AD NUMBER

AD041655

NEW LIMITATION CHANGE

TO
Approved for public release, distribution unlimited

FROM
Distribution authorized to U.S. Gov’t. agencies and their contractors; Specific authority; 31 Oct 1966. Other requests shall be referred to Naval Proving Ground, Dahlgren, VA.

AUTHORITY

USNSWC ltr, 20 Jan 1976

THIS PAGE IS UNCLASSIFIED
<table>
<thead>
<tr>
<th>UNCLASSIFIED</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AD NUMBER</strong></td>
</tr>
<tr>
<td>AD041655</td>
</tr>
<tr>
<td><strong>CLASSIFICATION CHANGES</strong></td>
</tr>
<tr>
<td>TO:</td>
</tr>
<tr>
<td>unclassified</td>
</tr>
<tr>
<td>FROM:</td>
</tr>
<tr>
<td>confidential</td>
</tr>
</tbody>
</table>

**LIMITATION CHANGES**

| TO: |
| Distribution authorized to U.S. Gov’t. agencies and their contractors; Specific authority; 31 Oct 1966. Other requests shall be referred to Naval Proving Ground, Dahlgren, VA. |

| FROM: |
| Controlling DoD Organization. Naval Proving Ground, Dahlgren, VA. |

**AUTHORITY**

31 Oct 1966, DoDD 5200.10; 31 Oct 1966, DoDD 5230.24

THIS PAGE IS UNCLASSIFIED
Because of our limited supply, you are requested to return this copy WHEN IT HAS SERVED YOUR PURPOSE so that it may be made available to other requesters. Your cooperation will be appreciated.

NOTICE: WHEN GOVERNMENT OR OTHER DRAWINGS, SPECIFICATIONS OR OTHER DATA ARE USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH A DEFINITELY RELATED GOVERNMENT PROCUREMENT OPERATION, THE U. S. GOVERNMENT THEREBY INCURS NO RESPONSIBILITY, NOR ANY OBLIGATION WHATSOEVER; AND THE FACT THAT THE GOVERNMENT MAY HAVE FORMULATED, FURNISHED, OR IN ANY WAY SUPPLIED THE SAID DRAWINGS, SPECIFICATIONS, OR OTHER DATA IS NOT TO BE REGARDED BY IMPlication OR OTHERWISE AS IN ANY MANNER/licENSING THE HOLDER OR ANY OTHER PERSON OR CORPORATION, OR CONVEYING ANY RIGHTS OR PERMISSION TO MANUFACTURE, USE OR SELL ANY PATENTED INVENTION THAT MAY IN ANY WAY BE RELATED THERETO.

Reproduced by Best Available Copy

DOCUMENT SERVICE CENTER
KNOTT BUILDING, DAYTON, 2, OHIO
NOTICE: THIS DOCUMENT CONTAINS INFORMATION AFFECTING THE NATIONAL DEFENSE OF THE UNITED STATES WITHIN THE MEANING OF THE ESPIONAGE LAWS, TITLE 18, U.S.C., SECTIONS 793 and 794. THE TRANSMISSION OR THE REVELATION OF ITS CONTENTS IN ANY MANNER TO AN UNAUTHORIZED PERSON IS PROHIBITED BY LAW.
BORE SURFACE TEMPERATURES IN
THE 3"/70 TYPE E MOD 0 GUN
USING HOT AND COOL POWDERS

DEPARTMENT OF THE NAVY
BUREAU OF ORDNANCE

U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

Copy No. 8

Date: 4 October 1954
Bore Surface Temperatures in
the 3"/70 Type E Mod 0 Gun
Using Hot and Cool Powders
by
J. Nanigian
Armament Department

NPG REPORT NO. 1296
Foundational Research
Project NPG-M-11016-9
4 October 1954

APPROVED: J. F. BYRNE
Captain, USN
Commander, Naval Proving Ground

E. A. RUCKNER
Captain, USN
Ordnance Officer
By direction
CONTENTS

Abstract ........................................ ii
Foreword .......................................... iii
Introduction ....................................... 1
Description of Material ........................... 1
Description of Test Equipment ..................... 2
Procedure .......................................... 3
Results and Discussions ........................... 3
Conclusions ........................................ 5
References ......................................... 5
Appendix:
  A. Distribution

Figures:
  1. Sketch of Thermocouple Assembly.
  2-7. Pressure and Bore Surface Temperature
        Oscillograms.

