FRAGMENTATION OF SINGLE AND DOUBLE WALL CYLINDRICAL WARHEADS

This document has been approved for public release and sale; its distribution is unlimited.

The Ballistic Research Laboratories Technical Note is designed for use within the laboratories or for issuing available information, when the occasion demands speed.

The contents of this paper are of the nature of advance information and may be extended or otherwise revised.
Subject: Request for Scientific and Technical Reports

To: Commanding Officer
Army Ballistics Research Lab
Attn: AMXBR-XS
Aberdeen Proving Ground, 21005

1. The report referenced below is believed to be a DoD-funded document. It has not been located in the Defense Documentation Center (DDC) collection.

2. Current DoD directives require that copies of each report be forwarded to DDC. At least one (1) copy should be black printing on white background (or if typed, the ribbon copy), suitable for reproduction by photographic techniques.

3. Documents must be marked with an appropriate distribution statement according to DoD Directive 5200.20 (AR 70-31, NAVMATINST 4000.17, AFR 310-2). This includes information on the releasability of unclassified, unlimited documents for sale to the general public by the Clearinghouse for Federal Scientific and Technical Information of the Department of Commerce. These distribution statements are found on the reverse of this letter.

4. Return the copy of this letter as your reply marking the reverse accordingly, i.e.: a. When reports are forwarded, or have previously been forwarded, check and fill in statements opposite A or B as applicable, or b. If the document is not releasable to DDC, indicate the category of exception by checking the applicable statement under C.

5. A mailing frank is enclosed to use for shipment of documents. Enclosed are a DDC Form 50 and a DDC Form 79 which explains its use.

FOR THE ADMINISTRATOR:

M. B. KAHN
Chief, Accessions Division

3 Encl
1. Franked label
2. DDC Form 50
3. DDC Form 79

Ballistics Research Lab - Aberdeen PG, Md

BRL-TN-554

FL-88
Jun 70.
DISTRIBUTION STATEMENTS
(DoD Dir. 5200.20)

Statement No. 1 - This document has been approved for public release and sale; its distribution is unlimited.

IN ADDITION TO SECURITY REQUIREMENTS WHICH APPLY TO THIS DOCUMENT AND MUST BE MET (This phrase precedes all the following statements when the document is classified).

Statement No. 2 - This document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of (controlling DoD office).

Statement No. 3 - Each transmittal of this document outside the agencies of the U. S. Government must have prior approval of (controlling DoD office).

Statement No. 4 - Each transmittal of this document outside the Department of Defense must have prior approval of (controlling DoD office).

Statement No. 5 - This document may be further distributed by any holder only with specific prior approval of (controlling DoD office).

A. [ ] Copies are forwarded herewith.

B. [ ] The Document was previously forwarded to DDC on __________ (date) and the AD number is __________.

C. [ ] In accordance with the provisions of Department of Defense Instructions, the document requested is not supplied because:

[ ] It is TOP SECRET.

[ ] It contains cryptographic and communications security.

[ ] It is excepted in accordance with DoD instructions pertaining to communications and electronic intelligence.

[ ] It is a registered document or publication.

[ ] It is an administrative paper, memorandum or report, a contract or grant proposal, or an order.

[ ] Other. Release Statement A

HERALD H. LAMBERT
Print or Type Name
Chief, Security Division

AUTHORIZED SIGNATURE
FRAGMENTATION OF SINGLE AND DOUBLE WALL CYLINDRICAL WARHEADS

Static fragmentation tests were made to investigate the fragmentation characteristics of a double wall cylindrical warhead as compared to a single wall cylindrical warhead of the same overall dimensions. The purpose of these tests was to obtain a quantitative estimate of the difference in fragment mass, numbers, velocity and spatial distribution between a double and a single wall cylindrical warhead.

DESCRIPTION OF WARHEADS

Standard 3" M2A1 shells were machined into cylinders 6" in length with the diameter dimensions as follows:

<table>
<thead>
<tr>
<th>Single Wall Cylinder</th>
<th>Double Wall Cylinder</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Outer</td>
</tr>
<tr>
<td>Outside diameter</td>
<td>2.70&quot;</td>
</tr>
<tr>
<td>Inside diameter</td>
<td>2.28&quot;</td>
</tr>
</tbody>
</table>

Tolerances were held to within ± .002". Fibre tubing machined down to the size of the cylinder was attached to each end (Figures 1 and 2). The fibre end extensions were used to reduce any effect which would change the fragmentation characteristics of the ends of the cylinders. The warhead was fully loaded with Composition C-3 and a tetryl booster was imbedded in the explosive near the initiated end. The weights of components, in grams, were as follows:

