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TITLE Blast Wave Effects at Short Distances

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BLAST WAVE EFFECTS AT SHORT DISTANCES

by

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ABSTRACT

The peak shock overpressures for a blast wave have been calculated by several methods, and the results have been verified by a large number of experimental measurements. The use of the standard overpressure curve, however, may lead to serious underestimation of blast wave effects at very short distances (probably at scaled distances of less than one meter). We have calculated the blast wave from a detonating sphere of explosive using the one-dimensional reactive hydrodynamics code HYDROX, and have obtained good agreement with the standard curve. To describe the interaction of the blast wave with a flat plate, the calculation was also done with the two-dimensional code 2DE (with a much coarser mesh). The air shock matches into the plate at the predicted pressure, but a second, stronger shock is then produced by the arrival of the detonation products. The strength of the second shock decays more rapidly with distance than the first (air) shock. This effect has been verified experimentally.

The peak overpressures for an explosively driven blast wave have been calculated by several methods, and the results have been thoroughly verified by a large number of experimental measurements.[1] A standard curve of peak overpressure ratio vs scaled distance describes these data very well and can be used with confidence for predicting blast wave effects, except at the very short distances that are the subject of this work.

We modeled the detonation of a 3.096 kg sphere of PBX 9501* using the reactive hydrodynamic codes, HYDROX[2] and 2DE[3], with Forest Fire reaction rates.[4] The PBX-9501 was initiated by a hot-spot at the center of the sphere. The blast wave was then followed through air that was modeled with the BKW equation of state.[5] The one-dimensional spherical HYDROX calculations were run to 0.67 m (26 in.) in air and were run into aluminum plates (spherical) at 0.1524 m (6 in.) and 0.3043 m (12 in.) from the center of the donor sphere. The 2DE cylindrical calculations were run with a rigid wall (reflective boundary) at the same distances in order to model the interaction of the spherical blast wave with a flat plate. The sphere has a radius of 73.878 mm (2.91 in.), so these distances are approximately 2- and 4-charge radii.

Figure 1 shows the results of the calculations performed with HYDROX. The two data points from the 2DE calculation illustrate the agreement between the two methods. The detonation runs through the sphere of explosive at a velocity of 8.7 mm/μs, sending a shock into the air at an initial velocity of greater than 8 mm/μs, decaying to 4.4 mm/μs after 50 μs of run time. The detonation products maintain a sharp interface with the air in this model, and the interface region is pulled to a vacuum as the air shock separates from the interface. The behavior of the air shock and the air/detonation products interface is shown in Figs. 2 and 3. The air shock pressure at 0.16 m (6.3 in.) is about 46 MPa (6.8 kpsi), and the pressure in the center of the products is 8.0 GPa (1180 kpsi). At 0.31 m (12.2 in.), the air shock pressure has dropped to 23 MPa (3.4 kpsi) and the pressure peak in the products has moved away from the center and dropped to 70 MPa (10.3 kpsi). The peak pressure in the products is 3 MPa less than the air shock pressure when the air shock expands to 0.405 m (16 in.), and it contines to decay. The resolution

*PBX 9501 is composed of 95% HMX bonded with Estane and BDNPA/BDNPF, with a density of 1.833 mg/mm^3 (Ref. 6). It is similar to LX 14, which has a TNT equivalence of ~167%.[1]