Tables:
  1. Chemical and Physical Characteristics of
     Powders Used in Test.
  2. Summary of Firing Data.
ABSTRACT

Bore surface temperatures were recorded at the origin of rifling and the base of the cartridge case in the 311/70 Type E Mod 0 Gun. Rounds were fired using "hot" and "cool" powders. As a result of this test it is concluded that the bore surface temperatures produced by the "hot" and the "cool" powders are significantly different.

Additional firings were conducted to determine the characteristics of the NPG bore surface thermocouple. It was observed from these tests that:

Two bore surface thermocouples installed at the base of the cartridge case on the same round agreed within 15°C with one another.

The depth of recess of the thermocouple surface from the bore varied from 0.0090 to 0.0009 with no significant effects on the recorded temperatures.

Response of the NPG bore surface thermocouple is extremely fast. The response time was shown to be below a limiting value of approximately 0.068 milliseconds. The corresponding rate of temperature rise, for the conditions of the test, is 15,000°C per millisecond.

The NPG bore surface thermocouple has been used on 13 single round firings thus far with no evidence of having reached its maximum life.
FOREWORD

The tests reported herein were conducted under the Foundational Research Program of the Naval Proving Ground as authorized by reference (a). This is the second partial report on Foundational Research Project NPG-M-11016-9, Bore Surface Temperature Measurements.

The firings reported in this paper were conducted during October - November 1953.

This report was reviewed by:

S. E. HEDDEN, Acting Head
   Interior Ballistics Division
   Armament Department
H. S. OVERMAN, Director of Research
   Armament Department
L. C. KLINGAMAN, Commander, USN
   Armament Officer
   Armament Department
N. A. M. RIFFOLT, Director of Research
INTRODUCTION

In the development of new weapons and propellants, the bore surface temperature histories are of special interest. The processes of gun erosion, thermal stress and heat transfer depend upon the transient temperatures at the bore surface.

An extremely rugged fast-responding bore surface thermocouple was developed by the Naval Proving Ground during 1952-1953 and a complete description of it is contained in reference (b).

The primary objective of this project was to record the bore surface temperatures at the origin of rifling and at the base of the cartridge case for both "hot" and "cool" propellants fired in the same gun under similar conditions. Included in this report are the recorded bore surface temperature-time curves, along with reproductions of the original temperature oscillograms and simultaneous pressure-time records.

A secondary objective of this test was to determine more accurately the characteristics of the NPG bore surface thermocouple. Such characteristics as (1) response of two thermocouples at the same axial location in the gun on the same round, (2) effects of varying the distance between the thermocouple surface and the bore wall, (3) thermocouple response rate and (4) the durability of the thermocouple design were determined and the results of these tests are also included in this report.

DESCRIPTION OF MATERIAL

Gun

The 3"/70 Type E Mod O Gun was used for this test. The gun dimensions, gauge hole, projectile and cartridge case dimensions are contained in reference (c).
Powder

Two types of powders were used in this test; SPDN-10114 and EX 6586. The physical and chemical characteristics of these powders are contained in Table 1. The calculated flame temperatures of these powders are 2391°C and 2065°C respectively. These particular powders were chosen because they had the widest range in calculated flame temperatures among the available powders for the test gun at the time of these firings.

DESCRIPTION OF TEST EQUIPMENT

A brief description of the construction of this thermocouple is contained below.

A strip of metal foil, approximately 1/8" wide and 0.00002 thick, is sandwiched between the flat surfaces of a split cylinder of another metal. Two thin sheets of mica (3-6 microns thickness) are used for insulation between the two elements. The two metals comprising the thermocouple may be made of any thermo-electric combination; however, it is best to use for the split cylindrical sections the same material as the metal wall whose temperature is to be recorded. In this way the flow of heat through the split cylinder approaches the heat flow pattern of the wall itself. Nickel and steel were chosen for the elements of this thermocouple.

