.1721	.1722	.1723	.1724	.1723	.1723	.1724
20	.1720	.1720	.1722	.1723	.1726	.1725	.1724	.1725	.1726

VANHOVE ANTICIPA VMD EXTENSIE BEKEND

JUNE 1

TABLE III

LAND DIAMETER OF .17CAL WATER COOLED BARREL

RDS INCH	0	1000	2000	3000	4000	5000	6000	7000	8000
1	.1680	.1685	.1685	.1686	.1687	.1689	.1688	.1689	.1689
2	.1681	.1684	.1685	.1686	.1687	.1687	.1689	.1688	.1690
3	.1681	.1684	.1685	.1686	.1687	.1686	.1688	.1688	.1689
4	.1679	.1684	.1684	.1686	.1687	.1685	.1688	.1689	.1687
5	.1680	.1685	.1685	.1686	.1687	.1684	.1687	.1687	.1687
6	.1680	.1684	.1685	.1686	.1686	.1684	.1686	.1687	.1687
7	.1681	.1684	.1685	.1686	.1685	.1685	.1686	.1688	.1688
8	.1680	.1684	.1685	.1686	.1685	.1685	.1687	.1688	.1687
9	.1681	.1684	.1684	.1685	.1686	.1685	.1685	.1687	.1686
10	.1681	.1684	.1684	.1685	.1684	.1683	.1683	.1680	.1680
11	.1681	.1684	.1684	.1684	.1684	.1684	STUCK	.1685	STUCK
12	.1681	.1684	.1684	.1684	.1684	.1684	.1683	.1685	.1683
13	.1681	.1683	.1684	.1685	.1685	.1683	.1684	.1684	.1685
14	.1680	.1683	.1684	.1684	.1684	.1683	.1684	.1685	.1684
15	.1680	.1683	.1684	.1684	.1684	.1684	.1685	.1685	.1685
16	.1681	.1683	.1684	.1685	.1684	.1684	.1685	.1685	.1685
17	.1681	.1682	.1684	.1684	.1684	.1685	.1685	.1687	.1687
18	.1680	.1682	.1684	.1685	.1685	.1688	.1687	.1692	.1690
19	.1681	.1681	.1683	.1689	.1689	.1694	.1690	.1695	.1697
20	.1680	.1681	.1685	.1692	.1704	.1699	.1695	.1705	.1708

