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U. S. NAVAL PROVING GROUND  
DAHLGREN, VIRGINIA

REPORT NO. 63

GUNFIRE TEST OF GOODYEAR SELF  
SEALING FUEL CELLS WITH 20mm PRACTICE  
AND .60 CALIBER BALL AMMUNITION

FINAL Report

Task

Assignment TED No. NPG AE538041

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Gunfire Test of Goodyear Self Sealing Fuel Cells  
With 20mm Practice and .60 Caliber Ball Ammunition  
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PART A

SYNOPSIS

1. This is a final report on the gunfire tests of the Goodyear self sealing fuel cells conducted under TED No. NPG AE538041.

2. The object of this test was to determine the self sealing qualities of the fuel cells when subjected to 20mm and .60 caliber gunfire. The test was conducted in accordance with the requirements set forth in the Army-Navy Aero Specification AN-T-49a-1.

3. Two 20mm Practice and two .60 caliber ball projectiles were fired into cell number 86. A total of eight wounds was produced, five of which sealed satisfactorily. Round number four, a .60 caliber ball projectile, produced extensive damage to the area around the exit wound and the testing on this cell was discontinued.

4. Three 20mm practice and four .60 caliber ball projectiles were fired into cell number 71. A total of fourteen wounds were produced, eight of which sealed satisfactorily according to the requirements of reference (b). Five of the wounds which failed to seal satisfactorily did seal to damp in four minutes. Round number six, a tumbled .60 caliber ball projectile, punched out the sealant in the entrance wound.

5. It is concluded that the self sealing performance of the fuel cells was unsatisfactory according to the requirements of reference (b).

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Gunfire Test of Goodyear Self Sealing Fuel Cells  
With 20mm Practice and .60 Caliber Ball Ammunition

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PART B

INTRODUCTION

1. AUTHORITY:

This test was conducted under TED No. NPG AE538041, established by reference (a) which directed the gunfire test of the Goodyear non-metallic self sealing fuel cells.

2. REFERENCES:

- a. BuAer ltr Aer-AE-53 dated 17 May 1948.
- b. Army-Navy Aeronautical Specification AN-T-49a-1.
- c. Copy of Goodyear Tire & Rubber Co. ltr dated 16 April 1948.

3. BACKGROUND:

The Goodyear Tire & Rubber Company has submitted to the Naval Proving Ground two 1' x 2' x 3' non-metallic self sealing fuel cells. This report deals with the gunfire testing of the subject fuel cells.

4. OBJECT OF TEST:

As requested by reference (a), this test was conducted to determine the self sealing qualities of the fuel cells when subjected to 20mm and .60 caliber gunfire. Paragraph F-5c of reference (b) was used as a guide in conducting this test.

5. PERIOD OF TEST:

- |                                     |               |
|-------------------------------------|---------------|
| a. Date of Project Letter           | 17 May 1948   |
| b. Date Necessary Material Received | 19 April 1948 |
| c. Date Test Started                | 11 June 1948  |
| d. Date Test Completed              | 11 June 1948  |

Gunfire Test of Goodyear Self Sealing Fuel Cells  
With 20mm Practice and .60 Caliber Ball Ammunition  
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## 6. REPRESENTATIVES PRESENT:

Mr. John Checkovich  
Mr. James Merrill  
Mr. Clyde Wheeler

Bureau of Aeronautics  
Goodyear Tire & Rubber Co.  
Goodyear Tire & Rubber Co.

PART CDETAILS OF TEST

## 7. DESCRIPTION OF ITEM UNDER TEST:

The dimensions of the two Goodyear non-metallic self sealing fuel cells are 1' x 2' x 3'. The construction of the cells is as follows:

| <u>Cell No. 71</u>                                                                   | <u>Thickness<br/>(Inches)</u> | <u>Weight<br/>(lbs/sq.ft.)</u> |
|--------------------------------------------------------------------------------------|-------------------------------|--------------------------------|
| 1st Ply Inner Ply GRN                                                                |                               |                                |
| 2nd " Sealant (Natural Rubber)                                                       | .030                          | .170                           |
| 3rd " Nylon cord fabric coated<br>on both sides with natural<br>rubber sealant       | .040                          | .200                           |
| 4th " Sealant (Natural Rubber)                                                       | .032                          | .130                           |
| 5th " Nylon cord fabric coated<br>on both sides with natural<br>rubber sealant       | .040                          | .200                           |
| 6th " Sealant (Natural Rubber)                                                       | .032                          | .130                           |
| 7th " Nylon cord fabric coated<br>on both sides with natural<br>rubber sealant       | .040                          | .200                           |
| 8th " Sealant (Natural Rubber)                                                       | .032                          | .130                           |
| 9th to 15th Ply Nylon cord fabric coated                                             | .040                          | .200                           |
| (Incl.) both sides Plioform resin                                                    | .032                          | .158 ea.                       |
| 16th Ply Nylon cord fabric coated<br>one side Plioform resin<br>and outside with GRN | .032                          | .154                           |
| Estimated cement                                                                     |                               | .100                           |
|                                                                                      | <u>.542</u>                   | <u>2.72</u>                    |

The actual weight of Cell number 71 is 66 pounds.

Gunfire Test of Goodyear Self Sealing Fuel Cells  
With 20mm Practice and .60 Caliber Ball Ammunition  
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Cell No. 86

Cell number 86 is constructed the same as Cell number 71 except the total plies of non-metallic material is six instead of eight. The estimated total gage is .478 inches and the estimated total weight, 2.37 pounds per square foot. The actual weight of the cell is 59 pounds.

8. DESCRIPTION OF TEST EQUIPMENT:

The following equipment was used in conducting this test:

- a. 20mm aircraft machine gun, M-3.
- b. .60 caliber aircraft machine gun, T17E3.
- c. 20mm practice ammunition, T-24.
- d. .60 caliber ball ammunition, T-77.
- e. Non-metallic tumble board.
- f. 40% aromatic blend of aviation gasoline.

9. PROCEDURE:

This test was conducted in accordance with the requirements of paragraph F-5c of reference (b) with the exception that 20mm practice and .60 caliber ball ammunition was used in lieu of the specified .50 caliber.

10. RESULTS AND DISCUSSION:

a. Two 20mm practice and two .60 caliber ball projectiles were fired into cell number 86. A total of eight wounds was produced, five of which sealed satisfactorily. Round number four, a .60 caliber ball projectile, produced extensive damage to the area around the exit wound, necessitating the discontinuance of the test on this cell. Figures 1 and 2 show the damage to this cell.

b. Three 20mm practice and four .60 caliber ball projectiles were fired into cell number 71. A total of fourteen wounds was produced, eight of which sealed satisfactorily; however, five of the wounds which failed to seal in accordance with reference (b), did seal to damp in four minutes. Round number six, a tumbled .60 caliber ball projectile, punched out the sealant in the entrance wound. Figures 3 and 4 show the damage to this cell.

c. The tabulated results of the gunfire test are contained in Appendix (B).

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Gunfire Test of Goodyear Self Sealing Fuel Cells  
With 20mm Practice and .60 Caliber Ball Ammunition  
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PART D

CONCLUSIONS

11. It is concluded that the self sealing performance of the two fuel cells was unsatisfactory according to the requirements of paragraph F-5c of reference (b).

PART E

DISPOSITION OF MATERIAL

12. Instructions from the Bureau of Aeronautics as to the disposition of the fuel cells is requested.

SUBMITTED:

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B. K. LLOYD  
LCDR, USN  
Aviation Ordnance  
Special Projects Officer

CONCUR:

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Ordnance Officer  
By direction.

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U. S. NAVAL PROVING GROUND  
DAHLGREN, VIRGINIA

Classification cancelled  
or changed to *Unclassified*  
AUTH: *W.H. 1st Lt. 13 Feb 60*  
By *Chester Beck*  
Signature and Grade  
Date *15 Jan 60*

Final Report

on

Task Assignment TED No. NPG AE538041

-----  
Gunfire Test of Goodyear Self  
Sealing Fuel Cells With 20mm Practice and  
.60 Caliber Ball Ammunition

Project No: TED No. NPG AE538041  
No. of Pages: 6

Date:

28 JUL 1948

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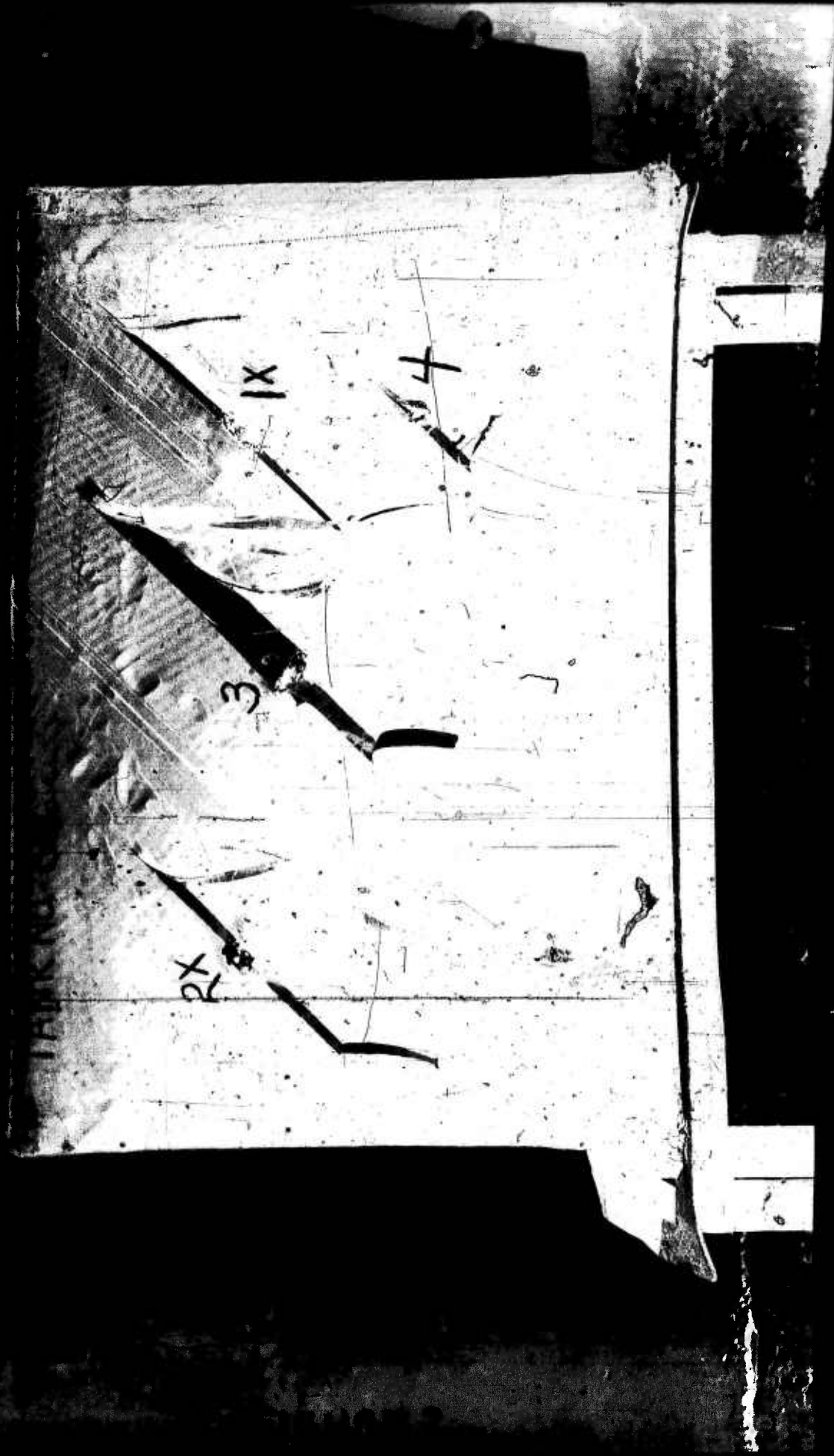




NP9 36577 - Gunfire Test of Goodyear Non-Metallic Self Sealing Fuel Cells. A view showing the entrance and exit wounds in a side panel of Cell No. 86. The cell was filled to within 2" of the top with a 40% aromatic blend of aviation gasoline and gunfire tested with 20mm and .60 caliber ammunition.