The assembly containing the split cylinder, mica and nickel foil is threaded into an appropriate steel housing. Set screws and a press-fit ring are then used to keep the unit together tightly. Finally, the end surface of the assembly is ground flat and polished with a fine abrasive. The direction of grinding and polishing is perpendicular to the slit between the halves of the plug. A number of thermo-electric junctions are thus formed on the exposed surface. A sketch of the thermocouple is contained in Figure 1. The same thermocouple used in the preliminary firings contained in reference (b) was used for this test. Additional thermocouples, of similar design, were constructed for use at the base of the cartridge case.
### CHEMICAL AND PHYSICAL CHARACTERISTICS OF POWDERS USED IN TEST

#### CHEMICAL CHARACTERISTICS

<table>
<thead>
<tr>
<th>Powder Index</th>
<th>Nitrocellulose</th>
<th>Dinitrotoluene</th>
<th>Diphenylamine</th>
<th>Centralite</th>
<th>Diethylphthalate</th>
<th>Total Volatiles</th>
<th>Total Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPN 10114</td>
<td>82.63</td>
<td>14.63</td>
<td>.98</td>
<td></td>
<td></td>
<td>1.76</td>
<td>.07</td>
</tr>
<tr>
<td></td>
<td>Nitroglycerin</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Nitrocellulose</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Picrite</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Picrite</td>
<td></td>
</tr>
<tr>
<td>EX 6586</td>
<td>20.33</td>
<td>8.90</td>
<td>60.74</td>
<td>2.09</td>
<td>7.94</td>
<td>.20</td>
<td>.24</td>
</tr>
</tbody>
</table>

#### PHYSICAL CHARACTERISTICS

<table>
<thead>
<tr>
<th>Powder Index</th>
<th>Diameter (D) (In.)</th>
<th>Diameter of Perf. (d) (In.)</th>
<th>Tab (In.)</th>
<th>Length (L) (In.)</th>
<th>Tab Var.</th>
<th>L/D</th>
<th>D/d</th>
<th>Form</th>
<th>No. of Grs.</th>
<th>Calc. Flame Temp.</th>
<th>Nominal Flame Temp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPN 10114</td>
<td>.2511</td>
<td>.0243</td>
<td>---</td>
<td>.0445</td>
<td>.0045</td>
<td>.6087</td>
<td>--</td>
<td>--</td>
<td>Cyl.</td>
<td>7</td>
<td>648</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EX 6586</td>
<td>.1425</td>
<td>.0132</td>
<td>.0248</td>
<td>.0266</td>
<td>.0257</td>
<td>.3500</td>
<td>7.0</td>
<td>2.45</td>
<td>Cyl.</td>
<td>7</td>
<td>3326</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
INTERIOR BALLISTICS DIVISION
WEAPONS SECTION
SKETCH OF THERMOCOUPLE ASSEMBLY

SKETCH OF THERMOCOUPLE ASSEMBLY

TO D.C. AMPLIFIERS

COPPER WIRE LEADS

REFERENCE JUNCTION AT AMBIENT TEMP.

SCREW INSULATED FROM STEEL SLUG

PLEXIGLASS INSULATION

BARREL WALL

PURE NICKEL RIBBON (.0002 INCHES THICK)

MICA SHEETS (3 to 10 MICRONS)

SOFT STEEL SEATING GASKET

DUAL STEEL PLUG (HARDENED 50 RC)

SOFT STEEL GAS SEAL

SOFT STEEL RING PRESS FITTED ON

BORE SURFACE

FIG. 1
PROCEDURE

Three rounds with each type of powder were fired in the 3"/70 gun with other firing conditions identical. Pressure and bore surface temperature-time data were recorded at the base of the case and the origin of rifling.

Ejection times were recorded by a strain gauge mounted circumferentially about the barrel 90° from the muzzle. Thus "ejection" represents the instant the after rotating band of the projectile reached the point 90° from the muzzle.

RESULTS AND DISCUSSIONS

Table 2 contains a summary of firing data for each round. Reproductions of original pressure and temperature oscillograms are contained in Figures 2 through 7. Figures 8 and 9 contain the bore surface temperature-time curves obtained on these firings.