<table>
<thead>
<tr>
<th></th>
<th>Single Wall</th>
<th>Double Wall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight of outer cylinder</td>
<td>---</td>
<td>656</td>
</tr>
<tr>
<td>Weight of inner cylinder</td>
<td>---</td>
<td>607</td>
</tr>
<tr>
<td>Total weight of steel cylinders</td>
<td>1264</td>
<td>1265</td>
</tr>
<tr>
<td>Weight of fibre tubing, long</td>
<td>52</td>
<td>50</td>
</tr>
<tr>
<td>Weight of fibre tubing, short</td>
<td>36</td>
<td>33</td>
</tr>
<tr>
<td>Weight of fibre end disc, rear</td>
<td>15</td>
<td>22</td>
</tr>
<tr>
<td>Weight of fibre end disc, front</td>
<td>10</td>
<td>21</td>
</tr>
<tr>
<td>Weight of Comp C-3</td>
<td>862</td>
<td>835</td>
</tr>
<tr>
<td>Empty Weight</td>
<td>1377</td>
<td>1391</td>
</tr>
<tr>
<td>Loaded weight</td>
<td>2239</td>
<td>2226</td>
</tr>
</tbody>
</table>
METHOD OF TESTING

The field set up for the single wall warhead consisted of placing seven cane fibre filled recovery boxes tangent to a circle of 6" radius measured from the center of the warhead, (Fig. 3). The warhead was suspended with its longitudinal axis vertical 3' 1/4" above the ground level, as measured from the top of the warhead, and detonated with a 5/16" engineer's special electric blasting cap.

The field set up for the double wall warhead consisted of placing four cane fibre filled recovery boxes tangent to a circle of 12' 1-3/8" radius measured from the center of the warhead, (Fig. 4). One box (Box No. 3) was faced with .040" aluminum sheet painted black for the purpose of measuring the fragment velocity by the photographic method. Fragments were not recovered from that box. The warhead was suspended with its longitudinal axis vertical 6' above the floor level, as measured from the top of the warhead, and detonated with a 5/16" engineer's special electric blasting cap.

RESULTS

The percent of the total number of fragments recovered in various weight intervals is given in Table I. The "predicted" values (Column 5) of the double wall warhead were obtained from the mass distribution of the single wall warhead by assuming that the fragments in each weight interval were reduced in mass by 1/2 and doubled in number. It can be seen that the "predicted" values for the double wall warhead are in good agreement with the observed values, indicating that the breakup of the single and double wall warheads were the same with respect to the length and width of the fragments and differed only in thickness. It should be noted that the fragments from 0-10 grains and 0-5 grains of the single and double wall warheads respectively were not considered. If the small fragments were included the two for one breakup of the larger fragments is not evident. This can be seen by examining Table II or Figure 6 where the fragment recoveries, including the smallest fragments recovered, are given. The reason that the two for one breakup is not evident in Table II is not known but it appears that either the breakup of the small fragments is different than the large fragments for the two warheads or the recovery of the small fragments was not complete.

The average weight of recovered fragments greater than 10 grains, single wall, is 34.0 grains, and average weight greater than 5 grains, double wall, is 15.3 grains.

Figure 5 shows fragments recovered from one recovery box for each warhead. The lengths and widths of the larger fragments from the single wall warhead are roughly equal to the lengths and widths of the larger fragments from the double wall warhead. The thicknesses of the double warhead fragments are roughly one-half that of the single wall warhead fragments.
The weight of fragments recovered from the cane fibre board was 83% for the single wall warhead and 84% for the double wall warhead with respect to the theoretical recovery computed from the known geometry of the test setup.

The computed initial fragment velocity for either warhead is 5100 ft/sec as determined from Gurney's formula using the total explosive weight contained in the steel cylinder for C and the steel cylinder weight for H. The observed average initial fragment velocity was not measured for the single wall warhead, but was 5700 f/s for the double wall warhead. This higher value may not be significant and further checks are necessary. It does appear, however, that there is little, if any, loss in fragment velocity due to the use of a double wall.

The spatial distribution of fragments from the double wall warhead was satisfactory in the sense that adjacent fragments from each cylinder were separate in space and showed no evidence of being fused together. Fragment holes in the first sheet of the celotex appeared to be randomly spaced and there was no evidence of pairing of the fragments.

