Report of Trip to YTS - Operation Dorothe

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Place Visited: U. S. Army Activity
Yuma Test Station
Yuma, Arizona

Dates of Visit: 28 February - 11 March 1961

Purpose: To conduct Operation Dorothe, a sensitivity test of MTN, a liquid explosive.

Discussion:

Operation Dorothe was performed to answer the question: "Can liquid H.E., specifically MTN, withstand a 12,000 g acceleration without detonating?" If this relatively insensitive liquid H.E. detonated in setback, liquid H.E.'s in general would be unsuitable for the RAIL device. We found that MTN could withstand this acceleration.

The high g loadings were achieved by firing modified M107 projectiles, filled with MTN, from a 155 mm howitzer. Eleven rounds were fired at a nominal 15,500 g/s (a 3,500 g overttest). Of these, five were inert rounds used to calibrate diagnostic equipment. Of the other six rounds, four were filled MTN under a 25 millibar vacuum, and two were filled at atmospheric pressure. To increase the sensitivity of the H.E., the last two rounds also contained hollow glass beads of approximately 1/4 inch diameter, and one cc of echo sphere simulating trapped air and grit. The test rounds approximated the exposed surface area and liquid column height that will be common to the RAIL device.

The test was terminated when round C-90-13 detonated in the howitzer tube. Mechanical failure of the shell permitted no propellant gas to contact the MTN. The low order detonation was not caused by acceleration.

Test Results:
<table>
<thead>
<tr>
<th>Firing Date</th>
<th>LRL Rad. No.</th>
<th>Type</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 March 1961</td>
<td>C-90-1</td>
<td>Inert</td>
<td>Shell intact until impact</td>
</tr>
<tr>
<td>&quot;</td>
<td>C-90-2</td>
<td>&quot;</td>
<td>Shell intact until impact</td>
</tr>
<tr>
<td>&quot;</td>
<td>C-90-3</td>
<td>&quot;</td>
<td>Shell intact until impact</td>
</tr>
<tr>
<td>7 March 1961</td>
<td>C-90-4</td>
<td>Inert</td>
<td>Photos show trail of vapor following shell</td>
</tr>
<tr>
<td>&quot;</td>
<td>C-90-7</td>
<td>H.E. (Vac)</td>
<td>Shell intact until impact</td>
</tr>
<tr>
<td>8 March 1961</td>
<td>C-90-8</td>
<td>H.E. (Vac)</td>
<td>Shell intact until impact</td>
</tr>
<tr>
<td>&quot;</td>
<td>C-90-9</td>
<td>H.E. (Vac)</td>
<td>Vapor trail appears at 5/100 Sec. Nose cover plate then separates.</td>
</tr>
<tr>
<td>&quot;</td>
<td>C-90-11</td>
<td>H.E. (Vac)</td>
<td>Vapor trail appears at 6/100 sec. Nose cover plate separates at 7/100 sec.</td>
</tr>
<tr>
<td>9 March 1961</td>
<td>C-90-6</td>
<td>Inert</td>
<td>Shell intact until impact</td>
</tr>
<tr>
<td>&quot;</td>
<td>C-90-12</td>
<td>H.E. (Beads)</td>
<td>Photos show vapor trail from point of launch. Nose cover plate separates at 5/100 seconds. TMM odor detected after impact.</td>
</tr>
<tr>
<td>&quot;</td>
<td>C-90-13</td>
<td>H.E. (Beads)</td>
<td>Low order detonation occurred in gun tube. 13 inch long bulge resulted 24 inches from muzzle. Test terminated.</td>
</tr>
</tbody>
</table>

In recapitulation, two H.E. rounds survived the launch entirely, three suffered a separation of the nose cover plate but survived launch, and one detonated low order in the gun tube.

Recovery of the nose cover plates, and photographic evidence, (see attached film strip) show that flexure of this plate ruptured an "O" ring seal and
severed retaining screws. Thus, propellant gas was allowed to contact the NTN. At first yaw (the rounds were not stabilized) the nose cover plate separated from the round. Since this separation did not always happen, its occurrence may be correlated to the quantity of liquid present in the shell. Inert rounds filled under vacuum were devoid of air and thus the liquid supported the nose cover plate, preventing flexure and thus separation. Those filled at atmosphere contained air and thus could not support the plate. In the case of the H.E. vacuum shots, the NTN boiled during filling, releasing dissolved air. For the C-90-7 and C-90-8 shots, this air was bled off and these shots flew intact. For the C-90-9 and C-90-11 shots, which realized separation, less time was allowed for the air to be bled off, as our confidence in the material increased. Hence an air void existed. The C-90-12 shot, which separated, had a built in void in the form of beads, as did C-90-13 which detonated.

Since the aerodynamic forces involved were not sufficient to separate the nose cover, only the setback force could have. Thus, the liquid seal was broken inside the gun tube. Hot propellant gas, flowing C-90-13 as it progressed down the tube, contacted the liquid H.E., resulting in detonation.

No further testing of NTN at full scale is considered necessary. Test vehicles will be modified to eliminate the current mechanical difficulties in preparation for subsequent testing of more exotic liquid/slurry H.E.'s.

Personnel at Yuma Test Station performing this test were most interested and helpful. Some diagnostic difficulties were realized, but will be rectified prior to future tests.

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Vapor Trail appears as nose cover plate. Separates 80 ft. from howitzer.

C-90-12
H.E. (Bead) filled at atmospheric pressure with NTN.