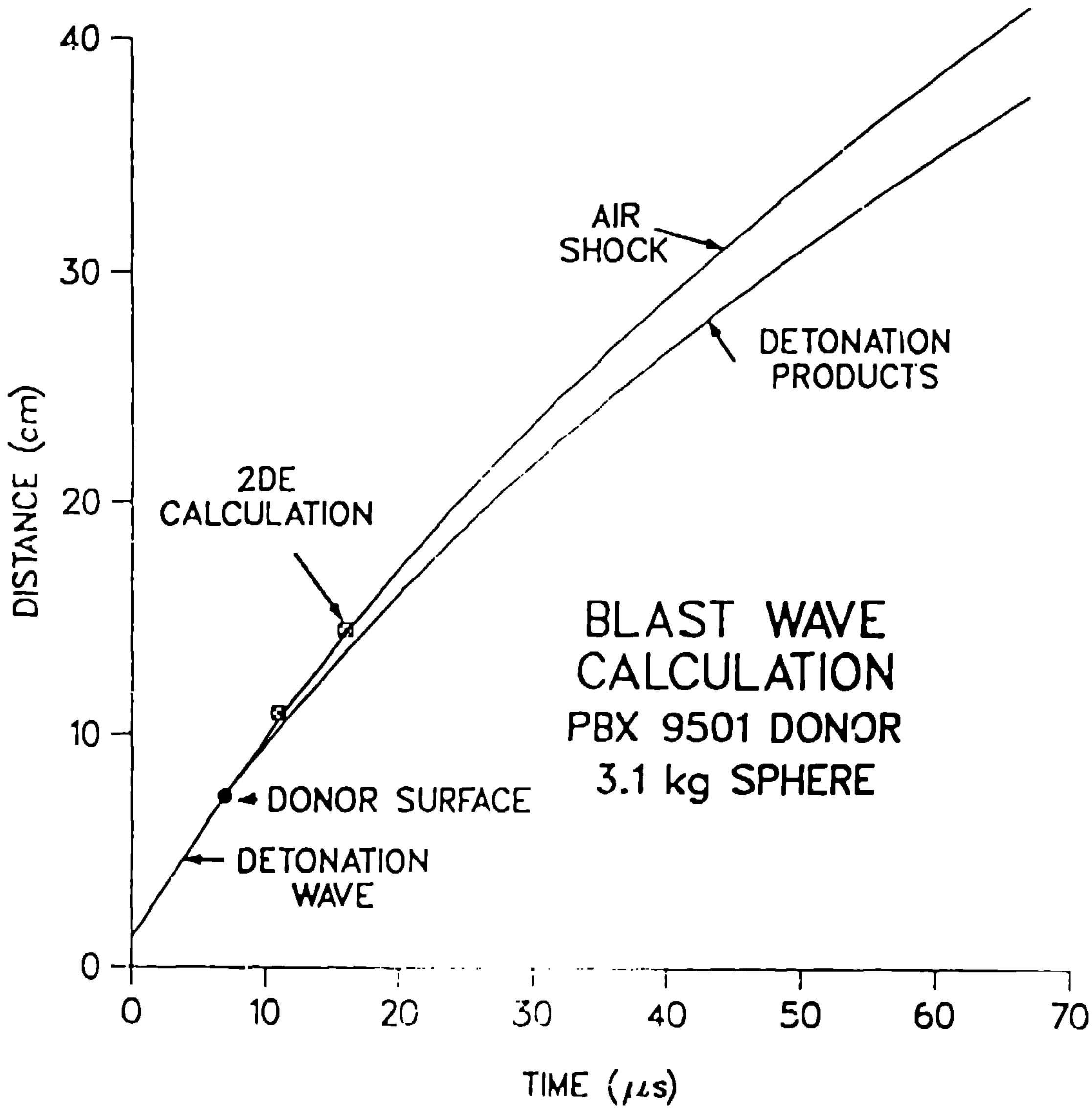

Fig. 1. x-t diagram for the detonation of a 3.1 kg sphere of PBX 9501. from the 2DE calculation (2 mm cells) is too coarse to show clearly the separation between the air shock and the products, in contrast to the 0.1-mm cells in the air shock region of the HYDROX calculation.

Figure 4 shows the decay of the air shock pressure. The results from HYDROX and 2DE calculations are found to be in reasonable agreement with the values obtained from the standard curve.[1]