Comparison of Temperature Curves

There were significant differences in the bore surface temperatures between the "hot" and "cool" propellants used in this test. The maximum temperatures at the origin of rifling average 1075°C and 980°C for the "hot" and the "cool" powders respectively. Similarly, the maximum temperatures in the case average 370°C and 280°C. Approximately 40 milliseconds after ejection, the bore surface temperatures at the origin of rifling average 350°C and 250°C for the "hot" and "cool" powders respectively.

Consistency of Thermocouple Measurements

The variations in the recorded temperatures from one round to the next, using a given powder, were very slight.
### TABLE 2

<table>
<thead>
<tr>
<th>Rd.</th>
<th>Date</th>
<th>Powder Index</th>
<th>Charge Wt.-Lbs.</th>
<th>Maximum Case Pressure (psi)</th>
<th>Maximum 34%0 Pressure (psi)</th>
<th>Maximum 186%0 Pressure (psi)</th>
<th>Muzzle Velocity (fps)</th>
<th>Recess (in.)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10/8/53</td>
<td>SPDN 11014</td>
<td>8.0</td>
<td>60100</td>
<td>11200</td>
<td>3417</td>
<td>3.392</td>
<td>0.090</td>
</tr>
<tr>
<td>2</td>
<td>10/13/53</td>
<td>SPDN 10114</td>
<td>8.0</td>
<td>66000</td>
<td>11000</td>
<td>3392</td>
<td>3.025</td>
<td>0.090</td>
</tr>
<tr>
<td>3</td>
<td>11/10/53</td>
<td>SPDN 10114</td>
<td>2.0</td>
<td>65000</td>
<td>11500</td>
<td>3413</td>
<td>0.025</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>10/27/53</td>
<td>EX 6586</td>
<td>8.8</td>
<td>55000</td>
<td>11500</td>
<td>3295</td>
<td>0.090</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>11/14/53</td>
<td>EX 6586</td>
<td>8.8</td>
<td>54000</td>
<td>11800</td>
<td>3266</td>
<td>0.025</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>11/15/53</td>
<td>EX 6586</td>
<td>8.8</td>
<td>54700</td>
<td>11400</td>
<td>3318</td>
<td>0.090</td>
<td></td>
</tr>
</tbody>
</table>

* All distances measured from breech face.

** "Recess" is the radial distance from the groove surface to the thermocouple surface.
Firing Data

Charge: SDM 10114, Charge Wt. 8.0 lbs
Primer: Mk. 46
Proj.: HE 11, Projectile Wt. 15 lbs.
Muzzle Velocity: 3417 f.p.s.

Trace Identifications

1 - Pressure at 3410 from Breech Face
2 - Pressure at 18670 from Breech Face
3 - Strain Gauge Ejection
4 - Thermocouple at Face of Case
5 - Thermocouple at Base of Case
6 - Thermocouple at 3410 from Breech Face

ROUND I
PRESSURE & BORE SURFACE TEMPERATURE OSCILLOGRAMS
October 1953
3770 Type E Mod. 0 Gun

CONFIDENTIAL
Firing Data
Charge: SDM 10ll4, Charge Wt. 8.0 lbs
Primer: Mk. 46
Proj: XI ll, Proj. Wt. 15 lbs.
Muzzle Velocity: 3392 f.p.s.

Trace Identifications
1. Pressure at Base of Case
2. Pressure at 3470 from Breach Face
3. Pressure at 18620 from Breach Face
4. Strain Gauge Ejection
5. Thermocouple at Base of Case
6. Thermocouple at 3470 from Breach Face

ROUND 2
PRESSURE & BORE SURFACE TEMPERATURE OSCILLOGRAMS
October 1953
NP9-62536
CONFIDENTIAL
3"/70 Type E Mod. 0 Gun
Close of Firing Key

Firing Data
Charge: SPDN 10114, Charge Wt. 8.0 lbs.
Primer: Mk. 46
Proj: EX 11, Proj. Wt. 15 lbs.
Muzzle Velocity: 3413 f.p.s.

