A STUDY OF THE BOUNDARY LAYER IN A LARGE SCALE BLAST WAVE OVER A NATURAL SURFACE

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A study has been made of the boundary layer above the ground surface in the blast wave produced by the explosion of a hemispherical surface-burst 2,431 ton charge of ammonium nitrate and fuel oil (MINOR UNCLE). Numerical simulation and a variety of measurement techniques were used in the study.
A two-dimensional numerical simulation was carried out using the SHARC code to predict the variation of the physical properties in the blast wave as functions of height above the ground surface at several distances from the centre of the explosion. The simulation assumed a ground roughness of 0.5 cm, which seemed appropriate for the graded radials along which diagnostic measurements of the blast wave were made. A shock-following grid was used to maintain high resolution at and near the shock front. A version of the K - c turbulence model, in conjunction with a rough law-of-the-wall, was used to describe the formation and growth of the real-surface boundary layer. The calculation was carried out from booster Detonation to a time of 1.5 seconds. This time corresponds approximately to the end of the positive duration at the 5 psi level.
Attempts were made to observe and measure the boundary layer characteristics using various methods, including vertical arrays of horizontal cantilevers, displacement cubes placed on and elevated above the ground, and high speed photography of the displacement of vertical smoke trails.

Seven vertical arrays of horizontal cantilevers were used to measure the variation of dynamic pressure with height: five along the North radial over graded ground at the 50, 30, 20, 10 and 5 psi levels, and two over ungraded ground at the 50 and 30 psi levels. Steel cantilevers were used at the higher pressure levels and aluminum at the lower levels. The effect of the boundary layer was observed in all cases, and excellent agreement was obtained when the time-resolved dynamic pressure profiles from the numerical simulation were used to calculate the expected Deformation of the cantilevers. The boundary layer over the ungraded ground was shown to be significantly higher. than that over the graded ground.

An array of vertical smoke trails was established at the 5 psi level, produced by launchers placed in buried silos so that the trails extended from the ground surface. The motion of the trails in the blast wave was recorded by a high speed camera. Analysis of the recorded motion indicated a boundary layer that had grown to a height of 25 cm after a flow time of 100 ms. This result also agreed very well with the prediction of the numerical simulation for this overpressure level.

Cubes made from several different materials and of several sizes have been exposed to a large number of blast waves, and the displacement of the cubes serves as a passive diagnostic measure of the dynamic pressure forces in the blast wave. For the boundary layer experiment cubes with edge lengths of 152 mm and 51 mm were placed on the ground and raised above the ground on short pedestals. The centers of the elevated cubes were 254 mm above the surface. The displacement of the cubes indicated a boundary layer effect only for the small cubes.

Based on the comparisons between results of the numerical simulation and the measured properties of the blast wave, it is concluded that the simulation gave an excellent description of the boundary layer between the 50 psi and 5 psi levels.