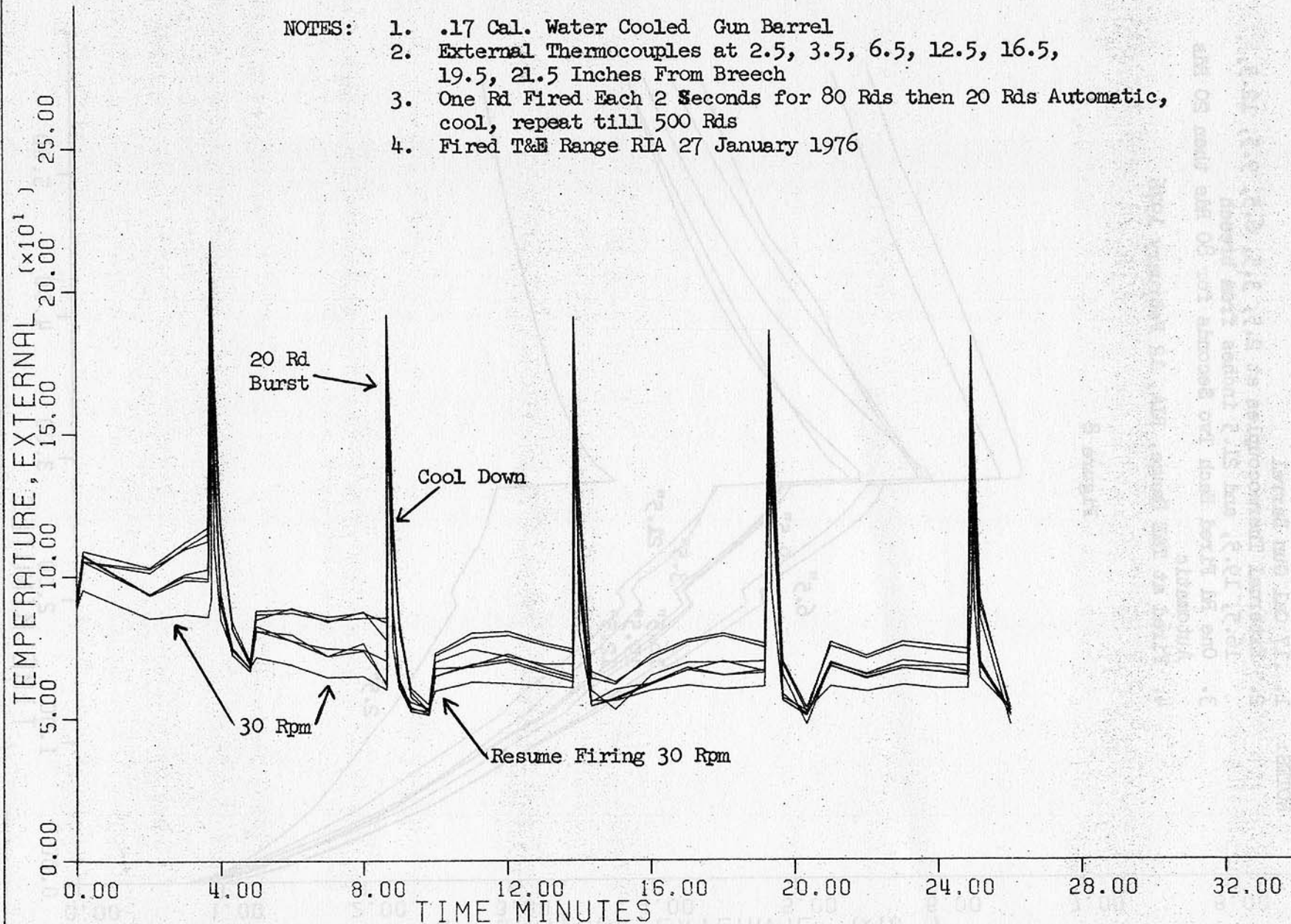
Standard non-cooled barrel temperatures are shown in Figure 8 for a hundred rd cycle. The 30 spm schedule runs significantly hotter while the burst spike temperature are roughly identical to the cooled barrel, as can be seen in the comparison Figure 9. Figure 10 shows 300 rds fired at an average rate of 30 spm.



Figure 7.