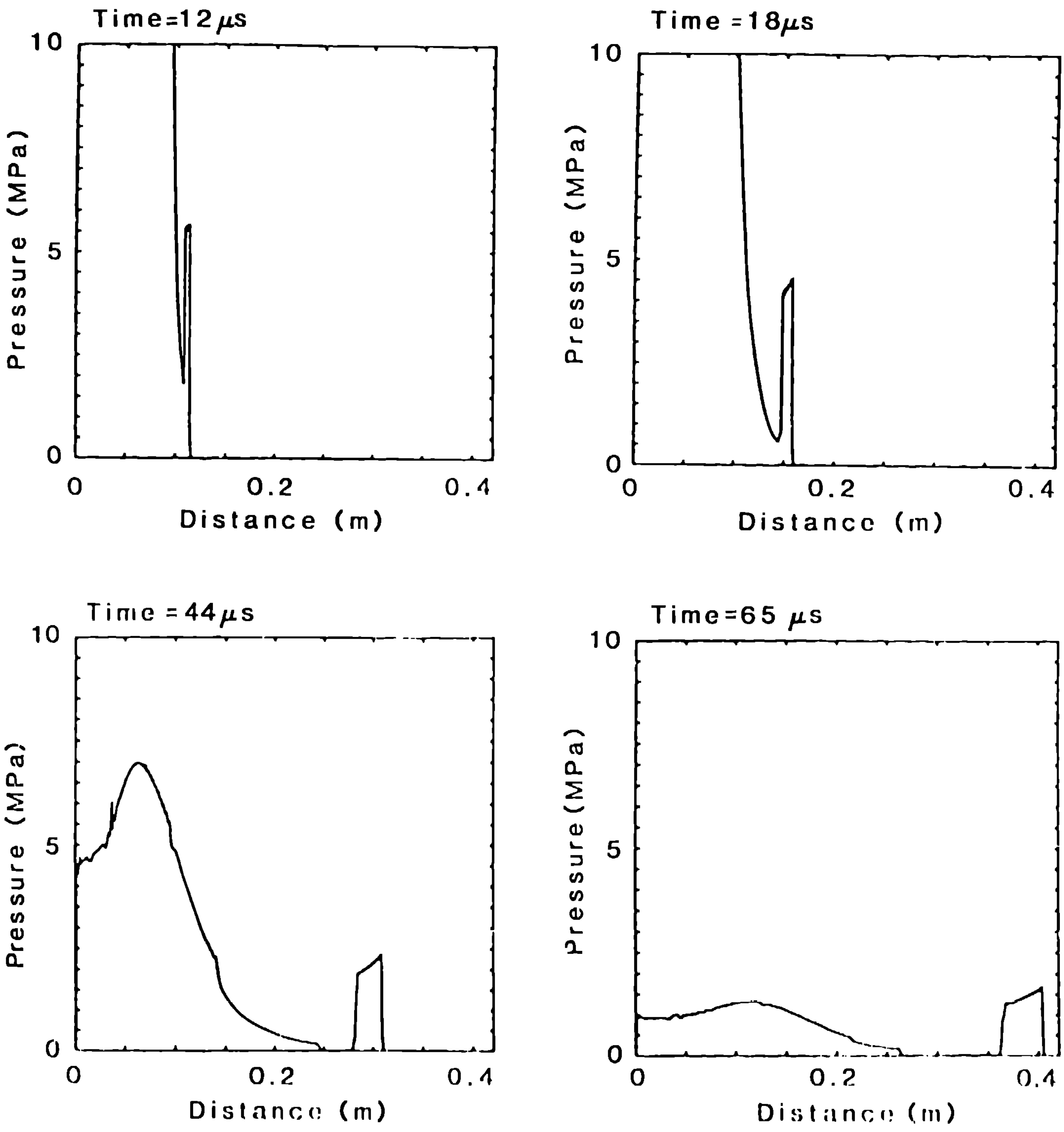

Fig. 2. Plots of pressure vs distance. The peak pressure at 12 μs is 8.5 GPa, and at 18 μs is 8.0 GPa.