Trace Identifications
1 - Pressure at Base of Case
2 - Pressure at 3470 from Breech Face
3 - Pressure at 18510 from Breech Face
4 - Strain Gauge Ejection
5 - Thermocouple at 3750 from Breech Face
6 - Thermocouple at Base of Case

10 Milliseconds

5 6

10 Milliseconds

ROUND 3
PRESSURE & BORE SURFACE TEMPERATURE OSCILLOGRAMS
November 1953
NP9-65687
CONFIDENTIAL
3"/70 Type E Mod. O Gun
Close of Firing Key

Firing Data
Charge: EX 6586, Charge Wt. 8.8 lbs.
Primer: Mk. 46
Proj: EX 11, Proj. Wt. 15 lbs.
Muzzle Velocity: 3295 f.p.s.

Trace Identifications
1. Pressure at Base of Case
2. Pressure at 3470 from Breech Face
3. Pressure at 18670 from Breech Face
4. Strain Gauge Ejection
5. Thermocouple at Base of Case
6. Thermocouple at 3470 from Breech Face

1234
56
10 Milliseconds

ROUND 4
PRESSURE & BORE SURFACE TEMPERATURE OSCILLOGRAMS
October 1953
NPS-62535
CONFIDENTIAL
3770 Type E Mod. 0 Gun
Firing Data

Charge: XX 6586, Charge Wt. 8.8 lbs
Primer: Mx. 46
Proj.: XI 11, Projectile Wt. 15 lbs
Muzzle Velocity: 3256 F.p.s.

Trace Identifications
1-Pressure at Base of Case
2-Pressure at 34% from Breech Face
3-Pressure at 186% from Breech Face
4-Strain Gauge Ejection
5-Thermocouple at Base of Case
6-Thermocouple at 34% from Breech Face

ROUND 5
PRESSURE & BORE SURFACE TEMPERATURE OSCILLOGRAMS
November 1953
MP9-52537
CONFIDENTIAL
3770 Type E Mod. C Gun
**Firing Data**

- Charge: 6586, Charge Wt. 8.8 lbs.
- Primer: M. 46
- Proj.: 11, Proj. Wt. 23 lbs.
- Muzzle Velocity: 3315 f.p.s.

**Trace Identifications**

1. Pressure at Base of Case
2. Pressure at 34/0 from Breech Face
3. Pressure at 18670 from Breech Face
4. Strain Gauge Ejection
5. Thermocouple at Base of Case
6. Thermocouple at 34/0 from Breech Face

**ROUND 6**

**PRESSURE & BORE SURFACE TEMPERATURE OSCILLOGRAMS**

November 1953

37/70 Type E Mod 0 Gun
Effect of Varying the Distances Between Thermocouple Surface and Bore Surface

The surface of the thermocouple at the origin of rifling was moved closer to the bore wall by inserting successively thinner seating gaskets when installing the thermocouple. After each installation, the actual location of the thermocouple surface was measured with a star gauge type bore micrometer. The depth of recess of the thermocouple surface from the bore surface was varied from 1090 to 1009 and no variations were noted in the recorded temperatures. However, as the depth of recess was decreased, the amount of coppering on the thermocouple surface was reduced.

Agreement Between Two Bore Surface Thermocouples at the Same Location on the Same Round

In Round 1, two bore surface thermocouples were installed at the base of the cartridge case. The oscillograms are reproduced in Figure 2. The lead wire of one of the thermocouples was shorted at about the instant of maximum temperature. Up to this instant, the temperature curves from these thermocouples agreed within 15°C with one another.

Temperature of Gases Leaking Ahead of Projectile

Occasionally the bore surface thermocouple at the origin of rifling records a temperature change prior to the passage of the projectile. This is attributed to gases escaping past the rotating band.

Thermocouple Response

An approximate calculation of the rapidity of the thermocouple response can be made if one assumes that the temperature change at the position of the origin of rifling (3410 from the breech face) is applied in the form of a square wave step function. The response time of the

Firings with 1009 recess are not included in the data in this report. They will be treated in a later report.
thermocouple is then arbitrarily defined as the time required for the thermocouple to produce 63.2% of its maximum output when this step-temperature change is introduced at the bore surface. The records from the thermocouple located at 3410 from the breech face for rounds 1 and 2 were read under high magnification to determine this response time. The time constant of this thermocouple was thus found to be approximately .068 millisecond. (Measured times were .065 millisecond and .071 millisecond on rounds 1 and 2, respectively.) The corresponding maximum rate of recorded temperature rise was approximately 15,000°C per millisecond.

