Abstract

During the era of Nuclear testing, the U.S. government detonated 36 weapons over water. Barge shots (films of detonations over water) have not been studied as extensively as shots over land. We studied barge shots this summer, and we noticed that on all shots with yields of 100 kt or larger, a mysterious line appeared on the films. We found that for all yields, the ratio of the elevation of the entrainment line to the elevation of the fireball evolved similarly with time. By looking into previous studies, we were also able to confirm that the water entrainment line was caused by fine mist circulating above the fireball. Studying these shots gives us a unique opportunity to study Mach 100 shock waves interacting with water, which is not something that can be studied within the walls of a laboratory.

Research Objectives

- Study high Mach speed shock wave interacting with water.
- Measure the time evolution of the water entrainment line.
- Determine the optical effects which cause the water entrainment line.

Motivation

- We observed a previously unnoticed horizontal line within the outline of the shock wave on films of detonations with yields of 100 kt and over.
- This water entrainment line can potentially explain the asymmetry in barge shots we previously did not understand.

Methods

- Used PixelStick (a computer app) to measure the vertical radius, the horizontal diameter, and the height of each water entrainment line in pixels.
- Determined absolute time scale for each film using timing mark analysis.
- Calculated when the shock wave temperature reached 3300 K with: $T_{3300} = 0.004056 \cdot \frac{E}{\text{megaton}}^{1/3}$.
- Calculated "relative time" by dividing absolute time by the time at which the shockwave cools to a temperature of 3300 K.
- The line height ratio evolves logarithmically with time. The average ratio evolution follows the curve $\text{line height ratio} = 0.0989 \ln(\text{relative time}) + 0.4717$.

Results

- Evolution of the Entrainment Line to Fireball Height Ratio

Discussion

- An article by Andrzej Teodorczyk and Joseph E. Shepherd on the interaction of a shock wave with a water layer assisted in determining the cause of the water entrainment line.
- In Teodorczyk and Shepherd’s experiment, the shock wave raised fine droplets into the air. These droplets simulate the water entrainment in barge shots.
- The shock wave formed a wave which created a mist cloud.
- When the downward component of the shock wave initially strikes, it pushes the water radially outward.

References


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