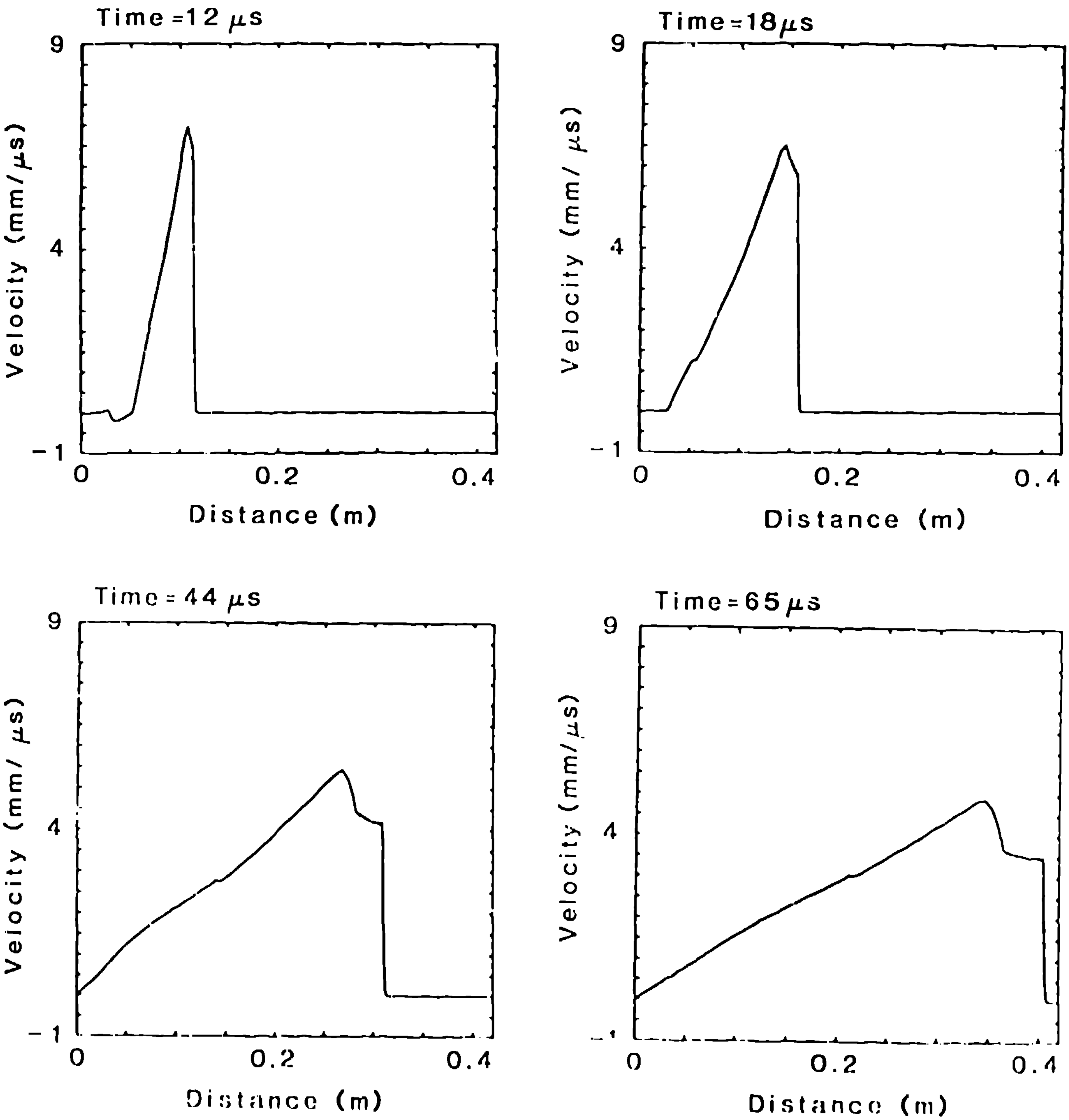

Fig. 3. Plots of particle velocity vs distance.