TEMPERATURE VS TIME

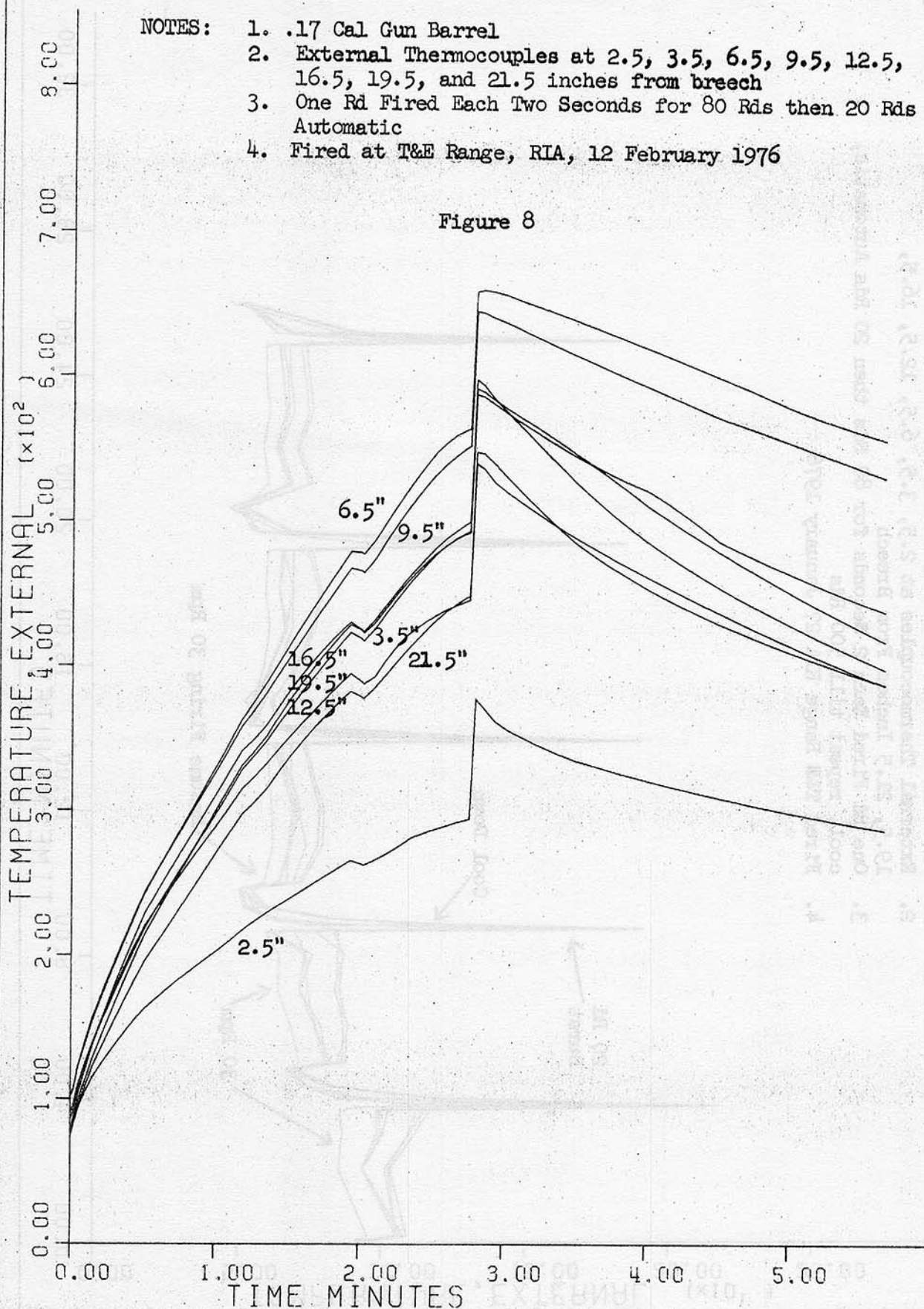
- NOTES:
1. .17 Cal. Water Cooled Gun Barrel
  2. External Thermocouples at 2.5, 3.5, 6.5, 12.5, 16.5, 19.5, 21.5 Inches From Breech
  3. One Rd Fired Each 2 Seconds for 80 Rds then 20 Rds Automatic, cool, repeat till 500 Rds
  4. Fired T&E Range RIA 27 January 1976



# TEMPERATURE VS TIME (Non-Cooled Std Barrel)

- NOTES:
1. .17 Cal Gun Barrel
  2. External Thermocouples at 2.5, 3.5, 6.5, 9.5, 12.5, 16.5, 19.5, and 21.5 inches from breech
  3. One Rd Fired Each Two Seconds for 80 Rds then 20 Rds Automatic
  4. Fired at T&E Range, RIA, 12 February 1976

Figure 8



# TEMPERATURE VS TIME

- NOTES:
1. Comparison of Standard and Water Cooled Barrels
  2. External Thermocouples at 2.5, 6.5, and 19.5 inches From Breech
  3. One Round Fired Each Two Seconds for 80 Rds then 20 Rds Automatic
  4. S-Standard Barrel, W-Water cooled Barrel
  5. Fired at T&E Range, RIA, 27 Jan and 12 Feb 76