**SUMMARY**

For the present experiment, a double wall reduced the weight of and increased the number of fragments by an amount which is predictable from the fragments of a single wall warhead, except for the smallest fragments. If the smallest fragments are excluded, the observed average reduction in weight was about 1/2, the number increasing by a factor of 2. One possible application of multi-wall casings is for high explosive artillery or mortar shell where the present weight of the larger fragments is heavier than is necessary against personnel.

Cylindrical warheads of thicker casings and more layers are being made for the purpose of investigating further the fragmentation characteristics of multi-wall cylindrical warheads.

---

TABLE I

Comparison of Fragment Mass Distribution by % of Number Recovered

<table>
<thead>
<tr>
<th>Weight Interval</th>
<th>Single Wall Warhead</th>
<th>Weight Interval</th>
<th>Single Wall Warhead</th>
<th>Double Wall Warhead</th>
<th>Predicted Percent of Total Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grains</td>
<td>Percent of Total Number Recovered</td>
<td>Grains</td>
<td>Percent of Total Number Recovered</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-20</td>
<td>31.41</td>
<td>5-10</td>
<td>36.48</td>
<td>31.41</td>
<td></td>
</tr>
<tr>
<td>20-30</td>
<td>25.00</td>
<td>10-15</td>
<td>22.61</td>
<td>25.00</td>
<td></td>
</tr>
<tr>
<td>30-40</td>
<td>16.03</td>
<td>15-20</td>
<td>17.61</td>
<td>16.03</td>
<td></td>
</tr>
<tr>
<td>40-50</td>
<td>8.33</td>
<td>20-25</td>
<td>8.81</td>
<td>8.33</td>
<td></td>
</tr>
<tr>
<td>50-60</td>
<td>8.97</td>
<td>25-30</td>
<td>6.28</td>
<td>8.97</td>
<td></td>
</tr>
<tr>
<td>60-70</td>
<td>3.85</td>
<td>30-35</td>
<td>5.03</td>
<td>3.85</td>
<td></td>
</tr>
<tr>
<td>70-80</td>
<td>.64</td>
<td>35-40</td>
<td>.63</td>
<td>.64</td>
<td></td>
</tr>
<tr>
<td>80-90</td>
<td>2.56</td>
<td>40-45</td>
<td>2.52</td>
<td>2.56</td>
<td></td>
</tr>
<tr>
<td>90-100</td>
<td>.64</td>
<td>45-50</td>
<td>0</td>
<td>.64</td>
<td></td>
</tr>
<tr>
<td>100-110</td>
<td>.64</td>
<td>50-55</td>
<td>0</td>
<td>.64</td>
<td></td>
</tr>
<tr>
<td>110-120</td>
<td>1.29</td>
<td>55-60</td>
<td>0</td>
<td>1.29</td>
<td></td>
</tr>
<tr>
<td>120-130</td>
<td>0</td>
<td>60-65</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>130-140</td>
<td>.64</td>
<td>65-70</td>
<td>0</td>
<td>.64</td>
<td></td>
</tr>
<tr>
<td>--------------</td>
<td>--------</td>
<td>-----</td>
<td>------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>Observed Number</td>
<td></td>
<td>352</td>
<td>50</td>
<td>29</td>
<td>20</td>
</tr>
<tr>
<td>% of Total Number</td>
<td></td>
<td>63.08</td>
<td>8.96</td>
<td>5.20</td>
<td>3.58</td>
</tr>
<tr>
<td>Weight</td>
<td></td>
<td>400.15</td>
<td>351.47</td>
<td>359.57</td>
<td>343.36</td>
</tr>
<tr>
<td>% of Total Weight</td>
<td></td>
<td>6.69</td>
<td>5.93</td>
<td>6.01</td>
<td>5.75</td>
</tr>
<tr>
<td>Observed Number</td>
<td></td>
<td>98</td>
<td>58</td>
<td>36</td>
<td>28</td>
</tr>
<tr>
<td>% of Total Number</td>
<td></td>
<td>38.13</td>
<td>22.57</td>
<td>14.01</td>
<td>10.89</td>
</tr>
<tr>
<td>Weight</td>
<td></td>
<td>220.37</td>
<td>400.15</td>
<td>439.19</td>
<td>468.98</td>
</tr>
<tr>
<td>% of Total Weight</td>
<td></td>
<td>8.59</td>
<td>15.60</td>
<td>17.12</td>
<td>18.27</td>
</tr>
</tbody>
</table>
### TABLE II (contd)