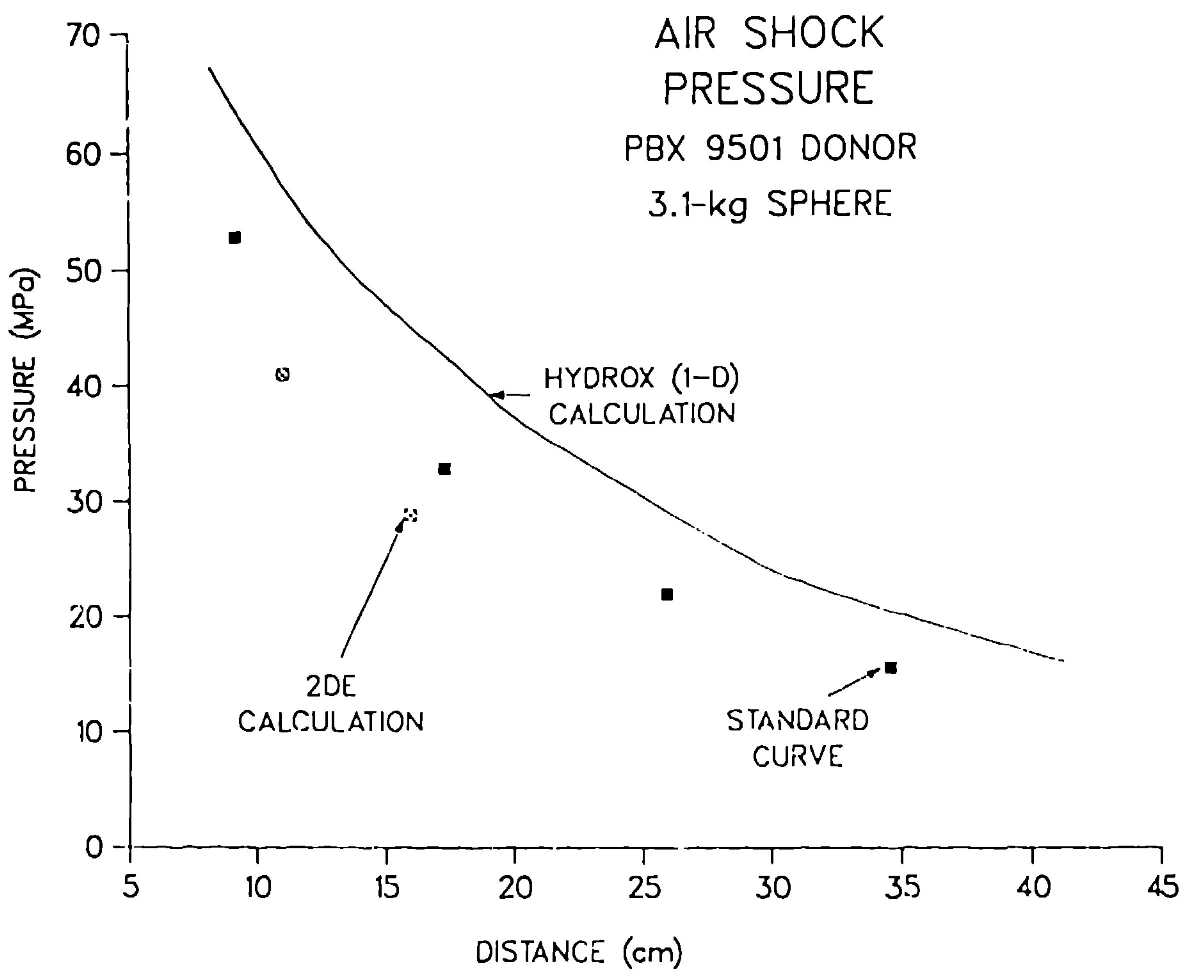

Fig. 4. Peak overpressure of the air shock as a function of distance.

Figures 5 and 6 show the interaction of the blast wave with a rigid wall. According to HYDROX calculations, the air shock sends a 0.42 GPa (62 kpsi) shock into an aluminum plate at 0.152 m (6 in.) and a 0.20 GPa (29 kpsi) shock at 0.305 m (12 in.). The detonation products increase the pressure at the wall to 2.06 GPa (303 kpsi) at 0.152 m (6 in.) and to 0.23 GPa (34 kpsi) at 0.305 m (12 in). We consider this second shock loading to be the major source of blast wave damage at very short distances. This study indicates that the effect of the detonation products decays rapidly with distance, becoming negligible at a distance of approximately 5 charge radii. The effect of the detonation products at very short distances has been described previously in a combined experimental/modeling study of the sympathetic detonation of bare explosive charges.[7]