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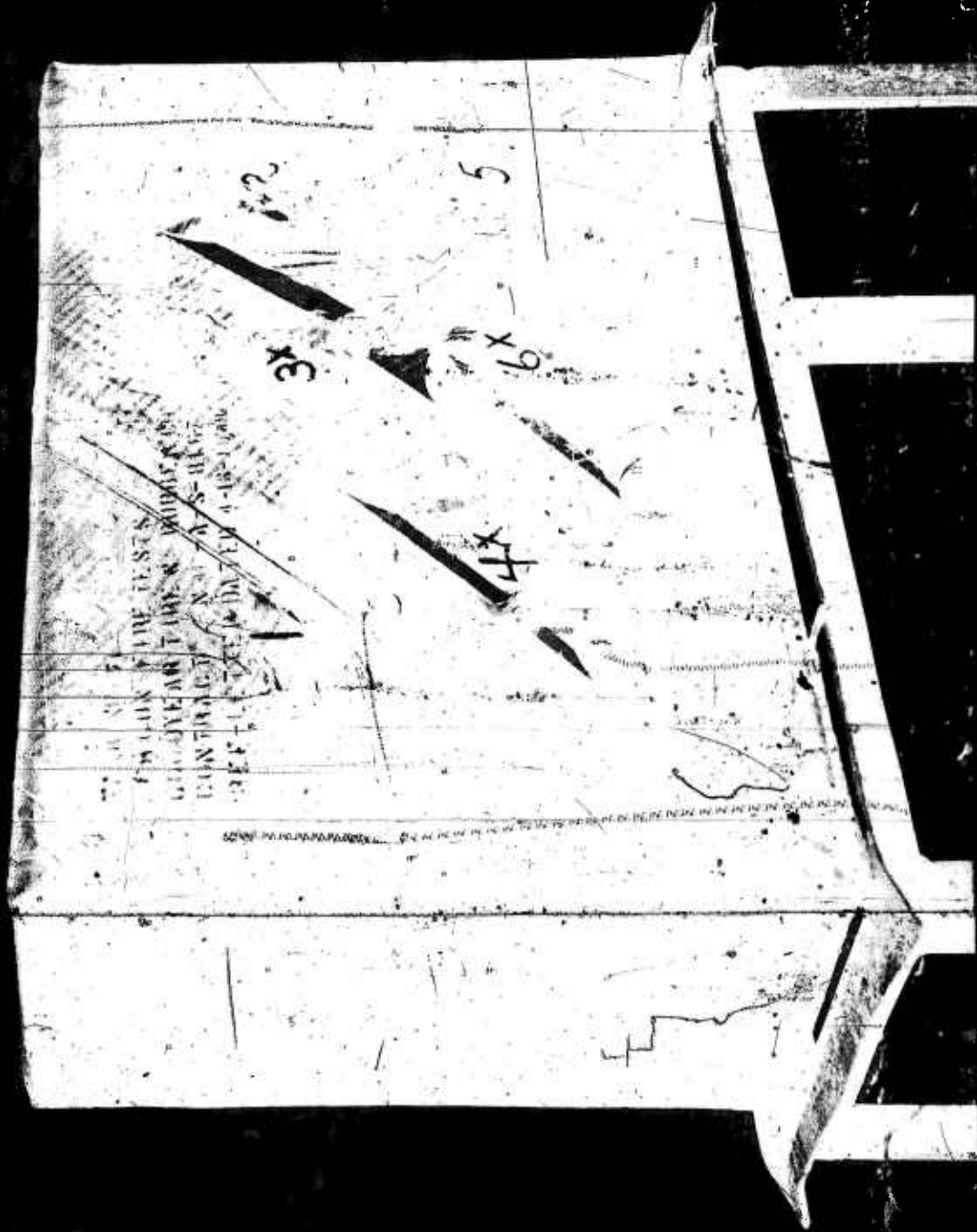
14 June 1943



170 36578 -- Gunfire test of Goodrich-Metallic Self Sealing Fuel Cells. The entrance and exit wounds in a side and end panel of Cell 10. 71. Cell was filled to 100% top with a 40% concentration of liquid. Cell was tested with 20mm and .60 caliber ammunition.