Clearly, the temperature rise of the bore surface is not a step function. Consequently, the time constant as measured will exceed the true time constant of the thermocouple alone. The significance of the reported value is that it defines a lower limit for the true quality of response. It is reasonable to expect that the true response is appreciably faster.

CONCLUSIONS

As a result of the test conducted, it is concluded that significant differences in the bore surface temperatures exist between "hot" and "cool" powders fired in the 3"/70 Type E Mod 0 Gun. As would be expected, the bore surface temperature rise is roughly proportional to the difference between adiabatic flame temperature and ambient temperature. Powders with $T_0$ of 2500°C and 2100°C produced temperature changes of 1075°C and 980°C respectively at the origin of this gun. This temperature change is approximately 50 percent of the elevation of $T_0$ above ambient.

REFERENCES

(a) BUORD ltr Reb-1:mmt NP9 of July 1952
(b) NPG Conf Report No. 1130 "A Thermocouple to Record Transient Temperatures at the Bore Surface of Guns" 15 July 1953
(c) NPG Conf Raport No. 918 "Interior Ballistic Studies in the 3"/70 Caliber Gun Type E, Mod 0, Using Cool Propellants" 21 February 1952
DISTRIBUTION

Bureau of Ordnance:

Ad3 1
Re2 1
Re2a 1
Re2d 1

Chief of Ordnance
Department of the Army
Attn: ORDTX-AR 2

Armed Services Technical Information Agency
Document Service Center
Knott Building
Dayton 2, Ohio 5

Commanding General
Aberdeen Proving Ground
Aberdeen, Maryland
Attn: Technical Information Section
Development and Proof Services 1

Commander, Operational Development Force
U. S. Atlantic Fleet, U. S. Naval Base
Norfolk 11, Virginia 1

Chief of Ordnance
Department of the Army
Washington 25, D. C.
Attn: ORDTU 2

Chief of Ordnance
Department of the Army
Washington 25, D. C.
Attn: Ammunition Branch
ORDTA, R. and D. Division 1

Aerojet Engineering Corporation
P. O. Box 296
Azusa, California
Attn: Librarian, Nyra T. Grenier 1

Allegany Ballistics Laboratory
P. O. Box 210
Cumberland, Maryland
Attn: Dr. L. G. Bonner 1

CONFIDENTIAL 1
DISTRIBUTION (Continued)

Armour Research Foundation  
Technology Center  
Chicago 16, Illinois  
Attn: Dr. LeVan Griffis  

Atlantic Research Corporation  
812 North Fairfax Street  
Alexandria, Virginia  
Attn: Dr. A. C. Scurlock  

A. D. Little, Inc.  
Cambridge 42, Massachusetts  
Attn: Dr. C. S. Keevil  

Bureau of Mines  
4800 Forbes St.  
Pittsburgh, Penna.  
Attn: Dr. B. Lewis  

Catholic University of America  
7th Street & Michigan Ave., N. E.  
Washington, D. C.  
Attn: Dr. F. O. Rice  

Chief of Staff, USAF  
Washington 25, D. C.  
Attn: DCS/D (AFDRD-AV-?)  
Mr. M. Lipnick  

Commander, U. S. Naval Ordnance Test Station  
Inyokern, China Lake, California  
Attn: Technical Library Branch  

Commander, Naval Ordnance Laboratory  
White Oak, Silver Spring, Maryland  
Attn: Library  

Commander, U. S. Naval Air Missile Test Center  
Point Mugu, California  
Attn: Technical Library
DISTRIBUTION (Continued)

Commanding General, Frankford Arsenal
Bridge and Tacony Streets
Philadelphia 37, Penna.
Attn: Pitman-Dunn Laboratory 1

Commanding General
AMC Wright-Patterson AFB
Dayton, Ohio
Attn: MCREXP-53 2

Commanding Officer
Office of Naval Research
1030 E. Green Street
Pasadena, California 1

Commanding General
Aberdeen Proving Ground
Aberdeen, Maryland
Attn: Ballistic Research Laboratories 1

Commanding Officer
Picatinny Arsenal
Dover, New Jersey
Attn: ORDBB-T 2

Commanding Officer
Redstone Arsenal
Huntsville, Alabama
Attn: ORDDW-R, Technical Library 2

