August 19, 1944

R. W. Carlson

J. O. Hirschfelder and W. G. Penney

Static Strength of Jumbo

It is proposed to explode 4500 lbs. RDX Comp. B in Jumbo having a volume of 1700 cu. ft. We were asked what pressure would be attained when the shock waves had died out and before the gases cooled.

Under these conditions (using methods and data given in NDRC A-116 by Hirschfelder, McClure, Curtiss, and Osborne) the isochoric adiabatic flame temperature is 3366°K and the number of moles of gas per gram of explosive is .04464. The static pressure is then found to be 8000 p.s.i. This is considerably higher than the 5000 p.s.i. for which Jumbo was designed.

The principle reason for this discrepancy is that Carlson considered the powder gases to have the same composition at the static pressure as Bright Wilson and Kent give for the detonating explosive (at 100,000 atm.). In the detonating explosive a large percentage of the carbon is in the form of carbon black and would not contribute appreciably to the gas pressure. At the 8000 p.s.i. and 3366°K it is easy to show that no carbon can be formed for RDX Comp. B, and therefore the gas volume is considerably larger than Carlson had supposed. (Even for TNT there is hardly any carbon formed under these conditions.)

Our value of 8000 p.s.i. is altogether conservative. It supposes that the only gases present are the water gas constituents and nitrogen (H_2, H_2O, CO, CO_2, N_2). Actually there will be some dissociation of these molecules to form more gas (perhaps 2%). The effect of gas imperfection makes the static pressure 5% greater than would be estimated from the

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perfect gas equation of state.

If TNT were used instead of Comp. B, the final pressure would be 6000 p.s.i., the temperature would be 3040°K, and the number of gas moles produced per mole of TNT would be 8.49, or 0.0374 per gm. of TNT. (These figures are obtained from the equation of state and the equilibrium constants calculated by H. Jones R.C. 212 for TNT; (density 1.5, energy release under these conditions 1000 cals/gm.)

Assuming that the inner diameter of Jumbo is 5 ft., and that the wall thickness of the cylindrical part is 1 ft. and of the hemispherical ends is 6 in., with Comp. B the greatest tension occurs at the inside and is about 45,000 p.s.i. In the hemispherical ends this tension is isotropic in all directions; in the cylindrical portion this tension is circumferential, and the longitudinal tension is about half as much.

A high probability therefore exists that the 2 tons of Comp. B in a Jumbo will cause failure, simply because the final pressure is too high. Self stressing a Jumbo during manufacture may improve the safety, but the shock wave blows of the explosion will certainly cause plastic deformation of the walls and the effect will largely be to remove the original self stressing.

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L. M. Redman
OCT 24, 1980

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