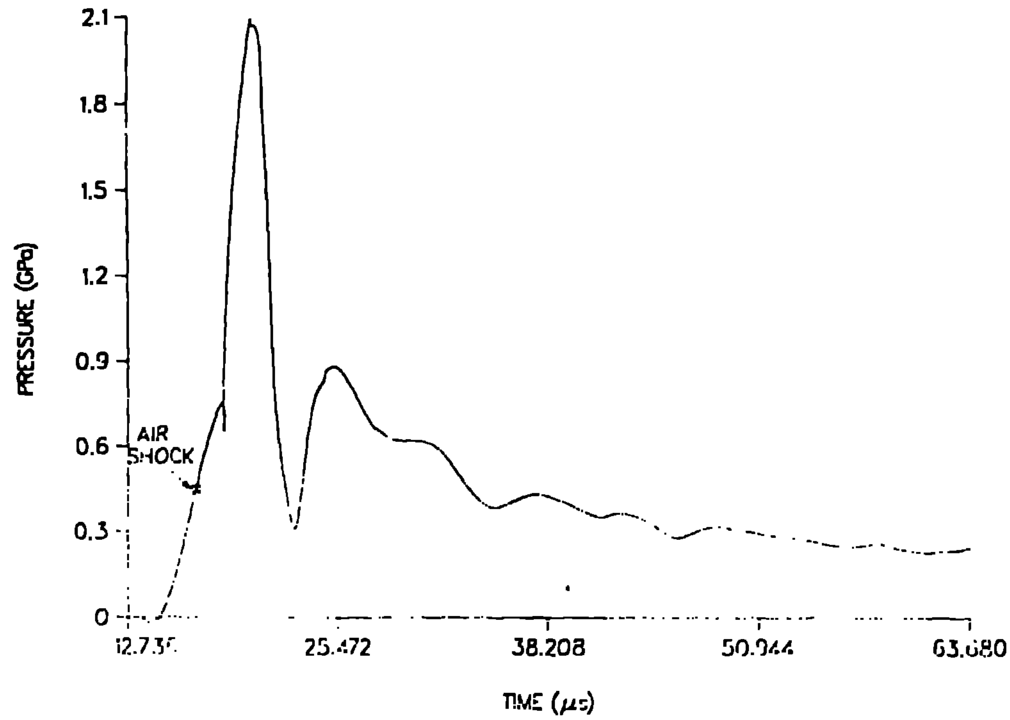

Fig. 5. Pressure vs time at a rigid wall 0.152 m (6 in.) from the center of a 3.1 kg sphere of PBX 9501.

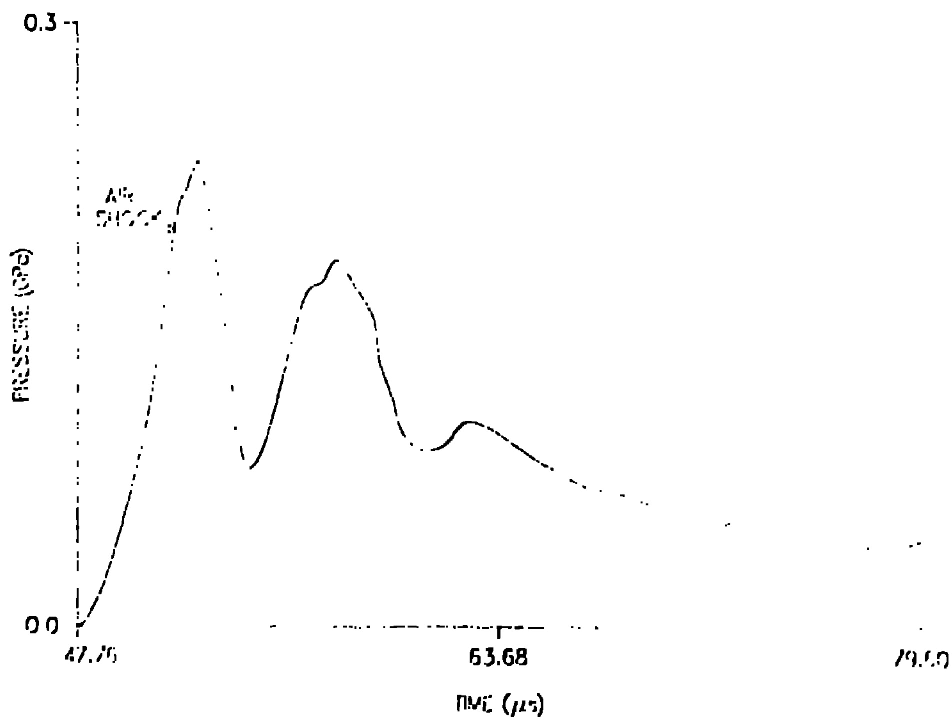

Fig. 6. Pressure vs time at a rigid wall 0.305 m (12 in.) from the center of a 3.1 kg sphere of PBX 9501.

REFERENCES

1. G. F. Kinney and K. J. Graham, Explosive Shocks in Air, 2nd Ed., (Springer-Verlag, New York, 1985).

2. M. S. Shaw and G. K. Straub, "HYDROX: A One-Dimensional Lagrangian Hydrodynamics Code," Los Alamos Scientific Laboratory report LA-8642-M (1981).

3. J. D. Kershner and C. L. Mader, "2DE: A Two-Dimensional Continuous Eulerian Hydrodynamic Code for Computing Multicomponent Reactive Hydrodynamic Problems," Los Alamos Scientific Laboratory report LA-4846 (1972).

4. C. A. Forest, "Burning and Detonation," Los Alamos Scientific Laboratory report LA-7245 (1978).

5. C. L. Mader, Numerical Modeling of Detonations (University of California Press, Berkeley, 1979).

6. T. R. Gibbs and A. Popolato, eds., LASL Explosive Property Data (University of California Press, Berkeley, 1980).

7. A. L. Bowman, J. D. Kersher, and C. L. Mader, "Numerical Modeling of Sympathetic Detonation," Los Alamos Scientific Laboratory report LA-7989 (1979).