Commanding Officer
U. S. Naval Powder Factory
Indian Head, Maryland
Attn: Research and Development Department 2

E. I. du Pont de Nemours and Co.
10th and Market Streets
Wilmington, Delaware
Attn: Dr. W. F. Jackson
Rm. 5462 Nemours 1
Goodyear Aircraft Corporation
Akron 15, Ohio
Attn: Dr. H. E. Sheets
        Aerophysics Dept.  1

Hercules Experimental Station
Wilmington, Delaware
Attn: Dr. A. M. Ball  1

Hughes Aircraft Company
Florence Ave. at Teale St.
Culver City, California
Attn: Dr. M. C. Beebe  1

Jet Propulsion Laboratory, C.I.T.
Pasadena 4, California
Attn: Dr. L. G. Dunn  2

Midwest Research Institute
4049 Pennsylvania
Kansas City, Missouri
Attn: Dr. G. E. Ziegler  1

M. W. Kellogg Company
Ft. of Danforth Ave.
Hersey City, New Jersey
Attn: Mr. Samuel Baig  1

Purdue University
Department of Chemistry
Lafayette, Indiana
Attn: Dr. H. Feuer  1

Solid Propellant Information Agency
Applied Physics Laboratory
Johns Hopkins University
Silver Spring, Maryland
Attn: Mr. R. H. Petty  4
DISTRIBUTION (Continued)

University of Michigan
Department of Engineering Research
Ann Arbor, Michigan
Attn: Dr. J. Brier

Western Cartridge Company
Olin Industries, Inc.
Alton, Illinois
Attn: R. L. Womer

Southwest Research Institute
8500 Culebra Road
San Antonio, Texas

Local:

OR
OML
OMI
OMIR-21
OM-1
File

1
1
1
1
1
1
Subject: Bore Surface Temperatures in the 3"/70 Type E Mod 0 Gun Using Hot and Cool Powders by J. Nanigian, Armament Department, U. S. Naval Proving Ground, Dahlgren, Virginia

4 October 1954

ABSTRACT

Bore surface temperatures were recorded at the origin of rifling and the base of the cartridge case in the 3"/70 Type E Mod 0 Gun. Rounds were fired using "hot" and "cool" powders. As a result of this test it is concluded that the bore surface temperatures produced by the "hot" and the "cool" powders are significantly different.

Additional firings were conducted to determine the characteristics of the NPG bore surface thermocouple. It was observed from these tests that:

Two bore surface thermocouples installed at the base of the cartridge case on the same round agreed within 15°C with one another.

The depth of recess of the thermocouple surface from the bore varied from 0.090 to 0.009 with no significant effects on the recorded temperatures.

Response of the NPG bore surface thermocouple is extremely fast. The response time was shown to be below a limiting value of approximately 0.068 milliseconds. The corresponding rate of temperature rise, for the conditions of the test, is 15,000°C per millisecond.

The NPG bore surface thermocouple has been used on 13 single round firings thus far with no evidence of having reached its maximum life.
Subject: Bore Surface Temperatures in the 3"/70 Type E Mod 0 Gun Using Hot and Cool Powders by J. Nanigian, Armament Department, U. S. Naval Proving Ground, Dahlgren, Virginia
4 October 1954

ABSTRACT

Bore surface temperatures were recorded at the origin of rifling and the base of the cartridge case in the 3"/70 Type E Mod 0 Gun. Rounds were fired using "hot" and "cool" powders. As a result of this test it is concluded that the bore surface temperatures produced by the "hot" and the "cool" powders are significantly different.

Additional firings were conducted to determine the characteristics of the NPG bore surface thermocouple. It was observed from these tests that:

Two bore surface thermocouples installed at the base of the cartridge case on the same round agreed within 15°C with one another.

The depth of recess of the thermocouple surface from the bore varied from 0.0090 to 0.0009 with no significant effects on the recorded temperatures.

Response of the NPG bore surface thermocouple is extremely fast. The response time was shown to be below a limiting value of approximately 0.068 milliseconds. The corresponding rate of temperature rise, for the conditions of the test, is 15,000°C per millisecond.

The NPG bore surface thermocouple has been used on 13 single round firings thus far with no evidence of having reached its maximum life.