Figure 9

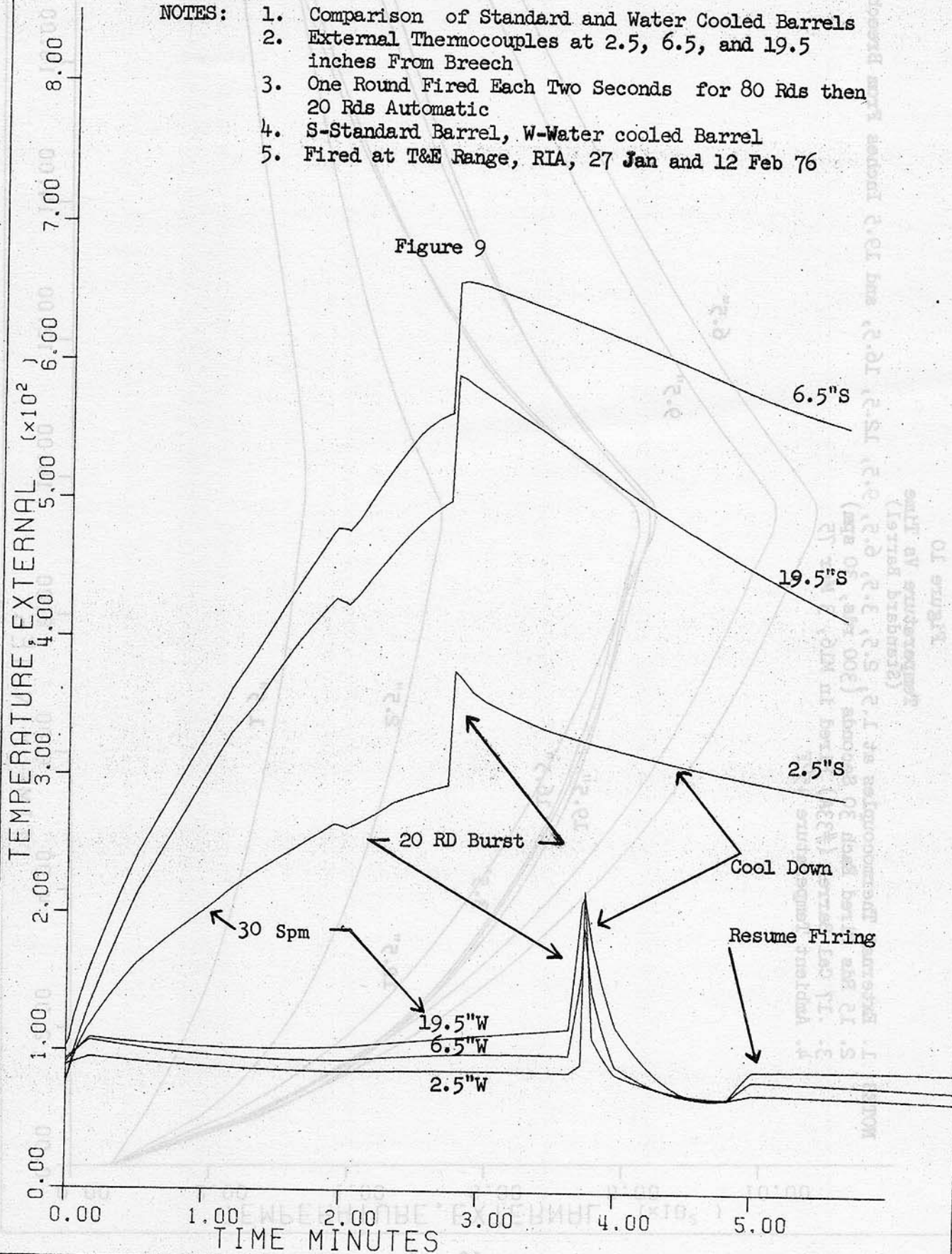
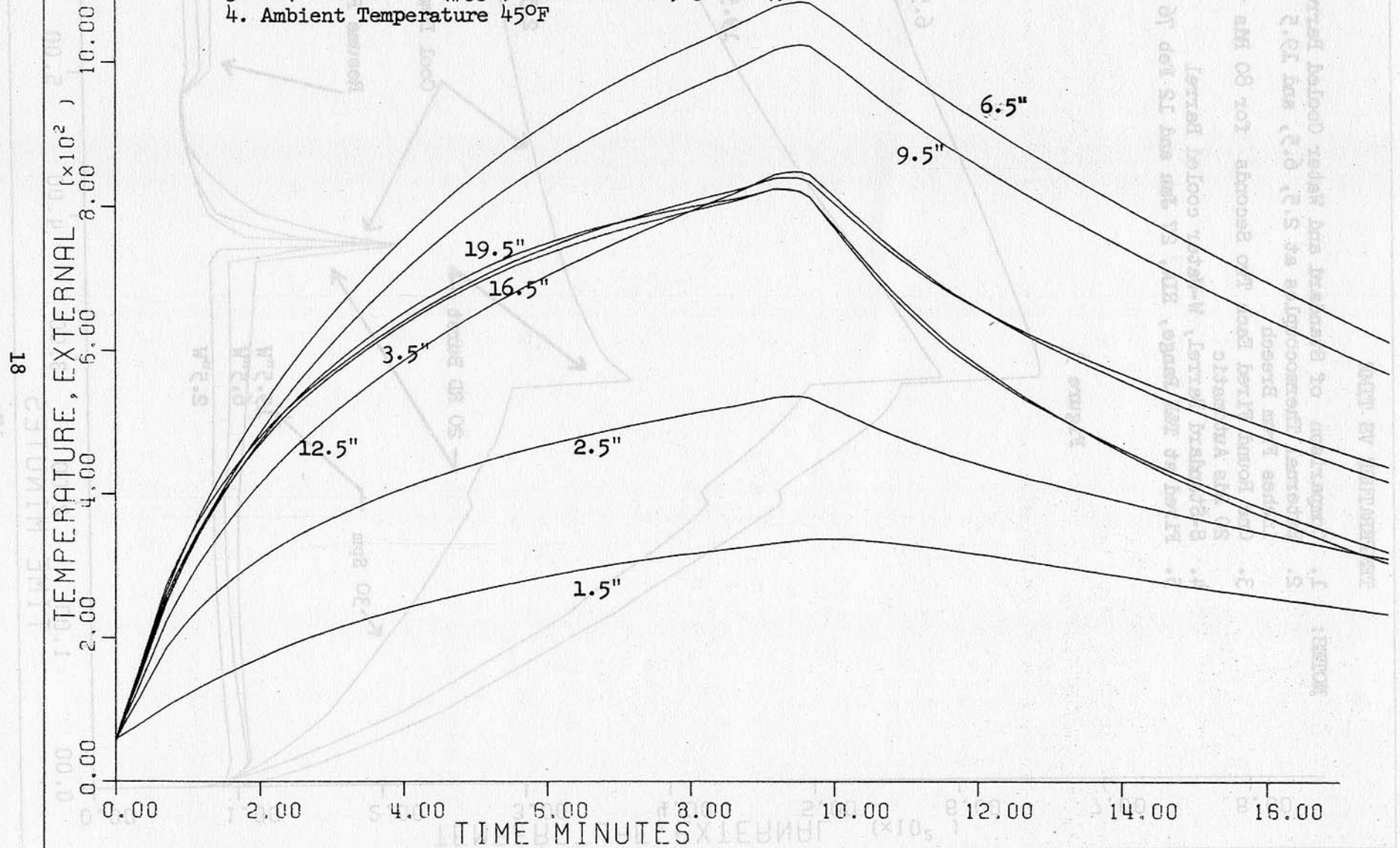




Figure 10

Temperature Vs Time  
(Standard Barrel)

- NOTES: 1. External Thermocouples at 1.5, 2.5, 3.5, 6.5, 9.5, 12.5, 16.5, and 19.5 Inches From Breech  
2. 15 Rds Fired Each 30 Seconds (300 rds, 30 spm)  
3. .17 Cal Barrel (#33A) Fired in M16, 3 Mar 75  
4. Ambient Temperature 45°F



## CONCLUSIONS

It must be emphasized that this testing was based on one sample, and that the results must be judged accordingly. However, the increased barrel life cannot be overlooked. Obviously, the .17 Cal gun barrel cannot be water cooled, however, lower transient operating temperature can be obtained with increased barrel mass. Therefore, it is recommended that further testing be undertaken utilizing a statistically representative number of barrels. This testing would involve firing barrels at different temperature levels (controlled by water cooling) such that a curve of barrel life versus operating temperature could be obtained at the prescribed firing schedule. This data would give a more accurate measure of the relationship between barrel erosion and barrel operating temperature for the .17 Cal barrel.