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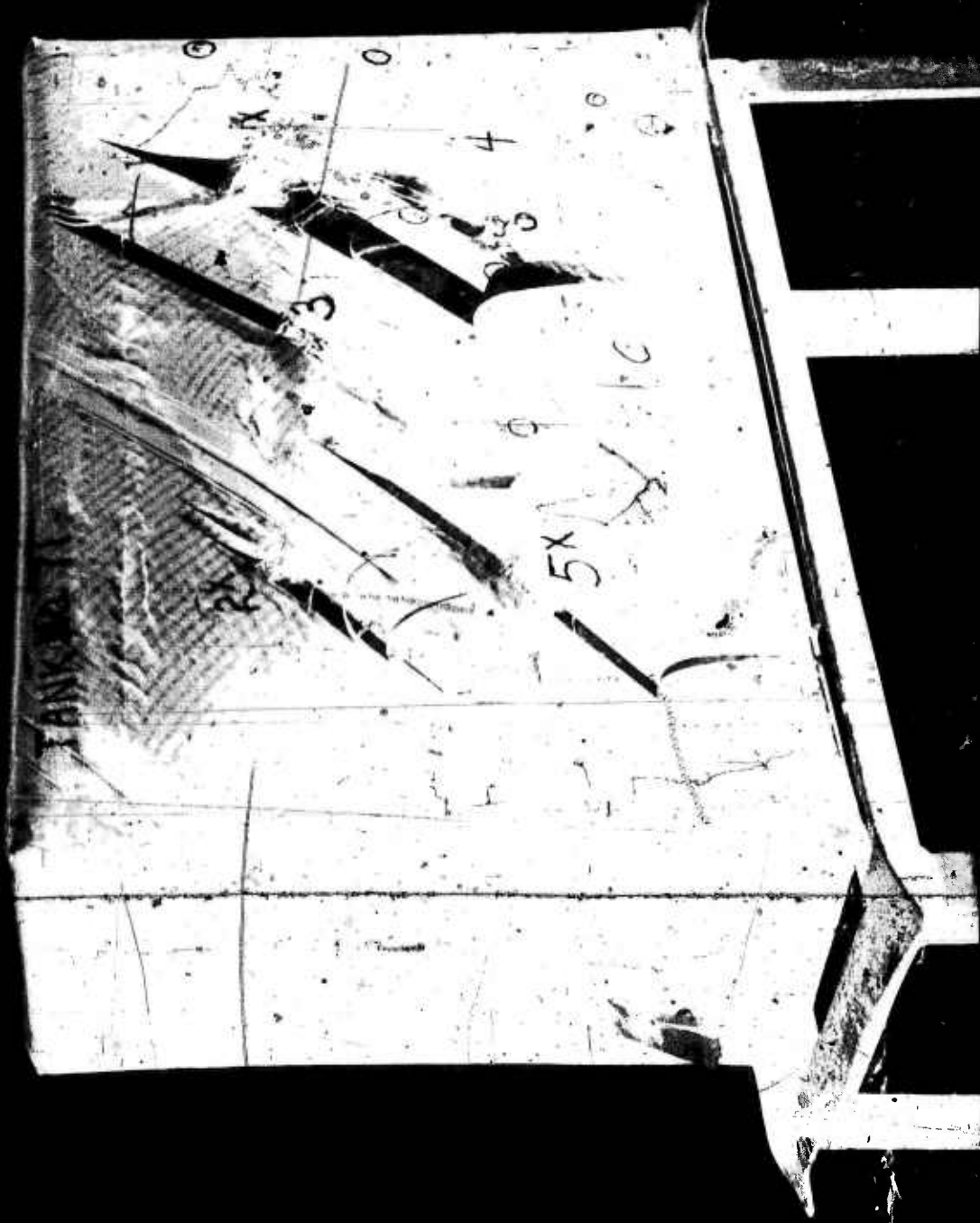


NP9 36579

- Gunfire Test of Goodyear Non-Metallic Self Sealing Fuel Cells. A view showing the entrance and exit wounds in a side and end panel of Cell No. 71. The cell was filled to within 2" of the top with a 40% aromatic blend of aviation gasoline and gunfire tested with 20mm and .60 caliber ammunition. The encircled wounds were produced by the fragments of the projectile's jacket.

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Gunfire Test of Goodyear Self Sealing Fuel Cells  
With 20mm Practice and .60 Caliber Ball Ammunition  
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TABULATED RESULTS OF GUNFIRE TEST

Preliminary Notes:

1. In the first column of the following table, the numbers with "x" after them refer to the exit wound made by the subject round.

2. Angle of impact as used in the following table is the angle between the line of fire and the surface on which impact occurs.