**Weight Distribution of Fragments**

<table>
<thead>
<tr>
<th>Wt. Interval Grains</th>
<th>110-115</th>
<th>115-120</th>
<th>120-125</th>
<th>125-130</th>
<th>130-135</th>
<th>135-140</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed Number</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>% of Total Number</td>
<td>.18</td>
<td>.18</td>
<td>0</td>
<td>0</td>
<td>.18</td>
<td>0</td>
</tr>
<tr>
<td>Weight</td>
<td>113.13</td>
<td>115.89</td>
<td>0</td>
<td>0</td>
<td>133.64</td>
<td>0</td>
</tr>
<tr>
<td>% of Total Weight</td>
<td>1.90</td>
<td>1.95</td>
<td>0</td>
<td>0</td>
<td>2.25</td>
<td>0</td>
</tr>
<tr>
<td>Wt. Interval (Grains)</td>
<td>55-60</td>
<td>60-65</td>
<td>65-70</td>
<td>70-75</td>
<td>75-80</td>
<td>80-85</td>
</tr>
<tr>
<td>----------------------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>Observed Number</td>
<td>5</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>% of Total Number</td>
<td>.90</td>
<td>1.08</td>
<td>0</td>
<td>0</td>
<td>.18</td>
<td>.54</td>
</tr>
<tr>
<td>Weight</td>
<td>186.42</td>
<td>175.16</td>
<td>0</td>
<td>0</td>
<td>79.32</td>
<td>345.06</td>
</tr>
<tr>
<td>% of Total Weight</td>
<td>4.79</td>
<td>6.28</td>
<td>0</td>
<td>0</td>
<td>1.33</td>
<td>4.10</td>
</tr>
</tbody>
</table>

TABLE II (contd)

Weight Distribution of Fragments
FIGURE 1
SINGLE WALL CYLINDRICAL WARHEAD

FIBRE END DISC.

FIBRE EXT.

FIBRE END DISC.

TETRYL BOOSTER

FILLED WITH
COMP. C-3

STEEL CYLINDER

ENG'S SPECIAL ELECT. BLAST CAP

CYLINDER MACHINED FROM STANDARD
3" M 42Al SHELL
FIGURE 2
DOUBLE WALL CYLINDRICAL WARHEAD

CYLINDERS MACHINED FROM STANDARD
3" M42AI SHELL
FIGURE 3
TEST SET-UP SINGLE WALL WARHEAD

NOMENCLATURE:
81-7 = RECOVERY BOX 4' X 2' X 1'
FIGURE 4
DOUBLE WALL WARHEAD SET-UP

RECOVERY BOX NO. 3 FACED WITH .040" ALUMINUM SHEET PAINTED BLACK

1-2-3-4 = 8'x4'x3' CANE FIBRE FILLED RECOVERY BOX
FIGURE 5
FRAGMENTS FROM SINGLE AND DOUBLE WALL CYLINDRICAL WARHEADS

SINGLE WALL WARHEAD

DOUBLE WALL WARHEAD

0-120 GRAINS

0-45 GRAINS
FIGURE 5
HISTOGRAM OF FRAGMENT MASS DISTRIBUTION FOR
SINGLE AND DOUBLE WALL WARHEADS

PERCENT WEIGHT OF FRAGMENTS RECOVERED
IN WEIGHT INTERVALS

SINGLE WALL DISTRIBUTION
DOUBLE WALL DISTRIBUTION

PERCENT NUMBER OF FRAGMENTS RECOVERED
IN WEIGHT INTERVALS
DISTRIBUTION

No. of Copies

1

The New Mexico Institute of Mining and Technology Research & Development Division Socorro, New Mexico
Attn: E. J. Workman

2

Director
Central Air Documents Office
U. S. Building
Dayton 2, Ohio
Attn: CADO-D

2

Commanding Officer
Picatinny Arsenal
Dover, New Jersey

1

Applied Physics Laboratory
Johns Hopkins University
8621 Georgia Avenue
Silver Spring, Maryland
Attn: Mr. Arthur Norris

THRU:
Naval Inspector of Ordnance
Applied Physics Laboratory
Johns Hopkins University
8621 Georgia Avenue
Silver Spring, Maryland

1

Director
Naval Research Laboratory
Aerostation Station
Washington 20, D. C.
Attn: Dr. Irwin

3

Chief of Ordnance
Washington 25, D.C.
Attn: ORDTE-Bal Sec