3. The following abbreviations are used:

|     |                     |
|-----|---------------------|
| SRH | Small round hole.   |
| LH  | Leaking heavily.    |
| LM  | Leaking moderately. |
| LS  | Leaking slightly.   |
| SM  | Seeping moderately. |
| SS  | Seeping slightly.   |

Gunfire Test of Goodyear Self Sealing Fuel Cells  
With 20mm Practice and .60 Caliber Ball Ammunition

TABULATED RESULTS OF GUNFIRE TEST

| Round No. | Cell No. | Ammunition     | Angle of Impact (degrees) | Approx. Head of Fuel (inches) | Size of Wound (inches) | Leakage After Impact | Sealed to | Time (min) | Remarks                                                       |
|-----------|----------|----------------|---------------------------|-------------------------------|------------------------|----------------------|-----------|------------|---------------------------------------------------------------|
| 1         | 86       | 20mm Pract.    | 90                        | 6                             | SRH                    | Dry                  |           |            | None.                                                         |
| 1x        |          |                |                           | 7                             | 1/2                    | Dry                  |           |            | Shredding of outer ply.                                       |
| 2         | "        | .60 Cal. Ball. | "                         | 8                             | SRH                    | SM                   | Dry       | 2          | Projectile was tumbled.                                       |
| 2x        |          |                |                           | 8                             | 1/2                    | LH                   | LM        | 4          | None.                                                         |
| 3         | "        | 20mm Pract.    | "                         | 9                             | 1                      | Dry                  |           |            | Projectile was tumbled.                                       |
| 3x        |          |                |                           | 10                            | 2                      | LM                   | SH        | 4          | None.                                                         |
| 4         | "        | .60 Cal. Ball. | 35                        | 12                            | SRH                    | Dry                  |           |            | None.                                                         |
| 4x        |          |                |                           | 13                            | 3                      | LH                   | LH        | 4          | Heavy damage to area around the wound. Test was discontinued. |
| 1         | 71       | 20mm Pract.    | 90                        | 6                             | SRH                    | Dry                  |           |            | None.                                                         |
| 1x        |          |                |                           | 7                             | 1 1/2                  | Dry                  |           |            | None.                                                         |
| 2         | "        | 20mm Pract.    | "                         | 7                             | SRH                    | Dry                  |           |            | None.                                                         |
| 2x        |          |                |                           | 7                             | SRH                    | Dry                  |           |            | None.                                                         |

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APPENDIX B

Gunfire Test of Goodyear Self Sealing Fuel Cells  
With 20mm Practice and .60 Caliber Ball Ammunition

TABULATED RESULTS OF GUNFIRE TEST

| Round No. | Cell No. | Ammunition     | Angle of Impact (degrees) | Approx. Head of Fuel (inches) | Size of Wound (inches) | Leakage After Impact | Sealed to | Time (min) | Remarks                                      |
|-----------|----------|----------------|---------------------------|-------------------------------|------------------------|----------------------|-----------|------------|----------------------------------------------|
| 3         | 71       | 20mm Pract.    | 90                        | 10                            | 1 1/4                  | SS                   | Dry       | 1          | Projectile was tumbled.                      |
| 3x        |          |                |                           | 10                            | 1 1/2                  | LM                   | SH Damp   | 2 5        | None.                                        |
| 4         | "        | .60 Cal. Ball  | "                         | 13                            | SRH                    | LS                   | SH Damp   | 1 4        | None.                                        |
| 4x        |          |                |                           | 13                            | SRH                    | Dry                  |           |            | None.                                        |
| 5         | "        | .60 Cal. Ball. | 90                        | 14                            | SRH                    | SS                   | Damp      | 1          | None.                                        |
| 5x        |          |                |                           | 15                            | 1                      | LS                   | Damp      | 4          | None.                                        |
| 6         | "        | .60 Cal. Ball  | "                         | 14                            | 1                      | LH                   | LH        | 4          | Projectile was tumbled. Sealant punched out. |
| 6x        |          |                |                           | 14                            | 1 1/4                  | SS                   | Damp      | 2          | None.                                        |
| 7         | "        | .60 Cal. Ball  | 0                         | 8                             | SRH                    | LS                   | SS Damp   | 2 4        | None.                                        |
| 7x        |          |                |                           | 10                            | 1 3/4                  | SH                   | SS Damp   | 2 4        | None.                                        |